2017 SBIR/STTR Phase II and PFI Grantees Conference

Abstract Book




ATLANTA MARRIOTT MARQUIS

JUNE 5-7, 2017

COVER IMAGE CREDITS

(left to right)

Farhang Wireless, Inc.
NSF Award ID: 1632569

STTR Phase II: Scalable Detector for Multiple-Input Multiple-Output (MIMO) Communication Systems

Eight stream wireless testbed used in demonstrating the high spectral efficiency, high data rate, and low cost of the Markov Chain Monte Carlo (MCMC) MIMO technology.

Image Credit: Farhang Wireless, Inc.

Spensa Technologies Inc.
NSF Award ID: 1430996

SBIR Phase II: A Multimodal Sensor Platform for Automated Detection and Classification of Pest Insects

Image Description: Z-Traps ready to deploy out to Z-Trap Network sites.

Credit: Spectrum nonGMO Seed

Neural Analytics, Inc.
NSF Award ID: 1556110

SBIR Phase II: A Novel Non-Invasive Intracranial Pressure Monitoring Method

Image Description: The Lucid™ M1 transcranial Doppler Ultrasound System is indicated as an adjunct to the standard clinical practices for measuring and displaying cerebral blood flow velocity within the major conducting arteries and veins of the head and neck. Additionally, the Lucid™ M1 System measures the occurrence of transient emboli signals within the blood stream.

Credit: Neural Analytics, Inc.

ConsortiEX, Inc.
NSF Award ID: 1660080

SBIR Phase II: Development of a Track-and-Trace Medication Barcoded Label

Image Description: Phamacists utilize ConsortiEX's Assure-Trak® IV Workflow system to produce compounded sterile preparations (CSPs) inside the clean room. (Assure-Trak® IV Workflow system is a software solution utilized via a tablet mounted in the hood in the clean room to track the compounding process.)

Credit: ConsortiEX, Inc.

INTRODUCTION

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

The SBIR/STTR program was conceived at the National Science Foundation (NSF) in 1976. Roland Tibbetts initiated an NSF program that would support the small business community with a specific objective to provide early-stage financial support for high-risk technologies with commercial promise. Today the government-wide program is administered by the Small Business Administration (SBA) and includes eleven federal departments that collectively award over $2.5 billion to small high-tech firms. The primary objective of the NSF SBIR/STTR Program is to increase the incentive and opportunity for small firms to undertake cutting-edge, high-risk, high-quality scientific, engineering or science/engineering education research that would have a high-potential economic payoff if the research is successful.

The current portfolio of the NSF SBIR/STTR program covers a variety of technology topic areas:

- Advanced Manufacturing and Nanotechnology (MN)
- Advanced Materials and Instrumentation (MI)
- Biological Technologies (BT)
- Biomedical Technologies (BM) and Smart Health (SH)
- Chemical and Environmental Technologies (CT)
- Educational Technologies and Applications (EA)
- Electronic Hardware, Robotics and Wireless Technologies (EW)
- Information Technologies (IT)
- Internet of Things (I)
- Other Topics (OT)
- Semiconductors (S) and Photonic (PH) Devices and Materials

To learn more about NSF SBIR/STTR Program, visit our website at http://www.nsf.gov/eng/iip/sbir/

Partnerships for Innovation (PFI) Program

The NSF Partnerships for Innovation (PFI) program is an umbrella for two complementary subprograms, Accelerating Innovation Research (AIR) and Building Innovation Capacity (BIC). Overall, the PFI program offers opportunities to connect new knowledge to societal benefit through translational research efforts and/or partnerships that encourage, enhance and accelerate innovation and entrepreneurship.

The PFI:AIR program supports research to overcome technology barriers or knowledge gaps in the transformation of fundamental science and engineering discoveries into market-valued solutions. The program provides funding for academic researchers to translate prior NSF-supported research discoveries toward commercial reality. Researchers develop a proof of concept, prototype, or scale-up of the prototype that addresses real-world constraints and provides a competitive value in a potential application space. Some grantees have already formed a small business while others have been guided from the outset by business partners who are interested in commercializing their translated discoveries. All are interested in moving their technologies closer to commercial application, creating new partnerships, and learning about additional markets/applications where their technologies could be competitive. In addition, an important component of the AIR program is to offer an opportunity for post-docs and graduate students to engage in entrepreneurial and market-oriented thinking along with their traditional research experience.

To learn more about the PFI:AIR program, visit our website at https://www.nsf.gov/eng/iip/pfi/air-tt.jsp.

The PFI:BIC program supports academe-industry partnerships led by an interdisciplinary academic research team collaborating with a least one industry partner. In this program, there is a heavy emphasis on the quality, composition, and participation of the partners, including their appropriate contributions. These partnerships focus on the integration of technologies into a specified human-centered service system with the potential to achieve transformational benefits, satisfying a real need by making an existing service system smart(er) or by spurring the creation of an entirely new smart service system. The selected service system should function as a test bed. PFI:BIC funds research partnerships working on projects that operate in the post-fundamental/translational space; grantees must be mindful of the state of the art and the competitive landscape. These projects require additional effort to integrate the technology into a real service system, incorporating human factors considerations to assure the system's efficacy. The research tasks in turn might spawn additional discoveries inspired by this interaction of humans with the technology.

To learn more about PFI:BIC program, visit our website at https://www.nsf.gov/eng/iip/pfi/bic.jsp.

The Conference

The annual NSF SBIR/STTR Phase II and Partnerships for Innovation Grantee Conference provides an opportunity for small businesses that have received Phase II awards and academic faculty and students from the PFI program to share their technical and commercial achievements with each other, NSF staff and potential partners and investors. In the spirit of networking and resource sharing, we have designed this Abstract Book as a resource for conference attendees, potential investors, and strategic partners. We also hope to provide a snapshot of the current portfolio of these important programs. Industry and investor attendees are encouraged to use this resource to identify grantees of interest for one-on-one meetings onsite during the event and also to visit this page on our conference website for additional opportunities: http://www.nsfiipconf.com/2017sbirp2/industry-investors/.

WE HOPE YOU ENJOY THE CONFERENCE!

Abstract Table of Contents

ADVANCED MANUFACTURING AND NANOTECHNOLOGY (MN)

Access Sensor Technologies

Program: SBIR Phase II

NSF Award No.: 1534786

Award Amount: $750,000.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Measuring Aqueous Metal Concentrations with the Chemometer

The broader impact/commercial impact of this Small Business Innovation Research (SBIR) Phase II project is in promoting the protection of human health, the environment, and our nation's natural resources by providing new sensors that enable fast, accurate, cost-effective sampling and analysis tools to monitor pollution and exposure. The innovations developed here will allow for the rapid identification and detection of hazardous compounds in water at substantially reduced cost. These technological innovations will translate into triple bottom-line savings of companies by enhancing our ability to protect people and the planet, while simultaneously providing cost and time savings to the business. The technology embodies the concepts of sustainability and ease of use, and will achieve broad commercial appeal by saving businesses money, time, and effort while also giving them more data on potential sources of pollution. Scientifically, this technology will enable more precise assessment of environmental pollution by providing more rapid measurement capability at a larger scale than is currently possible.

This project will develop an innovative, market-disruptive technology for measuring toxic metals in water. This technology is inexpensive, portable, and does not require any power or external reading equipment. Furthermore, it can be adapted to a wide range of toxic compounds after initial commercialization around metals analysis. The system costs an order of magnitude less than the current "point of need" technologies capable of quantitative determination of toxic metals in water, and two orders of magnitude less than the traditional laboratory tests. Access Sensor Technologies is a new startup, but the core team has a strong track record in the field of microfluidic paper-based analytical devices for environmental analysis where the proposed system represents a major innovation in the field. The proposal has four technical objectives: (1) Expand the palette of applicable chemistry to include additional metals: cadmium, lead, manganese, and both chromium 3+ and 6+; (2) Test the prototype system in a relevant laboratory environment or in a simulated operational environment; (3) Achieve a successful customer-driven demonstration of the system in the field; and (4) Identify key elements of manufacturability that define the roadmap to production of the system at market scale.

Air Squared, Inc.

Program: SBIR Phase II

NSF Award No.: 1534668

Award Amount: $298,118.00

Start Date: 11/15/2015
End Date: 10/31/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Compact Torus-Shaped Organic Ranking Cycle for Distributed Solar Thermal Power Generation

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in Organic Rankine Cycles for distributed solar power generation at micro scale and will offer a cheaper alternative to solar photovoltaic (PV), with a payback period of just 4.5 year without government incentives. The use of solar thermal to generate power at residential level would offer a renewed encouragement to the solar thermal industry. With the ability to provide heat and hot water plus electricity, the solar thermal powered product would fulfill the energy requirements of a home single handedly. Most are familiar with the traditional perspective on the societal impact of a system like the Compact ORC - lower energy demand and reduced greenhouse gas. In addition the CORC positively impacts health and wellbeing by improving indoor air quality and providing affordable access. A number of clinical studies connect improved indoor air quality from efficient systems with a reduction in respiratory and cardiovascular conditions. Combining the health benefits of clean indoor air and improved living conditions, the downstream impact on healthcare cost would be enormous.

This project attempts to solve the problem of high cost for renewable energy from solar energy, both PV and solar thermal, at the residential and light commercial level without government incentives. Solar thermal can provide heat and hot water but not electricity. PV can provide electricity but not heat and hot water. The Compact ORC concept can do both with Combined Heat and Power (CHP). Current ORC systems are bulky and inefficient and most importantly high cost. The objective of this research is to combine all of the components of the ORC in one compact, integrated, low cost package. The expander, pump, and generator will all be mounting on a common shaft. The evaporator and condenser heat exchangers will be mounted integral with the ORC reducing inefficiencies and packaging cost. There will be no external piping of components together. The result will be a compact unit that is cost and performance competitive with grid energy.

AnCatt Co.

Program: SBIR Phase II

NSF Award No.: 1556403

Award Amount: $704,730.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Polyaniline Epoxy Primer with Related Topcoat: the Anticorrosion Coating System of a Barrier to Cations with a Barrier to Anions

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in bringing epoxy based conductive polymer anticorrosion paint system to the market. Corrosion will cost the US economy over $1 trillion in 2015. It is highly desirable to develop more effective anticorrosion technologies to reduce this huge economic cost of corrosion. The most effective anticorrosion pigments in use today are based on heavy metal pigments, such as chromates, lead compounds, and zinc/ zinc compounds. Environmental, health, and safety concerns are driving the elimination of heavy metal pigments. The proposed new product will not only reduce toxicity introduced by current heavy-metal based anti-corrosion pigments, but also provide much improved corrosion protection. The project is especially targeting replacement of the epoxy based zinc-rich primer coating systems that are widely used on highway, marine, and energy infrastructures. Solving the poor processibility of environmentally friendly conductive polymers should enable open up a range of new applications beyond anti-corrosion coatings such as electrostatic dissipation, electromagnetic interference shielding, static resistant fibers, conductive inks, toners, and adhesives, etc.

The intellectual merit of the proposed project lies in using advanced knowledge and understanding of anticorrosion coatings. It is generally assumed that organic coatings act as barriers to water and oxygen at the coating - environment interface. But corrosion of metals is an electrochemical reaction process that relates to both cations and anions. The present proposal suggests developing an ion barrier anticorrosion coating system: conductive polymer nanoparticle pigmented epoxy primer with a topcoat. The combination of the primer and topcoat constructs a barrier to both anions and cations, that inhibits the electrochemical corrosion reaction, therefore, provides efficient corrosion protection to the metal. This system will not use heavy metal anticorrosion pigments any more. If present proposed research succeeds, it will demonstrate how an ion barrier coating provides corrosion protection to a metal substrate, and how to formulate an ion barrier anticorrosion coating, and lead to the next generation of anticorrosion coating.

Atacama, Inc.

Program: SBIR Phase II

NSF Award No.: 1556133

Award Amount: $766,078.00

Start Date: 03/15/2016
End Date: 02/28/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Second Skin: 3D Microfluidics-Enabled Technology for Perspiration Management

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in increasing the comfort of people, such as athletes during their high intensity workouts and competitions, warehouse workers who require protective clothing in hot and humid environments, and safety (e.g. firemen and first responders) and military personnel who must endure extreme working conditions. Our revolutionary moisture management technology utilizes a novel 3D microfluidic transport principle to move sweat from the skin to the outside of clothing, where it can drip away or be controlled. Compared with conventional moisture wicking products which are based on capillary absorption, our technology allows fabric and apparel products to remain lightweight, always dry, highly breathable and never-saturated. ATACAMA's technology is designed to provide the wearer an improved regulation of body temperature and comfort level during high intensity activities, contributing to both performance and safety.

This project aims at solving the current problems of moisture-management products that are inadequate when dealing with large amount of moisture (e.g. sweat). In high sweat or high heat situations, apparel can become quickly saturated with moisture, leading to a wet, heavy, sticky feeling that impacts the performance of the wearer. Our proposed research aims to develop a broad range of textiles that can continuously transport moisture, so that fabric remain dry, breathable and lightweight during high intensity physical activities in hot and humid environment. Utilizing the large-scale manufacturing process developed in Phase I, ongoing research efforts will focus on the implementation of the technology on a broad range of fabric materials (e.g. polyester/polyurethane blends, cotton). As well, scientists at ATACAMA will optimize designs of the fluidic channels based on body sweat mapping research and will further enhance the robustness of the fluidic network. A series of breakthrough textile products (e.g. fabrics and apparel) integrated with optimized and robust 3D microfluidic-enabled moisture management technology will result from the completion of Phase II.

Branch Technology, LLC

Program: SBIR Phase II

NSF Award No.: 1632267

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Additive Manufacturing in Construction

This Small Business Innovation Research Phase II project is in support of Branch Technology's novel Additive Manufacturing (AM) process that combines 3D printing technology and conventional construction materials to enable a new way to create buildings. The construction market in the US is approximately 8% of GDP. Any portion of the market that could be enhanced would have a large impact in the US economy. To that end, Branch is creating a process similar to building found in the natural world. In the formation of natural systems, material is the most expensive commodity; a structure is derived by the efficient use of material, but shape is free to be created in almost any form. Branch can approach this efficiency with additive manufacturing, where form is created and material is deposited only when needed and little waste is created. At the core of Branch's method of AM-based construction are three key developments: a three-dimensional freeform structure (the cellular matrix or lattice) which serves as a scaffold for other materials, a robotically- controlled extrusion mechanism by which the cellular matrix is produced, and the algorithms necessary to control the robot for successful production. The proof of concept for this process and more have already been demonstrated by Branch in Phase I of this grant.

The technical objectives for Phase II focus on improving the procedures and technology already created. The focus areas for this phase are algorithm development, hardware improvements, the application of finishing materials, code compliance testing, and material science experiments. Algorithm development consists of refining and creating the software necessary to extrude the printed matrix and support a client base. Hardware improvements are necessary to improve the speed and efficiency of the process to create a commercially viable workflow. This research will necessitate the purchase of extra hardware for experimentation. American Society for Testing and Materials (ASTM) testing for load bearing capacity is necessary to enter the market and provide code compliant construction. Experimentation in the application of finished materials to the 3D printed lattice such as spray foam and concrete are vital to the realization of complete buildings.

BTI Targetry, LLC

Program: SBIR Phase II

NSF Award No.: 1632484

Award Amount: $749,924.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Boron Nitride Nanotube Cyclotron Targets for Recoil-Escape Production of Carbon-11 For PET/CT Medical Imaging

This Small Business Innovation Research (SBIR) Phase II project intends to meet the need for low cost dose-on-demand production of Carbon-11 isotope for biomarker and radiotracer applications in nuclear medicine. Biomarkers and radiotracers are commonly used for Positron Emission Tomography and Computed Tomography (PET/CT) metabolic imaging, in support of research, drug discovery, and detection of cancer and other illnesses. They are also used for therapy staging of cancer, to determine if treatment is effective. Common examples include myocardial perfusion imaging of the heart to visualize blood flow and function, PET scanning of the brain to detect early onset Alzheimer's and brain tumors, and Choline PET/CT for the diagnosis and staging of prostate cancer. Carbon-11 is an important radiotracer/radiopharmaceutical that offers unique advantages due to its ability to be easily incorporated into many molecules without impacting biological activity. Carbon-11 is currently produced by using specialized targets on high-energy commercial cyclotrons. These cyclotrons cost millions of dollars to install, and existing targets are inefficient. Low energy cyclotrons are significantly less expensive, and are currently under development by multiple commercial companies. This project seeks to develop a novel cyclotron target methodology for producing Carbon-11 at low energies using unique nanomaterials, resulting in significantly lower costs.

The intellectual merit of this project is in the use of novel nanomaterials to produce Carbon-11 more efficiently and at lower cost, through development of recoil escape targets. It is challenging to find a good target material suitable for both efficient production of Carbon-11, by one of several available nuclear reactions, and efficient recovery of the produced radiotracer in a usable form. The produced Carbon-11 can be difficult to recover, as it is easily trapped in many conventional target materials, resulting in low yields. Recent advances in nanoscience and technology allow for production of novel materials with unique characteristics. Boron nitride nanotubes (BNNT) are composed of fibers with single atomic thickness, or at most a few atoms thick, allowing Carbon-11 to be efficiently produced and recovered in the form of carbon dioxide gas using low energy cyclotrons. Prototype production targets will be developed and tested at commercial cyclotron sites. The process for collecting the produced Carbon-11 gas will be optimized to achieve the highest yields of usable radiotracer material. Efforts will be made to further develop BNNT materials with ideal characteristics, including high purity and optimal density.

Carnot Compression, LLC

Program: SBIR Phase II

NSF Award No.: 1660248

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Isothermal Gas Compression

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in reducing the energy consumption from air and gas compression. In the United States, industrial air compressors consume over 12% of manufacturing electricity consumption, or 399 trillion BTU. 5% of natural gas production in the US is consumed by compression to move the gas to the end-user. On a global basis, compressors driven by electric motors are estimated to consume 32% of the electricity consumption from electric motor driven systems, or 2,267 terawatt hours per year. At $0.10 per kilowatt hour, this translates into nearly $227 billion of annual electricity costs for compression. Carnot's technology has the potential to reduce energy consumption from compression by 20% or more across multiple compression applications. By reducing the energy consumed for air and gas compression, the technology will reduce the carbon footprint of industrial and commercial activity in the US and internationally.

Isothermal compression has been thought unachievable due to the requirement of rapidly capturing the heat of compression. The Phase I project allowed us to integrate proven design elements from prior prototypes, along with a complete liquid recirculation and heat dissipation system, into a single platform. This project will build upon research performed under the Phase I project to bring our compression technology to commercial readiness. A 2-year research and development plan will be executed to address key systems engineering elements of the technology to achieve commercial ready status. A combination of lab experiments, thermodynamic modeling, design, engineering, and benchtop prototyping will be used to develop a commercial ready system design that can be applied to a broad range of industrial compression applications. Further study and exploitation of isothermal compression may lead to an ever-evolving field of application, potentially creating additional areas of research and learning.

Eclo, Inc.

Program: SBIR Phase II

NSF Award No.: 1556080

Award Amount: $753,502.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Footwear Fitting System for Online Retailers

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in online retail industry for garments, orthoses and prostheses. Each human body is unique, and the fitting approach is often reduced to trying on products in-store or in-clinic. While this approach works to some level, increasingly more purchases are made online, and a similar trial and error method leads to a high return rate for retailers and a significant time burden for customers. The fitting system Eclo is developing will dramatically reduce the shipping costs for online retailers and increase the convenience for online shoppers. Additionally, the virtual fitting technology will help remove the dependency of companies on brick-and-mortar stores and to reduce the cost of goods by half in some cases. Furthermore, the technology proposed is the key for mass manufacturing of custom garment since all geometric properties of the body will be readily using smartphones. The databases of body scans could also be used for designing better products. Lastly, the shoe scanner in this project requires a small scanner head design for internal volumes; this technology can be tailored to making endoscopes for medical or rescue applications.

This project will prepare a virtual fitting system for commercial use in online shoe retail and address a 25% return rate. The virtual fitting system will give online shoppers a size recommendation based on scans of their feet. A foot scanner allows users to obtain a 3D model of their feet by taking a video with a smartphone. This process will be made simple, robust, and user-friendly with the aid of augmented reality. Using smartphone sensors and strategically selecting images from videos will make this process fast and accurate. A shoe scanner scans the inside of shoes and will be upgraded to also scan the outside of shoes. A fitting algorithm will be developed to detect important features on feet and shoes to make size recommendations. A custom device will be made to measure the material properties of shoes to give online shoppers a description of comfort and support levels of shoes. Online shoppers will be given a size recommendation and an in-depth fit description with visual graphics.

Foundation Instruments

Program: SBIR Phase II

NSF Award No.: 1556127

Award Amount: $750,000.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Evaluating the Feasibility of a Fully-automated, On-line, Real-time Analyzer for Simultaneous Determination of Individual THMs and HAAs

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in the ability of the haloacetic acids (HAAs) analyzer proposed here to change how superintendents of drinking water utilities go about understanding their drinking water treatment plants. The HAAs analyzer will allow superintendents to continuously map, monitor and then optimize their drinking water treatment practices using detailed and high quality measurements on the federally-regulated HAAs, which are carcinogens. Optimizing of the water treatment practices using the HAAs analyzer will reduce chemical usage (save money) while simultaneously providing the highest quality drinking water for their customers by minimizing HAAs. The commercial U.S. market for Drinking Water chemicals, contract operations, consulting/engineering, instrument and testing is $19.3 billion. The entire U.S. Water industry market is $86.4 billion. The major target of this proposal is the 28,643 traditional community water systems serving 90 % of the U.S. population. Some water systems struggled to meet Stage 1 Disinfection By-Product (DBP) regulations. Stage 2 of these regulations is stricter. The DBP regulations address long-term (decades' timescale) exposure to HAAs. Superintendents can use the proposed HAAs analyzer to understand hourly, short-term variations in their treatment plants to enhance long-term minimization of HAAs.

This project will commercialize the first state-of-the-art instrument for fully automated, on-site process monitoring of the drinking water disinfection by-products known as haloacetic acids (HAAs). The HAAs analyzer proposed here has the potential to significantly reduce the cost of water treatment through reduction of treatment chemical usage at the water treatment plant while simultaneously improving and stabilizing water quality with respect to the carcinogenic and federally regulated HAAs. Currently, most drinking water treatment plants use contract laboratories to determine HAAs concentrations in the distribution system. This approaches can take 2 - 3 weeks to return the results at a significant expense for the equivalent hourly data provided by the proposed HAAs analyzer. The research objectives for this Phase II SBIR proposal are to develop components for the HAAs analyzer to enable long-term, maintenance free operation with minimal operator intervention. Simultaneously, costs will be reduced for both construction and operation of the HAAs analyzer to establish commercial feasibility. The anticipated results will be a HAAs analyzer that will provide water treatment personnel individual and Total HAAs concentrations once per hour, on-site and automatically.

Georgia Tech Research Corporation

Program: PFI:BIC

NSF Award No.: 1631803

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:BIC Next Generation Real-Time Distributed Manufacturing Service Systems Using Digital Process Planning and GPU-Accelerated Parallel Computing

The research project will enable scaling of novel manufacturing analysis applications in a smart, human-centered manufacturing service system. This manufacturing service system will enable highly functioning relationships between a range of users, including service consumers (e.g., designers, entrepreneurs, makers) and service producers (e.g., manufacturers). Design organizations and new entrepreneurs have limited access to the advanced manufacturing processes needed for innovation due to longstanding barriers associated with: (1) cost and availability of advanced manufacturing platforms and (2) technical skill and experience needed to design manufacturable products in a correct-by-construction framework. While direct-to-print paradigms, such as 3D printing, have increased the capabilities for users to make parts directly from digital product designs, the capital equipment for manufacturing functional components are still housed in mostly private enterprise facilities. Additionally, challenges to accurately specify product manufacturing requirements remain as barriers toward facilitating large-scale, consumer-driven manufacturing services. Smart manufacturing service systems that address these persistent challenges will dramatically accelerate innovation across multiple industrial sectors by removing technological barriers for functional manufacture. The consumerization of manufacturing services will also enable manufacturers with excess production capacity to access a significantly broader customer base, facilitating stabilization of production capacity through decentralization of service demand. Democratization of access to manufacturing capabilities and the associated sharing economy benefits will lead to transformative advances in product realization for the US economy.

To facilitate these collaborations, this research project leverages prior discovery for rapid, digital process planning based on novel hybrid dynamic tree representations and graphics processing unit (GPU) accelerated parallel computing. To implement this novel discovery in a distributed service system, the digital process planning method will provide product and process intelligence for each user class. Human subjects experiments and user requirements modeling will inform system design for user interface functionality, service consumer cognitive processing, service provider informational needs, and consumer-to-producer interaction requirements. The service system architecture will be designed to interface with users, facilitate user transactions, receive and shape input data, and enable archival functionality. To realize the foundational digital process planning discovery in a novel human-centered service system, new information models for manufacturing-related data and service provider production capabilities will be established. Advanced computational algorithms will also be derived for scaling GPU-accelerated process analyses in a many-user, cloud-based environment. Comprehensive system testing will inform efficacy of the underlying user requirement models, service system architecture, manufacturing information models and GPU-accelerated computing for generalized human-centered manufacturing service systems.

The research project assembles a collaborative team of experts in the fields of manufacturing, design, computing and psychology and a diverse range of industrial partners and nonprofit agencies to realize a next-generation manufacturing service system. The lead institution is Georgia Tech with faculty from mechanical engineering, computing and psychology. The industrial partners, Tucker Innovations (small business), Mazak (large business), Morris South (large business), represent manufacturing technology developers and platform builders with interest in facilitating broad access of enterprise-level technologies to consumer end users. The partner industrial consortia, National Center for Manufacturing Sciences (non-profit), National Center for Defense Manufacturing and Machining (non-profit) and Digital Manufacturing And Design Innovation Institute (non-profit), provide access to a strong membership base spanning many industrial sectors. Collaborations at Georgia Tech with The Center for the Enhancement of Teaching and Learning, Vertically Integrated Projects Program and VentureLab will facilitate connections of research outcomes to educational outcomes for the broad community of makers.

Graphene Frontiers, LLC

Program: SBIR Phase II

NSF Award No.: 1330991

Award Amount: $1,151,526.00

Start Date: 09/15/2013
End Date: 07/31/2017

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Roll-to-roll Production of Uniform Graphene Films at Atmospheric Pressure and Low Temperature

This Small Business Innovation Research (SBIR) Phase II project will demonstrate and develop technology for the roll-to-roll production of continuous graphene films. The graphene production technology is based upon innovations in the graphene synthesis and graphene handling, addressing critical deficiencies limiting industrial manufacture of graphene. The synthesis process is performed at atmospheric pressure, allowing roll-to-roll graphene formation on continuous tapes of copper foil passed through the growth region. This eliminates the need for an expensive vacuum furnace and allows fabrication of graphene films larger than the furnace size. The graphene handling process developed during Phase I enables the transfer of graphene sheets from the metal catalyst to nearly any smooth surface without any high temperature steps and without the use of harsh chemicals. Most importantly, the graphene transfer preserves the original metal substrate for reuse. The reusable substrate dramatically reduces the cost of graphene production and eliminates the largest source of waste in the process. In Phase II, we will demonstrate the continuous film processes for graphene synthesis and transfer to new surfaces and design a large area roll-to-roll graphene production system.

The broader impact/commercial potential of this project is through the industrial scale availability of high quality, low cost graphene sheets. Transparent, electrically and thermally conductive, strong, flexible, and gas impermeable, graphene is an emerging 'super material' with innumerable proposed applications including flexible transparent conductors for displays and photovoltaics; high frequency electronics for communications; chemical and biological sensors; corrosion barrier; filtration and water desalination; energy storage; and many more. Industrial quantities of graphene films will enable the development of these and other applications, with substantial benefit to society. The technology that we will to develop has advantages of cost, quality, and design flexibility over competing concepts. Successful completion of this SBIR project will establish Graphene Frontiers as a leading commercial supplier of high-quality graphene to the business and research communities at an attractive price. Our business model includes revenue from sale of the graphene material, licensing of our proprietary growth technology, and specialized products. Our first graphene-based product, TEM grids for electron microscopy, is already on sale with a development partner. These advances will position Graphene Frontiers to attract additional funding from investors, customers, and other non-SBIR sources.

Hummingbird Nano, Inc.

Program: SBIR Phase II

NSF Award No.: 1555996

Award Amount: $746,770.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Innovative Platform Technology for Rapid Three Dimensional Fabrication of Capillary Electrophoresis Chips: Phase II Proposal

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in developing a novel method of manufacturing micro sized parts in three-dimensions without layers at high volume. With no parting lines, the technology represents a significant advancement over current state of the art molding and 3D technologies for certain applications. As this represents an entirely new field of research, not merely an extension of solid freeform fabrication (SFF) techniques, it opens and enables wide research areas in engineering and chemical disciplines. More imminent is using the technology to create capillary electrophoresis (CE) chips that vastly reduce the amount of reagents, provide previously unattainable properties, and at a significantly lower price. By doing so, the technology will accelerate and broaden the adoption of microfluidics which are currently used in applications such as forensics, genomics, drug making, drug analysis, clinical diagnostics, biosensors, and environmental testing, among countless others.

This project automates and expands a novel platform technology to manufacture high resolution micro parts. The technology is focused on a unique and inexpensive method to fabricate microfluidic channels and wells, which form the basis of all microfluidic chips. The objectives for Phase II are to: 1) Expand the versatility of the system by inclusion to the platform system of fiber optic cables, temperature control capillaries, microfluidic design of static mixer and expansion of molding materials, 2) Design and construct a pilot automation system to increase control and reduce variability, 3) Test the automation system, 4) Test chips produced via the automated system and test additional versatility components from (1), and 5) Continue to commercialize the products. The technological outcome is an automated system with expanded versatility that will center on the construction of capillary electrophoresis chips, with the objective of making the system on that can manufacture a wide variety of microfluidic chips.

Intact Solutions

Program: SBIR Phase II

NSF Award No.: 1556007

Award Amount: $740,530.00

Start Date: 03/15/2016
End Date: 02/28/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Cloud-based Simulation Service for Makers

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in the democratization of manufacturing through democratization of design and simulation technologies. Geometric design systems and CAD tools are now widely available as standalone systems or cloud-based services, but simulation technologies remain inaccessible due to high cost, tedious data preparation, and demand of expertise in structural simulation. This project aims to make structural simulation widely available to both novice and expert users as a low cost fully automated service that requires no preprocessing or data conversion. The cloud-based simulation service is a disruptive technology that will make structural simulation widely available to communities of makers, as well as manufacturing enterprises, leading to dramatic improvements in performance, manufacturability, sustainability and cost savings. Wide adaption of simulation tools is also an important ingredient of STEM education and workforce development.

This project will address the technical challenges identified in Phase I of the project, focusing on the goal of making cloud-based structural simulation service easily accessible and widely used. The key ingredients of the proposed approach are: (1) Development of novel user interaction modes and scenarios that enable rapid creation, composition, and editing of structural simulations by novice and expert users; (2) Guided interactive interpretation and exploration of simulation results aimed to not only to convey and explain simulation results, but also to engage the users into improving their designs by creating improved simulation scenarios. (3) Context-integrated simulations, where automated simulations are fully integrated with other services and delivered seamlessly within the context of common design or manufacturing applications, such as shape design, 3D printing, or manufacturability analysis.

MagAssemble, LLC

Program: SBIR Phase II

NSF Award No.: 1556031

Award Amount: $733,870.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Reducing Size and Cost of Optical Devices with Nanomanufacturing - a Novel use of Disk Drive Technology

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in advanced manufacturing. This project will develop a low cost, small-footprint high-resolution nanomanufacturing platform for building optical devices that are traditionally manufactured using cleanroom microlithography. Compared with modern cleanroom approaches that require significantly more complicated and expensive facilities, this platform holds strong promise to build visible-to-infrared wavelength optical components that are both smaller and lower cost, in order to serve the fiber-optic sensor, telecommunications, and lens markets. If this platform can deliver optics components that meet specifications, demand could reach 8-figures for a single customer, thus transforming optics manufacturing across the entire spectrum of markets that use photonics: biomedical, energy, military, and consumer. If it meets the needs of the photonics sector, this platform could penetrate a much broader commercial marketplace such as information technology, nanoelectronics and personalized low-cost consumer devices. The scientific and technological understanding created by developing this platform could enable businesses to leverage low-cost US-based nanomanufacturing to address markets for advanced materials and components around the world.

This project will commercialize an innovative nanomanufacturing platform for producing diffractive optical elements (DOEs) with potential to reduce component cost and size. Recently fiber-optic communications has expanded beyond its traditional function of long haul or backbone communications. Reducing the size, cost and complexity of optical components could allow DOEs to further expand their reach. Ideally the functionality of these components could be built right onto the end of an optical fiber. The proposed technology could allow true fiber-to-fiber components at a cost equal to or less than currently available optical components. It could further allow for sensing capabilities of “lab on a fiber” with the lab incorporated onto the end-face of a fiber. The project will focus on scaling the nanomanufacturing capability demonstrated during Phase I for end product prototype demonstrations that incorporate the DOEs.

Mark Miles Consulting, Inc.

Program: SBIR Phase II

NSF Award No.: 1456103

Award Amount: $909,425.00

Start Date: 03/01/2015
End Date: 08/31/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Solar Thermal Collector Using Advection Enhanced Nano-Porous Insulating Media

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will profoundly improve the economics of solar water heating (SWH) systems. Little innovation has occurred in this area since the advent of evacuated tube solar thermal collectors in the 1980s. Despite these advances the cost of SWH systems is much higher than the cost of fossil fuels in the U.S. Thus while there exists a flourishing global market in excess of $20B, the market for such systems in the U.S. is virtually nonexistent. The solar thermal collector technology under investigation has demonstrated performance in terms of efficiency vs. output temperature that is already superior to that of state-of-the-art collectors. Economic modeling further indicates that in high volume production the collector would be substantially less expensive than commercial products. This combination of improved performance and reduced cost has the potential to make SWH economically viable in more than 40 states in the U.S. An outcome which could provide a solid economic foundation for the revival of a domestic industry, and accelerate the proliferation of these systems worldwide.

This Small Business Innovation Research (SBIR) Phase II project will extend the performance envelope of two solar thermal collector architectures identified during the Phase I effort. Current solar thermal collectors exhibit non-economic price/performance metrics and are constrained to water heating applications in only a few markets worldwide. The first architecture utilizes advection to improve the insulating properties of a granular nano-porous medium. The Phase II effort will transition this architecture from prototype to the fabrication and characterization of an engineering scale collector. It is expected that increasing the size and solar simulator output (currently below reference standard) will increase efficiency significantly. Material dopants, heat transfer fluid dynamics, and optical absorber thermal properties will be examined computationally and experimentally to further improve performance. The second architecture significantly extends the operational range. This effort will explore techniques to expand this range including the use of material dopants to modify optical characteristics and the development of passive technique for concentrating optics. Computer simulations suggest that outputs comparable to that of a parabolic trough are possible.

Micro Laser Assisted Machining Technologies, LLC

Program: SBIR Phase II

NSF Award No.: 1330439

Award Amount: $1,188,661.00

Start Date: 09/01/2013
End Date: 09/30/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Micro Laser Assisted Machining

This Small Business Innovation Research (SBIR) Phase II project enables an innovative high-productivity approach to manufacturing hard and brittle materials like ceramics, semiconductors, and glass. The objective of this proposal is to build on the successful Phase I feasibility study to demonstrate an efficient and productive method that could manufacture ceramic and semiconductors with excellent part quality. The process, termed Micro-Laser Assisted Machining (micro-LAM), allows a cheaper (~40-60%), faster (by two to five times), and better method of machining and manufacturing hard and brittle materials by combining the preferential heat from a laser source and extreme pressure from a diamond tool. The status quo technology for manufacturing these materials requires extensive machining hours to obtain good part quality, which is not economical. The demand for high-end ceramics and semiconductors is continuously increasing; however, high production costs have forced manufacturers to use other materials with inferior properties. The goal of this effort is to address this unmet need by commercializing the micro-LAM technology by the end of Phase II. A minimum viable product will be tested at industrial partner sites to obtain firsthand customer feedback, which is key to accelerating the commercialization process.

The broader impact/commercial potential of this project will be felt in semiconductor (microelectronics) manufacturing, optics (mirrors and windows), and precision mechanical products (bearing and seals), where the superior properties of advanced semiconductor and engineered ceramic materials are required to achieve performance criteria. This technology will enable entirely new capabilities for production of materials and products currently not viable or achievable due to processing limitations. The micro-LAM technology also has potential applications for emerging technologies, such as wind turbines and plug-in electric vehicles, where high-power and high-temperature operation of advanced devices is required. The current target market size, including optics, semiconductor, advanced ceramics and glass parts manufacturing, is approximately $250 million, with a 15%/year growth rate. Once market acceptance is established in the target market segment, the micro-LAM tooling will be launched into the larger diamond turning machine (DTM) market, with a total size of $2.4 billion. There are approximately 10,000 DTMs in the United States alone (with ~ 500 new tools introduced per year).

MTPV, LLC

Program: SBIR Phase II

NSF Award No.: 1256583

Award Amount: $1,089,905.00

Start Date: 04/15/2013
End Date: 09/30/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Epitaxially Grown GaSb Thin Films on GaAs Substrates For Near-Field Conversion of Heat to Electricity

This Small Business Innovation Research (SBIR) Phase II Project goal is to produce GaSb photovoltaic devices of multicell (MIM) construction for TPV use. Current devices use single cell. MIM devices have significant advantages over single cell in efficiency and cost. A MIM device is composed of many sub-cells physically isolated on the same substrate. This proportionally increases output voltage and decreases output current resulting in lower internal power loss. To date there have been no publications describing MIM Ge or GaSb MIM devices. The Phase I Program demonstrated that high lifetime GaSb can be epitaxially grown on semi insulating GaAs and an IR&D program demonstrated that 50 subcell MIM devices can be fabricated from epitaxial germanium on semi insulating GaAs. Combining these elements will produce an ideal device. Although the Ge MiM is suitable for TPV a GaSb MIM would give a three to tenfold improvement in performance.

The broader impact/commercial potential of this project is to economically & efficiently recover waste heat as electricity. 57% of all power generated in the US is rejected as waste heat, however, to date there have been no successful attempts to recover this heat as electricity as opposed to steam for heating purposes. MTPV is developing a thermophotovoltaic solution to address this problem and is a pioneer in the use of near-field evanescent coupling to dramatically increase the power density obtainable from a heat source at a given temperature. MTPV has published a clear demonstration of this phenomenon and is engaged in commercializing its use. Silicon emitter chips designed to transfer energy from a heat source in such a manner as to facilitate the formation of a sub-micron gap are currently being produced in a foundry as well as both single cell and MIM Ge devices. The unique housing that is required to contain these chips and allow insertion into an 1100 degree C furnace is designed/ fabricated at MTPV's facility where power generation tests are conducted.

Nano Hydrophobics, Inc.

Program: SBIR Phase II

NSF Award No.: 1632244

Award Amount: $749,997.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Simple and Effective Fouling Release Coatings To Make Industrial Heat Exchangers More Energy Efficient

This Small Business Innovation Research (SBIR) Phase II project will further develop and commercialize an innovative coating which minimizes the accumulation of mineral fouling on industrial heat exchanger surfaces. Heat exchangers are used to heat or cool fluids in industrial processes, such as chemical manufacturing, oil refining, power generation, food processing, electronics manufacturing, and many more. Air conditioning for factories and large commercial buildings also represents a significant use of heat exchangers. Fouling occurs when naturally dissolved minerals in water, often called "hard" water, precipitate out of the water when it contacts a hot surface. This fouling can be seen in a typical home on the surface of a teakettle or showerhead. The resulting mineral crystals adhere strongly, and form an insulating layer that materially reduces the thermal efficiency of industrial heat exchangers. Mineral fouling is estimated to cost U.S. industry $40 Billion per year, and waste $3 Billion of energy, representing upwards of 1% of U.S. greenhouse gas emissions. In addition to wasting energy, this worldwide, never-ending problem increases factory downtime and maintenance costs, causes industry to spend large amounts on chemical treatment of water supplies, and decreases the useful life of heat exchanger systems. An effective coating will result in substantial environmental benefits including the elimination of greenhouse gas emissions resulting from the wasted energy, and a reduction of the water treatment chemicals, which eventually enter community wastewater streams.

The coating material is a low surface energy, self-assembling hydrophobic material which is a composite of a host polymer and a nanoparticle. The low surface energy of the coating impedes the attachment of the minerals to the coated heat transfer surface. Phase I results showed that any fouling accumulation on a coated surface exhibits low adhesion strength, which allows any fouling that does occur to predominantly be dislodged by the force of the water flowing over it - a phenomenon call "self-cleaning." The coating is very thin - less than 500 nm - which minimizes impedance of heat transfer due to the presence of the coating itself. Phase II research will focus on optimizing the properties of the coating, including substrate adhesion, surface energy, and toughness to ensure a useful life under industrial conditions. This will be accomplished by changing the host polymer chemistry to facilitate self-assembly, and also by changing the chemistry of the nanoparticle to obtain a covalent bond between the host polymer and nanoparticle. Work will also be performed to design the application process for industrial scale, and validate lab results with field trials at industrial sites.

Nanomaterial Innovation, Ltd.

Program: SBIR Phase II

NSF Award No.: 1456291

Award Amount: $624,507.00

Start Date: 06/01/2015
End Date: 04/30/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Carbide Bonded Graphene Coating for Enhanced Glass Molding

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in significantly lowering the cost of high precision glass molding through a low-cost carbide-bonded graphene coating. In optical industry, optical glasses have been the de facto choice. These lenses are used in cameras, projection systems and military equipment. However, cost and other considerations frequently lead to the choice of injection molded plastic lenses with their acceptable but lower image quality. The innovative carbide-bonded graphene coatings are both low cost and durable, and could allow use of precision optical glasses in places where plastic products are used today. The coatings also have the potential to spread to other markets such as advanced thermal management, next generation electronic components, and biosensors based on the unique combination of excellent mechanical, physical, optical transparency and biocompatibility properties together with tunable optoelectronic characteristics. Such products may greatly improve our daily lives in areas such as portable electronics and optics, energy saving and green manufacturing.

This project will further advance the chemically vapor deposited carbide-bonded graphene coating process demonstrated during Phase I that involved using silicon wafers with micro/nano-patterning. With the help of our industrial partners we now intend to scale the technology to the commercial level. The process development is targeted to developing low-cost and mass-producible high precision glass molding, micro-optics, and NIR aspheric optics for cell phones and high performance laser collimators. These activities would also enhance our understanding of carbide-bonded graphene coating technology.

NBD Nanotechnologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1456339

Award Amount: $899,999.00

Start Date: 03/01/2015
End Date: 08/31/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Surface Coatings for Enhanced Efficiency of Industrial Condensers

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in demonstrating the commercial implementation of NBD Nanotechnologies, Inc.'s (NBD) Enhanced Condensation Coating. NBD's external surface coating sustains dropwise condensation on copper-based tubes, resulting in energy savings and increased efficiency for industrial condensers in steam power and thermal desalination plants. NBD's innovative and proprietary techniques ensure adhesion onto the substrate while not compromising the thermal resistance with the coating's sub-microscale thickness. NBD has validated the increased efficiency of its external surface condenser coating technology at a lab-scale and will carry out pilot tests to quantify the efficiency gain and technology durability at a system-level in industrial condensers, as requested by utility customers. NBD presents a technology that addresses the key commercial bottlenecks of durability, scalability and performance, which have stymied coatings in condensers, presenting a leapfrogging technology that addresses the water-energy nexus. Every 1% improvement in power plant efficiency results in $10MM revenue per plant per year, as stated by a partnering power generation company. Thus, any improvement in the efficiency of a steam condenser has significant impact that directly benefits both global energy and water sustainability efforts.

This project contributes to R&D advancement focused on: large-scale chemical and coating processing, surface wettability, nano-and micro-scale heat transfer, condensation, and water and energy resource sustainability. The project's multidisciplinary nature reflects the dynamic aspects of condensation heat transfer phenomenon, which covers varying length scales (nano, micro, meso and macro scale) and time scales. Thus, the challenging nature of optimizing and sustaining enhanced condensation invites innovative and creative solutions to mitigate the water and energy resource management problems. During Phase I, the project demonstrated the proof of concept of the coating's condensation enhancement for both industrial condensers with pure steam (and trace amounts of non-condensable gases) and for HVAC/dehumidification systems where condensation occurs with higher concentrations of non-condensable gases. The objective of phase II proposal is to address and facilitate the required steps for scaling up and integrating NBD's condenser coating into industrial condensers' supply chain. NBD has identified industrial condensers as its primary entry market, where a greater increase in condenser system performance and savings in cost and fuel consumption can be reached. NBD has been establishing partnerships for pilot studies to perform larger scale experimental tests to validate its technology's performance, durability and system-level efficiency gains empirically.

Nova Photonics

Program: SBIR Phase II

NSF Award No.: 1555965

Award Amount: $733,263.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Barrier Centrifuge for Aluminum Purification

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in reducing the environmental impact of Aluminum production. Global production of aluminum from bauxite ore currently accounts for 1% of global electricity consumption, and 2.5% of CO2 emission. Over the last 15 years global production has doubled, and is expected to continue to increase over the next decades with expanded use in automotive applications. To meet increasing demand while reducing the environmental impact of production requires cost effective means of removing contaminating metals such as iron from aluminum. Commercial application of the technologies investigated here would positively affect the global aluminum industry and reduce its environmental impact. Applied to conventional primary production, the technology can be used to increase the yield from bauxite, or allow kaolinite clays to be used for primary production. The former will reduce the environmental and economic costs of production, while the latter would allow domestic producers to reduce their reliance on imported bauxite. If the technology is applied to primary production using carbothermic reduction, the impacts on the global aluminum industry would be even greater. Greenhouse gas emissions could be reduced by up to 50%, and electricity consumption reduced by up to 20%.

The objective of this Phase II SBIR research is to demonstrate a cost effective barrier centrifuge technology to remove contaminating elements from aluminum alloys. In the Phase I research we demonstrated the basic technology using a liquid gallium alloy instead of aluminum. In Phase II, we will fabricate an apparatus for handling liquid aluminum and characterize its purification efficiency and costs to own and operate. Using the barrier centrifuge to purify aluminum in secondary production would reduce the need for dilution by primary aluminum, thereby reducing the demand for the primary aluminum with a consequent reduction in electricity consumption, greenhouse gas production and waste disposal needs from the bauxite refining process.

PAX Scientific, Inc.

Program: SBIR Phase II

NSF Award No.: 1660247

Award Amount: $740,406.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: PAX Rotor Optimization for Flexible Micro-Hydro

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in the effort to bring our biomimetic rotor design to the marine hydrokinetic (MHK) market. MHK energy is a socially and environmentally friendly alternative to hydroelectric power, which harnesses energy from rivers, tides, ocean currents and manmade waterways without the use of a dam. This market is potentially large but still nascent due to high technology costs, concerns over turbine survivability, fish friendliness, and difficulty in permitting deployments. Our rotor's small, flexible configuration is a unique approach that addresses many MHK challenges with the mission of reaching the largest set of individuals underserved by current energy technologies. Our rotor seeks to displace diesel generation and complement intermittent renewable energy sources by providing an affordable, baseload clean energy solution for any individual or community; with the objective of scaling up to larger deployments by leveraging the scalable rotor design. This R&D Project will expand the body of knowledge for the rapidly emerging field of biomimicry by developing a flexible micro-hydro solution that enables energy generation from flowing water by allowing fluids to move over the surfaces of the rotor in their naturally preferred way.

This project will transform our promising proprietary rotor design into an optimized MHK turbine to be incorporated as the key component of a flexible micro-hydro system that addresses many of the challenges faced by the MHK market. The rotor is based on biomimicry and was designed using streamlines found in moving bodies of water with a deep profile to maximize the power transfer from low speed flows. The logarithmic design with receding edges results in a turbine that avoids damaging impacts with debris and marine life. The design is stable in variable flow conditions, which allows for a flexible power takeoff configuration with both the generator and power electronics housed above the water for improved affordability. During the project, computational fluid dynamic modeling will be used to simulate design changes and drive performance improvements. The most promising designs will be prototyped and integrated with multiple generator and tether combinations to determine the most efficient flexible power takeoff system. Conversion to power output for 12V battery charging will also be tested and optimized resulting in a complete power conversion chain. The performance of the rotor and system will be characterized by full scale testing locally and with The University of Washington.

PowerTech Water

Program: SBIR Phase II

NSF Award No.: 1632490

Award Amount: $744,440.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Novel Cathode for Long-cycling Capacitive Deionization

This Small Business Innovation Research (SBIR) Phase II project will demonstrate the use of a new carbon-based water treatment process to condition and soften hard water sources. Specifically, this treatment process uses functionalized porous carbon sheets and small applied electrical voltages (<1.2 V) to target (adsorb and desorb) salt molecules from hard water streams. In addition, this process is reversible, resulting in a carbon-based filter that can soften water streams without significant maintenance or upkeep and providing a water softening solution that does not add to the "throw-away" culture that is common to many water treatment devices. Importantly, no salt or chemical additives are needed for this softening technique, further limiting its environmental impact in comparison to conventional salt-based softeners, and the energy required for this separation may best the most efficient techniques in use today.

The proposed process is called inverted capacitive deionization (i-CDI). In i-CDI, salt molecules are naturally attracted to the carbon electrode surfaces due to the creation of electrodes possessing significant surface charge in aqueous environments. Electrodes are then regenerated using a small voltage, matched to the surface chemistry of the functionalized carbon electrodes, and salt is concentrated into a discharge stream. Through this Phase II project, the i-CDI process will be demonstrated for water softening applications in both food & beverage and industrial environments. Currently, water softening in these industries is carried out through chemical treatments, ion exchange, or selective membranes. In this project, surface charged carbon electrodes will be used in "flow-through" cell modules to demonstrate preferential removal of calcium, magnesium, carbonate, and other hardness-causing ions to soften multiple hard water sources. Comparisons will be drawn between this new i-CDI technology and incumbent water treatment techniques to outline benefits towards equipment downtime, energy costs, and effectiveness of the separation. Liquid sampling and lifetime studies will be conducted to further prove the benefits of this membrane-free, salt-free system.

Purdue University

Program: PFI:BIC

NSF Award No.: 1632154

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:BIC MAKERPAD: Cognitively Intuitive Shape-Modeling and Design Interface enabling a Distributed Personalized Fabrication Network.

Currently product design and manufacturing are accessible only to enterprises and professionals such as engineers and designers. Everyone has ideas but only a select few can bring them to fabrication. This is because of lack of intuitive and easy-to-use design tools, detailed knowledge required to make prototypes, help needed for users with difficulties, and access to fabrication facilities. This gap could be seen as a waste of untapped human creative resources and economic potential to the Nation. MAKERPAD will bridge the gaps between the need for design tools for personalized production and the rapid growth of 3D fabrication technologies by providing intuitive tools for designing and access to remote fabrication resources. Using the cloud, MAKERPAD will enable personalized fabrication technology easily accessible and available to makers and students.

MAKERPAD is enabled by (a) 3D mixed and augmented reality, (b) cloud-powered algorithms (shape modeling, computer vision, human computer interaction), and (c) service models supporting 3D scanning, searching and printing. Using the affordances created by depth sensing cameras that are being embedded into both mobile and intuitive fabrication oriented design modeling, smart algorithms will be enabled to work real-time over the cloud. MAKERPAD will develop and use the human-centric cognitively intuitive design interfaces, digital modeling in the virtual cloud world, thus enabling connectivity to a personalized fabrication network. Using a new robotic toy platform as well as accessories as the use case, the service model design will appropriately support consumers at various levels of capabilities. The workflow at the user and system level will be designed in a seamless fashion for the users to obtain laser cut and 3D printed models of their designs. If successful, this system will support different levels of service, quality and sophistication of digital designs and physical models depending on the user requirements, usage context, budget and time constraints. The smart system will dynamically configure the appropriate technologies, providers and approaches, such as Do-It-Yourself (DIY) as well as concierge services, to deliver the optimal level of solution to the user.

This project is a collaboration between Purdue University (Mechanical, Electrical and Computer Engineering, and Business School) and primary implementation partner gesture interface technology ZeroUI (San Jose, CA, small business). Secondary partners for test-beds include a museum (Imagination Station, Lafayette, IN, non-profit) and gifted education research institute (GERI, Purdue University). Other partners include augmented reality - Meta (Portola Valley, CA, medium business); and depth sensing camera - Leap (San Francisco, CA, medium business).

Redbud Labs, Inc.

Program: SBIR Phase II

NSF Award No.: 1660223

Award Amount: $725,804.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Microfilm to Enable Enhanced Mixing in Low-resource Diagnostics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in its ability to improve healthcare in fundamental ways, such as (1) low volume draws that will enable diagnostics in low-resource settings like drug stores, at home, or in developing countries, (2) higher quality small-volume samples to make Point-of-Care (POC) diagnostics more competitive with lab tests, enabling faster results in critical care/outpatient environments, and (3) low draw volumes, coupled with small volume diagnostic tests, that will enable improved care for patients at risk for hospital-acquired anemia, including neonates and patients with bone marrow damage caused by cancers or suppressed bone marrow due to cancer drugs. Our technology will enable medical testing from a small amount of blood, which could significantly impact global neonatal and pediatric healthcare, particularly in developing countries, and expand the market for blood containers.

This project aims to design a microliter-scale blood container that offers the same analytic stability and consistency as blood samples obtained by larger volume tubes. Critical to specimen stability is the ability to rapidly and uniformly distribute an anticoagulant in a blood specimen. In larger containers, mixing is achieved by shaking a collection tube, creating turbulent flow wherein eddies and vortices mix the blood with the stabilizing reagent. In low volume containers, fluid flow is laminar and shaking does not produce mixing. Typical low volume containers rely on diffusion driven mixing. This process is slow, and frequently results in the formation of micro-clots prior to complete specimen stabilization. We will use our proprietary actuated, surface-attached posts (ASAP) to rapidly and thoroughly distribute anticoagulant in blood, increasing the accuracy and the reproducibility of results obtained from small volume draws. This project will begin with an assessment of the biocompatibility of materials and specimen processing procedures. We will test a number of ASAP configurations in order to minimize the time required for specimen stabilization. The project will culminate with the production of a fully functional prototype that will be validated via comparison against blood stabilized in a larger volume specimen tube.

Robocasting Enterprises, LLC

Program: SBIR Phase II

NSF Award No.: 1535588

Award Amount: $625,319.00

Start Date: 10/01/2015
End Date: 09/30/2017

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: High Efficiency Robocasting for Ceramic Product Application

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in the creation of commercial viability for 3-D printing unique ceramic structures by transforming 3-D printing of advanced ceramics into mass-production additive manufacturing. This will be a new capability for the US. The 3-D structures being considered can't be easily made with traditional manufacturing techniques but have significant advantages over traditionally manufactured geometries. If 3-D printed structures could be manufactured economically, the societal impact could be tremendous ranging from creation of hundreds of US manufacturing jobs to reduction in CO2 emissions. Commercially viable products that can improve existing markets and enable new markets are realistic expectations. Structures for improved filtration, catalytic production of clean fuels, H2 reformers, emission controls for stationary fuel cells, and CO2 sequestration have been inspired by Other Equipment Manufacturers and are already being jointly developed as a result of Phase I progress. Interestingly, these products and more could be produced from the same product lines just by changing a computer program. This great efficiency of infrastructure is a fortunate trait of additive manufacturing. In short, this project will position Robocasting Enterprises as a US exporter into world-wide markets for economic and societal benefit.

This project is based on foundational technology called robocasting for 3-D printing ceramic materials. Robocasting is an additive technique demonstrated to be useful for rapid fabrication of ceramics into advanced lattice structures for enhanced filtration and catalytic performance. However, robocast products have been largely limited to products with dimensions less than 2 inches because of problems related to cracking. The goal of this project is to make additive manufacturing much more commercially viable for ceramics by: (a) overcoming the technical challenges for robocasting large ceramic parts and; (b) designing and implementing a scaled-up manufacturing line commercially competitive with traditional manufacturing processes and production from low-wage countries. To achieve these goals; materials, processes, and equipment improvements are required. Developments will include: 1) material innovations to reduce cracking in large ceramic bodies; 2) processing innovations to reduce cracking in large ceramic bodies; 3) equipment and automation innovations to increase production rates. At the end of Phase II it is anticipated that rapid manufacturing of large (i.e., 5-10 inch) advanced ceramic lattice structures will be demonstrated to be commercially viable and penetration into several markets will be significant. The technology will be perfectly poised for investment from larger companies and Phase III growth.

Rutgers University New Brunswick

Program: PFI:AIR-RA

NSF Award No.: 1537197

Award Amount: $800,000.00

Start Date: 10/01/2015
End Date: 09/30/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:AIR-RA: Commercializing Pharmaceutical Process Modeling for Continuous Manufacturing

This PFI: AIR Research Alliance project focuses on the translation and transfer of pharmaceutical process modeling for continuous manufacturing, derived from the Engineering Research Center for Structured Organic Particulate Systems (ERC-SOPS). The high cost of pharmaceuticals has a direct effect on healthcare costs and is a financial burden on uninsured or underinsured populations in the US. In the developing world, people suffer or die from curable or treatable diseases and illnesses due to a lack of affordable pharmaceuticals. Reducing manufacturing costs through innovations and technology transfer represents an opportunity to significantly bring down the cost of pharmaceuticals. At the present most pharmaceuticals are produced using batch manufacturing technology. In a batch process all of the material is processed at the same time leading to typical equipment that is meters in size that would process hundreds of kilograms of material. Not only is it problematic to process so much material at once, many pharmaceutical manufacturing processes have changed little in decades, and are expensive and difficult to scale. Replacing batch manufacturing of pharmaceuticals with continuous manufacturing is a major technology advance that can change the landscape of pharmaceutical manufacturing in the next decades. In a continuous process, material flows continuously through the system so typical equipment would be tens of centimeters in size and would process a few hundred grams of material at a time. Continuous manufacturing of pharmaceuticals has the potential to be transformative by simplifying development and scale up, and allowing major changes in production. This will result in lower development and production costs for the pharmaceutical industry, and higher quality products and more robust manufacturing processes that will reduce manufacturing costs and benefit society as a whole.

An industry/academic innovation ecosystem will be established for the development and commercialization of pharmaceutical process modeling for continuous manufacturing. The innovation ecosystem that will be created includes Janssen Supply Group, Patheon and Control Associates/QbD Process Technologies. A framework for connecting the process models will be established, and these will be linked to available control models in an integrated system. The potential economic impact is expected to be development of process models and commercial modeling software and creation of new jobs in the next 3-5 years. Students and post-doctoral fellows will gain entrepreneurial and technology translation experience through training materials, seminars and meetings with entrepreneurs.

An essential part of the development of continuous pharmaceutical processes and the implementation of continuous manufacturing of pharmaceuticals is modeling of these processes. In this project, integrated models will be developed to replace the current mode of trial-and-error design of a continuous manufacturing system. The integrated models will allow for model guided experiments and state-of-the-art process design and will be developed as part of the ecosystem and then commercialized. In this ecosystem, a repository of unit operations will be developed that can be used to model continuous manufacturing of pharmaceuticals. The end product will include a process model library consisting of unit operations, a controller model library that includes different kinds of controllers, and finally the capability of connecting all of these libraries of process templates.

Solution Deposition Systems, Inc.

Program: SBIR Phase II

NSF Award No.: 1556498

Award Amount: $750,000.00

Start Date: 02/01/2016
End Date: 01/31/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Low-Cost and Green Deposition of Multifunctional Oxide Films

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project could be very significant for the field of light emitting diodes (LEDs) and other optoelectronics. This project is aimed at developing a solution based technology for depositing transparent conductive zinc oxide (ZnO) layers for use in LEDs and other optoelectronic devices. This ZnO deposition technology has potential to provide a lower cost and higher performance alternative to the physical vapor deposited indium tin oxide (PVD-ITO) layers that are currently used. The technology could be commercialized for LED manufacturing in only a few years. Lighting is one of the modern world's primary usages of energy and the adoption of high efficiency LED lighting has potential to significantly reduce lighting energy demand. By lowering manufacturing cost and improving performance, the technology developed in this project can help increase LED adoption and energy savings. In the longer term, this technology may also be used to lower manufacturing cost and improve performance of solar cells, impacting clean energy supply as well as demand.

This Small Business Innovation Research Phase II project is aimed at commercializing a technology which addresses the problem of Transparent Conductive Oxide (TCO) film performance and cost, in particular for light emitting diodes (LEDs) and other Gallium Nitride based optoelectronics. This proposal aims to bring a solution based method for depositing Zinc Oxide (ZnO) based TCO films to the point of commercial competiveness, with the longer term goal of providing significantly lower materials, energy, and capital equipment costs than current deposition methods and TCO materials. The approach being taken in the proposal relies on well understood characterization techniques as methods of determining successfulness as well as direct feedback from device manufacturers. The small business has the support and validation of strategic partnerships with device manufacturers eager to support this development of this technology.

Spherical Block, LLC

Program: SBIR Phase II

NSF Award No.: 1660075

Award Amount: $718,842.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Topological Interlocking Manufactured Concrete Block

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in providing manufactured concrete blocks that can be used to build arches, including roofs. This feature has never been done with manufactured concrete block, and holds the potential to greatly expand the uses, benefits and capabilities of concrete block to an entirely new market segment. The structures expected to be made possible with this novel masonry system include inexpensive, high-performance, energy efficient buildings with increased fire safety ratings, resistance to termites, increased safety for tornadoes, hurricanes, tsunamis and other sever weather events, and greatly increased building life cycle time. This technology could have a large positive economic impact on masonry construction and on the concrete block manufacturing industry in particular, both across the US and around the globe. This work is expected to provide a greater understanding of the anisotropic strength of manufactured concrete block, and how this anisotropic strength is to be maximized within a given structure; this scientific understanding is expected to benefit the catenary thrust-line analysis of masonry arches. This technology is expected to make superior construction available to homeowners, businesses, government buildings and public works (including bridges) at greatly reduced cost.

This project will create a design for a building which will utilize as many of the common features made available by this masonry system which the average user (homeowner, building owner, business, government agency, etc.) is expected to want to use. This building will be designed as a planetarium for Alfred University's Stull Observatory, and will include a twenty-four foot diameter planetarium room, as a domed hemisphere, made as a third frequency truncated icosahedron. This building will also include a separate meeting room and a separate office. This building will include Gothic windows, arched roofs, and flying buttresses which will create an outdoor porch which rings the outside of this building. This building will be designed with a Professional Engineer and a Registered Design Professional (architect) to show all the equations, stress analyses, free body diagrams, etc., which were used to arrive at the final design. Once completed, this building will serve as a test or sample building used to obtain an Evaluation Report by the International Code Council - Evaluation Services (ICC-ES). A positive Evaluation Report from ICC-ES will allow this technology to be sold globally in accordance with the International Building Code (IBC).

Supercool Metals, LLC

Program: SBIR Phase II

NSF Award No.: 1555870

Award Amount: $689,362.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Economical Fabrication of Bulk Metallic Glass Sheets through Roll-Stretching

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in enabling wide range of commercial applications of bulk metallic glasses (BMG). BMGs are novel metallic materials that are fundamentally different from, and advantageous to conventional alloys. They are stronger than most crystalline metals, but at the same time shapeable like plastics. Additional benefits of BMGs include extremely high precision of parts, increased complexity and elimination of expensive machining. Use of BMGs will provide broad opportunities for manufacturers in areas such as watch making and precision mechanics, electronics, biomedical, nano-imprint, defense, aerospace, and automotive. The current barrier to industrializing BMGs is non-availability of practical feedstock material such as BMG sheets. Technologies that we are developing as part of this project include BMG sheet fabrication and thermoplastic forming (TPF) of final components for a variety of applications. Using sheets, manufacturers can leverage BMGs unique processability to fabricate complex shapes at highest precision and ease through thermoplastic forming methods. Our technology also has significant societal implications. It will empower innovative small and medium size U.S. companies by bringing them a novel manufacturing technology that is highly versatile, energy efficient and low in capital investment.

This project is based on the recent scientific discovery of BMG sheet fabrication using the thermoplastic forming technology. This is a low-force, high-rate deformation method with great potential for large-scale commercial manufacturing. We expect that our findings will lead to a better understanding of TPF-based processes. Specifically, for multi-step TPF-based sheet fabrication, the proposed work will reveal process stability and how it is affected by processing parameters. Proposed research will also determine the effects of TPF-based processing on mechanical properties of BMGs, will help identify suitable BMG alloys for sheet fabrication and provide insights into their commercial feasibility. In addition, the proposed work will also enhance theoretical understanding of BMG sheet fabrication and help develop a predictable and quantitative model description. Such models can allow prediction of alloy-specific processing conditions in industrial settings in the future. Finally, this project will result in a commercially viable sheet fabrication process and apparatus for BMG sheets of unprecedented sizes. It will significantly advance opportunities for bulk metallic glasses in a wide range of applications, bringing two decades of academic discoveries to the commercial arena.

ThermoAura, Inc.

Program: SBIR Phase II

NSF Award No.: 1330650

Award Amount: $1,407,999.00

Start Date: 10/01/2013
End Date: 09/30/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Development and Manufacture of a New Class of High-figure-of-merit Bulk Thermoelectric Nanomaterials

This Small Business Innovation Research (SBIR) Phase II project seeks to enable the commercialization of a scalable bottom-up microwave synthesis process invented and demonstrated for obtaining bulk thermoelectric nanomaterials with 25% higher figure-of-merit ZT at 50% cost savings than the state of the art. We anticipate the results of the project to expand the scope of, and transform, high efficiency thermoelectric refrigeration and waste-heat harvesting technologies. In particular, this project aims to transmute our synthesis approach to a manufacturing technology that consistently yields ton-scale nanothermoelectrics with ZT>1. The objectives are to 1) Complete the design of, and implement a microwave manufacturing platform with a 10 tons/year capacity, 2) Develop protocols for industrial-scale wafer production from the nanomaterials for device fabrication, and 3) Devise methods to further increase ZT through process optimization. The knowhow generated from the demonstration of kilogram-scale production shown in Phase I provides the foundation for the Phase II effort. We will focus on the widely used bismuth and antimony tellurides, and their alloys. We will strive to maximize process flexibility to facilitate greater ZT gains through process optimization and to facilitate the adaptation of our process technology to other thermoelectric nanomaterials for refrigeration and waste-heat harvesting.

The broader impact/commercial potential of this project will be to unlock and access the multi-billion dollar potential of thermoelectrics for transforming solid-state cooling. Thermoelectric materials already support a ~$1B/year industry, but has promise to be multi-fold higher if the conversion efficiency is increased just two-fold by using nanomaterials. The project will scale-up a nanomaterials manufacturing technology targeted to create new high efficiency solid-state cooling devices that can replace the current refrigeration and air-conditioning technologies based on environmentally unfriendly gases, and create high-efficiency electricity generators from waste heat, significantly expanding the thermoelectric markets and impacting global energy usage and addressing global environmental concerns. The work performed in the project will result in low-cost high-value thermoelectric nanomaterials manufacturing to replace extant energy-intensive methods that cannot cost-effectively produce high-efficiency materials. This will lead to introduction of a new class of nanomaterials with superior properties than that available currently in the marketplace. The work will expand the scope of thermoelectric device applications, paving the way for power generation technologies through implementation of our manufacturing method for other materials systems. The project is anticipated to create 10-25 jobs in 3-5 years besides making New York State a global player in thermoelectrics innovation and nanomaterials manufacturing.

Tivra Corporation

Program: SBIR Phase II

NSF Award No.: 1534736

Award Amount: $892,231.00

Start Date: 08/15/2015
End Date: 07/31/2017

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Ultra Low Defect Gallium Nitride Mediated by Metal Alloys

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project addresses a path to achieve the metric of less than $1 per kilolumen in Gallium Nitride (GaN) based light emitting diodes (LEDs). This is expected to spur widespread adoption of solid state lighting which, according to the US Department of Energy, could result in electricity savings equal to the output of 44 gigawatt power plants by 2027. The price for LEDs is slowing adoption. LEDs don't typically need to be better; they need to be cheaper. This project could directly address this adoption problem by lowering the cost of making LEDs by eliminating one of the most expensive steps in the LED production process.

This Small Business Innovation Research (SBIR) Phase II project will address the technical problems in Gallium Nitride (GaN) based light emitting diodes (LEDs), namely using traditional buffer layers to grow GaN on non-GaN substrates. Traditional approaches are typically expensive and result in crystalline defects because the buffer materials used are non-ductile crystalline structures which very effectively propagate, rather than annihilate, defects. This project develops a new substrate made with a patented crystalline metal and process that will let the manufacturers spend less time and effort to get the same or even better LED crystalline quality than they can achieve today. Low cost growth techniques are used and to reduce defects in GaN LEDs and to improve the dollar per kilolumen cost to performance metric.

Trustees of Boston University

Program: PFI:AIR - TT

NSF Award No.: 1601583

Award Amount: $200,000.00

Start Date: 04/15/2016
End Date: 09/30/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:AIR - TT: Cost-Effective Membrane-Based Green Electrolytic Process for Solar and Semiconductor Grade Silicon Production

This PFI: AIR Technology Translation project focuses on translating technology that will change the state-of-the-art silicon production process from an energy-intensive and environmentally detrimental one into a cost-effective green process. The new process is an order of magnitude better in energy cost than current practices, and also emits well below half the carbon dioxide (CO2) of the most efficient existing metallurgical processes. The goal of the project is to generate the necessary process data to evaluate scalability and cost-effectiveness of this solid-oxide-membrane-based green electrolytic process for semiconductor and solar grade silicon production. Upon successful implementation, this process will demonstrate several advantages over current processes. They include: very low energy usage relative to free energy required for silicon dioxide (SiO2) reduction; use of inexpensive raw materials that require little to no pre-treatment; no carbothermic reduction, which emits 10 kg of CO2 per kg silicon (Si) product and whose contaminants typically reduce purity of silicon from 99.6% in natural quartzite to 97-98% in metallurgical grade (MG) Si; possibility of inherent boron removal by borium triflouride (BF3) volatilization; absence of any carbon or chlorine in the process; and there are no anode effects resulting in perfluro and/or perchloro carbon emissions.

Current methods for Si production include, fluidized bed reduction processes, carbothermic reduction of high-purity silica, slag/crystal refining, liquid Si electrorefining, and electrolysis of chlorides and fluorides. Some of the major limitations of these processes include extensive raw materials pre-processing, low yields, detrimental environmental impact and substantial energy requirements. In the proposed process, a one-end-closed oxygen-ion-conducting stabilized zirconia (SOM) tube will be used to separate pure silica (SiO2) dissolved in molten flux from an inert anode placed inside the SOM tube. To ensure product purity, a pre-reduction step using a secondary cathode at lower applied potentials will be employed to remove impurities that are more electronegative than Si. The impurity-laden secondary cathode will be removed, and then employing a liquid tin cathode the applied potential will be increased to reduce silica. The Si reduced will go into solution in the liquid tin cathode. Less electronegative impurity ions compared to Si will remain in the flux. Thus impurity oxides of both more and less electronegative impurities are not reduced along with silica. Si is over 95 atom% soluble in liquid tin at high temperatures but at lower temperatures pure Si and Sn are immiscible. This will allow directional solidification to be employed after electrolysis to produce high-purity Si ingots and demonstrate this as a cost-effective carbon-free method for mass production of Si from commercially available sources of silica. This project will provide research opportunities for graduate and undergraduate students to work with our industrial partners and move the technology closer towards commercialization. It will also provide a rich set of case-study materials for introduction into both undergraduate and graduate classroom teaching.

Infinium, a clean metals company, and SunEdison Semiconductors, consumer of semiconductor grade silicon will be engaged in the research program to assess quality, scalability and cost-effectiveness of the green technology for mass production of silicon starting from commercially available sources of silica.

University of California, San Diego

Program: PFI:BIC

NSF Award No.: 1724982

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Program Director: Alexandra Medina-Borja

Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:BIC: Smart Factories -An Intelligent Material Delivery System to Improve Human-Robot Workflow and Productivity in Assembly Manufacturing

Manufacturing represents a quarter of all employment in the US. To reshore jobs, improve operations, and recruit, retain, and retrain skilled workers, companies are increasingly using robotics technology. Ideally, robots will not replace humans but team with them to improve productivity. However, most industrial robots are poorly integrated into human workflow, causing expensive work stoppage problems ($1.7M per hour), worker stress, and talent loss. The research goal of this project is to address this problem by designing novel methods to improve human-robot workflow and productivity in assembly manufacturing through the use of an intelligent material delivery system (IMDS), which will closely integrate with and support the manual work process. This project will investigate innovative, multi-disciplinary approaches to this research area, dramatically advancing the state-of-the art in smart manufacturing and human-centered robotics. The research team will make the following contributions to human-centered smart service systems: 1) Revolutionize the use of robotics in assembly manufacturing processes to closely support skilled human workers, enabling them to focus on tasks they value (their trade) as opposed to tasks that distract from their talent (material movement). 2) Dramatically improve the productivity and flexibility of factories through nimble, real-time scheduling of an IMDS system that dynamically incorporates real-time models of human workflow. 3) Deeply explore the socio-technical implications of having an IMDS system in the workplace, in terms of human workers' cognition, fatigue, affect, and job satisfaction. The project's approach serves as a direct contrast to industry state-of-the-art, which relies on strict bifurcation of human and robot work, and rigid delivery schedules that fail to take local trim-line variations into account. By closely integrating an IMDS into the manual work process and understanding worker and material status, the project will readily enable flexibility and reconfigurability of a human workforce, an absolute necessity in made-to-order, small-batch manufacturing settings. This project will help the US manufacturing sector dramatically improve their operations by using automation to directly support a talented, skilled workforce. It has the potential to impact all major US manufacturing sectors, including automotive, construction, healthcare, energy, and goods. It will help US companies reshore operations, as well as create new opportunities for US worker STEM skill acquisition. Furthermore, this project involves a detailed investigation of multiple human worker implications of the transition from traditional to intelligent material delivery using robotics. By understanding reactions to such change, there will be new understanding on how to optimize a system not only for workflow and task efficiency but also for the human experience. Such knowledge is critical to maintaining job satisfaction, safety and health, and long-term well-being of the human workforce. The lead institution is the University of Notre Dame, Department of Computer Science and Engineering, in collaboration with the Massachusetts Institute of Technology, Department of Aerospace and Aeronautics (Cambridge, MA) and University of Colorado at Boulder, Department of Civil, Environmental, and Architectural Engineering (Boulder, CA). The primary industrial partner is Steelcase, Inc. (Grand Rapids, MI), a large manufacturer that specializes in customizable, made-to-order furniture. This proposal is co-funded by The Directorate for Computer and Information Science and Engineering (CISE), Divisions of Information and Intelligent Systems (IIS) and Computer and Network Systems (CNS)

University of Florida

Program: PFI:AIR - TT

NSF Award No.: 1602032

Award Amount: $198,881.00

Start Date: 03/01/2016
End Date: 08/31/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:AIR-TT: Scalable Hydrothermal Flow Manufacturing of High Value-Added Precision Nanoparticles

This PFI: AIR Technology Translation project focuses on translating a continuous flow hydrothermal reactor technology to address industry needs for scalable high precision production of nanomaterials. The hydrothermal reactor technology will be applied to the production of nanomaterials for use in water quality testing sensors. Current production of nanomaterials is dominated by batch synthesis techniques, which lack reproducibility, are often poorly scalable, and are inefficient. These limitations present a barrier to industrial production and use of nanomaterials. The continuous flow hydrothermal reactor technology can address these limitations by providing a system capable of rapid scalable production of nanomaterials with high precision, significantly reduced waste relative to conventional batch processes, reduction or elimination of harmful organic solvents, and fully integrated one-step production.

One of the most important resources of a healthy civilization and environment is the availability of clean water. Trace water testing represents a significant societal benefit by allowing water quality issues to be understood and correctly addressed before public health is affected. However, existing trace water quality testing typically relies on slow and expensive analysis methods, which decreases the availability of routine testing. Sensors based on surface enhanced Raman spectroscopy (SERS) have the potential to provide a rapid and inexpensive test for trace level contaminants, making testing of potable, natural, and industrial process waters much more available. The effectiveness of these chemical sensors is critically dependent on the quality and reproducibility of the nanomaterials used in their manufacture. This project will apply the advantages of the continuous flow hydrothermal reactor technology to the manufacture of various nanomaterials for water quality testing sensors in order to increase particle quality and reproducibility, improve production efficiency (by reducing cost, waste, and synthesis time), and improve sensor performance. At the conclusion of this project, a fully integrated scalable pilot reactor system will be constructed and optimized for the production of various sensor nanomaterials.

This PFI : AIR TT project addresses technology gaps related to the scalable reactor design, optimized synthesis chemistry, and inline coating as the technology translates from research discovery toward commercial application. Based on industry requirements and the unique capabilities of the continuous flow hydrothermal reactor technology, the synthesis chemistry and reactor materials will be tailored to maximize the precision, quality, and size range of the product particles. Studies on the growth kinetics, reactor design criteria, and reactor construction will be conducted to determine optimal reactor design parameters for scalability and production of the particles of interest. Optimization of the online particle characterization and determination of process control parameters will occur. Finally, the inline surface modification system will be developed to complete the fully integrated reactor system and allow for single step production of sensor particles.

In collaboration with OndaVia Technologies, a company with expertise in water quality sensing and SERS sensor technology, nanomaterials will be incorporated into sensor cartridges for evaluation. Personnel involved in this project, including one graduate student and at least three undergraduate students, will gain innovation, technology transfer, and entrepreneurship experiences through interactions with OndaVia Technologies and the UF Entrepreneurship & Innovation Center, and participation in the research activities.

University of Michigan, Ann Arbor

Program: PFI:BIC

NSF Award No.: 1534003

Award Amount: $1,000,000.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

PFI:BIC - Cyber-Physical Service System for 3D-Printing of Adaptive Custom Orthoses

This Partnership for Innovation: Building Innovation Capacity (PFI:BIC) project aims to develop a service system for Internet-based design and rapid manufacturing of foot orthoses and ankle-foot orthoses with custom fit and motion sensors. Orthoses are externally applied assistive devices that meet the personal needs of people with disabilities. They are designed to achieve one or more of the following goals: control of biomechanical alignment, correction or accommodation of deformity, and/or protection and support of an injury. Custom-made orthoses provide a better fit for users. They are more comfortable and facilitate more effective treatment. However, the traditional plaster molding fabrication method for custom orthoses requires a long delivery time and multiple visits to the clinic, which are often physically, mentally, and/or financially difficult for users of orthoses and their caregivers. The service system is targeted for the One-Day Visit by facilitating the measurement, design, fabrication, and evaluation of foot orthoses and ankle-foot orthoses all within the same day of the patient's visit to the clinic. The current custom orthoses design also lacks both the adaptability to adjust the stiffness for individual needs and the sensors to measure and record the motion data for clinicians and users. This project plans on creating a cyber-physical service system aimed to fulfill these needs.

The projected service system utilizes cloud-based design and 3D-printing, a rapid manufacturing technique for custom orthoses, to enable the One-Day Visit. For this system, the clinician scans the foot and leg of the patient and uploads the geometrical and clinical prescription data to a cloud-based Cyber Design Center, which has the biomechanical models, baseline inertia measurement unit (IMU) sensor data, and a user-in-the-loop framework developed in this project to design the user-adaptive, sensor-embedded custom orthoses. Advanced lightweight, energy-efficient motion sensors measure and record the orthosis motion in the living environment for a week. While recharging the battery of the IMU data logger, the subject's motion data are uploaded to a cloud database and analyzed for evaluation of the gait and orthosis functions for the user. This research connects three key aspects of the fused deposition modeling (FDM) for fabrication of custom orthoses: the measurement of defects using nano-computed tomography, prediction of plastic material properties based on the defect geometry, and FDM process optimization. The ruled-based biomechanical decision-support model that can automatically design the shape of custom foot and ankle-foot orthoses based on user information and clinician prescription is studied for orthosis design practice. The development of a user-based optimization framework with long-term motion data of a user as the input will advance the scientific knowledge of user-in-the-loop design and control of assistive devices. This cyber-physical service system for custom orthoses presents a vision wherein the cloud-based design and 3D-printing technologies can harmonize with healthcare by providing a better service for assistive device users and their caregivers. The efficacy of treatment and the quality-of-life

V-Glass, LLC

Program: SBIR Phase II

NSF Award No.: 1556094

Award Amount: $723,552.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Ambient-Pressure Plasma Degassing for Low Cost Vacuum Glass

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in significantly reducing global carbon emissions using vacuum insulating glass. Vacuum glass is like a flat and transparent thermos bottle for windows. Vacuum glass has three times less heat loss than triple pane glass but costs no more to manufacture. This disruptive value proposition will drive rapid market penetration, regardless of energy price, and without the need for government subsidy. This project will produce vacuum insulating glass that will enable R-10 windows, consistent with the goals and schedule of the DOE Windows Roadmap. Immediate benefits include improved occupant comfort and reduced heating bills without thermostat setback. Furthermore, vacuum windows will be condensation-free and fog-free forever. The potential impact is huge. Buildings represent 40% of total U.S. carbon emissions. Near-universal use could reduce total U.S. energy use by 3% (about 3 quadrillion BTU/year), while adding no cost to building infrastructure. Germany, Japan, Australia, China, and Russia have vacuum glass development programs; a successful development under this project will ensure that the U.S. stays at the scientific and technological forefront of this technology, and participates in a large and growing market.

This project will develop the use of plasma degassing to achieve a vacuum life beyond 20 years, a condition for private investment. Without adequate degassing, moisture attached to internal surfaces is trapped at the time of seal-off. Trapped moisture molecules will later outgas, causing vacuum decay. Traditional high-temperature bakeout is too costly for affordable vacuum glass. Bakeout takes hours, but plasma degassing takes minutes. A German vacuum glass development effort tried plasma degassing under vacuum, which is inefficient. In contrast, this project will use atmospheric pressure plasma degassing, which is both faster and cheaper. Building on lessons learned during the Phase I project, a plasma treatment protocol will be developed to produce VIG panes as large as 25% of the average residential window size. Working in parallel, Lawrence Berkeley National Laboratory will work to optimize the insulating performance of the design to enable an R-10 window for the DOE Windows Roadmap. Thereafter, an integrated pilot line will be assembled, able to produce vacuum glass units suitable for meaningful retrofit projects. Finally, the National Renewable Energy Laboratory will conduct accelerated life testing. Independent life data, combined with a successful operating pilot line, will help secure private investment for commercialization.

Vistex Composites, LLC

Program: SBIR Phase II

NSF Award No.: 1534709

Award Amount: $750,000.00

Start Date: 01/01/2016
End Date: 12/31/2017

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Automation Enabled, Low-Cost, High-Volume Production of Advanced Composites

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in the automated manufacture of lightweight high-strength carbon fiber composite materials. Experts agree that composite manufacturers must lead innovations in sustainability, price reduction, and cycle-time reduction to meet end-market needs. The innovations proposed in this project, coupled with Vistex Composites' cutting edge Specialized Elastomeric Tooling process, directly address these needs by significantly advancing the state-of-the-art in composites manufacturing equipment. The prevailing motivation for short automated cycles is posed by the automotive industry, where lightweighting delivers major benefits for fuel consumption but where current processes cannot affordably and quickly produce carbon fiber automotive parts in large numbers. The equipment innovations proposed will not only enhance the automotive market but will have substantial commercial value across all composite markets as they allow the manufacture of equivalent quality products, faster, with less waste, significant energy savings, and at lower cost. Furthermore, the proposed automated process will enable Vistex in its aggressive path towards not only broader adoption of its Specialized Elastomeric Tooling process technology but also broader adoption of composite materials. This will directly drive manufacturing job creation, for Vistex and its customers, as composites displace foreign produced goods.

This project addresses the design, fabrication, and analysis of an automated composite manufacturing cell using Vistex's patented Specialized Elastomeric Tooling process as the central technology. The standard composite manufacturing process, the autoclave, has long cycle times (hours), requires significant manual labor, and is expensive. Vistex's proposed manufacturing cell addresses these concerns. In the proposal manufacturing cell will be designed and fabricated to make a composite product using Specialized Elastomeric Tooling but where parts (1) can be moved rapidly and accurately using automation, (2) rapidly cured using Specialized Elastomeric Tooling, and (3) rapidly ejected/removed from the tooling, all while creating an equivalent or superior product to with significant cycle time savings over the industry's standard autoclave process. Through the use of material testing, cost analysis, and other metrics, each stage of the proposed manufacturing cell will be benchmarked against industry standard processes. The anticipated result will be a prototype turnkey rapid automated manufacturing cell and commercially usable products for project partners.

WattGlass, LLC

Program: SBIR Phase II

NSF Award No.: 1556072

Award Amount: $756,366.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: High-Performance Self-Cleaning, Anti-Reflective Coating for Photovoltaic Glass

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to reduce the cost of solar generated electricity by increasing the efficiency of panels and reducing cleaning and maintenance costs. This improvement is created using a nanoscale glass coating that increases transmittance of single side coated solar PV glass and creates an antifogging and self-cleaning surface. These savings increase with photovoltaic device efficiencies as well, so as the next generation of solar cells will see even greater benefit from the proposed innovation. Reducing the cost per watt of solar generated electricity is one of the grand energy challenges and has immense societal and governmental impacts. The proposed project is one component of addressing that challenge. The technical advances made in this project will also be applicable to additional market opportunities in LED lighting and other cutting-edge markets.

This Small Business Innovation Research (SBIR) Phase II project investigates the deposition of water-based nanoparticle solutions using industrially scalable methods and results in valuable scientific knowledge that is not currently available in the field. Nanoparticle-based antireflective glass coatings have been presented in both the scientific literature and commercial products. However, most coatings suffer from either high deposition costs, or a trade-off between durability and performance. In this project, methods to increase the durability of a low-cost, high-performance nanoparticle that were developed in the Phase I project are scaled to high throughput and low cost fabrication methods. The process/structure/property relationships of this novel coating will be investigated and lead to new scientific knowledge related to the large-scale deployment of nanoparticle based technologies. The coated glass will be subjected to industry standard reliability and durability tests. The expected outcome of this work is the demonstration of this technology at a pilot level with industry collaborators.

XPEED Turbine Technology, LLC

Program: SBIR Phase II

NSF Award No.: 1660224

Award Amount: $749,669.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Rajesh Mehta

Topic: Advanced Manufacturing and Nanotechnology (MN)

SBIR Phase II: Aerodynamic Flow Deflector for Current and Future Wind Turbines to Increase the Annual Energy Production by 10% and Reduce the Levelized Cost of Energy by 8%

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in enabling more efficient Annual Wind Energy Production (AEP) while reducing the cost of energy (COE). This will make wind energy more attractive economically, improve the energy security of the U.S, create jobs, and indirectly help reduce greenhouse gas emissions. A 2% AEP increase is generally considered attractive. Two turbines (5kW and 50kW) tested during Phase I have shown an increase in AEP between 2% to 8% while reducing the COE by 1% to 6%. About 150,000 turbines worldwide can be potentially be retrofitted with this technology.

This project will address challenges related to aerodynamic efficiency of wind turbines and the cost of wind energy. It is based on a deeper understanding of wind turbine aerodynamics from a more 3-dimensional point of view; most wind turbine designs are based on 2- dimensional theories. The key technical challenge in bringing this technology to market is to demonstrate the increase in AEP of utility scale turbines retrofitted with our deflector technology in realistic field conditions while reducing the COE. This will be addressed by performing testing at a few customer wind farms and NREL testing centers. The R&D plan consists of designing, manufacturing, and installing deflectors on a few utility size turbines (30-100 meters diameter rotors). The tests will include power performance comparison between baseline and retrofitted turbines according to international standards.

ADVANCED MATERIALS AND INSTRUMENTATION (MI)

4 D Technology Corporation

Program: SBIR Phase II

NSF Award No.: 1556049

Award Amount: $709,926.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: High-Resolution Shop Floor Video-Rate Surface Metrology System

This Small Business Innovation Research (SBIR) Phase II project will develop and produce a robust, hand-held, video-rate three-dimensional surface metrology system with vertical and lateral resolution of several micrometers, in order to bridge a critical existing metrology gap for precision-machined surfaces. Many modern manufactured parts, such as turbine blades, drive shafts, orthopedics, and various additive manufactured components require in-situ metrology with high resolution for accurate characterization during manufacturing and/or maintenance operations. Current high-resolution surface measurement systems are slow, vibration-sensitive and laboratory-based and thus are impractical for everyday use by manufacturing technicians. Meanwhile, shop-floor inspection is often only visual, and thus qualitative rather than quantitative, leading both to rejections of acceptable components as well as potential acceptance of failing ones. The absence of high-precision, in-situ metrology has hindered manufacturers from applying real-time data analysis and closed-loop process controls that can improve yields and reduce manufacturing costs. This research program will yield a hand-held, easy-to-use, robust, and quantitative shop-floor measurement system, allowing manufacturers to improve lifetimes, performance, and yield as they rapidly assess the features under test and feed the results back to improve process control.

During Phase I, a breadboard system was designed and implemented using a polarization-based fringe projection method and micropolarizer phase-mask technology to achieve vibration insensitive measurement in a compact package. This Phase II program leverages that research to design a video-rate, compact, robust and portable system for handheld surface measurements in shop-floor environments. This will first involve improvements to measurement resolution with an improved optical design and new self-calibrating measurement modes; new optical elements will lower noise artifacts caused by imperfections in the earlier design and to reduce system size. Once performance of the new design is verified, an ergonomic, compact, robust, wireless housing for the instrument must be created to enable shop-floor use; the system must handle drops of over one meter onto concrete, have useful battery life for extended field operations, be light enough to not fatigue users and have intuitive controls and feedback. A final, critically important development effort will create automated software routines for measurement, analysis, and system diagnostics to enable adoption by unskilled personnel in manufacturing environments. Lastly, extensive applications testing in the field will allow optimization of the system to handle a wide range of potential use cases and environments.

Akervall Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1353873

Award Amount: $1,256,861.00

Start Date: 04/01/2014
End Date: 10/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: High-performance Polymer Composites for Mouth Guards

This Small Business Innovation Research Phase II project anticipates bringing forth a disruptive mouth guard technology that answers the urgent need for better dental protection. In the US alone, every year more than 1 million dental injuries occur, resulting in medical costs of roughly $500 million. The proposed technology will involve novel manufacturing methods to incorporate energy absorbing solid/liquid suspensions into novel thermo-polymer mouth guard designs to achieve enhanced impact energy absorption capacity. The specific technical objectives are to optimize the energy absorbing capacity of the formulated solid/liquid suspensions, develop the necessary manufacturing technology for incorporating such solid/liquid suspensions monolithically into the thermo- polymer, and finally to characterize the mouth guards by subjection to stress testing (chemical, physical, and thermal). This energy absorbing mouth guard will deliver on-demand, tunable energy absorption capacity that can be specifically tailored to provide superior dental protection to users in several venues including medical, sports, industrial and military. This R&D effort will produce the first ever mouth guard made with material that adaptively absorbs impact energy, a stark technological contrast to the conventional (passive) mouth guard. This new technology will also contribute basic understanding to the emerging field of nanorheology.

The broader impact/commercial potential of this project is significant. In just the mouth guard arena, realizing this technologically advanced mouth guard will likely bring a novel product into the dental protection market. Then there is the untapped market to provide much needed dental protection for patients undergoing medical procedures. Yearly about 150,000 dental injuries occur just during endotracheal intubations, required when undergoing general anesthesia. Further, the new energy absorbing fluid-thermopolymer material technology to emerge could serve as the technical groundwork for a plethora of energy dampening products. In addition, the research stands to seed a new body of knowledge, small- scale (millimeter) leveraged use of energy absorptive fluids. Realizing the technical objectives of this Phase II R&D effort will help foster local economic growth when the company's new manufacturing facility opens for the fabrication of mouth guards based on this technology. A large number of jobs will be created requiring very diverse technical skills, and the company is committed to fill these jobs with a diverse work force.

Akron Ascent Innovations

Program: SBIR Phase II

NSF Award No.: 1456266

Award Amount: $905,385.00

Start Date: 03/01/2015
End Date: 08/31/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Prototyping Reusable Dry Adhesives based on Scalable Fiber Spinning Technologies

This Small Business Innovation Research (SBIR) Phase II project presents novel technology to fabricate dry, removable, reusable adhesives based on aligned polymeric nanofibers using scalable electrospinning methodologies. This new approach offers the potential advantages of significantly lower costs and easier scale-up using nozzle-free nanofiber spinning processes. Dry reusable adhesives as a replacement for messy liquid glues will improve product safety and reduce environmental impact. Removable and reusable adhesive tapes and labels will also eliminate waste and facilitate product recycling. The resulting products will have strong shear adhesion and easy peel, leading to broad application with a wide range of substrates like glass, metal, wall board, and plastics. Proof-of-concept samples have confirmed market-driven value propositions. The Phase II project will develop commercial products and applications for consumer and industrial applications, for automotive assembly systems, for decorative wall murals, and for medical device and health care uses. Fiber spinning and collection techniques will be engineered to improve product performance, reduce costs and improve scalability of the manufacturing process.

The Phase I project has confirmed proof-of-concept dry adhesive samples with shear adhesion strengths exceeding 20 N/cm2 in dynamic mode and 45 N/cm2 in dead weight mode. The resulting samples have low peel strength and are reusable. In Phase II, the electrospinning process will be optimized using novel polymer blend systems to achieve performance targets for specific customer product development. The nozzleless electrospinning process will be scaled to the pilot level for product testing and to provide the engineering design basis for commercial manufacture. A continuous roll-to-roll process to produce aligned nanofibers will break new ground in the electrospinning industry. New applications in medical devices have been proposed by strategic partners to capitalize on the self-adhesion properties of these materials. Dry adhesive applicator systems will be developed to allow the aligned adhesive nanofibers to conform to surface asperities. With the Phase I success of proof-of-concept prototypes, the Phase II effort will move the development of aligned nanofiber dry adhesives into the market introduction phase in preparation for commercial manufacture and sales.

Altaeros Energies, Inc.

Program: SBIR Phase II

NSF Award No.: 1430989

Award Amount: $1,240,679.00

Start Date: 10/01/2014
End Date: 02/28/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Ultra-light, Modular Wind Turbine

This Small Business Innovation Research (SBIR) Phase II project will develop an ultra-light, modular wind turbine for use in buoyant airborne wind energy systems. Reduced turbine weight has a cascading effect on total airborne system mass, allowing a significantly smaller, lower cost buoyant structure to be used to access high altitude winds. At heights up to 2,000 feet winds are strong and consistent, allowing for the production of low-cost, reliable power at a broad array of sites. High altitude winds have over five times the energy potential of ground winds accessed by tower-mounted turbines, opening the potential for a major new renewable energy resource to be harnessed. In addition, the containerized deployment of airborne wind turbines has the potential to expand wind development to sites that are not feasible today, including sites that are remote or have weak ground-level winds. Overall, the technology holds the potential to significantly lower energy costs and improve reliability for remote industrial, community, and military customers and represents a major step forward in unlocking the abundant high-altitude wind resource to help in the global pursuit of greater adoption of renewable energy sources.

This SBIR Phase II project will focus on reducing the total weight of the wind turbine system. Turbine weight is one of the most critical cost drivers of buoyant airborne wind energy systems. For each kilogram removed from the turbine, an additional kilogram can be removed from the inflatable shell and tethers, resulting in a significantly smaller and lower cost system. The lightest commercially available small- to medium-sized wind turbine weighs 31.1 kilograms per kilowatt of capacity, which is too heavy for an economically-viable airborne turbine. By incorporating a compact, modular architecture, a lightweight permanent magnet direct-drive (PMDD) generator and high-strength composite materials, the proposed Phase II research effort aims to double the power density of traditional medium size turbines, making the proposed system suitable for use in an airborne application, while maintaining a high level of reliability and cost performance.

Bio-Adhesive Alliance, Inc.

Program: SBIR Phase II

NSF Award No.: 1556041

Award Amount: $750,000.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Production of Bio-adhesive from Animal Waste

This Small Business Innovation Research (SBIR) Phase II project will develop a technology to transform swine manure into sustainable alternatives for petroleum-based adhesives, with a first opportunity in the asphalt market. This project builds on a successful Phase I effort as well as a prior Innovation Corps award. The major socio-economic impact of the technology will be in rural areas, as it will allow pig farmers to alleviate the burden of manure management and create a new revenue stream. This project also offers a novel approach to develop low-cost, durable, and eco-friendly construction adhesives, reduce the cost associated with manure management and lagoon maintenance, create new manufacturing and engineering jobs, and reduce our dependence on petroleum resources. Current practices for handling manure release carbon to the atmosphere, either from manure storage or anaerobic digestion of manure. In contrast, the proposed technology sequesters carbon in bio-adhesives, while passing nutrients to the effluents, bio-char, and grey water, which can then be used as fertilizer. The Phase I research results have shown that bio-adhesive is more durable, lower in cost ($0.50/gallon, as compared with $2.00/gallon) and more eco-friendly (lower volatile organic compound levels) than many petroleum-based adhesives.

The core technology to be developed further in this effort uses thermochemical liquefaction to convert swine manure to bio-oil, followed by the polymerization of bio-oil to produce bio-adhesives. This technology will eventually enable use of the six billion gallons of swine manure that are generated annually in the U.S. to supply about 88 million barrels of bio-adhesive. As a result of the Phase I effort, a study of the effects of heating rate on the yield and quality of bio-adhesive was completed; this in turn, helped ensure that the conversion process takes place successfully, thereby addressing one of the main scale-up challenges. The resulting data were used as an input for the design of a pilot bio-reactor, including central heaters and a heat exchanger. After the design phase, the team began the fabrication and assembly of this bio-reactor, and followed up with multiple trials. In the Phase II project, building on these successful trials, we will complete the troubleshooting of the bio-reactor while finalizing the design and construction of the oil separation and polymerization column, and sampling valves. These items will permit a fully-realized pilot plant by the end of this project.

BioInspira, Inc.

Program: STTR Phase II

NSF Award No.: 1660263

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

STTR Phase II: SMART Colorimetric Sensor for Airborne Methane Detection

This Small Business Technology Transfer (STTR) Phase II project aims to develop a sensor with the ability to provide an accurate, small, cost-effective, and low-power device for the detection and quantification of natural gas. The current U.S. industrial natural gas leak detector market is estimated to be $325 million, while the residential natural gas detector market exceeds $2 billion, both of which indicate the strong market potential of this technology. Phage-based colorimetric sensing is a new sensing mechanism, and has the potential to replace and improve detection across many applications. This project, if successful, will have a number of broader impacts. Firstly, 670 billion cubic feet (cf) of methane is leaked annually in the U.S. natural gas industry. Better monitoring and recapturing of the lost gas will result in less reliance on imported gas (3 trillion cf in 2015), thus stimulating economic growth and reducing waste. Additionally, a new type of sensor that provides accurate, compact, inexpensive, and power-efficient natural gas monitoring with wireless communication capabilities will enable large scale natural gas emission monitoring studies, providing a tool for scientists and regulators. Finally, a reduction of methane emissions will help combat climate change, as methane is a powerful greenhouse gas.

During the Phase I project, we have successfully fabricated colorimetric thin-film sensors, developed a data analysis algorithm, and shown our sensors are both consistent and selective against individual components of natural gas at industrially-suitable sensitivity. In Phase II, we will further improve the production and performance of the phage sensors. There are six objectives in this Phase II project. The first is to do sensor calibration using precise gas calibration instrumentation to improve sensor accuracy. Secondly, the sensors will undergo environmental stress testing to evaluate longevity. Third, a scale-up feasibility study will be undertaken to determine and optimize sensor cost. The fourth task involves the development of improved and more inexpensive sensor designs, while the fifth task will optimize the production process of the new sensor. The sixth objective involves a more comprehensive characterization of the sensor. It is anticipated that by the end of Phase II, we will have a precisely- calibrated gas sensor with data recognition algorithms, and an established and scalable manufacturing model, resulting in an improved colorimetric sensor development kit for natural gas that better meets customer needs in the field.

bioMASON, Inc.

Program: SBIR Phase II

NSF Award No.: 1534787

Award Amount: $728,997.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Efficacy of Scaled up Optimized Urease Producing Microorganisms for Manufacturing Biocement Binders towards a Viable Masonry Construction Material

This Small Business Innovation Research Phase II project is focused on the continued development of biologically grown masonry units as a commercially-viable and sustainable alternative to traditional fired masonry materials. This product is grown in ambient temperatures utilizing a natural calcium carbonate cement formation induced by a urease-producing microorganism. The Phase II project will focus on material testing and further optimization and cost reduction of biocement products, with the intention of demonstrating pilot manufacturing and rapid commercialization via licensee manufacturers. Using biologic products and fermentation procedures developed in the Phase I effort, improvements will be made to scale up manufacturing and reduce cost in the manufacturing process. The commercial potential of this technology is critically dependent on achieving cost and performance parity, if not superiority, with traditional materials. Each year, 1.23 trillion fired bricks are produced globally for use in construction, resulting in over 800 million tons of carbon emissions. The societal impacts of this research would include a dramatic reduction in these emissions, as well as a corresponding reduction in industrial by-product waste. This project will enhance the technological understanding for commercial viability and test data including durability and physical performance.

Technical objectives for this effort include evaluation of the resulting biocement masonry products through rigorous American Society of Testing Materials (ASTM) testing methods, reduction of raw material costs through continued optimization, creation of in-house production capability for the requisite biologic product, and the creation and testing of a manufacturing process suitable for transition to licensees. Main focus areas of the Phase II project include rigorous material testing for physical performance, weathering and durability, in-house production of robust raw material constituents, and commercial testing coupled with pilot manufacturing. Rigorous ASTM testing methods will be done at two accredited labs, and labor requirements will be reduced via the adoption of lean automation in the production process. Additionally, the utilization of existing material handing manufacturing equipment at licensee facilities, where possible, will be evaluated. Expected project results will include a comprehensive statistical analysis of multiple physical samples, as well as a corresponding failure analysis. Additional expected deliverables include the successful commission of in-house pilot scale manufacturing for biocement constituents as a simplified additive to be used by commercial partners and licensees.

Boston Electrometallurgical, Inc.

Program: SBIR Phase II

NSF Award No.: 1534664

Award Amount: $497,484.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: A New Molten-Oxide Electrochemical Process for Producing Primary Iron and Ferrochromium

The broader impact / commercial potential of this Small Business Innovation Research Phase II project is to advance the state of knowledge and industrial practice toward cleaner, cheaper, greener steel and stainless steel. The project will focus on the production of iron, part of a $1.1 trillion annual market worldwide, and ferrochromium, a $2.2 billion worldwide annual market. Molten oxide electrolysis with an inert anode has been demonstrated at the laboratory scale to produce low-carbon iron and ferroalloys, which are the basis of many high-performance steels. The current low-carbon metals sell at a premium. Published cost models show that both the capital and operating cost of MOE will be lower than competing technologies already in the marketplace. MOE can also reduce the environmental impact of producing these metals, even with today's electricity, and can produce even greater improvements with renewable energy. In summary, MOE will produce primary metals of higher quality at a lower cost and with lower environmental impact than current methods.

The objective of this Phase II research project is to develop a cheaper, more energy efficient route to production of important metals including iron and ferrochromium. Economical separation of these metals from their ores by molten oxide electrolysis (MOE) is enabled by the recent invention of an inert anode material. The essential next step in understanding the behavior of the new inert anode in MOE is longer-duration testing than was possible in the laboratory cell. This test can only be achieved at a larger scale. The models and testing on surrogate systems in Phase I have shown the way to provide this long-duration testing in Phase II. These tests will point the way toward industrial-scale production of iron and ferrochromium by MOE.

BrightSpec, Inc.

Program: SBIR Phase II

NSF Award No.: 1556035

Award Amount: $746,143.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: A Programmable Residual Solvent Analyzer based on Fourier Transform Molecular Rotational Resonance (FT-MRR) Spectroscopy

This Small Business Innovation Research Phase II project will develop a new analytical chemistry instrument for rapid quantitation of residual chemical impurities in complex mixtures. The target application for this project is the detection of genotoxic impurities during early drug development in pharmaceutical manufacturing. The instrument to be developed uses Fourier transform molecular rotational resonance (FT-MRR) spectroscopy to identify molecules based on their three dimensional geometry, which permits high chemical specificity. FT-MRR is a high-resolution spectroscopy technique that makes it possible to directly analyze gas mixtures containing a large number of chemicals without the need for prior chemical separation using chromatography - a time-consuming step of current analysis methods that requires significant technical supervision. As a result, FT-MRR based chemical analysis instruments have the potential to speed up innovation for pharmaceutical manufacturers by reducing analytical development cycles from weeks to hours during the high-throughput drug innovation process. Chemical analysis instruments using FT-MRR spectroscopy enable faster innovation in research and development labs with the added benefit of seamless method transferability to on-line process monitoring applications and routine quality control for final product release.

The ability to transfer analysis methods into routine analysis is important to the industry goal of continuous manufacturing for pharmaceuticals. It is enabled for FT-MRR in part (yet critically) by the two main objectives of this Phase II effort: the development of sampling automation for FT-MRR and the design of a cost-reduced, targeted FT-MRR system. Concepts for both of these designs were successfully tested during Phase I. The intellectual merit of this project is the introduction of a new technique for chemical analysis that senses chemicals based on the absolute molecular structure, with no orthogonal analysis required. FT-MRR spectral fingerprints can distinguish molecular isomers, conformers, isotopologues, and even enantiomers. With this kind of absolute structure information, FT-MRR can enable new studies that trace chemical pathways with site-specific isotopic ratio information and chiral detection. Both concepts are otherwise very challenging with current technology. The FT-MRR instrument to be built for this project combines recent advances in high-power, solid-state millimeter wave (mm-wave) light sources, low-cost microwave synthesizer integrated circuits, and high-speed digital electronics to implement a time-domain, Fourier transform (FT) measurement approach. Standard methods for chemical sampling will be integrated to maximize the ease-of-use and robustness of FT-MRR instruments.

CetoTech, Inc.

Program: SBIR Phase II

NSF Award No.: 1534697

Award Amount: $728,877.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Manufacturing High Performance Natural Fiber Composites for Building Applications

This Small Business Innovation Research (SBIR) Phase II project aims to develop and commercialize novel high-performance green composites for the exterior building materials market. These materials can address a $30 billion market opportunity with broad applications in many industries, including construction, automotive, defense, energy infrastructure, etc. This phase II effort will focus on developing exterior building materials with an estimated commercial potential of $882 million over the next five years. In addition, this new class of sustainable composites will provide multiple broader impacts including 1) significant weight and cost reductions to enable their use in structural components and fuel efficient vehicles; 2) improved water and ultraviolet (UV) resistance over conventional materials for green buildings that optimize the indoor environmental quality with lower maintenance costs; 3) stronger building materials and safer vehicle panels due to the high vibration damping and impact resistance of these composites; 4) the use of renewable resources for sustainable materials production to achieve energy and environmental efficiency; and 5) potential LEED credits and/or tax rebates to end users.

The technical goal of this Phase II program is to determine full-scale production parameters, performance specifications, and quality control procedures for lightweight and high strength natural fiber composites to prepare for commercialization of these products for exterior building materials use. Two prototype products have been successfully developed through the Phase I effort to address the high cost and low durability of current building materials (e.g. plywood, fiber cement board) in these markets. The specific technical objectives of this program include determining the flexural rigidity of the composites through modeling and experimental work, optimizing product performance and cost, determining full-scale production parameters and quality control procedures, and conducting service life characterization of the final products. The technical results of this program will enable the production of a new class of green composites to create sustainable building materials, and provide a stronger value proposition to end users in the exterior building market.

Chirp Microsystems

Program: SBIR Phase II

NSF Award No.: 1456376

Award Amount: $970,999.00

Start Date: 04/01/2015
End Date: 09/30/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Ultrasonic 3D Rangefinding for Mobile Gesture Recognition

This Small Business Innovation Research (SBIR) Phase II project proposes the development of an ultralow-power ultrasonic three-dimensional (3D) rangefinder system for mobile gesture recognition. The proposed 3D rangefinder uses an array of tiny piezoelectric ultrasound transducers which are built on a silicon wafer using microfabrication techniques. Custom electronics are used to control the transducers and the system emits sound into the air and receives echoes from objects in front of the transducer array. The proposed ultrasonic 3D rangefinder has the potential to be small and low-power enough to be left on continuously, giving devices such as smartphones, tablets, and wearable electronic devices a way to sense physical objects in the surrounding environment. Based on the smartphone market alone, the potential market size for this device is over one billion units per year. Mobile contextual awareness will enable 3D interaction with smartphones and tablets, facilitating rich user interfaces for applications such as gaming and hands-free control in automobiles. Looking beyond the smartphone and tablet market, the proposed rangefinder will feature size and power advantages that will permit integration into centimeter-sized devices which are too small to support a touchscreen.

During Phase II, the major technical goals of this project are to transfer the ultrasound transducer manufacturing from a university laboratory to a commercial production facility, to develop a custom integrated circuit for signal processing, and to develop engineering prototypes. In Phase I, micromachined ultrasound transducers having a novel structure designed to improve manufacturability were developed and a demonstration prototype was built using signal processing algorithms running on a personal computer. In Phase II, the ultrasound transducers will be manufactured in a commercial facility for the first time and signal processing algorithms will be realized on a custom mixed-signal integrated circuit. A prototype package for the transducer and integrated circuit chips will be developed and detailed acoustic testing of the packaged prototypes will be conducted.

Connora Technologies

Program: SBIR Phase II

NSF Award No.: 1632433

Award Amount: $733,902.00

Start Date: 10/01/2016
End Date: 09/30/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Sustainable Performance Composites for Energy Efficient Transportation Applications

This Small Business Innovation Research Phase II project seeks to improve and expand the technology of recyclable thermosets by creating a new class of higher temperature performance, multivalent polyamines that retain a cleavable bond. If successful, this effort will lead to a new class of high-performance composite resins which can be recycled. Increased emphasis on energy efficiency is driving the adoption of lightweight, thermoset composites in the transportation sector. But the intractability of traditional thermosets limits the value and therefore adoption of recycled composites. Industry composites recycling experts estimate the overall scrap cost for the composites industry is between $500 and $750 million a year. Post-manufacturing scrap can account for up to 50 percent of the input materials. Carbon fiber composites for automotive applications represent an emerging and high-growth potential area for epoxy thermosets. A small volume, composite car line represents roughly 400 metric tons of polyamine curing agent. In the Phase II effort, novel, recyclable polyamine structures will be designed and synthesized, and further formulated with various epoxy resins to meet the glass transition temperature (Tg) requirements for transportation composites manufacturing. Doing so will help composite manufacturers lower costs and meet regulatory compliance for recyclability and manufacturing waste disposal.

The intellectual merit of this project will be an expanded knowledge base and chemistry platform for synthesizing and formulating recyclable thermoset resins. Multivalent amines, by nature, provide higher structural rigidity of a matrix. Multivalency, by nature, translates to an overall higher cross-link density of a thermoset epoxy material. For example, composites of higher glass transition temperature, and faster cure speed can be achieved. New multivalent structures will complement the initial generation of recyclable aliphatic diamines, and enable applications previously unattainable by recyclable aliphatic structures alone, such as transportation composites. Pre-screened target cyclic scaffolds have been identified and targeted for synthesis. Successfully synthesized molecules will be further screened for physical properties and recyclability. Candidate molecules will then be formulated into full resin systems and optimized for a high-pressure resin transfer molding (HP-RTM) process, to meet the processing and cost needs of automotive manufacturers. Partners in the automotive industries will aid in testing and evaluating the performance of the formulated material. By creating new recyclable molecules that "mimic" other major industrial classes beyond aliphatic amines, the addressable market for these materials will be expanded and the adoption of recyclable thermoset composites will be accelerated.

Double Helix, LLC

Program: SBIR Phase II

NSF Award No.: 1353638

Award Amount: $796,405.00

Start Date: 04/01/2014
End Date: 08/31/2017

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Widefield Three-Dimensional Superresolution Microscopy Module

This Small Business Innovation Research (SBIR) Phase II project is focused on the design, development, and testing of a ground-breaking three-dimensional (3D) multifunctional quantitative optical microscopy module with single-molecule sensitivity suitable for live cell studies and nanometer scale sensing. In spite of the current revolution in optical microscopy, commercial solutions to achieve resolution beyond the diffraction limit have been slow to market, lacking in flexibility, and costly. Furthermore, most commercial products are too tailored to the systems being investigated and are difficult to generalize for widespread use. The instrument to be developed is based on an integrated design of the illumination, optics, data collection, and reconstruction algorithms for fluorescence imaging. These techniques enable the determination of the 3D position of emitters with great precision leading to 3D imaging with better resolution and depth of field than competing methods. Experimental results have consistently shown 3D capability with resolutions below 20 nm, representing one order of magnitude improvement over optical microscopes currently in use at most research institutions.

The broader impact/commercial potential of this project addresses a major opportunity in the expanding microscopy market. The module's unique characteristics and accessible price point will offer multifunctional 3D superresolution imaging capability to thousands of laboratories in the US and worldwide. In an effort to accelerate commercialization, the project seeks to implement a cost-effective, flexible modular subsystem that can be integrated with existing commercial scientific microscopes. With its widespread accessibility, the instrument will impact multiple fields of science and engineering including biophysics, cellular biology, and biomedical science and engineering. From a broader perspective, this project will increase scientific and technical capabilities by providing nanoscale optical imaging for everyday biological research, thereby strengthening the US presence in the worldwide optical microscopy industry.

DropWise Technologies Corporation

Program: SBIR Phase II

NSF Award No.: 1660225

Award Amount: $724,037.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Anti-fouling Surface Modifications for Purification Membranes

This Small Business Innovation Research (SBIR) Phase II project will address the challenge of fouling on membranes used in biopharmaceutical processing. The successful application of this coating would enable increase in the membrane lifetime and product yield of various production streams as less of the valuable compounds remain trapped in the membrane. This can increase production capacity for life-saving medicines, reduce production costs and, in certain cases, enable continuous biopharmaceutical manufacturing. Furthermore, functionalization of membranes currently involve significant quantities of environmentally harmful solvents, which may be leachable during usage of the membrane. This issue is avoided in the current project by utilizing initiated chemical vapor deposition (iCVD) process which does not require any solvent. This coating technology can also be extended to other systems including wastewater purification, food & beverage production, industrial separations, and medical devices that rely on a similar functionalization.

The objective of Phase II will be to demonstrate a commercially viable manufacturing process to produce surface modifications within porous membranes using the iCVD process. Previous work in this subject has focused on top-coats on the top surfaces of reverse osmosis membranes, but the chemistries utilized have never before been demonstrated within interior structures of the membrane filters. During the Phase II work, the performance of the coatings will be optimized by using existing deposition equipment to tune the coating chemistry and process conditions to maximize the flux and throughput by minimizing protein fouling. The other main technical goal of the work will be to translate the current batch process into a continuous roll-to-roll process that is amenable to large-scale manufacturing. The outcome of this study will be a proven coating chemistry that is effective and durable in the membrane application, and an optimized manufacturing process capable of being implemented within current standards of membrane manufacturing.

Essentium Materials, LLC

Program: SBIR Phase II

NSF Award No.: 1560753

Award Amount: $721,101.00

Start Date: 03/15/2016
End Date: 02/28/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: High Performance Structural Composites with Cellulosic Nanoparticles

This Small Business Innovation Research (SBIR) Phase II project seeks to commercialize high-strength thermoplastic composites reinforced with cellulosic nanoparticles (CNs) as a replacement for heavier glass‐reinforced composite materials for structural automotive components. The broader impact/commercial potential of this project is to create sustainable, high‐performance nanocomposites. Expected weight savings is between 13 and 20% per component. Corporate Average Fuel Economy (CAFE) regulations require significant increases in fuel economy for vehicles, which has led carmakers to look for innovative ways to shed vehicle weight. It has been shown that for every 10% in weight savings, vehicle fuel consumption is reduced by 7%. The target application is to replace heavy glass reinforcement in polymeric composites with CNCs for car parts, providing lighter weight vehicles with increased fuel efficiency. On‐going research into CN materials has resulted in significant reductions in cost (with more reductions expected), making CNs an increasingly attractive functional natural nanofiller, the processing of which will provide jobs in both the manufacturing and the technology sector. Successful implementation of CNs into composites could not only lighten vehicles and reduce environmental impact, but also transform a waste stream into value-added materials, reducing the amount of waste produced by these industries.

During the SBIR Phase I period, the company showed that lighter thermoplastic composites reinforced with cellulosic nanoparticles could meet the tensile strength values of glass-reinforced composites with much higher loadings, thereby saving part weight. The Phase II grant will allow the company to scale up the manufacturing processes necessary to produce these lighter, more sustainable composites for the automotive industry. Furthermore, the company will improve performance of these materials in order to attain performance parity with higher‐loaded glass‐reinforced parts and potentially to compete with ultra‐high performance materials such as carbon fiber composites and metals. This technology will be produced using efficient and economical manufacturing processes, allowing this to become a true drop‐in technology for automotive part-makers.

Inprentus, Inc.

Program: SBIR Phase II

NSF Award No.: 1353454

Award Amount: $1,380,292.00

Start Date: 03/01/2014
End Date: 06/30/2018

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: A Novel Method to Manufacture Ultra-Precise Diffraction Gratings for X-Ray Analysis and Imaging

This Small Business Innovation Research Phase II project will revolutionize the manufacture of ultrahigh precision, x-ray diffraction gratings. Mechanically ruled, x-ray gratings are used at synchrotron radiation and free-electron laser facilities, where they define the wavelength of x-rays used for chemical analysis and imaging studies in the fields of photovoltaics, electronic materials, catalysis, structural biology, environmental science, and others, serving a wide variety of industries and academic disciplines. This effort will advance a new approach to fabricating such gratings that uses a pair of atomic force microscopes (AFMs) operating in tandem - one for scribing and the other for in situ imaging. This combination provides unprecedented control over feature shape and positioning, and will allow scribing of features with nm-scale precision over areas exceeding 400 square centimeters. If successful, the result will be a new approach to fabricating holographic optics for use not only at synchrotron and free-electron laser facilities, but for a variety of other applications.

The broader impact/commercial potential of this project stems from the fact that, between 2009 and 2011, a crisis occurred in the x‐ray grating market. The only two world suppliers of mechanically ruled gratings ceased to take orders, either because their technology was obsolete or because of severe infrastructure problems. This vanishing of world capacity has taken place when demand for x‐ray gratings is at an all-time high and growing. Extensive market research via direct communication with x-ray facilities has revealed a current need for 430 gratings worldwide, which at a sale price of $60,000 implies a global market opportunity of approximately $26 million. If successful, it should be possible to capture this market and bring this area of manufacturing back to the U.S. Gratings aside, this project presents a new approach to creating holographic optics that could enable new technologies based on the engineering of customized, optical wave fronts. This approach can scribe curved lines, forming arcs or ellipses, providing lateral focusing, or exhibiting topological defects that create electromagnetic vortices having high angular momentum. These features may find use in microscopy, extreme ultraviolet (EUV) lithography, or the creation of masters for the mass market for optical grating replicas.

Invenio

Program: SBIR Phase II

NSF Award No.: 1330175

Award Amount: $1,389,075.00

Start Date: 07/01/2013
End Date: 06/30/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Dual-Wavelength Picosecond Fiber Laser Source for Label-Free Microscopy

This Small Business Innovation Research (SBIR) Phase II project aims to develop a novel research microscope based on coherent Raman scattering (CRS). In contrast to other techniques, CRS is a label-free method that requires excitation with two synchronized laser pulse trains (ultra-short pulse duration) with precisely tunable wavelengths (<1nm). The key innovation of the Phase I proposal was the realization that the difference frequency of the two major gain media used in the telecommunication industry, Erbium and Ytterbium, corresponds to the wavelength range where most CRS imaging is performed. This provided a path to an economical laser source for CRS based on a robust all-fiber implementation of low-cost telecom components. Following successful proof-of-concept in Phase I, the Phase II proposal aims to complete the development of the laser system and integrate it into an easy-to-use and environmentally stable solution for CRS microscopy.

The broader impact/commercial potential of this project is in the area of biological and material science research, and ultimately medical diagnostics. CRS allows microscopic imaging with chemical contrast based on intrinsic spectroscopic properties of the sample. It circumvents the issues associated with fluorescent labeling or dye staining, which can be especially problematic for imaging molecules that are smaller than typical labels or for use in vivo in patients. Wide ranging applications including studying lipid metabolism, trans-dermal drug delivery, biomass conversion to biofuel, and tumor margin delineation during cancer surgery, have been demonstrated. Current laser systems for CRS are expensive, require experienced personnel for operation, and are not robust. This greatly limits access to this exciting new technology and prevents use in medical diagnostics. The proposed integrated CRS microscopy solution aims to overcome these limitations.

Lehigh University

Program: PFI:AIR - TT

NSF Award No.: 1543038

Award Amount: $208,170.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Topic: Advanced Materials and Instrumentation (MI)

PFI:AIR - TT: Proof of Concept Low-cost Energy Efficient Multi-hazard Resistant Wall System

This PFI: AIR Technology Translation project focuses on translating an innovative building envelope system to fill the industry need for enhanced resistance to natural and man-made hazards including explosions and impact events from wind or water-borne hazards. It also provides energy efficiency and ease of construction. This building envelope system, the comb-tie envelope system, is important because it will enhance the understanding of how insulated wall panel systems can be used to provide a thermally efficient and blast resistive envelope to building systems. Competitive technology is not currently available and thus the system will create new markets by providing a cost effective solution for federal and military building construction where blast protection and energy efficiency are required. The technology will also complement existing technology used for conventional construction applications. The technology can be manufactured in the U.S. providing the potential for new business and employment opportunities. The project will result in a proof-of-concept of the comb-tie envelope system with the following unique features: ease of installation, the ability to support loads under large panel displacements, and thermal efficiency. These features provide the following advantages: performance under extreme loads, cost savings, and thermal efficiency when compared to the leading competing composite panel systems in this market space.

This project addresses the following technology gap(s) as it translates from research discovery toward commercial application. The system relies on an innovative shear tie connector and a supporting design approach. The knowledge gaps addressed will include determination of the idealized connector shape for installation and pullout and shear performance, the strength provided by the connector, verification of the capacity under loading, and validation of the design approach. The project will finalize the detailing of the tie system developed for the insulated panels through finite element modeling of the system. The ability of the tie to provide composite action to the wall system and the ability to be easily installed will be quantified. The refined details will be prototyped and experimentally evaluated through pullout tests and shear tests to quantify the strength provided. These component property results will be used for finalizing the design approach which allow for fabrication and load testing to ensure that the design strength and deformation performance levels are achieved. The complete system will also be verified under explosive loading to verify the dynamic capabilities of the systems. In addition, personnel involved in this project, undergraduates and graduate students, will receive innovation and technology translation experiences through the proof-of-concept development, and market opportunity investigations with industry trade organizations and wall panel producers.

LighTopTech Corporation

Program: SBIR Phase II

NSF Award No.: 1534701

Award Amount: $760,000.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Nondestructive/noninvasive Three-dimensional Imaging with Gabor-domain Optical Coherence Microscopy

This Small Business Innovation Research (SBIR) Phase II project will explore the applicability of a Gabor-domain optical coherence microscopy (GD-OCM) instrument to image and evaluate optical materials as part of the manufacturing process. The immediate broader impact of this project is to effectively provide both qualitative and quantitative information about product quality in manufacturing, with an initial focus on contact lens manufacturing. Providing high-speed, industrial, micrometer-level resolution in all three dimensions, GD-OCM enables contact lens manufacturers to replace multiple inspection steps with a single measurement done automatically, reducing the opportunity for damaging the samples and human error, and ultimately leading to increased productivity and yield. The resulting improvements in contact lens performance and extended wear effects are poised to have a positive impact on a significant percentage of the population. Recent evaluations of GD-OCM have indicated its ability to provide a new wealth of characterization methods for quality control of various materials that are otherwise impossible to characterize nondestructively, including gradient refractive index polymers, glass and layered structures. Additionally, GD-OCM will enable new advances in a wide variety of scientific fields via its capability to non-invasively optically section samples of a variety of material types.

The objective of this Phase II project is to establish the effectiveness of the emerging GD-OCM technology for nondestructive on-line metrology of contact lenses in manufacturing. Quality control and detection of product-significant defects, and a corresponding increase in production yield, represent the value proposition for the introduction of GD-OCM instrumentation into the contact lens production environment. The project will result in two major outcomes: 1) implementation of a robust production-environment instrument to effectively provide micrometer-level resolution in all three dimensions and quantification of yield-relevant contact lens quality metrics not previously available in a single instrument; and 2) demonstration of the technology for inspection in a production environment to rapidly and accurately monitor defects and quantify contact lens quality using product relevant metrics. This nondestructive, on-line optical inspection system can have significant impact not only on the process control and thereby yield of contact lenses, but also in manufacturing of layered materials in general, including polymers, plastics, and glass. Longer-term, the technology offers new paths for tissue imaging, guided surgery, and monitoring of eye disease.

LumiShield Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1660132

Award Amount: $741,257.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: A Cost-effective, Environmentally-responsible Alternative to Toxic Metal Coatings

This Small Business Innovation Research Phase II project will address a pressing need for more environmentally responsible coating alternatives in the anti-corrosion market through the commercialization of a novel aluminum-based coating. If successfully commercialized, the aluminum electroplating process will displace multiple existing anti-corrosion coatings, which are based on toxic metals. The current market for these coatings is valued at $10 billion annually. The replacement of the toxic metals with aluminum will eliminate their release into the environment. The process is also expected to be less expensive than the incumbent technologies. The reduction in cost arises from decreases in plating solution, waste treatment, and metal costs. By decreasing the cost of corrosion-resistant coatings, it may also be possible to reduce the flow of plating jobs to less environmentally responsible areas overseas. For the aerospace industry, which is the initial target market, the availability of the process will mean safer conditions for workers, less environmental impact, and lower costs. In the process of addressing these needs in the coatings market, the research will elucidate a variety of interesting phenomena associated with electroplating of highly active metal species.

The intellectual merit of this project is associated with its exploration of aqueous electroplating of highly active metals in the presence of atmospheric moisture and oxygen. Typically, electroplating of aluminum has taken place from organic solvents such as toluene at elevated temperatures under an inert purge. The expense and difficulty in scaling this technology has prevented its adoption for many applications, which might make good use of aluminum coatings. The goal of the project will be to overcome the technical challenges in scaling-up an aqueous aluminum electroplating process for producing aluminum coatings. Challenges to be addressed include mass transfer, current distribution, and coating quality control in industrial-scale plating baths. To address these challenges, the project team will work closely with partners in the electroplating industry, ultimately demonstrating the technology at scale in a working commercial plating shop.

Mallinda, LLC

Program: SBIR Phase II

NSF Award No.: 1632199

Award Amount: $750,000.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Development of Advanced Composite Materials for Athletic Equipment

This Small Business Innovation Research (SBIR) Phase II project is for the development of scaled processes for the industrial manufacture of end-user moldable advanced composite materials for use in protective athletic equipment. Currently, protective athletic equipment and accessories must be produced using industrial manufacturing techniques that have high tooling costs. As a result, manufacturers produce a small range of predetermined sizes and shapes, which do not provide a custom fit for end users. In the case of athletic gear, there is a growing market for hard-shell protective equipment which can be custom molded for a better fit. Polyimine polymers and advanced composites offer a compelling blend of strength and malleability in order to create more user-friendly lightweight and durable advanced composites that may be shaped by the end-user. In addition to creating greater user customization, both the virgin polyimine polymer, and advanced composites that incorporate polyimines, are intrinsically recyclable in a closed-loop, low-energy, solution-based system. The total U.S. composite materials market is $25 billion, representing 36% of the global composites sector. Polyimine polymers and advanced composite derivatives will reduce environmental waste and increase manufacturing efficiencies across a broad range of vertical markets in the composites sector including personal protective equipment, aerospace, automotive, and infrastructural materials.

The intellectual merit of this project derives from the development of the unique chemistry of polyimine polymers. Polymers can be broadly grouped into two categories, thermosets and thermoplastics. Thermosets are strong due to the chemical characteristics of the plastic. However, once cured, thermosets cannot be reshaped. As a result, thermosets are neither repairable, nor are they efficiently recyclable. In contrast, thermoplastics, which are weaker than thermosets, may be molded and remolded. However, remolding requires very high temperatures. Polyimine polymers represent a new class of moldable and remoldable thermoset materials. Importantly, these polymers combine high rigidity and tough mechanical properties with mild molding temperatures. This Phase II research project will include scaled processes for the industrial manufacture of end user moldable composite materials that are a maximum of one-quarter inch in thickness and meet industry standards for limb joint protective equipment. The Phase II effort will also include a variety of types of material and mechanical testing, both in-house and at certified laboratories, in addition to extensive efforts at proving out manufacturability, as well as pilot production.

Massachusetts Materials Technologies, LLC

Program: SBIR Phase II

NSF Award No.: 1660214

Award Amount: $749,996.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Hardness Strength and Ductility Tester for Field Assessment of Structures

This Small Business Innovation Research (SBIR) Phase II project will support the technological refinement and concomitant commercialization of the first accurate and portable instrument that can perform in the field nondestructive test for hardness, strength and ductility of existing infrastructure. The material properties measured include yield strength, work hardening exponent and ultimate tensile strength of metals, specifically steel. The on-shore oil and gas pipeline transmission industry has pressing needs for non-destructive tests because of the aging infrastructure, national need for energy, and recent explosions and leaks that have cost lives and billions in remediation. Although transmission pipelines have low failure rate per mile of assets, pipeline operators are asked to proactively enhance pipeline integrity where they do not have all the necessary strength data. Therefore, there is an immediate need to verify strength during the 80,000 excavations done each year so that the life of these costly assets can be extended by identifying and remediating the few sections that are vulnerable within the extended network of 300,000 miles of pipelines. Pipe cut-outs and hydrostatic pressure tests are alternatives to nondestructive testing, but both damage the asset and require expensive and complex service interruption.

The overall technical objective of the Phase II work is to perform the necessary research and development to enable the development of engineering specifications, system integration, and validation of the instrument to successfully perform valuable nondestructive testing to provide precise and accurate material property data. The research and development program includes three milestones, each enabling the implementation of the research into design and manufacturing of beta test units. Milestone 1 is to enable full instrument functionality under adverse field environments such as vibration, moisture, and extreme temperatures. Milestone 2 is to perform the necessary work for designing ruggedized field units. Completion of this milestone will enhance the capability for initial field testing services. Milestone 3 is to develop the knowledge to fully and reliably integrate the system, validate the sub-systems, and package it for manufacturing. The overall goal is to enable the company to have the necessary knowledge and experience to enter the instrument market with a leasing program for use in pipeline inspections.

Maxterial, Inc.

Program: SBIR Phase II

NSF Award No.: 1660246

Award Amount: $735,060.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Program Director: Debasis Majumdar

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Non-Stick / Easy-Clean Coatings for High Temperature Applications

This Small Business Innovation Research (SBIR) Phase II project will develop a novel heat-resistant easy-clean coating that can effectively be applied to surfaces of oven cavities and pipes. Ovens and heat-exchangers, as the primary application domains of this technology, present an estimated annual market size of $40.9 million and $19.4 billion, respectively. The technology will provide a safe and environmentally-friendly solution for the unmet market demand for heat-resistant easy-clean coatings. In addition to its impact on the aforesaid market, the proposed development in Phase II will be an implementation of a new generation of non-stick coatings that can provide answers to a broad range of existing technological challenges.

The development project is based on patent-pending technology for scalable and affordable manufacturing of textured coatings using existing electroplating facilities in the industry. The proposed technology will create a new generation of coatings that provide non-stick functionality where the existing nonstick coatings fall short. The existing non-stick coatings decompose at high temperatures and may produce toxic fumes. The challenge for the existing non-stick coatings is even greater when application is needed for hard-to-reach areas, such as inside of oven chambers and pipes. The anticipated outcome of the Phase II proposal is an inorganics-based and PTFE-free non-stick coating that can provide more thermal-resistance than existing non-stick coatings and can be applied to different surfaces through a scalable and affordable route.

Molecular Vista, Inc.

Program: SBIR Phase II

NSF Award No.: 1353524

Award Amount: $1,409,994.00

Start Date: 04/15/2014
End Date: 05/31/2018

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Program Director: Debasis Majumdar

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Resonance Force Microscopy for Nanoscale Manufacturing Process Monitoring

This Small Business Innovation Research (SBIR) Phase II project aims to develop a production prototype of an automated nanoscale manufacturing process monitoring tool based on the resonance force microscope (RFM). The tool will combine image force microscopy (IFM, a version of RFM that measures the linear part of the susceptibility) and scattering near-field optical microscopy (sSNOM) with atomic force microscope for use in the hard disk drive (HDD) and semiconductor industries. sSNOM measures the dipole-dipole interaction force while IFM measures the dipole-dipole force gradient, both with nanometer spatial resolution. These techniques allow direct imaging of resonances associated with electrons, phonons, and plasmons. The capability to image plasmon resonances is well suited to probe the near-field (NF) profile associated with a plasmonic structure called near-field transducer (NFT) utilized in heat-assisted magnetic recording (HAMR). With HAMR universally viewed as the next generation technology for HDD industry, the need for a monitoring tool for mass production of HAMR head is acute since there is currently no simple way to probe the NF profile of NFTs. The objectives of the proposed project are (1) to successfully prototype an automated NFT characterization tool and (2) to field test it with one or more HDD manufacturers.

The broader impact/commercial potential of this project will be felt not only in the HDD industry but across many industries. While the monitoring of NFT production is the near-term niche application for the automated tool, the same tool will have longer-term value for in-line characterization of physical and chemical properties of nanoscale materials and structures in the manufacturing environment of diverse industries, including, for example, the measurement of stress in the channel layer and chemical characterization of defects in semiconductor industry and monitoring of protein-based pharmaceuticals. In R&D and academic settings, the RFM technique provides the capability to image individual biomolecules in situ, such as for the real-time monitoring of membrane protein dynamics on cells, which will provide unprecedented utility in biomedical and clinical research. A reliable label-free imaging tool with the capability to identify chemical bond information at the molecular level will potentially bring about revolutionary advances in many fields of basic and applied biological science, including drug discovery, proteomics, structural biology, and personalized medicine. The RFM technique will be simpler to implement as compared to other hybrid instruments involving high resolution microscopy, resulting in an affordable instrument for academic and research institutions.

Northeastern University

Program: PFI:AIR - TT

NSF Award No.: 1601895

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Program Director: Barbara H. Kenny

Topic: Advanced Materials and Instrumentation (MI)

PFI:AIR - TT: Sustainable Permanent Magnets For Advanced Applications

This PFI: AIR Technology Translation project focuses on directed development of the crystal structure, microstructure and magnetic structure of equiatomic FeNi (Iron-Nickel) to create an advanced permanent magnet entirely comprised of easily accessible, earth-abundant elements. Advanced permanent magnets underlie operation of myriad devices and machines, including hybrid/electric vehicles, direct-drive wind turbines, motors and generators and thus are technologically and industrially important. At present, advanced permanent magnets require rare-earth metals that are in limited supply in the current situation of the global supply chain. Equiatomic FeNi with the chemically ordered tetragonal structure, known as tetrataenite, is found naturally only in selected meteorites subjected to extraordinarily long cooling periods and has been confirmed to exhibit excellent permanent magnetic properties. This PFI: AIR Technology Translation project will deliver enabling proof-of-concept synthesis and processing protocols, based on existing industrial metallurgical techniques, to greatly accelerate the formation of tetrataenite to industrially-relevant timescales. The end-stage magnets made from the synthesized tetratenite will not only feature maximum theoretical energy products that approach 66% of those characterizing the best rare-earth-based magnets, but are also anticipated to exhibit high-temperature performance exceeding that of the best neodymium (Nd) based magnets. In addition, complementing clear advantages in cost and supply chain availability, such magnets would exhibit superior corrosion resistance and associated extended technological lifetimes.

This project will provide enabling insight into the conditions and processes necessary to favor the formation of tetrataenite, as well as inform microstructural aspects of this material as it transitions from the research lab to commercial production and application. In particular, techniques to simultaneously apply controlled processing parameters, such as temperature, strain and magnetic field, will be designed and implemented. Parallel development of transport measurement protocols to identify the earliest stages of desired phase formation from the parent alloy will be conducted. In addition, personnel involved in this project (one post-doctoral associate, one graduate student and undergraduate cooperative education internship students) will receive experiences in the science, engineering and technology of permanent magnetic materials, including industrial and global supply chain perspectives.

This project engages Rogers Corporation at the Rogers Innovation Center in Burlington, Mass. and at Rogers Headquarters in Rogers, Conn., to build closer linkages between academic research at Northeastern University, industry know-how, and commercialization of research. In this manner materials solutions to address global challenges for clean energy and safety and security will be pursued, facilitating and accelerating translation from research discovery toward commercial reality.

Polnox Corporation

Program: SBIR Phase II

NSF Award No.: 1632258

Award Amount: $745,146.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Development of Macromolecular Corrosion Inhibitors Based on Renewable Resources for Biolubricants and Lubricants

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to help protect the environment by replacing existing toxic and environmentally-hazardous corrosion inhibitors used as lubricant additives with more eco-friendly alternatives. Release of lubricants (for example from loss during use, improper disposal of waste lubricants, accidental spillage, or off-shore drilling) has the potential to cause damage to the environment. Awareness of the toxic nature of current lubricant additives is a driver to develop new technologies for more environmentally friendly products. This project addresses the development of novel, environmentally friendly corrosion inhibitor lubricant additives. Besides the environmental benefits of the new technology, the lubricant industry may also benefit by expansion into environmentally sensitive market sectors (for example, marine lubricants used on ships) through the use of safer and less toxic additives. The new products also utilize non-petroleum based raw materials from renewable and sustainable resources, thus reducing dependence on petroleum. Apart from being non-toxic and environmentally friendly, the proposed products are also expected to be more effective inhibitors as compared to the products currently used in the market.

The objectives of this Phase II research project are to design and develop environmentally friendly corrosion inhibitors providing high performance while meeting the eco-toxicological requirements of environmentally acceptable lubricants (EAL), including bio-lubricants. The use of corrosion inhibitors in lubricants is essential to protect metal surfaces. Unfortunately, many commercial corrosion inhibitors present issues with aquatic toxicity, persistence in the environment, and/or bioaccumulation that render them unacceptable for use in EAL or bio-lubricants. Awareness of the eco-toxicological problems of current inhibitors and the implementation of new regulations mandating the use of EAL in certain applications (e.g. marine lubricants) has created an urgent need in the market to replace existing products and the opportunity to develop new technologies for corrosion inhibition. This proposal addresses the key steps involved in the product development of corrosion inhibitors for biolubricants; namely (a) molecular design optimization, (b) cost-effective process scale up, (c) preparation of pound scale of lead products in the laboratory set-up; as identified in Phase I, (c) assessment of eco-toxicological properties using industry standard OECD/ASTM test methods and structure activity relationship (SAR) calculations, and (d) product storage stability testing.

Rare Resource Recycling

Program: SBIR Phase II

NSF Award No.: 1632711

Award Amount: $749,926.00

Start Date: 11/01/2016
End Date: 10/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Sustainable Rare Earth Element Recycling from Neodymium Magnets

The Small Business Innovation Research (SBIR) Phase II project will implement a proprietary rare earth extraction process on recycled NdFeB magnets at pilot scale to prove commercial production feasibility. By recovering rare earth elements (REEs) readily available in waste streams, this effort will help create a secondary source of these critical elements, thereby reducing U.S. dependence on an unstable, limited supply from China. This will, in turn, lay the groundwork necessary for the production of cutting-edge technologies reliant upon these materials to return to the U.S. The Nd and Dy elements which are recovered from this process are the critical components that increase the efficiency of electric motors by up to 30%. The availability of these resources will also significantly improve the vertical integration of manufacturing for national security technologies that depend heavily upon REEs, such as guided missile actuators and jet-fighter control panels. This project will also impact the electronics recycling sector by creating a new, reliable revenue stream for electronics recycling companies.

The process to reclaim REEs from NdFeB magnets is simple and energy-efficient, with a minimal environmental footprint. The Phase I SBIR project demonstrated the feasibility of developing the process beyond laboratory scale to pilot scale, improved the purity of the end product and reduced the amount of waste from processing. The Phase II project will focus on the following objectives: 1) designing a scale up strategy and building a pilot scale production plant; 2) optimizing the pilot scale production process; 3) maximizing product recovery at pilot scale; 4) designing a wastewater treatment and reuse strategy; and 5) minimizing residual contamination in the final products. To achieve these Phase II objectives, we will develop process parameters for maximum yield, maximum purity, and minimum processing times at pilot scale. The first stage will be to successfully obtain production yields of 90+% and purity levels of 99+% in pilot scale batches. For the second stage, we will focus on scaling production to prove commercial-scale feasibility, with ideal product yields and purities of 95+% and 99+% respectively. Throughout all stages, we will focus on understanding and treating the accompanying waste products, including wastewater and residual metal impurities.

Renuvix

Program: SBIR Phase II

NSF Award No.: 1556069

Award Amount: $760,000.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Program Director: Debasis Majumdar

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: High-Performance, Environmentally Friendly Polymer Systems for Paints and Coatings

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to provide the paint and coatings industry with new high-performance, cost-competitive polymer/resin systems that reduce solvent emissions and use of petrochemicals. In addition, these new polymer/resin systems enable one-component, ambient-cure coatings to be produced. This means that highly protective coatings can be produced without the need for mixing multiple components together prior to application or applying heat or light to cure the coatings. The one-component, ambient-cure features of these polymer/resin systems largely eliminate waste and energy costs associated with coating application and lend themselves to the production of paints and coatings that can be applied by the average person. Compared to the current state-of-the-art in one-component, ambient-cured resins, these new polymer/resin systems provide dramatically shorter drying times, dramatically better chemical resistance, and much higher film hardness, while exhibiting excellent impact resistance and flexibility. The highly desirable properties of these new cost-competitive polymer/resin systems will enable commercial success, while their low solvent emissions and high renewable content will reduce impact on the environment.

The objectives of this Phase II research project are to: 1) further optimize the polymer/resin systems to produce compositions that minimize solvent content and maximize performance, while meeting the cost constraints of the market; 2) put in place a pilot-line to provide potential customers with adequate sample sizes to enable their own evaluation of potential products, 3) generate weathering, corrosion, and storage/shelf stability data to further understand the application potential of optimized polymer/resin systems; and 4) optimize the polymer/resin production process to minimize cost and minimize production waste. By meeting these objectives, the Phase II project will result in the generation of new polymer/resin systems that will enable the development and commercialization of new paints and coatings that are one-component, ambient-cured, low in solvent content that exhibit exceptional properties, while being primarily based on renewable materials. Optimized polymer/resin systems will be provided to potential customers for their own internal evaluation. If necessary, feedback from customer evaluations will be used to modify polymer/resin system composition to meet customer needs. By the end of the Phase II project, the technology will be ready to proceed to manufacturing scale-up and product commercialization.

Scuba Probe Technologies

Program: SBIR Phase II

NSF Award No.: 1556128

Award Amount: $747,082.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Encased Cantilevers for Ultra-Sensitive Force and Mass Sensing in Liquids

This Small Business Innovation Research (SBIR) Phase II project will improve the performance of encased atomic force microscopy (AFM) cantilevers, reduce their fabrication costs, and optimize their properties for next-generation scanned probe microscopy technologies. Atomic force microscopy is a workhorse technique for providing nanometer-scale information of materials, but its performance is compromised by viscous damping when operated in fluid. The encased cantilevers to be developed in this project significantly reduces damping, leading to high force sensitivity and performance which is identical to AFM imaging done in air. This aids quantitative interpretation of data and simplifies instrument operation. Encased cantilevers are a drop-in replacement, permitting the transformation of existing instruments into cutting-edge tools simply by exchanging the probe. The impacts of these products will be felt in fields from biology to clean energy to materials science.

The first technical objective of this research is to create new cantilever geometries that push the performance of our devices to the theoretical limits. The Phase I research resulted in a novel low-cost technique to fabricate encased cantilevers, thanks to the development of specialized semi-automated processing and quality control tools. The next technical objective of Phase II research is to further reduce fabrication costs by improving yields, increasing batch size, and implementing more manufacturing automation. We expect to demonstrate low-cost processing methods in which many high quality probes are fabricated efficiently. The third technical objective is to optimize these devices for next-generation scanned probe technologies including quantitative nanomechanical mapping, high-speed imaging and promising novel techniques such as photo induced force microscopy. At the end of the project period we will have optimized products specifically targeting these high growth applications.

Sigray

Program: SBIR Phase II

NSF Award No.: 1556020

Award Amount: $749,678.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Development of a Dual Energy Micro-focused X-ray Excitation Beam for Chemical Analysis and Materials Characterization

This Small Business Innovation Research (SBIR) Phase II project will develop a microfocus dual energy x-ray excitation beam delivery system to be used for micro x-ray fluorescence (micro-XRF) analysis. The development of this system will address critical needs in a variety of disciplines for substantially improved detection sensitivity (particularly of low atomic number elements), higher spatial resolution, better analysis accuracy, and increased throughput. The proposed project is expected to impact the $ 900 million XRF market by further accelerating the rapid adoption of this tool, which has been utilized for a variety of research and industrial applications, including: development of advanced materials, toxicology of trace metals, mapping mineral distribution in healthy and diseased biological tissues, determining efficient oil extraction methods for specific reservoirs in oil & gas, monitoring mine efficiency by analyzing mine wastes, and chemical analysis of buried structures and packaging components in the semiconductor industry.

Currently, achieving high spatial resolution mapping of elemental composition at the micrometer scale resolution with analysis sensitivity in the low parts per million (ppm) levels is only possible at synchrotron micro-XRFs, of which there are only a limited number of around the world, and which are often oversubscribed. The performance of existing laboratory micro-XRF systems is largely limited - in terms of focus size, focusing efficiency, and spectral response - by the x-ray optics which are employed. The project will permit the development of an innovative x-ray compound mirror lens which will enable a microfocus dual energy x-ray excitation beam delivery system with high analytical sensitivity to both low- and high-Z elements, large x-ray flux (up to thirty-fold better than leading systems), microns-scale spatial resolution, and large working distances (5 cm). This beam delivery system will be usable as an attachment in a scanning electron microscope and in a standalone micro-XRF system.

Spectradyne, LLC

Program: SBIR Phase II

NSF Award No.: 1534631

Award Amount: $746,153.00

Start Date: 08/15/2015
End Date: 07/31/2017

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II:A Low-cost Instrument for Rapid Sub-micron Particle Size and Concentration Measurement

This Small Business Innovation Research (SBIR) Phase II project supports development of a nanoparticle characterization instrument that will fill the critical unmet need to rapidly and accurately measure the size and distribution of nanoparticles from 30 nanometers to 1 micron. Initially the technology will target two applications: protein aggregation in biopharmaceuticals, and nanoparticles in medicine (e.g., tumor-targeted drug delivery). The importance of nanoparticle analysis, however, goes well beyond therapeutics. Currently the market for nanoparticle analysis instrumentation across the life sciences is $5.6 billion, and there are increasing concerns about nanoparticles in consumer products such as food and cosmetics, as well as in drinking water, effluents, and the environment. A major challenge in understanding the health impacts of nanoparticles is simply in accurately and easily detecting their presence and size distribution. Additionally, improved nanoparticle instrumentation will enable new discoveries in biotechnology and environmental and health sciences.

This challenge can be met by developing a practical method for counting and sizing submicron particles in polydisperse mixtures. NSF Phase I/IB funds supported development of a prototype instrument that detects individual nanoparticles and accurately measures their size, at very high count rates. This instrument has successfully demonstrated robust detection of individual particles as small as 60 nm in diameter at rates approaching 10,000 particles per second, and has already begun to deliver useful information to particle manufacturers in the pharmaceutical industry, with on-going measurements of actual customer samples. The Phase II support will considerably enhance the utility of this instrument by addressing several outstanding technical challenges; most significantly, by extending the range of detectable particles to span the full range from 30 nm to 1000 nm, and by further maximizing the range of measurable particle concentrations. In addition, the Phase II work will drive significant improvements in functionality and ease of use, driven by innovations in its control software. Finally, the instrument will be further validated using a wide variety of particle types relevant beyond the pharmaceutical space.

Spheryx, Inc.

Program: SBIR Phase II

NSF Award No.: 1631815

Award Amount: $748,011.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Total Holographic Characterization of Colloids Through Holographic Video Microscopy

This Small Business Innovation Research (SBIR) Phase II project will enable a commercial implementation of holographic video microscopy, a fast, precise and flexible technology for measuring the properties of individual colloidal particles suspended in fluid media. This disruptive technology solves critical manufacturing problems across industries that work with colloidal dispersions. Demonstrated applications include: 1) monitoring the growth of nanoparticle agglomerates in precision slurries used to polish semiconductor wafers where scratches due to slurry agglomerates are responsible for waste valued at $1 billion annually; 2) tracking concentrations of dangerous contaminants in wastewater streams; and 3) measuring the concentration of protein aggregates in biopharmaceuticals, a safety concern noted by the Food and Drug Administration (FDA) in this $250 billion industry. Holographic video microscopy is unique among particle-characterization technologies in providing comprehensive information about the size, shape and composition of individual particles in real time and in situ. Having access to this wealth of data facilitates product development, creates new opportunities for process control and provides a new tool for quality assurance across a broad spectrum of industries enabling safer, less expensive products for consumers while providing cost savings to manufacturers.

The technical objectives of this project are: 1) to optimize the design of the underlying holographic microscopy system without compromising the quality of results; 2) to enable quantitative concentration determination including corrections for perturbations introduced by flow dynamics; 3) to expand the domain of operation to characterize non-spherical particles and 4) to apply machine-learning algorithms for automated robust operation. Using holographic video microscopy for commercial applications requires adaptation and innovation in the design of the prototype instrument that was used to demonstrate feasibility. Streamlining the optical train will require advanced modeling and the creation of new methods of correcting optical aberrations to enable ease of manufacture. Additional improvements in design will include advances in improving microfluidic flow control to generate accurate concentration determination, to adapt holographic analysis algorithms for characterizing the structure of aspheric particles, and to extend analytical capabilities for turbid fluids. Finally, innovative machine-learning using neural network algorithms demonstrated significant improvements for analytical robustness in Phase I and will be extended to a wider range of applications. The Phase II effort will enable holographic video microscopy of real-world samples with typical measurement times of a few minutes.

Sunstrand, LLC

Program: SBIR Phase II

NSF Award No.: 1430777

Award Amount: $934,976.00

Start Date: 08/01/2014
End Date: 06/30/2017

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Bamboo Fiber Processing for Use in Reinforced Composites

This Small Business Innovation Research Phase II project will eliminate remaining barriers to the production of bamboo fibers for use as a reinforcement in polymer composites. The broader impact/commercial potential of this project will be an increased usage of sustainable materials, increased revenue for US agriculture, and increased domestic and international sales of a new and innovative product line. Success in this project will also lead to domestic job creation needed to support the research, manufacturing, and sales of these composites. The processes to be finalized during this Phase II project will support the growth of a nascent based on US-manufactured, environmentally-friendly products. Within three years of launch, it is expected that over $4 million in revenue will be generated by sales of bamboo fiber. Moreover, increases in bamboo cultivation as a result of these new products will help mitigate adverse environmental impacts and improve public health. This will be done by the inherent sequestration of carbon dioxide in the plant growth cycle, and a reduction in the pollution associated with the use of high-energy glass fiber and plastics processing techniques.

This Phase II project will address the following research topics: species variations, manufacturability, additional high value products, additional composite properties, processing and treatment optimization, and commercial scale-up. The team will assess the mechanical and physical implications of variations in feedstock by the use of filament tensile testing. Surface treatments specific to bamboo fibers will be finalized, with the goal of increased fiber-matrix interfacial adhesion, mitigation of water absorption, and compatibility with at least three major resins systems. These treatments will be evaluated via composite tensile testing, filament testing and water immersion testing. Manufacturing studies will be performed to verify compatibility with commercial scale manufacturing equipment. The design and manufacture of a small scale, batch plant will address technological and automation challenges. This plant will provide a bridge to a commercial-scale plant designed to produce 6 million pounds of fiber yearly. Additional innovative aspects to the project lie in the assessment of a bamboo species compatible with climates in the US, automation of raw bamboo processing, and implementation of a fully optimized multi-step material functionalization process.

Thermal Expansion Solutions, LLC

Program: SBIR Phase II

NSF Award No.: 1632571

Award Amount: $750,000.00

Start Date: 11/01/2016
End Date: 10/31/2018

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Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Zero Thermal Expansion Alloys For Lasers

This Small Business Innovation Research (SBIR) Phase II project will develop new alloys whose thermal expansion properties can be tailored for laser applications. The tailored thermal expansion alloys will prevent shifts in laser output frequencies, i.e. laser color, by preventing the natural temperature-induced thermal expansion and contraction that occurs in laser housings. This temperature stability is extremely important for fiber-optic systems that are the backbone of the telecommunications industry. According to Strategies Unlimited, the telecommunications laser market was $3.515 billion in 2014, and it is expected to increase with the increasing number of mobile devices and growing demand for high-speed internet. While oil and gas telecommunications systems were identified as the beachhead market, the alloys developed through this project will also have potential to add value to the wider telecommunications market and a number of other industrial and electronics applications.

The intellectual merit of this project lies in a new method to exhibit unprecedented control over thermal expansion properties in metal alloys. The discovery that mechanical deformation tailors or “programs” the thermal expansion of a bulk metal to match that of other common materials (metals, polymers, and ceramics) will change the way scientists and engineers design for thermal compensation. These alloys can also be tailored not to expand or contract with temperature changes and even be made to shrink when heated. This wide range of tailored alloy responses is achieved without chemical changes or composite fabrication methods upon which competing technologies rely. This Phase II project will reduce the risks associated with implementing the tailored thermal expansion alloy technology in laser applications by developing high thermal conductivity alloys and testing prototypes. Alloys will be purchased, engineered to have a desired coefficient of thermal expansion, and tested for laser performance. The expected outcome of this work is the realization of tailored thermal expansion alloys in laser prototypes.

Trace-Ability, Inc.

Program: SBIR Phase II

NSF Award No.: 1555815

Award Amount: $760,000.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Development of a Simple Device that Eliminates Bottlenecks in Radiopharmaceutical Production

This Small Business Innovation Research Phase II project aims to deliver a cost-effective automated quality control (QC) system for manufacturing of radioactive drugs used in Positron Emission Tomography (PET). This system will replace current QC procedures, which involve 18 manual operations, 8 visual assessments, 6 devices, and 8 samples of radioactive drugs. The industry's current reliance on manual operation, subjectivity and untraceable records impedes progress in radioactive drug manufacturing and presents compliance risks. Therefore, introduction of an automated system combining all these tests on a single platform will facilitate adoption of PET imaging technology beyond top tier medical centers. By addressing a critical current Good Manufacturing Practice (cGMP) compliance need in radio-pharmaceutical production, which cannot be addressed with any other solutions available today, this solution is positioned for rapid adoption. After adopting this system, it is expected that manufacturing facilities will realize 20% operating cost reduction and 50% reduction in time spent on QC-related activities. A reduced cost of compliance associated with introduction of automated QC will further contribute to the adoption rate. This project will open the door to new applications of plate reader technology, an approach which has been traditionally confined to the fields of biochemistry and diagnostics.

This Phase II effort includes four technical objectives. Firstly, the approach will be adapted to minimize the required sample volume. Methods developed in Phase I of the project required 0.5 ml of sample, a value which is not optimal for small manufacturers. To bring this value down to 0.2 ml, test sensitivity will be adjusted, keeping in mind the potential dynamic range trade-offs. Secondly, we will design a plastic consumable that supports adoption by a commercial manufacturer. Current plastic prototype components are only suitable for academic sites with highly-skilled personnel. To reduce the amount of training required, and to expand the applicability of this method, a new plastic component will be designed in order to further automate sample loading. Third, we will optimize the formulation of the reagents to achieve a one-year shelf life for the consumable kit. The shelf life of the reagents developed in Phase I remains unknown. Therefore, accelerated stability studies will be performed to estimate the rates of decomposition processes, and appropriate changes will be made to enhance shelf life. Finally, we will develop a pilot production process for the newly-designed kit, in order to support early installations.

University of Connecticut

Program: PFI:AIR - TT

NSF Award No.: 1500293

Award Amount: $200,000.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Topic: Advanced Materials and Instrumentation (MI)

PFI:AIR - TT: A Hybrid Metal/Glass Composite System for Multihazard Resilient Bridge Columns

This PFI: AIR Technology Translation project focuses on translating a novel bridge column system to fill the need for cost-effective and sustainable bridges that are resilient to natural and man-made hazards such as earthquakes, terrorist attacks, vessel collisions/fires, and corrosive environments. The hybrid metal-glass composite column system is important because our nation is in critical need for durable and safe transportation infrastructure. Conventional structural materials, such as reinforced concrete and steel, are vulnerable to various hazards and environmental conditions. Traditional bridge construction methods are expensive, time consuming, and cause major traffic interruptions. This product enables accelerated construction of new bridges, increased work zone safety, and reduction of travel delays, which optimizes the stewardship of public funds to grow the nation's infrastructure. The project will result in the proof-of-concept of a novel hybrid composite column system. This hybrid composite system integrates the unique energy dissipation of steel material, the excellent strength-to-weight ratio of glass fibers, and the exceptional durability of polymeric resins. These features provide the following advantages: superior structural performance, durability, cost-efficiency, and ease of construction when compared to the leading competing systems like conventional concrete-filled FRP tube (CFFT) systems in this market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application: 1) understanding morphology of hybrid steel-glass composites, 2) validating superior structural performance of the column system, 3) developing reliable structural design methodology, and 4) identifying and addressing potential scalability and manufacturing difficulties. A series of structural experiments will be performed on tubes with diverse composite architecture under various loading conditions. This will be complemented by high fidelity finite element simulations to optimize the design of the prototype. After finalizing the design, structural testing of a large-scale bridge column will be performed. In addition, personnel involved in this project including multiple graduate and undergraduate students, some from underrepresented groups, will receive entrepreneurship and technology translation experiences through collaboration with industry partners and communication with Departments of Transportation and bridge construction companies.

The project engages NOV Fiber Glass Systems to provide expertise in manufacturing of filament wound composite tubes and access to their testing facility in this technology translation effort from research discovery toward commercial reality.

Xallent,LLC

Program: SBIR Phase II

NSF Award No.: 1632534

Award Amount: $750,000.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Program Director: Ben Schrag

Topic: Advanced Materials and Instrumentation (MI)

SBIR Phase II: Integrated Nano-Electro-Mechanical Scanning Probes for Failure Analysis of the 10-Nanometer Node and Beyond

This Small Business Innovation Research (SBIR) Phase II project will develop and commercialize a breakthrough suite of probes and probing platforms for the imaging and probing of semiconductor devices and thin film materials at scales below 100 nm, where conventional techniques are challenged. The resulting products will allow customers to perform a rich range of tests at the nano-scale at costs and times that are a small fraction of those required for conventional platforms such as scanning electron microscopes (SEM), scanning probe microscopes (SPM), and a range of automated test equipment (ATE) based on these technologies. Miniaturization across a range of sectors is driving the development of devices and materials at increasingly minute length scales. Multiple large-scale trends including mobile devices and the internet-of-things are driving an unprecedented volume of engineering at the nanoscale. Much of this is now dependent on the single-tip SPM that has evolved into a broad array of instruments for the analysis of physical, chemical and electrical properties, and to detect and isolate flaws.

The Multiple Integrated Tips (MiT) technology that is the focus of this effort takes a radically different approach to enable an even richer range of tests at length scales below one micron, with a faster, simpler and much more cost-effective platform. Given a large install-base of capital equipment, we are focused on probes coupled with adapters that plug into the most popular SEMs and SPMs. These probes significantly expand the functionality of existing systems, and do this with low barriers to acceptance given modest price points and seamless integration into standard industry platforms. A portfolio of probes will be developed to address high-volume needs across the semiconductor and thin film markets, starting with 4-tip devices for the electrical characterization of thin films, and configurable or non-configurable 3-4-tip devices for probing integrated circuits. These will be offered in a variety of sizes and geometries, currently from hundreds of nm to 65 nm, and extending below 10 nanometers within a year. In Phase II, probe functionality will be enhanced to enable coupled imaging and probing with design to operate in AFM mode. The portfolio of products will be continuously expanded to additional two- and three-dimensional geometries via co-development with lighthouse customers.

BIOLOGICAL TECHNOLOGIES (BT)

AmebaGone, Inc.

Program: SBIR Phase II

NSF Award No.: 1534650

Award Amount: $754,826.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Biological Technologies (BT)

SBIR Phase II: Natural Biocides for Treating Bacterial Pathogens in Pome Fruits and Vegetable Crops

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be the development of a new natural means of treating diseases of fruit orchards and crops as an alternative to antibiotic use. Over 90% of the world's antibiotic use in agriculture is primarily to control fire blight, a disease that kills fruit trees. Fire blight has emerged as the most devastating disease of apple and pear trees worldwide. Growers apply streptomycin or oxytetracycline multiple times during bloom and following plant injuries to prevent the growth of the causative agent of fire blight, Erwinia amylovora (Ea). Resistant Ea strains have been isolated, and are expected to impact the human food chain. The proposed technology will replace these antibiotics with the microscopic predators of bacteria, slime molds, which are benign to humans, animals, and plants. These bacterial predators represent a new proprietary biocontrol approach. The proposed project will focus on reducing orchard carriage of Ea, and the general approach should be extensible to treating agricultural infections of other species of bacterial pathogens. Ultimately, this innovation will contribute to increased public health by providing safer alternatives to existing antibiotics and disinfectants.

This Small Business Innovation Research Phase II Project proposes a novel approach to treating fire blight, a pathogenic disease affecting pome fruits caused by E. amylovora, and tomato canker caused by C. michiganensis. Both pathogens form biofilms connected to their virulence in plants. There is currently no treatment although the incidence of reoccurring infections by E. amylovora and C. michiganensis contribute to millions of dollars of losses in fruit production. Antibiotics and disinfectants typically kill only growing cells. This approach consumes growing, dormant, or biofilm-enmeshed bacteria. Inclusion of biofilms as targets will help to identify a means to solve some of the most intractable infections known. The research objectives of this Phase II SBIR proposal are to: 1) Screen Dictyostelid (Dicty) isolates in vitro for biocontrol capabilities for orchards and decontamination of plants/ equipment, 2) test efficacy of Dicty candidates en planta, and 3) design methods for spore production and packaging. For commercial applications, the goal is to use probiotic bacteria to amplify Dicty and produce spores. For spore preservation and dispersal, the plan is to use methods proven to be successful and safe for other biocides. Natural biocides products will be developed for agricultural research and to treat pathogenic outbreaks in fruit and vegetable crops.

Animated Dynamics, Inc.

Program: SBIR Phase II

NSF Award No.: 1534699

Award Amount: $754,066.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Biological Technologies (BT)

SBIR Phase II: Development of a Microscope to Detect Cellular Motion in Three-dimensional Tissue

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to develop a new microscope that integrates biodynamic imaging with conventional phase contrast microscopy for use in drug development and other research applications. Accurately capturing the signatures of three-dimensional biological systems provides more realistic measures of drug efficacy and response heterogeneity - two critical aspects of the drug-development process that help find the right drug doses and combinations to kill cancer cells with minimal toxic side effects. This tool will extract functional information at greater tissue depths than conventional microscopies by using cellular motions inside living tissue. The motion is detected by reflected light that carries with it important information about the action of drugs inside 3D tissue, allowing drug evaluations in heterogeneous three-dimensional tissues systems, and providing new insights for pharmaceutical development.

This SBIR Phase II project provides a tool capable of extracting high-content information from inside three-dimensional living tissue culture and tumor biopsies. It extracts this functional information at greater tissue depths than conventional microscopies by using Doppler tags on light scattered from intracellular motions inside living tissue. These novel Doppler tags carry phenotypic profiling information about the action of drugs inside 3D tissue, allowing drug evaluations in heterogeneous three-dimensional tissues and providing new insights for pharmaceutical development and therapeutics. The project goals are to construct a new type of microscope based on the detection of cellular motions, and to integrate the microscope with a software platform that is easy to use by customers. Upon completion of this Phase II, a commercial biodynamic microscope product will be ready for value-added resale of leading microscopes to life sciences customers.

Ascent Bio-Nano Technologies, Inc.

Program: STTR Phase II

NSF Award No.: 1534645

Award Amount: $750,000.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

STTR Phase II: Development of Bio-compatible and Bio-safe Cell Sorters

The broader/commercial impact of the Small Business Technology Transfer (STTR) Phase II project will be a cell sorter, a new research tool for life science research, animal reproduction, and cell-based therapy. In the past decade, cell sorters have become vital in many fields, such as molecular and cellular biology, immunology, plant biology, animal reproduction, and medical diagnostics and therapeutics. Despite their significant impact, current cell sorters have the following drawbacks: high equipment and maintenance costs, significant bio-safety concerns, and reduced cell viability and function. These drawbacks reduce the effectiveness of cell sorters in many important research studies and clinical applications. Enabled by this innovation, researchers will be able to better understand the causes of diseases, identify new therapies, and test new drugs and vaccines. It also has the potential to improve dairy production efficiency, and aid medical doctors in making better decisions about diagnosis and treatment. In Phase II, the goal is to improve performance of the instrument, and validate the performance with end users.

This STTR Phase II project will demonstrate the feasibility of a microfluidic-based, bio-compatible, bio-safe, fluorescence-activated cell sorter. Cell sorters are powerful, high-throughput, single-cell characterization and purification tools that are vital for labs in fields such as molecular biology, pathology, plant biology, stem cell biology, and medical diagnostics. The technology is based on acoustofluidic (i.e., the fusion of acoustics and microfluidics) cell sorting chips that preserve the integrity and functionality of sorted cells. Current cell sorting systems reduce cell viability, integrity, and cell function due to high shear stress, high impact force, and high driving voltage, which reduces their effectiveness as a research tool, and in clinical applications. Unlike current cell sorters that use electrostatic force to sort cells, which require 12,000 V of driving voltage, the proposed technology uses acoustic tweezers to sort cells, and requires only 10 V, which significantly reduces cell damage. Compared with existing cell sorters, the proposed microfluidic cell sorter will have the following advantages: 1) high bio-compatibility; 2) high bio-safety; and 3) lower costs and lower maintenance. In addition, the cell sorter will be more accessible to researchers and address existing unmet needs in the market (e.g., sorting fragile or sensitive cells while preserving high viability and function). This will accelerate research findings and improve diagnostics and therapeutics.

Cairn Biosciences

Program: SBIR Phase II

NSF Award No.: 1632576

Award Amount: $750,000.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: A Novel Multicolor Cell Line Engineering Platform that Enables High-throughput Microscopy-based Screening of Living cells for Drug Discovery

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development of new tools to understand the dynamic behavior of cellular machinery that is disrupted in disease. Unraveling the dynamic aspects of cellular physiology that may be targeted therapeutically requires new technologies capable of profiling the response of entire signaling pathways to pharmacological intervention targeted at single pathway nodes. The availability of physiologically relevant live-cell models that are compatible with visualizing and quantifying the spatiotemporal regulation of disease-relevant signal transduction pathways and cellular machinery will be key to enabling this approach. The ability to monitor multiple facets of key cancer signaling pathways in this way represents a valuable opportunity to identify potent and selective therapeutic inhibitors of "undruggable" targets, such as the Ras protein, which is a crucial driver of more than 30% of cancers. By enabling development of a robust and scalable high-throughput live-cell assay platform, this technology may reduce the time and cost to pinpoint the mechanism of action and off-target effects of pharmaceutical chemicals, thus delivering new capabilities to rapidly and cost-effectively identify safe and effective therapeutics.

This SBIR Phase II project will develop a robust and flexible platform for rapid generation of precision-engineered, multicolor fluorescent cell lines and associated high-throughput microscopy-based assays. This platform contrasts with industry standard methods for developing such cell lines and assays, which are lengthy and inflexible. The project comprises optimization and execution of four components: 1) Generation of a panel of cell lines compatible with rapid, reliable stable reporter integration; 2) Delivery of a library of approximately 25 multicolor reporters of the Ras/MAPK pathway; 3) Rapid generation and validation of a library of approximately 100 validated stable reporter cell lines expressing all therapeutically relevant mutations and isoforms of the Ras/MAPK pathway; and 4) 384-well plate assay development and screening of these Ras/MAPK reporter cells using tool compounds. The project aims to demonstrate the capability of the platform to rapidly pinpoint compound mechanism of action and potential off-target effects by monitoring multiple facets of previously inaccessible biology associated with a critical, high-value oncology target in live cells. The standardized platform established in the course of this project will allow rapid expansion to additional clinically relevant signaling pathways.

Cinder Biological, Inc.

Program: SBIR Phase II

NSF Award No.: 1556089

Award Amount: $749,893.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: Improving Food Safety using Hyper-stable Enzyme Cleaning Products

The broader impact/commercial potential of this Small Business Innovation Research Phase II project will be to improve cleaning in the food processing industry by integrating hyper-stable enzymes into cleaning products. Industrial enzymes are a growing, multi-billion dollar green industry that reduces energy, water, and harsh chemical use while improving process efficiency in many sectors. Despite the broad use and success of industrial enzymes, their application and economic impact has been severely limited by narrow thermal and chemical operational ranges available. The company has developed heat and acid stable enzymes that significantly expand the reach of enzyme applications. The goal is to develop an initial product for the dairy cleaning market that will have the potential to increase production due to faster cleaning, achieve better removal of protein contaminants and biofilms, reduce water usage, and reduce food product exposure to chemicals and chemical waste. Better cleaning with enzymes has the potential to prevent food-borne illness, and decrease water use, while increasing food-processing profits and providing a biodegradable alternative to chemical cleaners.

This SBIR Phase II project proposes to demonstrate the feasibility of using the first practical protein expression platform to produce hyperstable enzymes for commercial use. Although the genes from extreme organisms have been studied for over forty years, their commercial potential has not been realized due to their incompatibility with traditional protein expression systems. The unique hyperstability of enzymes produced using the company's technologies indicate that enzyme stability is not encoded entirely by gene sequence. In Phase II, the goal is to develop more comprehensive cleaning formulations and test these with laboratory and field trial methods established in Phase I. The project encompasses a set of integrated experiments spanning molecular biology, microbiology, biochemistry, dairy processor field trials, and practical industrial bioprocess optimization. The aim is to transform the world's most extreme enzymes into the world's most effective products for membrane defouling and sanitation in the dairy industry and beyond.

Data2Discovery, Inc.

Program: SBIR Phase II

NSF Award No.: 1660155

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Semantic Link Association Prediction for Phenotypic Drug Discovery

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development of an informatics-based software platform that will help pharmaceutical companies create more new, effective, and safe drugs earlier in the R&D pipeline. This software platform will address a need for data integration and analysis tools to aid pharmaceutical researchers in 1) phenotypic screening, 2) toxicology analysis, and 3) drug repurposing. It will help these researchers quickly gather and interpret complex molecular and phenotypic data, making the drug discovery process more efficient and creating value for pharmaceutical companies. The economic impact of reducing the preclinical drug discovery process by just two weeks is estimated to be a $252 million cost savings for the industry. By using data more effectively earlier in the R&D process, this software platform also promises to enhance the quality of drugs that enter clinical trials. Thus, it provides an opportunity to reduce overall R&D spending and increase the number of drugs that enter the market - resulting in more economically priced medicines available to the population.

This SBIR Phase II project proposes to build an informatics-based software platform that solves cross-domain data integration, analysis, and user application challenges in order to effectively use data to draw insights earlier in the R&D process and compress the development pipeline for new or repurposed drugs. Using highly scalable semantic graph technologies, a flexible three-layer architecture is being developed that includes the 1) Biomedical Data Layer, 2) Computational Layer, and 3) Application Layer. This architecture allows the system be fully scalable and extensible to other datasets and biomedical applications. The system will be beta-tested by pharmaceutical researchers and evaluated though the creation of scientifically relevant use-cases. This development will result in a commercial software system that makes important biomedical data and insights available to all researchers within a pharmaceutical organization by addressing high need data integration, analysis, and application challenges.

Elucid Bioimaging, Inc.

Program: SBIR Phase II

NSF Award No.: 1353532

Award Amount: $1,353,339.00

Start Date: 04/01/2014
End Date: 09/30/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: Computer Aided Prognosis of Debilitating Disease

This Small Business Innovation Research (SBIR) Phase II project proposes to develop robust and effective imaging techniques for assessment of atherosclerotic disease severity for prognostic and longitudinal use. In the United States alone, approximately 5 million patients suffer pre-stroke symptoms of which 795,000 go on to a stroke annually. About 610,000 of these are first or new strokes, while the remainder are recurrent strokes. Despite these statistics, there is no effective test to tell who will or will not suffer acute events or to measure whether medical therapies are effective at reducing the risk. In this project, multivariate quantitative descriptors are developed using data from controlled outcome studies on a specialized model to discover and validate prognostic signatures that, in composite, perform well in both cross-sectional prognostic and longitudinal applications with high predictive value. Phase I results are extended to support histologically verifiable tissue types, expanding the functional and performance attributes of the product with a tie to localized ground truth maps made possible with co-registration of histology with MRI. The plan is to iteratively validate the developed capability under commercially accepted design controls.

The broader impact/commercial potential of this project will be the development of effective means for computer-aided prognostics using quantitative imaging phenotypes. Physicians face a complex and heterogeneous series of clinical manifestations of disease. Because disease arises through a complex interaction of multiple molecular signals and pathways often confounding the eventual effect, tools and approaches are needed to identify key pathways that reflect the underlying pathological processes. Functional imaging modalities have recently emerged for characterization of these disease processes and to obtain a better mechanistic understanding of the underlying biologic processes to distinguish more aggressive from less aggressive disease phenotypes. Computer-aided prognosis (CAP) of disease is a new and exciting complement to the field of computer-aided diagnosis (CAD). Since CAP approaches distinguish between different subtypes of a particular disease (as opposed to CAD schemes trying to distinguish diseased from benign processes), there is a need for more sophisticated image analysis, computer vision, and machine learning methods to identify subtle disease signatures that can separate unstable from stable disease. The chosen application in this project is a use case that has the potential to radically increase the power of applications to support clinicians in pursuit of personalized medicine.

Geneshifters, LLC

Program: SBIR Phase II

NSF Award No.: 1632575

Award Amount: $747,453.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: New Dwarfing Genes to Improve Yield and Abiotic Stress Tolerance in Wheat

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to improve wheat yield globally by deploying newly developed, region-specific dwarfing genes. World population is predicted to grow to 9.6 billion by 2050. Wheat demand is expected to increase also due to a shift from rice to wheat consumption due to an expected increase in wealth around the globe. The increased wheat demand will have to be met under less land area and changing climate. Water use efficiency and increase in wheat yields will be important factors in meeting this demand. The proposed technology is poised to increase wheat yield under abiotic stress conditions. All of these benefits are expected to have a major positive impact on humanity. The wheat seed business is currently valued at up to $8.3 billion. The proposed technology will provide a competitive advantage to capture a significant market share of the wheat seed industry while contributing positively towards food security during the changing climate.

This SBIR phase II project proposes to further develop and test alternative dwarfing genes to improve wheat yield and abiotic stress tolerance around the globe. Responsible for the "green-revolution," dwarfing genes are required to obtain higher yields, but the two dwarfing genes present in more than 90% of the currently grown wheat varieties have serious ill-effects including abiotic stress sensitivity, reduced root length and biomass, seedling emergence, and vigor. During the Phase I research, four new dwarfing genes were identified and shown to be significantly better than the currently used genes. Phase II will focus on the comparison of the new genes with the old genes to show their true benefits. This research also will generate valuable data required for the development of "release-ready" varieties. Genetic background effects will be studied by transferring one of the new dwarfing genes into two different backgrounds followed by field and controlled condition evaluation. Future competitive advantage will be maintained by pyramiding the new dwarfing genes with complementary gene action. Closely linked DNA markers will be developed for an efficient transfer of the technology into diverse backgrounds.

Glauconix, Inc.

Program: SBIR Phase II

NSF Award No.: 1660131

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Development of a High-Throughput Drug Screening System for Eye Diseases

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development of a drug screening system that will accelerate drug discovery for several eye diseases, including glaucoma, diabetic retinopathy, and macular edema. This technology will fulfill unmet needs of small and large biopharmaceutical companies engaged in drug discovery for various eye diseases by reducing development cost, expediting preclinical research, and increasing the chances of clinical success. From the socio-economic standpoint, this technology will result in the development of more effective ocular drugs that will decrease eye disease treatment cost. Furthermore, this model will facilitate more rapid development of technologies for the diagnosis of glaucoma and new surgical techniques in the management of this disease. Overall, this screening system will accelerate the development of medications for eye diseases, enhancing the quality of life for millions of people.

This SBIR Phase II project will address the lack of effective models for testing targeted glaucoma therapeutics and additional ocular diseases. Currently, none of the available glaucoma medications target the eye tissue responsible for this disease due to absence of clinically relevant testing platform that incorporates this particular eye tissue. Presently, animal or human cadaver eyes are used to study and test the effects of medications on such tissue, however, these preparations are cumbersome and expensive. The proposed work will be the first-of-its-kind to engineer physiologically-relevant 3D human eye tissues utilizing novel cell culture methods along with microfabrication techniques and a microfluidic system. These 3D tissues will facilitate the development of disease-relevant in vitro model systems for understanding not only glaucoma but also diabetic retinopathy and macular edema pathology. This tool will help increase the success rate of glaucoma and ocular vasculature-related medications at later stages of drug development pipeline.

InnovaNutra

Program: SBIR Phase II

NSF Award No.: 1660142

Award Amount: $749,995.00

Start Date: 04/15/2017
End Date: 03/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Encapsulation Solutions for Improving Stability and Delivery of Natural Food Ingredients

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to enable significant improvement in the shelf-life of unstable natural food ingredients and enable replacing artificial with natural colors in a large portfolio of products of interest to the food and beverage industries. Consumer demand for all-natural ingredients in food has increased multifold, primarily due to health concerns. Despite the strong consumer demand, delivery and stability of natural food colors pose a great challenge for the food and beverage industry. This challenge results due to an inherent chemical instability of natural ingredients and due to their accelerated degradation during food processing and storage. But the current solutions are not cost-effective and require the use of synthetic additives and preservatives, which are not desired by the consumers. This project is aimed at providing an array of low-cost, stable natural ingredients that will improve the overall stability of the finished products both during food processing and storage. This will also address the unmet societal needs for healthy food ingredients and improving sustainability of food products.

This SBIR Phase II project aims to develop bio-based encapsulation solutions to improve natural food color and phytochemical stability in food and beverage products. Current solutions are sub-optimal providing limited pH (color), heat or oxidative stability and short expiration dates on food and beverage products. To address this unmet need, this project aims to develop encapsulation of natural colors and bioactives that will enhance the overall stability of a finished food product. This will be achieved by working on the primary objectives of this project: Selection and screening of the carriers and natural ingredients to be encapsulated, physico-chemical stability testing of the encapsulated ingredients, scale-up methodologies, stability testing in a finished food/beverage product, consumer evaluation and customer validation of the formulations. As a result of the proposed approach, solutions will be provided that will allow the food and beverage industry to replace artificial with natural colorants as well as significantly extend shelf-life of their desired food products. This will also benefit the consumer who is seeking natural health-promoting ingredients in what he/she consumes.

Lattice Automation, Inc.

Program: SBIR Phase II

NSF Award No.: 1660188

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Fully Integrated Design and Automated Fabrication Services Software Platform for Engineering Living Systems

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be the development of a software platform for the engineering of living systems. Specifically, it will complete a software ecosystem that builds upon a core set of computational tools for the specification, design, build, test, analyze, and archive activities in synthetic biology and couple them with a rich set of interfaces to expert services (e.g., DNA synthesis, data analysis). The proposed work involves the completion of state-of-the-art design approaches and algorithms and couples it with the ability to create customized, modular workflows based on genetic circuit design, metabolic pathway modification, and genome engineering. The proposed work advances computational approaches in synthetic biology as well as innovating in the way that software services are monetized with biotechnology companies. The anticipated result of this work is a commercial software package and associated service agreements that can be deployed to both large and small biotechnology companies fundamentally changing the way that synthetic biology designs are conceived, designed, and physically created.

This SBIR Phase II project will develop a software platform where the goal is to combine bio-design automation (BDA) software with explicitly integrated access to expert services in a workflow-driven software ecosystem. The creation of novel living systems using biotechnology to engineer new medicines, materials, and fuels is frequently an ad-hoc process involving long iteration cycles, wasted resources, and sub-optimal designs. The software will allow for the automated specification, design, fabrication, test, and archival of complete plans for the engineering of novel engineered biological systems. This software includes mechanisms for specifying biological “rules,” DNA assembly strategies, and automated generation of robotic instructions. In particular, this effort will focus on the creation of genetic circuits, engineered metabolic pathways, and genome engineering. The approach provides tools representing state-of-the-art advances in BDA while introducing novel methods of interacting with a large, diverse set of expert service providers. Further, the approach will empower novice experimentalists while enabling expert computational engineers.

Macromoltek

Program: SBIR Phase II

NSF Award No.: 1632399

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: Automated Design Methods of Antibodies Directed to Protein and Carbohydrate Antigens

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to develop an online, fully automated platform for designing high-affinity antibodies for use as potential drug candidates. The success of antibody-based drugs has generated interest in faster and more efficient methods to discover and optimize antibodies. The goal of this project will be to develop and implement a computational method for producing protein sequences of humanized antibodies. This will be achieved by providing software that allows scientists to move some of their initial experiments into the cloud, and achieve results much more quickly by using computational methods saving time and cost for new drug development. In addition, it is anticipated that this will improve the features of antibody-based drug candidates, enhance the success rate of clinical studies, and accelerate the commercialization of new drugs.

This SBIR Phase II project aims to develop and implement computational tools for designing antibodies that are more effective, have fewer side effects, and have fewer problems in manufacturing. Current computational design methods rely almost entirely on the expertise of scientists iterating between experimental and bioinformatics approaches. An automated, systematic approach will help researchers design better antibodies with desired features in a shorter amount of time. The final platform will allow researchers to incorporate experimental and structural information to develop better drugs by determining which experiments will be necessary, assessing the viability of a potential candidate, and identifying structural features responsible for the molecule's stability, immune response, and binding properties. The typical antibody design process takes many months and tens of thousands of dollars. With the aid of a computational process, this time can be cut back to the click of a button.

Mission Bio, Inc.

Program: SBIR Phase II

NSF Award No.: 1556119

Award Amount: $748,729.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: Low-cost Detection and Enrichment of Nucleic Acids by Interfacing with Commercially Available Cell Sorters

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) project will be to enable affordable detection and enrichment of rare DNA or RNA molecules from a large background population. Currently, such detection is performed on expensive, dedicated instruments that have low sensitivity and are not able to enrich. The strategy is to encapsulate the fluorescently-identified target molecules in thin oil shells so that they mimic cells, and then process them on sensitive and high-throughput cell-sorting instruments that are commonly available. By offloading the detection and enrichment to such machines, all that is required by researchers is a simple tool that encapsulates the molecules in thin oil shells. Applications made possible by high sensitivity and enrichment are numerous, from rare pathogen or cell detection to target capture of uncommon mutant sequences with the goal of downstream sequencing. Between the reduced cost and expansion of capabilities, this approach is likely to become a widely adopted method.

This SBIR Phase II project proposes to develop a deployable instrument that allows high-throughput, low-cost quantitation of DNA/RNA molecules in a sample by interfacing with existing flow cytometry instruments. The initial objective is to quickly engineer all the functionality desired in that final instrument into a rough alpha version. Its features will include reliable droplet generation from iteratively optimized hard-plastic microfluidic chips, and automation via an advanced fluid handling system with precise feedback control. The second objective is to build the actual beta version for customer trials. The beta version will replace most of the off-the-shelf parts with streamlined, custom engineering and focus on reducing size and cost while still improving function through more iterative chip optimization. The final objective is to use the beta instrument to optimize the protocols and reagents for several applications using customer samples and benchmarking. At the conclusion of the project, the goal is to have instruments at customer sites generating data.

MSTM, LLC

Program: STTR Phase II

NSF Award No.: 1556043

Award Amount: $736,878.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Topic: Biological Technologies (BT)

STTR Phase II: Novel Ionization Process for Materials Characterization using Mass Spectrometry

The broader impact/commercial potential of this Small Business Technology Transfer (STTR) Phase II project will be the discovery of new ionization technology for use with mass spectrometry. This technology will enable lower cost, lower energy use, and reduced user expertise, which may potentially drive mass spectrometry into large and underserved markets such as medical diagnostics and field portable instruments designed specifically for use in homeland security, bedside diagnostics, or bio-threat detection. The new technology changes the current understanding of ionization processes used in mass spectrometry and provides opportunities for new innovations to advance science through improved measurements, impacting fields such as health, safety, and security. The aims of this Phase II project are to develop interfaces to incorporate the platform developed in Phase I on most major mass spectrometer manufacturer's instruments and to develop technologies for rapid automate analyses even of surfaces. The research of Phase II is aimed to better understand the fundamentals of this new technology in order to drive commercial success in high sensitivity rapid analyses at a competitive price. Mass spectrometers are widely used representing a $4 billion industry of which ionization technology represents a significant commercial opportunity.

This STTR Phase II project proposes to revolutionize ionization in mass spectrometry by providing commercial products that utilize a simple and powerful ionization technology. The newly discovered process spontaneously converts large and small, volatile and nonvolatile compounds to the gas-phase ions necessary for analysis using mass spectrometry without employing currently used high cost lasers or high voltage. The method is broadly applicable for analysis of compounds such as drugs, lipids, carbohydrate conjugates, peptides, and proteins directly from bodily fluids or tissue, as well as synthetic polymers and inorganic catalytic surfaces. This technology is anticipated to augment or even replace older ionization methods in applications such as clinical analyses, pharmaceuticals, forensics, environmental, and food safety. The aims of the Phase II project are to implement the multifunctional platform developed during Phase I on a variety of manufacturer's instruments, automate the process to allow lower cost and faster analyses, and provide an automated surface analysis platform. Besides determining the best sample preparation methodologies and choice of solvents/matrices, the research objectives include innovative automated sample introduction technologies that eliminate the need for a conventional "ion source" while reducing the pumping requirements, which currently hinder development of small, low-cost portable mass spectrometers.

PhylloTech, Inc.

Program: SBIR Phase II

NSF Award No.: 1632247

Award Amount: $766,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: Plant Bioproduction of Therapeutics and Antibodies for the Treatment of Ebola and Other Diseases

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be the development of genetically engineered tobacco plants that produce antibodies for the treatment of individuals infected with the Ebola virus. In the recent Ebola outbreak, a new antibody-based drug was shown to be effective in treating infected patients that was based on a transient tobacco-produced Ebola antibody cocktail called ZMapp (Mapp Biopharmaceutical, Inc, San Diego, CA). Unfortunately, Mapp Biopharmaceutical's supply of antibody was quickly depleted, as the manufacturing method was not able to keep up with demand. The technological innovation in this proposal is the targeted production of antibodies within the gland cells of the tobacco leaf surface structures called glandular secreting trichomes. The research objectives will be to demonstrate the secretion of antibodies to the Ebola virus from tobacco trichome glands. The goal is to generate a line of N. tabacum plants that is optimized for antibody production in plant trichomes to provide a biomanufacturing platform for the large-scale production of antibodies that may be used in the treatment of Ebola infection, and in the future, other diseases.

This SBIR Phase II project proposes to use a recently developed plant-based biomanufacturing system to scale-up the production of antibodies to the Ebola virus for use as a therapeutic treatment. Mapp Biopharmaceutical has produced a drug based on antibodies to the Ebola virus produced in a tobacco plant transient gene expression system. Using this system, they have identified a glycosylated antibody variant (glycoform) with enhanced antibody-dependent cell cytotoxicity. Using glycosyl-transferase knockout lines of N. benthiamiana and transient expression strategies, the company utilizes plants to produce glycosylated antibodies that produce optimal recruitment of natural immune effector cells (Olinger et al., 2012). Other expression hosts (Chinese hamster ovary cells, yeast) yield product with reduced potency, and are not suitable alternatives. To recover active antibody with their current plant expression technology, Mapp Biopharmaceutical must destructively harvest plants, and isolate antibody from plant tissue homogenates. Unfortunately, this method has not been able to produce enough antibodies to satisfy the demand. The proposed method will allow for the production of antibodies in tobacco plants in large scale. In addition, the proposed system will use antibody harvesting strategies that do not require destructive homogenization as the antibodies will be secreted onto the surface of the leaf, and recovered by washing. The goals of this project are to increase the functionality of plant-produced antibodies, scale-up production, and reduce the costs of production further through system optimization.

Plant Sensory Systems, LLC

Program: SBIR Phase II

NSF Award No.: 1660184

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Nutrient-Enhanced Soybean for Aquafeed

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be the production of enhanced-nutrition soybeans that have high levels of protein for use in aquafeed. Meat and fish consumption is rapidly growing due to increased world population and affluence. Aquaculture is the fastest growing food sector. Small wild-caught fish are used for aquaculture feed. Wild-caught fish harvests have not changed in 25 years and overfishing small fish jeopardizes the marine ecosystem. Aquafeed producers are turning to soy-based protein to replace fishmeal but soy-based proteins lack taurine and are deficient in methionine, two important nutrients for fish. To meet fish nutritional requirements, producers supplement soy-based aquafeed with synthetic taurine and methionine. In addition to added costs, synthetic taurine and methionine are produced from hazardous substances, and synthetic taurine has been shown to contain arsenic. Successful development of enhanced-nutrition soybean seeds would reduce the amount of supplemental nutrients required in aquafeed, a $2.2B global annual cost predicted for 2020, and could save aquafeed producers 20% of their additive feed costs. Enhanced-nutrition soybean seeds would be an economical, healthy, sustainable, environmentally friendly and secure source of taurine and methionine for the rapidly growing aquaculture industry.

This SBIR Phase II project will use a biotechnology approach to increase the essential nutrients in soybean seeds for use in aquafeed. Many aquafeed producers use plant-based protein, primarily from soybean, as a replacement for fishmeal. However, plants lack some nutrients required for normal fish growth and development. Taurine and methionine, two nutrients either lacking or limited in soybean, are supplemented to soy-based aquafeed, thus increasing feed-production costs. The goal of this project is to increase the levels of taurine and methionine produced in the seeds of a commercial-grade, high-protein soybean variety that has high feed digestibility. Molecular and biochemical methods will be used to identify soybean seeds with: (1) taurine and high methionine levels; (2) uncompromised quality and viability; (3) unaffected levels of other nutrients; (4) normal to higher-than-normal protein content; and (5) low levels of nondigestible compounds. The anticipated results are the production of soybean seeds with a minimum of 0.2% taurine (dry seed weight) and at least 50% more total methionine compared with control seeds.

PureBiomass, LLC

Program: SBIR Phase II

NSF Award No.: 1660227

Award Amount: $747,857.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Large Scale Cultivation of Phytoplankton via Novel Photo-Bioreactor Technology

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to provide a sustainable, low-cost, and replicable method for large-scale production of micro-algal biomass. Microalgae production is a form of aquaculture capable of producing valuable products including: Nutraceuticals, specialty chemicals, pharmaceuticals, feed for finfish, shellfish, and livestock, as well as food for human consumption. Moreover, microalgae can be used as a feedstock for biofuels while simultaneously removing CO2 from the environment. However, for the nascent algae cultivation industry to achieve its full commercial potential, the technology must be improved. While typical algal cultivation relies on high-density cell growth, this project will focus on the science of low-density algal cultivation to achieve high productivity, while minimizing process requirements for supplemental energy and concentrated CO2. In addition, the development of a closed-system photo-bioreactor with emphasis on low cost and modular design will allow the process to be easily replicated on a variety of lands with otherwise marginal value. As such, the system can become the basis for a robust aquaculture and biofuels industry, leading to greater economic development in marginal communities and a source of sustainable products for the growing world population.

This SBIR Phase II project proposes to further optimize the design of the large-scale algal production system developed during the Phase I project to address key challenges in algae cultivation including frequent contamination, low productivity, and increased operating costs due to inefficient use of water and energy. Research activities will focus on four main objectives: 1) Finalize key design specifications for reactor geometry, materials of construction, and system components in order to maximize productivity and minimize capital costs; 2) optimize harvest apparatus design and biomass concentration procedure to further reduce water consumption; 3) develop a new media formulation to allow for stable pH control without the need for concentrated CO2; and 4) refine manufacturing of the reactor bladder to ensure sterility, durability, and product consistency. In addition to the basic algae cultivation techniques employed in Phase I, Phase II will make greater use of engineering /computational analyses to arrive at optimal designs. The target outcome of the project is a 120,000-L closed photo-bioreactor capable of sustaining H. pluvialis algae production rates of greater than 9 g/m2/d for a minimum of 4 months without detrimental contamination. In addition, the system will provide significant reductions in consumption of energy, water, and concentrated CO2.

RedLeaf Biologics, Inc.

Program: SBIR Phase II

NSF Award No.: 1659039

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: Biomanufacturing Red Natural Food Dye

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to develop natural alternatives to synthetic chemicals that are used to impart color to food, medicine, and cosmetics. Negative health impacts of some high volume synthetic colorants are driving demand for natural and safe colorants that are obtained from biological sources. This project will advance the commercial feasibility of a class of naturally occurring pigments that have properties of color, functionality, stability, and safety that make them attractive as food colorants. Based on six years of prior university research, a potentially suitable botanical source of a red pigment has been identified. The goal of this project is to develop a commercial process to produce the pigment from this botanical source. The pigment will be tested as a replacement for a synthetic red pigment that has been widely used as a food additive. The goal is to provide a natural alternative to reduce the health risks associated with artificial colorants.

This SBIR Phase II project proposes to develop a naturally occurring red pigment from a plant source as an alternative food color additive. Phase I demonstrated that the red pigment could be extracted at small-scale and performed well in food applications. The goal of this Phase II project is to scale up commercial processes for extraction and purification of this red pigment, and to conduct further performance testing. The pigment, which previously has not been available in commercial quantities, will be produced from a selected variety of a major crop species. The goal is to develop processes to scale pigment production under conditions that will validate a commercial scale. This will include the integration of mechanical separation, food grade extraction, and various commercially-available clarification systems. The products will be tested for performance characteristics and consistency of quality during scale up by examining thermal, pH, and light stability in a range of probable food and other applications. In addition, yield produced will be evaluated to validate economic competitiveness.

Solinas Medical, Inc.

Program: SBIR Phase II

NSF Award No.: 1329172

Award Amount: $1,143,994.00

Start Date: 09/01/2013
End Date: 02/28/2018

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: Application of a Durable Self-sealing Material for Hemodialysis Blood Access

This Small Business Innovation Research (SBIR) Phase II project focuses on the development of a novel self-sealing materials technology for the primary application of designing durable blood access systems for hemodialysis patients. Nearly 580,000 people in the United States alone have end stage renal disease (ESRD), and over 400,000 people are treated using hemodialysis as the primary mode of treatment. Current access systems are neither designed for repeated access nor managing bleeding after hemodialysis treatment, and as a result commonly lead to secondary complications. The research aims of the proposal are to: 1) Develop manufacturing methods for device production, 2) Determine biocompatibility of the materials technology, and 3) Develop an animal model to evaluate potential clinical impact.

The broader impact/commercial potential of this project, if successful, will yield a unique and novel material that will create a paradigm shift from the treatment of complications due to hemodialysis to prevention. This will address clinical market needs and shift reimbursement policies to create better clinical outcomes and contain costs. Currently, $27 billion is spent on the delivery of hemodialysis treatment for ESRD patients. The materials technology under development will lead to vascular access devices suitable for nearly the entire hemodialysis patient population, thereby creating an estimated addressable market size of more than $500 million. This research will enhance scientific understanding by introducing novel engineering and manufacturing methods for a broad range of applications beyond hemodialysis where repeated access and reliable sealing is required.

Sonanutech, Inc.

Program: SBIR Phase II

NSF Award No.: 1534756

Award Amount: $775,951.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Biological Technologies (BT)

SBIR Phase II: Rapid Detection of Phages in Microbial Fermentation Processes

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) project is to reduce cost and loss of productivity due to bacteriophage (phage) contamination in fermentation of dairy and other products. Bacteriophage contamination is the leading cause of failure in fermentation processes used in the food and pharmaceutical industries. The risk of phage contamination in food fermentation processes, particularly in the dairy industry, is significantly enhanced due to a large diversity of suppliers of both the raw ingredient (milk) and the necessary microbial cultures. The current and emerging analytical technologies cannot rapidly detect phages in food materials such as milk. Thus, the combination of the risk of contamination, and the lack of rapid detection methods, results in a significant economic loss for the dairy industry. Early detection of phage contamination will permit early intervention in the fermentation process, which will lead to significant cost savings. In addition, the test could be extended to other food areas, pharmaceutical production, and biochemical production.

The SBIR project addresses the need for rapid detection of phage contamination in a fermentation process through a novel photonic platform. The platform combines nanophotonics, microfluidics, and electrophoresis, and is based on discoveries made at University of California - Davis. The system is focused on the manipulation of charged phages with electrophoresis, and their accelerated amplification in bacteria. In addition, the system uses electrophoretic capture of phages into a nanophotonic crystal to achieve highly sensitive detection of the target phages. The salient features of the platform are: a) High-throughput, fast trapping of phages; b) excellent sensitivity and large dynamic range for quantification of phage concentration; and c) scalable design that can be produced at low cost.

SQZ Biotechnologies Company

Program: SBIR Phase II

NSF Award No.: 1555789

Award Amount: $750,000.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Program Director: Ruth M. Shuman

Topic: Biological Technologies (BT)

SBIR Phase II: Development of an Intracellular Delivery Platform for Accelerated Drug Discovery Using Genetically Engineered Human Immune Cells

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be the development of technology for the intracellular delivery of biomolecules directly into cells. This microfluidics-based platform has the potential to become an enabling technology for intracellular delivery, which may be used to accelerate drug discovery R&D by allowing reliable, efficient delivery of diverse material classes without having to engineer the material or the cell to natively uptake these molecules. Such capabilities could allow pharmaceutical companies to assess the efficacy of drug candidates faster than ever before, especially with integration into high-throughput robotic workflows that are already well-established and efficacious. The technology could dramatically reduce the time to market for new drugs by decoupling determination of a candidate's activity from the cell's affinity for the molecule. It also could facilitate a deeper understanding of biological processes and pathways. Initial studies with leading drug developers and academic laboratories towards this goal have been very encouraging, and, in the future, the platform could potentially enable robust engineering of cell function for cell-based therapies targeting a diversity of diseases including influenza, cancer, and even autoimmune disorders.

This SBIR Phase II project proposes the continued development of the intracellular delivery technology to address relevant applications in drug discovery R&D. New drug discovery is often hampered by the inability of membrane-impermeable drug candidates to enter the cell cytosol, necessitating exogenous materials for delivery such as strong electric fields or viral vectors. However, these materials tend to cause off-target effects or toxicity, presenting a need for a technology that can facilitate delivery without altering post-treatment cellular function. The goal of this project is to demonstrate a platform geared towards market adoption of microfluidic hardware as the standard method for transfection and intracellular delivery. During Phase II, the platform will be fully-characterized, validated, and verified in order to produce the consistent, repeatable results necessary to achieve market entry. In addition, research is planned to demonstrate the ability of the platform to support drug discovery R&D by developing the use of the CRISPR/Cas9 gene editing system for use with this intracellular delivery technology.

TeselaGen, Inc.

Program: SBIR Phase II

NSF Award No.: 1430986

Award Amount: $1,266,000.00

Start Date: 10/01/2014
End Date: 05/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: An Intelligent Rapid Prototyping System for Synthetic Biology

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to accelerate the pace of microbe development for the biomanufacture of valuable proteins, advanced enzymes for industry, or therapeutic medicines. DNA cloning is an everyday practice in the course of both industrial- and university-based research. Cloning technology has remained largely unchanged for the last 20 years. As a consequence, researchers consume a significant amount of time and money designing and constructing DNA, rather than on designing and conducting experiments. Over the past few years, standardized experimental DNA construction methods have been developed that lend themselves well to automation and rapid assembly of DNA. Process automation is progressing from luxury to necessity, as target applications demand the fabrication of large combinatorial DNA libraries in the search for better antibodies, faster enzymes, and more productive microbial strains. The proposed technology will allow rapid forward engineered biological libraries of recombinant DNA. The commercial availability of this technology will provide a low cost alternative to current methods.

This SBIR Phase II project aims to develop a bioCAD/CAM (Computer Aided Design and Manufacturing) technology that enables rapid DNA assembly for synthetic biology. Wedding recent advances in DNA assembly methods, and the software algorithms used to design those DNA assemblies, the proposed research will result in a platform technology for facilitating an optimized combination of direct synthesis and DNA assembly to make large combinatorial libraries. After the construction of the DNA libraries, screening for constructs with the desired activity remains a major scale-limiting bottleneck, both in terms of cost and time. The proposed technology will allow rapid prototyping and characterization of forward engineered biological libraries of recombinant DNA, proteins, or whole cells. The goal is to commercialize an easy-to-use platform for assembling complex constructs onto vector backbones, transfecting them into host microbes, and doing a rapid assessment of product yield. Results are captured, saved, and returned to a design database after data cleansing and analysis.

Texas Tech University

Program: PFI:AIR - TT

NSF Award No.: 1500234

Award Amount: $194,432.00

Start Date: 08/15/2015
End Date: 01/31/2018

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Program Director: Barbara H. Kenny

Topic: Biological Technologies (BT)

PFI:AIR - TT: Design of Functionally-tested, Genomics-informed Personalized Cancer Therapy Drug Treatment Plans

This PFI: AIR Technology Translation project focuses on translating mathematical modeling and design of combination therapy based on Probabilistic Target Inhibition Maps to fulfill the unmet clinical need of developing functional and genomic-informed personalized cancer therapy. The goal is to improve treatment outcomes by directly addressing drug synergy and disease recurrence. Successful implementation of the Probabilistic Target Inhibition Map innovation is expected to have a significant impact on society by providing an alternative approach to therapy design for cancer patients who have failed, or want alternatives to, first and second line therapies. Even with advances in chemotherapy and radiation, there are over 450,000 deaths attributed to solid tumor cancers in the U.S. alone; resulting in a significant need for alternative approaches involving personalized drug combinations for cancer patients failing standard of care treatments. The project will result in proof of concept validation for application of Probabilistic Target Inhibition Maps to synergistic drug combination design. The Probabilistic Target Inhibition Map framework has the unique features of (i) integrating functional and genomic data in model generation, (ii) increased prediction accuracy over existing techniques and (iii) optimized selection of drug combinations from FDA-approved targeted drugs. This approach will provide rapid, evidenced-based, reduced toxicity personalized therapies, leading to greater treatment efficacy and lower chances of recurrence. The resulting technology will be unlike existing precision cancer therapy approaches available in the market, and will be very competitive with comparable approaches.

This project addresses the following technology gaps as it translates from research discovery towards commercial application: (a) characterizing combination drug toxicities by incorporating existing side effects data of individual drugs to predict expected system-level toxicity, and integrate additional compound-level and patient-level data to identify potentially unexpected toxicity issues, (b) design of optimization algorithms for selection of drug combinations incorporating toxicity estimation and (c) integrating mutation data and mapping targets to known Protein-Protein Interaction (PPI) networks for providing further evidence for the significance of targets elucidated by the Probabilistic Target Inhibition Map framework. In addition, graduate students involved in this project will learn about translating fundamental research to commercially viable product by addressing technology gaps and being part of the intellectual property development process. The project engages Children's Cancer Therapy Development Institute and University of Utah to provide experimental validation capabilities and commercialization expertise in this technology translation effort from research discovery towards commercial reality.

Triton Animal Products

Program: SBIR Phase II

NSF Award No.: 1555951

Award Amount: $728,550.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: Production of an Affordable Synthetic Colostrum Replacer in Edible Green Algae

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to produce colostrum proteins in edible green algae that have the potential to reduce the use and dependence on antibiotics in livestock animals. Colostrum proteins have both beneficial health and growth properties that may drastically decrease the dependence on antibiotics. Unfortunately, there is a limited supply of colostrum. Algae provide an affordable and scalable system for the production of the valuable proteins found in colostrum. Recently, it was demonstrated that the use of antibiotics in livestock animals caused the formation of antibiotic resistant bacteria. Colostrum proteins naturally stimulate the animal's immune system and allows them to improve their own ability to fight off infections and ultimately increase their rate of weight gain. The production of colostrum proteins at a large scale in an untapped market that has the potential to gain market share from the multi-billion dollar antibiotic industry.

This SBIR Phase II project proposes to demonstrate the feasibility of producing colostrum proteins in algae using biomanufacturing. Some of the problems associated with having the animal livestock industry adapt a new product is demonstrating cost and feasibility. To accomplish the goal of decreasing antibiotic use, this project will first focus on optimizing the production process to drive the cost of producing colostrum proteins in algae down. Next, work will be done on developing optimal formulations of colostrum proteins and testing them in mice models before moving to larger livestock animals. Once an optimal formulation is established, trials will be done in pig models. In the pig models, colostrum proteins produced in algae will be tested to determine their ability to assist animals in fighting off infections and also their ability to improve the animal's rate of weight gain. Finally, this project will strive to demonstrate that colostrum proteins produced in algae can give the same positive outcomes in animals when compared to animals given antibiotics. By accomplishing these goals, algae colostrum proteins can drastically decrease the dependence on antibiotics and their negative side effects.

UC2

Program: SBIR Phase II

NSF Award No.: 1534522

Award Amount: $1,258,559.00

Start Date: 09/01/2015
End Date: 08/31/2019

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Topic: Biological Technologies (BT)

SBIR Phase II: Using Microbial Genetic Data to Improve Oil Production Efficiency and Reduce Environmental Impact

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to increase the efficiency of domestic oil production. Using current methods, the oil industry is able to extract only 5% of the known hydrocarbon from shale formation. This represents more than $500B of potential oil and gas that cannot be economically produced for the US economy. The aim is to increase the efficiency of oil production by providing novel subsurface information to improve operational decision making. The resulting value increase for a producer can be up to $1M per well. In addition, it is possible to significantly reduce the environmental impact of the hydraulic fracturing process, which is currently only 50% efficient. By providing novel subsurface data for the industry, this information can reduce environmental impact by saving up to 45B gallons of fresh water and 1M rail cars of mined sand. Furthermore, the analysis of subsurface microbiomes is a rich area for new academic knowledge. Over 80% of the microbial strains identified in Phase I have never been documented in public references. This work not only provides economic and social value, but also expands scientific knowledge.

This SBIR Phase II project proposes to use next-generation microbiome analyses to increase the efficiency of domestic oil production. The research objective is to analyze the subsurface hydrocarbon microbiome to characterize hydrocarbon reservoirs and leverage this new data source to increase current efficiency rates. The goal is to analyze 50 producing wells in the Southwestern US, and develop statistical models linking microbial profiles to key reservoir properties that can increase production efficiencies. The analytical method employed will utilize technology stemming from over $20 million in government funding to the University of Colorado used to create bioinformatics software known as "QIIME." The QIIME technology has been extensively tested in analyzing and modeling the human microbiome, but has never been applied to the subsurface hydrocarbon microbiome prior to the Phase I work. By combining advances in cloud computing, DNA sequencing, and novel software analytics, this project will demonstrate that these microbial communities correlate to meaningful production parameters for the oil and gas industry. In so doing, the project will demonstrate at pilot scale that this new information source can be utilized as a novel, non-invasive, low-cost reservoir characterization tool that allows the industry to maximize hydrocarbon production while minimizing environmental impact.

University of Maryland Baltimore County

Program: PFI:AIR - TT

NSF Award No.: 1601935

Award Amount: $199,396.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Biological Technologies (BT)

PFI:AIR - TT: Using A. Niger as a Host to Express Recombinant Endolysin

This PFI:AIR Technology Translation project focuses on an important agricultural and human-health related problem. For over 50 years, it is has been common practice in the agricultural industry to add low doses of traditional (i.e., "medically important") antibiotics to animal feed to improve production efficiency of food animals. While these "antibiotic growth promoters" provide tremendous economic benefit, this practice also leads to antibiotic-resistant bacterial strains which have the potential to infect humans. As a result, the US Food and Drug Administration has implemented measures to stop this practice. While numerous alternatives to medically important antibiotics have been proposed, most have not been commercially successful as they are not adequately effective. As an alternative to medically important antibiotics, the use of antimicrobial proteins has great promise, but a significant limitation to their commercial production has been cost. Thus the ability to economically manufacture antimicrobial proteins would represent a significant benefit to the agricultural industry as it would allow farmers to maintain high levels of productivity while not generating antibiotic-resistant strains that pose a danger to humans. This proposal explores the potential of replacing medically-important antibiotic feed-additives with antimicrobial protein (AMP). Work described here seeks to generate proof-of-concept data, expressing model AMPs, at commercially viable titers, using recombinant filamentous fungi.

This project employs a commercially-relevant fungal species (Aspergillus niger), to express model endolysin proteins with demonstrated bactericidal activity. To increase both expression and extracellular secretion of two different endolysin enzymes several approaches will be used, exploring the impact of genomic location, transcriptional promoter, and secretion signal sequence. Employing several approaches will increase the likelihood for success and will also allow identification of the most relevant factors leading to a high-producing recombinant fungal strain. This understanding will allow efficient generation of additional production strains for different proteins or peptides. In addition, personnel involved in this project, both a postdoctoral scientist and several undergraduate students, will be trained in a cross-disciplinary environment that will increase their research capacity. Personnel will also participate in entrepreneurial education experiences, through conducting customer discovery activities related to this project. This will primarily involve contacting potential stakeholders, along the entire value chain, to test hypotheses related to future commercialization.

VariFAS Biorenewables, LLC

Program: SBIR Phase II

NSF Award No.: 1555918

Award Amount: $674,011.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Topic: Biological Technologies (BT)

SBIR Phase II: Novel Enzymes for Producing Homogeneous Preparations of Individual, Monounsaturated Industrial Fatty Acids

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development and scale-up of a manufacturing platform for producing bio-based chemicals for application in lubricants. This manufacturing platform will utilize biologically derived sugar carbon-source and transform this carbon to higher value products via microbial fermentation. In contrast to the complex mixture of fatty acids currently produced in the oleochemical industry, the technology developed in this project will deliver a product stream containing simpler mixtures of monounsaturated fatty acids, which will eliminate the costly separation cost and be directly used to synthesize cost-efficient high-performance lubricants. Due to the improved lubrication performance of these molecules, this technology will potentially increase the energy efficiency of industrial and transportation machinery. By utilizing biological carbon feedstocks and producing bio-degradable products, this technology has the potential to reduce the environment footprint of the lubricant industry. More beneficial impacts are anticipated as we expand the application of monounsaturated fatty acids into other industries, such as surfactants and polymers. A large commercial potential of this technology has been identified in the lubricant market, currently valued at $123B per annum, and predicted to grow to $178B per annum in the next 5-years.

This SBIR Phase II project proposes to develop technology that will deliver novel bio-based monounsaturated fatty acids that provide new chemical structures allowing innovations in lubricants not possible from petroleum-based raw materials. Based on successful development of bacterial strains capable of producing enriched monounsaturated fatty acids in the Phase I project, the Phase II project will further de-risk the technology and scale up the capability to produce sufficient quantities of monounsaturated fatty acids to be evaluated by potential customers. By optimizing and scaling up the fermentation process and developing the product extraction procedure, large quantity of the first generation product (55% enriched monounsaturated fatty acids) will be produced. It will be used to chemically synthesize high-performance lubricants (i.e., polyol esters), whose physical-chemical and tribological properties will be evaluated and provided to potential customers. In this project, metabolic engineering, system biology, and evolutionary strategies will be applied to further improve the strains for producing second generation products that are more enriched in monounsaturated fatty acids (70-80%) and achieve commercial viable technology metrics. The monounsaturated fatty acids are envisioned as platform chemicals for subsequent chemical conversion to numerous specialty chemicals that have applications in additional markets, such as surfactants and polymers.

BIOMEDICAL TECHNOLOGIES (BM) AND SMART HEALTH (SH)

Acadia Harvest, Inc.

Program: SBIR Phase II

NSF Award No.: 1430710

Award Amount: $819,221.00

Start Date: 03/01/2015
End Date: 08/31/2017

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Development of On-Land, Closed Containment Integrated Multitrophic Sustainable Aquaculture by means of Ecological Diversity.

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will demonstrate an entirely new approach to farming seafood. To date only a limited amount of marine aquaculture on-land and indoors is carried out anywhere utilizing a technology requiring only saltwater, limited space and our novel zero waste approach,. This approach takes advantage of ecological principle whereby diverse aquatic species - including fish, sandworms, algae, oysters, seaweed and more - are cultured together in a cyclic system in a way that allows the waste from one to serve as nutrition for others. Because such facilities are not in the ocean, seafood culture will no longer be restricted by certain naturally ideal habitats, competition for space, strict environmental regulations, occasional pollution and hazardous weather. Indeed, they offer what may be the only technology able to satisfy the ever growing global demand for protein. The inputs required are sunlight for the plants and feed, but even the latter can be cultured either internally or derived from ever-present, external waste streams. The approach is commercially attractive, too, especially when combined with alternative energy sources. Being modular, the first unit can be readily emulated everywhere.

The proposed project seeks to break away from dependency on the oceans for seafood production sites and, of course, to do so in a manner that is economically viable. On-land production does offer challenges, many of which are overcome by farming diverse kinds of seafood together, a second break-away that confers health and generates byproduct revenues. To do so requires new farm designs, a grasp of each aquatic crop's special needs and full understanding of how each interacts beneficially with others within the shared space and seawater. To achieve this so that the first full scale, commercial operation can be undertaken with confidence, it is deemed vital that a pilot plant be operated for not less than two years. Within that period, approximately ten forms of marketable marine plants and animals will be introduced. Health, growth and overall water quality will be carefully monitored. Special attention will be given to purely practical aspects of aquafarm management so that, when commercial, any reasonably capable farmer can manage the operation, guided by a computer model that, along with equipment design, will be a major deliverable of the research in addition to the proposed demonstration. From apparent complexity, simple commercial methods will emerge.

Acadia Harvest, Inc.

Program: SBIR Phase II

NSF Award No.: 1534772

Award Amount: $744,571.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Developing Alternate Aquafeeds by Using Sustainable Methods of Bio-remediation of Seafood Residuals

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to enhance global food security. Aquaculture is the fastest growing agroindustry while the world fisheries catch has leveled out. Consequently, half of all seafood consumed today is farmed. Unfortunately, at least 30% of fish feed is derived from forage fish, the anchovy and sardine-types at the base of the food chain. With demand for forage fish growing while wild populations remain level at best, the price of fish meal and oil (FM&0) climbs by 15% yearly. Clearly, dependence on FM&O is unsustainable. For fish farmers to thrive without abusing the oceanic ecosystem, substitutes are essential. One solution is to use vegetable-based ingredients such as wheat and soy, but these lack vital omega-3 fatty acids. Another is to turn to the insect world, especially by culturing ecofriendly black soldier fly larvae (BSFL). The larvae are fed seafood residuals mixed with marine kelp and/or microalgae so that the natural omega-3 passes through. The larvae are dried and separated into FM&O-like meal and oil. The overarching question is: can this be accomplished competitively? Apparently it is possible, but a 2-year pilot plant is required to prove the practicality.

The proposed project will not only demonstrate that very large volumes of BSFL can be cultured using omega-3 loaded wastes and algae, but that substitute fish feeds that are palatable, stimulate growth and confer health are feasible. This is best achieved by simultaneously conducting feeding trials with a variety of species, including isolated bottom dwellers such as black sea bass and, alternatively, schooling pelagic creatures such as California yellowtail. Observing degrees of palatability is straight forward. But as with any cuisine there are numerous ways to enhance the offering: live, dried or pelletized and, if the latter, unit size, moisture content and even some surface additive that confers a natural taste - perhaps crab-like for black sea bass and squid-like for California yellowtail. Such refinements grant significant economic margins by virtue of better survival rates, shorter time in the tanks and less costly ingredients. At this local level, both the farmer and the consumer benefit while globally these gains can favorably impact food security, especially with marine species that only require saltwater, with recirculating system that discharge little or no waste and, of course, with substitute foodstuff derived from waste bio-remediated by flies.

AivoCode, Inc.

Program: SBIR Phase II

NSF Award No.: 1660165

Award Amount: $748,324.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A Novel Platform to Enable Directed Delivery of Therapeutics into Brain Injuries

This Small Business Innovation Research (SBIR) Phase II project is to develop precision-guided delivery of drugs or diagnostic compounds to the site of damage in traumatic brain injury (TBI). TBI is quite common; every year, over 10 million people worldwide injure their brain, and it is the most common cause of death and disability in young people. There are currently no drugs available that would limit the additional damage to the brain from swelling and inflammation after the injury or help repair the brain. The company's technology allows one to guide a drug to the injured brain and keep it there until it has done its job, while less of the drug goes to normal tissues. This way, it will be possible to use drugs that, while beneficial in brain injury, may do damage elsewhere. It also makes it possible to use new types of drugs that would otherwise not reach their target in the brain. If the company is successful in bringing this technology to the clinic, it may make brain injury victims better, and significant savings to the healthcare system may also be obtained.

The proposed project will develop a highly efficacious technology platform for site-specific delivery of drugs to acute brain injury. The main reasons for the failure of neuro-protective agents in clinical trials are lack of specificity and the dose limiting effects of the therapy. Targeted delivery can circumvent this problem. In Phase I, the company described a novel peptide, CAQK, which specifically delivers various types of payloads to sites of brain injury from systemic administration. Developing improved variants of this peptide with high affinity and stability is important in ensuring optimal clinical translation of this technology. The objective of this project is to optimize the delivery platform by exploring different modifications of the CAQK peptide, and to use high throughput screening of chemical compound libraries to search for compounds that reproduce the CAQK activity. The outcome of this Phase II application will be a panel of stable, long-circulating, high affinity peptides and/or small molecule chemical mimetics that can be used for targeted drug delivery to injured brain. The most promising compounds will be validated in animal models of brain injury. Transformative advances in brain injury treatment in the form of increased efficacy, reduced side effects, and ease of administration should ensue.

Aperiomics, Inc.

Program: SBIR Phase II

NSF Award No.: 1534469

Award Amount: $906,151.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Rapid Pathogen Diagnostics and Biosurveillance using Multiplexed High-throughput Sequencing

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to improve our ability to fight infectious diseases that negatively impact agricultural yields and reduce the efficiency of global food production and distribution systems. This innovation will enhance scientific and technological understanding by leveraging the power of high-throughput sequencing and bioinformatics to provide a pathogen identification and surveillance tool with demonstrated efficacy against known and unknown infectious agents. This platform is fast, sensitive, and cost-effective, and can be used for any animal sample to detect virtually all possible microbes even microbes that have never before been characterized. Hundreds of samples can be rapidly screened without relying upon known genetic/genomic data of microbes. The global molecular diagnostics market is expected to grow at a compound annual growth rate (CAGR) of over 14% from 2012 to 2017, with infectious disease testing being the leading application at 26% share, therefore the commercial opportunity of this project is vast.

The proposed project follows up on the validation of the diagnostic platform (SBIR Phase I) and delves deeper into improving virus detection and genetic data generation. In addition, this proposal seeks to develop a basal informatics infrastructure that together with sample preparation improvements will be conducive of scalable, high-throughput analysis of several samples. Current diagnostic methods rely on what is already known about target microbe genetics, and provide limited information in the form of presence/absence of a known target sequence. The SBIR Phase I was instrumental to lowering the technical risks associated with a high-throughput unbiased pathogen detection platform based on DNA sequencing and Bayesian statistics. In the pursue of standardizing and validating our metagenomics pathogen identification platform, this project proposes to: 1) improve viral detection capabilities and accuracy, 2) develop new functionalities, and 3) incorporate Phase I and Phase II advances into an integrated in-house web-accessible interface.

Avitus Orthopaedics, Inc.

Program: SBIR Phase II

NSF Award No.: 1430763

Award Amount: $1,425,999.00

Start Date: 10/01/2014
End Date: 09/30/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Development of a Minimally Invasive Device for Harvesting Autologous Bone Graft

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project can strongly influence the healthcare system. The technology of the proposed project has the potential to make a broader impact by decreasing the risk of performing the bone graft harvesting procedure compared to current methods and consequently increase the number of surgeons who choose to collect a patient's own bone graft in lieu of using inferior bone graft alternatives/substitutes. Furthermore, whereas fewer new, inexperienced surgeons are currently being trained to utilize the patient's own bone graft because of the risks of current harvesting methods, these surgeons may be encouraged to perform the harvesting procedure with the introduction of the proposed concept. The increase in use of the patient's own bone will benefit patients because of the widely accepted clinical benefits of autogenous bone graft compared to synthetic or exogenous alternative solutions. The proposed technology may also have a significant commercial impact to hospitals because of potential decreases in operating room time and post-operative patient hospitalization time (compared to the standard harvesting procedure) as well as decreased per-procedure product costs (compared to substitute bone graft products).

The proposed project addresses the important unmet clinical need of enabling orthopaedic surgeons to collect bone graft from the patient's pelvic bone in a minimally invasive manner without the patient morbidity and added surgical time intrinsic to the current standard bone graft harvesting methods. The research objectives of the proposed project are to explore various design enhancements to the minimum viable product and assess the impact of these changes on the value proposition; and to explore adjustments to the minimum viable product and assess their fit for use in additional surgical procedures not accessible by the minimum viable product. These objectives will be completed by investigating various new product features and manufacturing processes as well as testing these concepts in various pre-clinical settings. This project has strong intellectual merit because this transformative technological concept has the potential to disrupt the current methods that surgeons employ for harvesting bone graft by introducing a novel solution that improves patient outcomes, surgical time, and hospital costs.

Brigham Young University

Program: PFI:AIR - TT

NSF Award No.: 1543559

Award Amount: $199,898.00

Start Date: 09/15/2015
End Date: 12/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Robust High Porosity Filter for Circulating Tumor Cell Enrichment

This PFI: AIR Technology Translation project focuses on translating robust, high open area microfilters to fill the need for rare cell separation in various research and diagnostic contexts. The microfilter is important because it makes possible rapid, high purity separation of rare cells from complex mixtures, such as cancer cells circulating in blood. This high purity separation could enable the early detection of cancers and other diseases. The project will result in a prototype and scalable process for the manufacture of microfilters with greater than 40% open area. The resulting microfilter will be unique due to the combination of a high open area while maintaining mechanical robustness required for integration with standard medical equipment. These features enable both a higher purity separation and a higher volume capacity when compared to track-etched filters, the leading filter material in this market space.

This project addresses the following technology gap(s) as it translates from research discovery toward commercial application. First, the method of manufacture will be determined so that a prototype can be made with greater than 40% open area. This will be developed by applying variations of known three-dimensional microfabrication techniques. Second, through testing and iteration, design parameters will be determined to achieve sufficient burst strength. Third, tests will be performed with clinical samples to determine if the filtration capacity and purity meet minimum requirements for an initial application as a cancer diagnostic. In addition, personnel involved in this project, undergraduates and a postdoctoral researcher, will receive technology translation experience through participating in the customer development process as interviews are conducted.

This project engages two partners to enable clinical testing and continuation of other business activities. Precision Membranes LLC is a startup co-founded by participating personnel to lead customer development and business model generation activities. Astrimmune LTD will incorporate prototype filters into a clinical trial and provide feedback about performance parameters of various designs.

BriteSeed, LLC

Program: SBIR Phase II

NSF Award No.: 1660240

Award Amount: TBD

Start Date: TBD
End Date: TBD

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Label-free Imaging for Real-time, Intraoperative Blood Vessel Visualization

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase I project is to develop a novel, intraoperative imaging technology to address the problem of inadvertent cuts to vasculature during minimally invasive surgeries. More than 17% of patients who undergo these types of in-patient surgeries suffer from an intraoperative bleeding event. When a vessel is injured, there is a higher probability of hospital borne infection due to the loss of blood, and the added cost of care per patient increases by thousands of dollars due to corrective action and extended length of stay for the patient. The risk of vascular injury is compounded by risk factors, such as obesity, which limit the surgeon's ability to visualize and navigate vasculature. Therefore, there is a critical need to identify and assess hidden vasculature in real time. The proposed technology helps identify blood vessel before a cut is made. Importantly, this system will be designed for seamless integration into a suite of surgical instruments for multiple applications. Long term, the company will provide surgeons with the preeminent imaging platform to view, assess, and characterize a range of vessels (i.e. arteries/veins, ureters and bile ducts) in real-time for improved surgical guidance and outcomes.

The proposed project will develop a novel blood vessel detection and visualization platform using low-cost optical imaging sensors and light-emitting diodes (LEDs). The proposed technology will provide visual and quantitative information about vessel presence and size in real-time that can supplement a surgeon's technique. This system will be simple, cost-effective, easy to employ, and highly accurate. Traditionally, the avoidance of blood vessels during minimally invasive surgery is accomplished by visualization or costly intraoperative imaging. The proposed technology will use pulsatile light absorption characteristics of blood vessels to provide quantitative information about vessel presence and size in real-time, supplementing a surgeon's technique. This project will also add significant value to the body of research conducted in the areas of signal processing and image analysis. In addition, the proposed technology will remove the risk of data loss due to artifacts in general and motion artifacts in particular. The proposed technology will be validated ex vivo and in vivo using a porcine animal model.

Camras Vision, Inc.

Program: SBIR Phase II

NSF Award No.: 1555923

Award Amount: $865,805.00

Start Date: 03/01/2016
End Date: 08/31/2018

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Adjustable Eye Pressure Control within an External Shunt

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project allows for a more effective glaucoma treatment by adjusting eye pressure based on disease progression for each patient. In 2015, the US glaucoma market is estimated to be over $2 billion and our addressable market, glaucoma surgical therapies, is estimated to be $534M. The incidence for glaucoma increases with age, and as the baby boomer population gets older, there will be a growing need for glaucoma treatments. To treat glaucoma, patients undergo lifelong drug regimens, multiple laser procedures, and invasive surgical procedures. However, even with all these treatment options glaucoma patients still go blind from glaucoma. The proposed novel design and approach to glaucoma will personalize the treatment for patients and remove the need for numerous and costly procedures. Most importantly, the personalization of glaucoma therapy will optimize visual protection for every patient.

The proposed project will validate the safety and efficacy of a glaucoma drainage device to adjust and set pressure in the eye. Glaucoma is a leading cause of irreversible blindness and is only treatable by reducing eye pressure. Surgical treatments are unpredictable with suboptimal success rates based primarily on the choice of drainage site. The proposed novel device drains to a new area of the eye to avoid the complications and unpredictability associated with the current glaucoma surgeries. The device also can provide the first-ever personalized treatment for millions of glaucoma sufferers by fine-tuning pressure based on the needs of the patient throughout his or her lifetime. Phase I/IB studies have shown feasibility of the device with an adjustable component. However, its efficacy and safety have yet to be fully investigated. Therefore, in this Phase II research grant, we will optimize the device for safety and efficacy and perform the necessary preclinical testing according to FDA standards to further develop the product.

Cardiac Motion, LLC

Program: STTR Phase II

NSF Award No.: 1660253

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

STTR Phase II: Development and Commercialization of a Wearable Long-term Monitor for Cardiac Arrhythmias

The broader impact/commercial potential of this Small Business Technology Transfer (STTR) Phase II project is far-reaching in terms of improving the quality of life and the cost/efficacy of healthcare for more than 20 Million people in the USA. We address the need for better methods for identifying and guiding the treatment of ambulatory patients with dangerous heart dysfunctions such as intermittent arrhythmias and heart failure. For example, atrial fibrillation arrhythmia afflicts nearly 8 Million patients in the USA, approximately 460,000 new patients every year, and the patient load is projected to grow to 12.1 million by 2050. The disease and its complications (stroke, congestive heart failure, seizures, death, etc.) add $26B to the nation's annual healthcare costs. Heart Failure currently afflicts nearly 5.7 Million people in the US growing to 8 Million by 2030. Their treatment and frequent hospitalization costs are already at 14B$ and will grow to 29B$ by 2030. Together with reducing the economic impacts, it would be of an enormous benefit to human health to create a device that improves the diagnosis and guides effective therapy for these patients while they remain fully ambulatory and going about their normal activities outside the expensive confines of the hospital.

The proposed project has the following intellectual merits. In our Phase I STTR program we focused on developing a wearable Atrial Fibrillation monitor to assist physicians in the diagnosis of paroxysmal or episodic versions of that disorder. In Phase II we have pivoted towards the even more critical need of ambulatory monitoring of paroxysmal tachycardia and eventually heart failure patients. The current industry standard of ambulatory ECG does not provide enough sensitivity or specificity to determine if the patient has atypical or typical atrial flutter, paroxysmal supraventricular tachycardia as well as various forms of ventricular tachycardia. Accurately diagnosing and monitoring these disorders is critical to patient treatment and outcomes. Our device will be capable of ambulatory patient monitoring for any sort of arrhythmia, and we believe it can be the preferred choice for all portable monitoring if it provides in one device ECG, heart motion and breathing rate/pattern/volume. So, the overarching technical research goal of our Phase II work is to develop a full featured prototype cardiac motion sensor as described above that can be used for initial clinical tests. These features include: wearable, battery powered, signal storage, cardiac motion from radar, disposable antenna, onboard ECG, and breathing rate.

Cognita Labs, LLC

Program: SBIR Phase II

NSF Award No.: 1556075

Award Amount: $760,000.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Handheld and Low-cost Pulmonary Function Testing Device using Smart Coherent Multi-signal Oscillometry Technique

The broader impact/commercial impact of this Small Business Innovation Research (SBIR) Phase II project is the development of a pulmonary function testing device for detection and diagnosis of pulmonary conditions. Today more than 650 million globally, nearly 10% of the world's population, suffer from lung conditions like Asthma and Chronic Obstructive Pulmonary Disease (COPD). Currently, the most well-established method for lung function testing is spirometry, which requires the patient to conduct an unnatural breathing maneuver. In addition, spirometry cannot detect certain lung conditions. The proposed technology will be used without special breathing maneuver, and will be able to differentiate more lung conditions than spirometer. Since the proposed device can be used while the patient is breathing normally, it will also cater to currently under-served patient segments, e.g. young children and senior citizens, for detection and diagnosis of pulmonary conditions. By targeting a portable form-factor, the proposed technology will empower point-of-care pulmonary testing where it is currently infeasible.

The proposed project will develop the first handheld implementation of the well-studied principle of forced oscillation technique (FOT), where an acoustic pressure wave is sent via the mouth to a patient's lungs and reflections are used to measure lung function. Thus, no special breathing maneuver is required from the patient. Cognita Labs will adopt a modular approach for product design, and develop product-caliber advanced and integrated devices, that will include hardware, tablet app and EHR integration. The design will include all the innovations developed during Phase I to reduce the device size and cost while increasing its measurement accuracy. The proposed device will further develop and integrate a new ultra-sound based non-invasive sensor into the device to significantly reduce the cost of the consumable (disposable mouthpiece) and ultimately the cost of test. The team will also develop a new multi-resolution pre-screening test, with the objective to reduce bench time in outpatient clinics.

ConsortiEX, Inc.

Program: SBIR Phase II

NSF Award No.: 1660080

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Development of a Track-and-Trace Medication Barcoded Label

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase I project is aimed at improving healthcare patient outcomes, potentially saving lives, and decreasing healthcare costs. The Drug Quality and Security Act of 2013 set stricter manufacturing standards on sterile injectable compounded medications that have closed many third party suppliers, thus creating shortages and higher prices. In response, the American Society of Hospital Pharmacists expects 40% of the US market, 2000 hospitals, by 2018 to receive insourced compounds. Hospitals that insource hope to decrease their costs and improve patient safety with higher quality product. Today, insourcing hospitals often have multiple information systems and use paper records cobbling together how a compound is made and to whom it has been administered. When an ingredient recall occurs, hospitals spend hundreds of man-hours identifying the problem source and affected patients. To prevent further patient risks speed is demanded. This SBIR Phase I project will provide hospitals the capability of an end-to-end quality management that will track every production process step and tracing medications to patients. Hospitals will be able to prevent patients from receiving recalled medications and identify quality production compromises thus improving patient outcomes and potentially saving lives.

The proposed project is a novel medication barcoded label encryption technology compatible with existing hospital scanners to provide track and trace capabilities of intravenous medication compounds. Key objectives include both patient specific and anticipatory workflows with labels, a Passive Auditing management system for compounding quality control, and an innovation to improve operating room environment medication barcode scanning compliance. Today, healthcare providers utilize multiple barcoded label technologies with minimal embedded medication data across disparate systems. Medication labels could be the link across these systems for ingredient traceability. However, existing solutions are inadequate to meet 2013 legislative traceability mandates. The project invention will encrypt serialization fields within the barcoded label connecting a specific medication to its production data, and eventually to the patient. Compounding process data, such as ingredients, environmental conditions, and production instructions, will be connected to individual medication labels and stored in the patient's electronic record. When an ingredient is recalled or questionable process identified, an extraction algorithm will pull the encrypted data from the EHR and will be connected to production data. Success of this project will be label readability by existing hospital scanners and retrieval of the serialized data from the EHR

CONTINUUS Pharmaceuticals, Inc.

Program: SBIR Phase II

NSF Award No.: 1555647

Award Amount: $758,000.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Program Director: Henry Ahn

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel Pharmaceutical Manufacturing Technologies to Deliver more Affordable Medications to Patients Faster and with Better Quality

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to enable the availability of a revolutionary manufacturing process for pharmaceuticals. The project consists of the development of novel process technologies, as well as the integration of these processes into an end-to-end continuous manufacturing line that can produce drugs continuously (24/7 basis). This is different from the current methodology that produces large quantities of drugs at discrete time points (e.g. large batch quantities are produced several times a year). A working pilot plant of this process demonstrated significant operational advantages with a marketed drug-production time was reduced from 200 days to 2 days, plant footprint decreased by 90%, projected costs reduced by 50%, while improving product quality. The impact on society will be considerable: patients will receive better quality drugs; drug shortages will be greatly reduced; and pharmaceutical companies will be able to manufacture and distribute their drugs in a much more cost-effective and efficient manner, allowing them to reallocate more capital to Research and Development (new drugs developed). Finally, it will be possible to relocate manufacturing plants and jobs back in the U.S. (more efficient processes = lower costs).

The proposed project builds upon a successful Phase I SBIR project, as well as five years of collaboration between a premier research institution and a leading pharmaceutical company aimed at developing a novel continuous manufacturing process to overcome the limitations of the current standard, batch manufacturing. The first objective of this NSF project is to further develop two novel elements of a multistep, continuous manufacturing process (i.e. heterogeneous crystallization and electrospinning for solid dosage forms), so they run reliably under different operating conditions. This is important because commercial production requires that they perform consistently and reliably 24/7. Thus, these novel unit operations will be studied under different operating conditions and starting materials, while their design is optimized. Success will be defined when the unit operations achieve: 1) maximal operational efficiency, 2) industry standard manufacturing capabilities, and 3) qualification to be used across the Research and Development manufacturing spectrum. The second objective is to integrate these two units into a broader end-to-end continuous manufacturing process capable of producing high-quality pharmaceuticals on a continuous basis. The integrated process will also feature three unit operations on separation, filtration and drying that were developed during Phase I of this SBIR project.

Cornell University

Program: PFI:BIC

NSF Award No.: 1430092

Award Amount: $711,899.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC: Nutriphone: A Nanoparticle-based Optical Contrast Assay to Monitor Vitamin and Micro-nutrient Levels Using Smartphones

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from Cornell University aims to develop a simple, cost-effective technology to obtain personal micronutritional status using a smartphone. This system would provide this information allowing users to accurately track their nutritional status directly rather than relying on guesses based on diet. The "NutriPhone" system is comprised of a hardware accessory that attaches to a smartphone, custom test strips that accept a blood sample and conduct a detection assay, and a software app. The app operates the smartphone, interprets the test strip results, displays the results to the user in an intuitive fashion, and provides therapeutic suggestions, if needed. The personalized self-report and automated data streams are expected to yield greater awareness and self-management of health and diet.

Vitamin and micronutrient deficiencies are responsible for a multitude of adverse health conditions, including anemia, rickets, scurvy, adverse pregnancy outcomes, infant growth inhibition, osteoporosis, and cancer. Worldwide, over 1,000,000 people die every year from vitamin A and zinc deficiencies alone. Domestically, as many as half of patients with hip fractures are thought to be vitamin D deficient. Fortunately, many deficiencies and their symptoms are reversible through changes in diet or by taking supplements, particularly if detected early. Very few people, however, have information as to their own personal micronutrient status, what the potential outcomes of their deficiencies are, or the recommended treatments. Having nutritional status information could significantly enable healthier living. In addition to commercial outreach, NutriPhone technology will be integrated into Cornell's Division of Nutritional Sciences' community extension programs both domestically and internationally, including the NutritionWorks program (nutritionworks.cornell.edu), to improve and strengthen capacity, particularly around nutrition and health.

A unique nanoparticle-based binding reaction allows the creation of an optical contrast depending on the level of the particular marker (e.g., vitamin D). The technology allows the measurement of this optical contrast using the smartphone camera, which is integral to every smartphone. Among the important aspects of this use of the smartphone camera is that it dramatically reduces the cost of the accessory. The state of the art currently is to use liquid chromatograph mass spectrometry (LCMS) to measure vitamin D. A nanoparticle-based optical contrast assay is a major advancement. The research program is structured to address the scientific and engineering challenges with the development of the NutriPhone in parallel with the equally important consumer uptake and business model development challenges. This is done through a series of user trials that will be conducted throughout the program at Cornell and extensive product development support, market

Covaris, Inc.

Program: SBIR Phase II

NSF Award No.: 1555667

Award Amount: $732,082.00

Start Date: 03/15/2016
End Date: 08/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Continuous Manufacturing of Nano- and Micron-particle Drugs Using Focused Acoustics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase I project is the enablement of new and improved therapeutic drug development. One hurdle in the development of new drugs, is their relatively low effectiveness due to poor water solubility limiting formulation choices and/or limiting cellular uptake. Forming drug nano particles, by way of controlling the drug crystal formation process, is one tool to overcome this low solubility hurdle. Acoustical energy has been shown to aid in the formation of drug crystallization however, current acoustical technologies are not able to reliably achieve the crystal size and distribution needed for many new drug candidates. A reliable method for nanoparticle drug production will allow better and more effective drugs to make it to market. Additionally, the Pharmaceutical industry is transitioning from batch to continuous flow manufacturing processes. This has significant impact on cost, responsiveness, and quality control of the drug supply chain, and will enable more rapid and lower cost drug development and manufacturing.

The proposed project will develop equipment and processes that enable the continuous manufacture of drug nano and micron sized particles by controlling the crystallization using a novel focused acoustical field. Focused acoustics has the advantage of delivering a highly efficient, controllable, scalable energy field to the crystallization zone. The project will demonstrate a focused acoustics crystallization process capable of being developed into commercial grade equipment suitable for use in a continuous flow production pharmaceutical manufacturing environment.

DeviceFarm

Program: SBIR Phase II

NSF Award No.: 1533478

Award Amount: $904,702.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A Medical Device based Treatment of Onychomycosis

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to provide a safe and effective cure for fungal nail infections. In addition, the technology developed in this project could be utilized in other healthcare treatments such as skin and wound disinfection, decontamination of teeth and gums (oral hygiene), and the sterilization of medical instruments and implanted devices. Fungal nail infection rates are growing at an estimated 7% annually following both the general aging of the population and the rise in the incidence of diabetes. 50% of elderly over the age of 70 and 30% of all diabetics are affected. For many people, their infected nails are painful and embarrassing. Worst of all, diabetics with fungal nail infections are at increased risk for foot ulcerations, gangrene, and amputation. 38 million Americans suffer from nail fungal infections and spend over $3 billion dollars each year on treatments that are ineffective and sometimes unsafe. People suffering with nail fungal infections express widespread dissatisfaction with the limited success, side effects, high cost and inconvenience of current treatments.

The proposed project will complete prototype development of a novel, safe, and effective treatment option for onychomycosis (nail fungal infection). The medical device will allow a doctor to fumigate the infected nail with gas because gas can penetrate the nail and kill the fungus where all other treatments cannot reach. The human toe nail lacks a blood supply to deliver optimal immune system protection to fight off fungal infections. This project will develop a device that converts the air above the surface of the toe nail into the same gases used by the immune system to fight infection. Hence, the gas treatment would safely mimic the normal blood supply of anti-microbial chemicals. This SBIR project will reduce technical development risks, improve the device usability by doctors, and establish the manufacturability of the device. Device prototypes will be validated in the laboratory and with users (Podiatrists). The clinical-ready prototypes developed during this project will be used in future clinical trials that will prove the efficacy and safety of the device needed to sell the product. The device promises to fulfill the unmet medical need for a safe and effective treatment option for the millions of Americans suffering with fungal infected nails.

Elidah, Inc.

Program: SBIR Phase II

NSF Award No.: 1630203

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel Treatment for Stress Urinary Incontinence

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the expedited development of a novel non-surgical medical device and therapeutic treatment for the approximately 1 in 3 women over the age of 30 who suffer from urinary incontinence, two thirds of whom, in part due to notable deficiencies of available solutions, elect to live without treatment while their symptoms progressively worsen. Urinary incontinence, although a very private concern, has far-reaching physical, psychological, social, and economic implications. For example, urinary incontinence has been found to reduce health-related quality of life measures on par with depression, incontinence is the number one reason for admittance into nursing homes, and the annual cost to the US healthcare system is estimated at $25 billion. Through design and validation activities this project will demonstrate the functionality of a wearable device that provides discreet, comfortable, easy-to-use therapy for female stress urinary incontinence. The technological understanding gained through this work lays the groundwork for subsequent commercialization of an FDA cleared product that will enhance the lives of tens of millions of American women.

The proposed project provides a new framework for wearable therapeutics by enabling the patient to treat incontinence via discreet surface electrical stimulation without interruption to daily activity. Current non-surgical care often involves electrical stimulation via intravaginal probe, a treatment most woman are not willing to adopt or maintain. This project builds on successful Phase I feasibility work in which a contiguous array of cutaneous electrodes placed proximate the perineal tissue to deliver sufficient electrical muscle stimulation to promote pelvic floor toning were shown to maintain this efficacy under conditions associated with continuous wear. The Phase II project goal is to develop an incontinence specific electrical muscle stimulator to function with the electrode array. The system architecture will enable manipulation of the therapeutic waveform to support future multi-armed clinical studies designed to test the efficacy of various treatment regimens. The system will also track treatment frequency, duration and intensity to provide information to clinical researchers. Activity will include design, prototype fabrication, performance testing, human factors assessments, iteration and electrical safety validation. Refinements to the electrode array are also anticipated. The project will deliver a device suitable for future evaluation a human clinical studies, FDA clearance and product commercialization.

Esculon, LLC

Program: SBIR Phase II

NSF Award No.: 1660238

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel Device for Maintaining Continuous Fluid Drainage in Small-Bore Chest Tubes after Cardiothoracic Surgery

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to significantly improve outcomes for cardiothoracic surgical patients while reducing healthcare costs by ensuring proper post-surgical drainage. In the United States, approximately 750,000 major cardiothoracic surgeries are performed each year. Each of these patients receives an average of two chest tubes to drain fluid and facilitate proper recovery, but approximately 36% of chest tubes become clogged. Patients with clogged chest tubes are more likely to experience post-surgical complications, which can result in life-threatening conditions and significantly increase the cost of care. To mitigate the risk of clogging, surgeons typically use large-bore chest tubes, which are more likely to be misplaced and to cause injury to surrounding organs. The novel device under development addresses these issues by preventing clog formation in small-bore chest tubes, thus maintaining proper fluid drainage. Anticipated impacts of the device include reduced time to ambulation and discharge, hospital readmissions, and nursing time. Commercially, the device addresses a $300 million initial market opportunity and has the potential to save the U.S. healthcare system approximately $1.7 billion per year from costs associated with preventable chest tube complications.

The proposed project aims to develop a novel chest tube device to address the clinical need of maintaining proper fluid drainage after cardiothoracic surgery while enabling the use of small-bore chest tubes. Existing systems are prone to clogging, which can lead to life-threatening conditions, longer hospital stays, and increased costs. Building on the feasibility demonstrated in Phase I, the objective of this research is to continue development of the device and prepare for market entry; the research will be performed in three Aims. In the first Aim, critical aspects of usability and manufacturability will be addressed and incorporated into the final device design. In the second Aim, verification and validation activities will be performed to ensure the device meets all safety and functional requirements before clinical use. In the third Aim, the device's supplemental ability to monitor lung healing status in patients undergoing thoracic surgery will be refined and tested on the benchtop and in an in vivo animal study.

FlexDex, Inc.

Program: SBIR Phase II

NSF Award No.: 1430536

Award Amount: $1,371,608.00

Start Date: 12/01/2014
End Date: 11/30/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Enhanced Dexterity Minimally Invasive Surgical Platform

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is that more patients will benefit from minimally invasive surgery, in which operations are completed through tiny incisions. In addition to patient benefits of less postsurgical pain, less scarring, and quicker recovery, minimally invasive surgery also reduces healthcare cost due to shorter hospital stays and lower risk of post-operative complications. Minimally invasive surgery impacts all surgical specialties, including gynecology, general, bariatric, urologic, and cardiothoracic. Although more than 1.5 million such procedures are performed in the US each year, wider adoption is limited by the high cost of current surgical robots, training burden of traditional hand-held instruments, and complexity of certain minimally invasive procedures. The technology developed via this project will enable surgeons to perform complex minimally invasive procedures such as hysterectomy with minimal training and at a fraction of the cost of surgical robots. Surgeons will benefit from this ergonomic design that will significantly reduce the incidence of workplace related injury associated with many laparoscopic instruments. This development effort will lead to a versatile platform technology that can impact nearly all kinds of surgeries enabling a wider adoption of minimally invasive surgery.

The proposed project aims to complete the design, development, verification, validation, regulatory clearance and commercial launch of a laparoscopic articulating needle driver. This novel low-cost minimally invasive surgery technology provides enhanced dexterity and intuitive control that is seen only in multi-million dollar surgical robots. Minimally invasive surgery is performed through small holes on a patient's body to minimize trauma, blood loss, and recovery time, and generally involves suturing, knot-tying, and fine dissection, all of which would benefit from enhanced dexterity in the surgical instrument. Currently available low-cost mechanical (non-robotic) instruments either lack dexterity or are counter-intuitive to operate, resulting in surgeon fatigue and significant training requirements. Robotic instruments provide exceptional dexterity and intuitive control, but are costly and beyond the reach of many hospitals and patients. The proposal minimally invasive surgery technology platform overcomes this affordability versus functionality tradeoff via a novel forearm mounted tool configuration and innovations in parallel-kinematic virtual center mechanisms that makes the tool input joint coincident with the surgeon's wrist. This results in a natural and intuitive motion transmission from the surgeon's hand to the tool end-effector via a low-cost design that does not require any sensors, actuators, or computer-control.

Guiding Technologies Corporation

Program: SBIR Phase II

NSF Award No.: 1632257

Award Amount: $732,215.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Using Data Mining to Optimally Customize Therapy for Individuals with Autism

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will revolutionize the treatment of individuals with autism. One of every sixty-eight US children has autism (over 1.1 million). The estimated cost of providing Applied Behavior Analysis (ABA) therapy to those who could benefit is $7.5 billion dollars annually. Societal impacts include: 1) more individuals with autism across the globe will receive treatment regimens that will enable them to live more fulfilled lives and reach their full potential; 2) families whose children are good candidates for treatment and receive it will experience reduced stress and better family life; and 3) the additional lifetime cost of not effectively treating children with autism, which is approximately ten-fold the cost of treatment, will be reduced. Because high-quality, contextually rich ABA performance data will be collected for the first time, efforts to apply data analytics will contribute in two important ways: a) patterns may be discerned across individuals with autism to better understand variations in autism and create therapies to target these differences; b) expansion of the frontiers of data mining to provide guidance in real time will contribute to a number of areas within and beyond ABA therapy.

The proposed project will optimize therapy outcomes for individuals with autism by transforming agent-based guiding technology into an adaptive and intelligent ABA therapy assistant for supervisors and instructors. The project pushes the boundaries in providing cost-effective, adaptable, intelligent, real-time guidance and data-collection support to instructors that integrates naturally into the instructional process and is easy to learn and use. ABA therapy experts, supervisors and instructors will verify the analyses and resulting guidance incorporated into the technology. Advanced theories of usability engineering, including some developed by the project team, will be used to build interfaces that supervisors and instructors can intuit without the need for learning new concepts and syntax. The project will utilize the collected logs from multiple sessions with multiple therapy recipients and multiple therapy providers to uncover hidden patterns and assist supervisors in selecting appropriate therapy steps personalized for the individual with autism. The project will build on a large body of recent work in visualization, machine learning on temporal predictive modeling and sequential pattern mining, including some of the previous results of the project team. Special attention will be paid to the recent work in educational data mining and intelligent tutoring.

Histogen, Inc.

Program: STTR Phase II

NSF Award No.: 1660301

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

STTR Phase II: A Novel Wound Dressing for Infection Control and Tissue Regeneration

The broader impact/commercial potential of this Small Business Technology Transfer (STTR) Phase II project is to overcome limitations that prevent effective treatment of wound infections. There is a large potential market for this product as the U.S. spends over $50 billion per year on wound care and current wound care products have a high risk of rejection, scarring, and antibiotic resistance. The proposed novel wound care product will reduce the costs to treat infected wounds and limit the number of medical procedures required to restore tissue function. The product consists of a patented human extracellular matrix (hECM) coupled to a novel antimicrobial peptide (AMP). The main innovation of the proposed product, compared to current treatments, is that it is designed to be toxic to infective bacteria and other pathogens, without harming human tissue. The hECM has regenerative and anti-inflammatory activity to enhance wound healing and improve treatment outcomes. In addition to creating a transformative product in a global market, achievement of AMP extracellular matrix tethering will lead to a broader understanding of AMP activity and unlock their commercial utility. The product can be used as a temporary wound dressing, a tissue restoring implant, or an implant coating.

The proposed project will utilize a patented recombinant protein with an antimicrobial peptide, combined with a human extracellular matrix (hECM) material. The patented antimicrobial protein (AMP) is designed to bind collagen in the hECM. The combination of hECM and AMP will result in an antimicrobial regenerative matrix that will reduce the incidence of infection and improve wound healing. The objectives of the project are to scale-up hECM and AMP manufacturing processes, establish methods for assessing product characteristics and performance for manufacturing quality assurance and release criteria, and evaluate the shelf-life and in vivo performance of the scaled-up manufactured AMP-hECM product in a clinically relevant infectious wound healing model. The AMP-hECM will be evaluated using biochemical, antimicrobial, mechanical and cell growth performance assays. Scale-up of the bioengineered AMP and hECM will be achieved by optimizing the in vitro manufacturing bioreactor growth parameters and processing methods to improve overall product yield. The anticipated outcome of the project is to have defined the large-scale manufacturing protocols and release criteria for the AMP-hECM product. This milestone will enable the execution of validation production runs, and advance the regulatory and commercialization pathways for the product.

InnSight Technology, Inc.

Program: SBIR Phase II

NSF Award No.: 1660236

Award Amount: $749,973.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel, Point-of-service Device for use in Diagnosing the Severity of Anterior Eye Injures with an Objective Measure of the Ocular Tear Film

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to improve the quality of care for anterior ocular wounds. To accomplish this, the project is focused on the development of a novel, hand-held, point-of-care device that can be used to evaluate the ocular surface in post-trauma or post-surgical patients. The device should be able to provide an accurate, objective measurement of a tear film biomarker that can be used by medical professionals to identify dangerous fluid leaks in the front of the eye which can save vision. Currently, this evaluation is only performed by trained eye doctors and requires positioning the patient at an expensive, immobile machine called a slit lamp to evaluate their eye. This cannot be done on patients who are unconscious or uncooperative and availability of this machine is limited. The lack of adequate tools for evaluation results in limited access to care, costly hospital transfers and missed diagnosis of wound leaks which can cause severe ocular infections and permanent vision loss. Successful commercialization of this product is expected to improve the accuracy of ocular examinations in 3.8 million Americans annually and may introduce a new frontier of tear film testing.

The proposed project is focused on developing the device for direct use for patient care. The technological aim of the research is on the creation of a sophisticated biosensor that can accurately and noninvasively evaluate the tear film concentration of a specific biomarker. This work is expected to include the development of the electrical circuitry, the chemical composition and the channels for connection to the base unit. The plan is to also design the model for the handheld device. In order to make the device safe for patient use, the device can then be tested for its shelf-life stability and develop the proper sterilization. The next steps of testing can include clinical patients to evaluate the ability of the device to record the findings from the tear film. This information can then be used to refine the exact testing parameters for the device. The anticipated result of this research is a final prototype of the device that can be used for regulatory approval and clinical trials. The goal of the project is to transform the current standard of care for eye professionals and enable physicians to have an objective measure that can warn them about possible wound leaks and potentially save vision.

LambdaVision, Inc.

Program: SBIR Phase II

NSF Award No.: 1632465

Award Amount: $742,188.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Design and Optimization of a Biocompatible Protein-Based Retinal Implant for the Treatment of End-Stage Retinal Degeneration

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to develop and commercialize a high resolution, protein-based retinal implant intended to restore vision to the millions of patients blinded by retinal degenerative diseases, particularly retinitis pigmentosa and age-related macular degeneration. These currently incurable and blinding diseases affect between 30-50 million people worldwide, and lead to a loss of independence for the individual, as well as an increased burden on their caregivers. While improved quality of life is the most vital outcome of this technology, reduction of medical costs of treating chronic retinal degeneration and limiting time with doctors will also be of benefit to the broad healthcare field. The work outlined in this SBIR proposal also has the potential to significantly impact our understanding of retinal degenerative diseases, which will help in developing better and more effective treatments for a number of ophthalmic indications. The subretinal implant under development provides the framework for the next generation of high-resolution retinal prosthetics, while offering a cost-effective solution to vision restoration, and will help these patients regain independence and thus improve their quality of life.

The proposed project will expand on the data collected from the in vivo surgical development and ex vivo efficacy studies supported by our Phase I/IB awards. First, a 40-animal rat study will be undertaken to further investigate the biocompatibility of the retinal implant. Second, previously developed surgical procedures will be refined in pigs to ensure reproducible and safe subretinal implantation. Third, a high-throughput in vitro assay will be designed to investigate a number of implant parameters, as well as the integrity and biostability of the retinal implant using retinal pigment epithelial cells. Additionally, medical device sealants will be investigated in this in vitro study, and the functional integrity of the implant will be measured using time-resolved absorption spectroscopy and an ion-sensitive detector, which is being developed specifically for this application. Lastly, this ion-sensitive detector will provide an opportunity to further measure the spatial sensitivity of the retinal implant with high resolution. These in vivo and in vitro studies are vital for the continued evaluation of biocompatibility, surgical feasibility, and efficacy of the implant. The results from these studies will further demonstrate the commercial viability of the technology under development.

Lehigh University

Program: PFI:AIR - TT

NSF Award No.: 1543109

Award Amount: $212,000.00

Start Date: 09/01/2015
End Date: 02/28/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Proof of Concept Study and Scaleability of Injection Molded Nanostructured Biomedical Consumables

This PFI: AIR Technology Translation project focuses on translating multi-scale injection molding technology to applications in biological research, specifically for in vitro cell growth. Cells grown in vitro are critically useful tools in biomedical research and development. Recent research in the area of in vitro cell growth has led to a number of important discoveries with regards to how cells behave and respond to their environment. These discoveries have significantly altered the way that researchers think about how cells grow; however, few commercial products reflecting this knowledge exist, possibly causing bottlenecks in applications ranging from in vitro fertilization (IVF) to disease model development for pharmaceutical testing. The project will result in a family of cell culture substrate prototypes designed to improve cell growth and development over the traditional flat polystyrene surfaces currently used in the industry today. The prototypes will be designed for high-volume manufacturing to ensure commercial usefulness and cost-effectiveness in the biomedical sector.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. First, traditional silicon tooling for multi-scale molding at the micro/nanoscale is cost-prohibitive. Second, the high-volume manufacturing of injection-molded polymeric devices that possess features at the low micro to nanoscale is currently limited by factors such as tooling life and manufacturing robustness. Third, a robust in vitro cell response to such products is required for future commercialization. To address these technology gaps, the team will employ designs inspired by native cell environments, using a well-established in vitro cell growth assay for mouse embryos. Molds for high volume manufacturing will be produced using bulk metallic glass tooling, on which mold robustness will be analyzed. Polymer rheology will be controlled in a variety of ways to ensure feature consistency and reproducibility. Costs associated with mold production and other tooling will be built into the current working financial model to determine the next phase of the commercialization effort. In addition, personnel involved in this project, including a graduate student and a team of undergraduate/high school students will receive innovation and entrepreneurship experience by developing the designs, talking to potential customers, and aiding with the development of a commercialization plan for the technology.

Lehigh University

Program: PFI:AIR - TT

NSF Award No.: 1602057

Award Amount: $200,000.00

Start Date: 05/15/2016
End Date: 10/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR-TT: Preclinical Evaluation of Bioactive Tailored Amorphous Multiporous (TAMP) Powder for the Treatment of Dentin Hypersensitivity

This PFI: AIR Technology Translation project focuses on translating recently developed technology for the regeneration of damaged dentin and pulp tissue, which is needed for the cure of dentin hypersensitivity (DH). DH is a dental condition that inflicts severe pain in majority of people sometime during their lifetime. The currently available products attempt only to treat the symptoms temporarily, and there is no lasting cure of the problem. This project focuses on nano-macro porous glass fabrication technology and applying a new class of bioactive materials to the regeneration of dental tissue. The resulting glasses, which have tailored amorphous multiporous (TAMP) structure, promote the growth of bone as well as soft tissue. The project will result in new TAMP compositions and establish their potential for the regeneration of damaged dentin and pulp tissue to cure DH. The selected TAMP powders that comprise of interconnected nano-macro porosity, which can be tailored to desired surface area, have the unique potential to cure the problem at its source. Consequently, when placed inside the body, a TAMP powder of appropriate composition can supply therapeutic ions in a controlled manner, providing a microenvironment that is expected to occlude dentin tubules to stop the painful symptoms more effectively than currently available products. More importantly, the new TAMP powders are also expected to stimulate tissue regeneration by the cells for a lasting cure. In contrast, the present products in this market space, available over the counter or by prescription, make no attempt to regenerate damaged tissue.

The project addresses the following technology gap(s) as it translates from research discovery toward commercial application. A simple TAMP powder based on calcium silicate has shown proliferation of bone forming cells in laboratory tests and also regeneration of bone and soft tissue regeneration under in vivo tests in animals. However, a demonstration of its ability to regenerate dental tissue (dentin and pulp) has been lacking. The project attempts to obtain evidence for the therapeutic capabilities of TAMP powder for dental tissue regeneration, and thereafter prepare it for clinical trials. It is also developing new compositions that combine the benefits of different treatments in one product. For example, novel TAMP powders with fluoride, zinc and potassium ions embedded within the molecular structure of silicate glass are being fabricated, to provide a lasting supply of fluoride ions at the site of DH, zinc ions that promote regeneration, and potassium ions that desensitize pain-sensing nerves. Further, tests are being performed to assess in vitro differentiation of dental pulp stem cells, and in vivo formation of pulp-dentin complex on TAMP silicates implanted in a mouse model. With this knowledge compositions are optimized for more adherent and faster developing occlusion layer as well as pulp-dentin tissue regeneration.

This technology translation from research discovery toward commercial reality is a team effort led by a glass scientist who developed the TAMP fabrication technology portfolio under prior NSF supported research, together with an endodontist with expertise in dental tissue regeneration, a cell biologist with expertise in cell response to TAMP materials, and a healthcare industry expert with experience in the early stage commercialization of biomedical products. During its course the project is directly training three graduate students in use-inspired research and practical problem-solving through a cross-disciplinary approach that combines materials engineering, cell biology and dental science. The combination of innovative TAMP technology and its potential societal impact has drawn much general student interest, which will be further expanded through more definitive results of this project.

Liberate Medical, LLC

Program: STTR Phase II

NSF Award No.: 1632402

Award Amount: $749,408.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

STTR Phase II: A Novel Abdominal Stimulator to Assist with Ventilator Weaning in Patients

The broader impact/commercial potential of this Small Business Technology Transfer (STTR) Phase II project, in which a non-invasive respiratory muscle stimulation device and approach to weaning patients from mechanical ventilation will be developed, is a reduction in public health care expenditure and a reduction in morbidity for the half a million patients who have difficulty weaning from mechanical ventilation each year in the US. These patients suffer from an array of clinical complications (for example, pneumonia) and cost the US health care system $16 billion annually, a great deal of which is borne by Medicare and Medicaid. In addition, the current reimbursement landscape economically incentivizes hospitals to wean patients at the earliest possible time. The proposed innovation has the potential to positively benefit society by providing a solution to this serious healthcare problem. In addition, it promises to improve our scientific understanding of respiratory muscle physiology and mechanics in difficult to wean patients. It will also improve our technical understanding of non-invasive respiratory sensors and biofeedback algorithms for the purposes of electrical muscle stimulation. Finally, as demonstrated by the number and cost of difficult to wean patients, as well as current healthcare reimbursement policies, the proposed innovation has potential to results in a considerable commercial impact.

The proposed project will develop a non-invasive electrical stimulator that automatically applies stimulation to the respiratory muscles in synchrony with a patient's voluntary breathing pattern. This approach is expected to address the imbalance between respiratory muscle strength and respiratory muscle load - a major factor responsible for weaning difficulty - by assisting ventilation during weaning sessions and strengthening the breathing muscles that have become weakened as a result of mechanical ventilation. In Phase 1 a functional prototype was developed; clinical feasibility of the approach was also demonstrated. The Phase II proposal focuses on refining the stimulation algorithm to maximize its clinical effectiveness and on developing a novel stimulation electrode system so that the device can be quickly applied to patients. In addition, methods will be developed to interface the technology with a mechanical ventilator to expand its clinical application. Finally, a complete works-like, looks-like prototype will be developed that is designed to international standards and is safe for clinical testing. The work completed in this Phase of the project will enable a controlled clinical trial of the proposed approach and ultimately allow the device to gain FDA regulatory clearance.

Madorra

Program: SBIR Phase II

NSF Award No.: 1660255

Award Amount: $749,997.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Developing a Novel, Non-Hormonal Device for Vaginal Atrophy for Breast Cancer Survivors and Post-menopausal Women

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to develop a hormone-free treatment alternative for women suffering from vaginal atrophy. Vaginal atrophy is a condition in which the vaginal tissue is thin, dry, and inelastic. Women with vaginal atrophy experience day-to-day vaginal dryness and pain with intercourse. This SBIR project catalyzes the development of a technology platform that will enable a novel home-use, hormone-free medical device to treat vaginal atrophy. This project represents a medical device treatment for vaginal atrophy developed specifically for women wishing to avoid hormone-based therapies. Currently available treatment options fall in two categories: over-the-counter products and hormone-replacement therapies. Over-the-counter products, like lubricants, are available at drugstores, but these products are often limited in their efficacy relative to the severity of symptoms many women experience. Hormone-replacement therapies on the other hand, such as estrogen creams, can be effective for women; however they are contraindicated for large market segments of women (e.g. breast cancer survivors and women with cardiovascular risk factors). Therefore, this SBIR project is critical to the development of a safe treatment alternative for women and represents a chance to significantly improve their quality of life.

The proposed project supports the technical work required to develop this medical device treatment and addresses a major unmet need for breast cancer survivors and post-menopausal women. The work supported by this SBIR grant will complete necessary device improvements and prepare the technology platform for commercialization. The main objectives of this project are to 1) optimize the device for safety and usability, 2) execute specific design enhancements to ensure cost-effective manufacturability, and 3) complete all necessary quality system testing to meet FDA (Food and Drug Administration) requirements. To achieve the first objective, the company will complete all prescribed activities under the company's quality management system. User interviews will also be completed with device prototypes to explore features that enable and encourage appropriate device use. This work will be completed in cooperation between the company's engineering team and an outside industrial design firm. The second objective will require design for manufacturing activities, which will also be completed in a partnership with an outside firm. The third objective will be executed again by following the company's quality management system policies, processes, and procedures. All of these activities, once complete, will ensure the company's device is ready for commercialization.

Michigan State University

Program: PFI:BIC

NSF Award No.: 1632051

Award Amount: $994,999.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC: iSee - Intelligent Mobile Behavior Monitoring and Depression Analytics Service for College Counseling Decision Support

Depression is the leading health issue on college campuses in the U.S. Today, college students are dealing with depression at some of the highest rates in decades. Unfortunately, university counseling centers (UCCs), which are the primary access points for students to receive mental health services, are facing significant challenges in meeting the increasing demands. Specifically, clinicians at UCCs still rely on patients' inaccurate and biased self-reported symptoms for depression assessment. In addition, UCCs provide mental health services only during working hours in clinical settings. The lack of service access when needed could leave patients floundering helplessly and lead to lifelong consequences. Furthermore, with tight budgets, clinicians at UCCs have not grown and some UCCs even downsized. As a consequence, more students did not receive timely treatment. This project focuses on designing and developing iSee, a smart device based behavior monitoring and analytics platform. iSee harnesses smartphones/wristbands to extend the reach of mental health care far beyond clinical settings and to deliver timely therapies when needed. Furthermore, the continuously tracked depression symptoms allow UCCs to be more accurately informed with the severity of each patient and thus reduces unnecessary visits so that clinician time can be better utilized. If successful, iSee has the potential to enhance mental health services in thousands of colleges and universities, benefiting millions of college students. Although focusing on depression of college students, the technology can be extended to other mental health conditions such as anxiety, bipolar disorder, dementia, and schizophrenia; adapted to patients beyond college students; and deployed at other settings such as public hospitals and private clinics.

iSee consists of a smartphone/wristband sensing system running on the patient side to continuously and passively track patient's daily behaviors using onboard sensors; a behavior analytics engine using machine learning and causality analysis algorithms running on the cloud side to translate behavior sensor data into meaningful analysis results for identifying the patient's depression severity and revealing behavioral causes that lead to the mitigation or the deterioration of the patient's status; and a dashboard running on the clinician side to visualize behavior information as well as analysis results to help clinicians make clinical decisions and conduct treatment. The system would allow clinicians to access an objective, quantitative, and longitudinal record of patients' daily behavior to support evidence-based clinical assessment. This project involves a multi-disciplinary and cross-organizational team of researchers from Michigan State University (lead institution) and Northwestern University (Chicago, IL). The primary industry partner is Microsoft Research (Redmond, WA), which is a large business company in U.S. Michigan State University Counseling Center (East Lansing, MI), which will be the test bed for the integration and evaluation of the iSee smart service system. Finally, the broader context partners include the MSU Office of the Vice President for Student Affairs and Services and MSU Technologies (East Lansing, MI).

This award is partially supported by funds from the Directorate for Computer and Information Science and Engineering (CISE), Division of Information and Intelligent Systems (IIS).

Microdevice Engineering, Inc.

Program: STTR Phase II

NSF Award No.: 1632678

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

STTR Phase II: Microdevice for Rapid Blood Typing without Reagents and Hematocrit Determination

The broader impact/commercial potential of this Small Business Technology Transfer (STTR) Phase II project is the development of a portable, low cost blood typing and anemia screening device for use in blood donation centers, hospitals, humanitarian efforts and the military. This helps society because every two seconds in United States someone needs blood, yet less than 4% of Americans donate blood. Unfortunately, 15-20% of blood collected is wasted due to over collection of unneeded blood types and related blood type logistics. 12 million units of blood are collected annually in US with 108 million units worldwide. U.S. blood centers are under significant economic pressures to reduce per unit blood costs and thus waste reduction tools and strategies are in demand. Blood unit costs approach $200 per pint of blood, so this device provides the ability to pre-screen donors by blood type and selectively direct the donation process (i.e. plasma, red cells) to reduce blood product waste and better match supply with hospital demand. This portable technology could also be translated to remote geographical locations for disaster relief applications. The potential economic savings has the potential to be $400M and will contribute to reducing the overall cost of U.S. health care.

The proposed project will advance knowledge across multiple fields. It adapts knowledge in microfluidics and the use of electric fields to characterize cells to identify the molecular expression on blood cells responsible for ABO-Rh blood type. This project advances the use of electric fields to rapidly measure cell concentration. This project develops software for real time tracking of cell population motion, which is highly valuable in many cell microscopy applications. This project also adapts advanced pattern recognition tools like machine learning to extract even more information from the cell behaviors. This work also extends statistical analysis from static population means to analysis of functional data - a field in its infancy - via a critical application. Finally, the device and electronics engineering will advance under the principle that “simple is best”, leading to fewer potential failure points and less costly manufacture. This work advances scientific knowledge and will be published and widely disseminated after securing additional IP. It is also a powerful alternative to expensive antigen/antibody molecular recognition reactions (i.e. traditional blood typing) for medical screening and diagnosis for future point of care diagnostic applications.

Neural Analytics

Program: SBIR Phase II

NSF Award No.: 1556110

Award Amount: $753,756.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A Novel Non-Invasive Intracranial Pressure Monitoring Method

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to improve the quality and decrease the high costs associated with treating patients who suffer severe traumatic brain injuries. This project aims to develop an accurate, affordable (<$100 per use) and non-invasive device to monitor a patient's intracranial pressure following head injury. Increased intracranial pressure can result in poor health outcomes including long-term disability or death, if left untreated. However, the only available method to monitor intracranial pressure is expensive (~$10,000 per patient) and requires neurosurgery. The lack of a method to accurately screen patients to determine who needs surgery results in misdiagnoses and incorrect treatment in about 46% of patients among an estimated 50,000 patients in the US alone, and hundreds of thousands more globally. Successful commercialization of product is expected to result in savings in the range $250 million ever year to the US healthcare system.

The proposed project will develop a medical device to accurately display a patient's intracranial pressure non-invasively and for use outside of the neurocritical care unit. The core technological approach of the proposed work is the analysis of blood flow velocity waveforms using advanced signal processing methods in a machine-learning framework. The machine-learning framework allows experience-based learning utilizing prior, established databases of waveforms that have been well-characterized. Three new machine-learning paradigms that utilize the shape features of the blood flow velocity waveforms will be utilized to progressively increase accuracy of intracranial pressure estimation. The first will establish a basic estimate using shape features of individual waveform pulses, considered independent of neighboring pulses. Subsequently, clinically established features of the waveform will be utilized to learn causal changes in the shape features resulting from changes in intracranial pressure. Finally, the shape features in successive pulses will be used as a sequence to machine-learn the intracranial pressure estimate. Together, these will enable increased accuracy in estimation. All of the methods proposed in this program are entirely novel. This approach allows for real time monitoring at an affordable price point that is within current reimbursement limits for ultrasonography procedures.

Northwestern University

Program: PFI:BIC

NSF Award No.: 1534120

Award Amount: $1,000,000.00

Start Date: 08/15/2015
End Date: 07/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC - A Smart, "Always-on" Health Monitoring System

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project aims to develop a smart, "always-on" health-monitoring system capable of transforming healthcare from reactive and hospital-centered to proactive, evidence-based, individual-oriented and human-centered. In particular, the project seeks to overcome use problems with mobile-wearable electronics systems that have undermined long-term patient acceptance. Based on the "epidermal" electronic platform developed by the principal investigators, the system will offer "skin-like" properties, to enable intimate, complete, non-invasive integration with people in ways that are impossible with any technology that exists today. This mobile-wearable health-monitoring system will be mechanically "invisible" (i.e., not constraining natural motions or processes of the skin), and will be compatible with daily life activities to ensure long-term sustained engagement of users. It will interact with people through self-detection, self-diagnosis and self-monitoring and will allow clinicians to monitor their patients through wireless communications and data transmission to facilitate self-correcting and self-controlled functions. It will allow the general public to continuously assess personal health and well-being. Continuous monitoring of medical devices may help to prevent serious medical problems through early intervention, particularly in high risk groups of people, thereby providing critical capabilities to the healthcare service system.

In pursuing the basic goal of spurring the development and maturation of flexible skin-applied sensors with wireless connection to monitoring and diagnostic systems, the project combines the research expertise of the principal investigators in the core intellectual content of the proposed platforms, which includes nanomaterials, sensors, advanced signal processing, system design, industrial design/human factors and clinical studies. This integration will lead to smart systems that have the potential to transform healthcare. The research entails the following:
*Development of "skin-like" temperature, hydration, and electrophysiology sensors, with wireless operation. These systems will exploit unique hardware, formed using extensions of ideas from the principal investigators' recent work on epidermal electronics and sensors.
* Studies of interactions between this technology and people, particularly in order to account for human factors relevant to the technology development to ensure lifestyle compatibility.
* Development of effective and robust computational modeling and algorithms for statistical signal processing of the sensor data and pattern recognition to create a user-friendly interface for clinicians, patients and even the general public to enable the interpretation of these data and their implications for health and well-being.
* Application of the proposed health monitoring system to skin. The continuous capture, storage and transmission of sensor data will be critical to the design of these smart, "always-on" health-monitoring systems.

The mechanical "invisibility" of the wearable devices means that they do not interfere with people's daily lives. Accounting for lifestyle compatibility can be illustrated as follows: the less behavior change a device requires in order to simply wear it, the more likely it is that it will drive long-term sustained engagement for users and thus overcome the major limitation of most wearable devices.

The primary partners at the inception of this research include the Lead Institution: Northwestern University, McCormick School of Engineering and Feinberg School of Medicine; MC10, Inc (Cambridge, Massachusetts, small business); and University of Illinois at Urbana-Champaign (Champaign, Illinois, non-profit, educational).

Pennsylvania State Univ University Park

Program: PFI:AIR - TT

NSF Award No.: 1601385

Award Amount: $200,000.00

Start Date: 04/01/2016
End Date: 09/30/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Continuous Urine Assay Instrumentation for Monitoring Kidney Function

This PFI: AIR Technology Translation project focuses on a technology to address the detection of early acute kidney injury (AKI). AKI occurs in 5 - 7% of hospitalized patients and results in a mortality rate of about 50%. The financial costs of AKI are estimated to be 8 billion dollars per year, or about $130,000 per life-year saved. It is unlikely that this high mortality and associated cost will be reduced until there are better tools for the early diagnosis of renal injury. This project translates a quartz resonator based thermal biosensor concept into a biomedical instrumentation system for continuous monitoring of kidney function. The project will focus on prototype engineering, instrumentation, and extensive benchmarking with the aim to provide accurate and automated measurements of urine creatinine. Coupled with in-line urine flow, and periodic serum creatinine concentration measurements, a system for near-continuous creatinine clearance measurement in AKI patients will be developed. The unmatched stability, sensitivity, and reproducibility of this system will allow for collection of such data for clinical analysis and early detection of conditions such as sepsis. The sensor design based on enzyme immobilized alginate beads placed in a Kapton® tubing, as an easy to swap disposable cartridge represents a promising clinical diagnostic prototype demonstration with a viable business model.

This project will develop a calorimetric biosensor prototype based upon differential measurement as a way to compensate for background thermal effects. Development of a differential sensor is expected to improve both the sensitivity and the precision of measurement. The reproducibility, accuracy, and stability of the measurement system will be critically evaluated using urine samples. Intra-assay and inter-assay variability will be experimentally determined by repeated measurements and statistical methods. Accuracy will be determined by comparison of the creatinine concentrations determined by HPLC (the gold standard) and the quartz resonator. Agreement between the two methods will be determined by Bland-Altman analysis. Stability of the system will be determined by measuring the creatinine concentration of known creatinine test solutions at regular intervals over a period of 48 hours. The plot of measured concentration vs time will be used to determine the time to failure. In addition, personnel involved in this project, one graduate and one undergraduate student, will receive regulatory compliance experiences through collaboration with our partner company focused on improving patient outcomes through the successful implementation of innovative technology into medical devices. The team will be also participate in several commercialization conferences and events to establish strategic alliances and partnerships for the technology translation and commercialization.

Phase Diagnostics, Inc.

Program: SBIR Phase II

NSF Award No.: 1660130

Award Amount: $749,830.00

Start Date: 05/01/2017
End Date: 04/30/2018

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Program Director: Henry Ahn

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A Handheld, One Step Paper-Based Device for Rapid Self-Testing of Sexually Transmitted Infections

This Small Business Innovation Research (SBIR) Phase II project is to develop a handheld, one-step paper-based device for rapid self-testing of sexually transmitted infections. The company aims to replace lab-based assays for Chlamydia trachomatis (CT) and expand testing access to previously unreachable settings. The technology combines the ease-of-use and very low cost of rapid point-of-care (POC) diagnostics with the high accuracy of lab-based tests, enabling unprecedented reliability at the POC and at home. CT infection is one of the most prevalent STIs in the US. An estimated three million new cases occur each year with direct annual medical costs of greater than $3.5 billion. Untreated CT, symptomatic or not, may cause long term pregnancy complications, even infertility. Traditional lab-based CT assays prevent the ability to test-and-treat within one patient visit. This delay results in a high number of cases that do not get treatment due to loss-to-follow up (especially for young STI patients) and increased infection transmission. Phase Diagnostics' novel device will be: (1) Fast: Results to the patient in less than 15 minutes; (2) Affordable: Costs less than $1 to manufacture; (3) Accurate: Sensitivity and specificity on par with lab-based assays; (4) Convenient: Handheld with no required equipment or training.

The key innovation of the company's novel device is to use aqueous two-phase systems (ATPSs) to selectively pre-concentrate the pathogenic bacteria prior to detection, thereby dramatically enhancing the accuracy of conventional rapid LFA POC technology and enabling the use of urine samples for the detection of CT. During Phase I, the company was able to adapt ATPS to urine medium, attain improved limits of detection of its system and make considerable progress in fully integrating all components into a true one-step paper microfluidic strip. The objective of Phase II is to fully develop the company's proposed device to be ready for FDA 510(k) clearance and CLIA waiver enabling clinical studies. The company will first complete the product optimization work initiated in Phase I and perform additional device robustness studies. As these experiments near completion, the company will work with a contract prototyper to design and develop prototypes based on the final optimized device components. At the same time, the company will establish small scale manufacturing processes to ensure that it can generate a reproducible pilot batch. The company will then perform Alpha and Beta product testing to determine the clinical performance of its prototype as well as obtain feedback from end-users to determine areas for optimization.

Phi Optics, Inc.

Program: SBIR Phase II

NSF Award No.: 1353368

Award Amount: $1,546,326.00

Start Date: 04/15/2014
End Date: 10/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Quantitative Phase Imaging for Life Sciences

This Small Business Innovation Research Phase II project proposes to develop a faster and more accurate optical instrument for studying live cells and tissues. The study of live cells has yielded numerous discoveries (e.g. germ theory, the Krebs cycle, cell division) and is important for drug discovery and disease treatment. Live cells are transparent and need to be observed for long periods of time (days, weeks) in their natural state. To make the cells visible and measure them quantitatively, current state of the art instruments require injecting the cells with staining agents or light emitting fluorophores. Both processes are invasive, labor intensive and expensive and long term observations of live cells is difficult: staining embalms the cells and the fluorophores fade quickly and kill the cells in hours. The Phase I project produced a proof-of-concept prototype that provides quantitative imaging of live cells by processing the light transmitted through the cells in their natural state. Completion of the Phase II objectives will upgrade the Phase I prototype to a commercial grade instrument: improve optical design and build a housing enclosure, develop commercial grade software and automate the hardware controls and develop task-specific software applications to solve particular biological problems.

The broader impact/commercial potential of this project is to enable life scientists with a new and powerful instrument for studying live cells. The greatest impact of the commercial instrument developed in Phase II project will have is enabling researchers to do science better than before, i.e., more accurately, more quantitatively, and more noninvasively. The range of breakthroughs enabled by the instrument will likely include: novel drug discovery by accurate monitoring of cell response to treatment, fundamental studies of cell proliferation and growth, minimally invasive automatic diagnosis of cancer biopsies, and fast and accurate blood testing instruments. Scaling up the production of the instrument will create new jobs and increase the US dominance in the biotechnology area. Due to their full automation, the instruments can also operate in areas with limited access to trained personnel and provide the digital data necessary for remote diagnosis, such as Medically Underserved Areas/Populations in United States.

Phytoption, LLC

Program: SBIR Phase II

NSF Award No.: 1556121

Award Amount: $759,785.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Program Director: Henry Ahn

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: New Ingredients Technology to Enhance the Safety, Quality, and Value of Active Substances for Pharmaceuticals, Food, and Personal Care

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be accomplished through a proprietary technology with its extraordinary capability to enable a large number of high-value, hard-to-formulate active ingredients for pharmaceutical, food, and personal care products. In the pharmaceutical and personal care industries, this technology is able to solubilize and enable poorly water-soluble drug substances to achieve enhanced therapeutic effect, improved safety profile, and reduced cost. In addition, it may strongly support the long-term activities of drug discovery and development through activating potentially efficacious, but hard-to-handle chemical entities. By supporting new drugs development and reducing manufacturing cost, this technology will benefit the public health and meanwhile create commercial values to the industry. In the food and supplement industries, this technology may enable the industry to replace non-healthy or even hazardous additives, such as artificial colors and preservatives, with natural and healthy alternatives, thus greatly contribute to long-term food safety and security as well as public health. To achieve commercialization success, a solid portfolio of intellectual properties has been established. Seasoned business leaders will work with renowned scientists to incorporate cutting-edge technologies into drug, food & nutrition, and personal care products.

The proposed project will substantially support the development of this new technology. The core problem/opportunity this technology targets is a large number of high-value whereas poorly water-soluble active ingredients that have been challenging the drug and food industry for a long time. For example, around 80% of drug candidates identified by modern drug discovery technologies are poorly water-soluble. For food, a large number of vitamins, nutrients, antioxidants, and natural colors are poorly water-soluble. Overall, poorly water-soluble compounds constitute an enormous formulation challenge. To address this need, this team has created a platform technology that is highly effective and non-specific. The goal of this project is to further develop the technology, scale up the synthesis of a core material, obtain the data on its safety profile, and advance the commercialization activities by providing prototypes to potential customers. This project will be conducted through close collaborations among the start-up company, a major university, and a number of major pharmaceutical, ingredients, food, and personal care companies. The deliverables of this project include the specifications of core material, initial safety evaluations, and prototypes provided to customers. This project will support the start-up company to form a solid foundation for commercialization and long-term growth.

Protein Dynamic Solutions, LLC

Program: SBIR Phase II

NSF Award No.: 1632420

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel, Accurate and Reproducible Platform for the Developability Assessment of Protein Therapeutics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will address ALL of the factors attributing to protein aggregation by determining the: size, identity, extent, mechanism of aggregation and stability, thus addressing Biopharma industry needs. This information is critical to the development of drug pipeline contributing to a $190 BN biologic's market where $87BN in first generation biologics face patent expiration before 2020. A successful technical approach for its implementation will provide essential information for decision making towards which candidates will enter the market, thus increasing the Biopharma valuation and ensuring supply of drugs to patients. In the end, improving the quality of life of patients with chronic diseases.

The proposed project will address the need for a multivariate high-throughput technology to address the risk of protein aggregation, that when adopted in R&D, will increase pipeline approvals, reduce late stage withdrawals and total costs of drug development. Average R&D development costs for the mere 1% of candidates reaching FDA approval have risen to $2.6 BN per product. Protein therapeutic development needs to be guided by a full understanding of protein stability and aggregation. Research objectives are to: develop our innovative First-in-Class high throughput platform for screening protein therapeutics; develop original software capable of deciphering protein aggregation mechanism, size, identity and extent of aggregated protein and product stability; commercialize the innovative technology platform. Fully automated evaluation of protein candidates during early R&D phase will be conducted. Best-in-class image acquisition technology will be employed towards this end, using a label free chemical mapping technology, dedicated software using auto recognition algorithms, and correlations to decipher protein aggregation. We through the use of its breakthrough technology will determine: the aggregate free candidate under various stressor conditions, optimum formulation conditions for the protein therapeutic, the most stable candidate, and electronic data reporting that establishes accuracy, reproducibility, critical quality attributes of the protein product.

Radial Analytics, Inc.

Program: SBIR Phase II

NSF Award No.: 1534781

Award Amount: $909,999.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: System for Patient Risk Stratification through Electronic Health Record Analytics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is significant; transitions of care impact millions of Americans every year. The healthcare system bears substantial cost and inefficiency on account of suboptimal care transitions and overspending. This Phase II project will support progress towards a “learning healthcare system” and will extend the capabilities of data mining and machine learning in healthcare

The proposed project seeks to improve data mining technologies for healthcare decision support. This project will focus on the analysis of a broad variety of data types that are common in healthcare settings. The anticipated improvements would allow frontline care staff, operational managers, and healthcare executives to assess and make stronger evidence-driven decisions regarding quality, cost, and access as patients move through the healthcare system. The enhanced data mining system would utilize state-of-the-art pattern recognition and machine learning techniques to dynamically process and interpret clinical, claims, and other types of healthcare data. If successful, this research will impact the state-of-the-art in healthcare analytics.

Rivanna Medical

Program: SBIR Phase II

NSF Award No.: 1329651

Award Amount: $1,410,000.00

Start Date: 09/15/2013
End Date: 06/30/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Safe, Portable, Non-ionizing Bone Imaging with an Ultrasound-based X-ray Replacement Device

This Small Business Innovation Research (SBIR) Phase II project addresses the clinical and market need for an X-ray replacement technology that is portable, low-cost, and safe. While X-ray is the current dominant modality for diagnostic imaging of bone anatomy, it possesses many limitations: emission of radiation, bulky, and expensive. In the Phase I project, we demonstrated feasibility of the technology with a handheld ultrasound prototype, which demonstrated 3D freehand bone imaging using an ex vivo whole pig lumbar spine model. Phase II research objectives include: 1) Design and build a preproduction ultrasound prototype; 2) Develop a model registration-based 3D bone imaging application and release a clinical software version with formal verification and validation testing; and 3) Prepare the device for clinical use with human subjects and experimentally validate in an ex vivo porcine lumbar spine model with physician testing. It is anticipated that this project will result in the demonstration of a new medical device with demonstrated efficacy for improved administration of spinal anesthesia via 3D portable real-time spinal bone imaging.

The broader impact/commercial potential of this project is an X-ray replacement technology based on medical ultrasound, which addresses market segments including spinal anesthesia, orthopedic, and emergency medicine. Rivanna Medical is targeting the spinal anesthesia market first because of the compelling market and clinical need. Due to lack of availability of safe, portable, and inexpensive medical imaging for bone anatomy, these procedures currently exhibit high first-attempt failure rates. Failures result in poor patient outcomes and higher costs for health care providers. In this application, our lead device, the SpineFinder, would improve success rates via real-time guidance of spinal injections at the patient's bedside. The societal impact of a safe, inexpensive, portable bone imaging products includes more successful procedures, better patient outcomes, and lower healthcare costs. Additionally, the public would benefit by an overall reduction in ionizing radiation exposure from X-ray and a subsequent reduction in cancers. The general scientific and technological understanding of acoustics will be enhanced through this project by a better understanding of ultrasound interactions with specular reflecting surfaces, such as bone.

Roundtable Analytics, Inc.

Program: SBIR Phase II

NSF Award No.: 1632410

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Data-Driven Decision Support Services for Emergency Department Operations

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is very significant. Suboptimal operational decision-making in emergency departments and hospitals leads to inefficiencies that result in excessive patient wait-times, the diversion of ambulances to other emergency departments, wasted resources and patients who either leave before being treated or against medical advice. By connecting modern analytical approaches, including statistical modeling and systems engineering methods, to real-time data routinely collected by hospitals, the proposed project promises to result in a tremendously valuable analytics platform that will assist administrators in making dozens of operational and staffing decisions each day. This informed decision-making will not only improve hospital efficiency, it will lead to both healthier and more satisfied patients and simultaneous dramatic increases in revenue and profit. The technology proposed will have the potential to add significant value to the approximately 5,000 hospitals in the U.S., often on the order of millions of dollars annually. Hospitals and health systems now realize the value of effective analytics, and the analytics platform proposed here will be an obvious investment for any emergency department or hospital whose goal is to provide the best care to its patients at lower costs.

The proposed project promises to yield a set of decision-support applications upon which emergency departments and hospitals will base their decisions each day. Substantial investments by hospitals and health systems on information technology, and in particular, electronic health records, have set the stage for evidence-based, data-driven decisions. These decisions will effectively leverage real-time data along with analytical methods such as statistical forecasting and event-simulation modeling. In particular, this proposed project will develop software applications, based on these analytical methods and linking to real-time data sources, tailored to emergency departments and hospitals. This project will involve 1) addressing the real-time needs of hospital operational decision-makers, 2) further developing a statistical and simulation modeling platform to inform these real-time needs, specifically reflecting emergency departments and whole hospitals, and 3) ultimately ensuring that actionable insights are delivered in a timely and intuitive manner to key stakeholders. These actionable insights that derive from the data and sophisticated methods must be delivered to the right decision-maker at the right time and in the right format, but will then have the capacity to substantially improve both the quality and efficiency of care-delivery throughout the hospital.

Sense Diagnostics, LLC

Program: SBIR Phase II

NSF Award No.: 1632270

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Novel Device for Monitoring Brain Hemorrhage using Radio Waves

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is the reduction of deaths and long-term disabilities in people suffering from bleeding in the brain caused by intracerebral hemorrhage (ICH) or traumatic brain injury. Currently, physicians detect worsening bleeding through a clinical exam where a patient shows outward signs of deterioration in their neurological status. By the time these signs of additional bleeding appear, much of the damage to the brain has already occurred. About a third of people who suffer a severe traumatic brain injury either die or are left disabled. For hemorrhagic stroke, 60% die and 70% of survivors are left with significant disabilities. A device which transmits and receives very low power radiofrequency signals has been created that can be put on a patients head. The presence of blood outside of the brain's vessels and arteries creates a characteristic change in the radio signal used by the device. Using radio waves to non-invasively detect brain bleeds will allow treatment to start sooner, which will save lives, reduce disabilities and lower the cost of treating severe brain injuries.

The proposed project tests (i) the ability of the device to detect and characterize small changes in ICH size and location over time and (ii) the ability to display changes in the bleed in a meaningful way to physicians. An algorithm for determining the size and location of the hemorrhage will be tested using both a phantom model that mimics the human brain and an IACUC-approved pig ICH model. Multiple hemorrhage volumes and locations will be used to test the algorithm's ability to detect hemorrhage volume changes within 1 mL, location within 1 cm, and distinguish changes due to the hemorrhage from physiological changes in a living pig's brain. Signal measurements taken before, during, and after infusion of blood will be captured at each time point to test the accuracy of the algorithm. Software will be developed to display the information from the algorithm in three-dimensions while giving doctors and nurses control over thresholds for triggering an alarm and how often the device scans. To test the software, the data collected during the pig experiments will be used to determine how accurate the display matches the location and size of the hemorrhage from CT images collected during testing.

Shasqi, Inc.

Program: SBIR Phase II

NSF Award No.: 1660258

Award Amount: $749,906.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Henry Ahn

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Biomaterials and Chemistry to Enhance the Delivery of Medicines in the Body

This Small Business Innovation Research (SBIR) Phase II project supports the development of a technology to improve the way drugs are delivered in the body. Less than 2% of the dose of any medication finds its way to the place in the body where it is needed. The other 98% is either eliminated or, even worse, concentrates in areas where they can lead to side effects. This happens with all medications from daily anti-inflammatory drugs to the latest cancer therapies. If successful, this new approach will turn a regular drug into a medicine that is concentrated and activated only at the area where it is needed. This advance should increase the efficacy of the therapy and minimize its side effects. For example, the local drug activation can target chemotherapies to tumors with minimal side effects. Antibiotics could be delivered at higher local doses than is currently possible, eliminating local infections and limiting the creation of drug-resistant bacteria. Anti-inflammatory medications could be more powerful, improving the management of post-operative pain, potentially reducing the use and misuse of opioid drugs. Overall, this technology could reduce the costly burden of adverse drug events, estimated at more than $177 billion.

To create targeted medicines, researchers rely on the endogenous differences between diseased tissue and the rest of the body (e.g., molecular markers or differences in enzymatic activity). Local drug activation provides a new path to create targeted medicines. The approach starts by injecting a biodegradable polymer at the desired site. The material contains exogenous chemical activators that do not exist anywhere else in the body. Then a drug is given systemically that is inactive until it comes in contact with the gel improving local efficacy and diminishing systemic side effects. Phase 1 results showed that an inactivated chemotherapy eliminated tumors in mice after only 10 days of therapy with minimal side effects. The Phase II project will expand the benefits of the local drug activation platform to other therapies, including cancer therapies and pain medications. The long-term goal is to show the applicability of the approach to multiple classes of drugs and increase their potential to improve outcomes for diseases that affect local areas of the body. If successful, this advance should enable medications for people who are too frail to receive them and enable therapies to work in combinations that were previously impossible due to dose-limiting toxicities.

SiMPore, Inc.

Program: STTR Phase II

NSF Award No.: 1660177

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

STTR Phase II: Development of Ultrathin Nanomembranes for Home-based Hemodialysis

This Small Business Technology Transfer (STTR) Phase II project aims to disrupt hemodialysis delivery for treating end-stage renal disease (ESRD), a significant health burden in the US. Trends are moving toward patient-managed, in-home treatments. The goal of this proposal is to accelerate adoption of safer home hemodialysis therapy through development of continuously operating, wearable hemodialysis systems enabled by ultrathin and highly permeable silicon nanomembranes. Despite the recognized economic, health and quality-of-life benefits of more frequent hemodialysis treatments, adoption of home hemodialysis using present systems is being limited by doctors' and patients' safety concerns. Simpler and safer hemodialysis therapies will require breakthroughs in both device components and form-factors. The development of a small-scale, highly efficient dialysis system enabled by silicon nanomembranes holds potential for increasing adoption of home dialysis and its related benefits for the 430,000 US ESRD patients.

Phase I results demonstrated feasibility of methods for large area nanomembrane fabrication, strengthened membranes and identified membrane area requirements for a dialysis system embodiment. Phase II objectives focus on completing larger area membrane fabrication, optimization of membrane filtration properties, integration of membranes into dialyzer modules and testing dialysis efficacy of these dialyzer modules in a nephrectimized sheep model.

Sintact Medical Systems, LLC

Program: SBIR Phase II

NSF Award No.: 1660209

Award Amount: $748,176.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Henry Ahn

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Development of a Barrier Film to Prevent Post-operative Internal Scarring

This Small Business Innovation Research (SBIR) Phase II Project will continue development of a non-resorbable surgical film which prevents internal tissue-attachment. The proposed device will improve post-surgical outcomes from patients who suffer from internal tissue-attachment triggered by cardiothoracic or neurological surgery. Patients who undergo surgery are at risk for developing unwanted tissue-attachment due to trauma as a result of surgical intervention. This tissue-attachment can lead to severe complications and increase the burden of post-operative care resulting additional expenditures through extended hospital stays, readmissions, and increased morbidity and mortality rates. In addition, undesirable tissue attachment can obstruct the surgical field upon re-operation when necessary. Surgical related tissue-attachment is a problem amongst many surgical procedures in a number of areas. However, cardiothoracic and neurological procedures are often more complicated than gastrointestinal or gynecologic procedures, making any complications more expensive and risky to providers, payers and patients. Additionally, re-operations in cardiac or neuro-spine cases are extremely difficult, which underscore the need for an effective solutions to prevent this malady even more urgent. A product that can effectively prevent undesirable tissue-attachment and provide the surgeon with a clear surgical field and plane of view would be highly desirable in both cardio-thoracic and neurological surgery.

The proposed project will conduct additional pre-clinical work leading to a regulatory submission for a cardio-thoracic indication and additional validation within the neurological field. Positive animal studies completed during Phase I & IB efforts revealed the capacity of the Sintact Film- to reduce tissue attachment and provide for a clear field of view upon re-entry or re-operation. Initial Phase II work will examine the feasibility of scaling-up certain manufacturing and production processes resulting in a clinical grade product which will undergo sterility, safety, animal, biocompatibility, and mechanical testing. This testing will be compared directly to a predicate or equivalent approved medical device. Results will need to show equivalency of the Sintact Film to the predicate device across all testing metrics. Additional Phase II work will enable further validation of the Sintact Film for neurological indications. A larger definitive neurological study will be completed to address the capability of the Sintact Film to be deployed effectively in a neurological setting. Positive results from this study will provide a basis for pursuing expanded indications and additional market opportunities. If successful the implications that a non-resorbable product can be an effective countermeasure in these areas would alter the current methodology in the field.

Sonavex, Inc.

Program: SBIR Phase II

NSF Award No.: 1632424

Award Amount: $749,953.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Automatic Vascular Flow Reconstruction with Adaptive Three-Dimensional Doppler Ultrasound

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project includes the reduction in severe patient morbidity and elimination of hundreds of millions of dollars of expenditures by the U.S. healthcare system each year on revision surgeries and unnecessary procedures associated with late detection of post-surgical blood clots. Surgeons have the ability to prevent these catastrophic events, but only if the onset of the clot can be detected in a timely manner. Currently, of the patients who form clots after the targeted surgeries, half will suffer from a surgical failure due to the shortcomings of current modalities. This technology gives clinicians the ability to non-invasively track changes in blood flow within critical vessels to enable intervention prior to any compromise in health and prevent a majority of these catastrophic incidents. Beyond significant decreases in patient suffering and morbidity, such interventions will have an enormous positive economic impact on the health care system. This technology can also substantially improve clinical understanding of the clotting process and possibly enable non-invasive therapeutic treatments for these patients who otherwise would receive surgery.

The proposed project offers significant intellectual and scientific merit associated with new methods of ultrasound flow analysis. The objective of this work is to develop a system that is able to collect a 3D volume of ultrasound data and automatically extract the blood flow data in the region of interest by detecting an implantable component. This novel approach to measuring vascular flow will be the first to enable detection of localized post-operative clot formation rather than detecting clot-related issues via delayed and indirect methods that leave patients at risk for surgical failures. This technique can allow for intervention earlier than all other available methods, thus improving patient outcomes and reducing hospital costs. Furthermore, this method enables automatic detection of critical changes in blood flow, eliminating the risk of human error. Lastly, dissemination of the technology developed in this proposal represents an important milestone towards the creation of simpler, more automated ultrasound systems that can place this non-invasive, non-ionizing modality in the hands of non-expert clinicians for use in a broader spectrum of medical applications.

SonoVol, LLC

Program: SBIR Phase II

NSF Award No.: 1533978

Award Amount: $881,890.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Developing a New Platform Technology for 3D Ultrasound Imaging

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development and commercialization of a new technology for non-invasive preclinical imaging. This platform technology will be used in studies of disease or in in drug development. The project will further develop and validate an imaging platform based on three-dimensional (3D) ultrasound, which is a low cost, high-throughput alternative to existing whole-body imaging modalities, and will provide more sensitivity and field of view than current two-dimensional (2D) ultrasound approaches. The technology developed will reduce costs of whole-body preclinical imaging, and enable access to this technology to smaller research organizations. Increased availability of a low-cost imaging tool for preclinical disease and drug development studies could accelerate progress in improving human health while reducing cost burdens on life science labs.

The proposed project addresses the problem that 2D ultrasound is a preferred imaging modality in preclinical studies due to the adequate resolution, high throughput, and low cost; however, it suffers from user variability and inadequate field of view. The research objectives will be to continue the development and validation of a 3D ultrasound system which overcomes challenges of user variability and inadequate field of view. Specific technical goals will be to improve both the hardware and software of the system for increased throughput, integrating the system components into a cohesive customer-facing product, and calibrating and validating the system for its intended preclinical imaging application. Expected results will be a novel technology - an automated 3D preclinical ultrasound system, which will substantially improve the performance and capabilities of preclinical ultrasound imaging, yet will retain the low-cost and high throughput characteristics of ultrasound imaging. This new technology will fill a need present in nearly every academic research institution as well as pharmaceutical and contract research organizations worldwide.

Springbok, Inc.

Program: SBIR Phase II

NSF Award No.: 1556135

Award Amount: $747,567.00

Start Date: 03/15/2016
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A Non-invasive Image-based Skeletal Muscle Analytics Tool

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to provide a new tool revealing important information regarding skeletal muscle strength and health. Muscle weakness is a pervasive problem across our society, including people with joint disease, aging people, obese people, and people with neuromuscular disorders. All of these problems affect muscles across the body in different and non-intuitive ways; however, to date there has not been marketed technology that allows for quantitative measurement of muscle size on a muscle-by-muscle basis and specific analysis to address the muscle weakness problem. Due to the current high cost, the initial targeted customers will be elite athlete organizations, with the goal of using the technology to improve performance as well as to provide more quantitative metrics for predicting injury susceptibility and make return-to-sport decisions. However, with research and development to bring down the cost, the ultimate goal is to make a broadly used clinical tool for prevention, diagnosis, and treatment of health conditions related to musculoskeletal disease and mobility, which will have broad societal impact.

The proposed project will provide a major advancement in image-based modeling and data analysis tools in order to allow high-throughput imaging, rapid and accurate segmentation of muscles and efficient data analysis. Currently, physical therapists, athletic trainers and strength and conditioning coaches only have very blunt tools to assess each individual's strength and very limited information about the optimal muscle profile. Therefore, training and rehabilitative approaches are developed via experience and trial and error. The technology proposed here solves these problems by making using of an image-to-model pipeline to quantify muscle size and provide valuable and actionable information based on the quantification. However, the obstacles for a wide adoption of this technology include specific magnetic resonance imaging (MRI) protocols and lengthy image segmentation process. In the previous funding cycle these two problems have been addressed with substantial technology advancements. The proposed activities in this funding cycle will continue the technical development process to further bring down the cost with improved image segmentation process and provide additional value with advanced data analysis. It will ultimately be a revolutionary tool to improve muscle health.

Stasys Medical Corporation

Program: SBIR Phase II

NSF Award No.: 1534750

Award Amount: $510,317.00

Start Date: 10/01/2015
End Date: 03/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: Development of a Rapid Assay for the Personalized Assessment of Clot Dysfunction due to Trauma

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to create a medical device capable of rapidly guiding treatment to stop bleeding in trauma patients. Trauma can affect the body's ability to form clots to stop bleeding. Of the more than 2 million severe cases of trauma in the U.S., approximately one third will develop a condition: trauma-induced coagulopathy (TIC), which increases mortality 4-fold. TIC can be corrected; however, current tests to identify TIC take too long to effectively guide treatment. This leads to sub-optimal care and increased mortality and morbidity. The current standard-of-care to correct TIC is the transfusion of blood products. A patient should only be transfused if necessary because unnecessary transfusions can lead to complications resulting in longer hospital stays and even death. A rapid assay that can evaluate a trauma patient's coagulation status can help guide treatment of their injuries, resulting in improved standard-of-care that can both save lives and healthcare dollars. Yearly trauma rates unfortunately remain stable, and with an addressable market of more than $400M per year in the U.S., the commercial impact for such an assay is significant.

The proposed project is to develop a rapid assay that provides an individualized assessment of a trauma patient's coagulation status. A significant subset of trauma patients develop impairment to the normal coagulation process as a result of their injuries. Current assays to identify this impairment take too long to effectively guide treatment. Therefore, successful completion of this project will yield a disposable microfluidic card (microcard) that has multiple advantages over current assays, which are slow and non-specific. The microcard will measure clot characteristics currently used by emergency room physicians to guide treatment, but will do so in less than five minutes. This is a critical feature as it quickly guides treatment, meaning that there is time for re-evaluation to determine if treatment is effective. The microcard will also include on-board positive and negative controls that indicate a patient's individual coagulation profile. This will result in personalized and more accurate treatments that can reduce complications and mortality. The rapid and specific microcard assay will significantly improve care of injured patients while conserving resources and time, ultimately saving money for the U.S. healthcare system.

TAO Connect, Inc.

Program: SBIR Phase II

NSF Award No.: 1631871

Award Amount: $709,003.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: An Intelligent Mental Health Therapy System

The broader impact/commercial potential of this Small Business Innovation Research, Phase II project is to help make therapy more consistent with patient preferences, beliefs, and values to maximize engagement in therapy and improve patient outcomes. Therapy for mental health problems is highly effective, yet many patients drop out before getting the full benefit because they are not satisfied or engaged in the therapy. The proposed project involves collecting data on all of patients actions in the online treatment system along with their ratings of each activity and their symptom improvement over time. The research and development team will use this data to create a machine learning system that will make suggestions for best next steps in therapy based on what thousands of other users experienced. This is the intelligent counseling system. It will work very similarly to movie streaming services or online book sellers who recommend movies or books to you based on your past preferences and the preferences of thousands of other users.

The proposed project will develop a feedback and recommendation system based on advanced analytics and machine learning techniques to provide personalized treatments to customize and individualize online mental health treatment, the Intelligent Counseling System (ICS). This personalized system will contain a number of alternative treatment items from several theoretical perspectives, using a variety of patient interactive activities, varying in format, length, pace, and other characteristics. In such a setting, a recommendation system can predict the users' preferences and recommend the subsequent treatment component. In addition, to achieve maximum adherence and to decrease the attrition rate, the platform will enable personalized motivational interventions and supportive messaging. The delivery times and the content of supportive messaging will adapt and vary depending on the projected treatment progress. Our machine learning based system will be trained incrementally as more data becomes available over time, thus it will benefit from improved accuracy over time. We will extract local, semi-local, and global temporal features at multiple temporal resolutions and will use feature selection techniques to identify which factors contribute to the success of treatments for patients, and to predict if a user is improving or is deteriorating. This will result in adaptive motivational messages and recommendation for tailoring treatment in term of important identified treatment features.

Texas A&M Engineering Experiment Station

Program: PFI:AIR - TT

NSF Award No.: 1543226

Award Amount: $212,000.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI-AIR-TT: Wearable Sleepwear for Quantitative Prognostication and Noninvasive Therapy of Obstructive Sleep Apnea

This PFI: AIR Technology Translation project focuses on translating an advanced prediction and prognostics approach to fill the need for affordable and effective at-home solutions to treat sleep disorders. Sleep disorders such as obstructive sleep apnea (OSA) are prevalent in an estimated 6.6% of the national population. The market for sleep treatment is noted to exceed $23 billion per year, and is set to grow at over 15% annually. However the current treatment procedures suffer from severe drawbacks and are highly criticized in consumer forums. Recent advancements in sensors and wireless communication offer an unprecedented opportunity for cost-effective home care options to treat sleep apnea. This project will result in a prototype of SleepEaze technology that captures this opportunity. This technology is based on using a wireless biometric sleepwear to monitor the apnea patient's biorhythms during sleep, and it employs a patent-pending algorithm to predict apnea events several minutes ahead of their onset. Then the muscles responsible for the obstruction can be stimulated when the event is predicted to be imminent ("nip in the bud"), allowing the patient a more restful sleep. The use of the innovative prediction algorithm as well as low power electronic elements offer a breakthrough in the noninvasive stimulations that can lead to a new class of affordable wearable devices for sleep apnea treatment with high commercialization potential.

This project plans to pursue three major objectives: (a) Technology Improvement, which includes: the refinement of the wearable sensor layout to enhance comfort, tuning of parameters of the prediction model based on nonparametric Dirichlet Process Mixture of Gaussian Process representations to reduce computational overhead associated with multi-step look ahead procedures, and optimization of the stimulation modality, location, and time-frequency stimulation profiles using a novel low power electronics to effectively avert sleep apnea events; (b) Extended testing using an early prototype, extending an ongoing human subject study to benchmark signal quality, prediction and stimulation performance, and sleep quality improvement from the technology in preparation for approvals (510K) from the federal regulatory agencies; and (c) Prototyping of a updated wearable multi-sensor unit for real-time treatment of sleep apnea episodes, as well as its testing and benchmarking. If successful, the proposed project will result in a functional, refined prototype of the SleepEaze device (hardware and associated software interface) that offers a radically new approach for OSA treatment. In addition, personnel involved in this project, including a post-doctoral associate and two graduate students, will receive entrepreneurship experiences offered through Texas A&M University and the NSF Southwest I-Corps node.

Texas A&M Engineering Experiment Station

Program: PFI:AIR - TT

NSF Award No.: 1602045

Award Amount: $199,098.00

Start Date: 06/01/2016
End Date: 11/30/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR-TT: Self-adaptive Growing Rod for the Treatment of Pediatric Scoliosis

This PFI:AIR Technology Translation project focuses on translating a novel titanium alloy to address the need for improving the outcome and reducing implant-related complications during growing rod treatment of adolescent scoliosis. The adaptive growing rod is important because of its potential to reduce the high incidence of implant loosening and failure, which are the primary sources of complications in the treatment of severe early-onset scoliosis in children and often necessitate costly and painful revision surgeries. The project will result in a working prototype of an adaptive growing rod and demonstrate its feasibility in a standardized biomechanics model. This device has the unique features of simultaneous high strength and ultra-low stiffness matching that of human bone, and the ability to vary its stiffness depending on location. When compared to the leading competing growing rods based on the Harrington rods system in this market, these features reduce the number of revision procedures required by reducing a leading source of complications, facilitating healthy development of the spine from better load sharing, and improving the overall efficacy for treatment of severe scoliosis in children.

This project addresses the following technology gaps as it translates from research discovery toward commercial application: there is a current lack of quantitative understanding of how stress at the bone-screw interface is affected by implant stiffness in growing rod constructs. This is important because high stress at the bone-screw interface is believed to be responsible for implant loosening and pull-outs. Furthermore, it is not known how location-dependent implant stiffness modifies such stress. The project seeks to bridge these gaps by quantitatively monitoring how stress at the bone-screw interface is affected by variations in the implant stiffness introduced by microstructural engineering and thermo-mechanical training in a Ti-Nb alloy. Experiments are performed using a modified ASTM standard model that accounts for the changing stiffness of the growing spine. In addition, personnel involved in this project, including a Ph.D. level graduate student and undergraduate researchers, will receive entrepreneurship and technology translation experiences through direct involvement in the customer development process. Students will participate in all conversations with surgeons, hospital officials, regulatory personnel, and medical devices manufacturers. Students will be asked to make customer contacts independently, and receive training of the lean-startup strategy central to the NSF I-Corps program.

The project engages pediatric orthopedic surgeons and a medical devices manufacturer to ensure a clear and current understanding of clinical needs and challenges, as well as regulatory and reimbursement hurdles of this technology translation effort from research discovery toward commercial reality.

University of Arizona

Program: PFI:BIC

NSF Award No.: 1430062

Award Amount: $800,000.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC Making Full Use of the High-Resolution Image Capability of Smartphones to Collect Data through Ophthalmic Devices for Smart Mobile- and Tele-Health

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from the University of Arizona is designed to extend healthcare to remote patients suffering from eye diseases. The field of Mobile Health, or M-Health, is the merging of mobile technology and healthcare. Its purpose is to extend the reach of healthcare services to people living in rural, remote, or isolated areas who do not have routine access to healthcare. M-Health allows for effective medical analyses and decisions to be made where remote patients are located, rather than requiring them to travel to a distant city to receive medical care. Ocular trauma, glaucoma, and macular degeneration are all significant causes of preventable vision loss, if detected and treated early. A series of devices is proposed which act as medical examination extensions to a smartphone. A visiting healthcare practitioner attaches such a device to a smartphone and runs a custom app to perform a specialized examination of specific portions of the eye. Using a WiFi or cell signal, the smartphone app submits the collected examination data to a remote "expert system," which provides in-depth medical analysis processing. The analysis results are sent back almost immediately and are displayed onscreen to the healthcare practitioner. Through this process of telediagnosis, the project offers the potential of greatly improving remote patient screening and triage. It will help to ensure that patients with undiagnosed eye diseases are detected early and can arrange to visit an ophthalmologist in time to prevent permanent eye damage. The result of establishing this paradigm of remote medical care will extend healthcare to those most in need.

The project establishes a smart service platform in ophthalmology by creating a server-based telediagnostic analysis capability for current and future smartphone-based ophthalmic examination devices, three of which are to be developed in this effort: a microscopic extension, a panoptic ophthalmoscope, and a portable slit lamp. This capability would allow examination data, gathered with such devices, to be sent wirelessly to a remote server for automated analysis, the results of which would be sent back to the originating smartphone. This server-based telediagnostic analysis capability allows for either tele-expert or automated machine-based in-depth evaluation and diagnosis of the submitted image data. This is made possible because smartphones are ubiquitous and Internet-connected. This capability enables both real-time and store-and-forward teleconsultation and communication to other health professionals for a full diagnosis later in time when convenient or possible. These handheld devices will enable field-conducted examinations that are otherwise restricted to clinical settings (e.g., medical offices and clinics). Compared to state-of-the-art ophthalmic equipment, the proposed devices will be miniaturized, portable, and usable even by non-specialists outside clinical settings.

At the inception of the project, the partners are the lead institution, University of Arizona (Departments of Biomedical Engineering and Electrical & Computer Engineering and Department of Ophthalmology and Vision Science), and a small business, Breault, Inc. (Tucson, AZ). Broader context partners are Tech Launch Arizona (University of Arizona, Office of Technology Transfer) and California Institute of Technology.

University of California, Irvine

Program: PFI:AIR - TT

University of California, Irvine
NSF Award No.: 1604014

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017
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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Integrated Microfluidic System for Cell Separation and Enrichment

This PFI: AIR Technology Translation project focuses on translating an integrated microfluidic device capable of processing milliliters of whole blood by rapidly isolating and enriching rare cells (such as circulating tumor cells, CTCs), resulting in faster sample preparation for high fidelity diagnostic and prognostic measurements that are critically needed in many therapeutic applications. This integrated microfluidic platform is important due to the direct impact on cancer patients and supporting infrastructure resulting from bringing this game-changing microfluidic device to market. Patient diagnosis and monitoring would become simpler, cheaper, faster, and more convenient. Moreover, the usage of this microfluidic platform is not limited to cancer diagnosis, but extends to any disease or condition measured via changes in cellular physical properties in a sample of biological fluid. The project will result in an optimized, integrated cell separator and enrichment prototype microfluidic device. The team will demonstrate its utility with clinically relevant levels of CTCs in whole blood to determine its feasibility for improved cancer diagnosis and monitoring. This integrated microfluidic device has the following unique features: (a) label-free cell separation, enrichment, and release, (b) clinical scale sample volumes and single pass through device to achieve complete cell isolation and enrichment (100% target capture) in approximately 20 minutes, and (c) device is amenable to mass production. When compared to the leading competing methods for CTC isolation and purification from whole blood in this market space, these features provide the following advantages: (a) simpler operation, (b) quicker, more reliable test results, and (c) lower cost per test and small form factor towards a potentially portable system for use in various point-of-care applications or resource limited settings.

The main technology gaps to be addressed during the project are associated with optimizing the microfluidic device to achieve the rigorous performance levels required for CTC analysis (isolate and enrich 5 CTCs/7.5mL whole blood for downstream detection). These gaps will be bridged by having multiple integrated microfluidic devices working simultaneously in parallel and improving the sensitivity of the device to sufficiently separate and capture cells of similar size. In addition, personnel involved in this project, especially undergraduate students, graduate students, and post-docs, will gain innovation and technology translation experiences. They will become well versed in microfluidic cell sorting, enrichment, chip design, manufacturing, and the needs of primary end-users in multiple business spaces around the world. They will also gain firsthand experience in working in a multidisciplinary academic-industrial environment.

University of California, Los Angeles

Program: PFI:BIC

NSF Award No.: 1533983

Award Amount: $1,012,000.00

Start Date: 10/01/2015
End Date: 09/30/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC Human-Centered Smart-Integration of Mobile Imaging and Sensing Tools with Machine Learning for Ubiquitous Quantification of Waterborne and Airborne Nanoparticles

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project focuses on the creation of a human-centered smart toolset and service system for on-site and ubiquitous quantification and automated charaterization/classification of nanosize objects. Nanoparticles are being used in more and more commercial and industrial products while their health and environmental implications are still under debate. The toxicity of nanomaterials not only varies among different materials, but is also highly dependent on the dose of exposure. Developing a sensitive method to detect the release and spatio-temporal distribution of nanoparticles in the environment as well as in daily lives is a high priority before their toxicity effects are fully understood via long-term toxicological studies. Despite this urgent need for widespread detection and quantification of nanoparticle distributions, current technologies are lacking appropriate features for ubiquitous and cost-effective mapping and quantification of nanoparticle contamination. This project aims to create a transformative and human-centered toolset for on-site and ubiquitous quantification and automated characterization of nanomaterials found in houses, workplaces and the environment based on the cost-effective integration of computational imaging and mobile sensing techniques with big data based dynamic machine learning algorithms.

The central challenge in this project is to translate the bulky and expensive laboratory equipment currently used for nanoparticle quantification and characterization to field-portable, easy-to-use, cost-effective, and rapid analysis devices and smart service systems aiming to be massively used by consumers in their daily routines. To solve this challenge, highly sensitive optical imaging systems will be developed based on mass-produced Complementary Metal-Oxide Semiconductor (CMOS) sensor chips embedded in mobile phones with extraordinary signal to noise ratios (SNR) and large fields-of-view for high-throughput machine learning based automated nanoparticle analysis and classification. One approach this will take is to combine computational microscopy with self-assembled nanolenses around nanoparticles that significantly enhance imaging SNR and contrast. The aim of this approach is to enable automated detection and sizing of individual nanoparticles, mono-dispersed samples, and complex poly-dispersed mixtures, where the sample concentrations can span ~5 orders-of-magnitude and particle sizes can range from 40 nm to millimeter-scale, which provide unmatched performance metrics compared to existing nanoparticle sizing approaches. Another approach that will be implemented is the development of highly sensitive multi-modal (e.g. fluorescence plus dark-field) mobile phone based microscopy platforms for distributed nanoparticle imaging and sensing. Furthermore, in terms of big data analysis and machine learning tools, the techniques in this project can adaptively learn "semantic" similarities that can be used for more accurate data classification. These techniques are unlike existing techniques developed so far in the literature. The extant technologies are based only on signal similarities, which do not work well on multi-modality data. The smart and adaptive methods of this project are the first in the literature that come with confidence bounds, that is, they not only have the capability to accurately classify the information, but they also provide guarantees about the accuracy of this classification, which is quite important for self-learning smart service systems.

Through these field-portable devices that are integrated with adaptive big data based decision analytics and quantification algorithms, spatio-temporal maps of nanoparticle concentrations and size distributions in various consumer samples will be created for public or personal monitoring (e.g., measurements of waterborne/airborne particles at home, workplace, or airborne particles along a freeway, etc.).

The broader impacts of this transformative research include (1) The development of these nanoparticle sensing and quantification platforms and smart service systems will extend the boundaries of current optical metrology science, resulting in new advances in the fields of nanophotonics and optical microscopy (2) These devices will also be easy to translate into various biomedical, chemical and material science applications, significantly impacting the use and regulations of nanotechnologies in consumer market and related products. (3) This project would deliver a paradigm-shift by ubiquitous quantification and spatiotemporal mapping/monitoring of nanoparticle contamination and exposure even in non-laboratory settings, assisting in the revelation and better understanding of various cause-effect relationships at the consumer level that have remained unidentified so far due to the limitations of existing nano-imaging, detection and quantification technologies, also providing maps of potential health risks. (4) This project will also establish a complementary educational outreach program based in California.

The lead institution and primary partners included in this cross-organizational interdisciplinary project are: Lead Academic Institution: University of California, Los Angeles, CA, School of Engineering, Electrical and Bioengineering Departments; Primary Industrial Partner: Holomic LLC (Small Business located in Los Angeles, CA); Other Industrial Partner: Google Inc. (Large Business located in Mountain View, CA).

University of Cincinnati, Main Campus

Program: PFI:AIR - TT

NSF Award No.: 1500236

Award Amount: $200,000.00

Start Date: 04/01/2015
End Date: 09/30/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Developing an Engineering Prototype for Ultra-Low-Cost Blood Coagulation Diagnostics Using Paper-based Microfluidics

This PFI: AIR Technology Translation project focuses on translating capillary-based paper microfluidics to fill the need for ultra-low-cost blood coagulation diagnostics. The diagnostic device is important for patients who receive blood thinner medication because of cardiovascular disease. These patients require constant blood coagulation analysis in order to monitor the efficacy of the anticoagulation medication. If the anticoagulant drug level is too low, the risk of blood clot formation is high. Conversely, if the drug level is too high severe bleeding (hemorrhage) can occur. Conventional hospital- or lab-based coagulation measurement is expensive and time consuming. The project will result in the development of engineering prototypes of simple paper-based diagnostic screening devices with several unique features: rapid indication of blood coagulation status; ease of use, with no other apparatus needed, thus allowing patient-operated home use; ultra-low-cost allowing one time use and preventing contamination; fast response time. These features provide significant cost savings compared to the leading competing blood coagulation portable measurement systems, thus greatly expanding the availability of point-of-care testing to currently underserved segment of the population.

This project addresses technology gaps in using blood samples with paper-based lateral flow assays (LFA) as it translates from research discovery toward commercial application. This includes specific design of test kits (LFA materials and cassettes) for use of small blood sample volume, enhanced sensitivity to coagulation conditions, low-cost manufacturability. A major consideration is the development of industrial-quality manufacturing processes, with particular consideration to reproducible fluid flow in the LFA nitrocellulose (NC) membranes. The geometrical definition of the NC membrane by mechanical cutting will be compared to a laser milling approach. In addition, personnel involved in this project (research assistant and research associate) will receive entrepreneurship and technology translation experiences through the Center for Entrepreneurship & Commercialization at the University of Cincinnati.

The project engages with industrial partners in this technology translation effort from research discovery toward commercial reality. Meridian Bioscience Inc. will provide guidance with overall prototype engineering, evaluation of product costs, regulatory requirements. Specific assistance with the design and optimization of the LFA unit will be provided by Diagnostic Consulting Network Inc.

University of Colorado at Denver, Downtown Campus

Program: PFI:AIR - TT

NSF Award No.: 1602128

Award Amount: $200,000.00

Start Date: 06/01/2016
End Date: 11/30/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Proof-of-concept Fiber-based Miniature Multiphoton Microscope using Adaptable Optics

This PFI: AIR Technology Translation project focuses on combining miniature adaptable optics with multiphoton laser scanning microscopy to fill the need for a versatile, implantable, three-dimensional imaging system for studying brain activity in awake behaving animals. The fiber-coupled miniature multiphoton microscope is important because it allows neuroscientists an unprecedented ability to study dynamics of complex neuronal circuits while animals are undergoing different behavior tasks. The project will result in a proof-of-concept demonstration of our product operating in freely moving animals. The fiber-coupled miniature multiphoton microscope will allow full three-dimensional scanning through active focusing with no mechanically moving parts in a compact, light weight design. The product can be readily connected to a commercial-laser scanning microscope. These features allow for reduced cost, flexibility in configuration of the wavelength or imaging modality to be performed, and can provide imaging over larger brain volumes when compared to the leading head-mounted microscope systems in this market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. Although light microscopy has rapidly advanced for studies of biological systems, one major gap is the ability to use these advanced imaging tools for dynamic studies in the brain in freely moving animals. We propose to combine the advantages of two-photon excitation with depth scanning using adaptive optics in a compact fiber-coupled design. Current commercially available miniature microscopes only allow for single imaging planes, do not enable active focusing during imaging and do not allow both targeted imaging and optogenetic stimulation. The miniature multiphoton fiber-coupled microscope will use a fiber-bundle to translate the laser-scanned signal to the distal microscope head and miniature adaptable optical elements to provide fast active focusing. This will accomplish high versatility for applications such as fast region-of-interest imaging, optogenetic stimulation, and depth imaging with multiphoton techniques. Personnel involved in this project including undergraduate and graduate students, will receive experience in technology translation through meetings with business partners, attending technology conferences, and participating in outreach events.

This project engages 3i (Intelligent Imaging Innovations), an international company that specializes in delivering advanced optical microscope systems. This collaboration will allow implementation of this fiber-coupled microscope into commercial systems and speed delivery to a global commercial market.

University of Illinois, Urbana-Champaign

Program: PFI:BIC

NSF Award No.: 1534126

Award Amount: $999,995.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC - Pathtracker: A Smartphone-based System for Mobile Infectious Disease Detection and Epidemiology

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project will develop a mobile sensor technology for performing detection and identification of viral and bacterial pathogens. By means of a smartphone-based detection instrument, the results are shared with a cloud-based data management service that will enable physicians to rapidly visualize the geographical and temporal spread of infectious disease. When deployed by a community of medical users (such as veterinarians or point-of-care clinicians), the PathTracker system will enable rapid determination and reporting of instances of infectious disease that can inform treatment and quarantine responses that are currently not possible with tests performed at central laboratory facilities.

Polymerase Chain Reaction (PCR) and Loop-Mediated Isothermal Amplification (LAMP) currently represent the most sensitive and specific approaches for identification of viral or bacterial pathogens, with intense research focus directed towards miniaturization, acceleration, and automation of the protocol for amplifying disease-specific DNA sequences to easily-measured concentration. The plan is to apply the results of previously NSF-funded advances in photonic crystal enhanced fluorescence (PCEF) and smartphone fluorescence spectroscopy to implement PCR or LAMP assays within sub-µl liquid volumes for reduction in the assay amplification time to register a measurable fluorescent signal. Importantly, the detection approach enables >10x multiplexing of PCR (or LAMP) reactions within a chip that can be "swiped" through a custom handheld detection instrument that interfaces with the back-facing camera of a conventional smartphone in a manner that is similar to reading a credit card. A mobile device software application will guide the user through the assay process, interpret the results of the detection (including correlation of assay measurements with on-chip experimental controls), and communicate results to a cloud-based data management system along with other relevant information provided by the user. Importantly, the app will enable the user to view the results of tests performed by other users, with a mobile device interface that enables simple visualization of the locations, times, and circumstances surrounding positive/negative tests. The system will enable users to request customizable alerts when positive tests occur within the network of users, and to highlight confirmed positive cases when conventional laboratory tests can confirm results of positive field tests. The app will track outcomes and report statistics on system performance, including Receiver Operating Characteristic of assays.

While the system will initially be deployed in the context of equine infectious disease representing an opportunity to mitigate enormous economic losses associated with infectious disease in the horse industry, the developed technology will be equally applicable to humans, food animals, and companion animals. Considering the economic and health impact of ebola, HIV, tuberculosis, and malaria, when PathTracker is fully deployed within developing nations, the potential of the system to save lives by rapid delivery effective treatment, quarantine of infectious patients, and rapid identification/reporting of new cases is enormous.

At the inception of the project, the primary partners are the lead institution: University of Illinois at Urbana-Champaign (Department of Electrical and Computer Engineering, Department of Bioengineering, and National Center for Supercomputing Applications); University of Washington at Seattle (academic institution); Perkin Elmer, Diagnostics R&D Division, (Waltham, MA) (Large business); Motorola Mobility (Chicago, IL) (Large business);and Dr. David Nash, D.VM.(Lexington, KY) (Individual practitioner veterinarian).

University of Maryland Baltimore County

Program: PFI:AIR - TT

NSF Award No.: 1601999

Award Amount: $199,988.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: RestEaze: Accessible Measures of Leg Movements during Rest and Sleep

This PFI: AIR Technology Translation project focuses on translating a fully functional prototype for RestEaZe, a leg-worn device comprising capacitive and inertial sensors to distinguish between general leg movements (GLM) and periodic leg movements (PLM) during sleep. These leg movements can be associated with a variety of medical conditions including restless leg syndrome (RLS), attention deficit hyperactive disorder (ADHD) and insomnia, which collectively affect millions of adults and children. RestEaZe is an in-home sleep monitoring product that will give the user an immediate, scientifically accurate view of quiet vs. restless sleep, and changes in sleep, over several nights along with professionally developed interactive guides for improving sleep based on the RestEaZe results. The doctor will get advanced movement and sleep analyses with interactive graphic and numeric summaries of the patient's sleep over several days. There is currently no easily used at-home way to measure PLM, GLM and sleep/leg position.

Leg movements in sleep divide into two phenotypes: General Leg movements during Sleep (GLM) are defined by actual leg movements and periodic leg movements of Sleep (PLM) are defined by periodic dorsiflexion of the foot at the ankle. GLM patterns reveal texture and severity for sleep-behavioral intervention and in this project GLM characteristics are related to arousal risk (GLMA); PLM reveal possible medical conditions such as restless legs syndrome (RLS), cardiac morbidity and REM (rapid eye movement) behavior disorder. PLM, GLM and GLMA along with sleep position will be used to develop metrics for PLM/hr, sleep time, wake during sleep and quiet vs. restless (fragmented) sleep to support evaluations and treatments. To address this technology gap, this project is developing and commercializing a novel system, RestEaZe that identifies GLM (leg movements), PLMS (foot flexions), and leg position using a single point measurement system in a home setting. Specifically, this project combines a flexible proprietary ankle band developed at the University of Maryland, Baltimore County, with proprietary PLM analytics developed at Johns Hopkins University. RestEaZe will be an enabling technology for identifying sleep status, evaluating treatments, e.g. oral iron, behavior therapy, RLS medications, and identifying possible medical conditions.

The graduate students involved in the project will be exposed to a start up like environment where milestones have to be met within strict time limits. They will also participate in presentations and demonstrations that the faculty researchers will have during events such as the Technology Breakfast (an event where entrepreneurs demonstrate their prototypes in Baltimore), exposing them to the world of entrepreneurship and commercialization.

University of Mississippi, Medical Center

Program: PFI:AIR - TT

NSF Award No.: 1640519

Award Amount: $199,992.00

Start Date: 09/01/2016
End Date: 02/28/2018

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Thermally Targeted Biopolymers for the Delivery of Anticancer Drugs

This PFI: AIR Technology Translation project, Thermally Targeted Biopolymers for the Delivery of Anticancer Drugs, focuses on translating a thermally responsive biopolymer technology into a new cancer treatment drug delivery system. This system has the potential to improve outcomes and reduce drawbacks now experienced by patients during cancer treatment. Currently, only a small fraction of chemotherapeutic drugs reach tumor sites. The rest of these drugs, systemically administered at dosages strong enough to eradicate cancer cells, are distributed throughout the body, causing extensive damage to normal tissue. The developed drug delivery system attaches a powerful chemo-drug, Doxorubicin, to a thermally responsive, biopolymer, elastin-like polypeptide (ELP). At physiological temperatures (37°C), this ELP exists in a more liquid state (soluble). However, the ELP can be prompted by an externally applied, clinically available, mild hyperthermia (40-41°C) to undergo a phase transition (into being more solid) and aggregate at the tumor site. To help these aggregated ELPs and their attached Doxorubicin enter the tumor cells at this site, a cell-penetrating peptide (CPP), is also conjugated to the ELP. This drug delivery system thus makes an innovative use of conjugated drug delivery biopolymers, an external, localizing heat, and a peptide able to mediate entry into cancer cells, where it can release the Doxorubicin for a more targeted and efficient tumor cell uptake and action.

The project will yield an externally triggered drug delivery system that can greatly improve the selective delivery of anti-cancer drugs to breast tumors by its unique exploitation of three key features: (1) the passive targeting properties of macromolecular carriers deriving from the enhanced permeability and retention effect, (2) active drug targeting to tumor sites by a clinically available external trigger, and (3) efficient, intracellular tumor drug delivery mediated by a cell penetrating peptide to reduce tumor growth, improve treatment outcomes, and retain better patient quality of life. The developed drug delivery system confers important advantages over competing systems based on drug-polymer conjugates, drug antibody conjugates, liposomes, and nano- and microparticles: (1) this drug delivery system enhances drug half-life and improves drug pharmacokinetic profile; (2) ELP modification by a CPP dramatically (15-20 fold) enhances cellular uptake, yielding more efficient tumor vasculature penetration and greatly enhancing efficacy in both tumor cell entry and the targeting of specific cellular compartments; (3) the water-solubility of lipophilic or water-insoluble drugs can be attained/much improved by their coupling to ELP biopolymers; (4) ELP biopolymers, based on simple genetic code, are simple and inexpensive to manufacture, can be easily modified to add therapeutic peptides for intracellular targeting, and can contain more than one drug, permitting their use in combination therapy. With this targeted drug delivery system, therapeutic drugs can be administered at maximum tolerated dose, but with substantially reduced side effects, resulting in greatly increased cancer treatment efficacy. The system thus addresses current drug delivery technology limitations and yields a competitive advantage over existing approaches for treating localized tumors, one better targeting tumor cells and sparing healthy tissue.

In addition, through a structured program of seminars and workshops, graduate students and post-docs will be guided in recognizing and implementing key steps for advancing the commercial potential of research. They will be introduced to case-based business research and collaboration, as well as regulatory and market research skills, crucial to creating viable business plans that permit the translation of vital research discoveries to the marketplace where their potential benefits can be maximized. The project engages CytRx Inc., a biopharmaceutical research and development company specializing in oncology, to provide guidance on technological aspects of the project and its technology translation from research discovery to commercial reality.

University of South Florida

Program: PFI:AIR - TT

NSF Award No.: 1602020

Award Amount: $209,858.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Enhancing the Balance and Control of Crutch Walking Using a Novel Crutch Tip

This PFI: AIR Technology Translation project focuses on enhancing the efficiency of using crutches to walk. Walking with crutches requires significantly more energy than walking without a crutch, yet most of the recent advances have only focused on making crutches more comfortable. Enhanced crutch walking efficiency is important because it can increase independence, improve stability, and reduce fatigue in the approximately six million individuals that rely on crutches for daily mobility. This project will result in a feasible design for a kinetic crutch tip that makes crutch walking more efficient without requiring any external power. It can also help users maintain control when walking down a slope by reducing their speed. The kinetic crutch tip is expected to help existing crutch users gain additional mobility and allow more people to use crutches instead of wheelchairs and other more sedentary assistive devices that do not encourage the same level of daily activity.

This project addresses several technology gaps as it translates from research discovery toward commercial application. Conventional crutch tips have a standard point or constant radius tip that cannot assist the user during walking; all forward progression forces must be generated by the user pushing themselves forward over the crutch. In contrast, the kinetic crutch tip uses a special shape to predictably redirect the user's downward force into a propulsive force that assists the individual in forward ambulation. This assistance is provided passively, so no motors or power supplies are required. The assistance force helps the individual use less energy while moving forward over level ground and when walking uphill. The crutch tip shape can be rotated to reverse the assistance force and provide a more controlled descent down a hill by reducing the user's momentum. The scientific challenge of this project lies in determining precisely what roll-over crutch tip shape should be used for each of the four commonly used crutch gait patterns and how the tip affects the gait dynamics and energy used during each crutch gait. The focus will be on the unstable and fast-moving swing-through crutch gait predominately used by short-term crutch users and on the more stable and slow-moving 2- 3- and 4-point crutch gait patterns typically used by long-term disabled individuals. The combination of engineering, physical therapy, and business start-up expertise on this project enables the development of this new method to assist individuals that rely on crutches to walk. In addition, undergraduate and graduate students involved in this project will receive experiences in innovation and entrepreneurship.

The project engages two partners to advance this technology translation effort from research discovery toward commercial reality. Tao Life Sciences will guide the commercialization aspects by identifying the market segment(s) to focus on and will help in redesigning the research prototypes that have shown success in the lab for larger-scale testing focused on the identified customer segment. The engineering and design related to this project will be presented to the general public through a collaboration with the Museum of Science and Industry (Tampa, FL) where an exhibit will highlight research into assistive and rehabilitation technologies. Visitors will be able try out the different types of crutches and learn about the difficulties that individuals with impairments have in performing simple daily tasks.

University of Southern California

Program: PFI:AIR - TT

NSF Award No.: 1601340

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: Wireless Implantable Pressure Sensor for Continuous Monitoring of Chronic Disorders

This PFI: AIR Technology Translation project focuses on translating the first wireless, microfabricated, microbubble-based pressure sensor for physiological monitoring to fill the current technology gap in chronic, implantable diagnostic sensors. The translated technology offers reliable pressure recordings in real-time for patients suffering from chronic, often life-long medical conditions for which elevated pressure is a risk factor or indicator, and removes the need for bulky exterior diagnostic tools. The microbubble pressure sensor has the following unique features: biocompatible construction, small footprint (less than 0.1 sq. mm.), wireless control and power, and a microbubble transduction mechanism. The microbubble transduction mechanism circumvents failures modes such as mechanical fatigue and biofouling, which plague sensors that rely on deflection in elastic membranes. These features provide for an unobtrusive, reliable implant, with greater application to chronic in vivo monitoring compared to current state-of-the-art in physiological pressure monitoring. The project will result in a working prototype pressure sensor and critical data to de-risk on-going development.

This project addresses current technology gaps by integrating wireless circuitry for power and telemetry into the existing prototype microbubble transducer and by generating critical characterization data on long term accuracy, precision and repeatability, as necessary steps for translating the technology toward commercial deployment. Graduate and undergraduate researchers will work to finalize device electronics and packaging and calibrate the prototype pressure sensor with thorough benchtop testing. In addition, all personnel involved in this project, will benefit from translational education programs offered by our I-Corps node and Coulter workshop series that will expose them to customer discovery, customer interviews, Lean Startup methodology, medical device commercialization, and regulatory and reimbursement strategy.

The team is collaborating with neurosurgeons at the Children's Hospital Los Angeles; they will provide guidance in design and deployment of biomedical technologies for hydrocephalus. The team will also leverage industry connections and technology commercialization programs for guidance and training on commercialization, manufacturing, and financing as they pertain to the potential to translate the technology into a competitive commercial reality. The potential economic and societal impact of this project include greater US competitiveness in biomedical sensing technology, and the improvements in healthcare quality and reductions in healthcare cost realized by new clinical pressure sensors, that offer data driven diagnostics and timely medical interventions for chronically suffering patients.

University of Texas, Austin

Program: PFI:AIR - TT

NSF Award No.: 1602085

Award Amount: $199,873.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Program Director: Barbara H. Kenny

Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: A Novel Bimanual Upper-body Exoskeleton for Stroke Therapy

This PFI: AIR Technology Translation project focuses on translating a robotic exoskeleton technology to deliver physical therapy to stroke subjects. Stroke is a leading cause of long-term disability in the US with nearly 80% of all stroke survivors experiencing some form of upper limb paralysis. Prior work by the PI has led to the development of a sophisticated exoskeleton for upper limb rehabilitation, called HARMONY. This PFI:AIR-TT award will support a novel controls framework for HARMONY that holds potential to improve the rehabilitation outcomes of not only stroke patients but also those with upper extremity neurological and musculoskeletal impairments. Currently there is only one robot commercially available for delivering physical therapy to the upper body. HARMONY offers improvements over this system through the following features: i) HARMONY can power entire shoulder movement; ii) HARMONY is bimanual, so it can simultaneously deliver therapy to both arms, which opens up possibilities for novel bimanual therapy; and iii) HARMONY allows for customization of the robot's force is at each joint which is critical for physical therapy.

This project will develop a new controls framework that ensures patient involvement and provides the appropriate amount of assistance so that subjects can complete the desired task. To achieve this objective, the following two specific aims will be pursued: Aim 1) Develop and test novel controls framework for multi-DOF, bimanual human-exoskeleton interactions and Aim 2) Demonstrate the efficacy of the adaptive controllers through experiments with healthy subjects. The team, involving two participants with business and commercialization expertise, will advance understanding of the business aspects, including IP, regulatory issues and market need, and will generate a commercialization plan.

With mentoring from personnel with business and commercialization experience and the focus on developing a commercialization plan, this project will create a unique opportunity for educating the academic participants in the process of translating basic research into deployed technology. Successful completion of this project will aid in the development of the next generation of innovators and business leaders.

University of Washington

Program: PFI:BIC

NSF Award No.: 1631146

Award Amount: $999,996.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Program Director:
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Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:BIC - Smart Laser-Based Imaging and Optical Spectroscopy System: Optical Quantification of Bacterial Load, Oral Health Surveillance, and caries Prediction.

Caries and gum disease are especially prevalent and severe in low-income and rural communities, which often lack access to convenient and affordable dental care. Members of these communities are more likely to visit hospital emergency departments with advanced stages of oral disease that need surgical treatment; this increases the cost of dental care for families and burdens hospital resources. Tooth decay is the most common chronic disease in American children and adolescents age 6-19 despite being a preventable disease. In 2010, untreated tooth decay, or caries, affected 2.4 billion people worldwide. Early childhood caries leads to pain, infection, and discomfort. And in adults, chronic oral infections may increase the risk of preterm birth and diseases like diabetes and atherosclerosis (hardening of the arteries). This project will develop a hand-held electric-toothbrush-like device with a user-friendly interface that can be used in the home or by community health workers in schools or rural clinics. The wand, which uses a safe optical scanning method, will send data and images to a dentist, who will be able to monitor how well dental treatments are working. The data and images collected by the device can be analyzed to discover where plaque and bacteria are present, providing a way to predict, and then prevent, disease. The wand will be able to prompt the user to address problem areas. This system, which will connect remote users to a dental provider, has the potential to improve the prevention and treatment of oral disease and the quality of life for people who do not have convenient access to regular, in-person dental care.

To enable this vision, this project will develop a smart system that offers screening, surveillance, and prediction for people to improve their oral health and prevent disease. A mature technology of laser-based imaging that is spatially registered with fluorescence spectral analysis will be used to study the complexities of the oral biofilm and dental demineralization. The bacterial measurement is performed with a hand-held single wavelength optical scanning probe that forms images from both reflectance and fluorescence contrast, with the option of taking laser-induced fluorescence spectra for diagnosis of enamel demineralization. To provide a smart interface, the optical information will be analyzed to identify trends, a new modality for the dental field. With analyses of the fluorescence signal from the plaque deposits displayed as a trend, the user, in collaboration with clinician, can monitor variations in oral health and the effectiveness of treatments. The research team will use an iterative process to develop, design, evaluate, and refine the tool. The tool will be tested for three scenarios: (1) a plaque- and caries-screening program for a trained lay user on an untrained “patient” (e.g., parent for a child, school nurse for pupils, pediatrician for young children, or staff at a remote rural clinic for patients); (2) a caries surveillance program for trained lay users electronically connected to a dentist who can guide the use of the tool; and (3) a caries prediction program, initially for clinical users.

This project brings together a multidisciplinary team from the University of Washington (UW), in Seattle, Washington, with expertise in human centered design, engineering, sensing and machine learning, oral biology, and dentistry: Eric J. Seibel (Principal Investigator, PI), Mechanical Engineering; Sean Munson (co-PI), Human Centered Design & Engineering; Shwetak Patel, Computer Science & Engineering; Zheng Xu, DDS, School of Dentistry, Pediatric Dentistry; Jeff McLean, School of Dentistry, Periodontics. Lead industry partner Water Pik, Inc. (Fort Collins, CO), brings experience and knowledge about building, marketing, and distributing advanced dental devices to consumers: Deborah Lyle, Director of Professional & Clinical Affairs, and Jay McCulloch, Vice President, Global Marketing, Oral Care. Broader context partners are UW CoMotion (Seattle, WA), a technology transfer partner; QualComm Tech, Inc. (San Diego, CA), a wireless technology leader; Open Photonics, Inc. (Winter Park, FL), a business partner; and the Alaska Native Tribal Health Consortium (Anchorage, AK), a non-profit community partner interested in the development of an optical diagnosis device for use with its rural beneficiaries.

This award is partially supported by funds from the Directorate for Computer and Information Science and Engineering (CISE), Division of Computer and Network Systems (CNS).

Vanderbilt University

Program: PFI:AIR - TT

NSF Award No.: 1542996

Award Amount: $200,000.00

Start Date: 09/01/2015
End Date: 02/28/2017

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Program Director: Barbara H. Kenny

Topic: Biomedical Technologies (BM) and Smart Health (SH)

PFI:AIR - TT: External Stents to prevent vein failure in dialysis grafts

This PFI: AIR Technology Translation project focuses on developing and commercializing a shape memory polymer external stent, VenoStent, to prevent vein failure in hemodialysis patients. Although hemodialysis is the primary lifeline for patients with end-stage kidney disease, vein failure necessitates expensive, rather ineffective interventional techniques and re-do operations. This puts the patient at an undue risk of infection, extensive hospitalizations, and death, with substantial, adverse ripple effects on the economy. This project will result in an optimized prototype of the VenoStent positioned for clinical translation. VenoStent has the unique capability to robustly encompass the complex, variable geometry of the graft-vein junction, where the majority of failures occur. It is also biocompatible, biodegradable, ductile, and tunable for optimal venous responses. In contrast to other competing technologies in development, these features enable sutureless, custom-fittable encompassing of the vein to reduce surgery times, risk of infection and wound reopening. These features should also impart reductions in hospitalizations, interventional techniques, re-do surgeries, and costs.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. First, the prototype must be optimized for its ability to encompass the venous anastomoses and promote a healthy vascular smooth muscle cell (VSMC) phenotype, as VSMCs play an integral role in the underlying neointimal formation responsible for vein failures. Sustained release of a therapeutic peptide, MK2i, from the external supports will also be evaluated in vitro for future commercialization adaptability incorporating a therapeutic. The precise geometry of the construct, pore size, and molar composition will be defined and then tested in an ex vivo model of the venous anastomosis. In addition, personnel involved in this project, namely a graduate student and post-doc, will receive extensive entrepreneurial and technology translational opportunities through participation in business courses, pitches, competitions, accelerator programs, and professional conferences.

Vaxess Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1632434

Award Amount: $750,000.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Program Director: Jesus Soriano Molla

Topic: Biomedical Technologies (BM) and Smart Health (SH)

SBIR Phase II: A New Approach to Developing a Heat-stable Rotavirus Vaccine

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to increase global access to vaccines and reduce mortality associated with infectious diseases. As an example, Rotavirus is a major cause of severe gastroenteritis among young children and lack of vaccination results in 450,000 deaths annually. A thermostable rotavirus vaccine would create cost-savings for vaccine manufacturers, national governments, and non-profit vaccine buyers and enable market access in areas of the world that lack sufficient cold-chain capacity. Successful development of a stable rotavirus vaccine would not only have significant positive impact on global rotavirus immunization efforts, but may also revolutionize the general approach to vaccine delivery and distribution. This Phase II project will advance towards commercialization a novel platform technology that both stabilizes vaccines and enables novel delivery formats. This technology has significant commercial potential in that it can be broadly applied to numerous emerging and existing vaccines in the $24 Billion global market.

The proposed project seeks to leverage the unique properties of silk to meet the global need for robust, thermostable vaccines. Thermal instability is a long-standing problem in vaccine development. Despite efforts to improve stability, current formulation approaches do not allow product storage under ambient conditions. Temperature excursions during shipment and storage are common and result in wastage or administration of suboptimal vaccines. The use of silk fibroin, a low-cost biomaterial, represents a novel approach to vaccine stabilization. The goal of the proposed research is to advance the silk-stabilization platform towards commercialization of vaccines that do not require cold storage. Building upon successful Phase I results, advanced formulation optimization studies will define a final product formulation for rotavirus that is compatible with scaled manufacturing and achieves all storage and in vivo attributes necessary for a commercial product. Through process optimization studies, fabrication of a dissolvable thin strip for oral delivery of rotavirus will be translated into a scalable manufacturing process that provides an attractive alternative to traditional drying methods. Evaluation of stabilized rotavirus vaccine films in an improved animal model will enable validation of in vivo immunogenicity and offer insight into vaccine stabilization and oral film delivery more broadly.

CHEMICAL AND ENVIRONMENTAL TECHNOLOGIES (CT)

Amriton, LLC

Program: SBIR Phase II

NSF Award No.: 1660215

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Regenerable Adsorbent Filter for Water Purification

The broader impact / commercial potential of this Small Business Innovation Research Phase II project is to offer a low-cost novel filter to purify water with higher effectiveness and superior performance than currently available technologies such as carbon filters. The global water scarcity, including some parts of the US such as the southwest, has led to a strong need for efficient technologies to purify wastewater for direct or indirect potable reuse. Recently, there has been growing concerns over emerging contaminants such as perfluorinated compounds (PFCs e.g. PFOA and PFOS) in surface and groundwater. These PFCs are being found at many groundwater sites and in drinking water wells affected by PFCs. Current technologies are not efficient for the removal of PFCs from water, and there is an immediate need for new cost-effective treatment technologies. To address this unfulfilled need, this project seeks to develop a low cost, reusable filter unit for water purification to remove emerging contaminants such as PFCs. The technology is expected to be used by entities conducting industrial wastewater and groundwater treatment, and wastewater utilities that have a focus on water reuse.

The objectives of this Phase II research project are to develop a prototype water filter, test and optimize it for the removal of emerging contaminants with a focus on PFCs. Specifically, the project will focus on: (1) optimization of the adsorbent performance and synthesis method; and scale-up of the synthesis method for bulk production of filter media; (2) optimization of the filter regeneration process; and (3) design, construct, and test a prototype unit of the technology; and determine the process cost. The work will confirm the effectiveness of the filter in removing the target contaminants as well as the effectiveness of the regeneration process to reuse the filter. The PFC contaminants will be first removed from the water and then destroyed. The overall performance of the technology will also be evaluated and compared with other available technologies to determine its cost-effectiveness.

Colorado School of Mines

Program: PFI:BIC

NSF Award No.: 1632227

Award Amount: $959,945.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Program Director:
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Topic: Chemical and Environmental Technologies (CT)

PFI:BIC: Self-Correcting Energy-Efficient Water Reclamation Systems for Tailored Water Reuse at Decentralized Facilities

Many small communities own and operate small, decentralized wastewater treatment facilities, many of which are old and not flexible enough to adjust for treatment of variable water quality. Many of these communities do not have the resources to improve the treatment system or comply with new discharge regulations. While most wastewater treatment plants are fully automated, including small plants, their susceptibility to failure are high and their ability to quickly recover and resume operation are low. In this project the research team will be developing an innovative smart monitoring and control system to provide early detection of wastewater treatment system failure at small facilities and low-cost, remote monitoring and control systems for small, decentralized wastewater treatment systems.

Water reclamation and reuse is not new, but discussions about new paradigms in water reuse, such as direct potable reuse, are accelerating across the country. Thus, when the source of water is explicitly impaired and it is destined to become drinking water, or even water for other beneficial applications, monitoring of water quality, early warning of treatment system failure, responsive operation, and an informed public are all critical to securing future water resources and protecting the public and the environment. A smart sensor network supported by smart data acquisition/processing and system-learning programs will ensure that next generation wastewater treatment systems can operate sustainably and continuously without negative impact on people and the environment. More than ever, plant operators and the public are highly informed and must have better tools to understand water quality and economics of domestic water reuse, and the negative impacts of water contamination. The human-centered system that will be developed through this project will provide these tools and stimulate energy efficiency system behaviors.

A unique testbed will be used to conduct this research. It consists of an advance sequencing batch membrane bioreactor (SB-MBR) hybrid system treating >7,000 gal/day of real domestic wastewater. The research team will use this platform to integrate existing and new wireless sensor networks to monitor water quality and for process monitoring and control, to facilitate and test the development of a smart data acquisition/processing and self-learning control system. The smart service system will enable early warning of wastewater treatment plant failure, thus preventing long-term recovery and negative impact on community services. The testbed has five distinctive components: a demo-scale, advanced water reclamation system, a novel sensor network incorporating cutting edge analytical probes and instruments, a novel data processing and self-learning control system, energy management optimization module, and a public interaction center. It will also enable treatment of water to different end quality to produce water for different reuse applications (i.e., tailored water reuse). This new generation, smart system for tailored water reuse will have flexible and adaptable control systems that utilize new, smart sensor technologies, which interact with each other, learn from past performance, and can predict future performance and adapt the system to achieve preset objectives. After testing the new monitoring and control system at a demonstration scale, the team will work with their industrial partners to deploy, incorporate, and test the novel system at existing, decentralized treatment plants.

This project is led by the Colorado School of Mines (Department of Civil & Environmental Engineering and Department of Electrical Engineering & Computer Science) and Baylor University (Department of Applied Mathematic and Statistics). Aqua-Aerobic Systems (AAS), Inc. (Rockford IL; small business) and Kennedy/Jenks Consulting (San Francisco, CA; small business) are the primary industrial partners. Additional broader context partners include GE Power & Water (Boulder, CO), Ramey Environmental (Firestone, CO), and Southern Nevada Water Authority (Las Vegas, NV).

Cycladex

Program: SBIR Phase II

NSF Award No.: 1555601

Award Amount: $712,215.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: An Economic, Sustainable, Green, Gold Isolation Process

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is the potential to change the way gold mining is carried out by improving the process economics and reducing the environmental impact of mining operations. Current gold isolation methods involve the consumption of vast quantities of sodium cyanide, where cyanide is contained in large tailing dams, posing an environmental threat as exemplified by documented breaches. In the United States there are gold deposits which have not been exploited because of technology limitations and environmental concerns. The technology being developed in this project will improve the profitability of existing mines, as it can be employed with only minor changes in plant design. It will also but will also lead to new jobs. Another opportunity is to extract gold from copper tailings dams. The proposed technology will potentially make cleanup of these sites profitable and can be applied worldwide. In the longer term, the process could be adopted in third world countries which still rely on mercury which pollutes, not only the environment, but also the food chain.

The objectives of this Phase II research project are to (i) scale up the extraction of gold using both the heap and vat leach processes, (ii) optimize the crystallization of Au(III) in the presence of the natural product á-cyclodextrin, and (iii) isolate the gold. For heap leaching, it is proposed to operate at the 400-MT level, concentrate the gold salt and crystallize the gold-cyclodextrin complex. Scale-up will require designing the process to utilize existing equipment (built originally for the sodium cyanide process) and introducing new chemicals. For vat leaching, a small pilot system will be built to accept crushed ore as the feed, and the resulting gold-containing extract will be taken through the crystallization process. Optimization of the leaching agent, mass transfer, kinetics and materials consumption will be ongoing. Regulatory approval for vat leaching, once secured, can be applied on-site globally to demonstrate the environmental and economic benefits of the process. This technology has the potential to significantly make existing and new mining operations more environmentally sustainable.

Duke University

Program: PFI:BIC

NSF Award No.: 1632069

Award Amount: $996,363.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Program Director:
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Topic: Chemical and Environmental Technologies (CT)

PFI:BIC - A Smart, Flexible, Large-Scale Sensing and Response Service System (LASSaRESS) for Monitoring and Management of Ground, Air and Waterborne Contaminants

Oil leakage from underground cable systems leads to environmental damage and economic loss. World-wide, the impact is estimated at $2 billion in direct economic losses. When environmental and productivity costs are considered, the total harm from underground oil leakage is estimated to be much higher. The goal of this project is to develop a cost-effective, scalable, smart underground oil leak location system that can be modified to serve a host of applications in leak detection and pollution measurement including applications in gas leak detection, water leak detection, and pollution monitoring. The techniques developed through this project have the potential to improve future generations of distributed networked sensors through application of cloud computing technologies. This new smart system, when implemented to detect underground leaks, and more generally, pollutants is expected to make significant, positive environmental impacts. Given the team's past successful work in underground oil leak detection and mitigation, an immediate impact in scaling oil leak detection is expected. At the same time, the mini-mass spectrometers can in the future be configured to monitor many contaminants, thereby addressing a variety of environmental challenges.

Project objectives are: 1) build the core smart system components, 2) develop core algorithms and build the smart system test bed, and 3) validate the test bed functionality in the field. First, mini-mass spectrometers will be fabricated, and a dynamically configurable cloud computing network will be developed with the goal of connecting multiple mini-mass spectrometers into an analytical system to collect leak source data. Collected data will be analyzed and leakage locations will be identified based on distributed sensor readings using an algorithm developed to dynamically optimize sensor positioning and identify leak location. Finally, the smart system will be implemented in the field to monitor a controlled, low-level, perfluorocarbon tracer leak. The expected outcome of this program is a low cost, self-configurable, highly flexible, mobile system that can locate leaks and contaminants with minimal human intervention.

The team consists of faculty at Duke University (Pratt School of Engineering, Nicholas School of the Environment, and Psychology and Neurosciences), and staff at UNC's Renaissance Computing Institute (Chapel Hill, NC) as well as industry partners, PFT Technology, LLC (Bellmore, NY; small business). Duke's team combines material science, computer engineering, mass spectrometry, behavioral science and commercialization expertise. RENCI brings expertise in the latest cyber tools and technologies. Our industry collaborator, PFT Technology, LLC is recognized internationally as the leader in the field of perfluorocarbon-based leak detection, demonstrating successful leak detection programs for utilities in both the U.S. and the U.K.

The project will impact multiple levels of students. Two PhD students (Duke) will be employed by the project. Professional Masters and PhD students in the Nicholas Environmental Innovation and Entrepreneurship Certificate Program (Duke) will, through their coursework, actively follow the progress of this research program to learn important aspects of translational research activities. Undergraduate students in Duke's Pratt School of Engineering Pratt Fellows and Grand Challenge Scholars programs will be offered opportunities to work on the project through these programs. This project will also engage students and faculty at Jordan High School by offering engagement opportunities such as independent study or science fair projects.

Ecovia Renewables, Inc.

Program: SBIR Phase II

NSF Award No.: 1660217

Award Amount: $749,929.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Efficient Production of a High Performance and Eco-Friendly Superabsorbent Microbial Biopolymer for Hygiene Applications

The broader impact/commercial potential of this Small Business Innovation Research Phase II project includes tremendous commercial potential, societal benefits, and scientific advances. Conventional superabsorbent polymers (SAP) are based on polyacrylates or polyacrylamides derived from petroleum feedstock. They are widely used in the absorbent cores of hygiene products, with disposable diapers representing approximately 85% of the global SAP market of $6B. Increasing consumer and supply chain demand for more natural, sustainable materials and products has driven the development of eco-friendly / natural labeled absorbent hygiene products (AHP). Eco-friendly diaper products currently make up about 3% of the global market and are experiencing strong growth at 10-15% compound annual growth rate (CAGR). This project will lead to the commercialization of a low-cost high-performance biobased SAP, offering significant environmental benefits as a more sustainable, eco-friendly alternative to petrobased SAP. This project could also generate positive economic impacts on domestic agriculture by creating new demand for bio-feedstocks such as waste glycerol. Finally, this project advances the scientific and technological state-of-the-art by developing a new bioprocess based on microbial co-cultures that could be extended to render more efficient, cost-effective routes for producing other biobased fuels and chemicals.

The objectives of this Phase II research project are to develop a new biological route, based on microbial co-cultures, for cost-effective production of gamma-polyglutamic acid (PGA) and to commercialize cross-linked PGA SAP for AHP applications. In Phase I of this project, a microbial co-culture process was developed for efficient production of PGA via in-situ precursor production (ISPP) from low-cost bio-feedstocks. materials. Building on promising results in Phase I, further R&D will aim to reach pilot-scale production by the end of Phase II. Three specific technical objectives will be pursued: Objective 1: Strain engineering and bioprocess optimization to develop an ISPP fermentation process with commercially viable performance metrics. Objective 2: Optimization of downstream purification, SAP cross-linking, and finishing to produce a high performance finished PGA SAP product. Objective 3: Pilot-scale process demonstration to produce commercial quantities of PGA SAP for large scale customer/partner trials. This R&D plan will lead to transformative technological outcomes. The proposed process based on microbial co-cultures represents a distinct shift from the conventional paradigm of utilizing single-species monocultures for bioprocessing and offers substantial cost-savings. The engineering and process development strategies developed during this project will be transferrable for a broad range of other co-culture bioprocessing applications.

EIE Materials, Inc.

Program: SBIR Phase II

NSF Award No.: 1534771

Award Amount: $885,626.00

Start Date: 08/01/2015
End Date: 07/31/2017

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Novel Compositions for Narrow Bandwidth Light Emitting Diode Phosphors

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the development of a novel phosphor material system that drives up to a 20% improvement in energy efficiency of phosphor-converted LEDs (pcLEDs) over current state-of-the-art phosphor material systems in nearly all pcLED applications. The market for LED phosphors in 2012 was roughly $500 million and is expected to reach $1.2 billion by 2016. The 20% improvement in the packaged LED efficiency will also trigger a cascade of tangible impacts at the end-product system level such as using fewer LEDs, increasing efficacy (lumens per watt) and mobile device battery life, reducing electronic driver complexity, reducing heat, a thinner form factor, and a far more brilliant color gamut. The anticipated results from this grant will satisfy the 2020 goals for down-converting materials laid out in the U.S. Department of Energy's 2013 Multi-Year Program Plan, bringing these efficacy and efficiency goals and standards to market four years ahead of schedule.

This Small Business Innovation Research Phase II project aims to further develop a novel and proprietary phosphor material system for use in phosphor-converted light-emitting diode (pcLED) applications that will improve pcLED efficacy up to 20%. In display backlighting, 20-40% of the light emitted by the state-of-the-art phosphors miss the sweet spot of the display's color filters resulting in unused light and wasted energy. Similarly, in general lighting approximately 15% of the emitted light falls outside the visible spectrum, again resulting in wasted energy. The technology developed is a phosphor material utilizing a novel chemistry that exhibits a narrow light emission spectrum to increase LED brightness and energy efficiency by 10-20% in display backlighting and up to 15% in general lighting applications. Prototype materials have been synthesized that exhibit a narrow emission peak at target wavelengths, and the next steps include optimization and characterization of the most effective compositions. The anticipated results of this project are narrow-band phosphor materials that exhibit performance and reliability characteristics commensurate with industry standards.

framergy, Inc.

Program: SBIR Phase II

NSF Award No.: 1632486

Award Amount: $728,083.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: A Novel Metal-Organic Framework Material for the Separation and Recovery of Unprocessed Natural Gas During Oil and Gas Production

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to provide a usable stranded and associated gas collection capacity for oil & gas exploration companies. During drilling operations, valuable gas is lost through intentional venting and flaring, causing losses in natural gas delivered to the power plant or city gate. With the sector's expansion into more remote low-volume sites, these losses are increasing dramatically. Through this project's proposed novel Metal-Organic Framework (MOF) based storage technology, this project seeks to deliver a re-usable and transport ready intermodal container, to store gas at low pressure, eliminating the need to use expensive gas capture, purification and multi-stage compression systems. An economically feasible unprocessed natural gas storage technology would provide a useful tool for the domestic oil & gas industry in capturing what would be flared or vented and delivering it to the American economy. Taking the proposed novel MOF technology to the bench and pilot scale will show the feasibility of a flexible, transportable, low-cost infrastructure to abate flaring and venting. Successful developments in this project will help develop the knowledge for scale-up to large-scale vehicular tanks to allow for commercial implementation.

The objectives of this Phase II research project are the development of stable and low-cost Metal-Organic framework (MOF) based storage technologies for the collection of usable stranded associated gas during drilling operations. In order to harness point source emissions, before being vented or flared, the project will develop a nano-engineered, MOF based sorbent for low-pressure capture and storage of unprocessed natural gas. The project will seek to develop a robust and scalable method to synthesize new MOFs containing other high-valence transition metal ions such as Al3+, Fe3+ and Cr3+. Furthermore, the project will screen a range of organic ligands for improving MOFs' surface property and storage capacity. Finally, by following alternative synthesis routes with low cost catalysts, the project will identify sorbent synthesis cost reduction strategies. The sorbent material will be tested with simulated vent/flare-gas compositions in a cyclic pressure range and the sorbent stability will be verified by an assortment of X-ray, spectroscopy, and microscopy methods. Following sorbent development, an ANG tank will be built and flare gas slipstream testing will be conducted in shale gas sites.

Glucan Biorenewables, LLC

Program: SBIR Phase II

NSF Award No.: 1632394

Award Amount: $749,373.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Catalytic Conversion of Lignocellulosic Biomass into Furfural and Dissolving Pulp using Green Solvents

The broader impact/commercial potential of this Small Business Innovation Research Phase II project provides a technology platform to convert non-food biomass, such as wood and corn stalks, into biofuels, chemicals, and bioproducts. Biomass utilization is a solution to increase global sustainability and decrease petroleum-based greenhouse gas emissions. This project will use wood biomass to simultaneously co-produce three high-end products, dissolving pulp, furfural, and technical lignin, of which the dissolving pulp and furfural are the focus of this project. Current methods of producing these products only use one of the three primary biomass components. By co-producing two products, revenues increase and unit production costs decrease as production costs are spread over a larger product volume. The use of this solvent obtained from the biomass is a unique approach in the biomass conversion industry and offers an alternative to conventional enzyme or microbial processing. Benefits include restoring furfural production in the United States, decreasing dissolving pulp production costs, and increasing the commercial value of renewable biomass that currently has low or no value. This sustainable and environmentally friendly technology will increase global sustainability and revitalize rural economies by stimulating investment and creating jobs.

The objectives of this Phase II research project are to demonstrate and advance to pilot scale our technology to simultaneously co-produce dissolving pulp and furfural from biomass using gamma valerolactone (GVL) as solvent. While other technologies focus on the production of a single product from biomass, GVLs' ability to fractionate lignocellulosic biomass into its three main components (cellulose, hemicellulose, and lignin) at high concentration and purity, produce significant cost and technical advantages. GVL fractionation produces solid cellulose at high yield (>90%) and purity (>90%), without the need for pre-treatment or further chemical refining. This cellulose can be converted into dissolving pulp for high-end applications such as textiles (rayon), cellophane, or microcrystalline cellulose. The hemicellulose fraction does not need to be separated from the GVL and is readily converted into furfural within GVL at high yields (>75%) and high concentrations, minimizing separation costs. Preliminary mass and energy balances and techno-economic modeling based on lab data predict attractive financial returns. Tasks will focus on biomass fractionation to produce dissolving pulp, furfural purification, and GVL recovery at bench-scale. This experimental work will inform the engineering development for an integrated, continuous process, pilot demonstration unit.

Ground Fluor Pharmaceuticals, Inc.

Program: SBIR Phase II

NSF Award No.: 1353246

Award Amount: $871,310.00

Start Date: 04/15/2014
End Date: 06/30/2017

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: PET Radiotracer Synthesis

This Small Business Innovation Research Phase II project develops positron emission tomography (PET) imaging products to manage neurodegenerative disorders, cancer, and cardiovascular disease. PET is now a key diagnostic and management tool in oncology, and compounds labeled with [18F]-fluoride provide optimal signal to noise ratios and resolution in medical imaging applications. Ground Fluor Pharmaceuticals (GFP) developed proprietary single-step fluorination technology that allows [18F]-labeled medicines to be prepared efficiently from cyclotron-produced [18F]-fluoride. Under this Phase II research project GFP will apply its new technology to produce the imaging agent 6- [18F]fluoro-L-DOPA (FDOPA), a compound useful in diagnosing Parkinson's disease and in cancer imaging, that is not currently readily available because of the difficulty in its production. GFP will scale-up and manufacture pharmaceutical grade ALPDOPA (GFP's precursor to FDOPA) under pharmaceutical cGMP conditions, and offer this material for research studies and for clinical imaging. GFP will develop an FDA drug master file and will provide technical and regulatory assistance to cyclotron pharmacy customers adopting GFP's technology for commercial production of FDOPA. In addition to helping to bring this valuable imaging agent to market, GFP will assist academic and pharmaceutical research groups in the development of new [18F]- fluorinated imaging products.

The broader impact/commercial potential is to expand the scope and utility of PET as medical diagnostic tool, thereby improving treatment and management of serious medical problems. Although [18F]-fluoride possesses, perhaps, the most advantageous properties for imaging, is relatively inexpensive, and is widely available, it is difficult to incorporate into medicines for imaging. GFP has developed a general enabling technology that uses the relatively inexpensive and widely available form of [18F]-fluoride to create new molecular imaging agents to advance personalized medicine. This technology, and the compounds it creates, will provide the physician with new opportunities to diagnose, assess, and more efficiently treat unmet medical needs. The manufacturing technology developed here is a broad platform applicable to the preparation of a wide range of new imaging agents. The commercial potential of PET imaging is significant; the worldwide market for PET is expected to grow to $15 billion by 2015.

Kepley Biosystems, Inc.

Program: SBIR Phase II

NSF Award No.: 1555752

Award Amount: $937,217.00

Start Date: 03/01/2016
End Date: 08/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: A New Sustainable Crustacean Bait

The broader impact/commercial potential of this Small Business Innovation Research Phase II project promises to deliver a convenient, sustainable, cost effective, and environmentally friendly bait for crustacean fishermen, worldwide. The patent- pending innovation offers a formulated, synthetic product that mimics scent cues released from traditional fish bait, while offsetting unwarranted ecological impacts of current practices. Specifically, scent cues can be released at variable rates to provide optimal results in addressing fishing methods and preferences in different conditions and regions. Given rising costs of fish due to competition with omega-3 supplements producers, as well as labor and frozen storage costs of obtaining wild bait, and vessel space needed for such bait when fishing, the new bait will save fishermen time, money, and inconvenience. Commercially, cost advantages are likely to generate significant demand in addition to the overall practical advantages. From a societal perspective, a sustainable, synthetic product can dramatically reduce "net fishing" for baiting crustacean traps. Thus, fish could be conserved in the oceanic food chain, and indiscriminate killing of sea turtles, dolphins and other by- catch would be diminished through reduced net fishing practices now employed in the capture of small wild fish traditionally used for crustacean bait.

The objectives of this Phase II research project are: to optimize solubility kinetics of the attractant-releasing matrix; further characterize naturally occurring molecules released by traditional bait fish; and validate product performance to catch indigenous crustacean species in the United States. Field research would focus on concentrations of chemo-attractants required to optimize manufacturing formulation and direct costs. The intellectual merit of the proposed activity will be the characterization of the chemical basis for cues emitted by piscine, avian and mammalian tissue that most intensely attract crustacean species while developing a range of matrix formulations for optimally releasing such attractants in various fishing conditions. In addition to globally urgent considerations of by-catch and wild stock depletion, the industry has been struggling with bait sustainability issues. These challenges have intensified with federal and state agencies seeking court orders to regulate catch limits, resulting in reduced supply and higher prices of bait fish. These circumstances frame an ecological and commercial opportunity for this synthetic bait alternative. Reducing the need to capture wild bait fish, as well as delivering cost and logistical advantages to commercial crustacean fisheries are expected to drive rapid market penetration upon completion of product research and development in this Phase II project.

Loci Controls, Inc.

Program: SBIR Phase II

NSF Award No.: 1632439

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Automatic Control of Landfill Gas Collection

This Small Business Innovation Research (SBIR) Phase II project seeks to improve the commercial viability of technology that enables the real time measurement and control of landfill gas extraction systems. It has the potential to improve the economics of the Landfill Gas to Energy (LFG-E) market and reduce the environmental impact of landfills. With industry-wide implementation, annual revenues from existing LFG-E projects could be increased by over $450 million. The additional energy produced would power over 350,000 homes. Methane is a powerful greenhouse gas (GHG), and the EPA estimates that in 2011, emissions from landfills accounted for nearly 17.5% of generation from all manmade sources in the US. The associated reduction in GHG emissions from improved landfill gas collection would be equivalent to the emissions of over 3.6 billion gallons of gasoline or 76 million barrels of oil. Furthermore, because of the improved economics, this Phase II project could encourage the development of new LFG-E projects, further expanding the size and value of this market. According to EPA estimates, currently undeveloped sites could account for an additional 850 MW of power generation, enough to power over 508,000 homes.

The technical objectives of the project are 1) to reduce the cost of various system components, and 2) to address new product requirements related to third party safety and other certifications that are demanded by the market. The approach to cost reduction is to replace several commercially available off-the-shelf components (specifically, NDIR gas sensors and an electrically-actuated control valve) with custom designed alternatives that can meet product functional requirements at a 30% reduction in cost. In order to achieve the certifications that are demanded by the market it will be necessary to define the specific standards and protection concepts that are applicable, and then re-engineer hardware in accordance with these standards. This will involve a combination of component substitution and system re-design, depending on the specific protection concept(s) and hazardous location classification that are identified. The research will build upon the reliability and product functionality improvements that were a key outcome of the Phase I project, and successful completion of the research goals will enable more widespread adoption of real time control technology in the landfill gas industry.

Mango Materials

Program: SBIR Phase II

NSF Award No.: 1256623

Award Amount: $1,395,197.00

Start Date: 02/01/2013
End Date: 07/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: A Novel Biodegradable Biopolymer from Waste Methane Gas

This Small Business Innovation Research Phase II project will use waste methane gas (biogas) as a feedstock to produce pellets of polyhydroxyalkanoate (PHA), a valuable polymer that is converted into a variety of high margin or high volume, eco-friendly plastic products such as childrens toys, electronic casings, water bottles, and food packaging containers. The current plastics market is dominated by petroleum-derived, non-biodegradable, energy-intensive plastics, which often persist in the environment upon disposal. Alternative plastics are derived from rapidly renewable biological resources (biobased) and consumed by microbes when no longer needed (biodegradable). Unfortunately, these alternative plastics are often costly to produce and their manufacturing process requires significant amounts of energy. Mango Materials has a novel, patented, energy-efficient method to produce a biodegradable, biobased polymer at a price competitive with petrochemical-based polymers. Phase II involves scaling the Mango Materials process to produce samples for customers to test while addressing associated challenges. Key goals are to optimize the production process and to verify that customers can process the product on existing manufacturing equipment. Key results include a more optimized process, customer validation of samples, a thorough understanding of polymer characteristics, and an updated cost and yield comparison.

The broader impact/commercial potential of this project will ultimately be the widespread production of low-cost bioplastics from waste biogas and the eventual displacement of petroleum-based plastics. Bioplastics have the potential to capture an increasing fraction of the plastics market, thereby giving consumers the choice to purchase affordable, environmentally friendly, bioplastic-based products. When products made from Mango Materials bioplastic are disposed in modern wastewater treatment plants or landfills, they biodegrade anaerobically (without oxygen) to methane. This methane can be cycled back and re-enter the process as feedstock to produce more PHA. Thus, the life cycle may be closed, creating a cradle to cradle system. This use of biogas will provide a strong economic incentive for facilities to capture their methane, rather than releasing or flaring it, which will reduce greenhouse-gas emissions and reduce corresponding impacts on global warming. The innovation will enhance scientific understanding by studying the production of bioplastic from waste biogas and by characterizing the microbial species responsible for this conversion. This project represents one of the first times that waste biogas will be used commercially as a feedstock for bacteria to produce a valuable product.

Membrane Technology & Research, Inc.

Program: STTR Phase II

NSF Award No.: 1632229

Award Amount: $729,221.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

STTR Phase II: New Perfluorodioxolane- and Perfluorodioxane-based Copolymer Membranes for Gas Separations

The broader impact/commercial potential of this Small Business Technology Transfer Phase II project is to produce a better natural gas treatment membrane that will allow end users to capture the ease of processing and environmental advantages of membrane technology at a substantially reduced price. Natural gas processing to remove CO2 and other contaminants is the largest industrial gas separation application with an estimated global separation equipment market of approximately $2-3 billion per year. At present, membrane processes have a 10% market share, while amine absorption processes account for the bulk of the market. Conventional membrane materials are limited by their relatively modest CO2/CH4 selectivity, which offsets their environmental and efficiency advantages. The novel perfluoro polymer membranes developed in this program show enhanced performance when treating gas mixtures at industrial relevant conditions. Study of these perfluoro polymer membranes will improve scientific understanding of structure/property relationships for a new family of materials. Most importantly, applied at a commercial scale, these new perfluoro membranes offer the potential to overcome the limitations of prior membranes, and thereby, transform natural gas processing.

The objectives of this Phase II research project are to complete the development of novel perfluoropolymer membranes for use in natural gas CO2 removal. During Phase I, membranes with superior CO2/CH4 separation performance compared to commercial membranes were identified in comparative high-pressure mixture tests. In Phase II, the research and development plan is to scale up production of the most promising perfluoro polymer. An optimized membrane based on this polymer will be made on a roll-to-roll production line and fabricated into membrane modules. These modules will be evaluated in laboratory parametric experiments and validation tested at an operating natural gas field site. Results from these tests will be used to update an economic evaluation of the perfluoro membranes compared to conventional technology applied to natural gas CO2 removal. Completion of these technical objectives will bring this advanced membrane technology to the cusp of commercialization.

Ohio State University

Program: PFI:AIR - TT

NSF Award No.: 1542995

Award Amount: $200,000.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Program Director: Barbara H. Kenny

Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Towards Commercialization of Potassium-Oxygen Batteries: Solving Safety Challenges

This PFI: AIR Technology Translation project focuses on translating a novel potassium-oxygen (K-O2) rechargeable battery technology to fill the increasing need for high performance batteries for transportation electrification and stationary energy storage. The K-O2 battery is important because it effectively provides better-than-Li-ion battery performance at less-than-sealed-lead-acid battery price. This novel energy-dense battery technology has the unique feature that its operation is based on the reversible one-electron oxygen/superoxide redox couple, which eliminates the need for high-cost electrocatalysts. This feature provides the following advantages: low cost, lightweight, high-energy efficiency and environmental friendly when compared to the foremost competing lithium-ion batteries and other metal-oxygen batteries in this market space. The technology would enable electric vehicles to travel longer ranges at affordable prices and solve the energy-storage problem on the electrical grid system when using intermittent renewable energies.

The project will result in a prototype of potassium-oxygen battery pack. This will require investigation into the following technology gaps to translate from research discovery toward commercial application: developing moisture-responsive electrolytes, safe anodes alternative to potassium metal, and functional potassium cation selective membranes with low oxygen permeation for anode protection to improve the battery cycle life. The fundamental limitation of potassium-air batteries is the crossover of molecular oxygen from the cathode to potassium anode. This leads to the formation of potassium superoxide on the anode surface and reduces the availability of metal that can participate in energy storage. Therefore, designing alternative anodes and membrane electrolytes can solve the technical challenges in battery safety and lifetime. In addition, personnel involved in this project, including postdocs, graduates and undergraduates, will receive experiences in technology innovation, translation and entrepreneurship through the proposed research activities, prototype development and commercialization efforts.

Oklahoma State University

Program: PFI:AIR - TT

NSF Award No.: 1543047

Award Amount: $199,999.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Program Director: Barbara H. Kenny

Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Transitioning Explosive Sensing Technology to the Marketplace

This PFI: AIR Technology Translation project focuses on translating the development of a sensor that is based on nanoparticles that change color in the presence of vapors from improvised terrorist explosives and the hydrogen peroxide used to manufacture them. The sensor is important because it improves public safety through a cost-effective way to detect peroxide-based explosives, as well as hydrogen peroxide itself during transportation spills or other accidental release events. The project will result in a prototype electronic "area sensor" that has high sensitivity coupled with high selectivity for peroxide based explosives using simple electronics and a color-changing sensor. These features provide significantly enhanced performance and major cost-savings when compared to the leading competing explosive sensing technologies in this market space.

Under this project, the best methods for preparing sensing films will be determined and the response of the sensing films with hydrogen peroxide and the improvised explosive triacetone triperoxide (TATP) will be explored. This will provide critical information for the design of the technology that lies at the heart of the prototype sensor and is important for the commercialization of the sensor. The research will also lead to the completion of the design and fabrication of operational sensors using off-the-shelf electronics to keep costs low. In addition, there will be an assessment of potential interferents to ensure that these don't pose problems in sensor commercialization. In addition, personnel involved in this project, including undergraduate and graduates students, will receive entrepreneurship and technology translation experiences through group meetings, workshops, and an entrepreneurship program. The project engages XploSafe, LLC to provide test environments and to guide the commercialization of this technology translation effort from research discovery toward commercial reality.

Picoyune, LLC

Program: SBIR Phase II

NSF Award No.: 1632560

Award Amount: $740,159.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Inline Plasmonic Mercury Monitors for Natural Gas Processing

This Small Business Innovation Research (SBIR) Phase II project will develop a robust, in-line plasmonic sensor for the detection of mercury in natural gas. Mercury naturally contaminates natural gas at the parts per million levels and can corrode critical aluminum components in processing facilities. Heat exchangers at Liquid Natural Gas (LNG) plants have failed catastrophically due to mercury corrosion, costing hundreds of millions of dollars of damage and injuring workers. Current monitoring methods cannot operate at the high pressures found in the process gas lines, leading to inaccurate measurements and unreliable instruments. LNG is a growing share of global energy as natural gas replaces more carbon intensive fossil fuels. By 2020, 30 LNG plants will be operating world wide, for a total mercury monitoring market of $136 million. Mercury monitoring at petrochemical facilities broadly is a $216 million per year market. Mercury itself is a neurotoxin and a global pollutant; our sensor has the potential to aid in efforts to detect and remove mercury before it can impact human health. Beyond mercury, plasmonic sensing is a novel technology with applications for a variety of chemical and biological species.

The intellectual merit of this project derives from the utilization of a novel sensing platform based on the localized surface plasmon resonance (LSPR) of a gold nanoparticle film. It will build upon the success of the Phase I project, which demonstrated the suitability of LSPR sensors for the detection of elemental mercury vapor. This Phase II project will proceed along two objectives. The first objective will be to adapt the sensor for operations at high pressure; included in this objective is the redesign of key components of the system and the construction of a high-pressure test bench. The second objective is testing the LSPR sensor in a natural gas matrix; preliminary results indicate that LSPR mercury sensors response well in methane, but the full range of response and lifetime performance will be investigated in this project. Upon completion of these two objectives, field trials will commence. The full system will be certified for use in a gas plant and demonstrated at a suitable natural gas plant. A commercial prototype LSPR based natural gas mercury monitor will be realized upon completion of this project.

PolyDrop

Program: SBIR Phase II

NSF Award No.: 1556434

Award Amount: $829,576.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Porous Conductive Polymer Nanostructures as Antistatic Additives for Coatings and Plastics

This Small Business Innovation Research Phase II project aims to continue the development of a family of new nanostructured conductive additives for use in high-performance coatings and composite resins. Static charge buildup from the environment is a critical problem in a number of vehicular applications, which increasingly utilize lightweight components constructed from non-conductive plastic or composite materials. Static charge buildup interferes with electronic components, such as distributed sensors, so that mitigation of this effect is essential for safe vehicle operation. The design of lightweight vehicles using composite materials, which requires high-performing antistatic coatings, will lead to large reductions in fuel consumption and carbon emissions in transportation. In 2011, emissions from transportation accounted for 28% of U.S. greenhouse gas emissions. Modern aircraft designs, utilizing composite materials, show more than 20% reduction in fuel consumption compared to traditional vehicles. Imminent increases in fuel efficiency standards in automobiles will also drive manufacturers to adopt the use of composite materials. The development of the proposed antistatic coatings is essential to enabling these new lightweight material technologies.

The new additives are based on the synthesis of self-assembling nanostructures from conductive polymers and structure-directing agents. When successfully incorporated in commercial paints and primers, the conductive properties of the coating are enhanced without compromising adhesion and durability. In this Phase II effort, we will further optimize these additives, based on key customer requirements, and develop a plan to scale up their production tenfold with reduced waste and production time. Corrosion properties for marine applications will also be evaluated, and the product portfolio will be expanded to address follow-on applications.

PolymerPlus, LLC

Program: STTR Phase II

NSF Award No.: 1534063

Award Amount: $868,357.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Program Director: Prakash Balan

Topic: Chemical and Environmental Technologies (CT)

STTR Phase II: Nanofiber Fabrication via Melt Coextrusion for Fuel Filter Membranes

The broader impact/commercial potential of this Small Business Technology Transfer Phase II project is to demonstrate a low cost, environmentally friendly co-extrusion fabrication method for producing high surface area micro- and nanofiber based nonwoven fuel filter sheets. The micro-/nanofiber nonwoven structures are fabricated from two different hydrophilic and hydrophobic polymers in a melt co-extrusion and subsequent exfoliation processing step. The resulting porous filtration media sheets have been shown to possess superior strength, tailorable pore sizes, and fuel filtration efficiency on par with currently utilized commercial fuel filter products. These accomplishments signify a path forward to a highly scalable manufacturing process for producing low cost thermoplastic filter products in addressing the increasingly stringent EPA regulation of ppm level water contaminant. The reduced manufacturing process complexity in melt co-extrusion is estimated to provide up to 60% reduced production costs when scaled to commercial production quantities. Additionally, a significant environmental impact will be realized through adoption of this novel production technology over competitive processes owing to its “greener” solvent-free manufacturing aspects that eliminates the annual need for millions of gallons of organic solvents and supporting reclamation equipment currently utilized by the filtration industry in creating elctrospun and wet-laid composite nonwoven filtration media.

The objectives of this Phase II research project are to fabricate nano/micro scale nonwoven fibrous filter mats for fuel filters via a novel melt co-extrusion approach, with high fuel/water filtration efficiency and superior mechanical properties, in a commercially relevant production scale, towards addressing the stringent EPA 2010 filtration regulations and its upcoming revisions in 2015. The first generation filter prototypes fabricated in Phase I STTR program exhibited up to a ten-fold increase in surface area, up to a two-fold increase in porosity and up to a six-fold the deformation strength of the commercial filters. The coextruded microporous filter fiber size distribution was comparable to a commercial melt-blown process sample and superior to the leading wet-laid technology samples. Preliminary filtration efficiency experiments on the coextruded micro-fiber filtration media prototypes exhibited 60 to greater than 80 % separation of water from ultra-low sulfur diesel as compared to 80 % water separation using commercial filter under same testing conditions. The commercial interest for the new multilayered, coextruded filtration media processing technique is centered on identification of new filtration media film polymer materials, achieving nano-sized pore distributions for improved filtration efficiency and achieving scale-up production cost savings through the improved filter film processing technique.

Precision Polyolefins, LLC

Program: SBIR Phase II

NSF Award No.: 1534778

Award Amount: $750,000.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Commercially Viable Ton-Scale Production of Stereoblock Polypropylene Thermoplastic Elastomers and XPURE™ Oils

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to use the transformational "living coordinative chain transfer polymerization" (LCCTP) technology of Precision Polyolefins, LLC (PPL) to produce new classes of polyolefins from readily available, inexpensive, and renewable chemical feedstocks and that can be used in the manufacturing of consumer products with superior performance to the benefit of society. More specifically, the commercial production of structurally-well-defined (precise) polyolefins, including stereoblock polypropylene (sbPP) thermoplastic elastomers, as replacements for technologically inferior polyolefins in adhesive and additives markets will serve to capitalize on the increasingly advantaged position of inexpensive propylene in the North America. The development of new technologies, such as LCCTP, will help the U.S. to regain its position as a world-leader in the discovery and commercialization of new polyolefin-based materials, and thereby, contribute to the future health and growth of the U.S. economy.

The objectives of the proposed Phase II research project are to address the needs for new commercial polymers against a back-drop of ever increasing consumer demand, a sluggish industrial response, and a limited pool of chemical feedstocks possessing high price and supply volatility from which they can be manufactured. The current project will seek to develop commercially-viable processes based on a living coordinative chain transfer polymerization (LCCTP) technology to provide a broad range of structurally-well-defined polyolefins that possess with superior properties relative to existing products. By conducting an in-depth investigation of polymerization catalyst structure / property relationships, the project will seek to optimize catalyst activity and thermal stability. In concert with scale-up process development, this catalyst optimization will lead to reduced material and processing costs, and a product portfolio of competitively-priced polyolefins with superior performance characteristics. Validation of an optimized scale-up process will be achieved through the ton-scale production of stereoblock polypropylene (sbPP) thermoplastic elastomers, for adhesive and additive markets, and low molecular weight proprietary oils, for cosmetics, lubricants, and adhesives markets. The anticipated result is that commercially relevant (> 1 kiloton) volumes of sbPP thermoplastic elastomers and proprietary oils can be manufactured as technologically and commercially viable products.

Protabit, LLC

Program: STTR Phase II

NSF Award No.: 1534743

Award Amount: $750,000.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Program Director: Prakash Balan

Topic: Chemical and Environmental Technologies (CT)

STTR Phase II: Development of a Computational Protein Engineering Platform and its Application to Methane Activating Enzymes

The broader impact/commercial potential of this Small Business Innovation Research Phase II project will combine computational protein engineering (CPE) software, tools and methods into a "platform technology" that enables new products and technologies in a wide range of scientific areas, including industrial enzymes, pharmaceuticals, therapeutics, medical diagnostics and bioenergy. This project will validate the CPE platform in an application that has both commercial and environmental value: engineered enzymes for utilizing methane as a feedstock. The engineered methane activating enzymes developed will open up numerous new biological routes to chemicals and fuels from natural gas, capitalizing on abundant domestic shale gas reserves and improving U.S. energy independence. This CPE enzyme technology has the potential to significantly decrease the capital cost of small-scale Gas-to-liquid (GTL) plant, enabling the capture and monetization of otherwise economically-stranded natural gas. In North Dakota, more than a quarter of the total gas produced is flared or vented, wasting a valuable natural resource and needlessly emitting greenhouse gases. By facilitating the conversion of stranded or flared methane to fuels and high-value chemicals, this research can help reduce carbon footprint and spur domestic manufacturing, investment, and job creation.

The objectives of this Phase II project are to develop and license a CPE Platform technology that will enable experimental biological scientists to harness the power of computational protein design and engineering; to validate the CPE Platform technology by engineering novel methane activating enzymes that have increased soluble expression and methane-oxidizing activity; and in collaboration with potential licensees of this technology, work to incorporate the engineered enzyme into their industrial host organisms. These organisms will be enabled to use methane as a feedstock for the bio-production of a wide range of end products, including liquid transportation fuels, commodity chemicals and high value fine chemicals. In Phase I, the Northwestern-Caltech-Protabit team succeeded in engineering the particulate MMO (pMMO) catalytic subunit (spmoB) to allow it to be solubly expressed in E. coli. This was the first demonstration of an active methane-oxidizing enzyme that can be solubly expressed and purified in significant quantities in a genetically-tractable recombinant host. Phase II will continue this work, with the objective of making the spmoB enzyme more effective by increasing its activity and solving certain other challenges for inserting it into an industrial host.

Proton Energy Systems, Inc.

Program: SBIR Phase II

NSF Award No.: 1555871

Award Amount: $691,209.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Hydrogen Bromine Electrolysis for Highly Efficient Hydrogen-Based Energy Storage and High Value Chemical Applications

The broader impact/commercial potential of this Small Business Innovation Research Phase II project includes applications ranging from peak load shifting, grid buffering for renewable energy input, frequency regulation, and chemical conversions. As the percentage of energy from renewables on the grid increases, energy storage will be essential to stabilize the supply and demand. Currently, 20-40% of wind energy is often stranded due to the inability to capture the energy in the peak generation periods. Germany, Europe, Japan, Korea, and other countries are funding significant efforts in energy storage projects. Energy storage is also a critical need for all of the United States armed services, including microgrids for forward operating bases. While batteries can demonstrate very good round trip efficiencies, they suffer from self-discharge, capacity fade, and high cost. Flow batteries separate the reactant and product storage from the electrode active area, enabling higher capacities through merely adding more storage. Many systems have not been practical in the past due to low energy density values, but fuel cell and electrolysis developments have provided pathways to higher energy density. Advances in these areas would find immediate commercial interest, and address key strategic areas related to energy security and grid stabilization and resiliency.

The objectives of this Phase II research project are: 1) flow field design for balanced fluid distribution in both operating modes and minimization of shunt currents; 2) selection of catalysts and membranes for reversibility, durability and efficiency requirements; 3) integration and testing of Proton components with the Sustainable Innovations embodiment hardware; 4) scale up to a full size stack and operation in both modes at SI; and 5) development of a performance model in collaboration with SI based on the final configuration. These objectives address present limitations in energy storage solutions. While traditional batteries can demonstrate very good round trip efficiencies, they suffer from self-discharge, capacity fade, and high cost. Flow batteries separate the reactant and product storage from the electrode active area, enabling higher capacities through merely adding more storage. Many systems have not been practical in the past due to low energy density values, but fuel cell and electrolysis developments have provided pathways to higher energy density. Advances in these areas would find immediate commercial interest, and address key strategic areas related to energy security and grid stabilization and resiliency. The anticipated result will be a highly efficient, durable flow battery system with high power density.

Provivi, Inc.

Program: SBIR Phase II

NSF Award No.: 1556064

Award Amount: $737,990.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Enzymatic Synthesis of Insect Pheromones

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is a breakthrough in insect control for the agricultural industry. Provivi, Inc. intends to develop biosynthesis technology for producing insect pheromones, with a dramatic reduction in the cost of goods sold compared to existing syntheses. This will enable the use of pheromones beyond niche markets such as fruits and nuts: the target market for Provivi's pheromone products are large acreage row crops. By introducing pheromone-based control as an inexpensive alternative in these markets, we are meeting a growing demand as conventional insecticides are becoming increasingly incapable of protecting crops due to insect resistance, regulatory constraints, and detrimental effects on beneficial insects. The societal and environmental benefits of using pheromones are numerous: pheromones are considered the safest possible insecticides with respect to human food consumption as well as environmental impact. The U.S. Environmental Protection Agency has characterized them as low risk. Our pheromone products will benefit consumers by creating a safer food supply with lower chemical residues, growers by introducing an effective and novel pest control solution and the environment by reducing the chemical exposure to the ecosystem.

The objectives of this Phase II research project are to improve the selectivity and productivity of our prototype biocatalyst to target commercial performance, and to demonstrate pheromone synthesis from a cheap feedstock using this biocatalyst. PRovivi's proprietary biocatalyst utilizes a novel monooxygenase to catalyze a reaction not found in nature. The research product of this project will expand the scientific knowledge for this class of biocatalysts. Additionally, since this class of biocatalysts has not been optimized for commercial viability for the specific reaction of interest, this research program could provide impactful research learnings to achieve target commercial performance. These learnings include but are not limited to changes in the biocatalyst physiology, metabolic pathways and potential stress responses. This research could provide valuable knowledge for both commercial and academic biocatalysis research that utilize this class of biocatalysts.

Pyrochem Catalyst Company

Program: STTR Phase II

NSF Award No.: 1555958

Award Amount: $899,999.00

Start Date: 02/15/2016
End Date: 07/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

STTR Phase II: Scale-Up of An Innovative Spray Pyrolysis Process for Producing Pyrochlore Catalysts

The broader impact/commercial potential of this Business Innovation Research Phase II project is to commercialize Pyrochem Catalyst Company's (PCC) catalyst materials. These catalyst materials are unique in that the catalytically active metal is atomically dispersed in a rigid crystalline matrix. This imparts unparalleled thermal stability, even at temperatures in excess of 1000°C. Conventional catalysts typically require much higher precious metal loadings (as much as 20 times) to achieve the same activity as the materials developed in this project and at high temperatures those active metals can agglomerate into large clusters reducing their performance and the lifetime of the catalyst. The series of catalysts developed in this project are designed in a way that all precious metal is optimally utilized and protected. This includes resistance from sulfur poisoning and the accumulation of carbon when operating under severe conditions. This makes these materials ideal for high temperature processes such as steam methane reforming for hydrogen generation, autothermal reforming for syngas production, syngas generation in oxygen transport membranes (OTM), and exhaust oxidation in automotive catalytic convertors.

The objectives of this Phase II STTR program are to build on the success of the Phase I objectives that developed a low cost and continuous catalyst manufacturing method for producing the pyrochlore powders that are the basis for the proposed catalyst product. The method may be equally effective for producing other types of mixed metal oxides like perovskites and fluorites. In Phase II, PCC will construct and test a scaled-up production platform, following the design elements of the proof of concept demonstrated in Phase I. The new unit will be designed to manufacture proprietary pyrochlore powders at a rate with a hundred-fold increase over production rates of the Phase I unit. The Phase II technical efforts also examine a range of catalyst synthesis parameters like oxidant gas concentration/composition, temperature distribution in the production unit, precursor residence times, synthesis solution chemistry, and optimizing heat and mass transport. Through a subaward, powders produced from the process will be characterized and tested for activity by the National Energy Technology Labs, Morgantown, WV. The overall goal of this project is the development of a high throughput / high yield manufacturing process that produces high performance catalysts for commercial sale.

Serionix, Inc.

Program: SBIR Phase II

NSF Award No.: 1256639

Award Amount: $1,023,587.00

Start Date: 02/01/2013
End Date: 02/28/2019

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Ion-Exchange Fiber Composites for Rapid and Selective Removal of Perchlorate from Water

This Small Business Innovation Research Phase II project will result in the continuing development of novel ultrafast, highly selective, high permeability ion-exchange fiber composites (IXFCs) for removing perchlorate from drinking water. The proposed material removes perchlorate 10-100 times faster than the best available technology and employs a low-cost production method compatible with widely available manufacturing equipment. Rapid contaminant removal is made possible by the use of micron-scale mass transfer distances; whereas commonly used beads and granular media are limited to much larger sizes resulting in drawbacks such as difficult containment and enormous pressure drops. However, IXFCs display both high permeability and self-containment due to their permanently intertwined, self-supporting structure. Serionix demonstrated the feasibility of this technology in Phase I and will continue in the Phase II with the following key goals: 1) optimization of ultra-high capacity IXFCs for perchlorate removal; 2) design/build IXFC purification cartridges for evaluation by industrial partners; 3) identify and validate chemistries for complimentary IXFCs that are selective for heavy metals such as lead and mercury; and 4) produce IXFCs at a pilot scale and develop strategy for commercial production.

The broader impact/commercial potential of this research is the development and commercialization of a low-cost technology enabling regulatory compliance and improved protection of human health. The first targeted application is perchlorate, which the EPA is set to regulate in drinking water by 2014. This represents only the first commercial opportunity for a platform technology with the ultimate potential to transform the industrial and residential water treatment landscape. Future applications may include ultrahigh efficiency water deionization, softening, and industrial wastewater recycling, personal protective equipment and clothing, and high activity solid acid/base catalysts. Dissemination of data and interpretation will contribute to improved understanding of mass transfer characteristics in fibrous sorbent materials used in both water and air treatment.

Symbios Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1256582

Award Amount: $1,151,436.00

Start Date: 02/01/2013
End Date: 10/31/2018

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Advancing a Novel Low-voltage Electric Arc Method to Oxidize Organic Material in Contaminated Water

This Small Business Innovation Research (SBIR) Phase II project will support the final development and commercialization of Symbios Technologies plasma treatment system to allow produced water in the oil and gas industry to be effectively treated, thereby allowing its safe discharge to surface waters or recycling to stimulate production in new wells, rather than being disposed of in injection wells. Produced water is the water brought to the surface, with or without hydraulic fracturing, along with the intended fuel products during extraction of oil, gas, and coal bed methane from formations underground. In general, produced water is contaminated with hydrocarbons, salts, and harmful microorganisms, meaning that it must be treated before it can be discharged or reused for agriculture and other purposes. This is an important environmental, public safety, and economic problem in the US. Research conducted during this project will be used to evaluate reactor improvements including process sensors and control systems, electrode geometries and surface coatings, degradation of contaminants in produced water, field testing, and techno-economic modeling. The anticipated technical results are that the Symbios plasma system will degrade hydrocarbon contaminants and kill microorganisms in frac flowback or produced water, leaving the waters suitable for safe reuse or discharge.

The broader impact/commercial potential of this project is that it will facilitate cleanup and reuse of a critical resource, water, in the oil and gas production industry, with crucial societal benefits for protecting the environment, guarding human safety, and keeping domestic energy costs down. The proposed technology is based on an innovative, low-voltage plasma discharge that creates powerful oxidizing species for destroying biological and chemical contaminants in produced water. Symbios Technologies has developed relationships and executed agreements with key companies in the produced water treatment field, which have identified numerous near-term business opportunities and provided crucial insights into preparing the technology for commercial success during Phase II. The customer-centered emphasis on solving water contamination problems in the oil and gas industry, which was estimated to have a global market size of $45 billion in 2010, will result in a high likelihood for commercial success. The Phase II R&D plan will enhance scientific and technical understanding as well as commercial impact by addressing reactor improvements pertaining to corrosion resistance and automated operation for a market-ready system, treatment of microbial and organic contaminants in produced water, on- site testing, and demonstration of economic competitiveness of the developed system.

TeraPore Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1430723

Award Amount: $1,412,318.00

Start Date: 09/01/2014
End Date: 02/28/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Asymmetric Block Copolymer Membranes for Ultrafiltration

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project addresses the high costs of manufacturing protein therapeutics, or biologics. Biologics are a growing category of therapeutic that can treat a range of diseases from rheumatoid arthritis to ulcerative colitis to Alzheimer's. Unfortunately, producing these highly effective therapeutics is extremely expensive, with most of the cost stemming from the purification of the target protein from a complex mixture. This Phase II project aims to develop a new filter device that makes purifying biologics faster and cheaper. The filter media will increase overall throughput, thereby easing bottleneck steps in the purification process. In addition to decreased manufacturing costs, the expedited purification also increases the overall capacity of the manufacturing line. This high throughput filter device is designed to fit seamlessly into existing purification modules, making it easy for end users to increase production efficiencies.

This SBIR Phase II project aims to dramatically improve the performance of ultrafiltration membranes used in protein separations. Currently existing ultrafiltration membranes suffer from either prohibitively low throughputs or broad pore sizes, limiting their efficacy in separation processes. This project takes advantage of a unique class of polymeric materials, known as block copolymers, to make membranes that overcome the previous structural limitations. Namely, the block copolymer membranes have very high throughputs and very uniform pore sizes. These important features are possible due to the distinct ability of block copolymers to self-assembly into periodic, ordered structures with length scales relevant for protein separations. Using a combination of block copolymer self-assembly and non-solvent induced phase separation, membranes with targeted pore sizes can be made in scalable way. The research objectives for this project are to increase the porosity of the supporting block copolymer material, attach the block copolymer membrane to a fabric backing, evaluate the performance of assembled membrane sheet stock, and package the sheet stock into a device configuration. Accomplishing these research objectives will result in a mechanically robust, easy to implement membrane material that can increase the rate of protein filtration by 3-10 fold.

Tetramer Technologies, LLC

Program: SBIR Phase II

NSF Award No.: 1330948

Award Amount: $1,149,989.00

Start Date: 09/15/2013

End Date: 04/30/2017

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Program Director: Anna Brady-Estevez

Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Commercialization of Innovative Low Refractive Index, High Temperature Perfluorocyclobutyl Polymers

This Small Business Innovation Research Phase II project will determine the technical feasibility and the commercial value proposition for high temperature, highly processable fiber optic coatings across a range of markets to include fiber lasers, fibers for oil and gas, avionics fiber, and medical fiber. Tetramer will perform research to modify the structure of polymer coatings to provide enhanced performance which will extend the capabilities of current fiber optics. Coatings developed will advance our understanding of structure property relationships and establish new boundaries for the polymer system. During this program, Tetramer will synthesize new monomers and polymers and evaluate their properties for use as fiber coatings. At the end of this program, Tetramer anticipates it will have developed 3 new types of polymers with a set of performance characteristics which are not available from any one single material today. New fiber coatings will be developed which are capable of operating at temperatures above 300 deg C, having greater processability, and for laser applications, having lower refractive indices.

The broader impact/commercial potential of this project will impact society in many ways due to the various markets in which the coatings can have a meaningful impact on the optical fiber performance. Fiber optic lasers are quickly becoming the preferred method for laser fabrication. By enabling fiber lasers to operate at higher temperatures, fiber lasers will immediately see increased output powers and longer service lifetimes. With applications in industrial metal working (welding, cutting, and engraving/marking), micromachining, and medical devices, doubling power output via improved coatings will have a major impact across many industries. Higher temperature fiber coatings will improve down-hole drilling and the overall efficiency of oil drilling operations through better temperature monitoring in deep wells. This has the potential to lower prices of oil and increase oil production. Additionally, these fibers can aid in geothermal well monitoring which would provide a green source of energy. The coatings under development have the potential to generate increased revenue and profit throughout the value chain through increased performance of products and enhanced market sizes through enhanced capabilities. Tetramer will also use this Phase II program to train undergraduate and graduate level students from nearby Clemson University

Tetramer Technologies, LLC

Program: SBIR Phase II

NSF Award No.: 1555998

Award Amount: $658,688.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: New Crystallization Modifiers for Low Calorie Fats in Food Products

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to facilitate the commercialization of low fat replacement EPG technology to help solve some of the largest obesity and related health issues facing the US while providing a patentable new additive platform for the $600 billion food industry. With high caloric density foods being the primary cause for the obesity epidemic, the facilitation of rapid development of 92% lower calorie fat replacers such as EPG will have a powerful impact on the health of a large portion of society, reducing health care cost for US citizens and providing a positive economic impact for the US. The highest initial impact will be the introduction of additive modified EPG fat replacers to the confectionary segment where the need for decreased caloric content is greatest due to the absence of compatible low-calorie fats. Locally, the development of this technology will result in growth of 20 + high technology jobs in South Carolina. During Phase II, Tetramer will work with undergraduates and high school students through the NSF Phase II supplemental programs, which have trained 25 undergraduate students and 9 high school students who have all gone into STEM careers.

The objectives of this Phase II research project are to provide critically needed additive control technology to allow the dramatically reduced caloric intake (up to 92%) of esterified propoxylated glycerol technology (EPG) to be used in many food products that today contain high calorie natural fats and oils. During Phase I activities, Tetramer discovered that the new EPG approach to mitigating the growing obesity epidemic in the US was hampered by the fact that being a new technology EPG processes differently than high calorie fats such as palm kernel oil or cocoa butter. This creates a manufacturing mismatch for a significant number of the products in the projected $2.6 Billion fat replacement market. To date the commercially available additives do not work, thus requiring a new additive molecular architecture “toolbox” to optimize the processing variables. Tetramer will use it’s synthetic organic chemistry and material science expertise to synthesize and optimize additives that will allow EPG’s to provide 92% lower calories, while still maintaining the same sensory, physical properties and processing efficiency as the natural oils they will replace. End use applications will be developed through collaborations with food industry leaders.

ThruPore Technologies

Program: SBIR Phase II

NSF Award No.: 1534759

Award Amount: $881,749.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Increasing Production of Palladium Supported on Hierarchically Porous Monolithic Carbon Catalysts

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is that the palladium on hierarchically porous monolithic carbon catalyst being developed promises longer lifetimes and higher performance to industrial chemical companies. This more active, more selective catalyst can lower the operating temperature in chemical reactions thereby decreasing energy usage and giving products with fewer impurities, requiring a smaller number of purification steps and producing less waste. Success will therefore impact both ecological and commercial sustainability in the chemical industry.

The objectives of this Phase II research project are 1) demonstrate that the carbon support is scalable while maintaining the mechanical properties needed for industrial use, 2) scale loading the palladium catalyst onto the support, 3) exhibit the same high catalytic performance as the laboratory prepared catalyst, and 4) enter full scale production while setting up a quality system. The catalyst to be produced at large quantities represents the first of a new class of hierarchically porous catalyst supports and so further validation of this new product will provide the foundation for introduction of a broad class of catalysts with these superior properties. If successful, full scale manufacturing of this new class of catalysts will be pursued.

University of California, Berkeley

Program: PFI:AIR - TT

NSF Award No.: 1542974

Award Amount: $239,989.00

Start Date: 09/01/2015
End Date: 05/31/2017

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Program Director: Barbara H. Kenny

Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Robust and Selective Catalysts Based on Organic-Functionalized Delaminated Zeolites

This PFI:AIR TT project focuses on translating catalyst materials science research discovery within the area of delaminated zeolites to fill society's need for more environmentally friendly and economically efficient production of chemical products. Functionalized delaminated zeolite catalysts are important because they can result in significant savings in energy due to their higher efficiency and longer lifetime, ease of catalyst recovery, and recycling during processing. These catalysts also aim to replace toxic reagents, which can harm the environment when leaked in the case of an accident, with catalysts that are environmentally benign and pose minimal danger of leakage due to their solid nature. All of these reasons ultimately result in cost savings for the production of key chemical intermediates that go into everyday products such as plastic containers, coatings, and paints. The project will result in a proof-of-concept prototype of an organically functionalized delaminated zeolite material, which can function as a robust catalyst for chemical industry. This functionalized delaminated zeolite has the following unique features: resistance to leaching, high activity and selectivity in producing a desired product outcome of a chemical reaction, and long lifetime with minimal deactivation. These features provide cost savings, energy efficiency, and minimal environmental impact, corrosion, and toxicity, when compared to the leading competing industrial catalysts in this market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. The research specifically develops structure-function relationships involving catalysis on surfaces. An understanding of how heteroatom environment influences catalyst activity and selectivity within the context of delaminated zeolites is provided, which is an emerging area for this new class of robust solid catalysts. The research also investigates catalytic effects of confinement within the context of 2-dimensional layered zeolitic structures, a developing frontier that is distinct conceptually from conventional 3-dimensional confinement within bulk zeolite structures. In addition, personnel involved in this project, graduates and post-docs, will receive innovation and technology translation experiences as part of entrepreneurship activities, and as part of a team that is geared to conduct the work of this proposal and further technology in the area towards commercialization.

The project engages industrial partners who are leaders in the production of chemical products, by aiming to synthesize new materials that will better serve their needs by decreasing the cost and environmental impact of such production. These partners will augment research capability by providing testing of new materials under industrially relevant environments, which will be used to guide the technology translation effort from research discovery toward commercial reality.

University of California, Irvine

Program: PFI:AIR-RA

NSF Award No.: 1538813

Award Amount: $800,000.00

Start Date: 10/01/2015
End Date: 09/30/2018

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Topic: Chemical and Environmental Technologies (CT)

PFI:AIR-RA: Commercializing of a Molecular Analysis Platform for Plant Genomics in an Industry/University Ecosystem

This PFI: AIR Research Alliance project focuses on the translation and transfer of an integrated microfluidic based screening and testing analysis platform that has the potential to dramatically improve the efficiency and effectiveness of breeding plants. In the current agriculture biotech industry, genetic analyses of complex communities of plant cells are typically carried out in a homogenized, whole community fashion where the output is global information on the average state of the population of cells. This can mask the true extent of cellular heterogeneity that is present by averaging properties and potentially missing intriguing outliers. Molecular analysis at the single cell level would lead to better capability to develop enhanced strains of plant cells that thrive under various conditions. Thus there is a need for a tool that can provide single cell-molecular analysis in large populations, capable of high throughput while preserving heterogeneity information, and tailored to the agriculture genetics industry. The goal of this project is to develop such a tool by applying microfluidic lab-on-a-chip technologies for molecular and single cell analyses derived from the NSF I/UCRC "Center for Advanced Design and Manufacturing of Integrated Microfluidics" (CADMIM) where expertise and discoveries in the design, microfabrication, and manufacturing of microfluidic devices for cellular and molecular processing and detection are utilized. Not only will the proposed technology enable the single cell analysis, it also has the potential to lower the cost per molecular test by an order of magnitude over current methodologies. Current technology used in the agriculture biotech industry relies on discrete, bulky robotic systems that are time and labor intensive and require larger amounts of power, sample, and reagents resulting in much higher cost per test to analyze large numbers of samples.

The innovation ecosystem that will be enhanced includes CADMIM, UC Irvine, Johns Hopkins University, and DuPont Pioneer. The UC Irvine site of CADMIM brings microfluidic cellular manipulation, lysing, and micro-scale fluidic handling expertise. Johns Hopkins University brings microfluidic molecular processing and detection expertise. DuPont Pioneer, a leading developer and supplier of plant genetics to farmers worldwide, brings the plant genomic expertise and agriculture biotech business knowledge. Students and post-doctoral fellows from both universities will gain entrepreneurial and technology translation experience through their frequent interactions with DuPont Pioneer's technical team in understanding the current limitations in plant genotyping biotechnology, how a multi-continent international company works to solve large-scale problems, what is required for disruptive technology to displace current working technology paradigms, and how interdisciplinary teams communicate to develop cutting edge solutions.

This project addresses several technology gaps as it translates from research discovery toward commercial application. Plant cell genotype screening requires millions of cell-level verification tests and subsequent further massive molecular analyses of specific cell types. The current plant cell processing and molecular analysis platforms consist of multiple cumbersome and expensive cell processing machines that are time consuming and rely on skilled lab workers operating them in sequence. This greatly limits the throughput of cells being analyzed and makes it cost prohibitive for applications that require field-based plant seed sampling and testing. With the integrated microfluidic technologies developed in this project, the multiple steps will be integrated on a compact and potentially portable platform, using smaller liquid volumes to obtain faster results.

University of Massachusetts, Lowell

Program: PFI:AIR - TT

NSF Award No.: 1543042

Award Amount: $222,000.00

Start Date: 09/15/2015
End Date: 02/28/2017

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Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: A Versatile E-Tongue for In Situ Detection of Heavy Metals in Water and Sediments

This Partnership for Innovation: Accelerating Innovation Research Technology Translation project focuses on translating a modular and field deployable electrochemical sensing technology to fill the unmet need for rapid, low cost, and on-site characterization of toxic metals such as arsenic, cadmium, copper, lead, zinc, and mercury in water and sediments. This project will result in the development and field demonstration of a modular prototype "E-tongue" probe. This E-tongue probe will facilitate accurate, rapid, and cost-effective detection and quantification of heavy metals and have a direct impact on improving health and safety of humans. Standard spectro-analytical methods are expensive, bulky and require trained personnel for operation. The E-Tongue probe has the following unique features and advantages over existing laboratory and portable technologies, including: a) Portability and robustness, enabling rapid on-site testing; b) High sensitivity to detect multiple toxic metal ions below EPA specified maximum contamination limits; c) Integrated pH and temperature sensor for additional data and improved accuracy; d) User-friendly; and e) Low cost. By ascertaining levels of heavy metal contaminants at sites with sufficient accuracy in real-time, the E-Tongue probe can assist engineers to make onsite decisions, such as determining optimum locations for placement of monitoring wells, identifying hot-spots for sample collection for detailed laboratory testing, and adjusting field activity to control remediation options. It will also provide regulatory agencies with critical information so that they can take appropriate steps such as communicating drinking water advisories in a timely manner.

The project will result in the creation of a field deployable prototype E-tongue probe comprising an electrochemical sensor array, data acquisition/control and intelligent pattern recognition software. To develop the prototype, and move from research discovery to commercial application, the project will address the following technology gaps: 1) Simultaneous detection of multiple analytes, 2) Interfering compounds and electrode fouling, 3) Effects of temperature and pH, 4) Sampling challenges in the monitoring well and sediment testing systems. These technology gaps will be overcome by the use of multiple modified electrodes to enhance selectivity and sensitivity, elimination of interference and fouling through the use of appropriate sampling electrolytes and electrode protection strategies, integration of pH and temperature sensors to compensate for variations in pH and temperature, and incorporation of automated sampling systems. This project will provide the investigators, postdoctoral researcher and graduate student, the experience in transforming novel discoveries into prototype devices to solve real-world problems, as well as interdisciplinary, multicultural, global entrepreneurship experience through the Manning School of Business "Global Entrepreneurship and Innovation" program.

Geoprobe and K2 Engineering will partner in manufacturing the prototype E-Tongue probe and princed circuit board (PCB) fabrication and assembly of the miniature potentiostat. Demonstration of the prototype E-Tongue probe will be conducted in collaboration with the Massachusetts Department of Environmental Protection (Mass DEP) and CH2M Hill. Mass DEP will help locate appropriate sites for prototype demonstration. CH2M Hill will partner in the demonstration of the E-Tongue probe in heavy metal contaminated river sediments. The diverse skills and complementary expertise of the team, and collaborations with industry and regulatory agencies (CH2M, and Mass DEP) will ensure the successful translation of this project.

University of North Carolina, Chapel Hill

Program: PFI:AIR - TT

NSF Award No.: 1602023

Award Amount: $199,936.00

Start Date: 06/01/2016
End Date: 11/30/2017

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Program Director: Barbara H. Kenny

Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Rapid, Quantitative, Molecular Diagnostics for Virulent Vibrio Pathogens in Water and Shellfish

This PFI: AIR Technology Translation project focuses on translating ecological research that has been previously conducted on a set of bacterial pathogens, Vibrios, found in estuaries and coastal systems. Vibrio cholerae is a well-known freshwater pathogen that is of concern in developing countries. Two lesser known, but important human pathogens in the USA are from the same bacterial group: Vibrio vulnificus and Vibrio parahaemolyticus. These are bacteria that are naturally found in estuarine systems, but they can also present a risk to human health when consumed in raw shellfish, or in rare cases, contacted in beach waters. This project will translate knowledge gained through prior ecological research into technology that permits the design of user-friendly, rapid, molecular testing kits. The existing ways to test for Vibrio species in water and shellfish samples are decades old, and they require 24-96 hours for results. Even new molecular approaches for testing of pathogenic forms of V. vulnificus and V. parahaemolyticus are compromised by a lack of specificity and/or a need for an enrichment step to improve sensitivity, making them require almost a day for completion. This project will permit generation of new, rapid molecular diagnostics for virulent forms of V. vulnificus and V. parahaemolyticus using a new approach for determining useful targets for the kits. It is envisioned that these kits could be used to 1) certify that shellfish is safe for raw consumption, 2) protect the health of at risk populations for water contact, 3) determine the patterns associated with dangerous forms of the bacteria for improved warning systems. The funded project will result in the design of commercially available molecular testing kits that will be easy to use, and will provide results in 2-3 hours. These features will permit accurate public notification and protection of public health.

This project addresses a specific knowledge gap in the transition from research to commercial application. Vibrio sp. are complex bacterial organisms, that are naturally found in estuarine and coastal waters, but only a small subset of them are capable of causing disease. The assembled team has valuable expertise in next generation sequence and sequence data approaches, Vibrio sp. ecology, and Vibrio sp. pathogenicity. The combination of knowledge permits known virulent (pathogenic) Vibrio samples to be analyzed for specific sets of “DNA motifs” that are related to the capability of the bacteria to cause disease. From a repetitive process of analyzing known virulent and avirulent cells, the project team can identify the DNA motifs, or signatures that can be used to design a DNA test kit. Subsequently, through support from this project the molecular test kits will be developed, optimized, validated, and commercialized.

In addition to the technical activities, undergraduates, senior graduate students, and post doctoral research associates as well as research assistant professors will be supported on this project. The will be exposed to a wide range of research and technology transfer activities, including market assessment, field based sampling and study, laboratory sample preparation, culture and molecular based analyses of samples, next generation sequence data annotation and analyses, and kit design and optimization. The project will be synergistic and contribute directly to the Molecular Training Facility run by PI Noble, where water quality professionals come to learn appropriate use of qPCR approaches and interpretation of qPCR data for water quality management.

The project also engages the Marine Biotechnologies-Center of Innovation, a group dedicated to advancing the translation of marine science research to commercial application. In addition, Orion Integrated Biosciences is a project partner. Orion Integrated Biosciences is a company dedicated to the advancement of unique and disruptive computational approaches to survey “big data” for sequence and molecular application. This project will directly impact the advancement of marine metagenomics due to the fact that the project team is utilizing a holistic approach to target complex organisms. The project is novel in that the approach moves away from the “single gene target” qPCR design approach, permitting the generation of diagnostic kits that are rapid, and cost-effective that shellfish harvesting, and water quality managers can use to manage precious resources and protect public health.

University of South Florida

Program: PFI:AIR - TT

NSF Award No.: 1602087

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Passive Membrane Photobioreactor for Cultivation and Harvesting of Algal Biomass and Sustainable Nutrient Management

This PFI: AIR Technology Translation project focuses on translating a passive floating membrane photobioreactor technology to fill the need for sustainable microalgae cultivation for biomass/biofuel while simultaneously removing nutrients from impaired waters such as wastewater. The ICARUS process (which stands for Isolated Cultivation of Algal Resources Utilizing Selectivity) is important because allows the simultaneous production of low-cost and sustainable algal-derived biofuel and bioproducts, while reducing environmental pollution from excess nutrient runoff and the associated costs of wastewater treatment. The project will result in a prototype system of ICARUS pods which are capable of cultivating and harvesting high-quality microalgae at a wastewater treatment facility. ICARUS has the following unique features: passivity, modularity, crop isolation and protection, and compatibility with existing infrastructure. These features provide the following advantages when compared to the leading competing algae cultivation and harvesting technologies in this market space: 1) ability to cultivate algae monocultures in a "dirty" environment like wastewater, while utilizing freely-available carbon, nutrients and water; 2) ability to grow multiple algal species separately but within the same feedstock tank; 3) enabling multiple simultaneous use of existing infrastructure at a wastewater treatment facility, thereby accelerating process intensification; 4) production of dense cultures which passively dewater, thereby greatly reducing the costs of harvesting and downstream processing.

This project addresses the following technology gap(s) as it translates from research discovery toward commercial application: 1) geometric considerations for scaling up reactor volume; 2) strategy for linking multiple pods into an interconnected ICARUS system; 3) process control for a linked system; 4) large-volume algal growth kinetics and productivity; 5) long-term membrane performance. In addition, personnel involved in this project, including a post-doc, a PhD student, and two undergraduate students, will receive training on entrepreneurship, intellectual property and commercialization, digital 3D design, process scaling, algal biology, wastewater process design and modeling, and membrane science.

The project engages Florida wastewater utilities and algae companies to develop a sustainable commercial product (algae biomass for bioproducts/biofuel), while simultaneously reducing the costs of wastewater treatment and helping utilities meet their regulatory goals.

University of Washington

Program: PFI:AIR - TT

NSF Award No.: 1542765

Award Amount: $199,846.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Topic: Chemical and Environmental Technologies (CT)

PFI:AIR - TT: Development and Commercialization of the HAOPs Water Treatment Process

This Accelerating Innovation Research: Technology Translation project focuses on translating a novel water treatment process from the laboratory ("proof-of-concept") stage to a stage where it can be tested at municipal water treatment plants. Both the developed and developing worlds face a critical need to produce clean, healthy water, cheaply, in the face of diminishing quantities and quality of water from current sources. One of the most promising developments in drinking water supply over the past two decades is the improvement in membrane-based treatment processes. However, these systems still operate well below their potential because the membrane pores are easily plugged (fouled). The process being developed in this project uses a new type of particle (heated aluminum oxide particles, or HAOPs) to collect contaminants and deploys the particles in an unconventional way (depositing an extremely thin layer of the particles on a support and passing the water through that layer), and thereby removes far more of the material that plugs the pores of membranes than can be removed using currently available processes. Furthermore, the process appears likely to use less energy and be less costly than current technology. The outcome of the project will be a design for a pilot-scale system that can be tested at an operating drinking water treatment plant.

The technical issues requiring investigation for the new treatment process to be successful include the development of a new module containing substantial surface area onto which the HAOPs can be deposited, while still maintaining a relatively small footprint. The proposed design is a monolithic, but porous, cylinder containing multiple small, cylindrical channels penetrating the full axial length. The HAOPs layer will be deposited along the walls of these channels, so that feed water must pass through the layer and then through the porous solid before exiting. The module must capture the HAOPs efficiently at the beginning of a treatment cycle and then release them equally efficiently at the end. Both the deposition and release steps require optimal choices and careful control of the water flow patterns, and that optimization step will be a major focus of the project. In addition, the approaches for dewatering and compacting sludge from the process will be explored, and a cost-benefit analysis of the overall process will be carried out. Finally, undergraduate and graduate students, as well as a postdoctoral researcher, will receive entrepreneurship and technology translation experiences through mentorship by a partner on the research team who has co-founded three companies in the energy efficiency and water treatment sectors, and by participation in meetings with potential manufacturers of the equipment and investors in the technology.

Villanova University

Program: PFI:BIC

NSF Award No.: 1430168

Award Amount: $800,000.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Chemical and Environmental Technologies (CT)

PFI:BIC Self-Learning Algorithms for Advancement of Smart Stormwater Green Infrastructure Systems

A pressing social and environmental issue on a national scale is the effect of stormwater on waterbody impairment, particularly in urban and suburban watersheds. For example, stormwater can diminish water quality by discharging pollutants like metals and nutrients as it runs over land and into the streams. Stormwater causes stream erosion, sedimentation, flooding and overflows in combined sewer systems. To combat these issues, municipalities must adopt innovative technologies, such as Green Infrastructure (GI) systems like bioretention, constructed wetlands, and vegetated roofs. Despite the advantages of GI systems, its adoption has been slow due to technological and human factors. These systems are not yet dynamic, cannot adapt to seasonal changes and are often able to accomplish only one performance goal resulting in high implementation and maintenance costs. Other potential factors include operation and maintenance issues, policy and financing issues, lack of buy-in from different stakeholders, and unclear return on investment. This research will develop “smart” (i.e., efficient, active and self-learning) stormwater service systems. “Smart” systems use sensor- and human-generated data to streamline GI maintenance programs to be less costly and more effective in performance, prediction and failure prevention. The broader impacts of the research activities are the improvement of stormwater management across treatment scales. The research activities will lead to more efficient and economical GI that demonstrates its need and benefit to society and all watershed stakeholders by making major progress towards flood mitigation and water quality improvement in impaired waterbodies. The underlying technologies allow for unique opportunities to directly connect infrastructure to stakeholders, system data is transmitted, stored, and processed in cloud-based data management systems and published as web services.

This project enlists a research-based approach that integrates application with the socio-technical system. This outcome will be achieved by optimally using all physical processes in a GI system (i.e., detention, infiltration, evapotranspiration), which uses sensors and controls integrated with real-time weather and system conditions, forecast data, and social media. Villanova University GI systems (green roof, constructed stormwater wetland, bioretention rain garden) will be equipped with sensors (e.g., soil moisture, water level, temperature and dissolved oxygen), as well as automated control structures (e.g., valves or gates), providing dynamic control algorithms that optimally operate during and after rain events. This GI system will be dynamically linked to a platform technology with real time visualization, data accessibility, quality assurance and real time control through physical computing. The entire automated system will operate at three time scales: 1) hours during, 2) days after the rain event, and 3) seasonal scale. All control algorithms will be geared to maximize storage available for stormwater and water quality improvement. These goals will vary across season and climate zones.

The primary partners include Department of Civil and Environmental Engineering, and Department of Computing Sciences from Villanova University (Villanova, PA); University of Pennsylvania School of Design (Philadelphia, PA); and Geosyntec Consultants, an industry partner (Boston, MA). The broader context partners include Veolia, Paris France; City of Austin, Texas; District Department of the Environment; City of Omaha, Nebraska; and Philadelphia Water Department.

Visolis, Inc.

Program: SBIR Phase II

NSF Award No.: 1660232

Award Amount: $687,510.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: High Performance Monomers from Biomass

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to develop a new technology that combines advanced bioengineering with traditional chemical manufacturing. This hybrid approach will allow production of high value chemicals for the polymer industry using biomass at a lower price than current petrochemical based processes. This unique approach allows for the retrofit of existing ethanol fermentation facilities in rural areas with a bolt-on chemical upgrading unit to produce chemicals with far higher value than ethanol, improving the economics of operating these facilities and creating new jobs. The initial chemical product targeted by this project has an estimated $100M annual market and is used in manufacturing a variety of consumer products including specialty polyurethanes, inks, and UV degradable plastics which can be dramatically expanded to $1B by 2020 through cost reductions enabled by this new technology. Eventually, this approach combining existing fermentation facilities with a bolt-on chemical processing unit can be used to produce carbon-neutral fuels that are fully compatible with gasoline, diesel, and jet fuel at price comparable to current petrochemical fuels. This project, while here focused on the higher value polymer market, will enable later development of cost competitive fuel production technology.

The objectives of this Phase II research project are to demonstrate at pilot scale a complete downstream process capable of manufacturing the target chemical from the intermediate platform molecule produced with fermentation. In upstream Visolis work, the key intermediate has been produced using fermentation facilities hosted at the Advanced Biofuels Process Demonstration Unit at Lawrence Berkeley National Laboratories and the National Renewable Research Laboratories (NREL) at pilot scale, and based on current performance metrics the intermediate can be manufactured at prices comparable to ethanol at commercial scale. The goals of this downstream project are to utilize the intermediate generated using a 9000L scale fermentation facility at NREL to demonstrate cost-effective production of the target product from this intermediate. The work includes construction of a pilot scale high pressure chemical reactor, production and testing of several catalysts for performance in producing the target molecule at different process conditions, optimization of the chemical production process, evaluation of the process and catalyst for long-term stability, purification of the products to the levels required by customers, and technoeconomic modeling to inform the design of a commercial facility.

Waste2Watergy, LLC

Program: SBIR Phase II

NSF Award No.: 1660116

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Next-Generation Microbial Fuel Cell for Highly Efficient Wastewater Treatment

The broader impact/commercial potential of this Small Business Innovation Research Phase II project, if successful, will be to advance the development of a novel microbial fuel cell (MFC) system that generates energy from the wastewater being treated. MFC technology could revolutionize wastewater treatment for small and mid-sized breweries, fruit processors and other food and beverage processing plants. Over 40 billion gallons of wastewater are produced every day by sources such as breweries, juice processors, dairies, and other bottling plants. The company's microbial fuel cell technology is expected to offer significant economic/technical advantages for these companies by reducing their disposal costs, reducing the footprint of treatment facilities, and helping them to adopt a more sustainable process for wastewater treatment. MFC technology also has potential in the low-cost, highly-efficient treatment of municipal wastewater.

The objectives of this Phase II research project are to construct and validate the performance of an innovative MFC technology in a scaled-up, simulated commercial-scale system and to validate the technical and economic benefits of utilizing this system to effectively clean brewery and fruit-processing wastewater at volumes representative of commercial operations. Small to mid-size breweries, fruit processers and other food and beverage processing plants are searching for an affordable and effective water-treatment option. A promising approach is microbial fuel cell technology; however, significant technical/economic challenges have prevented commercialization of this technology. During Phase II, the MFC technology will be scaled up and tested at near-commercial scale to demonstrate the same high performance metrics. The cost-effective cathode and separator components and highly efficient reactor design are expected to finally make MFCs practical for wastewater treatment applications.

White Dog Labs, Inc.

Program: SBIR Phase II

NSF Award No.: 1534704

Award Amount: $683,384.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Integration of carbohydrate and gaseous fermentations for maximum C3 and C4 chemical yield

The broader impact/commercial potential of this Small Business Innovation Research Phase II project is to develop renewable and domestic chemical production and transportation fuel technologies that are cheaper, greener and more sustainable. Additionally, chemical companies are constantly looking for ways to improve business sustainability by reducing carbon footprints along with cost of manufacturing. Mixotrophic fermentation can be a step-change improvement in microbial fermentation for the production of numerous intermediate and commodity chemicals. Yields from feedstock can be increased substantially, and CO2 gas produced from the fermentation, as a waste byproduct can instead be captured and assimilated into valuable chemicals, which translates into a significant improvement in yield and productivity for any applicable commodity or intermediate chemical production process. Consequently, the commercial and environmental implications of this innovative technological approach are tremendous. Furthermore, this project could significantly enhance scientific and technological understanding of microbial physiology and metabolism during gas and carbohydrate fermentation.

The objectives of this Phase II research project are to develop and scale-up platform strains for C3 and C4 chemical production using carbon efficient pathways. The approach being developed is referred to as Anaerobic Non-Photosynthetic (ANP) mixotrophic fermentation, and process advancements will focus on bioreactor operation parameters, media formulations, and integration with product separation. By the end of this project, the project will likely have demonstrated and validated enhanced mass yield of C3 and/or C4 metabolite production at pilot-scale using ANP mixotrophic fermentation.

Woods Hole Oceanographic Institution

Program: PFI:BIC

NSF Award No.: 1534054

Award Amount: $1,000,000.00

Start Date: 10/01/2015
End Date: 09/30/2018

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Topic: Chemical and Environmental Technologies (CT)

PFI:BIC A Smart Service System (ESPnet) for Enhanced Monitoring and Management of Toxic Algal Blooms

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project addresses a significant and growing societal problem: toxic or harmful algal blooms (HABs), commonly called “red tides”. Every year, millions of dollars are lost due to red tides and HABs throughout the US and the world. Losses can be direct, such as human illnesses and deaths from the consumption of contaminated food or the mortality of fish and shellfish resources, or indirect, such as the avoidance of all seafood products during red tides, even products that are safe. Management of areas threatened by HAB toxins currently involves monitoring programs that rely on weekly flesh-testing of shellfish collected from many locations along a coast. These programs are expensive, slow, providing protection through conservative harvesting closure policies that have not changed for decades. Red tide management can be greatly improved through the use of technological advances such as the Environmental Sample Processor (ESP), a submersible, self-contained “laboratory-in-a-can” that collects water samples and identifies molecules or genes that indicate the presence of hazardous species of algae. ESPs operate autonomously for months and transmit data, including environmental conditions, to shore. The goal of this project is to develop and demonstrate ESPnet, a system that will utilize these novel biosensors to provide environmental awareness and decision support capabilities for resource managers charged with protecting public health and the viability of fisheries industries and tourism from toxic HABs. This system is transformational, as it applies a new sensor technology to a major resource management problem that is currently addressed through monitoring programs that are expensive, slow, and outdated. No other service system of this type currently exists for managing HABs, microbial pathogens, or other water-borne diseases or problems.

ESPnet will be based on a network of ESPs that will supply real-time, high-frequency HAB surveillance information through a web portal complete with automated data analysis and visualization tools, allowing managers to view the coastal environment with unprecedented detail so they can act decisively and effectively. The three-year project will include field deployments of multiple ESPs at key locations along the Gulf of Maine (GOM) coast. The project team will work with their industry partner, McLane Research Laboratories, to modify ESP hardware and software to reduce power consumption and extend deployments to fully sample the HAB season in the GOM. Meeting the overall goal of this project requires a development effort to fully automate ESP data analysis and to merge that with geospatially rendered environmental measurements; this system must be tailored to non-experts and available via a user-friendly data portal. Human factors will be addressed through identification of user groups and characterization of receptivities to the new system, optimization of the manner in which system information is supplied to users, characterization of feedback among user groups, and estimation of economic costs and benefits from the ESPnet technology.

This project addresses fundamental issues underlying management of the most widespread of all HAB poisoning syndromes--paralytic shellfish poisoning or PSP. Project activities thus have important societal benefits. The ESPnet concept can be applied to PSP problems elsewhere in the U.S., as well as to other HAB poisoning syndromes, and to a host of non-HAB problems that affect water quality, such as viruses and microbial pathogens. This project therefore satisfies the criterion "fostering connections between discoveries and their use in the service of society". This project has extensive undergraduate and graduate training, as multiple students and interns will be involved. Project results will be broadly disseminated through scientific papers, workshop and conference presentations, and discussions with the media. This project thus meets NSF's Broader Impact Criterion II through "advancing discovery in understanding while promoting teaching, training, and learning".

Primary partners include Lead institution: Woods Hole Oceanographic Institution, Biology Department and Marine Policy Center (non-profit research and educational institution); Industrial partner: McLane Research Laboratories (Falmouth, MA; small minority-owned business); Academic partner: Monterey Bay Aquarium Research Institute (Moss Landing, CA; non-profit). Broader Context Partners include Northeast Regional Association for Coastal Ocean Observing Systems (NERACOOS; Portsmouth, NH; regional association); Maine Department of Marine Resources (W. Boothbay Harbor, ME; state agency); New Hampshire Department of Environmental Services (Concord, NH; state agency); Massachusetts Division of Marine Fisheries (New Bedford, MA; state agency).

Xylome Corporation

Program: SBIR Phase II

NSF Award No.: 1632255

Award Amount: $750,000.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Topic: Chemical and Environmental Technologies (CT)

SBIR Phase II: Novel Bioprocess for Lipid Production from Industrial Byproducts

The broader impact/commercial potential of this Small Business Innovation Research Phase II Project is to produce economically the next generation of sustainable, renewable, clean burning, high energy density, transportation biofuels. The proposed technology once successfully developed will enable existing biofuel producers to reduce their costs while increasing the value and diversity of their byproducts. It will convert their industrial waste products into tailored fatty acids suitable for biodiesel. The technology will be compatible with and complementary to cellulosic ethanol producers, and it could potentially double the amount of biodiesel produced in the U.S. today. The 227 domestic ethanol plants range in size from less than 50 to more than 150 million gallons, and they have a total annual capacity of 15 billion gallons. Every gallon of ethanol also yields 1.9 pounds of soluble organics that must be evaporated or disposed. Xylome's technology has the potential to convert half of this stream into biodiesel and to expand biodiesel production further with cellulosic feedstocks. By converting a larger fraction of the soluble cellulosic and hemicellulosic sugars along with fermentation byproducts, Xylome will increase the efficiency of existing ethanol plants and increase biofuel production.

The objectives of this Phase II research are to increase the rates of production, modification and release of fatty acids from non-conventional lipogenic yeast. Fatty acids have much higher energy density than ethanol, but similar specific energy yields. Fermentation of organics to lipids can potentially occur with efficiencies equivalent to ethanol production. Lipids normally accumulate under nitrogen limiting conditions after replication has stopped. They are not excreted from the cells so recovery does not require distillation. In Phase I, Xylome scientists identified and over expressed genes that increase lipid accumulation by 1.2- to 2-fold under high nitrogen conditions. In Phase II, they will use mating, selection, screening and evolutionary adaptation to combine the best of these modifications. Xylome scientists have also targeted additional genes to modify and release fatty acids from the cell. Xylome plans to optimize lipid production both from a cellular level with metabolic engineering and from an engineering perspective through bioprocess design and cultivation conditions. Xylome will also engineer cells to use rapidly the complex mixture of soluble oligosaccharides, hemicellulosic sugars and fermentation byproducts. By applying advanced molecular techniques and synthetic biology, Xylome will open up new opportunities for sustainable biofuel production.

EDUCATIONAL TECHNOLOGIES AND APPLICATIONS (EA)

Actively Learn, Inc.

Program: SBIR Phase II

NSF Award No.: 1534790

Award Amount: $760,000.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Personalized Reading Instruction

This SBIR Phase II project proposes to discover digital methods to personalize reading instruction such that students understand more when they read, retain knowledge, and build lasting skills. The academic research on reading supports the claim that active reading strategies that incorporate quality instruction can benefit students. However, instruction is usually not personalized to meet the needs of specific students, and even when an educator works 1:1 with a student they can only interpret a limited number of signals from a student to help guide instruction. The objective of the project is to take in several inputs when students read digitally and investigate whether personalized reading instruction can effectively be created and delivered such that students get extra help when they struggle and are challenged when they can succeed on their own. Two-thirds of students in the U.S. are struggling readers; they cannot understand the main idea when they read. These students are four times more likely to drop out of school. People who read critically have more success in school, obtain high quality jobs, and are able to contribute more to expand social resources. Researchers and educators have been trying to solve the “reading gap” for decades, but only now does the technology exist to make this possible.

This SBIR Phase II project proposes to use unique machine learning techniques to personalize reading instruction. The algorithms to personalize instruction will ensure that extra help, or scaffolding, is allocated to the students who need it, and removed when they no longer need it or when it threatens to become a crutch. This approach is different than other machine learning algorithms, which are built to minimize the overall error or maximize the overall reward. However, what is required for personalized reading instruction is different. The algorithm must learn how much to help a student not so they perform better with help, but so they perform better without it because the goal is for students to become better readers in the long term, not become reliant on scaffolding to read. The objective of the research is to fully develop and commercialize this personalized reading system and will involve data science, application development, and content authoring.

Alchemie Solutions, Inc.

Program: SBIR Phase II

NSF Award No.: 1659983

Award Amount: $707,360.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Game-Based Learning for Organic Chemistry Using Mechanisms

This Small Business Innovation Research Phase II project answers the call that science students go beyond memorizing facts to understand content on a deeper, conceptual level. In chemistry, this goal is particularly difficult to achieve because the underlying concepts describe the behaviors of particles that are not directly observable to students. College instructors are also under added pressure to transform their teaching methods to help ensure student retention and success. In the subject area of organic chemistry, this transformation is even more important, due to the relatively high fail-rate in the course, especially for under-represented minorities and first generation students. The mobile learning tools and data collection platform in this project would help to solve both of these issues with an innovative method for intuitive learning and assessment which helps to make molecules and reactions come alive with game-based mobile applications. The game apps are playable by students of all ages, so the concepts of organic chemistry, as well as other science courses, become familiar and accessible as early as middle school. The broader vision is to open the pipeline for students to progress into STEM careers which have been difficult to reach in the past.

This project makes the theoretical touchable for organic chemistry students by building mobile game-based learning tools based on mechanisms, a key underlying concept used to teaching the course. This project will produce the Mechanisms suite of game apps, and bring an intuitive, tactile interface to learning chemistry. The research and development of this phase of the project will expand the user interaction model from Phase I to multiple modules of content for students. The data from the mobile learning tools will be synthesized with machine learning techniques to create an adaptive method to ensure the applications provide the appropriate level of challenge to the student learner. Clinical and longitudinal efficacy studies will be part of the research effort as the game modules are developed and released. The data platform will be optimized to integrate with multiple learning management systems and to be readily expandable to subjects beyond organic chemistry. The dashboard of the platform will allow both instructors and students to access the data and inform learning processes to achieve greater comprehension and success in the course. Commercialization will be achieved through direct-to-student downloads, subscriptions of the data platform by institutions, and licensing the technology to courseware providers.

Andamio Games, LLC

Program: SBIR Phase II

NSF Award No.: 1660091

Award Amount: $728,284.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Glenn H. Larsen

Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Collaborative Game Approach to Support Classroom Instruction of Difficult-to-teach Science Concepts

This project will enable students to learn difficult science concepts using a collaborative gaming approach that aims to significantly increase student engagement and understanding. This game is being developed to improve the instruction of photosynthesis and cell respiration, which are required curriculum for high school students in life science courses. These processes are largely invisible, comprised of a complex and interdependent set of interactions, and difficult to teach. By creating educationally sound interactive tools to undertake complicated science subjects, the project aims to increase secondary student involvement and interest in STEM, and to help build the core scientific knowledge and higher-order thinking skills they will need to address the challenges of the 21st Century. The app content and design is based on evidence-based pedagogical approaches to effective science instruction. Developing a more immersive and practicable learning method upholds the NSF's mission to promote exceptional science education and will help attract and prepare more students for STEM-based careers. This work will provide teachers with an instructional tool that conveys accurate details of chemically-based biological processes, enable them to deliver differentiated instruction to their classes, and ensure that all their students, whatever their level of pre-existing knowledge and ability, are able to meet the prescribed national and state-level life science standards.

The project proposes to develop and implement a working simulator that produces scientifically accurate output for a virtual lab learning environment, with which students can quickly build practical understanding of the scientific method through trial and error. This enables a) the introduction of legitimate agency into student learning so that their choices drive the learning, b) the generation of meaningful (non-generic) instructional prompts that respond precisely to how each individual interacts with the game, and c) the establishment of a valuable framework for assessing student learning based on their multiple authentic interactions with the simulator. The simulator will represent biological processes using a mathematical model in order to support an arbitrary range of hypotheses. Additional innovations include a) automated tools that differentiate instruction at the classroom level to help teachers address a range of student proficiencies, from remedial to advanced, b) expanded device-to-device student interactions that utilize collaborative assessments and argumentation games, c) app management tools that enable teachers to organize, monitor and assess individual student participation within these collaborative activities, and d) the integration of relevant geohistorical climate data into each player's "reward garden" in order to build aptitude and foster interest in quantitative analysis activities. Classroom testing will be conducted to validate our approach and demonstrate efficacy.

Courագion Corporation

Program: SBIR Phase II

NSF Award No.: 1660021

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Science, Technology, Engineering, and Math (STEM) Career Literacy & Advocacy

This project will improve the awareness and perception of careers that require science, technology, engineering, and math (STEM) competencies. Advocacy is a critical component of career readiness, yet current advocates (parents, guardians, educators, or members of the community) are often not in the position to inform students of potential career options. Career and workforce readiness programs are resource constrained, don't meet the needs of differing learning styles, have inherent bias, and are largely focused on compliance over student competency building. Many underrepresented youths who would otherwise succeed in STEM are often deterred by a lack of role models. If youth understood the opportunities, they could pursue academic pathways to amass skills that better prepare them to enter the workforce. Furthermore, educators need professional learning experiences and access to insights about their students in order to improve STEM teaching and learning. Helping individuals select rewarding and suitable degrees, training, and careers will increase the likelihood of higher job retention. As more individuals are inspired to pursue and stay in STEM, taxpayers will benefit from increased innovation which in turn will provide tax dollars to invest in such things as healthcare, national security, education, or humanitarian assistance.

The project will address technical challenges of amassing and distributing massive amounts of 3rd party STEM (Science, Technology, Engineering, and Math) resource data (both structured and unstructured), developing an information management system for educators and families, developing adaptive learning skill modules, advancing a second generation smart recommendation engine based on big data, machine learning and predictive modeling techniques, and performing database mining and creating data visualizations to derive meaningful workforce development insights. In addition, the project will involve controlled experiments and usability tests whereby a large amount of anonymized and aggregated student data and business/education entity feedback will be collected. The ultimate goals of the R&D and experiments are to validate that the resulting application, predictive models, information management practices, advocacy networks, and data visualizations have the desired outcome of boosting immediate and near-term student outcomes regarding STEM career intentions and actions.

CueThink

Program: SBIR Phase II

NSF Award No.: 1660216

Award Amount: $747,318.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: An Embedded and in-context Professional Learning Platform for Math Problem-solving Instruction

This project proposes to develop an innovative approach to improve and sustain math educators' problem solving teaching skills. Despite the expectations placed on math teachers by the Common Core State Standards, most are insufficiently prepared to teach students how to become critical thinkers. Much of this problem is due to limited pedagogical skills of teachers in providing adequate problem solving instruction and supports on top of teachers' own limited problem solving skills. This project remedies this with its integrated modules and powerful analytics engine that suggests learning pathways for both expert and novice teachers. They anchor their research in National Council of Teacher's of Mathematics Principles to Action. It will help teachers develop confidence and skills in planning and evaluating their lessons, as well as understanding student misconceptions and intervening in a timely manner. Teachers who approach problem solving with confidence inspire students to approach difficult math tasks the same way. This has great implications for how many students will continue to enroll in Science, Technology, Engineering and Math programs. In addition, the project sets the stage for educators to develop 21st Century skills including critical thinking, communication and collaboration - essential job skills for the young minds they mentor.

This effort refines and scales up their product, which is a web and mobile application that works seamlessly in conjunction with our current student-facing platform, to provide teachers with timely supports for improving students' problem-solving skills and math communication. This project will deliver professional development continuously and in-context using virtual peers, rich rubrics, interactive tools and actionable data. The analytics engine leverages adaptive learning models in order to build robust modules. The Data Collector Layer will contain interfaces for users to get recommendations, receive user feedback and provide other analysis reports. The Analytics Core Layer will be implemented using a collection of machine learning algorithms. The Service Layer will calculate recommendations based on user profile, user feedback, pre-stored best practices and other use cases. The Persistence Layer will store and get calculated data to recommendation engine's own database. The company plans to conduct several formative evaluations during the course of the project, as well as two pilot studies at the end of each year with a control and experiment group. The results will enable them to determine the effectiveness of ongoing, just-in-time supports for improving teachers' skills and confidence inside and outside the classroom.

Edify Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1660072

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Empowering Music Learning Through Composition on Mobile Devices

This project will address the need for accessible, creative music education. Over 90% of Americans believe music education is valuable, but very few people ever learn enough to create their own music. Instrument lessons are a great way for some beginners to learn about music; however, instrument lessons are expensive and difficult, and focus on performance and technique at the expense of creativity. This project uses a simple audiovisual composition interface to empower music learners to create their own original music on mobile devices from the very beginning of their music education. By combining this intuitive composition interface with data tracking and analysis, this project creates the opportunity to provide music makers with personalized, adaptive feedback as they compose. Currently, $3 billion are spent each year in the United States on instrument lessons, even though they are unaffordable for many potential customers. By leveraging the proliferation of mobile devices worldwide, this project will deliver an accessible, low-cost digital music education option, creating a new market that includes customers who are currently priced out. Expanding participation in creative music education will increase the quantity and quality of music composed worldwide, while also building a sustainable, revenue-generating business and creating new jobs.

Through data-driven agile software development, this project will address the need for accessible music education through the creation of a technology platform that delivers adaptive learning to musical beginners. Because the platform upon which this project is built is already empowering the creation of thousands of songs each week and collecting usage data from live users, this project is uniquely positioned to tackle the complex problem of providing algorithmic feedback on creative work at scale. Research and development will proceed in four stages: (1) expanding internal tools to allow for direct analysis of the thousands of songs being created on the platform each week; (2) developing an algorithmic approach to analyzing songs and reporting the results to users; (3) applying analysis to match users with relevant communities and collaborators; and (4) implementing adaptive learning approaches to help users more effectively learn to create music. This staged development process will result in an innovative and highly differentiated technology that enables beginners with no musical experience to compose their own music, and uses data to actively support their individual needs as they learn.

Edwisetech, Inc.

Program: SBIR Phase II

NSF Award No.: 1632481

Award Amount: $747,271.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Big data Analytics Driven Adaptive Learning for STEM Education

This Phase II project will commercialize a big-data analytics-based adaptive online learning platform founded on the principles of adaptive learning. The online learning system provides adaptive learning strategies with real-time learner analytics. The system integrates learner analytics from four dimensional aspects of learning: multi-media, learning strategies, interactivity, and social interaction-- to deliver a personalized learning experience for science, technology, engineering, and math (STEM) students for significant improvement in the learning outcome. The adaptive learning software technology platforms with personalized learning strategies have demonstrated high completion and satisfaction rates for online students taking post-secondary courses. In this SBIR Phase II we propose to develop a unique data driven decision support interface that will result in real-time big data analytics for both individuals and large numbers of learners. The volume, velocity, variety, and veracity (the 4 Vs of big data) will be generated by the collection of data at individual schools first, with the potential to aggregate data from district, state, and even national levels. The big-data analytics of the learner trajectories through the adaptive learning platform will uncover patterns that can improve understanding of learner behavior in education.

Big data, generated by the adaptive learning systems related to learner behavior in each learning strategy, will lead to valuable insights on efficacy of the proposed methodology and further development of the product on mobile platforms in the Phase II. The learner analytics will provide the basis for intelligent feedback based on the statistical evidence. The proposed method of data driven decision process for adaptive learning is based on the real- time cross-correlation statistical analysis of the predictor variables for an individual learner. The field trials of the proposed method will be conducted in the participating high schools. Collection of data for a group of students collected during the field trials in high schools will lead to discovery of learning patterns for the clusters of learners in each learning strategy. The previous Phase I research has led to the development of an analytical model for volume, velocity, variety, and veracity of data collected at school-wide level. This reports form this data is used for the development of decision tree and regression analysis to find correlations (knowledge discovery) that can be used for the improvement of learning enterprise (school). The data-driven feedback to students and the group analytics for teachers will provide necessary feedback mechanism for improving competency and graduation rates for STEM education in schools and colleges.

Imagars, LLC

Program: SBIR Phase II

NSF Award No.: 1632408

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Ecosystem for Learning and Team Design

This Phase II project impacts the way engineering design is taught in design courses and contributes to the training of a strong workforce in areas related to science, technology and engineering. The Ecosystem is a software tool that automatically verifies designs against the requirements, to uncover oversights early in the process, but also fosters engineering judgement and creativity, allows for assessment of designs with less subjectivity, and facilitates smooth communication among team members. This results in productivity enhancements, higher quality designs and shorter time-to-market, but also in societal benefits (safer products, less risk of catastrophic accidents and more competitive design organizations). The target market consists of (1) educational institutions teaching engineering design, and (2) design companies striving to ensure compliance with the design specifications. The core innovation is three-fold. First, it consists of an e-design assessment engine that is being developed to a high degree of sophistication. Second, design repositories are investigated and developed for integration. Third, holistic (big data) analysis of design content and metadata is implemented.

The project seeks to develop an innovative design decision (learning) support system addressing problems related to the high cost of design oversights. Such oversights can result in catastrophic failures, product recalls, or simply in budget or schedule over-runs (due to rework). The Ecosystem offers a flexible, yet systematic and generic, framework, for guiding designers through the design process, and for automatically assessing design activities, from each stage in the design process, against the product design specification (PDS). At the center of the Ecosystem is the e-design assessment engine, which decomposes the PDS, correlates the design activities against individual requirements, and provides real-time advisories in case of design oversights. The assessment engine automatically configures popular development tools for engineering design, determines relevant analyses, and interprets the outputs. The Ecosystem interfaces with these development tools, but does not replace. The Ecosystem can translate qualitative customer requirements into solid engineering requirements, and verify the relevance of the design content provided through seamless interfaces with industry databases. The Ecosystem improves designers' productivity through automation of many administrative tasks (e.g., generation of project reports). Despite the automation, the learning experience is not diminished. The Ecosystem prompts for, captures, and preserves the rationale for relevant engineering decisions. It also supports accredited, generic learning objectives for engineering design.

Innovation Accelerator, Inc.

Program: SBIR Phase II

NSF Award No.: 1534740

Award Amount: $723,927.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: An Analogous Search Engine to Accelerate Innovation

This SBIR Phase II project is developing a novel software platform for conducting analogous search that moves beyond keyword search to support innovation in the fields of science, engineering, and legal. Our patent pending technology is based on the observation that as high as 90% of new innovations are really adaptations of existing solutions. The challenge addressed by this research is how to find these adaptable, existing solutions that are spread across many different fields of study and are described using vastly different jargon. These efforts will greatly increase the discovery of new, innovative solutions to a myriad of engineering problems. The end result will be many new inventions that could greatly improve Americans' lives in unforeseen ways, the potential to produce new jobs and tax revenues. These efforts also will benefit Intellectual Property attorneys to help protect these new inventions in all fields of science and engineering. This project supports the National Science Foundation's mission to support all fundamental fields of science and engineering.

The proposed research will further develop Analogy Finder, a novel software platform for conducting analogous search to enhance innovation. The technology is based on the observation that as much as 90% of new innovations are really adaptations of existing solutions. The technology enables engineers and scientists to move beyond keyword (literal) search to analogous (semantic) search to find relevant, adaptable solutions from other disciplines. Analogous search relies on the grammatical verb noun-phrase form, which describes the essential function needed to solve the problem (e.g., reduce concussions). This grammatical form is then transformed into a set of related search phrases using synonyms, key semantic connections, and a proprietary taxonomy. The resulting search output contains more relevant, adaptable solutions to the problem at hand when compared to keyword search. The objectives and methods to be used include: incorporate a unique problem visualization process; add more data sources to Analogy Finder's search capabilities; enable Analogy Finder to search based on multiple verb noun-phrase combinations; develop new ways to organize and prioritize results; and begin identifying metrics to compare Analogy Finder's results with other search engines.

JLG Innovations, LLC

Program: SBIR Phase II

NSF Award No.: 1660242

Award Amount: $742,148.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Closing the Digital Divide: Real-Time Multisensory Learning for Special Education Students

This project creates an educational, touchscreen-based software that translates visual educational content into accessible, multisensory content for students with special needs, and particularly those with blindness and visual impairments. Consider the challenge in the educational landscape today: schools are increasingly adopting digital tools oriented toward creating a more interactive, personalized experience for mainstream students, but at the same time, are struggling to accommodate their diverse student population, particularly, the 6 million students in special education in the U.S. This problem is exaggerated in Science, Technology, Engineering, and Math (STEM), where content is often complex and visual. This project addresses these challenges, building on what we already know about human information processing and haptic interfaces to create software that will automatically convert highly visual content into content that can be seen, heard, and felt in real-time in class. This project supports NSF's mission ensuring that inclusion of all students is at the forefront of the digital transformation of U.S. classrooms. The societal impacts of this work overcome several barriers impeding students with special needs from being independent and active contributors in the STEM educational experience and ultimately, many STEM professions. ViTAL projects a direct, financial return on investment for taxpayers within three years of operations, generating both revenue and new jobs, with plans to multiply this growth year over year.

The innovation in this project is the creation of methods and algorithms for effective translation of visual content into multimodal content, appropriately down sampled for the nonvisual sensory channels yet effective in conveying the most meaningful information. Such a conversion currently does not exist, which results in high overhead costs to create accessible graphics and is a major pain point in special education, particularly for individuals with visual impairments or blindness. Further, translating graphical content from the visual to the multimodal (visual, auditory, and haptic) space is not a straightforward conversion due to the limited bandwidth of human touch compared to vision and the complexity of features presented in graphical information. This challenge is exaggerated when accounting for the varying types of haptic feedback that can be provided from varying platforms (Android and iOS). This project addresses these challenges, creating a streamlined solution for generating accessible, multisensory content, in real-time, on commercial platforms for K-12 classrooms. The outcomes of this project will (1) create the algorithms needed to provide an automated conversion from the visual to multimodal space, (2) establish a teacher "dashboard" to streamline the proposed software's integration in the classroom, and (3) expand the software to the iOS market while simultaneously uncovering novel haptic effects that leverage Apple's unique Taptic feedback. Upon completion of the development, the software will be beta tested with partnering schools, and then released on both Android and iOS markets.

Kent Displays, Inc.

Program: STTR Phase II

NSF Award No.: 1534669

Award Amount: $732,044.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

STTR Phase II: Digital eWriter for The Classroom

This Small Business Technology Transfer (STTR) Phase II project develops eWriter devices for classroom use as a sustainable paper replacement technology and an effective tool for student-teacher interaction. The eWriters provide a paper-like writing experience and electronically capture, store, and transfer handwritten text and images. For education, eWriters introduce a sustainable paper replacement technology at a lower cost than other classroom technologies. The eWriters enable handwritten student work to be wirelessly uploaded to teachers and to virtual whiteboards. Positive societal impacts come from improved teaching methods and student-teacher interactions, particularly for high quality science, technology, engineering and mathematics (STEM) pedagogy, where handwritten notes are advantageous. The most immediate societal benefit of educational eWriters is significant reduction in paper usage, carbon footprints, and costs for schools. Expanding domestic high tech roll-to-roll production of eWriters benefits the flexible electronics supply chain and materials development. The eWriter display technology, developed and manufactured in Ohio, is exported around the world. This project helps sustain both the U.S. economy and the environment. Existing eWriter product, distribution, retail channels, and marketing give a strong platform for commercialization. This project impacts numerous and far reaching areas in education, environmental improvement, domestic manufacturing, materials improvements, and process development.

This project enables digital writing for K-12 and post-secondary classrooms along with a seamless information and communication system so teachers and students can effectively exchange handwritten work digitally and reduce paper use. The research objectives include the development of eWriter technologies (ruggedness, performance, design), the development of software ecosystems for classrooms (use models, user interface systems), and the development of usage strategies for new teaching techniques. Multidisciplinary methods will be used involving researchers in education, liquid crystal display technology, engineering, and software development to successfully achieve project objectives. Experts in the application of technology in education will develop and evaluate eWriter usage strategies for improved instruction and student performance depending on grade level and teaching style. This new type of education technology has tremendous and far reaching impacts in areas of pedagogical techniques, flexible electronics, liquid crystal and polymeric materials, and environmental sustainability. The anticipated results are a suite of eWriter devices and systems to be deployed in K-12 and post-secondary education. The lead organization will commercialize these new products into educational markets leveraging existing sales and marketing infrastructure.

Killer Snails, LLC

Program: SBIR Phase II

NSF Award No.: 1660065

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Program Director: Glenn H. Larsen

Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Learning From Nature: Marine Educational Games With Big IDEAS (Innovative Differentiated Educational Assessments in Science)

This SBIR Phase II project will develop an easy to use real-time formative assessment tool for educators that will be uniquely aligned to each student and deployed via a virtual reality learning game that uses venomous marine snails as a conduit for exploring scientific issues in nature. The USA is currently ranked 52nd in the world in science, technology, engineering, and mathematics (STEM) education. This is detrimental intellectually and economically to the future of American society. Recent studies indicate it is not what is taught, but how it is taught that enhances student-learning abilities, particularly as it pertains to STEM. As a result, this project is driven by the research objectives to understand how children learn specific science content and why certain game elements are better suited to convey scientific material. The outcome of this project is a proprietary multi-tiered formative assessment tool that can measure real time student learning of novel STEM content obtained through a virtual reality learning game experience. This project will enable teachers to nimbly tailor future instruction with individualized student learning goals. Commercialization of the products created in this project will transform scientific learning and measurable engagement in educational games for social and economic benefit to meet the NSF's mission of supporting education initiatives that improve the lives of U.S. Citizens, and generate income for tax revenue and jobs via the employment of software designers, educators and scientists.

The proprietary technology developed in this SBIR Phase II will be a first-of-its-kind assessment dashboard that will link virtual reality and web-based learning environments with formative assessment to fuel instruction and deepen learning. This project will build proprietary assessment tools into online and virtual reality games which continuously engage users in the process of scientific inquiry and discovery using novel formative assessments customized to each player. The proprietary assessment dashboard allows teachers and players to measure their progress in real-time and identify opportunities to enhance their STEM learning. Using Unity as the platform, player actions and decisions will be met with tailored formative assessments and ongoing feedback throughout game play. This feedback helps teachers delineate where their students are along their learning progressions and fuels further instruction. The novel approach of this assessment dashboard transforms qualitative and quantitative learning and has the potential to significantly enhance student engagement and commitment to scientific inquiry to support emerging science changemakers. The research objective of the player/teacher dashboard is to align feedback on student learning during game play with dynamic quantitative and qualitative formative assessment that create a seamless demonstration of knowledge acquisition while providing teachers with multiple opportunities to engage learners in deeper and

LaunchPad Central, Inc.

Program: SBIR Phase II

NSF Award No.: 1353566

Award Amount: $1,239,628.00

Start Date: 04/01/2014
End Date: 12/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Cloud-based Platform to Support Experiential Entrepreneurship Education Online at Scale

This SBIR Phase II project aims to provide web based software-as-a-service platform to deliver an experiential entrepreneurship methodology at scale. This two-sided platform consists of the tools for entrepreneurs to search for a repeatable and scalable business model and tools for instructors, mentors and portfolios managers to triage for early signs of failure and course correct. The project team is comprised of the chief architect, practitioners, and mentors of the highly experiential Lean Startup methodology. Collectively they possess the domain expertise to build and scale a platform for evidence-based entrepreneurship delivering the methodology and content to a global community of entrepreneurs, investors, and mentors. Phase II technology goals are to address one of the core pain points of effective mentoring by leveraging data science expertise to develop a self-learning algorithm capable of providing non-prescriptive suggestions (like an experienced mentor would ask a team) based on certain trigger events the startups would record in the platform.

The broader/commercial impact of this SBIR Phase II project is taking place at national, regional and local levels. With the success of the NSF Innovation Corps (I-Corps) program, other signification technology commercialization programs at a national level are adopting the platform to accelerate evidence-based commercialization efforts. Regional Economic Development agencies and the local Chamber of Commerce are bringing these best practices and tools to entrepreneurship ecosystems at the regional and local levels respectively. The simplicity and pragmatic nature of the offering has allowed for adoption all the way from high school students to undergraduate and graduate students in business and engineering to PhD and Post Doctorates and the Chief Innovation Officers at Fortune 500 enterprises.

LightUp, Inc.

Program: SBIR Phase II

NSF Award No.: 1632721

Award Amount: $750,000.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: An Augmented Learning Platform for Mobile Devices

This Phase II project is to the first personalized learning platform for hands-on education that works with the billions of mobile devices already in people's hands worldwide. Because the technology works on any mobile device and requires little instructor facilitation, it will be commercially successful in home settings when parents are busy and school settings where budget restrictions limit the number of facilitators. Beyond commercial impact, this project will help address the nation's need to prepare citizens for the 21st century economy, improve science literacy and help provide equal opportunities to underrepresented minorities in science, technology, engineering and mathematics (STEM). This project is an effective teaching tool because it employs personalized learning, where the content and pace of learning are optimized for the individual learner. Personalized learning has already been shown to result in higher learner engagement and increased retention of concepts in educational software. Through the use of proprietary augmented reality and adaptive learning technology, this project brings personalized learning to hands-on STEM education, enabling learners to develop problem solving skills in a more effective, engaging and lower cost way.

The key innovation in this project is a single software framework combining advanced augmented reality (AR) and adaptive learning (AL) techniques to capture learners' interactions with real world objects (for example, circuit blocks, fraction bricks or chemistry models) via a mobile device camera, analyze the significance of the interactions and automatically provide personalized guidance to each learner. The system will be the first to provide a high level API above the complexity of AR and AL, allowing designers of learning experience modules to focus solely on content and user experience instead of hundreds of thousands of lines of complex code associated with AR and AL. The methods employed will be the research, design and development of the augmented reality and adaptive learning engine, its integration with three learning experience modules: circuits, fractions, basic geometry, and an evaluation of the modules. To guide the development, pilot studies utilizing A/B testing with competing approaches, pre and post assessments, and behavioral analysis of users interacting with the system will be conducted periodically.

Mgenuity Corporation

Program: SBIR Phase II

NSF Award No.: 1632573

Award Amount: $772,749.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Avatar-guided System to Develop Mastery in Mathematical Problem Solving

This SBIR Phase II project will develop software that teaches 4th-10th grade students how to solve mathematical problems that seem difficult, maybe even hopeless at first. Problems, by definition, are hard to solve. They require intensive thinking and open-ended experimentation, which are often not possible in today's classrooms. In the software, an expert avatar takes students on math explorations in video-game-quality 3D where they visualize and discover eye-opening mathematical truths. The program helps teachers turn math into exciting explorations that students will love. For example, as students fly a jumbo jet from New York to Tokyo, they effortlessly discover methods for finding the shortest path between two points on the surface of a sphere, which is a difficult geometry problem. Teachers can easily fit the program into their daily instruction and get crucial details about the weak spots of each student. The joy of discovery is envisioned to increase students' interest in math, science, and engineering and to significantly reduce their math anxiety. Besides creating jobs and tax revenue, the project is expected to contribute to measurably improved math scores across the nation's 132,000 schools educating 58 million students.

The software being developed in this project is unique in that it emulates the natural style of communication between a student and an expert math teacher and immerses students in 3D virtual worlds where they develop deep mathematical insight and solve fascinating real-world problems. The program's ability to develop both mathematical content knowledge and problem-solving skills at the same time, as well as its capability to non-intrusively assess students during the mathematical explorations is also unmatched. During the Phase II project, the commercially viable software will be fully developed and its efficacy to improve students' mathematical problem-solving skills will be thoroughly researched. A pretest-posttest control group experiment will be conducted in authentic education settings to determine efficacy. The software's educational model and content may be adjusted if necessary based on the outcome of the research.

NeuroTinker, LLC

Program: SBIR Phase II

NSF Award No.: 1660086

Award Amount: $750,000.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Program Director: Glenn H. Larsen

Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Development of a STEM Educational Platform Using Electronic Neuron Simulators

This project seeks to develop, manufacture, and evaluate a novel nervous system simulation platform consisting of freely connectable electronic neuron modules. These devices will be used in the secondary education and post-secondary education classroom to further students' conceptual grasp of neuroscience, engineering, and physiology, and to generate lasting enthusiasm for a career path centered on the science, technology, engineering, and math (STEM) sector. Per a 2012 study by the Department of Education, undergraduate STEM major retention rates are only 35% from initial declaration through graduation. Studies have shown that unengaging introductions to STEM are partially to blame. The firm believes that their product's positive effect on new knowledge formation and student enthusiasm for STEM has the ability to increase this low retention rate. They also believe that the company will grow at a similar rate to our benchmark companies in STEM and neuroscience education which, after approximately five years in business, each have several dozen employees and annual sales greater than $1 million dollars.

The outcome of our proposed project includes development of an electronic neuron simulation ecosystem, as well as development of instructions, experiments, and curricula for NeuroBytes secondary and undergraduate education classroom use. The prototypes produced during Phase I of this project were suitable for proof of concept demonstrations and testing, but much work is needed to develop robust and student-friendly devices for large scale manufacturing at the end of Phase II. Through our Phase I customer development interviews, much important insight was gained into needed and desired input/output devices, accessories, and kits in the secondary and tertiary education segment. These accessories and devices will be an important outcome for increasing the commercial potential of our products. The curricula will be developed in conjunction with partner educators at the middle school, high school, and college levels to ensure that they are properly structured and documented for the maximum possible benefit by our future customers.

Quantum Applied Science & Research, Inc.

Program: SBIR Phase II

NSF Award No.: 1556096

Award Amount: $746,714.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Intelligent Tutoring System with EEG-based Instructional Strategy Optimization

This SBIR Phase II project will develop a computer-based tutoring platform that adapts its teaching strategy to each student by monitoring their brain activity. Access to individualized instruction by teachers or qualified tutors is limited for a vast number of students, particularly in disadvantaged areas and for science, technology, engineering and mathematics (STEM) subjects. Computer-based teaching technology could meet this demand, but currently relies on indirect inferences of a student's state, and therefore lacks some of the key abilities of human teachers to assess a student during a lesson. This project will address this challenge by enabling the tutoring system to determine how hard students are thinking and their level of focus. This will be accomplished by measuring a student's brain electrical activity using a newly-developed headset designed specifically for school-aged children. Information derived from brain activity patterns will be used to guide tutorial topic selection, difficulty of the content and the level of interactivity. This project could lead to a significant advance in education technology by enhancing the adaptability of computer-based tutoring platforms and expanding the depth of information on student performance available to teachers and parents. Adaptive computer-based education is now a rapidly growing market, and the technology developed in this project aims to provide companies with a unique capability to improve their products and to meet the need for truly scalable individualized tutoring.

The unique innovation of this project is to create a tutoring platform that closes the loop with the student by adapting its teaching strategy to the student's cognitive state. To overcome the limitations of current adaptive tutoring systems, this product will measure the student's cognitive workload and engagement, and use this information to adapt aspects of the instructional strategy such as topic selection, content difficulty and interactivity in a closed-loop fashion. The goals of this project are to modify current brain-wave measurement systems for use by children and young adults, extend associated computational algorithms and validate them to an industry standard, and evaluate the effect of adding brain-based metrics to student models that are at the core of adaptive technologies. To meet these objectives, we will perform research and development to advance technologies for brain-activity monitoring, and conduct studies with students in grades 6 through 12 who will be tutored in subjects such as math, biology and history while their brain activity is recorded. The results will be used to determine the effects of using brain activity data to improve the adaptability of computer-based tutors and expand the depth of information available to educational data analytics platforms.

SE3D, Inc.

Program: SBIR Phase II

NSF Award No.: 1632042

Award Amount: $726,272.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Plug-and-Play Bioprinting Educational Toolkit for Next Generation Science and Engineering Students

Three-dimensional (3D) bioprinting technology is giving rise to new methods and innovation in multiple fields across the biomedical and biotechnological industries. On-going progress is generating growth in the bioprinting market creating demands for new job skills in the near future. To address industry needs, schools must ready themselves with the right tools and equipment to train next generation students. Moreover, increased accessibility of technology in education can help to empower students and expand their scientific creativity. However, current 3D bioprinting instrumentation are primarily designed for industry use and expensive. Technical barriers further prohibit many schools from gaining access. To truly democratize technology innovation for next generation scientists and engineers, a sustainable solution catered to the education market is necessary. This SBIR Phase II project is aimed at addressing this opportunity gap and will create an affordable 3D bioprinting equipment and educational toolkit catered to high schools and colleges. The proposed bioprinting equipment will be multi-functional so that teachers can use it for a variety of classroom applications. In addition, the educational toolkit will include student-friendly software tools facilitating experiments in 3D bioprinting, bioreagent kits, and curriculum to support teachers in using the bioprinters in the classroom.

This Small Business Innovation Research (SBIR) Phase II project aims to create a highly functional and versatile bioprinting equipment and educational toolkit for the high school and college education market. The motivation behind this work is to increase accessibility of new and cutting-edge tools to next generation students who will not only benefit from gaining industry-relevant skills they need in the near future but provide them with the opportunity to innovate. The proposed multi-functional bioprinting equipment will facilitate increased hands-on learning activities in the classroom, a key component in learning science and practice engineering, and project-based learning. To this end, the development of curriculum to support use of the 3D bioprinter is critical in manifesting adoption in the classroom. From the hardware engineering perspective, the project will focus on engineering design to achieve integration of multiple functionalities in the proposed bioprinting equipment. Software tools that facilitate design and creation of bio-experimentation, and evaluation of experimental results through imaging tools will be developed to support activities spanning across the entire bioprinting process. Finally, bioreagent kits will be created to support consumable needs for the 3D bioprinter.

SmartyPAL

Program: SBIR Phase II

NSF Award No.: 1555811

Award Amount: $747,317.00

Start Date: 02/01/2016
End Date: 01/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Personalization Platform to Enhance Third-Party Children's Content and Improve School Readiness

This SBIR Phase II project addresses the issue that while mobile devices hold great promise for education, most of the kids' apps that claim to be educational ultimately amount to little more than brain candy. Furthermore, the few apps that are based on educational research are resource-intensive to develop and therefore have limited opportunity to scale their success. This project is building an educational platform that addresses the problems of both quality and scale in this market. It is creating a content enhancement system designed specifically for creating research-based educational content that allows developers and content studios to build mobile and web apps at a fraction (10%-20%) of the cost of traditional app development. The content built using this system is automatically integrated with analytics and personalization technology that tailors the content to each child based on the child's responses. The personalization technology applies methods from psychometrics and cognitive development to ensure that the content adapts to the child and facilitates learning in an engaging way. The project will deliver a large library of context-based and personalized learning content for preK and primary grades that parents know is based on sound research, and ultimately helps increase school readiness and learning outcomes. Given the growing demand for age-appropriate mobile educational content for children, this project has the potential to generate significant returns as a commercial enterprise and, importantly, through the economic gains resulting from improvements in educational outcomes. It will also give content developers the opportunity to economically develop and deploy new content that uses personalization technology, without having to build this complex technology themselves, thereby applying this innovation at a large scale.

This SBIR Phase II project is building a mobile game-based learning platform to onboard high quality third-party children's educational content and enhance their effectiveness through analytics and personalization. To achieve this, the project is developing two significant technical innovations: (1) a cloud-based personalization engine that powers adaptive learning in varied educational contexts and (2) a content enhancement system to efficiently and economically enrich third-party children's content (in the form of digital assets, books, or videos) with interactive learning games that are powered by the personalization logic. The personalization engine will use machine learning techniques combined with statistical methods of psychometric assessment and principles from cognitive development. It will inconspicuously measure children's interaction with the proposed platform's educational content and dynamically adjust game-play to suit each user's individual skills, interests and educational needs. The proposed model of leveraging and augmenting the efforts of many content developers is a dramatic departure from existing content development paradigms in this space. The goal of the project is to substantially increase the scale and reach of personalized, research-based

Sparkting

Program: SBIR Phase II

NSF Award No.: 1632266

Award Amount: $750,000.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Large-scale Creative Thinking Assessment for the Workforce

This SBIR phase II project is focused on quantifying and developing one's creative thinking abilities. In more details, this project will develop modules that measures one's domain-base and subject-base creativity and validate the modules using statistical validation techniques. Creative talent will remain the great differentiator in the coming world, and the organizations that thrive there will do so because they have the right potentials. Using the semantics-based psychometric approach, this project designs exercises and models that assess one's creativity. This project will help employers in acquiring creative employees and also train and educate current employees in ways by which they can become more creative. The market is vast, encompassing potentially all employers who hire and manage workers with symbol-analytic skills. According to the 2010 U.S Census, there are over 143M people employed in the workforce. This project will expand to various sectors of the workforce using strategic partnerships with distribution channels in workforce education companies, and talent/human capital management companies.

Currently, creative thinking strategies and assessments are taught by experts and consultants in the form of workshops. Such semantic creativity assessment is a manual, time-consuming and expensive process. This project creates a set of open-ended exercises and evaluates each exercise based on the four creative-thinking dimensions: 1) Originality: Original thinking capacity and ability to generate novel and out-of-the-box solutions; 2) Fluency: Ideation capacity and ability to push past the first set of known responses; 3)Flexibility: Divergent-thinking capacity and ability to think non-linearly; and 4) Elaboration: Detailed-oriented and ability to provide intrinsic details about each possible solution and response. This project automates such testing by using advances in semantic-based psychometric modelling, natural language processing (NLP), semantic networks from computational linguistics and computational power for statistical mining of large corpora. Due to ease of scalability, this solution is not limited to any one country or region. The solution can be deployed world-wide. Currently, this project has gathered data from 161 different countries around the world. This project is the first step towards automation of open-ended exercises in various fields and contexts such as situational judgement assessments, emotional intelligence and motivational assessments.

Speak Agent, Inc.

Program: SBIR Phase II

NSF Award No.: 1632488

Award Amount: $899,921.00

Start Date: 08/15/2016
End Date: 01/31/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Massive Open Online Platform for Language Learning Content

This Phase II project aims to help address the achievement gap for English Learners, who consistently average 21% below native English speakers on reading scale scores starting in 4th grade and are twice as likely to drop out of school. Eighty percent of teachers believe that materials for English Learners are sub-standard, which contributes to this gap. The project provides an online crowd-authoring and sharing platform that gives K-6 language teachers the tools to meet their unique instructional needs on demand. It is the first and only platform to enable practicing teachers to rapidly build digital language lessons and interactive games that align to their specific requirements, without any technical know-how. The platform provides built-in rich media resources that adhere to best practices based on the cognitive theory of multimedia learning. Any teacher may access these open educational resources at no cost, provided they make their own creations available for public reuse, revision and remixing. The project seeks to understand the dynamics of collaboration and quality assurance for interactive content at a massive scale. Crowd-authoring can invest educators with the power to transform language learning into a field that is highly responsive to the evolving needs of educators and learners.

This Phase II project will pioneer mass customization of interactive games and media in the field of second language acquisition. The project aims for teachers to create 175,000 custom digital lessons and interactive games using media resources provided by the project. Phase II will develop four new types of games that improve language acquisition using audiovisual experimentation, realtime chat with artificial intelligences, and a new technology that transforms visuals and narratives composed by students into grammatically accurate text and audio. Phase II will integrate these innovations into a crowd-authoring and quality assurance system capable of scaling to 100,000 new teacher-made learning objects per month. By giving language educators tools to rapidly create, share and customize content to meet their precise needs, the project seeks to significantly improve learning outcomes. Phase II will implement real-time formative assessment reports for teachers to evaluate student experiences and issues with the custom teacher-made interactive content. A controlled full-year, multi-site educational impact study will measure whether the project affects vocabulary acquisition, comprehension, grammar and sentence formation, and whether any skill gains transfer to other contexts. It will also reveal deep data insights about the process by which K-6 students acquire a second language.

Teachley, LLC

Program: SBIR Phase II

NSF Award No.: 1632238

Award Amount: $749,999.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Mobile Games Teaching Rational Number Operations

This SBIR Phase II project offers a unique approach to teaching the difficult content of operating with fractions through interactive, adaptive games. Existing products are not effective at teaching fractions, and half of US eighth graders cannot correctly order three fractions, a fourth grade standard. Current research and the Common Core State Standards emphasize using a number line to teach fractions, which is a more effective approach; however, leading curricula are not fully aligned to this method. This project aims to improve 3rd-5th grade students' understanding of fractions through engaging apps that encourage estimation and problem-solving. Unlike other apps, which typically end with just a score, this project will provide rich, actionable insight to help teachers screen and monitor students' progress over time, thereby improving teachers' instruction as well as student learning. Closely aligning with NSF's mission of improving mathematics education for all children, this project fills an essential need in the marketplace for engaging, effective software that aligns with Common Core and provides data-driven intervention support. This software will be specially designed for children who struggle in mathematics and will meet the criteria for intervention software, further increasing its commercial value for the school market and its potential to generate income.

This project aims to improve children's use of efficient strategies in estimating and solving fractions arithmetic by targeting children's metastrategic awareness and metacognitive abilities. This project will include the development of a series of fractions apps and game-based data reporting for teachers to help them tailor instruction and target interventions. Extracting actionable insight from children's gameplay rather than from standardized tests is a novel innovation that has the potential to dramatically change teaching and learning. The development process will include wireframing novel gameplay and developing app components and features. The backend system will identify learning patterns within clickstream data collected during play and apply data-mining techniques to these patterns. Instead of assessing single actions as correct or incorrect, the backend will identify series of actions and associate them with a particular strategy. This data will be used to inform instructors, test hypotheses, and provide evidence for learning. A dynamic content generation engine will use the insights extracted from student data to provide learners with highly targeted, fine-tuned activities. The project's research will include both informal design research and a randomized control study with 3rd-5th grade students to determine the effects of using the software on procedural and conceptual knowledge of fractions.

The Language Express, Inc.

Program: SBIR Phase II

NSF Award No.: 1660018

Award Amount: $746,756.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Serious Game for Job Skills

This SBIR Phase II Project will systematically develop, test, and revise a video game. Emerging technologies, such as educational videogames, have the potential to increase the accessibility of learning materials, promote readiness and knowledge of employment options, and improve students' attitudes toward full-time employment. Unfortunately, the lack of an accessible, coherent career planning system in the United States has left many high school students unprepared to meet the rigorous demands associated with being college and career ready. This project will teach critical life, social, and academic skills related to a career in Science, Technology, Engineering, and Mathematics (STEM). This project is designed to enhance student learning, reduce school costs, and increase the efficacy of transition plans, which are mandated for every student with a disability under Federal law. The game aligns with Common Core Standards and the Universal Design for Learning framework. While this project will be designed for students with disabilities, it is assumed the highly accessible career preparation software will also meet a critical need for other students at risk of learning failure or students without disabilities.

This project is a critical component of a comprehensive product line that will provide adolescents with virtual career training. During the project, participants will experience mini-games related to their daily living skills, a "day in the life" of a person in a STEM career, and social skills that those allow individuals to interpret different cultures in a STEM environment. A virtual mentor coaches the student to make choices that will lead to career advancement and explains the hierarchy of jobs within the chosen career. The virtual mentor also provides financial advice throughout the daily living games, modeling exemplary fiscal management and reinforcing decisions that have a high likelihood of leading to financial stability. The project team will build, test, analyze, and revise the mini-games and then compile the revisions into a beta version of the game. Initial friends and family tests of the alpha builds will include qualitative evaluation using observations and interviews. This will be followed with beta testing in public schools using a mixed methods design. Beta testing will include students with and without disabilities in grades six through nine, special education and general education teachers, counselors and parents.

ThoughtSTEM, LLC

Program: SBIR Phase II

NSF Award No.: 1632539

Award Amount: $766,000.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Cloud-Based Tutoring Software For Teaching Coding to K-12 Students through Integration with Popular Video Games

This Phase II project proposes to develop a computer science (CS) educational software that has the potential to inspire millions of U.S. K-12 students to learn computer programming. This software will leverage the motivational power of a popular video game, to teach CS to students by teaching them to reprogram the video game itself. The United States currently has a severe deficit of students pursuing CS. The Bureau of Labor Statistics predicts that over 1 million computing job openings will go unfilled by U.S. workers by 2022. By leveraging the power of a popular video game, the technology proposed in this Phase II project has the potential to expose millions of K-12 students to coding in the next 5 years. The commercial impact of the underlying technology developed in this Phase II project does not stop at the over 100 million users who currently play the popular video game with which the current educational software integrates. Because the underlying technology is transferable to any moddable (i.e. reprogrammable) video game, the technology has the potential to be used to teach CS with other popular titles from the rapidly growing video game industry.

This Phase II project proposes to continue the development of a software product that is a web-based coding environment for novice programmers. This software goes beyond the state-of-the-art technologies in this space (i.e., scratch.mit.edu) in several ways: 1) It uses automated tutoring techniques to customize the educational experiences for novices, 2) it facilitates writing programs that manipulate objects and terrain in a 3D environment, 3) it allows the novice user to reprogram a popular video game, 4) it has an in-browser, WebGL-based 3D runtime environment, 5) it supports both a novice-friendly visual programming language (Blockly) as well as a text-based language (JavaScript), 6) it leverages gamification techniques such as badges, points, and unlockable items, and 7) it supports multi-user, collaborative coding. The objectives of this Phase II project concentrate on improving student experiences in order to increase customer retention and acquisition and to finish the development of a marketable product that will teach 5 million K-12 students in the next 5 years. The first objective of this project involves developing and extending the browser-embedded game engine. The second objective focuses on improving systems that match students with appropriate educational content and motivate students to continue learning. Finally, the third objective involves implementing new systems that incentivize students to create and share with the community.

Triad Interactive Media

Program: SBIR Phase II

NSF Award No.: 1534770

Award Amount: $659,682.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Game-Based Leadership Program

This Small Business Innovation Research Phase II project is an online, game-based program to improve the leadership skills of individuals in science, education, the military, government, and industry. Leadership skills are key to innovation, efficiency, and effectiveness in all organizations. The program being developed is built on a proven leadership model and converts that traditional model into a role-playing game. The empirically tested model consists of three basic strategies and six practices that expand leaders' perspectives and enhance their problem-solving skills. The program uses a futuristic narrative, 3D-animated multimedia, and challenging leadership dilemmas to engage learners, who play the role of a novice world leader. The program provides instruction in leadership, and then learners apply their new leadership skills to build an alliance among warring factions and collectively solve a global problem. A series of game quests test learners' understanding, and they receive immediate feedback on all decisions and actions. Learners communicate through social media tools with other players and, at the end, participate in a virtual synchronous debriefing exercise with peers and trained facilitators to ensure full comprehension. An administrative dashboard provides real-time performance data. The game is scalable, accessible, and designed for repeat playability.

The most profound innovation of this project is that it conceptualizes, designs, and develops a system of game mechanics and algorithms that mimic the facilitator-led human aspect of a research-based, face-to-face model of leadership training. This design entails building out a backend system as an artificial intelligence tool designed to guide users engaging with instructional materials, anticipate player actions, make recommendations on actions and anticipated actions, and provide feedback similar to guidance an on-site facilitator would provide. Furthermore, the game logic supports multiple paths to success, with some paths being more efficient, optimal, elegant, or otherwise more appropriate choices. The game logic and technical design are built to reflect problem solving and leadership in the real world, which is largely based on open-ended decision making. The game mechanics and related backend technology are designed to support open-ended decision-making, thus making game play both more engaging and authentic for players. A final innovation is the linking of an asynchronous online video game learning experience with virtual facilitator-led synchronous debriefing, which can be done on a worldwide scale. The program will be tested as a global collaboration exercise with both high school students and corporate leaders.

TutorGen, Inc.

Program: SBIR Phase II

NSF Award No.: 1534780

Award Amount: $796,000.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: A Student Centered Adaptive Learning Engine

This SBIR Phase II project represents a revolutionary advance in adaptive educational technology systems by using data collected from previous exercises to automatically generate hints and feedback for students. This work addresses the SBIR Educational Technologies and Applications subtopic EA5 - Learning and Assessment by making adaptive learning widely available and by providing tools to assess student performance in order to make interventions as early as possible and help students succeed. While it is well known that adaptive Computer Based Training (CBT) is more efficient and more effective, it has traditionally been cost prohibitive to produce in most domains. By leveraging the latest research in Big Data analytics and Educational Data Mining (EDM), this project will produce adaptive capabilities automatically, dramatically reducing the costs of producing more effective training and making such training widely available. The core customers for this technology will be providers of training systems. This includes publishing organizations, developers of software tools for education, and providers of corporate and government training. Institutions that are struggling to educate students, particularly across STEM (Science, Technology, Engineering, and Mathematics) fields, will be able to use this technology in their existing teaching systems and thus improve student engagement and performance.

The final outcome of this project will be an integrated set of software tools that collect data from existing computer/web based training software, and automatically generate adaptive capabilities to create a personalized learning environment for students. It does this by using novel EDM and machine learning techniques to build and organize student and problem models that improve over time as more data is collected. It also provides for the tracking of student progress on specific concepts or skills (knowledge tracing), allowing for easy assessment at any point in time. The system also dynamically selects the students' next problems to maximize student learning and minimize time needed to master a set of skills (problem selection). For complex multi-step problems, this system will provide context-specific, just-in-time hints to help students as they learn. The final product will include data adapters that allow developers of existing software to seamlessly connect with this system. Finally, a main differentiator of this system is the transparent process of data curation and the related visualization tools that expose the problem- and student-model generation process. This combination of human input and machine learning will provide researchers, developers, and educators tools to explore student data and allow for new insights into how students learn.

VoiceVibes, Inc.

Program: SBIR Phase II

NSF Award No.: 1632582

Award Amount: $747,422.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Automated Public Speaking Assessment

This Phase II project aims to develop software to automatically assess public speaking skills and prepare students with better oral communications skills necessary to perform job tasks. Oral expression is the most highly valued ability throughout the economy and ranks as the second most highly-valued skill for high-wage, high-growth, high-skill occupations. Approximately 4.5 million college students take a basic communications course each year, however, as class sizes get larger and online learning becomes more common, public speaking instruction becomes increasingly difficult. Practice and feedback are essential aspects of these courses, yet it is a struggle for teachers to find enough time to sufficiently interact with students. This SBIR project aims to develop the key concepts of automated public speaking assessment such that a student's vocal delivery can be objectively measured and presented in a manner that creates an independent, personalized learning experience. Unlike traditional methods of public speaking assessment, the proposed system can be available at any time, provide objective feedback and track student practice and improvement. The proposed Software-as-a-Service is projected to generate $16 Million in revenue over five years and create more than 25 high-paying, US-based jobs.

This Small Business Innovative Research (SBIR) Phase II project proposes to develop an automated assessment system for public speaking that determines how a speaker would be perceived by an audience. Automated assessment for speech has already occurred in spoken language proficiency, which leverages Automated Speech Recognition (ASR) and semantic analysis. Automated voice assessment has also been utilized in lie detection and emotion detection, which focus on autonomic responses in the user's voice, such as when stress affects the vocal cords. The hypothesis behind this SBIR project is that speakers can consciously use and modify non-semantic speech behaviors to produce more desirable listener perceptions. Automatically linking listener perception to speech behaviors represents a novel direction in automated assessment for speech. The Phase II objective is to develop software sufficient for automated public speaking assessment such that a student's vocal delivery can be objectively measured and presented in a manner that creates an independent, personalized learning experience. Voice analytics capability investigated in Phase I will be enhanced and developed into a cloud-based service which helps students practice, track, and improve their public speaking habits.

Xemory, LLC

Program: SBIR Phase II

NSF Award No.: 1534795

Award Amount: $749,977.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: An Interactive 3D Game of Evolutionary Robotics for STEM-based Education

This SBIR Phase II project studies the problem of how to engage students in STEM (Science Technology Engineering and Mathematics) education through game-based learning in a Virtual Robotics computer game. In the game, students design, assemble and train virtual walking robots to compete against their peer robots to secure a seat on a virtual mission to Mars. The project analyses the effects of competition and collaboration on the learning and retention of key robotic control concepts. The project will produce a low-cost educational computer game, where far more U.S. middle schools and high schools students can learn about biomechanics, math, physics and computer algorithms through a robotic simulation game than is possible with current robot hardware approaches. The product provides the American educational system a solution to quickly engage students in STEM who might otherwise turn away. STEM field professions can lead to high paying jobs, which in turn can improve productivity and the economic landscape for America.

The project's education technology innovation is a cloud-based robot evolution game engine where students acting as a crowd can evolve the behavior of walking bi-pedal robots. The evolution of robot behavior happens on three levels: 1) the micro scale where an individual or small group of students evolves singular robot behaviors, 2) the mid-scale where groups exchange individual behaviors to form a behavior sequence to meet game level challenges. (For example, link a sequence of behaviors to stand, walk, jump, and turn to clear a section of obstacles and reach the prize goal), 3) the macro scale where the community evolves a cumulative set of behaviors through re-use and adoption of most efficient behaviors, discarding failed behaviors and creating new game level challenges. In particular, this project studies how individual and group learning is affected by adjusting the reward incentive, competitive motivation, novelty and surprise, and challenge level difficulty. During competition, the game gathers data regarding level of student learning and robot performance to answer two specific questions: a) do students learn more through small group or large group collaboration/competition, and b) are the students more engaged in small or large scale crowd-sourced environments.

Zyante, Inc.

Program: SBIR Phase II

NSF Award No.: 1430537

Award Amount: $1,366,989.00

Start Date: 09/01/2014
End Date: 08/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Developing a Web-based Authoring Framework for Animated Interactive University STEM Web Content via Curated Crowdsourcing

This SBIR Phase II project develops a new web-based publishing paradigm that creates interactive learning content for university-level science, technology, engineering, and math (STEM) fields. The interactive content, featuring animations, interactive question sets, and online tools, along with some text, may replace or enhance traditional textbooks, with studies showing significant improvements in student engagement and learning outcomes. The project addresses the nationwide high dropout rates of STEM students, due in part to outmoded learning materials. Such dropout rates not only prevent students from achieving their career goals, but result in a shortage of college graduates in nationally-critical STEM fields. The project creates novel web-based tools that empower teachers, and even students, to straightforwardly contribute new interactive content, thus tapping the latent talent and energy of many thousands of people. The project creates automated and human-overseen processes that efficiently and effectively percolate the highest-quality contributions to the top of lists, enabling content to be created and maintained at large scale and low cost. The project's new publishing paradigm can disrupt the existing publishing industry. The interactive quality content can increase the number of students who successfully graduate in STEM fields, which can strengthen the nation's economy and competitiveness.

The project develops a new web-based content authoring and delivery framework that supports a novel curated-crowdsourced publishing paradigm. The framework tightly integrates collaborative web-based authoring with delivery of animated interactive web-based content. The project develops elegant tools for instructors, and even students, to contribute new interactive items. Such tools include a novel browser-based animation creation tool, which allows powerful animations to be easily and quickly created via any web browser without requiring application installation or requiring extensive tool training. The project creates and tests new processes that, via a combination of peer evaluations, usage data, and assessments, automatically percolate quality contributions to the top, for final curation by instructors, authors, or editors. Such percolation crowdsourcing can yield superior learning materials, at scale and cost-effectively, while simultaneously yielding substantially lower prices than traditional textbooks.

Zyante, Inc.

Program: SBIR Phase II

NSF Award No.: 1534527

Award Amount: $750,000.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: Developing a Structured Student-guided Personalized Learning System for Mathematics

This SBIR Phase II project develops novel adaptive techniques for web-based learning materials, and creates Algebra and Statistics content using those techniques. College textbooks and homework are being replaced with web-based learning materials that are highly-interactive, involving animations, learning questions, and auto-generated auto-graded homework/quiz exercises. The project develops those exercises to adjust (adapt) to the learner's performance as well as to the learner's preferences, providing a novel structured form of adaptivity that maximizes learning efficiency while reducing student anxiety, in contrast to many other proposed adaptive techniques. The project creates new content for the topics of Algebra and for Statistics, two critical subjects with which many college students struggle. The result will be greater success (and less failure) in Algebra and Statistics courses by young college students, leading to more graduates in STEM (science, technology, engineering, and math) fields, which contribute greatly to the nation's productivity and competitiveness. The techniques can be applied to many other STEM and non-STEM subjects, and for learning beyond college courses too.

This SBIR Phase II project develops novel adaptive techniques for web-based learning materials, called structured student-guided adaptive (SSGA) techniques. In contrast to some recent adaptive commercial products, SSGA preserves the ability of an instructor to maintain a structured path through the material, which is critical for keeping students in synch with lecture/discussion sessions, for enabling students to study with classmates, and more. Adaptivity comes in several forms, including auto-generating successively-harder problems based on correct completion of earlier problems, with explanations and source material carefully integrated to ensure students learn underlying concepts. Also, the adaptivity is in part guided by the student, who can choose to start with simpler or harder problems, or can auto-generate self-quizzes based on performance, selected material, and more. In contrast with other products, student-guided adaptivity gives students appropriate control over their learning, yielding a sense of empowerment and reducing anxiety that can inhibit learning. The project builds the authoring platform necessary to support SSGA material creation, building upon a previously-developed authoring framework for interactive web material. The project also creates new material for college algebra and statistics courses, whose high attrition rates can be reduced by replacing traditional textbooks/homework with SSGA material.

Zyrobotics, LLC

Program: SBIR Phase II

NSF Award No.: 1555852

Award Amount: $760,000.00

Start Date: 02/15/2016
End Date: 01/31/2018

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Topic: Educational Technologies and Applications (EA)

SBIR Phase II: An Accessible Platform for Engaging Children with Motor Impairments in the Classroom Environment

This SBIR Phase II project focuses on developing an accessible educational platform that combines mobile interfaces and adaptive educational tablet applications (Apps) to support the needs of children with special needs. Tablet devices are known to provide an interactive experience that has revolutionized learning for children. Unfortunately, while these tablet devices are intuitive to utilize and easy for many children, those with disabilities are largely overlooked due to difficulties in effecting pinch-and-swipe gestures. This project thus addresses a direct need in our society by providing an integrated educational experience, focused on math education that addresses the diverse needs of children, while providing a solution for variations found in their disabilities. The contributions of this project include 1) the design of accessible math Apps usable by K-12 children with and without disabilities and 2) the design of apps that adapt educational content and provide feedback to parents and teachers based on real-time analytics. Given that there are over 93 million children worldwide living with a disability and, in the United States, children with disabilities are entitled to a free appropriate public education, there is a large potential of making both a commercial, as well as a societal, impact in this space.

This SBIR Phase II project addresses an unmet need by developing an innovative solution to enable children with motor disabilities access to mobile devices and Apps that could engage them fully into the educational system. This solution capitalizes on the availability of pervasive technologies by combining an accessible tablet interface and educational Apps that adapt to each child's abilities in order to provide an accessible mobile solution. Tablet devices are known to provide an interactive experience that has revolutionized learning for children. Unfortunately, while these tablet devices are intuitive to utilize and easy for many children, those with motor limitations tend to have difficulties due to the fine motor skills required for interaction. As such, to address the growing utilization of tablets in the classroom environment, the specific research objectives of this effort include the design of methods that enable the embedding of educational math content into accessible tablet apps for training and evaluating cognitive skills, the design of methods that enable adaptation of the educational content based on real-time analysis of interaction data and correlated performance of the child, and the hosting of interactive design sessions with teachers, parents, and children to evaluate the usability of the system.

ELECTRONIC HARDWARE, ROBOTICS AND WIRELESS TECHNOLOGIES (EW)

Akoustis, Inc.

Program: SBIR Phase II

NSF Award No.: 1556097

Award Amount: $918,570.00

Start Date: 02/01/2016
End Date: 07/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Single Crystal Group III-Nitride Bulk Acoustic Resonators and Bulk Acoustic Wave Filter Components for Mobile Communications

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to enable the development and commercialization of single crystal piezoelectric Bulk Acoustic Wave (BAW) filters targeting the mobile wireless market, providing much needed improvements over the incumbent poly-crystalline technology in critical components used in all smartphones and other wireless devices. The technical advantage based upon this innovation in single crystal piezoelectric material provides improvements in key parameters that will benefit consumers of the smartphone, of particular note are component insertion losses which will result in increased battery life and reducing the complexity of the RF front-end. Additionally, the commercialization of this technology will address cellular component market demand not being serviced with the incumbent technology. There is a general lack of competition around the incumbent technology based on limited access to existing intellectual property. The technology developed under this SBIR will enable new participants in this growing market.

This Small Business Innovation Research (SBIR) Phase II project will enable the first comprehensive study of wide bandgap, group III-Nitride single crystal materials for bulk mode resonator technology. This technology is the fundamental building block of RF filter technology and addresses a critical need in today's RF frontends. The need arises from the filter's location (between amplifier and antenna) and performance (half the power is lost due to inefficiencies). As a result, components must be over-designed to accommodate for the filter loss. The excessive losses degrade battery life and drive higher thermal management costs in the system. To address this need, a more efficient, lower loss Bulk Acoustic Wave (BAW) filter with lower losses and dramatically improved performance is proposed and offers high payoff in the end market. The effort continues the design and simulation of single-crystal piezoelectric resonators to support resonant frequencies from 1 to 6 GHz. Piezoelectric materials are synthesized on 150-mm silicon substrates and fabricated into resonators and BAW filters using an experimental fabrication process flow and novel circuit designs.

Alacrity Semiconductors, Inc.

Program: SBIR Phase II

NSF Award No.: 1555875

Award Amount: $744,115.00

Start Date: 03/01/2016
End Date: 02/28/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Novel Capacitor-less Dynamic Random Access Memory Technology with Energy Efficiency, Manufacturability, and Scalability

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to produce a new type of computer memory called Ferroelectric Dynamic Random Access Memory (FEDRAM). FEDRAM is cheap and can be mass-produced in current semiconductor manufacturing facilities. It also uses much less energy than current-state-of-the-art memories, and enables electronic devices to be much smaller in physical size. Commercially, FEDRAM works best as an embedded memory, which means they are ideally suited for products such as mobile phones where the processor and memory are on the same chip. Additionally, the same block of FEDRAM can be configured for high performance applications in addition to longer storage applications. This means that future devices will adapt to maximize power, performance, and usability. Due to the factors of price, performance, and low power, once FEDRAM is proven to work, it can potenitally be adopted in nearly every electronic device.

This Small Business Innovation Research (SBIR) Phase II project addresses the commercialization questions of Ferroelectric Dynamic Random Access Memory (FEDRAM). In SBIR Phase I, it was shown that FEDRAM cells can be manufactured in an existing foundry with no new materials or equipment changes, and that FEDRAM has leading performance characteristics. The next step is to prove the same characteristics in an array, which would be considered a minimum viable product; this is the goal of SBIR Phase II. By proving this array, it will be possible to quickly scale the FEDRAM memory array into embedded applications for commercial deployment. The performance characteristics to be demonstrated are read/write latency, switching time, endurance, retention, and energy use.

Arborsense, Inc.

Program: SBIR Phase II

NSF Award No.: 1660015

Award Amount: $580,822.00

Start Date: 04/15/2017
End Date: 03/31/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Wearable Nanoelectronic Vapor Sensors for Transdermal Alcohol Monitoring

The broader impact/commercial potential of this project is through providing a wearable alcohol monitoring device to the general population which will lead to a better awareness about alcohol consumption, and ultimately enhance health, lengthen life, and reduce burden of illness and disability. Incautious alcohol use causes health and social problems that either manifest over time due to sustained drinking (e.g., heart disease, cancer, liver disease, diabetes, etc.), or are short term effects of acute intoxication and/or impaired decision-making (e.g., motor vehicle crashes, violence, etc.). Excessive alcohol use led to approximately 88,000 deaths per year in the United States from 2006-2010 and in 2006 alone cost the economy approximately $224 billion. In light of the above social impact, the proposed graphene based wearable alcohol monitoring device addresses the urgent need to implement health approaches to reduce the loss of life and the huge economic costs that result from excessive drinking. In fact, the growing need for personalized health-care is highlighted by the estimated market size of $19 billion for wearable biosensors by 2018, pointing towards the potential commercial opportunity for self-monitoring alcohol sensors as well.

This Small Business Innovation Research (SBIR) Phase 2 project addresses the unmet need for a small, light, unobtrusive, convenient-to-use alcohol sensor for real-time self-monitoring of alcohol consumption. Excessive alcohol consumption is a health risk behavior and the fourth leading preventable cause of death in the United States. Most strategies to improve safe drinking rely on obtaining accurate and timely information about alcohol consumption; these include self-report of number and timing of drinks, breathalyzers, blood analysis by lab, and wearable devices. Wearable alcohol monitors have clear advantages in terms of accuracy and feasibility compared to other methods for self-monitoring. However, current wearable devices for alcohol monitoring are bulky, inconvenient to use, obtrusive, and do not provide consistent, real-time data on the level of intoxication. In this Phase II SBIR project, a stand-alone graphene nanoelectronic transdermal alcohol sensor integrated with calibration electronics and Bluetooth transceiver will be developed, tested and benchmarked on a large group of recruited adult volunteers. Good correlation between the graphene sensor and a legal grade breathalyzer in large-scale human tests will confirm the technical and commercial feasibility of the proposed sensors, which can then be shipped to early adopters, pitched to investors, and ultimately introduced for sales.

Bascom Hunter Technologies

Program: SBIR Phase II

NSF Award No.: 1632136

Award Amount: $725,942.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Interference Mitigation for Broadband Wireless Backhaul Systems

The broader impact/commercial potential of this project is to enable wireless industry carriers and equipment providers with an affordable technology solution to meet the continuing explosive societal/customer demands for data access. The telecommunication market sector has been increasingly consolidating to Asia and Europe where foreign governments are making strategic investments to encourage work in their respective countries. In a long-term, the proposed interference elimination technology can lead to increased investment in the telecom equipment sector and efficient use of the finite radio frequency (RF) spectrum in the United States. The expected technical and commercial outcome from the project is an active interference mitigation capability with product features including a significantly improved quality of service, simplified network equipment design and installation, and reduced requirements for many components such as antenna and filters. This in turn will reduce the overall cost per data link, as well as reducing the size, weight, and power requirements of the system.

This Small Business Innovation Research (SBIR) Phase 2 project addresses the critical need for disruptive RF interference mitigation solutions. As networks are moving toward higher performance to accommodate larger capacity than ever seen before, the network operators, industry organizations, and equipment providers are looking into innovative technologies for next generation 5G wireless networks. There are two advantages offered by the proposed interference elimination technology. One advantage is extreme wide instantaneous bandwidth and the other is flexible tunability over GHz of operating frequency. These advantages help to consolidate and reduce front-end hardware. The focus of this program will be first on developing an optical system-on-chip version of the interference cancellation system with monolithically photonic integrated circuits. With a complete and fully function development board, the second focus will be on demonstrating the application in in-band interference mitigation for wireless backhaul networks, and showing improvement in 2x spectral efficiency and potential 1000x increase in capacity.

BluHaptics, Inc.

Program: SBIR Phase II

NSF Award No.: 1556109

Award Amount: $747,179.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Collaborative Subsea Manipulation Interface

The broader impact/commercial potential of this project results from the advancement of telerobotic control technology for subsea operations. As humans deploy and maintain ever more complex underwater hardware, conduct subsea scientific sampling and exploration and develop natural resources in hostile, deep and remote locations, the need for ROVs (Remotely Operated Vehicles) is increasing. ROVs have transitioned from basic transport and inspection tools to mission critical machines for construction, maintenance and intervention. Despite advances in sensing and machinery, significant challenges persist which have plagued the industry with high costs and unacceptable downtime, as well as safety risks. Limited situational awareness, data deluge and inadequate manual operator controls combine to create high rates of equipment breakage, unpredictable and inefficient task completion and high mission overhead. This work is developing innovative products for 3-dimensional visual awareness and computer assisted control systems for subsea teleoperated robots. Divers can be replaced in hazardous situations by telerobots using this technology. The rate of untoward incidents and their severity will be reduced for a large range of subsea activities. Economic benefits include reduced costs, new employment opportunities, competitive advantages and contributions to the national technological infrastructure in subsea operations.

This Small Business Innovation Research (SBIR) Phase 2 project will address fundamental challenges of connecting higher-dimensional data from remote environments to intuitive controls. Its intellectual merit is the refinement of a collaborative approach to command and control allowing ROV pilots to communicate seamlessly with each other and the robotic system. This will be done by developing several foundational innovations that, separately, enhance capabilities (and may become individual products), and that together derive immense value to the customer. These technologies are in the areas of: (1) Pilot Interface/Control room software; (2) Sensor fusion and processing; (3) Task assistance and workflow management; and (4) Manipulator and vehicle control. Successful implementation of visualization, sensor fusion, control methods, and haptic virtual fixtures serves as an excellent demonstration example of these technologies. With these technologies combined into a single software platform and integrated with a robotic system, increased performance, predictability, and safety can be achieved in a way that surpasses what is currently possible for purely automated or manual robotic systems. Although this work is focused on underwater operations, it can also be extended to terrestrial applications, such as industrial assembly, welding and machining, nuclear maintenance and robotic dredging and excavation.

Board of Regents, NSHE, obo University of Nevada, Reno

Program: PFI:BIC

NSF Award No.: 1430328

Award Amount: $800,000.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC: Enhanced Situational Awareness Using Unmanned Autonomous Systems for Disaster Remediation

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from the University of Nevada-Reno has as its goal the enhancement of the situational awareness capabilities of law enforcement agencies and first responders by employing unmanned autonomous systems (UAS) with high-resolution sensing and imaging capabilities for disaster remediation. Law enforcement agencies and first responders face significant challenges during an emergency event, such as a natural or anthropogenic disaster (earthquake, tsunami, fire, hurricane, tornado, flood, power or nuclear accident, act of war, or terror). One of the major challenges is acting decisively based on available information and considering human factors, making high-quality real-time situational awareness critical to effectively manage and safeguard civilians and in- field personnel. This project focuses on creating a smart emergency-response service system using UAS, both air- and ground-based systems, equipped with state-of-the-art imaging, sensing, and communication systems to provide first response teams with high-quality, real-time information to act decisively and effectively via human-machine interactions. Such a smart service system will guide/escort humans to safety, direct rescue crews to access trapped humans, and provide in-situ communication, medication, water and food, and power. The program will develop the requisite human infrastructure of graduate students in mechanical engineering, computer science and engineering, electrical engineering, and social psychology. Working together in the interdisciplinary team, students will be exposed to research outside of their respective disciplines and to innovative opportunities for entrepreneurship. A successful smart service system will impact the operations of the public safety sector, and it could be adapted by similar organizations.

The project's objectives include the following: (1) develop and integrate UAS platforms, sensors, imaging and communication systems, and control and path planning algorithms to create a UAS-based smart service system for first response; (2) model the state of humans and infrastructure during a disaster, identify the scene, and create access paths to safety; (3) test prototypes and pursue commercialization opportunities; and (4) educate the public and train first responders on the technology. The translational research to create the UAS-based smart service system will focus on sensor data fusion, scene identification, modeling of the state of humans, infrastructure and their interactions as well as on the platform for testing and evaluating remediation strategies, communication schemes, and access path planning. Understanding of the system aspects will enable first responders and public safety command personnel to analyze and understand on-scene, active emergency situations through interactive, integrated data analysis and visualization; and give them the ability to sense, predict, and act in a variety of disaster scenes and human socio-psychological conditions.

Partners at the inception of this project are the University of Nevada at Reno (involving faculty across four departments: mechanical engineering, computer science and engineering, electrical engineering, and social psychology); industry partners: two small businesses, Drone America and SpecTIR, companies based out of Reno, Nevada; academic partners: University of Nevada, Las Vegas; and the University of Utah as well as experts from the UNR Seismology Lab and the Washoe County as System users; and broader context partners include the newly established Nevada Advanced Autonomous Systems Innovation Center (NAASIC) at UNR, the state-supported UAS program management office, Nevada Institute for Autonomous Systems (NIAS), and the Nevada Industry Excellence (NVIE).

Boulder Environmental Sciences and Technology, LLC

Program: SBIR Phase II

NSF Award No.: 1660250

Award Amount: $710,802.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Development of a Radiometric Receiver for 183 GHz.

The broader impact/commercial potential of this project is in the improvement of atmospheric state observations from various platforms. This compact, integrated and "plug and play" receiver design will make the existing observations more available, more economical, and will also enable previously unattainable observations of water vapor distributions within the atmosphere. This environmental sensor's small size and low power requirements enables its deployment on various airborne, spaceborne or ground-based platforms, such as unmanned aerial aircraft, nanosatellites, ocean buoys, and remotely located ground-based instruments. One promising commercial application is private weather observing satellite constellations. It has been estimated that around 400 remote sensing nano/microsatellites will be launched worldwide between the years of 2016-2018. Water vapor and cloud observations are among the most important observations promising further understanding of weather events and to better synoptic or mesoscale forecasts. Improved atmospheric observations are directly related to increasingly accurate and useful weather forecasts. The benefits are expected to extend widely across the economy. Meteorologists point to more accurate and rapidly refreshed atmospheric observations as one of the necessities for the continuous improvements in weather forecasting, understanding of the atmospheric physics and climate.

This Small Business Innovation Research (SBIR) Phase 2 project will complete the design and build a fully functional prototype of a very compact, direct detection radiometer receiver, operating in the vicinity of the 183 GHz water vapor absorption line. All the receiver components will be designed and evaluated, including a noise source, detectors, filters, Monolithic Microwave Integrated circuits and others, first as individual parts and then within the assembly. A novel receiver architecture and integration of all components into one assembly allow for a drastic reduction in the receiver size and reduction of its power consumption, while improving its observational capabilities and stability. There are several aspects of the proposed effort that are unique and would provide profound advances in ultra-compact microwave radiometry. The receiver is expected to consume less than 0.5 Watt of power and weigh around 100 grams, with a continuous two-point calibration capability at its input.

C-Motive Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1534684

Award Amount: $721,090.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Variable Capacitance Machines for Use in Linear Actuators for Industrial Automation

The broader impact/commercial potential of this project is to develop a novel platform technology: a high-torque electrostatic motor (EM). This readily scalable platform machine technology can provide any desired torque or power rating necessary along with increased energy accessibility and reduced energy/operating costs compared to traditional steel-copper-magnet based motors. Instead of using permanent magnets or wire coil mechanisms, this motor exploits electrostatic forces between closely spaced, conductive metal plates to create an electric field, with shaft-torque capabilities far beyond those of conventional machines. By allowing industry more efficient operations, resources will be freed for continued innovation, spurring economic growth. This EM uses domestically-sourced materials like aluminum, steel, and plastic instead of rare earth elements like neodymium, dysprosium, or samarium used in traditional motors, thus reducing both dependence on foreign supply chains of rare earths and market volatility. EMs will be lighter-weight and less expensive to produce than traditional motors. Value is offered to numerous commercial markets, including electric/hybrid-electric cars, industrial automation, renewable energy (wind turbines), and machines operating in extreme environments (aerospace or down-hole drilling) through lower materials costs, increased reliability, higher efficiencies at low speed, and reduced weight.

The Small Business Innovation Research Project (SBIR) Phase 2 project will expand understanding of electrostatic machinery, including operational principles, design principles, and strengths/weaknesses of this novel platform technology. This represents the first significant breakthrough in motor/machine technology in almost 150 years. Previously, electrostatic technology had few applications due to a limited body of knowledge, despite occasional study throughout the last century. This was primarily due to technological limitations (low capacitance, the necessity of vacuum used as an insulating medium), whose solution required knowledge spanning multiple technical fields (electric field theory, chemistry, mechanical engineering, material science, and power electronic controls). By addressing these technological limitations in P-I, this project already expanded the body of pertinent engineering and physics knowledge. This P-II project offers opportunities for additional study ranging far beyond those currently envisioned. For example, optimizing electrostatic/mechatronic systems such as sophisticated electrostatic drive systems will likely involve the use of highly-engineered materials (metamaterials and composites); next-generation 3D multiphysics simulation platforms to simultaneously solve fluid dynamic, electrostatic, and thermal behaviors; and development of chemical synthesis processes to maximize electrostatic force production. Advanced manufacturing technologies will likely emerge, leading to possibilities including injection molding or 3D printing of a machine.

California Institute of Technology

Program: PFI:AIR - TT

NSF Award No.: 1602119

Award Amount: $212,000.00

Start Date: 06/01/2016
End Date: 11/30/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Optimal Adaptive Charging System

This PFI: AIR Technology Translation project develops software for adaptive electric vehicle (EV) charging networks and transitions it to the marketplace. We are at the cusp of a historic transformation of our energy system into a more sustainable form in the coming decades. Electrification of our transportation system will be an important component because, today, vehicles consume more than a quarter of our energy and emit more than a quarter of our energy-related carbon dioxide (CO2). Electrification will not only greatly reduce CO2 emission, but EVs can also be critical resources to help integrate renewable sources, such as wind and solar power, into our electric grid. One of the key enablers to mass EV adoption is the availability of smart charging networks.

This project will design a set of novel and sophisticated algorithms that optimize a network of EV chargers, implement them in software, and pilot them in a Caltech garage where the researchers have already installed a network of programmable EV chargers. It will serve as a prototype that validates the technology and business potential of next-generation adaptive charging network (ACN). Compared with state of the art in the EV charging industry, ACN will enable massive deployment of smart chargers and provide the same charging capacity at a fraction of required infrastructure costs.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. At many workplaces in top EV cities in the US, there is a severe shortage of chargers relative to EVs, e.g., there is a charger for every 2-5 EVs. In the future, this ratio should be closer to 1:1. The bottleneck to a large-scale charging facility is, however, not the cost of electricity or chargers, but the limited capacity of electricity distribution system, as well as, in city centers, the real estate. The leading chargers in the current marketplace charge at their peak rates whenever EVs are plugged in. They cannot be deployed at scale without a prohibitively expensive upgrade of the electricity distribution system. The technologies to be developed in this project will optimally schedule the charging process of a network of adaptive chargers to satisfy energy requirements of all EVs within their deadlines without exceeding the capacity of the electricity distribution system whenever possible, and optimally and fairly allocate the available capacity among competing EVs otherwise. The ACN therefore maximally utilizes the most expensive resources in a charging ecosystem to provide a target charging capacity at a much lower infrastructure cost, creating a compelling value proposition.

The project will apply tools from optimization theory, control and dynamical systems, and algorithm design. The focus is to develop optimization software that will be ready for commercialization at the end of the project. The project will involve undergraduate and graduate students. In addition to research and software development, the project participants will be exposed to entrepreneurship and technology transfer.

Carnegie Mellon University

Program: PFI:BIC

NSF Award No.: 1534114

Award Amount: $998,387.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - A Cost-effective Accurate and Resilient Indoor Positioning System

This Partnerships for Innovation: Building Innovation Capacity project aims at developing a cost effective, accurate, resilient and smart indoor localization service to be used in built environments. Positioning systems have revolutionized how we interact with the world around us. Outdoor mobile devices make use of technologies like Global Positioning System (GPS) to deliver a wide variety of location-based services. Similarly, indoor positioning systems will enable delivery of new services that provide tremendous social and commercial value to humans in residential and commercial built environments. Indoor location services can be used by enterprises to track and manage assets. Building management systems can use indoor location information to enable services for building managers and occupants and first responders, such as effective emergency response, indoor navigation, and perimeter protection. Furthermore, indoor location services will enable implementation of important services such as coordination of people in a disaster scenario (e.g., natural or man-made (public shootings) disasters and navigation services for the blind). Unfortunately, satellite-based approaches, such as GPS, do not work indoors due to weak satellite signals that do not penetrate through building facades. Unlike existing methods, the proposed smart service will achieve high accuracy and robustness with respect to disruptions, while maintaining low installation and maintenance costs. In addition, users will be able to use their mobile device(s), (e.g., smartphone, tablets, smart watches), without the need to carry/wear additional equipment.

The project will develop and combine ultrasound, visible light and Wireless Local Area Network (WLAN)-based positioning techniques with Radio Frequency (RF)-based, magnetic signatures, human ambulation models and building information models (BIMs) for localization, tracking and visualization. The combined use of several independent positioning techniquse not only will dramatically increase the accuracy of positioning over any single technique, but it will add the necessary redundancy to withstand disruption of all but one positioning service, with provably bounded loss of performance. Even in the case of unavailability of all positioning techniques, ambulation models, together with BIM, will be able to provide indoor positioning at a coarser level of granularity. In turn, redundancy can be used to perform maintenance and periodic system calibration on any subsystem without service interruption. The impressive feature of the proposed methodology is that all these properties can be achieved at low installation and maintenance costs, as the system can piggyback on a building's existing audio, lighting, and RF communication capabilities. One unique property of the proposed positioning algorithm will be its modularity and extensibility. Information coming from different sensors will be incorporated seamlessly, allowing the algorithm to work under intermittent failure of one of its subcomponents. The inclusion of ambulation models, together with accelerometer, gyroscope and compass data available on the majority of today's smartphones, will allow the achievement of fine-grain tracking, which will provide smooth trajectories in place of sequence of locations. In the proposed scheme, Multi-sensor localization and BIM play a synergetic role. BIM will contribute to decreasing installation and maintenance costs, by providing precise positioning of the sources of ranging (e.g., light, ultrasound, Wi-Fi antennas) and accurate topological information to develop high fidelity ranging models. Additionally, the semantic information provided by BIM will help with detecting infeasible trajectories. On the other hand, Simultaneous Localization and Mapping (SLAM)-based techniques can help refine BIMs and keep them updated. Dynamic information can enhance BIMs by providing useful information to building managers about traffic patterns and occupancy. Importantly, the design of the smart service needs to be human-centered and to take into account each of the stakeholders, i.e., owner and facilities management team, the service developers, the users of the smart service application program interface (API), who will develop value-added services customized for a particular facility or more generally for many facilities, and, of course, the end-users, the occupants and visitors of the facility, who will use the smart services themselves. To understand the needs and wants of such distinct groups of stakeholders, the project will directly involve them by conducting a series of focus groups. Participatory design is an established technique where a design team works directly with stakeholders to design an artifact or service. Stakeholders will also be engaged in the formal testing of the software service, from installation to maintenance, to application design and to application usage.

At the inception of the project, partners include the lead institution: Carnegie Mellon University, (Departments of Electrical and Computer Engineering, Civil and Environmental Engineering, and the Human-Computer Interaction Institute) Pittsburgh, PA, with primary partners: Bosch RTC Pittsburgh (Pittsburgh, PA, large business) and Sports and Exhibition Authority (Pittsburgh, PA, large business).

Clarkson University

Program: PFI:BIC

NSF Award No.: 1534035

Award Amount: $999,720.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - Developing Advanced Resilient Microgrid Technology to Improve Disaster Response Capability

The Partnership for Innovation: Building Innovation Capacity (PFI:BIC) project, led by Clarkson University researchers, aims to develop advanced resilient microgrid technology to improve disaster response capability. Advanced resilient microgrid technology provides continuous electric service to support critical services to people displaced during extreme disasters; and provides electric service to support recovery crews working to restore services. In an emergency, the microgrid is an electrical "island", idependent of the main power grid and serves these critical loads through local power generation. This project will focus on the human-machine operational impacts of the microgrid both during normal operations as well as during disaster response. The development of "smart scheduler" technology will enable the microgrid operator and the local disaster response team to maximize the microgrid's performance during the disaster recovery. The microgrid must operate successfully disconnected from the grid for two weeks or more in catastrophic situations where the level of damage is unanticipated and the microgrid itself has experienced reduced capability. Human-machine capability will be developed to respond to rapidly changing community needs with a minimum of human effort.

The project will complement ongoing projects to plan and design a resilient underground microgrid in Potsdam, New York. The Potsdam microgrid features a unique partnership of generator owners, local government, regulated utility, and critical load entities. This diverse set of microgrid partners is key to providing the resilience required of the microgrid. At the same time, designing, building, and operating the microgrid as a unit with its diverse set of owners presents a range of challenges. Developing the capability to schedule and control the microgrid in both normal and emergency events is a critical element of this project. Equally important is the development of a microgrid design that provides this service at a minimum cost, by maximizing the benefit of the microgrid assets during the normal operation.

The lead institution is Clarkson University (Coulter School of Engineering, School of Business, and School of Arts and Sciences). The primary industrial partner on the project is National Grid USA (Waltham, MA), the electric service provider for a large part of New York and New England, including Potsdam, NY. National Grid would own the underground distribution network that is the backbone of the microgrid. The Electric Power Research Institute, Knoxville, TN, is the broader context partner on the project. In Potsdam, NY, Clarkson University, SUNY Potsdam, the Village of Potsdam, and Canton-Potsdam Hospital are among the entities that would participate in the microgrid and are potential generation owners on the microgrid.

Clemson University

Program: PFI:AIR - TT

NSF Award No.: 1602006

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Novel Low-power III-Nitride Heater Cantilever Based Selective VOC Sensor

This PFI: AIR Technology Translation project focuses on translating the discovery of novel microcantilever heaters to fill the need for highly sensitive and selective volatile organic compound (VOC) sensors with an ultra-low power requirement. These VOC sensors are important because of their strong impact on environmental protection and indoor air quality monitoring which has direct influence on human health and well-being. The project will result in the development of a commercially viable prototype of a novel VOC sensor packaged in the form of a miniaturized handheld device. This VOC sensor has unique features of high sensitivity and selective detection of VOCs individually and in mixtures, and operation at low heater temperature without catalyst coating. These features provide the advantages of faster and unique detection of VOCs in a complex environment, much lower power consumption, and higher reliability and operational lifetime, when compared to the leading competing pellistor and photo-ionization based sensors currently available in this market space.

This project addresses the following technology gap(s) as it translates from research discovery toward commercial application. The VOC sensor to be developed will address: (i) the inability of the current technologies to perform selective detection of analytes, (ii) higher operational power requirement due to high heater temperature, and low operational lifetime due to usage of a laser or catalyst coating. A combination of unique features of the proposed VOC sensor, including low heater temperature, lack of catalyst coating, and selective VOC detection utilizing their physical properties, enables it to address the aforementioned limitations of the current technology. In addition, the personnel involved in this project, at both graduate and undergraduate levels, will receive entrepreneurship and technology translation experiences through participation in the project activities directly related to commercialization and mentorship from the industrial partner.

The project engages Tangidyne Inc. to guide the commercialization aspects of the sensor developed, and provide unique business mentorship to the graduate and undergraduate students involved in this technology translation effort from research discovery toward commercial reality.

Cognitive Robotics

Program: SBIR Phase II

NSF Award No.: 1556058

Award Amount: $748,612.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Robotic System for the Sorting of Recyclable Waste

The broader impact/commercial potential of this project will be to change the fundamental economics of the recycling process. Although it is estimated that up to 95% of the waste stream could be recycled, only a third of the 250 million tons of municipal solid waste that are generated each year in the United States is currently diverted. Greater diversion would provide immense savings in landfill and processing costs, and benefit the environment as well. Tens of millions of pounds of greenhouse gas emissions from virgin material mining may be eliminated, and pollution from landfill waste reduced. The existing sorting process is expensive and unprofitable, requiring human workers to manually sort debris, an extremely dull, dirty, and dangerous profession. This innovation has the potential to eliminate these trade-offs between cost and environmental damage.

This Small Business Innovation Research (SBIR) Phase 2 project will create a scalable, integrated robotic system that autonomously sorts material for recycling. This advance in autonomous systems is made possible by a series of innovations in robotics: (1) tremendous improvements in both computer vision and robotic manipulation, allowing for the system to be deployed with virtually zero retrofitting in existing facilities; (2) new motion planning techniques that allow for trajectories to be generated in real time, customized for the characteristics of the waste, safety, and any uncertainty in individual objects' position;  and (3) modern machine learning techniques that allow the system to classify waste at levels approaching human performance, with a continual training signal obtained via human supervision. These innovations pave the way for a new era in recycling, where waste is sorted cheaply, safely, and reliably on a universal scale.

Cornell University

Program: PFI:BIC

NSF Award No.: 1632124

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - Energy Smart Community - Leveraging Virtual Storage to Turn Advanced Metering Infrastructure into a Smart Service System

Smart meters, which measure electricity use in near real-time, have been installed in more than 40% of homes in the United States, yet the promises of smaller electric bills, reduced electric generation capacity, greenhouse gas reductions, and a more energy-engaged society, have yet to materialize. This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project seeks to enable a next generation residential energy market that will reduce consumers' costs, increase the flexibility of the electric grid to integrate renewable energy of all types and sizes -- roof top solar to large scale wind farms -- while increasing the robustness of electricity delivery. This project will test whether adding rechargeable batteries (electric storage) to individual smart meters will turn these potential benefits into reality. This research leverages a new Energy Smart Community (ESC), comprised of 12,000 smart meters and a wireless data network in the Ithaca NY area deployed in response to New York State's Reforming the Energy Vision strategy. The network of 12 thousand homes equipped with smart meters will become the test bed for this project. Researchers, working with the primary partners, will actively engage residential customers in the design of the smart service system and involve consumers in the testing and optimization of the virtual storage systems. A smart service system will control when the battery charges (purchases electricity from the grid) and when it discharges (avoiding purchasing electricity from the grid) allowing the thus far unrealized savings for consumers, while creating potential new business opportunities and reducing greenhouse gas emissions. The resulting smart service system will be highly marketable and readily transferable to other communities and utilities throughout the United States and the world. This project is an integrated collaboration that is uncommon for universities. It engages a regulated utility, for-profit corporations, venture investors, residential community members and government agencies with a shared intent to bring solutions to the market at scale. This team will develop the smart service system infrastructure that will allow the retail energy market considered crucial to 21st century power distribution, to emerge.

A signature of this project is the use of computer models to simulate residential batteries, which may be either stand-alone or contained within an electric vehicle, allowing researchers to test situations where most residential homes have a battery without the cost or challenges of purchasing and installing them. A small number of homes will be outfitted with real batteries to ensure the computer models accurately capture how real batteries function. Five cross-disciplinary and cross-organizational tasks will leverage the team's skill sets: (1) Develop and test a unique experimental economics platform that will guide the design of market mechanisms that focus on customer-based distributed storage and generation capacity in electricity distribution systems, (2) Design, implement, and test a fully instrumented, control and communication capable, prototype smart service system at the individual residence level, (3) Develop virtual storage simulation modeling tools to integrate into the ESC advanced metering infrastructure (smart meters) to enable the efficient testing of different time-varying rate scenarios at low cost, (4) Design, implement, and analyze cross-disciplinary survey and focus group efforts to understand, engage, and collect feedback from the consumer, and (5) Carry out customer choice and consumer incentivization research.

The lead institution is Cornell University with its units the Atkinson Center for a Sustainable Future, Civil & Environmental Engineering, Electrical and Computer Engineering, Communications, Natural Resources, Applied Economics and Management, and Information Science (academic non-profit). Primary Partners are: AVANGRID, Inc. (New Haven CT, large business), BMW North America (Woodcliff Lake NJ, large business), SolarCity (San Mateo CA, large business) and Cornell Cooperative Extension -Tompkins County (Ithaca NY, non-profit). Distributed Sun (Washington DC, small business) is a broader-context partner.

Dartmouth College

Program: PFI:AIR - TT

NSF Award No.: 1542984

Award Amount: $199,994.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: High-Density Power Electronics for Large-Scale Distributed Battery Management with Real-Time Diagnostics

This PFI: AIR Technology Translation project focuses on translating research results in power management and diagnostic capabilities for large-scale distributed electrochemical systems, such as those needed in electrified transportation or energy storage for the electrical grid, to commercial use. This project is important because it addresses some of the fundamental limitations of current battery systems that ultimately impact energy-density (e.g. the driving range of hybrid or electric vehicles). It also provides new insight into failure modes in order to mitigate or correct them early in the life-cycle of the system. This could have a broader significance for a variety of automotive, military, and electrical utility applications while reducing barriers to low-carbon energy storage. The project will result in a proof-of-concept prototype of a reliable, low-cost and efficient battery management system. This active battery management system will have the following unique features: it will utilize an integrated circuit design of a resonant DC-DC converter to achieve high efficiency and high power-density, it will enable efficient, granular management of individual cells or groups of cells in a large battery array, and it will implement diagnostic capabilities based on electrochemical impedance spectroscopy in an embedded system controller. These features provide advantages of lower cost, smaller size, higher efficiency, and greatly expanded visibility into real-time electrochemical phenomena when compared to the leading competing battery management architectures in this market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application: the lack of high-density and suitably cost effective power electronics for use in active battery management systems, knowledge gaps in the control and regulation of large arrays of series-connected cells, and technology gaps that exist between diagnostic capabilities and power management in electrochemical systems. The first gap will be bridged by designing a high-density resonant switched-capacitor DC-DC converter, implemented in a mm-scale integrated circuit (IC) that has variable regulation capability. The second gap will be bridged by designing embedded control algorithms for large arrays of series-connected cells, using multiple-input, multiple-output control algorithms explored in previous research. The final gap is bridged by designing algorithms that can run on a system-level embedded controller to implement online electrochemical impedance spectroscopy on top of the power management platform.

In addition, personnel involved in this project, the PI and a graduate student, will receive innovation and entrepreneurship mentoring through affiliation with the Innovation PhD program at Dartmouth, which includes both coursework and experiential business education and through discussions with industry connections in the electric transportation sector. The Co-PI on this project is the Director of the Innovation PhD program and will provide additional mentoring and support specific to this project.

Double Helix, LLC

Program: SBIR Phase II

NSF Award No.: 1534745

Award Amount: $733,549.00

Start Date: 09/15/2015
End Date: 03/31/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Three-Dimensional Computational Optical Imaging Sensor

The broader impact/commercial potential of this project stems from the possibility of obtaining real-time precise 3D depth information using a miniature robust sensor system opening up a myriad of opportunities for commercial application. Imaging sensors are now widespread and inexpensive, as is computing power, already an integral part of most cameras. The 3D imaging sensor to be developed enables disruptive applications for manufacturing, robotics, human-machine interfaces, unmanned aerial vehicles, and emerging 3D scanners.

This Small Business Innovation Research (SBIR) Phase 2 project is focused on the design, development, and testing of a miniature, robust, low-cost optical imaging sensor system capable of acquiring three-dimensional (3D) information from a scene with high precision and accuracy, overcoming current state-of-the-art technologies. The sensor provides, from a single shot, an image and a depth map; associating each object feature with its precise 3D location. With the advances in sensing technology, 3D information is increasingly incorporated into real-world applications from manufacturing to entertainment and security. The proposed sensor provides improvements in depth resolution while being fast, compact, lightweight, and amenable for mass production at low cost.

Drexel University

Program: PFI:BIC

NSF Award No.: 1430212

Award Amount: $813,577.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Program Director:
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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI: BIC Wearable Smart Textiles Based on Programmable and Automated Knitting Technology for Biomedical and Sensor Actuation Applications

Many medical conditions would benefit from continuous patient monitoring and treatment, although this is currently impractical due to the cumbersome nature of current medical equipment. Recent advancements in specialized materials and fabrication technologies offer exciting opportunities to create seamless garments as sensors and actuators for biomedical applications. Knitting fabrication, known as the intermeshing of yarns into loops (resulting in fabrics), is an ancient form of textile production widely used in the fashion industry. Knitting technology has gained a great deal of attention in the field of wearable electronics and could become a widespread method of construction for smart textiles in the future. In this PFI:BIC project from Drexel University, the aim is to replace current bulky medical monitoring devices with a line of lightweight smart garments. The fiber content of these garments will be similar to those commonly used in active wear such as wicking polyester to insure breathability and comfort, while the actuators and sensors, made of smart materials, will be strategically placed in the clothing to comprise only a small percentage of the material used. The project will leverage intellectual property pertaining to fabric-based connectors, microwave antennas, super capacitors, and robotics, to integrate smart fabric sensors and actuators into comfortable clothing, providing unobtrusive sensing and treatment options that are not currently possible.

For textile communication, active and passive transceivers will be fabricated through knitting of different microwave structures. These knit microwave structures will also be used along with processing of passive RFID signals to create mechanical strain sensors. Mechanical actuation will be realized through knit robot technology making use of shape memory alloys. The knit antennas will be combined with knit supercapacitors to create wireless power systems for body area sensor networks. Focus groups with patients and healthcare practitioners will determine market needs. Prototype garments will be beta tested with sample target users. Industrial partners will provide raw materials, manufacturing advice, and commercialization expertise. Key is Shima Seiki knitting technology at Drexel University, which enables customization and innovation in the design and fabrication of wearable and machine washable smart (with integrated power and circuitry) textiles capable of wireless sensing and actuated treatment applications. Target applications that are the focus of this project will include a “bellyband” for uterine contraction monitoring during pregnancy, medical sensor patches, and knit robots for therapeutic massage.

Drexel University has formed an interdisciplinary academic team including expertise from industrial and fashion design, materials and electrical engineering, nursing and medicine, as well as management and entrepreneurship. To complement this academic team, a three-tier industry partnership representing all levels of production and commercialization has been formed. The Material Suppliers tier includes EY Technologies (small business, Fall River, MA), custom-engineering groups providing creative solutions for the development of specialized yarns allowing for the creation of raw materials with unique functionality for novel biomedical smart textiles. The Fabrication tier includes Shima Seiki USA (large business, Monroe Township, NJ), a leader in 3D knitting simulation software and computerized knitting machines to manufacture biomedical smart textiles at both laboratory and production scale. Finally, in the Commercialization tier, NetScientific America (small business, Harrison, NY) augmented by the industrial advisory board of the Drexel Coulter Translational Research program will help determine commercial viability of various biomedical smart textile solutions and carry promising technologies to the market. Ben Franklin Technology Partners/Southeastern PA (non-profit, Philadelphia, PA) will serve as a broader context partner building upon experience in launching university/industry partnerships that accelerate scientific discoveries to commercialization and seeding regional initiatives that strengthen the regional entrepreneurial community.

Etaphase, Inc.

Program: SBIR Phase II

NSF Award No.: 1534779

Award Amount: $760,000.00

Start Date: 08/15/2015
End Date: 07/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Enabling Ultra-Compact Photonic Integrated Circuits with Designed Disordered Dielectrics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to allow the Internet infrastructure to keep up with explosive growth demand. A core aspect of Internet operational viability is switching speed of optical devices at various points of the transmission, storage, calculation, and access chain. Current technologies are not poised to be able to meet the speed and stability needs of the projected growth in Internet data volumes and access speed requirements. These are currently growing well beyond a Moore's Law pace. Needed is a disruptive approach to optical switching that will allow data management to keep pace with market needs. Ability to delivery this essential capability will provide not only essential international leadership in internet services, but also avail companies involved in the innovation to make a substantial commercial impact directly for their shareholders and to those of their partners and affiliates.

This Small Business Innovation Research phase II project is an effort to cross the chasm between fundamental new physics insights relating to the structure of matter and an aggressive approach to commercializing 'Semiconductors of Light' in an emerging market for high density optical interconnects priced for datacenters. Until recently, the only known photonic bandgap solids were photonic crystal structures consisting of regularly repeating, orderly lattices of dielectric materials. It was generally assumed that crystal order was essential to have photonic bandgaps. This longstanding assumption is now known to be false. New photonic bandgap structures, characterized by suppressed density fluctuations (hyperuniformity), include disordered structures that are isotropic. This means that light propagates the same way through the photonic solid independent of direction (which is impossible for a photonic crystal). While the layout of waveguides in conventional photonic crystal and quasi crystal photonic bandgap materials is tightly-constrained to follow characteristic crystal axes, the layout rules for hyper uniform disordered solid waveguides have no such fundamental constraints. The universal protocol and highly-efficient computational framework covering the full range of photonic crystal, quasi crystal , and hyper uniform disordered solid-based photonic bandgaps will be generalized to a broad class of critically important photonic components by the application of a powerful new gradient-free optimization methods.

Farhang Wireless, Inc.

Program: STTR Phase II

NSF Award No.: 1632569

Award Amount: $750,000.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

STTR Phase II: Scalable Detector for Multiple-Input Multiple-Output (MIMO) Communication Systems

The broader impact/commercial potential of this project lies in its ability to implement multiple-input multiple-output (MIMO) detectors of any size. This, in turn, impacts the broad needs of wireless communications industry that is always in search of more efficient use of the scarce spectral resources. Since its invention 15 years ago, MIMO has been included in all wireless standards, e.g. WiFi, WiMAX, and LTE. As of today, MIMO products of sizes up to 4x4 (i.e. 4 transmit and 4 receive antennas) have appeared in the market, while the most recent standards, such as IEEE 802.11ac WiFi and LTE-Advanced cellular, have specified MIMO sizes as large as 8x8. For WiFi this can mean more effective hot-spots in public and workplace settings. For cellular this can mean improved connectivity in rural areas with fewer base-station towers, having a positive economic impact. Industry activities that attempt to build larger MIMO systems such as 16x16 are occurring. Massive MIMO networks with more than 100 antennas at the base stations have recently been proposed for 5G cellular and beyond. These trends indicate a large market opportunity for the scalable MIMO technology that this project builds upon.

This Small Business Technology Transfer Research (STTR) Phase 2 project plans to develop and commercialize a set of intellectual property (IP) software-codes/IP-cores related to multiple-input multiple-output (MIMO) communications. These cores address the needs of wireless chipset manufacturers. The main hurdle in the design and implementation of MIMO systems is their complexity which drives cost and power consumption. The complexity of an optimal MIMO detector grows exponentially with the number of transmit antennas. The same is true for most of the near optimal MIMO detectors that have been suggested in the literature and adopted by industry. This limitation has been the main impediment in developing commercial MIMO systems that support larger array sizes with increased range and data rate. This project adopts a novel technology that achieves near optimal performance having complexity that only grows linearly with the number of transmit antennas. It thus can be used to implement MIMO systems of any size, at an affordable complexity.

Ghodousi, LLC

Program: SBIR Phase II

NSF Award No.: 1534190

Award Amount: $730,331.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Assistive Digital Vision for the Blind

The broader impact/commercial potential of this project is to address the unmet needs of blind and visually impaired population in order to increased their mobility independence with the aid of an intelligent wearable electronic device, compatible with the white cane, in a simple and cost-effective manner. The outcome of this project will contribute to scientific and technological understanding of environmental sensing and process automation by developing an integrated system comprised of sensors and underlying algorithms capable of gathering, processing, and interpreting environmental data and communicating relevant information to the user. The envisioned product can potentially meet the needs of 2.1% of the U.S. population who are considered legally blind, as well as make further contribution to the field of robotics, artificial intelligence, and other assistive technologies wherein a better understanding of the environment is desired.

This Small Business Innovation Research (SBIR) Phase 2 project seeks to create a state of the art wearable device for the visually impaired that will enhance their situational awareness through the use of multiple sensors and intelligent algorithms. The main research objective is to develop an intelligent wearable device that will provide ability to detect above ground obstacles and recognize various categories of objects. In spite of significant technological breakthroughs, leading to many product innovations, there is very little technological progress for the visually impaired despite increased population longevity and significant demand for products that promote independent living. The proposed project will address the needs of the visually impaired in an intuitive and automated manner.

GridBridge, Inc.

Program: SBIR Phase II

NSF Award No.: 1430911

Award Amount: $1,631,703.00

Start Date: 09/01/2014
End Date: 02/28/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: A Highly Efficient GridBridge Grid Energy Router for Grid Modernization

The broader impact/commercial potential of this project is the development of a cornerstone for reliable electricity and a modernized grid able to evolve alongside emerging customer demands. Reliable electricity is key component of an industrialized market, critical for the information age, and an enabler for non-industrialized regions evolution and eventual world economic contribution. The societal benefit therefore of GridBridge's commercially feasible Grid Energy Router is colossal, as it is the step-function change required to truly orchestrate a grid to match this era. This project will enable numerous hindered technologies and scientific understanding related to energy storage, photovoltaic and other renewable generation, as well as electric vehicles and their correlated fast chargers. Energy savings are also a monumental aspect and are expected to be in the trillions of dollars. Society needs electricity to maintain civilization and an updated grid is imperative for supplying that electricity to an evolved consumer base. GridBridge's Grid Energy Router will be the crucial component for the modernized grid an enabler for numerous complementary technologies. GridBridge's GER will eventually replace millions of installed legacy grid technologies throughout the world. Furthermore, the continued GridBridge-ERC relationship establishes FREEDM ERC's commercialization ecosystem, which includes 200 diverse students.

This Small Business Innovation Research (SBIR) Phase 2 project combines various research aspects to commercialize the company's third breakthrough product for electric utilities, the Grid Energy Router (GER). GridBridge's Grid Energy Router will be cornerstone for an evolved grid that can integrate renewables and storage, offer dynamic efficiency gains, and intelligently route power. Although there has been early work with power electronics merely focusing in the area of high-voltage conversion, the approaches thus far limit commercialization and manufacturability. GridBridge will combine over three years of company market research and utility voice of the customer, a unique product roadmap, and cutting edge research in the areas of feature implementation and voltage conversion. Keeping in mind the end market, electric utility requirements have been incorporated: highly efficient, cost-competitive, manufacturable within a specific market window, and scalable both to high power and high voltage. This project facilitates a cost-effective and electrically-efficient product design ready for industrialization and ultimately grid integration, while simultaneously incorporating valuable features that justify utility expenditure and meet a market window of need.

InSense, Inc.

Program: SBIR Phase II

NSF Award No.: 1632268

Award Amount: $749,942.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Monolithic CMOS-Integration of Electroplated Copper MEMS Inertial Sensors

The broader impact/commercial potential of this project can lead to a revolution in the consumer electronics market (mobile handsets, tablets, game consoles and wearables), wherein high performance, low power, small footprint multisensing (not limited to inertial sensing) platforms with timing devices, are all directly microfabricated on a common ASIC substrate. Sensor fusion can produce unprecedented user experiences by using data collected from all sensors and processed using machine learning algorithms. This can further boost the sensor and timing markets that are expected to exceed $6 billion dollars by 2017. Moreover, the emergent Internet of Things (IoTs) and wearable markets are expected to reach $20 billion dollars by 2025, which can induce a rapid growth of such intelligent sensor fusion market. This can have a tremendous societal impact as wearable devices and IoT systems, interfaced with mobile platforms, can be used to monitor people's health, safety and energy consumption. Making these solutions affordable will make it amenable to low income households not only in the US but also around the world. It will also enable researchers to attain new frontiers of knowledge such as in digital sensory systems. The long-term goals are to provide such intelligent sensor fusion solutions.

This Small Business Innovative Research (SBIR) Phase 2 project seeks to demonstrate wafer-scale microfabrication of Micro-Electro-Mechanical Systems (MEMS) inertial sensors directly on the application specific integrated circuit (ASIC) substrates, by using electroplated copper (e-Cu) as a structural material. MEMS inertial sensors, such as gyroscopes and accelerometers, are pervasively used in consumer electronics and automotive industries. Current trends are, however, requiring higher device performance with smaller footprints, wherein multi-degree-of-freedom sensors are integrated on the same package, to enable new capabilities and user experiences. These requirements can be met by monolithically fabricating inertial sensors on ASIC substrates, which is complex to achieve with silicon as a structural material. Using e-Cu, which is currently used for ASIC metal interconnects, as the structural material, can enable easier routing to implement optimized mechanical structures, smaller dimensions given the high density of copper, extremely low cost as no wafer bonding is required, smaller form factors, multiple sensors on a single die, and much smaller parasitics providing low noise and higher performance. Phase II tasks will be to wafer-scale fabricate an inertial measurement unit that is monolithically integrated with its ASIC with optimal performance parameters.

Invictus Medical, Inc.

Program: SBIR Phase II

NSF Award No.: 1631818

Award Amount: $735,424.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Active Noise Reduction System With Voice Pass-Through

The broader impact/commercial potential of this project is in line with the trend in medicine towards a prevention paradigm, following the premise that preventing problems is generally less costly than treating the problem or managing a future deficit. Excessive noise in neonatal intensive care units (NICUs) has been clearly linked to cognitive deficits among the patients of these care areas. However, isolating the infants from any voice contact is also detrimental to language skill development. This project will investigate and develop a system that will provide for a more stable stay in the NICU, mitigate neurologic complications leading to developmental delays, and lessen the occurrence of hearing loss. The American Academy of Pediatrics' guidelines state that neonatal patients should not be exposed to noises greater than 45dBA yet hospitals struggle to achieve this. Deploying such a noise attenuation system with voice pass through capabilities will help hospitals provide the proper environment for their neonatal populations. Hospital administrators and clinical directors have expressed enthusiasm for this solution.

This Small Business Innovation Research (SBIR) Phase 2 project seeks to develop an active noise reduction system for use in an NICU incubator, while allowing a parent's voice to pass through essentially unattenuated. To achieve the noise attenuation, the unwanted noise is monitored outside and inside the incubator and a corresponding signal exactly out of phase with the detected noise is used to largely cancel the unwanted noise. The system will employ a multi-channel hybrid system employing both feedback and feedforward elements. While a more complex approach, this has been shown to have performance advantages over simpler solutions. In this phase, the size of the zone of attenuation will be expanded, the algorithm will be adapted to multiple incubators having differing shapes, and a set of fail-safe provisions will be implemented.

Iowa State University

Program: PFI:AIR - TT

NSF Award No.: 1602089

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: In-Situ Wireless Soil Sensor for Moisture, Salinity and Ions

This PFI: AIR Technology Translation project focuses on translating agricultural soil sensor development research into accurate monitoring of spatio-temporal variation of soil properties of agricultural interest. The development of the proposed soil sensors is important because they can enable the real-time, in-place monitoring of soil moisture, salinity, and nutrients in production agriculture, thus enabling precise nutrient management. This project will result in a feasible design/prototype of an in-situ soil sensor for agricultural application. This soil sensor has the unique features that it can measure the soil properties mentioned above in real-time when deployed in an underground grid configuration with support for wireless interaction. Current sensing systems do not support continual in-situ monitoring and also require manual operation, while the proposed system is a fully-automated solution, capable of continual in-situ monitoring and wireless transport.

This project addresses technical gaps as it translates from research discovery toward commercial application in soil sensors for agriculture. Specifically in this project, sensor prototypes, using dielectric-based moisture/salinity sensing and electrophoretic nitrate sensing packaged with signal processing and wireless capability for underground deployment, will be tested and evaluated.

In addition, personnel involved in this project, namely the two PhD students, will receive innovation and technology translation experiences through soil sensor development and evaluation research, regular participation in interactions with the Iowa State Office of Intellectual Property and Technology Transfer for disclosures and patents, and further interactions with agricultural domain industries for licensing, technology transfer and commercialization.

The project engages Microwaves by the Weber, Inc. as a consultant with experience in product design, development and commercialization to augment the team's research capability, and guide commercialization aspects in this technology translation effort from research discovery toward commercial reality.

K&A Wireless, LLC

Program: SBIR Phase II

NSF Award No.: 1632498

Award Amount: $749,958.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Cognitive Radio Small Cell for Pervasive Coverage and Sustained

The broader impact/commercial potential of this project includes: 1) Training of graduate students on complex research & development as well as enabling student understanding of service and hardware business models, 2) A potential economic impact that is between $0.9T and S1.7T (trillion) according to a McKinsey study of IoT technology in smart city applications, 3) The improvement of the stature of the countries in the world market where this advanced technology solution will be offered, such as Ibero-America, 4) A significant improvement of the ability to handle large number of devices on a network without bogging down the overall network while enabling future bandwidth intensive applications, and 5) The ability to provide low-cost Internet connectivity for underserved populations through city-wide wireless network deployments.

This Small Business Innovation Research (SBIR) Phase 2 project seeks to complete the development of a Spectrum Intelligent IoT Gateway initiated during Phase I. The key innovation of this system is a proprietary Spectrum Intelligence capability used to identify spectrum occupancy in the vicinity and modify transmission parameters in the network. The Intellectual Merits of this project include: 1) Implementing and testing a novel IoT Gateway with autonomous channel selection capability based on spectrum occupancy information; 2) Transferring spectrum sensing algorithms into an FPGA platform for its field deployment, and as the first step towards and spectrum sensing ASIC design; 3) Obtaining a model-based design for an enterprise network architecture of IoT Gateways; and 4) Implementing and testing new adaptive OFDM approaches to optimize power and frequency usage is 4g/5G wireless communications.

Lehigh University

Program: PFI:AIR - TT

NSF Award No.: 1601916

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: AGV-3D: A Low-Cost, Infrastructure-free Localization Solution for FlexibleWarehouse Automation

This PFI: AIR Technology Translation project focuses on translating technology to fill the need for an infrastructure free localization system to accurately estimate the position and orientation of an automated guided vehicle (AGV) in large-scale warehouse environments. The system is called AGV-3D, and it is important because it enhances current AGV technology, which in turn improves the efficiency of U.S. manufacturing by providing a reliable and safe means of meeting material movement demands. The project will result in an AGV-3D prototype being integrated into an actual AGV system, and demonstrated in a representative warehouse environment. AGV-3D has the following unique features: it integrates the latest in 3D imaging technologies to enable robust and accurate localization of an AGV vehicle in a large-scale warehouse facility without the integration of wires, magnets, or reflectors in the environment. These features provide the following advantages: lower per-vehicle cost, lower facility installation cost, and increased facility flexibility when compared to the leading competing 2D laser guidance technology in this market space.

This project addresses the following technology gap(s) as it translates from research discovery toward commercial application. The first significant challenge is that the required positioning accuracy of AGVs is on the order of 1 cm. The second is that the localization system must be extremely robust as AGV warehouse installations require very high levels of availability. Unfortunately, correctly associating landmark features will be far more difficult as unlike current 2D laser guidance technologies, artificial retroreflector targets will not be installed in the environment. Thus, there are significant challenges in both data association and reconstruction. To meet these challenges, AGV-3D leverages 3D data for both mapping the environment and landmark feature segmentation. First, a 3D reconstruction of the facility is created to extract salient natural features as landmarks. Next, a map-based localization approach leverages 3D LIDAR to enable 3D feature-to-landmark matching which minimizes the potential for data association errors. By employing the latest in 3D sensor systems, AGV vehicles will be able to track these 3D features in real-time. In conjunction with the map-based localization approach, centimeter level accuracy is expected. In addition, graduate students involved in this project will receive innovation and technology translation experiences through system development, and through direct interactions with companies in the robotics, AGV, and 3D sensing spaces.

Moai Technologies, LLC

Program: STTR Phase II

NSF Award No.: 1534010

Award Amount: $742,386.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

STTR Phase II: An Assistive Tool to Locate People and Objects with a Multimodal Thermogram Interface

The broader impact/commercial potential of this project is the assistive use by blind people of thermal imaging. The resulting product provides a person who is blind or visually impaired with the relevant information about the layout of an unfamiliar public space in order to assist blind users in everyday activities. Thermal imaging can differentiate people and objects from their background without the need for complex image analysis. The shape and the temperature of the human body allows the location of people to be easily determined. The societal impact will be assisting users in navigation of complex public spaces. A blind person can use a smartphone's haptic touchscreen display to examine the thermal image to determine the location of people in front of them. Information about the layout of an unfamiliar public space can be learned from the heat and shape of materials. Examples would be locating vending machines like ATMs and train passes. The market sector for this technology will likely extend beyond assisting blind users, to include additional commercial opportunities as well.

This Small Business Technology Transfer Research (STTR) Phase 2 project will leverage past National Science Foundation Funded research to develop a product that a blind/low vision user can use to receive practical navigation and interaction information about their environment from a multimodal thermogram (thermal image) interface on a smartphone. There are no practical assistive technologies for blind or low vision users that allow them to locate people, objects, and the layout information of their surroundings other than exploring with a cane. This development will address the objective of creating an interface that provides both practical utility and will be accepted by the target demographic of blind users. This project represents an excellent translational path from NSF-sponsored research programs to a product that is built from the ground up on solid theoretical underpinnings and empirical findings from multimodal human information processing. This development will use thermal radiation from people, machines, lighting and heat retention differences in building materials and convert this data into a user interface to facilitate blind navigation and environment interaction. The product resulting will be a multimodal (kinesthetic, vibro-tactile, and auditory) interface for blind users of a smartphone to interpret and gain useful value from thermal image information.

Mobosense, LLC

Program: SBIR Phase II

NSF Award No.: 1660233

Award Amount: $717,250.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Multiplexed Smartphone-Based Handheld Sensor for Ion Contaminants Detection in Environmental Water

The broader impact/commercial potential of this project is the potential dollars saved in healthcare costs to environmental protection. The greatest overall savings cannot be judged only in dollars, but in helping to preserve human lives and end diseases and illnesses caused by problems with water. The product will provide unique opportunity to populations to test their water for safety and health benefits, in locations where good water treatment facilities do not exist. The water testing equipment market is divided into low-end, low-cost on-field test equipment (such as nitrate strip) that gives qualitative information about the analytes, and high-end testing devices used in labs (such as mass spectrometer) providing accurate quantitative information. If successful, the sensor technology will bridge the gap by providing low-cost, sensitive, accurate tools for quantitative measurement of analytes. The portable, low-cost, plug and play sensor product will cater to the needs of the water quality monitoring market. The product will also mobilize "citizen scientist" to partake in environmental data collection and popularize sustainability education.

This Small Business Innovation Research (SBIR) Phase 2 project is expected to lead to the development of a multiplexed, low-cost, portable instrument capable of making real time measurements of nitrate and phosphate in water and soil samples. The sensor system for this instrument will be based on the highly selective nitrate and phosphate reducing working electrodes along with reagents contained in the microfluidics to perform real-time sensing without sample preparation. As the concentrations of phosphate in solution are usually small, and since the inorganic phosphate in a water sample is changing due to biological processes, time is often a critical factor in taking measurements of phosphate. Due to these factors, there is a need for sensitive, inexpensive, and portable instruments in order to monitor the eutrophication process effectively. Currently available instruments for making phosphate measurements in the field do not adequately address these needs. Phase I development showed that disposable electrode with microfluidic integration, and smartphone app controlled sensor is capable of detecting nitrate with high sensitivity and specificity. Phase II proposal is focused on commercialization of the nitrate sensor and development of multiplexed sensor platform to detect multiple ions such as nitrate, and phosphate for larger commercial market.

New Jersey Institute of Technology

Program: PFI:AIR - TT

NSF Award No.: 1500123

Award Amount: $199,985.00

Start Date: 08/15/2015
End Date: 01/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: A Novel Vector Acoustic Communication Technology for High Speed Underwater Modems

This PFI: AIR Technology Translation project focuses on translating novel vector acoustic underwater communication research findings to fill the need for high speed communication in oceans and other underwater environments. Three quarters of the earth surface is covered with water that overlays many resources upon which our lives depend. High speed wireless underwater data communication among underwater sensors, deepwater instruments and autonomous underwater vehicles is of high importance in many applications of national interest, such as environmental ocean monitoring to predict natural disasters such as hurricanes, and offshore oil and gas drilling. However, underwater channels are highly bandlimited and the data rates of existing modems are much smaller than what is needed for effective communication and management. The project will result in a prototype underwater modem that benefits from novel vector acoustic underwater communication concepts and methods. This underwater vector modem has the unique feature of utilizing acoustic particle velocity channels for data communication, in addition to the conventional acoustic pressure channel. This feature provides the following advantages: increased data rate, improved performance, and small size modems, when compared to the leading competing underwater modems in this market space.

This project addresses a number of technology gaps as it translates from research discovery toward commercial application. In the new vector acoustic and particle velocity communication paradigm, the underwater modem designer is facing new communication channels and transducers that are fundamentally different from those used in the past. Therefore, proper designs for different parts of the modem, including transducers and analog and digital transceivers will be developed. Analog electronics are supposed to interface with multi-channel transducers, whereas digital signal processing units are required to generate and demodulate multiple data streams. The personnel involved in this project, graduate and undergraduate students, will receive innovation, entrepreneurship and technology translation experiences through working at the interface of multiple disciplines such as electro-acoustic transducers, underwater acoustics, communication and signal processing hardware/software, as well as participating in an intensive boot-camp on technology entrepreneurship.

The project engages Teledyne-Benthos and Kongsberg, two leading companies whose underwater modems and autonomous underwater vehicles are sold worldwide, to assist in at-sea testing of the prototype modem developed in this technology translation effort from research discovery toward commercial reality. Development of the vector acoustic high speed modem prototype will eventually allow the growth of many underwater systems and businesses whose operations have been constrained by low wireless data rates or very expensive undersea cables.

OceanComm, Inc.

Program: SBIR Phase II

NSF Award No.: 1555928

Award Amount: $754,890.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Megabit-Per-Second Underwater Wireless Communications

The broader impact/commercial potential of this project is the introduction of high-speed wireless modems usable subsea and significant cost reduction of deep-water operations - industry experts estimate savings of nearly 20% of deep-water operations through the availability of subsea WiFi. Today, there is no broadband wireless communication available underwater. In the deep ocean, remotely operated vehicles (ROVs) require a tether for communication and a support ship for tether management; sensors and systems must either be physically connected, or retrieved from the deep sea to exchange data. An ROV support ship costs about $120k/day leading to over $7B spent on ROV support ships in 2013. The proposed megabit-per-second technology would allow ROV manufacturers and operators to cut the tether on many of their vehicles. Wireless ROVs can move unencumbered throughout coverage area, piloted from anywhere (e.g. from Houston), without expensive surface vessels. The proposed wireless modem technology connects ROVs and machinery to wired infrastructure, enabling safe operation of heavy subsea machinery without the possibility of cables or tethers getting tangled, causing damage or worse. This project will create 10 new jobs in the next three years, with many more to be added as the production scales.

This Small Business Innovation Research (SBIR) Phase 2 project proposes to develop a faster and more reliable wireless communication system for the sub-sea industry. Current state of the art communication links for the deep ocean are either tethered, requiring long, bulky, and expensive cables to connect machinery and systems, or have extremely low data rates, enabling only the most rudimentary of tasks. The proposed underwater wireless communication system will provide WiFi-like data rates in the Mbps (megabits/sec) range - 100 to 1,000 times faster than existing underwater wireless communication technologies - and enable video streaming and real-time control of subsea infrastructure, machinery, and mobile underwater vehicles. Since radio signals do not propagate far underwater, the proposed technology uses sound waves, as whales and dolphins do, for communication. The speed of sound is 200,000 times slower than the speed of radio propagation, and mobile acoustic transmitters and receivers hence suffer from severe Doppler distortion. The proposed technology dynamically measures, tracks, and compensates for this distortion, to enable wireless communication at data rates never before possible underwater.

Perception Robotics

Program: SBIR Phase II

NSF Award No.: 1555822

Award Amount: $761,043.00

Start Date: 05/01/2016
End Date: 04/30/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Object Pose Estimation System for Pick and Place Robots

The broader impact/commercial potential of this project is improvement in cost-efficiency, energy-efficiency, and quality in manufacturing automation, increasing worker productivity and reducing repetitive motion injuries. This integrated visual-tactile system will be 3-4 times more inexpensive ($20,000 purchase cost vs. existing $65,000-80,000 vision system), improve the speed and accuracy of current robotic handling systems, and facilitate the automation of repetitive, injury-prone manual tasks. By enabling new robotic applications and increasing productivity in current automation, this solution will help the U.S. maintain a competitive domestic manufacturing sector. In 2009 there were 36,190 logged repetitive motion injuries in the U.S.; the median missed work time from these injuries was 21 days (U.S. Bureau of Labor Statistics). This innovative solution will facilitate the automation of repetitive, injury-prone manual tasks and greatly improve the speed, accuracy, and cost-efficiency of current robotic handling systems. The immediate commercial applications are in industrial robotics, specifically robotics in agile manufacturing. In the long term, the technology will be applied in personal, healthcare, and military robots. The current market potential for tactile sensors for industrial robots is estimated as $576 million - $1.15 billion and expected to more than double by 2025.

This Small Business Innovation Research (SBIR) Phase 2 project will result in a combined visual-tactile system that will give robots an integrated sense of touch and vision, much like the hand-eye coordination of humans. It incorporates a technically novel compliant tactile sensing solution - a rubber “skin” that can be molded into any form factor and is inexpensive and durable. This advanced skin technology can resolve object shape, contact/slip events, and forces of contacted objects. It will uniquely fuse visual and tactile information for object handling and pose estimation resulting in flexible robotic system that handles objects more like humans do. This approach addresses key weaknesses in vision-based robotic manufacturing, such as occlusion and dislodging when parts are grasped. Current industrial robots are restricted in their ability to handle small, irregularly shaped, soft, or fragile parts. Existing solutions rely on expensive and complex 3D-vision systems or repetitive manual labor. This solution is two-fold: (1) A new flexible tactile sensor that can be tailored to a wide variety of form factors; (2) Software to fuse the tactile data with a vision system to estimate pose of objects in pick-and-place tasks.

PolyK Technologies, LLC

Program: STTR Phase II

NSF Award No.: 1556038

Award Amount: $755,860.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

STTR Phase II: Advanced Hybrid Piezoelectric Energy Harvester

The broader impact/commercial potential of this project is to manufacture an advanced hybrid energy harvester that can enable broad deployment of wireless sensor networks. Self-sustainable uninterrupted low-cost power supply with small size is in urgent need for internet of things, portable electric devices, wireless sensor networks, infrastructure health monitoring, active control, and battleground soldier support. Scavenging ambient energy from environment to power these devices can eliminate the cost of replacing batteries, particularly in remote environment. The hybrid energy harvesters developed in this project will significantly improve the power output and response dynamic frequency, therefore provide sufficient power to many such devices. The high power density will also enable more frequent data acquisition and transmission of such sensor networks, and promote more ubiquitous deployment of advanced sensor networks. The automatic manufacturing process will enable their adoption by various customers including internet of things.

This Small Business Technology Transfer Research (STTR) Phase 2 project will develop manufacturing processes for advanced hybrid energy harvesters. Although piezoelectric energy harvesters have found broad applications, their power density and mechanical-electrical conversion efficiency are still low, with values at microwatts to milliwatt and <10%, respectively since they primarily operate at the d31 mode of the piezoelectric transducer and the mechanical impedance mismatch between the vibration source and the harvesting device. The Phase I project successfully demonstrated that the advanced hybrid energy harvesting device can provide significantly higher power density at > 100 mW and conversion efficiency at > 40% by using the more efficient d33 piezoelectric mode and with reduced stiffness in a curved structure that can efficiently transfer the energy from the vibration source to the active piezoelectric materials. The Phase II project will be focused on developing low-cost innovative automatic manufacturing process to enable their practical applications in commercial and industrial market.

Purdue University

Program: PFI:AIR - TT

NSF Award No.: 1543078

Award Amount: $198,480.00

Start Date: 09/15/2015
End Date: 07/31/2017

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: A Novel Concept for Variable Delivery Flow Units for Fluid Power Applications

This PFI: AIR Technology Translation project focuses on translating a new design that transforms a standard, fixed displacement external spur gear machine (EGM), used in hydraulic motors and pumps, into a variable delivery flow machine that reduces energy demand and fuel consumption. This Variable Delivery - External Gear Machine (VD-EGM) technology offers energy-efficient, reliable and low-cost pumps and motors in engineering applications such as high pressure fluid power circuits (used in construction, agriculture, transportation, aerospace, manufacturing and entrainment) and low pressure fluid systems (fuel injection, washing systems, food and pharmaceutical industry). The VD-EGM concept preserves all typical advantages of EGMs, such as low cost, compactness, high efficiency, tolerance to both contaminants and cavitation, reliability; and it also permits application in efficient "flow on demand" systems layout configurations, for which traditional EGMs are not suitable. This will enable: 1) the use of more energy efficient system layouts in current applications of EGMs; 2) the use of EGMs in place of more expensive designs of variable displacement machines (such as axial piston pumps and vane pumps). As a consequence, the VD-EGM has the potential to impact almost all fluid power machines, which currently handle about 3% of the total national energy consumption, offering significant fuel consumption reduction (up to 40%) without significant cost increase. Similarities in the design and appearance of the VD-EGM with respect to standard EGMs will allow for an easy acceptance of the novel concept into the fluid power market.

This project will result in two functional prototypes (P1, P2): P1 will be a hydraulically operated VD-EGM suitable for power transmission systems involving high operating pressures (up to 250 bar), while P2 will be an electronically operated VD-EGM suitable for low pressure applications (up to 30 bar). To promote commercialization, the project will build a technology demonstrator, a hydraulic fan drive system, based on prototype P1.

The intellectual merit of this research is the novel principle for obtaining variable timing in EGMs, which uses asymmetric gear profile. This principle introduces an actuation system to modify the fluid dynamic features of the meshing process in such a way that a variable flow is delivered by the EGM. Although suitable to vary the displacement up to a certain range, this principle is applicable for both high- and low-pressure systems and enables high bandwidth associated with flow regulation. The research approach is based on a multi-objective numerical optimization procedure based on a detailed tribological model for EGM that has been created to assist the VD-EGM design. This procedure will advance knowledge not only about variable timing applications of EGMs, but also about the multiple physical characteristics of the meshing process and the displacing action of EGMs.

Personnel involved in this project include, the project PI, two graduate level students and two undergraduate students which will receive innovation and technology translation experiences by overcoming the challenges related to the design of the actuation systems of prototypes P1 and P2 of the VD-EGM. The students will also work with a business entity (Purdue Office of Technology and Commercialization) through the project co-PI, and receive feedback from a gear pump manufacturers that will be instrumental for product commercialization.

Rebound Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1533939

Award Amount: $906,699.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Regenerative Freeze Suppression for Thermally Bound Energy Storage Systems

The broader impact/commercial potential of this project includes peak demand relief for utilities, reduced freezer operating costs for retail stores, and natural refrigerants for regulators. Unfortunately, no state-ofthe- art system simultaneously addresses all these issues. Industrial/commercial batteries remain unaffordable, refrigeration costs account for 60% of a retail store's electricity bills and equipment manufacturers are only realizing incremental efficiency improvements with new vapor compression architectures. This project introduces an energy storage technology, embedded in a natural refrigerant cooling cycle, that provides load-shifting services and a 40% reduction in commercial freezer electrical purchases. More importantly, it achieves this at a 3-year payback without government incentives using natural, near ambient, materials.

This Small Business Innovation Research (SBIR) Phase II project will investigate an energy storage technique utilizing water as the storage material in a time delayed, freeze-point-suppression refrigeration cycle. The project will focus on the internal testing, third party validation and commercial demonstration of a 10kWth system. Successful integration within low temperature refrigeration architectures requires industrial design focused on skid/waste heat integration, validation testing to inform required part count reductions/system revisions and demonstration to monitor, learn and revise the technology in preparation for scale up.

Resensys, LLC

Program: SBIR Phase II

NSF Award No.: 1660096

Award Amount: $749,016.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Kaiser Trigger: A Nano-Watt Powered Technology for Ultra-Low Power Fatigue Crack Detection

The broader impact/commercial potential of this project is the result of introducing a new generation of low-power wireless sensors for detecting Acoustic Emission events and detecting fatigue damage in structures. According to the Federal Highway Administration (FHWA), the US transportation infrastructure has 605,102 operational bridges, of which 66,561 are structurally deficient. In particular, the fatigue damage monitoring technology of the project will initially target the more than 18,000 US highway bridges that are categorized as "fracture critical" by the Federal Highway Administration. The technique's ultra-low energy consumption will enable its use in low-power wireless sensors and make it an ideal response to this challenging problem. The anticipated benefits and commercial applications of this project are (1) a low-cost, easy-to-use mechanism for effective monitoring, allowing for early detection and timely repair of fracture and fatigue damage in infrastructure systems such as highway bridges; (2) improved public safety, with reduced maintenance costs and extension of the service life of critical and high-valued infrastructure systems; and (3) additional commercial applications in monitoring the structural health and integrity of other structures, including aircraft, oil and gas pipelines, machinery, cargo cranes, ships, etc.

Small Business Innovation Research (SBIR) Phase 2 project addresses distributed structural health monitoring (SHM) of infrastructure systems, particularly highway bridges. Because the creation of fatigue cracks in a structure is accompanied by the propagation of acoustic emission (AE) waves, wireless AE sensors can be used to detect such cracks. However, a challenge of AE detection sensors is high energy consumption, significantly more than the energy available in a battery-operated wireless device. As a result, conventional AE detection methods cannot be used with low-power wireless sensors. This project uses a novel and ultra-low power technique for long term monitoring of strain. Then, AE monitoring is activated only if history of tensile strain in the structure under monitoring suggests likelihood of fatigue damage. In addition, using history and pattern of AE events, the method estimates the severity of fatigue damage in a material. Moreover, the method uses a variety of techniques to eliminate the effects of mechanical noise on AE measurements and achieve a high reliability in fatigue damage assessment. After development, the method is planned to be evaluated on highway bridges, airframes, and pipelines.

RightHand Robotics, LLC

Program: SBIR Phase II

NSF Award No.: 1632460

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Versatile Robot Hands for Warehouse Automation

The broader impact/commercial potential of this project affects one of the fastest-growing sectors of the US economy. E-commerce sales in 2015 accounted for 7.4% of total U.S. retail and are expected to rapidly rise. The potential for the commercial impact of general each-picking systems is high, as current manual labor methods are pain points for distribution centers; human picking is unpleasant, expensive and inefficient due to high absenteeism, high turnover and human error. The success of the proposed technology will also contribute to American competitiveness in the robotics industry. Of the top 20 distribution system integrators, only three are currently based in the U.S. Robotics is going to be the key driver of progress in this area, where each-picking, our core product capability, is a key component of future automated distribution systems. Beyond warehousing logistics, applications that our technology can benefit include: broad applications of industrial automation and manufacturing; military applications (e.g., IED disposal, where robots can perform tasks that are dangerous for humans to perform); and assistive healthcare (e.g., where robots must be compliant enough to be safe around humans while interacting successfully with unknown environments).

This Small Business Innovation Research Phase II project will focus on the development of a state-of-the-art each-picking robotic system and its deployment, initially targeted at the order fulfillment industry. To date, robotic systems have enabled significant progress on transporting inventory on shelves or in totes. However, there has not yet been a deployed system that can perform the task of picking individual items from inventory bins and placing them in boxes for shipment. During Phase I of this project, RightHand Robotics developed a picking system far in advance of the research literature on robotic grasping, picking tens of thousands of items previously unseen objects, with error rates of less than 0.1%. During Phase II, the project will focus on advancing the state of the art in data-driven refinement of grasp planning using machine learning techniques, and will develop methods for box-packing that exploit the company's advanced compliant grippers. These improvements will result in an average pick-and-place time of 6 seconds or less and an undetected placement failure rate of fewer one in ten thousand.

S2 Corporation

Program: SBIR Phase II

NSF Award No.: 1330880

Award Amount: $1,058,002.00

Start Date: 09/15/2013
End Date: 12/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Photonics Enabled Extreme Bandwidth Wireless Communications Receiver

This Small Business Innovation Research (SBIR) Phase II project will adapt a photonics based signal processor to propel applications in extreme bandwidth spread-spectrum wireless communications. The signal processor prototype known as the spatial spectral holographic (S2H) extreme bandwidth analyzer / correlator (EBAC) will function as a correlating receiver for low probability of intercept (covert) and interference immune spread-spectrum communications in any radio frequency/millimeter wave (RF/MMW) band. The Phase I effort proof of concept demonstrations showed correlation and demodulation of >4 GHz bandwidth signals with processing gain exceeding 40 dB. The Phase II project will demonstrate continuous transmission signal generation and receiver processing prototype hardware with the ability to demodulate extreme instantaneous bandwidth up to 20 GHz spread-spectrum communications signals with long duration spreading waveforms up to 1 ms, with high data rates (1-1,000 Mb/s), and flexible frequency coverage exceeding 40 GHz. For particular intensive signal processing functions such as spectral analysis and correlation the S2H EBAC analog signal processor demonstrates higher performance and power efficiency than traditional digital signal processing. The intellectual merit of this project is in the advancement of the core technology and application to new real-world applications.

The broader impact/commercial potential of this project include opportunities for major academic and commercial developments in communication technology, spectrum analysis, and spectrum enforcement with wide operating bandwidths from 0.5-40 GHz IBW. Initial commercial market would be for spectrum analysis systems with a customer base in electro-magnetic environment testing, tactical DoD next-generation wideband passive surveillance systems, law enforcement surveillance, and intelligence community spectrum sensing. In wireless communications, this technology has the potential extend the reach of spread spectrum communications to new operational paradigms. Beyond communications, commercial applications include test and measurement systems, magnetic resonance imaging, weather radar, earth mapping, navigation, and spectrum use enforcement (the Federal Communications Commission (FCC) in the U.S.). The enabling technology has commercial, military and intelligence community benefits in the form of geo-location, direction finding, data selection and filtering, navigation, and imaging. With the collaboration with our university partner on this project, we will also support unique applications focused research experience opportunities for graduate and undergraduate students in STEM fields.

Skylark Wireless, LLC

Program: SBIR Phase II

NSF Award No.: 1632565

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: High-Speed TV-Band White Space Networks with Many-Antenna Multi-User Beamforming

The broader impact/commercial potential of this project is to provide wireless technology for economic high-speed internet connectivity in under-served rural regions, addressing the needs of 40 million Americans and over 50% of the global population. The technological developments in this project will pave the way for adoption of Massive, or Many-Antenna MIMO technologies in next-generation wireless systems by addressing scalability bottlenecks with innovative hardware and protocol design. The result of this project will be a revolutionary new wireless system for internet service providers addressing an $80 billion fixed wireless systems market and connecting under-served global communities to high-speed internet commerce, communications, education, and entertainment.

This Small Business Innovation Research (SBIR) Phase 2 project will develop a production-ready Television White Space (TVWS) Massive MU-MIMO wireless system for IP data traffic, then use it to characterize for the first time diverse, large-scale multi-user TVWS channels. This project will demonstrate the first economically-viable Massive MIMO system, as well as the first point-to-multipoint wireless system capable of non-line-of-sight ranges over 10s of miles with over 2 Gbps of aggregate capacity. The system will be used to measure and characterize TVWS channels at scale in various rural environments, with large beamforming arrays serving tens of clients tens of miles away. In particular, these measurements will explore the effect of range, environment, user separation, and polarization on real-world achievable capacity. The results will be used to guide the design, optimization, and deployment of rural TVWS broadband networks across the world.

Smart Electric Grid, LLC

Program: SBIR Phase II

NSF Award No.: 1660022

Award Amount: $734,080.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: A Robust State Estimator For Power Grids

The broader impact/commercial potential of this project include 1) the targeted problem (power system state estimator) is extremely critical in modern power grids or smart grids which may help prevent system-wide failures or blackouts if properly handled, 2) the certainty of commercialization of the proposed approach warranting significant NSF support because the provided solution is fast enough for real-time application and the new state estimator does not ask for additional inputs or requirements compared with existing solutions, 3) the research team is formed by technical as well as marketing personnel which ensures the success of the sales of the products, 4) the uniqueness of the proposed approach which provides competitive benefits to the market that cannot be met by alternate technologies and can attract further funding from non-SBIR sources and result in direct sales to power industry, 5) the proposed approach develops a unique formulation/solution of state estimation which very possibly leads to further innovations, 6) the new procedure of the proposed approach based on unique formulation and unique philosophy can promote teaching, training and learning in the area of state estimation.

This Small Business Innovation Research (SBIR) Phase 2 project contains intellectual merit that lies in 1) achieving a fast and robust solution to a 40-years' open problem of robustness in power system state estimation, which is a critical and challenging problem, 2) developing a unique formulation of state estimation which easily prevents robust problems suffered by the existing approaches to state estimation and which provides advanced knowledge and understanding in the area of state estimation, 3) a well-qualified team led by the PI who has research experience in state estimation for more than 15 years and has published actively and widely in state estimation and other related areas, 4) the high originality of the proposed solution which is developed based on a completely different philosophy than the existing ones, and is innovative even in the theory of statistics, 5) reflecting state-of-the-art in the area of power system state estimation - presently a major research activity, and 6) easy integration of synchronized phasor measurements into the proposed state estimator.

Solid State Ceramics, Inc.

Program: STTR Phase II

NSF Award No.: 1632476

Award Amount: $637,300.00

Start Date: 10/01/2016
End Date: 09/30/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

STTR Phase II: Low Temperature Cofired Multilayer Ceramic Power Transformers Incorporating Base Metallization Materials

The broader impact/commercial potential of this project is to a wide range of electronics in the areas of communications, Internet, portable electronics, and power electronics. Although magnetic based transformers have been the industry standard for over a century they have many negatives including miniaturization difficulties, electromagnetic interference issues, and issues with larger voltage step-up applications. The main goal of the research is to develop a ceramic replacement for magnetic transformers that is both conducive to miniaturization, provides higher power densities, provides a large increase in safe operating temperatures, and that is cost competitive with standard magnetic devices. This technology will provide important advantages for many applications; the ability to produce at low cost also opens up large new markets that are not easily reached using conventional magnetics.

This Small Business Technology Transfer (STTR) Phase 2 project aims to develop new low temperature sintering processes and transformer structures that enable the use of base metal electrodes to replace very expensive platinum. This drastically reduces costs of ceramic transformers and substantially improves performance due to the fact that a poor electrical/thermal conductor, Platinum, is now replaced with base metal (Copper) that is a high performance electrical/thermal conductor. This translates into both higher power throughput in devices that are lighter weight and lower profile and also a new ability to now match the high temperature range of wide bandgap power devices. The success of this program immediately leads to a revolutionary next step of being able to insert power management/conversion electronics directly within integrated circuits such as in application specific integrated circuits (ASIC) and field programmable gate arrays (FPGA).

Spensa Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1430996

Award Amount: $1,277,246.00

Start Date: 10/01/2014
End Date: 03/31/2019

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: A Multimodal Sensor Platform for Automated Detection and Classification of Pest Insects

The broader impact/commercial potential of this project is significant. The proposed technology could drastically improve the overall effectiveness of pest management programs in various agricultural industries. The proposed system not only eliminates one of the most laborious and dreaded activities of manually inspecting insect traps, but also provides unprecedented access to accurate, real-time insect population information to make more effective pest management decisions. This leads to reduced, spatially-restricted pesticide applications, better understanding of insect pest behaviors, and enhanced biological control. The automated trap's ability to monitor more than one species of insect not only achieves a higher level of efficiency in pest monitoring but also multiplies the technology's value to the end users. The potential market for the proposed technology is quite broad. In fact, the technology can benefit any industry that requires regular monitoring of insect populations. Furthermore, the proposed technology could be used for various state and federal pest monitoring programs, such as the Slow the Spread (STS) Project administered by USDA to monitor gypsy moths.

This Small Business Innovation Research (SBIR) Phase 2 project proposes to develop a multi-modal sensor platform for robust detection and classification of multiple insect pest species for automated monitoring of insect populations in production agriculture. The main goal of this project is two-fold: First is to demonstrate that bio-impedance sensor alone provides useful data to classify multiple insect species. A linear support vector machine classifier using mel-frequency cepstral coefficients extracted from bio-impedance data will be implemented on an embedded platform for detection and classification of two insect pest species. These bio-impedance based electronic traps will undergo large-scale field trials and be prepared for full commercialization. The second objective is to develop a multi-modal electronic trap with ultrasound, infrared and bio-impedance sensors that can simultaneously monitor four or more insect pest species. Measurement signals generated by the sensors will be analyzed to determine a set distinct features that can be computed on an embedded platform for real-time processing. These features will then be used in multi-modal sensor fusion algorithms for robust detection and classification. Different sensor fusion strategies will be investigated and the performance of each fusion algorithm will be evaluated both in controlled and field conditions.

SpringActive, Inc.

Program: SBIR Phase II

NSF Award No.: 1660235

Award Amount: $749,986.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Quasi-Active Prosthetic Ankle System: Dynamic Angle and Stiffness Optimizations for Multiple Gait Activities

The broader impact/commercial potential of this project is that the proposed system will enhance the ability of the 1.3 million people currently living in the United States with a lower limb amputation to walk in unconstrained environments. The proposed Quasi-Active Prosthetic Ankle System (QPAS) addresses the RH6: Human Assistive Technologies area. QPAS will be lightweight, have a long battery life, and optimize the passive dynamics of amputee gait in unconstrained environments by using battery energy to tune its physical system properties, ankle equilibrium angle and torsional stiffness. The device provides a unique set of features that do not currently exist in the market, strengthening its value proposition. The amputee population is growing; 2,000 new lower limb amputation are performed each week. Therefore, QPAS will have strong market potential and the significant societal impact of improving health by supporting a more active lifestyle for lower limb amputees. This will also lead to more community and family involvement. Additionally, because of the many possibilities to control QPAS, gait researchers will be able to study amputee compensation preferences. A better understanding of the kinematic and kinetic preferences could lead to improvements in the design of purely passive ankle prostheses.

This Small Business Innovation Research (SBIR) Phase 2 project addresses the needs of lower limb amputees. Lower limb amputees suffer from reduced self-selected walking speed, increased metabolic cost, increased reaction loads on the sound limb, poor gait symmetry, and reduced stability with increased risk of falling. Passive prosthetic feet are only tuned for level ground walking at one speed. QPAS will utilize a patented compliant actuator to achieve a unique set of features: passive energy storage with an articulating ankle joint, adaptable ankle angle for slope gait, low electrical energy usage, a large range of ankle motion, adaptable stiffness to optimize variable cadence level ground and slope gait, and controlled energy delivery to ensure energy builds naturally and smoothly. In this phase 2 SBIR, an intuitive and autonomous controller will be built for the QPAS and human subject evaluations will assist in refining the device towards commercialization. QPAS will become a successful product by focusing on improved amputee gait performance in unconstrained environments, and being simple to fit and adjust, reliable and affordable.

Stratio, Inc.

Program: SBIR Phase II

NSF Award No.: 1534793

Award Amount: $1,409,999.00

Start Date: 08/15/2015
End Date: 07/31/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Innovative Germanium-based Short Wavelength Infrared Image Sensors

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to allow a greater number of organizations, businesses, and individuals to access shortwave infrared (SWIR) imaging technology. Modern SWIR technology has existed for more than 40 years, but its expense has limited its use to the military and large corporations; this project is grounded in the belief that when everyone has access to SWIR technology, the benefits to society are exponential. SWIR image sensors have potential applications in food safety analysis (e.g., identifying harmful adulterated foods and revealing sub-surface flaws in produce), manufacturing (e.g., sorting), security (e.g., night vision), medical sensing (e.g., vein mapping and blood oxygenation monitoring), and the automotive field (e.g., night/inclement weather vision systems and for self-driving vehicles). A low-cost sensor will open the SWIR imaging market to players in these fields who have so far been shut out due to price. In addition, a low-cost, high-quality sensor will also make SWIR imaging directly available to the general public for the first time ever in the form of a SWIR camera smartphone add-on, establishing a new market for SWIR imaging.

This Small Business Innovation Research (SBIR) Phase II project will produce low-cost germanium (Ge)-based shortwave infrared (SWIR) image sensors with features superior to those of currently available SWIR sensors. The research objective is to resolve issues of resolution, power usage, size, and sensitivity that limit advancement in the SWIR imaging field. This project will address these problems by utilizing a unique Ge-based SWIR sensor structure. In addition, a monolithic method of integrating the image sensor material onto the Si readout integrated circuit will be pursued. This will enable precise alignment of the readout integrated circuit and the imaging device, which will lead to smaller pixel size and better resolution. Finally, issues of power use and sensitivity will be addressed through an innovative structure called Gate-controlled Charge Modulate Device. Research will focus on refining and improving the fabrication processes necessary to reliably produce low-cost, high-quality Ge-based SWIR image sensors.

SynTouch, LLC

Program: SBIR Phase II

NSF Award No.: 1534524

Award Amount: $864,042.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Artificial Characterization of Objects Relating to Human Tactile Perception

The broader impact/commercial potential of this project is to provide a new standard of quantifying touch for industries currently relying on qualitative data from expert sensory panels (the tactile equivalent of professional wine tasters). Advancing the understanding of the role and function of tactile sensing in perception and manipulation is also essential if robots are to behave like humans. Studies have demonstrated that humans who cannot feel due to permanent disease or temporary anesthesia perform poorly in fine manipulation tasks (similar to even the best robotic systems without touch). The research proposed in this project is the next step to bring tactile sensing and sensory-motor intelligence to the next generation of robotics. The successful demonstration of a tactile sensor with perceptual similarity to the human fingertip would mark substantial progress in the field of telemanipulation, bringing the world one step closer to remote haptic perception.

This Small Business Innovation Research (SBIR) Phase 2 project seeks to develop the world's first standard of human tactile perception. It has been proposed that tactile recognition presents a more difficult problem than vision and hearing, requiring not only intelligent sensory processing, but also intelligent algorithms to select and control movements, which have a tremendous influence on what is sensed. Artificial sensors that mimic the mechanical properties and sensitivity of the human fingertip have not existed until recently. The research proposed herein will test hypotheses that a biologically inspired robotic system can measure properties that correspond to subjective percepts, descriptors and associations that humans use to characterize objects by touch.

TACTAI

Program: SBIR Phase II

NSF Award No.: 1632274

Award Amount: $860,430.00

Start Date: 09/01/2016
End Date: 02/28/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Touch and Feel a Virtual Object with Life-like Realism

The broader impact/commercial potential of this project is to create a suite of consumer hardware and software products that provide realistic tactile feedback to users who are touching objects in virtual reality (VR) and augmented reality (AR). As evidenced by the current proliferation of low-cost head-mounted displays and motion tracking systems, three-dimensional interaction technologies are revolutionizing how people interact with computers, media, and each other. Since they are currently limited to vision and audio, endowing consumer-level human-computer interfaces with high-fidelity tactile feedback will vastly increase user immersion, making games more fun, online interactions more effective, and tools more efficient. Consequently, this project has the potential to expand the commercial reach of the burgeoning VR/AR market, opening up myriad opportunities for companies particularly in the gaming, entertainment, and e-commerce sectors. The innovation of this project also promises to enhance scientific and technological understanding of haptic human-computer interaction by establishing a new paradigm that blends minimal wearable hardware with sophisticated software algorithms. Finally, commercializing novel interactive technology also has the potential to help inspire a diverse array of young people to pursue a career in the critical areas of science, technology, engineering, and math.

This Small Business Innovation Research (SBIR) Phase 2 project aims to advance knowledge of low-cost technology that can provide realistic tactile feedback to a user touching objects in VR or AR: the project's intellectual merits center on testing a new approach that combines minimal haptic hardware and sophisticated software algorithms. The research objective is to create a fully functional industrial prototype of a wearable fingertip thimble and custom software that embody the proposed approach. When the user's finger moves to touch a virtual object, a platform inside the thimble will initiate contact with the fingerpad and press with a force that varies with penetration distance, to render surface softness. A thermal actuator will convey the object's thermal conductivity and temperature. When the finger slides along a virtual object, the user will feel its texture via carefully designed platform vibrations. Specific research tasks to be addressed include exploring haptic actuator options, building a library of haptic object properties (HOPs) that can be applied to virtual objects, and creating a communication protocol for exchanging haptic signals among devices. This project is expected to yield a fully functional industrial prototype and developer kits for the wearable fingertip thimble.

Tactical Haptics

Program: SBIR Phase II

NSF Award No.: 1632341

Award Amount: $749,307.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Program Director: Muralidharan S. Nair

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Intuitive Touch Feedback via Ungrounded Tactile Shear Feedback for Virtual Reality and Human-Machine Interfaces

The broader impact/commercial potential of this project is its potential to revolutionize human-machine interfaces, with possible applications in computer-aided design (CAD); military, maintenance, and pilot training interfaces; industrial and construction operator interfaces; robotic and laparoscopic surgery; physical therapy, rehabilitation, and swing training; education; telerobotics; automotive navigation and safety systems; and video games. While haptic interactions in these applications can already be portrayed with desktop robotic force feedback devices, the developed haptic technology could provide realistic haptic feedback at a much lower price point (required for consumer devices) and unlike current force feedback devices, the developed haptic devices can be used to naturally interact in large workspace applications like motion-input video games or VR experiences. The proposed research will enhance the scientific understanding of human-haptic and multi-modal interactions in virtual environments, and will create a model for this technology to migrate into adjacent fields.

This Small Business Innovation Research (SBIR) Phase 2 project seeks to meet the market demand for intuitive, immersive, and inexpensive haptic technologies in the emerging field of consumer virtual reality (VR). Multiple companies are now making inexpensive 3D head-mounted displays (HMDs) for VR, but current haptic interfaces are either too expensive, have limited range of motion, or are too crude to portray realistic haptic interactions in VR. The company has created an ungrounded haptic motion controller that utilizes a new form of touch feedback that applies in-hand shear forces to create compelling physical feedback at a price that is viable for consumer markets. The proposed research objectives are based on feedback from key stakeholders and VR enthusiasts who have tried the company's current high-end haptic controllers. Their feedback suggests improving the overall user experience of the controllers through reducing device size, mass, and system latency, while improving device ergonomics and reducing cost. The Phase II research builds on the findings of Phase I, which showed that even simpler implementations of the newly developed haptic technology were still found to be more compelling than traditional vibration feedback. The project will result in a reference design that can be mass produced.

Thalchemy Corporation

Program: SBIR Phase II

NSF Award No.: 1660175

Award Amount: $734,381.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Neural Algorithms for Multimodal Sensory Analysis

The broader impact/commercial potential of this project is to enable continuous sensing applications in a wide range of energy-constrained sensor-enabled devices. Without dramatic innovations in the development of ultralow power sensory processing, continuous and accurate sensing will remain a niche application limited to environments with a stable and plentiful power source and significant computing resources. The technology described in this proposal will demonstrate the viability and potential widespread deployment of continuous sensing devices in mobile or remote environments with strict energy constraints. An important immediate market for the proposed technology with significant customer base is the smartphone and wearables market, where many new and emerging end user applications could leverage environmental sensing to trigger context-based and anticipatory actions. The proposed technology is broadly applicable to a number of other markets and domains, including medical, health, and safety monitoring of critical patient sensors, personal fitness devices, military applications, and environmental monitors. The ability to flexibly deploy continuous sensing for these and other applications has the potential to revolutionize these markets and create entirely new and unforeseen application domains.

This Small Business Innovation Research Phase 2 Project plans to research and develop algorithms based on the properties of biological spiking neurons and the sensory processing capabilities of the human brain. The human brain is truly unique in its ability to use a basic computational element, the spiking neuron, and perform a broad variety of tasks. The brain has the ability to accurately classify sensory patterns from multiple modalities (touch, sight, etc.), to interpret the outside world, and to recognize the current context. A key intellectual merit of this project is a demonstration of how these novel neural algorithms can perform accurate, robust, and low power sensory analysis across multiple sensory domains. Just as the brain is capable of processing data from very different sensors. Researching and developing these neural algorithms will provide insight as to how the human brain learns to recognize important sensory information, how it is able to integrate information from such different sense modalities, and how it is able to perform complex analysis so efficiently.

University of California, Merced

Program: PFI:BIC

NSF Award No.: 1430351

Award Amount: $800,000.00

Start Date: 08/15/2014
End Date: 07/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC Humans-in-the-Loop: A Critical Link to Enable Smart Control of Building Infrastructure in a Complex Service System

This Partnerships for Innovation:Building Innovation Capacity (PFI:BIC) project from the University of California-Merced provides support for an academic-industry partnership to focus on the development of a crowd-based temperature control system to manage both building energy expenses and building occupant comfort effectively and efficiently, adapting university-created technology to real business applications. Buildings represent an important context for complex service systems. Americans spend 90% of their time inside buildings. Buildings accounted for near 40% of U.S. energy consumption in 2011, 75% of which was electrical energy. The energy expenditure in the building market is huge: in 2011, more than $431B was spent on energy. The climate-change footprint of buildings is correspondingly large, and the energy performance of buildings is poor, as measured by occupant comfort surveys. The modest goal of building professionals "that 80% of occupants should be satisfied with the thermal, air quality, acoustic, and lighting environments" is almost never met in practice. Though reducing energy consumption is a strategic national policy issue, comfort should not be overlooked, and the relationship between comfort and energy use must be taken into account. This project relies on a crowd-based control system for gathering occupant comfort data and managing building systems.

ThermoVote is a platform technology for gathering and analyzing thermal comfort data from large numbers of building users and for controlling building heating, ventilation, and air conditioning (HVAC) systems in real-time. It provides a critical link in a complex service system to enable smart control of building infrastructure. This project uses ThermoVote as a crowd-based environment control system in new building environments to harden the platform technology, integrate it with new building systems, and develop service scenarios and related components to implement the ThermoVote approach on a large scale. From an engineering perspective, design of complex systems given large numbers of participants has rarely been studied. From a cognitive perspective, complex, distributed cognitive systems have rarely been studied. From an interdisciplinary perspective, design of engineering systems has rarely been done given deep knowledge of complex multiple feedback loops created by interactions of large numbers of people and technologies. There are several key innovations to the project: use of real buildings to show system benefits; investigation of both individual and group behavior to save energy by adjustable autonomy; and novel algorithms using multiple criteria optimization (e.g., energy consumption and preferences). And there are a number of open questions: How can we design effective learning systems that are controlled by large groups? How should a system portray its changing behavior? What are the best schemes for indirect or direct control? Many questions lie at the intersection of systems and people.

This project is led by faculty in the Electrical Engineering and Computer Science group of the School of Engineering at the University of California, Merced, with participation by faculty in Management and Cognitive Science at the University of California, Merced. The primary industrial partner is HP Labs (Palo Alto, California), the research arm of Hewlett Packard, a large U.S. business.

University of California, Irvine

Program: PFI:AIR - TT

NSF Award No.: 1543242

Award Amount: $199,999.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI: AIR - TT: Single Channel Communication using Full Duplex Systems

This PFI: AIR Technology Translation project focuses on translating Full-Duplex (FD) technology to fill the need for efficient use of wireless spectrum resources in current and emerging wireless communication systems. FD technology is important because it allows wireless communication devices to receive and broadcast simultaneously, on the same frequency, thus effectively doubling spectrum utilization. The project will result in a prototype FD transceiver that can be easily integrated into current systems, leading to improved capacity and quality of service. By utilizing FD systems, spectrum assets worth billions of dollars can be redirected to create new opportunities for growth. This FD transceiver has the following unique features: a) Fully digital signal processing, b) reduced cost and c) compact footprint. These features allow for rapid deployment of compact, low cost, FD wireless systems capable of operating at double the spectral efficiency of competing Half-Duplex systems.

By utilizing smart training heuristics that control a beam-steerable antenna and new digital cancellation transceiver architectures, a reduction of more than 100 dB of the self-interfering signal is achievable, thus allowing for FD communication. Technology gaps between research discovery and commercial application that will be addressed include developing new heuristics that are capable of adapting to the dynamic indoor and outdoor wireless channels, as well as novel robust channel estimation and non-linearity estimation and mitigation algorithms. Finally, new interference management and avoidance techniques will be designed to enable robust FD systems. The novelty of the proposed research is that it aims to bridge the gap between theoretical performance of FD systems and practical considerations that take into account the unique features associated with FD systems. In addition, undergraduate and graduate students affiliated with this project will receive structured innovation and entrepreneurship experiences through the University of California, Irvine, Institute for Innovation, which is a hub that connects a vibrant community of students, scholars, industries and entrepreneurs.

University of Louisville Research Foundation, Inc.

Program: PFI:BIC

NSF Award No.: 1643989

Award Amount: $863,232.00

Start Date: 06/01/2016
End Date: 07/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - Adaptive Robotic Nursing Assistants for Physical Tasks in Hospital Environments

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project aims to provide next-generation assistive robots to support the activities of hospital-based registered nurses (RNs). There are nearly three million registered nurses employed in the United States, making them the largest pool of healthcare providers in the country. Technology that affects the performance of this large labor pool cannot fail to have impact. Due to advancements in robotics and computer technology, access to intelligent communication, sensing, and computing hardware is on the cusp of becoming common--not only for healthcare professionals, but also for patients themselves. The project led by The University of Kentucky at Louisville in collaboration with the University of Texas at Arlington will focus on the creation of new design tools that can configure the hardware and software of adaptive robotic nursing assistants (ARNA). ARNA will be specifically designed to assist nurses in healthcare facilities with simple tasks such as, lift assistance, delivery of everyday lightweight objects (medicine, medical wearable equipment), and some physical assistance with movement of heavier objects, such as furniture, gurneys, and the patients themselves. The design and engineering innovations resulting from insights gained in this project may have great value deployed as products in broader consumer markets in addition to hospitals. Examples include in-home service and assistive robots, robots for assistance in public venues, and co-Robot manufacturing where humans are in close proximity to robot workers. The improved understanding of human-robot and nurse-robot interaction could represent enabling technology that will facilitate research breakthroughs and increase productivity and social acceptance of robotics. The research will also advance the understanding of the perceptual effects of robot design aesthetics and interfaces.

The proposed Adaptive Robotic Nurse Assistants will navigate cluttered hospitals, while equipped with multi-modal skin sensors that can anticipate nurse intent, automate mundane low-level tasks, but keep nurses in the decision loop. Modular and strong hardware will be deployed in reconfigurable platforms specially designed for nurse physical assistance. Adaptive human-machine interfaces will play a key role in this project, as these interfaces directly impact the ability of robots to help nurses in a dynamic, unstructured environment. Rather than pre-programming robot behaviors, learning algorithms will be used so that robots adapt to human preferences. Two leading applications are envisioned for feasibility evaluation by quantitative and qualitative metrics, including patient sitters and walkers. The sitter robot will take vital sign measurements, evaluate risk from patient movement and pose, and provide continuous observation of patients and feedback to and from nurses. The walker robot will assist nurses and patients by providing partial balance support, navigating cluttered environments, and assisting with medical equipment transportation.

The lead institution is the University of Kentucky at Louisville in collaboration with the University of Texas at Arlington with its multidisciplinary departments including the College of Engineering, College of Nursing, and the University of Texas at Arlington Research Institute (UTARI). Primary industrial partners include QinetiQ-North America (Waltham, MA), a large corporation specializing in unmanned systems, and RE2 (Pittsburgh, PA), a small business specializing in modular robotic manipulators that will contribute unique battle-tested hardware and systems engineering. In-hospital testing and evaluation of the proposed robots will be carried out by nurse researchers at the University of Texas at Arlington College of Nursing and Texas Health Resources (Dallas-Fort Worth, TX), a large healthcare provider.

University of Maryland College Park

Program: PFI:AIR - TT

NSF Award No.: 1602012

Award Amount: $200,000.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Integrated Bidirectional Power Electronic Charger/ Converter for Plug-in Electric Vehicles

This PFI: AIR Technology Translation project focuses on translating an integrated bidirectional onboard charger and dc/dc converter technology to fill the need for compact and efficient power converters for plug-in electric vehicles. The proposed technology is important because it reduces the weight, volume and cost of onboard converters, while enhancing their efficiencies, and enabling bidirectional operation. The successful completion of this project will facilitate widespread adoption of electric vehicles, and lead to the creation of jobs through the small business partner once the technology matures toward commercialization. The project will result in a prototype of an integrated charger/converter for electric vehicles. This converter has the following unique features over current options: bidirectional operation, higher efficiency over entire charging period, less number of components, and an air-cooled thermal management system. These features provide the advantages of enhanced efficacy, greater power density, and considerable cost savings, in comparison to the competing conventional method of utilizing an individual charger and an individual auxiliary load converter in the current market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application: (1) theoretical advancements in the design and development of ultra-compact, integrated vehicle-to-grid (V2G) and grid-to-vehicle (G2V) chargers and converters; (2) innovative thermal management methods for wide band-gap Silicon Carbide (SiC) based power electronic converters; (3) demonstration of a functional prototype integrated charger/converter for plug-in electric vehicles, (4) evaluation and prototyping a commercially valuable solution of proposed converter against conventional technologies, and (5) developing a strategy for commercialization beyond this project. In addition, personnel involved in this project, PIs, undergraduates and graduates will receive innovation and technology translation experiences through technical and commercialization tasks. This will be achieved through design and packaging activities from the feasibility to prototyping stage.

The project engages researchers from University of Maryland and Genovation Cars Inc. to design, develop, and validate a prototype of this technology translation effort from research discovery toward commercial reality.

University of Massachusetts Amherst

Program: PFI:BIC

NSF Award No.: 1534080

Award Amount: $1,000,000.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - Utility-driven Smart Energy Services

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project focuses on the development of a utility-driven energy service platform. Since buildings consume a large fraction of society's total energy usage, even modest improvements in building energy efficiency have the potential to yield significant benefits. In recent years, utilities have deployed tens of millions of smart electric meters that record building energy usage over short intervals (e.g., every few minutes). While the original purpose of smart meters was to support basic utility operations (e.g., automated meter reading), this project uses them as the foundation for developing a new class of smart energy service systems. Specifically, the project focuses on analyzing the vast amount of data available from utility smart meters and other networked sensors to improve the energy efficiency of buildings and the electric grid. The research is utility-driven, since utilities have i) access to massive amounts of customer energy data, ii) a way to deliver the results of analytics to customers, and iii) strong incentives to improve customer energy efficiency (e.g., by reducing peak demand to reduce their own operational costs). The approach is scalable, since it leverages already available building smart meter data, rather than requiring the installation of new smart devices and control systems.

The project will develop utility-driven smart energy services to improve grid energy efficiency, encourage energy conservation, and promote the local renewable energy sources, such as rooftop solar. The research methodology includes developing new energy analytic techniques for smart meter data, combining these in novel ways to create specific applications that improve energy efficiency, packaging those applications as cloud-based web services that are accessible to end users, and evaluating their impact on user behavior and energy efficiency. In particular, the project will develop three specific smart energy service systems: i) iProgram to determine optimal thermostat schedules by analyzing smart meter data, ii) Green Demand Response (Green-DR) to opportunistically schedule elastic loads to align with renewable energy generation, and iii) PowerTrip to provide real-time energy event notifications and suggested conservation actions to users. The project will implement a prototype of each system and evaluate them on real-world data (rendered anonymous) from 18,000 smart meters. The research follows a human-in-the-loop model that integrates technical and user behavioral research in the design and implementation of smart energy services. Thus, the project includes user studies to assess each service's behavioral impact on users.

Broader impacts stem from the project's industrial partnerships with a local utility, a premier research lab (Microsoft Research), a small startup company (Budderfly), and an environmentally-conscious non-profit (WattTime.org). These partnerships will expose students to industry perspectives on addressing real-world energy-efficiency problems, and interdisciplinary research that spans technical and behavioral disciplines. The project will enable sustainability-aware curriculum, undergraduate REU projects, and sustainability-focused outreach efforts to local K-12 students through the newly established Massachusetts Green High Performance Computing Center.

The lead institution is the University of Massachusetts Amherst. The primary industry partner is Holyoke Gas and Electric (HG&E)) (Holyoke, MA), a municipal utility. Primary academic partners are the University of Maryland-Baltimore County (Baltimore, MD) and Williams College (Williamstown, MA). Broader context partners are Microsoft (Redmond, WA), a large business, WattTime.org (Berkeley, CA), a non-profit, and Budderfly (Shelton, CT), a small business.

University of Minnesota, Twin Cities

Program: PFI:AIR - TT

NSF Award No.: 1601644

Award Amount: $200,000.00

Start Date: 04/15/2016
End Date: 09/30/2017

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Program Director: Barbara H. Kenny

Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Non-Intrusive Position Measurement in Oscillating Piston Applications

This PFI AIR Technology Translation project focuses on translating research for determining the spatial location of a magnet into technology to fulfill the need for piston position measurement in piston-cylinder actuators. The developed sensor is important because it can enable automation in a number of industrial and mobile machines. The project will result in a robust prototype of a piston position measurement sensor. The proposed sensor will be non-contacting, non-intrusive, inexpensive, will not require line-of-sight access, and will involve minimal effort for installation on a cylinder. Due to these advantages, the proposed sensor has an opportunity to establish a significant market share in the piston position application domain.

This project addresses the following technology gaps as it translates from research discovery towards commercial applications: a) The need to place the sensor at an off-axis location on top of the actuator requires the development and use of complex two-dimensional magnetic field models. b) The sensor prototype needs to address problems due to hysteresis when the cylinder is made of soft steel which gets magnetized and demagnetized in real time due to oscillatory motion of a magnet. c) Extension of the previous linear position sensor technology to rotational applications requires new sensor architectures, development of new models, and new estimation algorithms.

Specific solutions to address the above challenges will be fully developed and evaluated in the project. The proposed solutions include development of analytical two-dimensional magnetic field models, development of a new analytical model for hysteresis that has significant advantages over the traditional Preisach model, and development of robust auto-calibration algorithms. In addition, a graduate student and a post-doc involved in the project will receive technology translation experience through prototype development and industrial interaction.

The project engages three major actuator companies to evaluate the sensor prototype on their actuator products, as the technology is translated from research discovery towards commercial reality.

University of Minnesota, Twin Cities

Program: PFI:BIC

NSF Award No.: 1631133

Award Amount: $999,733.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC: Smart Human-Centered Collision Warning System: Sensors, Intelligent Algorithms and Human-computer Interfaces for Safe and Minimally Intrusive Car-bicycle Interactions

This research project will develop a smart warning system to enable safe and minimally intrusive interactions between motorists and bicycles. Interactions with bicycles are rare for a typical motorist, therefore safety-conscious drivers naturally focus on other motor vehicles in the roadway, and may not become aware of the presence of a bicycle until it is too late. In contrast, interactions with motor vehicles are commonplace for a bicyclist. Furthermore, the bicyclist faces far greater consequences in an accident than a motorist. Therefore it is appropriate for a collision prevention system to be the responsibility of the cyclist. Continuous display of bright flashing lights or loud sounds may suffice to bring attention to the cyclist, but they may unnecessarily distract nearby motorists, or they may alarm passing drivers, and cause them to move dangerously far from their own lane. The system under development will guide motorists to pass bicycles with exactly as much distance as safety requires. Furthermore, it will provide alerts only to those drivers that have a significant probability of collision with the bicycle. The system to be developed will incorporate a knowledge base of likely collision scenarios, thus minimizing false alarms. The system will provide guidance cues to the bicyclist, to ensure a safe and respectful response to motor vehicles. Human factors studies will be used to design an alert system that provides motorists with specific and effective audio-visual cues. These studies will also be used to ensure that cyclists do not respond to the enhanced security by becoming more reckless. It is expected that the technology developed in this project will enable motorists to interact with bicycles safely and with minimal intrusion. It will reduce the approximately 48,000 bicyclist injuries and 700 fatalities that occur every year.

The development of a bicycle-mounted collision avoidance system must address a number of challenges beyond those required for a similar system on a car. These challenges include the need to address more complex collision scenarios, the need to provide alerts to the drivers of other vehicles, the need for inexpensive, light and smaller sensors, and the need to rely on human users for effective functioning of the system. These challenges will be addressed by development of unique custom-designed sensors, novel estimation algorithms for vehicle tracking and use of a rigorous human factors study to determine which warning systems will be effective and how such warnings should be provided to the involved motorist and bicyclist in real-world traffic scenarios. The warning presentation is designed to minimize the trade-offs between low reaction time and unnecessarily intrusive disturbances to nearby motorists. The custom sensors developed in the project include a triad sonar transducer unit for side vehicles, and front and rear laser sensors on real-time controlled rotational laser platforms to track vehicles at continuously changing lateral and longitudinal distances. The human factors studies in the project will enhance our understanding of human behavior in multi-modal collision avoidance systems and analyze possible long-term changes in behavior after prolonged use of the system. The project also includes an intensive 6-month field operational test in collaboration with an industrial partner to evaluate the effectiveness of the developed technology. The field operational tests will involve 10 bicycles, bicyclist volunteers with significant daily urban commutes and extensive analysis of bicycle data recorded in real-world traffic conditions. Due to the close industrial collaboration, the research conducted in this project will accelerate the path to commercialization of this smart system with its potential benefits to the country. The project will educate two graduate students and a post-doctoral researcher, providing them experience in inter-disciplinary research as well as an opportunity for strong industrial interaction.

This project is a collaboration between The University of Minnesota (Mechanical Engineering, Computer Science and Human Factors Engineering/Psychology) and primary industrial partner Quality Bicycle Products (QBP), (Bloomington, Minnesota, Large business). Broader context partners include The Minneapolis Bicycle Coalition, (Minneapolis, MN, nonprofit).

University of New Hampshire

Program: PFI:BIC

NSF Award No.: 1430260

Award Amount: $815,722.00

Start Date: 08/15/2014
End Date: 07/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC: The Living Bridge: The Future of Smart, User-Centered Transportation Infrastructure

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from the University of New Hampshire focuses on a "living bridge", which exemplifies the future of smart, sustainable, user-centered transportation infrastructure. Bridges deliver such a fundamental service to society that they are often taken for granted. Typically, bridges only stir the public's interest when they must unexpectedly be replaced at great cost, or, worse, fail. The Living Bridge project will create a self-diagnosing, self-reporting "smart bridge" powered by a local renewable energy source, tidal energy, by transforming the landmark Memorial Bridge--a vertical lift bridge over the tidal Piscataqua River, with pedestrian access connecting Portsmouth, New Hampshire to Kittery, Maine--into a living laboratory for researchers, engineers, scientists, and the community at large. The Living Bridge will engage innovators in sensor and renewable energy technology by creating an incubator platform on a working bridge, from which researchers can field test and evaluate the impact and effectiveness of emerging technologies. The Living Bridge will also serve as a community platform to educate citizens about innovations occurring at the site and in the region, and about how incorporating renewable energy into bridge design can lead to a sustainable transportation infrastructure with impact far beyond the region.

Sustainable, smart bridges are key elements in developing a successful infrastructure system. To advance the state of smart service systems and clean energy conversion, this project team will design and deploy a structural and environmental monitoring system that provides information for bridge condition assessment, traffic management, and environmental stewardship; advances renewable energy technology application; and excites the general public about bridge innovations. This PFI:BIC project is enabled through partnerships between academic researchers with expertise in structural, mechanical and ocean engineering, sensing technology and social science; small businesses with expertise in instrumentation, data acquisition, tidal energy conversion; and state agencies with bridge design expertise. The Living Bridge technical areas are structural health monitoring, tidal energy conversion with fluid-structure interaction measurements, estuarine environmental monitoring, and outreach communication. Sensors will be used to calibrate a three-dimensional analytical structural finite element model of the bridge. The predicted structural response from this model will assess the measured structural response of the bridge as acceptable or not. Instruments installed on the turbine deployment platform will measure the spatio-temporal structure of the turbulent inflow and modified wake flow downstream of the turbine. Resulting data will include turbine performance and loads for use in fluid-structure interaction models. Deployed environmental sensors will measure estuarine water quality; wildlife deterrent sensors will deter fish from the turbine. Hydrophones and video cameras will be used before and during turbine deployment to monitor environmental changes due to turbine presence. Outreach efforts will make bridge data, history, and information about new systems accessible and understandable to the public and K-12 educators, facilitated by an information kiosk installed at the bridge. Public awareness will be assessed with survey methods used in the N.H. Granite State Poll.

The lead institution is the University of New Hampshire (UNH) with its departments of Civil Engineering, Mechanical Engineering, and Sociology, and the Center for Ocean Engineering. Primary industrial partners are a large business, MacArtney Underwater Technology Group, Inc. (Houston, TX); and a small business, Lite Enterprises, Inc. (Nashua, NH). Broader context partners are New Hampshire Department of Transportation, NH Fish & Game Department, NH Port Authority, NH Coastal Program, City of Portsmouth (NH), Sustainable Portsmouth (nonprofit), Maine Department of Transportation, U.S. Coast Guard, Archer/Western (Canton, MA, large business), Parsons-Brinkerhoff (Manchester, NH, large business), UNH Tech Camp, UNH Infrastructure and Climate Network, UNH Leitzel Center for Mathematics, Science and Engineering Education, and Massachusetts Institute of Technology's Changing Places (a joint Architecture and Media Laboratory Consortium, in Cambridge, MA).

University of Pennsylvania

Program: PFI:BIC

NSF Award No.: 1430216

Award Amount: $799,860.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC: Affordable and Mobile Assistive Robots for Elderly Care

This Partnership For Innovation project develops and tests the use of service robots to monitor and improve health of the elderly. The growing elderly population coupled with low birth rates in the developed world is creating a crisis in healthcare. The number of senior citizens is outgrowing the number of working-age adults to care for them. In the U.S. alone, the number of seniors over age 65 is projected to double from year 2000 to 2030, reaching 71.5 million. With the scarcity of care options available, affordable robots are a welcome solution for assisting elders with small tasks that would normally be done by a caregiver. While helping elders with activities of daily living in an elder care facility, the system learns about them. It can then do things such as help ensure that they are eating or drinking healthily.

The project consists of two main parts: development of a low-cost mobile manipulator capable of a limited set of elder-relevant manipulation tasks (e.g., picking up dropped items or filling a water glass); and development of a data-driven service system that analyzes the use of the robot over time to monitor elder health via service requests and pro-actively offer assistance as needed. One key to making this system viable is maintaining effectiveness at low cost. This work builds on a commercial low-cost mobile robot platform being developed at Savioke and adds manipulation capabilities via a novel low-cost expanding prismatic joint arm under development at the University of Pennsylvania. This mobile manipulator robot will be used to perform service tasks, such as delivering water to elders. The data gathered by these robots and how elders use them in the field will provide information about how robots can help create a larger data-driven health monitoring system.

The partners at the inception of the project include University of Pennsylvania, both the School of Engineering and Applied Science as well as the School of Medicine (Philadelphia, PA) and Savioke (Sunnyvale, CA, a small business concern) along with broader context partner, “LIFE”--Living Independently For Elders (Philadelphia, PA, a non-profit organization).

University of Rochester

Program: PFI:AIR - TT

NSF Award No.: 1601850

Award Amount: $199,419.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Commercialization of Nanomembrane-based SERS sensors

This PFI: AIR Technology Translation project focuses on translating a novel photonic material with exceptional molecular recognition capabilities. Current molecular sensors are complex, expensive and suffer from limited reproducibility and scalability. These facts have hampered the adoption of molecular sensors despite immense industrial and scientific interest from the fields of forensics, toxicology, and biomedicine. Highly scalable and inexpensive, SERF (Sensitive Erasable Reproducible Flow-through) sensors will lead to an era of ubiquitous molecular identification devices for diverse applications such as biometric and health screening, trace hazard detection (biohazards, toxins, drugs, and explosive residues), and chemical quality control. In addition to affordable manufacturing, the SERF technology has a 7 fold higher sensitivity and greater uniformity than the leading commercial substrate (Klarite(TM); Renishaw Inc.). The SERF sensor also has first-of-a-kind capabilities in flow-through detection and surface cleaning for reuse. The project will identify the most commercially viable molecular target for the SERF sensor and optimize the material and a prototype for the detection of this molecule.

This project addresses several technology gaps as it translates a laboratory discovery into a commercial application. First, composed of a high density of optically responsive nanopores rather than the low-density micropatterned features, the SERF sensor improves both the sensitivity and uniformity of detection compared to the leading photonic-based sensors. Second, as a porous structure the SERF technology allows sample flow through the sensor, overcoming diffusion limited response times that are impractical (days) for trace molecules with existing sensors. Finally, the SERF sensor can be reused or cleaned with the application of a small current through its contiguous metallic surface. This feature can be used to reset sensors and to overcome performance loss due to fouling.

The project brings together a world-leading nanomembrane manufacturer (Roussie Co-PI; SiMPore Inc.) with a leading nanomembrane research laboratory (McGrath PI; University of Rochester) and world-class experts in photonics (Webb Co-PI; Nottingham University) to translate a novel laboratory discovery toward commercial impact in industries that improve human welfare. A University of Rochester graduate student and co-inventor of the SERF technology will receive hands on entrepreneurship training by working with PIs and Co-PIs in customer discovery interviews and in the development of a business model canvas.

University of Texas, Arlington

Program: PFI:BIC

NSF Award No.: 1534124

Award Amount: $999,946.00

Start Date: 08/01/2015
End Date: 07/31/2018

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:BIC - Adaptive Robotic Nursing Assistants for Physical Tasks in Hospital Environments

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project aims to provide next-generation assistive robots to support the activities of hospital-based registered nurses (RNs). There are nearly three million registered nurses employed in the United States, making them the largest pool of healthcare providers in the country. Technology that affects the performance of this large labor pool cannot fail to have impact. Due to advancements in robotics and computer technology, access to intelligent communication, sensing, and computing hardware is on the cusp of becoming common--not only for healthcare professionals, but also for patients themselves. The project led by The University of Texas at Arlington will focus on the creation of new design tools that can configure the hardware and software of adaptive robotic nursing assistants (ARNA). ARNA will be specifically designed to assist nurses in healthcare facilities with simple tasks such as, lift assistance, delivery of everyday lightweight objects (medicine, medical wearable equipment), and some physical assistance with movement of heavier objects, such as furniture, gurneys, and the patients themselves. The design and engineering innovations resulting from insights gained in this project may have great value deployed as products in broader consumer markets in addition to hospitals. Examples include in-home service and assistive robots, robots for assistance in public venues, and co-Robot manufacturing where humans are in close proximity to robot workers. The improved understanding of human-robot and nurse-robot interaction could represent enabling technology that will facilitate research breakthroughs and increase productivity and social acceptance of robotics. The research will also advance the understanding of the perceptual effects of robot design aesthetics and interfaces.

The proposed Adaptive Robotic Nurse Assistants will navigate cluttered hospitals, while equipped with multi-modal skin sensors that can anticipate nurse intent, automate mundane low-level tasks, but keep nurses in the decision loop. Modular and strong hardware will be deployed in reconfigurable platforms specially designed for nurse physical assistance. Adaptive human-machine interfaces will play a key role in this project, as these interfaces directly impact the ability of robots to help nurses in a dynamic, unstructured environment. Rather than pre-programming robot behaviors, learning algorithms will be used so that robots adapt to human preferences. Two leading applications are envisioned for feasibility evaluation by quantitative and qualitative metrics, including patient sitters and walkers. The sitter robot will take vital sign measurements, evaluate risk from patient movement and pose, and provide continuous observation of patients and feedback to and from nurses. The walker robot will assist nurses and patients by providing partial balance support, navigating cluttered environments, and assisting with medical equipment transportation.

The lead institution is the University of Texas at Arlington with its multidisciplinary departments including the College of Engineering, College of Nursing, and the University of Texas at Arlington Research Institute (UTARI). Primary industrial partners include QinetiQ-North America (Waltham, MA), a large corporation specializing in unmanned systems, and RE2 (Pittsburgh, PA), a small business specializing in modular robotic manipulators that will contribute unique battle-tested hardware and systems engineering. In-hospital testing and evaluation of the proposed robots will be carried out by nurse researchers at the University of Texas at Arlington College of Nursing and Texas Health Resources (Dallas-Fort Worth, TX), a large healthcare provider.

University of Wisconsin, Madison

Program: PFI:AIR - TT

NSF Award No.: 1542959

Award Amount: $212,000.00

Start Date: 09/01/2015
End Date: 02/28/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

PFI:AIR - TT: Microgrid Energy Manager (MEM) using Wireless Networks and Cloud Computing

This PFI: AIR Technology Translation project, Microgrid Energy Manager (MEM), focuses on translating the technology of electrical power control using wireless computing to fill the need for cost effectively matching supply and demand of electricity in microgrids. The MEM is important because it will enable the widespread adoption of microgrids, which in-turn enables the widespread adoption of distributed renewable energy resources. This leads to environmental benefits and reduced energy costs to consumers and businesses. The AIR-TT project will result in a field-tested MEM that will be ready for commercial adoption by energy service and integration companies. MEM has the following unique features: (a) wireless operation; (b) smart user-interfaces; (c) low power consumption; (d) internet of things; and (e) cloud computing. Together, these features will remove the hassle for the energy users from having to frequently negotiate the nuances of microgrids, and will provide a consumer experience wherein intelligent control with smart phone and/or web interfaces become useful for realizing reduced energy costs and improving end-use comfort simultaneously.

This project addresses the following key technology gap while translating the research discovery into commercial applications. The gap is a lack of design-oriented models that predict system-level interactions among power networks, wireless networks, embedded computing devices and cloud systems when they are deployed together. This project helps address this key technology gap by (a) building a definitive test-bed; (b) field-deploying the test beds to obtain performance data and (c) empirically identifying and refining design-oriented models.

In addition, personnel involved in this project, including undergraduate and graduate students from engineering and business schools, will receive course-work and project-based learning in the areas of entrepreneurship and technology translation through (a) interdisciplinary special topics courses (b) the Wisconsin Entrepreneurship Bootcamp (c) the business plan competitions such as the Wisconsin Energy and Sustainability Challenge, and (d) various fieldwork demonstrations.

The project engages the City of Madison and Seventhwave (formerly the Energy Center of Wisconsin), to provide a test environment, guide commercialization aspects, and provide partnership in consulting to develop field deployment so as to translate this research discovery into a commercial reality.

VERISTRIDE, Inc.

Program: SBIR Phase II

NSF Award No.: 1331108

Award Amount: $910,503.00

Start Date: 09/15/2013
End Date: 05/31/2017

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Topic: Electronic Hardware, Robotics and Wireless Technologies (EW)

SBIR Phase II: Real-Time Rehab to Improve Gait Symmetry in Amputees

This Small Business Innovation Research (SBIR) Phase II project will advance the technology research and development necessary to bring wireless instrumentation and smartphone technology used for feedback to lower-limb amputees about their real-time performance, for rehabilitation in situ. The intellectual merit of the proposed research lies in the opportunity to transform the field of rehabilitation and to advance healthcare by enabling a fundamental shift toward low cost, ubiquitous rehabilitation that can be used away from the clinic. This proposal will research and develop the pre-market alpha- and beta-prototypes of an instrumented insole, smartphone app, and HIPAA-compliant data transfer and remote server storage and analysis system, as an essential and transformative tool utilized for physical therapy and gait training outside of the clinic. While sensors have become small, inexpensive, and highly available, many research lab applications are limited to proof-of-concept evaluations that involve tethered systems and/or post-processing of the data. This research quantifies the effect of this low-cost, personalized, wireless assistive technology that can be used away from the clinic. Ultimately, this work lays a foundation for more complex rehab feedback systems, e.g. using a smartphone to detect gait and provide feedback to an orthotic or prosthetic for muscle stimulation.

The broader impact/commercial potential of this project includes the focus on mobility limitations in persons with lower-limb amputations, which affect twice as many minorities as Caucasians. The commercial potential of this wireless assistive technology is vast: with diabetes as the major contributor to amputations, the number of amputees is forecast to triple to 3.6 million by 2050. The knowledge gained can be expanded to impact individuals with a wide variety of mobility limitations, e.g. stroke, Parkinson's disease, multiple sclerosis, cerebral palsy, etc. The orthopedic market (773,000 total hip/knee replacements performed annually in U.S.) is also commercially relevant, as patients must affect an asymmetric gait following fracture repair or joint replacement to reduce weight-bearing on the healing limb. Another significant group are athletes seeking to improve performance or recover from injury through precision gait analysis and real-time feedback. In this Phase II proposal, this research will quantify the effect of this wireless assistive technology by enabling persons with amputations to use individualized proprioceptive feedback and to participate in the design of the personalized feedback methods. This work will enable a wealth of information collected away from the clinic, including a way to investigate how and whether patients follow treatment protocols.

INFORMATION TECHNOLOGIES (IT)

Arizona State University

Program: PFI:BIC

NSF Award No.: 1430144

Award Amount: $800,000.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Information Technologies (IT)

PFI:BIC Fraud Detection via Visual Analytics: An Infrastructure to Support Complex Financial Patterns (CFP)-based Real-Time Services Delivery

This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from Arizona State University focuses on building a platform that will integrate data from multiple sources and explore data analysis techniques that can more accurately detect indications of financial fraud. According to Federal Trade Commission's (FTC) annual "Consumer Sentinel Network Data Book", the most comprehensive database of U.S. fraud trends, American consumers submitted more than 1.5 million complaints - a 62 percent increase in just three years, and they reported losing over $1.6 billion to fraud in 2013. Detecting increasingly complex fraud schemes requires services that are able to integrate and enrich data from disparate financial and other data sources and hunt for recurring and often interconnected anomalous patterns in large networks. The proposed platform will enable integration and enrichment of limited private financial data with larger publicly available data sets to detect fraud and reduce losses due to fraudulent transactions. The project will also include training and research experience for undergraduate and graduate students.

The data linkage and financial pattern discovery platform which is to be developed via visual analytics will enable "smart" fraud detection and prevention services. Today, in order to obtain a single unified view of fraud activity across the enterprise and manage fraud on a cross-institution basis, fraud detection companies collect, verify, and analyze consumer data and financial information. Researchers recognize, however, that new insights into fraud and risk patterns require the ability to integrate financial data with domain independent data through real-time entity/identity discovery, resolution, cross-linking and schema mapping techniques. Therefore, the importance of the research discovery underpinning this project includes solving platform and processing challenges that arise from the need to integrate, filter, analyze, and visualize, in a secure and scalable manner, large private knowledge networks, also incorporating uncontrolled, unrestricted, untrusted, unstructured and unpredictable data from external domains. The ability to treat together financial and domain independent data will lead to enriched unified data, unprecedented predictive accuracy in fraud prevention and detection, and an entirely new suite of risk management services and products.

The partners at the inception of the project are Arizona State University (ASU) (School of Computing, Informatics, and Decision Systems Engineering and, notably, the investigators also are members of ASU's Information Assurance Center, certified by NSA and DHS); and a small business, Early Warning Services, LLC (Scottsdale, AZ).

Bay Labs, Inc.

Program: SBIR Phase II

NSF Award No.: 1556103

Award Amount: $740,788.00

Start Date: 04/15/2016
End Date: 03/31/2018

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: Guided Positioning System for Ultrasound

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be in the field of healthcare. The United States spends approximately $9,000 per person per year on healthcare. Ultrasound medical imaging is a medical imaging technology that could lower costs by providing an alternative to higher-cost imaging techniques. The technology created during this Phase II project is expected to increase the quality, value, and accessibility of medical ultrasound, which would in turn reduce medical imaging costs in the US healthcare system. Furthermore, the company's technology is expected to bring ultrasound to more clinical settings and improve system-wide efficiencies in the diagnosis and treatment of disease. The technology also has commercial potential in the international market, with $5.8B spent annually on medical ultrasound devices worldwide. Finally, by improving the utility of ultrasound, the technology will lead to improved patient care and may ultimately save lives.

This Small Business Innovation Research (SBIR) Phase II project will develop deep learning technology for ultrasound imaging in medicine. Ultrasound imaging has numerous benefits including real-time image acquisition, non-invasive scanning, low-cost devices, and no known side-effects (it is non-ionizing). However, variability in quality has encumbered its adoption and utility. As a result, more expensive imaging is typically utilized, often exposing patients to ionizing radiation. Our objective is to develop, improve, and test machine learning techniques, based on deep learning, to improve ultrasound acquisition and interpretation. We expect this project will create novel technologies that make ultrasound easier to use and improve the quality of ultrasound examinations. The end result will improve the quality, value, and accessibility of medical ultrasound examinations, will result in cost savings to the healthcare system, will produce improvements in patient care, and will support a sustainable business opportunity.

Codelucida, Inc.

Program: SBIR Phase II

NSF Award No.: 1534760

Award Amount: $750,000.00

Start Date: 08/15/2015
End Date: 07/31/2017

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Topic: Information Technologies (IT)

SBIR Phase II: Low-density Parity-check Error Correction for Enhanced Reliability of Flash Memories

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project are both technical and economic. The developed error-correction solutions will enable flash-memory-based devices to have higher capacities, higher reliability, and faster speeds at lower power while driving down the cost. This will have a major impact on mobile computing capabilities and enterprise storage by improving the efficiency and reliability of data centers, servers, and mission-critical storage that incorporate flash memories. Improved enterprise storage boosts the efficiency and growth of IT businesses, e-commerce, and financial trade. The solutions will also enable reduced power consumption and heat dissipation leading to greener systems. The benefits of the error-correction solutions are also applicable to the hard disk drive and communications industries.

This Small Business Innovation Research (SBIR) Phase II project will develop and validate novel low-density parity-check (LDPC)-based error-correction for flash memory-based solid state drives (SSDs). SSDs are rapidly being deployed for both enterprise and consumer storage due to their fast speeds, low power, and low heat dissipation. But they bring numerous technical challenges stemming from the fact that reducing flash memory cell sizes leads to an unavoidable degradation in the reliability. With a trend of increasing die density to enable higher storage capacities, the industry is swiftly moving towards adopting LDPC codes to provide more powerful error-correction. However existing LDPC solutions use complex post-processing and multiple reads to bring down the error rates to the desired levels which lowers the read speeds, making them unattractive for future SSDs. Novel binary LDPC-based solutions will be developed for a range of parameters, and validated in hardware. The design method will be extended to develop new non-binary LDPC solutions which provide even greater reliability enhancements, leading to greater endurance in SSDs.

Drexel University

Program: PFI:AIR - TT

NSF Award No.: 1640366

Award Amount: $199,997.00

Start Date: 09/01/2016
End Date: 02/28/2018

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Program Director: Barbara H. Kenny
Topic: Information Technologies (IT)

PFI:AIR - TT: A System for 3D Content-based Data Management

This PFI:AIR Technology Translation project focuses on translating 3-Dimensional (3D) content management technology to fill the need for systems that are capable of processing 3D content and sustaining expansion of 3D manufacturing. This 3D Content-based data management system is important because of its impact on information support for the 3D printing and manufacturing industry. The 3D manufacturing industry is facing a growing challenge in managing web-scale 3D content and the progress in managing 3D repositories is still in its early stages. As a result, systems that are capable of managing large-scale 3D content play a critical role in fostering a market for 3D content that is more accessible and offers the potential for new job and income opportunities for both content creators and consumers (e.g. by reducing the barrier for a startup to bring a new product to market). The project will result in a proof-of-concept of a web-scale system with the following unique features: object browsing, query processing, and interaction of 3D object composition/decomposition mechanisms. These features provide the advantages of an implementation based on a micro-services model for complex applications, which is a new architecture in this market space.

This project addresses several technology gaps in 3D information management as it translates from research discovery toward commercial application. Specifically, it includes computational methods such as similarity measurements based on a many-to-many matching algorithm that work with volumetric representations of 3D objects and produce a direct correspondence between two objects and their parts, which can be used for registration and juxtaposition. It will also transition several developed mechanisms for indexing a part-based representation of 3D objects, which in turn can be used for efficient retrieval of candidates from a database of models. Our proposal for partial matching of 3D parts will utilize a novel morphing of level sets of 3D surfaces that provides a shape similarity metric between the two surfaces. This metric will allow us to perform high accuracy matching of generalized surfaces. In addition, personnel involved in this project, including four upper-level (junior or senior) undergraduates, will receive entrepreneurship and technology translation experience through exposure to real-world software engineering processes, information retrieval, and large-scale data management tools. This experience will provide the skills, knowledge and experience to prepare the students for either academic careers or employment in industry.

The project engages 3D Industries (3DI) Ltd. to ensure the Drexel team's translational research efforts under the project remain on track to solve critical commercial needs and to minimize the time to market. 3DI's participation will augment the Drexel team's research efforts while also creating the opportunity for the Drexel team to quickly receive and adapt to feedback from real-work users.

Geospatial Data Analysis Corporation

Program: SBIR Phase II

NSF Award No.: 1660067

Award Amount: $748,212.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: High Resolution, Synthetic Satellite Imagery of the Earth

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to address a strong commercial and scientific need for operational synthesis of spatially consistent and temporally relevant historical and current high resolution satellite imagery for analytical purposes. The technology will contribute to the advancement of scientific knowledge especially in the geospatial arena and to market spillovers. By dramatically simplifying access to accurate imagery for any time and place, this technology will provide companies, researchers, educators, students, and regular citizens with a valuable tool for visualizing and exploring our changing planet and will contribute to increasing public engagement with science and technology. Further, the analytical capabilities offered by the imagery have great potential in scientific applications thus contributing to partnerships between academia and industry and improving datasets for research and education. Finally, this technology will be valuable in operational settings at the large providers of commercial satellite imagery, to individual users, and enable a wide variety of new visualization, analysis, and data mining applications. The examples of commercial applications for the technology are virtual earth, insurance and reinsurance, agriculture, emergency, change detection.

This Small Business Innovation Research (SBIR) Phase II project will operationally synthesize accurate regional-to-global, high spatial / high temporal satellite imagery of the Earth. The technology will utilize advanced data fusion algorithms to combine various sources of imagery while preserving the best spatial and temporal attributes of the data sources. The complexity of accessing, processing, and analyzing various sources of satellite imagery creates a significant barrier to its use. Synthesis of regionally and globally continuous high spatial / high temporal resolution imagery is a challenge as in addition to inherent differences in spatial and temporal resolutions of the source data, the new models need to account for enormous data volumes and sparse coverage of high spatial resolution imagery. Existing techniques to handle these challenges have severe limitations which curtail their use outside of the research arena. The technology will overcome these limitations by implementing algorithms that are robust, automated, scalable, deliver accurate data, and are usable in operational settings. They will provide spatially consistent and temporally relevant imagery which will empower businesses with regional and global outreach to make better decisions with better data.

Haselton Baker Risk Group, LLC

Program: SBIR Phase II

NSF Award No.: 1632429

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Rapid Calculation of Earthquake Repair Costs for Pricing of Building Risk

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is that it will enable a group of customers we call Risk Pricers (specifically, property and casualty insurance underwriters and mortgage bankers in financial firms) to profit from tailoring pricing on their products. They can do this by rapidly predicting financial losses for buildings having specific configurations, using the software developed in this proposal. These customers can then tailor pricing of earthquake insurance and mortgage terms based on refined analyses that we facilitate. Besides offering a clear financial benefit to Risk Pricers, this new analysis approach will also fundamentally change market forces and incentives around building safety. If a building's owner is incentivized to improve its earthquake performance (via lower insurance and mortgage costs), then high-performance buildings become more appealing and this will encourage design of better buildings. As the company's software makes more explicit the links between building properties and financial costs, society will benefit from more efficient resource allocation, ultimately leading to increased societal resilience.

This Small Business Innovation Research (SBIR) Phase II project will develop algorithms and software tools that provide financial guidance to customers interested in repair costs and closures of buildings due to earthquakes. To complete the development of its tool, the company will focus on calibrating statistical models to predict displacements and accelerations in a wide range of building types, when they are subjected to earthquake shaking. The company's method for rapid estimation of structural responses utilizes principles of engineering mechanics, but applied in a domain where academic research does not focus (i.e., estimating response of a structure whose properties are not fully known to the analyst). The key identified need is to calibrate a statistical predictive model for the response of a structure that is effective over all popular construction types of interest to customers in the insurance and mortgage banking markets (i.e., light frame wood, steel, concrete, concrete tilt-up). The company will also develop loss metric and calculation outputs that incorporate insurance contract conditions such as deductibles and limits, in order to link the calculations to customers' workflows.

i2k Connect, LLC

Program: SBIR Phase II

NSF Award No.: 1534798

Award Amount: $765,240.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Information Technologies (IT)

SBIR Phase II: Translational Information Management for Industry

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be more effective and efficient use of unstructured data. Limiting analysis to structured data ignores the massive amount of information in reports, memos, articles, and other written documents. Workers require information on past work and ongoing projects, best practices, current events and competitor and customer activities. However, companies with thousands of workers have millions of documents. It is prohibitively expensive to index them manually so that they can be found, analyzed and acted on. Moreover, overloaded workers do not have the time or training required to take on the task. The problem is exacerbated by mergers and acquisitions. In addition, over years, it is common for companies to accumulate large numbers of duplicate and out-of-date documents that workers do not take the time to rationalize and delete. The result is inflated storage costs and reduced productivity as workers struggle to find the relevant, up-to-date information. Inconsistent information governance also puts organizations at risk - litigation (retaining documents without legal or business value), safety (using out-of-date process safety management procedures) and operational (not leveraging best practices and lessons learned across the enterprise and beyond).

This Small Business Innovation Research (SBIR) Phase II project addresses the problem that text documents - especially those internal to an organization - are very difficult to locate and analyze unless they are classified and tagged. But manual classification and tagging are too expensive and inconsistent for large collections. Large companies store many millions of documents. And there is even more relevant information on the Web. The objective of the proposed research to is to provide software assistants that classify documents into pre-specified categories, add tags to describe what each document is about, and the entities named in the documents (e.g., oilfields). The assistants identify relevant documents and help people to learn of new developments by sending alerts when new documents of interest appear on the web or in the company's computers. The primary technical result will be a suite of software assistants that companies can adopt singly or as an ensemble to help manage information sustainably. These assistants build upon the proposed research to develop and integrate novel approaches to unsupervised machine learning, concept identification, and ontology construction. They will enable companies to overcome major problems, including overload, finding relevant, up-to-date information, analyzing unstructured information, and identifying unneeded documents for elimination.

InsightFinder, Inc.

Program: SBIR Phase II

NSF Award No.: 1660219

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Topic: Information Technologies (IT)

SBIR Phase II: Providing Automatic System Anomaly Management Software as a Service for Dynamic Complex Computing Infrastructures

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to greatly improve the robustness and diagnosability of many computing infrastructures including both public and private computing clouds. The proposed technology will significantly reduce the occurrence of performance degradation and service downtime in cloud computing infrastructures, which can attract more users to adopt cloud computing technology and thus benefit society as a whole, which depends increasingly on cloud technology. The project will also advance the state of the art in cloud system reliability research by putting research results into real world use.

This Small Business Innovation Research (SBIR) Phase II project will transform system anomaly management for dynamic complex computing infrastructures. The novelty of the company's solution lies in three unique features: 1) predictive: the solution can raise advance alerts before a serious service outage occurs; 2) self-learning: the solution automatically infers alert conditions and performs automatic root cause analysis using machine learning algorithms; 3) adaptive: the technology adapts to dynamic systems. The proposed research will produce novel and practical anomaly prediction and diagnosis solutions that will be validated in real world computing infrastructures. Specifically, the project consists of three thrusts: 1) adaptive learning in dynamic environments; 2) real-time feature extraction and pattern recognition over system metric and log data; and 3) full stack root cause analysis. During the project the company will implement its software products and carry out case studies with prospective customers on real world computing infrastructures.

Iowa State University

Program: PFI:BIC

NSF Award No.: 1632116

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Information Technologies (IT)

PFI:BIC- A Smart Service System for Traffic Incident Management Enabled by Large-data Innovations (TIMELI)

The Federal Highway Administration estimates that a quarter of the congestion on U.S. roads is due to traffic incidents such as a crash, an overturned truck, or stalled vehicles. Congestion costs the commercial trucking industry $9.2 billion annually, and incidents have been shown to increase the risk of secondary crashes by 2.8 percent with every minute of congestion. To address these economic and safety issues, traffic incident management (TIM) centers, typically operated by state departments of transportation (DOT), monitor roadways for traffic incidents, coordinate incident response, and provide traffic management and control to minimize the impacts of traffic incidents. This research will develop a new TIM system, called TIMELI (Traffic Incident Management Enabled by Large-data Innovations), that has greatly enhanced capabilities for incident risk assessment and response over current products. Software-based intelligent transportation systems (ITS) that are currently available are limited to very basic controls and do not provide comprehensive or dynamic decision support. These systems display streams of traffic data on a map and rely on technicians to input a control action. To address these limitations, this smart system aims to be a more effective data-driven TIM that provides user-centric information visualization and improved analytics and machine learning. Use of the system by state DOTs can reduce the duration and impacts of incidents and improve the safety of motorists, crash victims, and emergency responders. Use will also reduce the TIM technician fatigue and reduce their turnover rates.

The goal and outcome of TIMELI is to use emerging large-scale data analytics to reduce the number of road incidents through proactive traffic control and to minimize the impact of individual incidents that do occur through early detection, response, and traffic management and control. This will be achieved using end-to-end machine learning for situational awareness, the design and rapid solution of geo-temporally aware traffic models using partial differential equations, stochastic model predictive control, and user-centric advanced visualization techniques for decision assistance. Current technology gaps in data handling and archiving, analysis for decision support, and the design of output formats will be addressed using big data technologies. Multiple large data streams will be ingested and data analytics will be performed for quality assurance and anomaly detection. New algorithmic approaches, machine learning, and a stochastic framework will be used to detect anomalous outliers and implement context-sensitive traffic models. An advanced human machine interface will provide information visualization and decisions recommendations in an intuitive format to minimize any cognitive bottlenecks. The objectives are to develop TIMELI and to integrate it into an existing TIM system. These will be accomplished by the following methods: (1) defining TIM user requirements and identifying bottlenecks in technician tasks using human factors research; (2) developing a prototype that includes a big-data-enabled back-end solution, an analytics engine, and a front-end interface; and (3) conducting testing, evaluation, and integration within Iowa DOT's existing TIM environment. TIMELI's multiple innovations will transform current TIM systems by creating a smart and reliable decision assist system used to monitor traffic conditions in real time, proactively control risk using advisory control, quickly detect traffic incidents, identify the location and potential cause of these incidents, suggest traffic control alternatives, and minimize cognitive bottlenecks for TIM operators. The test bed will be the Center for Transportation Research and Education's fully functional traffic operations lab that is connected to the Iowa DOT's data streams.

This research will contribute to education by involving undergraduate and graduate researchers in Civil Engineering, Electrical and Computer Engineering, Mechanical Engineering and Human Factors Engineering, and will generate real-world data sets that will be used in developing educational material.

The partners in this project are Iowa State University (lead academic institutions), TransCore (a commercial provider of intelligent transportation systems, Des Moines, IA), and Iowa Department of Transportation-DOT (government agency, Ames, IA).

LeanFM Technologies Inc.

Program: SBIR Phase II

NSF Award No.: 1660158

Award Amount: TBD

Start Date: TBD
End Date: TBD

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Topic: Information Technologies (IT)

SBIR Phase II: Big Data Analytics for Facility Operations and Management

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project results from improving the efficiency in facilities management (FM) of institutional and commercial buildings by enabling a streamlined transition to efficient, proactive operations using the power of big data analytics. This provides an opportunity to reduce estimated $78.5 Billion - $127.3 Billion in waste due to reactive maintenance per year in the US commercial facilities market alone. A data driven, proactive approach provides a unique opportunity that enable facilities managers to assess as-is conditions of assets, avoid non value-add activities and plan maintenance tasks to avoid failures and shutdown. This will contribute towards transforming a traditional industry to an advanced data-driven one. It will also enable significant reduction in the disruptions caused to occupants due to failures in facilities. Given that Americans spend 85-90% of their time indoors and any disruptions caused by facilities directly impact their qualities of lives, the broader societal impact of reducing failures in facilities is significant.

This Small Business Innovation Research (SBIR) Phase II project intends to research, develop and demonstrate the feasibility of using big data analytics and machine learning to transform facilities operations and maintenance decisions. Owners and operators of the over five million commercial and institutional buildings in the United States are faced with the challenges of managing aging and crowded building infrastructure. They waste between 30% and 40% of resources by operating in a predominantly inefficient, reactive mode. This project targets development of computational mechanisms that automatically analyze integrated building information to identify patterns that lead to actionable insights that help reduce non value-add activities and improve resource utilization in FM daily operation and planning. By combining advanced machine learning technologies with existing building information modeling (BIM) resources, the company is proposing to develop high-impact, statistical and visual methods for optimizing the decision-making abilities of facility managers and with that, the performance of critical facilities infrastructure and maintenance crews. The results of this research will include algorithms and methods to normalize heterogeneous building data, detect patterns and anomalies, from which actionable insights can be derived with domain knowledge, and generate qualitative and quantitative output appropriate for improved decision making in managing commercial facilities.

Lumenous Co.

Program: SBIR Phase II

NSF Award No.: 1632533

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Reliable, Scalable Projection Mapping Systems with Reusable Content

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project includes new ways to inform, educate, advertise or entertain through a technology called projection mapping. This technology uses commodity video projectors to augment the surfaces of ordinary objects; applications range from advertising, events, and entertainment, to educational experiences at museums or schools, healthcare applications for rehabilitation and visualization, and simulation (e.g. military or employee training). Through multiple deployments at retail locations across the country, the company's prototypes have demonstrated that these applications will benefit not only the brands and companies that employ the technology, but also the end-users (students, consumers, etc), resulting in better engagement and faster learning when compared to achieving these same tasks through other media such as videos. Research performed during the Phase II project will allow the company to develop a scalable product and fulfill many deployments, bringing projection mapping to new markets. A free version of the company's software will also be available for non-commercial and academic use, enabling interdisciplinary research in fine arts and computer science. The R&D results generated from the research will be published and disseminated to the public.

This Small Business Innovation Research (SBIR) Phase II project will build a commercially viable and scalable projection mapping system. While projection mapping has a long academic history, this captivating medium still remains out of commercial reach. As learned from over 50 customer discovery interviews, retailers are shifting towards location-based experiences to increase customer engagement and sales. Many other industries have a similar need to attract attention and convey information, but without a scalable product that can be easily deployed and maintained, they lack the means to provide these experiences. To address this need, the company will develop hardware and software systems to enable captivating and immersive projection mapping experiences. The core of this system is in software: the developed algorithms will robustly calibrate projection mapping systems comprising any number of projectors/cameras, automatically align projected content to the scene and perform color-correction when the display surfaces are non-white/textured. These algorithms will be validated through standard benchmarks, resulting in novel, state-of-the-art practices. Additionally, these methods will allow for reusable projection mapping content, a critical feature lacking in existing software, as well as cloud deployment and monitoring. New hardware configurations will also be developed to achieve new uses for projection mapping.

Marinus Analytics, LLC

Program: SBIR Phase II

NSF Award No.: 1660190

Award Amount: $749,933.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Information Technologies (IT)

SBIR Phase II: Decoding Obfuscated Text to Find Trafficking Victims

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to combat modern day slavery in the United States and Canada. In this project the company will go beyond the public sector, selling its capabilities to the hospitality industry, which shares a role in tackling this problem. Banks also play a part in detecting financial transactions which stem from criminal revenue streams. These new markets expand the revenue opportunity and social impact of the technology. The proposed Phase II research and development will solve huge challenges voiced by the company's law enforcement users. The deployment of these research products through a platform that enables evidence management and collaboration will accelerate the impact by increasing communication among the fragmented law enforcement jurisdictions in the United States. This will enable agencies to conduct more effective investigations, and empower them to take on larger cases involving organized crime across state lines. Finally, human expertise will be developed within the company and through its partnership with Carnegie Mellon University to commercialize advanced computing research for real-world, social impact. These innovations will empower more victim rescues and exploiter prosecutions. The project will create a culture within the company to nurture engineers in social entrepreneurship.

This Small Business Innovation Research (SBIR) Phase II project will expand on machine learning technology created in Phase I to deobfuscate escort ads and implement end-to-end innovations for investigations. Each day, there are thousands of online data points related to prostitution. Hidden behind this content are victims of sex trafficking, those forced or coerced into sex work, including juveniles who have not reached the age of consent. Big Data presents the opportunity to seize this information to disrupt traffickers and organized groups who drive the cycle of exploitation. The company's research objectives include maximizing evidence recall using sophisticated crawlers and deobfuscation methods, as well as generating leads using natural language processing and multi-modal machine learning. The project will further develop computer vision capabilities to interpret features of an image and enable visual search for missing victims. It will formalize methods for collecting ground truth, preventing false positives, and diagnosing algorithmic performance relevant to users' needs. Finally, the company will deploy this research into accessible software products that provide real-time, digestible, and actionable information to law enforcement, resulting in the rescue of hundreds, or potentially thousands, of sex trafficking victims.

Misapplied Sciences, Inc.

Program: SBIR Phase II

NSF Award No.: 1660095

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Information Technologies (IT)

SBIR Phase II: Computational Pipeline and Architecture for Personalized Displays

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is in improving the performance of the computational back-end of a display system that delivers personalized information in public spaces. Currently, the primary method for an individual to receive customized information in public spaces is through personal devices. The heavy use of personal devices in public often leads to heads-down, isolating, and even hazardous situations. The delivery of personalized information through infrastructure can significantly improve these issues. However, the bandwidth requirements in doing so have been prohibitively high using standard computational architectures. This project aims to improve the performance of such a system, allowing practical applications that will broadly enhance safety, accessibility, transportation, and other areas.

This Small Business Innovation Research (SBIR) Phase II project focuses on creating a scalable computational pipeline and architecture that will allow a display system to direct personalized visual information in real-time to large numbers of people. Technically, this involves computing, transmitting, and displaying image data for large crowds in parallel. The architecture takes advantage of the inherent redundancies in this application to provide a cost-effective solution. The goal of the project is to create a computational back-end capable of driving, in real-time, a system equivalent to thousands of displays.

Mobile Enerlytics, LLC

Program: SBIR Phase II

NSF Award No.: 1660221

Award Amount: $749,998.00

Start Date: 03/01/2017
End Date: 02/28/2019

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Topic: Information Technologies (IT)

SBIR Phase II: Enabling Techologies for Energy-Centric Mobile App Design to Extend Mobile Device Battery Life

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will result from it having far-reaching societal, commercial, and technological impact. (1) Initial research by the Principal Investigator on analyzing the energy drain of AngryBirds has demonstrated the severe energy inefficiency of popular mobile apps in today's app market. The importance of this work is heightened by smartphones being an important enabler of Internet access for disadvantaged people in both developed and developing countries, and hence being an important tool in overcoming the "digital divide". (2) Commercially, the project will foster a paradigm shift in the mobile app industry ($101B industry in 2020) from the current feature-centric to energy-aware app design. Such a paradigm shift will have a significant, long lasting impact on the app industry. Energy-efficient apps lead to longer battery life, which in turn leads to longer user engagement time, which ultimately translates into millions of dollars of increased mobile revenue as all major businesses are shifting towards mobile. Hence this SBIR project will lead to a marketable product. (3) Technically, the proposed work will extend the performance profiling technology that is foundational to the software industry into the energy dimension, which is critical to the mobile software industry.

This Small Business Innovation Research (SBIR) Phase II project will develop the industry's first app energy management (AEM) solution to help app developers reduce app battery drain, and extend the battery life of billions of smartphones. The research objectives are (1) to develop advanced energy debugging techniques that can automatically identify energy drain opportunities from legitimate energy hotspots; and (2) to develop an SDK-based app energy monitoring system for monitoring app energy drain when running on consumer phones in the open market. These objectives pose significant technical challenges. While similar challenges on performance metrics (such as running time) have been well studied for traditional software, in particular in high-performance computing, in this project the company is expanding them to the energy dimension for the mobile app industry, which has not been attempted before. The company will develop novel machine-learning based solutions to learn, classify, and auto-detect energy optimization opportunities. As a result it expects to develop the first set of solutions to these fundamental challenges in optimizing the energy drain of millions of mobile apps in the app market.

Network Perception, Inc.

Program: SBIR Phase II

NSF Award No.: 1534676

Award Amount: $727,075.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: Dynamically Assessing Network Security Policy Compliance with NP-Live

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project results from it significantly strengthening the ability of network operators and security administrators to implement the correct set of rules to keep critical assets out of reach of cyber adversaries. The power grid has been said to be the most important engineering achievement of humankind. Modern civilisation depends on electricity at such an intrinsic level that we cannot imagine a world without it. In fact, disruptions of power infrastructures quickly lead to chaotic situations in which human lives are at risk. Now that power grid control centers are relying on IT infrastructures, it has become of the utmost importance to ensure the resiliency of systems and networks through methodical IT security protection, monitoring, and response. Through automated continuous verification technologies, this project has a direct impact on the capabilities of our nation to improve its resiliency. The benefit to the power industry, to computer science security, and for society at large is a technological advance to improve the security of our most important resources.

This Small Business Innovation Research (SBIR) Phase II project plans to develop a constructive approach to providing cyber security. Cyber security tools are often driven by the necessity to respond to market demand without having the time and resources to develop the proper formalisms and algorithms to solve long-term issues. The innovation proposed here is uniquely positioned to change this paradigm thanks to having roots in both a fundamental academic background and an extensive collaboration with industry partners. Consequently, this project responds to critical customer needs while providing innovations in science, technology, and engineering of critical infrastructure security. The approach taken to compliance assessment has been evaluated in the field and provides a basis for new research leading to theoretically sound solutions to network security modeling, and further development of innovative and provably correct algorithms and tools for accurate and scalable cyber security assessment under real industry constraints.

NGD Systems, Inc.

Program: SBIR Phase II

NSF Award No.: 1660071

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 08/31/2018

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: SSD In-Situ Processing

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to fundamentally change what a storage device can do, and give storage a third capability that is not addressed by existing storage technology - the ability to actually process user data. For the computation to take place, only the computational request and the resulting data need to transfer over the storage interface, reducing interface traffic and the required power. The advent of Big Data and the increasing use of Hyperscale Server technology have resulted in the creation of an additional storage tier that is different from traditional enterprise storage. This new tier requires significantly larger capacity yet lower cost, lower operating power, and yet must still exhibit enterprise level reliability. This combination of characteristics cannot be serviced by existing technologies, and execution with large data sets typical of Big Data results in inefficient solutions. The information being stored represents the large, unstructured data mined by today's companies for key information and trends that help dictate corporate direction, advertising, and monetization. Future applications include machine learning for video analytics, genome sequencing and enabling Fog Storage and Fog Computing, among others.

This Small Business Innovation Research (SBIR) Phase II project explores the Big Data paradigm shift where processing capability is pushed as close to the data as possible. The In-Situ processing technology pushes this concept to the absolute limit, by putting the computational capability directly into the storage itself and eliminating the need to move data to main memory before processing. The technology innovation begins with a solid foundation of an enterprise SSD tailored for the needs of modern Data Centers. Key technology that will be added to support these capabilities include hardware-assisted quality of service control, low-cost 3D-TLC and QLC NAND Flash enablement through the use of advanced ECC, and a proprietary elastic Flash Translation Layer to support extremely large capacity drives. The final element added to this foundation will be the ability to perform computation directly on the data with the addition of specialized In-Situ processing aided by hardware accelerators.

Northwestern University

Program: PFI:BIC

NSF Award No.: 1534138

Award Amount: $1,000,000.00

Start Date: 09/01/2015
End Date: 08/31/2018

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Topic: Information Technologies (IT)

PFI:BIC - Smart CROwdsourced Urban Delivery (CROUD) System

This Partnerships for Innovation:Building Innovation Capacity (PFI:BIC) aims to develop a crowd-sourced urban delivery (CROUD) system that promises an efficient, greener, urban delivery service system. The rise of e-commerce is rapidly changing the landscape of retail business. By 2017, online sales will account for more than 10% of this $4.5 trillion industry, according to a 2014 U.S. Census Bureau report. To stay competitive in this growing market, retailers are under enormous pressure to quickly deliver the goods to their consumers at low prices. Large asset-based carriers (e.g., UPS and FedEx) are not particularly cost-efficient for express local deliveries in urban areas, essentially because their distribution networks are designed to transport through hubs rather than directly between customers and retailers. This inherent inefficiency is aggravated by mounting demand for same-day delivery--widely considered the Holy Grail for e-commerce at present--that requires more frequent dispatch and in turn increases transportation cost. Recent arrival of tech giants such as Amazon, Google and Uber in this battlefield attests to the tremendous opportunities and challenges in the urban delivery industry. Ironically, there exists a large volume of unused capacity in the transport system. For one thing, because the urban delivery industry is highly fragmented, consolidating its capacity is often difficult. Another underutilized capacity exists in millions of private passenger vehicles on the road with empty trunks that could be used for delivery. Addressing this lack of adequate coordination between demand and supply holds the key to solving the express urban delivery challenge. A promising solution, enabled by recent advances in wireless communication and mobile computing, is crowd-sourcing technology that has been successfully applied in passenger transport (e.g., Uber and Lyft). The overarching goal of this project is to develop and evaluate a CROwd-sourced Urban Delivery (CROUD) system. With CROUD, consumers will enjoy faster, cheaper and more reliable delivery service. The retail industry will see a stronger consumer demand. The delivery industry will improve its profitability and reduce its environmental impact, while employing a highly mobile and efficient workforce. The project will also educate next generation entrepreneurs by providing training opportunities and materials for upgrading curricula in multiple disciplines.

The scientific contributions of the project span across several disciplines, and they are closely interconnected in supporting a human-centered smart CROUD system. First, the project will lead to pricing mechanisms that focus on matching consumers with couriers under varying market conditions. The use of matching models is novel in pricing analysis for two-sided markets, such as thouse found in CROUD systems, and it promises insights in other markets. Second, the project will help understand and predict behaviors and choices of humans in a CROUD system, a field completely new to behavioral econometrists. New econometric models, calibrated with behavioral data collected in this project, will be built into management strategies to enhance the consumer-courier-technology interaction in the system. Third, the proposed research will develop smartphone-based motion detection methods that are uniquely suited to track and interpret the activities of couriers. Finally, the project will create computational tools to facilitate collaborative delivery among couriers and to optimize routing plans based on real-time information. In doing so, new formulations, algorithms and insights will be generated for challenging problems in operations research and computational economics such as network design with relays, real-time vehicle routing considering transfer and environmental impacts.

This project will be led by Northwestern University through its Transportation Center (NUTC), with three researchers from two departments: Department of Civil and Environmental Engineering and Department of Managerial Economics and Decision Science. The primary industry partner is Zipments Inc. (small business, New York City, New York) and the other primary academic partner is the University of Illinois at Chicago (UIC) (non-profit research university, Chicago, Illinois). Two broader context partners will also join the team. They are Center for Commercialization of Innovative Transportation Technology (non-profit research institution operated within NUTC, Evanston, Illinois) and Center for Supply Chain and Logistics management (non-profit research institution affiliated with UIC, Chicago, Illinois).

Pointivo, Inc.

Program: SBIR Phase II

NSF Award No.: 1632248

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Automatic Generation of As-Built BIM Models Using a Single Video Camera

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to transform commercial construction through the democratization of scanning and automation of Building Information Modeling (BIM). Constant design and change management is a unique challenge that is costing the US construction industry billions of dollars annually. In order to prevent such a huge economic loss, this industry is in the path for a digital revolution. BIM is known as the first truly global digital technology that could revolutionize the construction industry. However, BIM usage is currently limited because it is only viable for large-scale projects. The primary reason is that the process is too laborious and expensive. The proposed technology will completely eliminate these barriers. Its ease-of-use, ubiquity of the capturing device, and automated object detection democratizes as-built BIM modeling. Enormous value could be generated due to streamlining and data management capabilities that are offered by the technology in the form of accelerated project schedules, reduced numbers of requests for information and change orders, and timely identified design clashes. This will pave the way to increase the competitiveness of the US construction industry, by enabling new products and services that support automatic BIM modeling.

This Small Business Innovation Research (SBIR) Phase II project investigates the technical and commercial feasibility of an automatic and inexpensive solution for the Scan-to-BIM problem in the construction industry. Scan-to-BIM refers to 3D scanning of a physical structure and converting the captured raw spatial data into an object-oriented, semantically-rich model. Although there are a few technologies that aim to facilitate this process, the 3D modeling component remains primarily a manual and time-consuming task. When using the proposed technology, a non-technical worker videotapes the target structure. The video is automatically sent to a server for processing. A unique videogrammetric 3D reconstruction engine reconstructs the 3D geometry of the structure in the form of a 3D point cloud. It then extracts object hypotheses from key video frames and spatial data in the form of observations. Afterwards, it optimizes a novel coherent joint probability distribution function and infers a 3D layout. The outcome is an object-oriented 3D representation of the structure with embedded geometrical attributes and property sets. The main novelty of this technology lies in a hybrid approach that combines low-level segmentation with high-level space modeling. This advances the state-of-the-art in robust intelligence, particularly the interpretation of complex, unstructured data.

Prairie View A & M University

Program: PFI:AIR - TT

NSF Award No.: 1543214

Award Amount: $251,999.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Topic: Information Technologies (IT)

PFI: AIR-TT: Developing a Prototype for the Next Generation of Petroleum Data Processing and Analytics Platform

This PFI: AIR Technology Translation project focuses on translating promising cloud computing and data processing research results to an application in the petroleum industry: a next generation petroleum data analytics platform. This integrated, easy-to-use platform will ease the daily work of big data processing and analytics in the petroleum industry. It will simplify the geophysicists' and data scientists' new algorithm design and facilitate their daily data interpretation and analytics work. The project will result in a prototype with the following unique features: high-level programming environment, rich data analytics packages, domain specific libraries, user-friendly web interface, flexible workflow and parallel seismic processing templates. These features provide the following advantages: scalable performance, high productivity, cost savings, and flexibility when compared to the leading competing generic data analytics platforms in this market space.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. 1) Design efficient data storage and distributions for petroleum data sets; 2) simplify parallelization efforts for new seismic data processing and analytics algorithm design; 3) apply the latest big data analytics discovery to support geological feature detection; 4) achieve both scalable performance and high productivity for petroleum data analytics. In addition, personnel involved in this project, including graduate and undergraduate students, will receive entrepreneurship experiences through I-Corps customer discovery work and this project.

The project engages TEC Application Analysis and the Texas A&M System Technology and Commercialization office to augment research capability with deep domain knowledge, guide commercialization aspects, and to perform marketing analysis in this technology translation effort from research discovery toward commercial reality.

Rensselaer Polytechnic Institute

Program: PFI:BIC

NSF Award No.: 1631674

Award Amount: $1,000,000.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Information Technologies (IT)

PFI:BIC: Multimodal-Sensor-Enabled Environments with Advanced Cognitive Computing Enabling Smart Group Meeting Facilitation Services.

Millions of meetings take place every day in the US, incurring a tremendous cost in terms of managers' and employees' precious time and salary. Unfortunately, group meetings suffer from serious problems that undermine productivity and collegiality, including overt or unconscious bias, "groupthink", fear of speaking, and unfocused discussion. Few automatic tools exist for keeping meetings on track, accurately recording who said what, and making group discussions more productive. The goal of this research is to design intelligent rooms that provide facilitation services by identifying meeting participants, understand their conversations, summarize discussions, and help the group efficiently get through an agenda, all without requiring the participants to wear microphones or other sensors.

The research will have broader impacts in several aspects. Any steps to make group meetings for complex, long-term projects more productive and easier to control would result in immediate economic impact. The success of a service system that facilitates long-term group interactions will result in a major opportunity for technology transfer and a highly marketable hardware/software platform for collaboration in domains including business, education, and finance. The project will result in new group meeting data to be used by researchers in different fields such as organizational psychologists, and computer scientists. Finally, the project will produce highly visible infrastructure for research and education that has the potential for greater public engagement with science and technology.

The research will be realized at different scales in two existing physical testbeds: the Smart Conference Room (SCR) at the Engineering Research Center for Lighting Enabled Systems and Applications (LESA) and the Collaborative Research Augmented Immersive Virtual Environment Lab (CRAIVE-Lab), a much larger space with a tall, panoramic screen. Both testbeds will be expanded as part of this project to integrate sensing and computing technologies developed by the partners. The major technology modules include: (1) advanced time-of-flight sensors for robust occupant tracking, resulting in centimeter-accurate, real-time locations of all participants in the meeting without requiring video cameras or wearable sensors; (2) custom beamforming microphone arrays for acoustical tracking and sound source separation, allowing highly-directional beams to be directed at each participant's instantaneous location, clearly isolating their speech without requiring lapel or headset microphones; (3) natural language understanding algorithms for extracting knowledge from the speech, enabling the system to learn meeting-specific terminology, link concepts, assess speaker roles, and summarize discussion; and (4) cognitive computing tools for meeting facilitation, including assessments of participation and productivity, ideation interventions for brainstorming, and active decision support. The resulting service systems will be cognitive physical environments that understand their occupants' locations, movement, speech, vocabulary, and intentions. A key aspect of the research is a multi-year study that tracks technical research groups that hold regular, unscripted meetings in the testbeds, assessing the effectiveness of the service system.

The lead institution for the project is Rensselaer Polytechnic Institute, with investigators from the departments of Electrical, Computer, and Systems Engineering, Computer Science, and Architecture. The industrial partners in the effort are IBM Research (large business, Yorktown Heights, NY) and Heptagon Advanced MicroOptics (large business, Zurich, Switzerland).

This award is partially supported by funds from the Directorate for Computer and Information Science and Engineering (CISE), Divisions of Information and Intelligent Systems (IIS) and Computer and Network Systems (CNS).

Runtime Verification, Inc.

Program: SBIR Phase II

NSF Award No.: 1660186

Award Amount: $750,000.00

Start Date: 03/15/2017
End Date: 02/28/2019

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: RV-Embedded: Runtime Verification for Embedded Systems

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is that the proposed runtime verification technology will lead to a more robust definition of and architecture for ensuring safety in automobiles, medical devices, and aerospace and defense systems. Through this, these forms of safety-critical infrastructure will be more resilient to attack and catastrophic failure resulting from both critical system failures and malicious attacks. As a result, the technology will help to address a slew of recent problems with software failures, security compromises, and other unintentional software behaviors that inevitably occur as systems become more complex, potentially saving lives and making millions of safety-critical embedded systems safer, easier to upgrade, and better tested.

This Small Business Innovation Research (SBIR) Phase II project will commercialize a first-of-its-kind complete solution for runtime verification and software analysis specifically tailored for embedded systems. From automobiles that connect to each other and drive autonomously, to control systems that run ever increasing networks that power our utilities, cities, and many other aspects of our daily lives, it is clear that embedded systems are here to stay in the most safety critical domains. A growing problem in embedded systems is how to ensure they behave correctly; a good case study for this is automobiles, in which several high profile hacks and recalls have called into question the security and integrity of vehicles. The proposed solution will fill this market niche with a suite of related analysis tools/modules, built on a common novel and formally rigorous runtime verification technology infrastructure, each module implementing unique instrumentation and analysis functionality. These tools/modules together provide what is needed to develop safe embedded systems.

SensorHound, Inc.

Program: SBIR Phase II

NSF Award No.: 1534707

Award Amount: $750,000.00

Start Date: 09/15/2015
End Date: 08/31/2017

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Topic: Information Technologies (IT)

SBIR Phase II: Resource-efficient Remote Monitoring and Diagnostics for Cyber-Physical Systems

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project derives from the fact that increasing the reliability and robustness of cyber-physical systems (CPSs) will directly increase their adoption in real world applications. CPS technology is directly applicable to a broad range of sectors, including utility grids, smart buildings, manufacturing, healthcare, transportation, etc. These sectors account for more than $32.3 trillion in economic activity, with the potential to grow to $82 trillion by 2025 - about one half of the global economy. CPSs are thus critical to the national interest in areas such as manufacturing competitiveness, defense, health care, energy production and usage, and disaster monitoring and recovery. Due to the increasing reliance on CPSs in the future, system defects could have drastic consequences. The proposed technology could significantly improve reliability of CPSs by catching defects before they result in significant loss, outages, or failures.

This Small Business Innovation Research (SBIR) Phase II project aims to develop an efficient remote monitoring and diagnostic software system to detect and diagnose software defects in cyber-physical systems (CPSs). CPSs have the potential to bring about a revolution in efficiency, robustness, and safety in application domains such as smart utility grids and smart healthcare. To unleash their potential, CPSs must themselves be robust. However, despite state-of-the-art testing, software defects currently do escape into deployed CPSs. Current state-of-practice monitoring and diagnostic systems cannot improve the situation as they were not designed with the constraints of CPSs in mind, which include real-time execution, unreliable links, and resource constrained processors. The proposed technology is aimed at creating a software system capable of monitoring embedded nodes in CPSs for anomalies and providing detailed execution information to quickly diagnose the software defects responsible for any anomalies. The proposed work extends the company's extensive research in efficient collection of information for diagnosing software defects. The company expects to create a monitoring and diagnostic software system for CPSs and demonstrate its effectiveness on existing software defects in CPSs.

TallannQuest, LLC

Program: SBIR Phase II

NSF Award No.: 1456408

Award Amount: $745,468.00

Start Date: 03/01/2015
End Date: 02/28/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Radiation-Hardened Integrated Circuits Using Standard Process Flows, and Electronic Design Automation Tool Implementation

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be to develop and commercialize radiation-tolerant integrated circuit (IC) technology for producing radiation-tolerant/hardened (rad-hard) ICs capable of being manufactured using leading-edge commercial IC processing instead of expensive specialized processes which use older, less efficient lithography nodes. The direct customers for the technology, to be delivered in the form of Electronic Design Automation (EDA) tools and support services, will be semiconductor integrated device manufacturers and semiconductor foundries. In the CT scanner industry, improved radiation-tolerance of the electronics will allow key components to be placed directly in the X-ray path, improving signal quality, and resulting in better images at reduced X-ray dose levels to patients. Reducing X-ray exposure from CT scans is a medical priority, as it has been estimated that 0.4% of current cancer incidents result from high X-ray doses from CT scans. Application of the patent-pending technology in radiation-hard ICs for a wide range of other commercial radiation-environment markets will follow, including commercial satellites, nuclear-power electronics, nondestructive testing, and medical electronics sterilization.

This Small Business Innovation Research (SBIR) Phase II project will provide integrated circuit (IC) designers access to leading-edge IC technology and advanced lithography nodes in developing ICs for radiation-tolerant applications, and is based on patent-pending transistor-level design and layout innovations and their implementation in EDA tools. In Phase I, proof-of-concept was established; transistor structures evaluated for X-ray and gamma radiation tolerance improved by a factor of 7 for 1.8V transistors, and by well over a factor of 10 for 5V transistors, with the use of the technology. The research objective of Phase II is to provide ready access to the benefits of the technology to IC designers by incorporating the methodologies for transistor-level design and layout improvements into industry-standard EDA tools. A number of technical challenges will be addressed in Phase II, including optimizing the tools for producing area-efficient and cost-efficient transistor layouts, and assuring seamless integration with existing design flows. A beta version of an EDA tool kit will be developed in Phase II; the anticipated result will be a tool that can be used by initial customers in producing rad-hard ICs used in CT scan electronics and other applications.

Tortuga Logic, Inc.

Program: SBIR Phase II

NSF Award No.: 1534602

Award Amount: $909,815.00

Start Date: 09/15/2015
End Date: 02/28/2018

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: Prospect: A Hardware Security Verification Tool

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is a dramatic increase in the security of modern computer hardware. This project presents a security verification software suite that detects security vulnerabilities in electronic hardware designs. Current state-of-the-art methods for detecting security vulnerabilities in hardware designs are very informal, consisting of security teams searching for these vulnerabilities through manual code review and committee discussion. This has already been shown to be ineffective in obtaining adequate security coverage, with security vulnerabilities remaining undetected and exploitable by malicious entities. With the unprecedented growth in the number of connected devices being developed for the Internet-of-Things (IoT), the number of security vulnerabilities will increase dramatically. The broader societal impact of this SBIR Phase II project is the increased security of computing systems, leading to more effective management of personal information and increased data privacy. The commercial impact is a unique software offering to semiconductor companies to help detect and prevent security vulnerabilities that could be used to compromise an IoT device. This greatly reduces the resources necessary to achieve high security coverage and eliminates long-term liabilities that can debilitate an entire company.

This Small Business Innovation Research (SBIR) Phase II project focuses on the technical development of a software suite for verifying security properties of hardware designs. The technology improves on the current methods in semiconductor companies that use manual audits in attempts to find security vulnerabilities in chip designs. It provides a systematic platform for verifying the security properties specified by the security teams on the actual hardware within these companies. This greatly improves the security coverage while reducing the time spent performing security audits. This SBIR Phase II project will develop the features requested directly by customers and perform the essential R&D efforts of the company's underlying information flow analysis technology in order to adequately solve customers' problems. The end result of this Phase II project will be a commercial grade product fit to detect and resolve security issues in modern electronic hardware designs.

University of Arizona

Program: PFI:AIR - TT

NSF Award No.: 1601784

Award Amount: $200,000.00

Start Date: 06/01/2016
End Date: 11/30/2017

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Program Director: Barbara H. Kenny

Topic: Information Technologies (IT)

PFI:AIR - TT: Resilient and Programmable Metro Fiber System

This PFI:AIR Technology Translation project focuses on translating optical networking control and switching technology invented in the NSF ERC Center for Integrated Access Networks (CIAN) to fill the need for fiber optical systems, the plumbing of the Internet, to be more flexibly reconfigured with changing service requirements. The resilient and programmable metro optical networking system is important because it can enable data traffic bottlenecks to be rapidly resolved and high bandwidth applications such as big data, telemedicine, and video to be flexibly moved to high capacity express-ways. For example, large volumes of data could be rapidly moved out of the path of natural disasters such as hurricanes. With this innovation, following a disaster, available live fiber connections can be flexibly managed to enable the highest available capacity and connectivity. This project will result in a proof-of-concept reconfigurable fiber system that has the unique capability to automatically switch the metro fiber connections between different metro, access, and data center optical transmission systems. These features provide a more efficient use of fiber infrastructure, more cost effective and reliable fiber capacity for high bandwidth services, and greater resilience to natural disasters.

This project addresses several technology gaps as it translates from research discovery toward commercial application. This new reconfigurable fiber system will enable optical networks to be reconfigured to provide wavelength and fiber scale bandwidth on demand in metro networks. The main concept involves using space switching in metro network nodes or central offices to reconfigure the fiber connectivity across multiple communication platforms including reconfigurable optical add drop multiplexing (ROADM) and other access and distribution optical systems. Novel optical physical layer control algorithms and software defined networking (SDN) based protocols will be used to manage switching over optically amplified links on fast time scales. Additional optical elements or accelerators are introduced based on the switching requirements. In addition, graduate students and post-doctoral researchers involved in this project will receive technology transfer and entrepreneurship experiences through the proof-of-concept development and evaluation, and the business and use case development together with industry and government leaders.

The project engages the New York City Department of Information Technology and Telecommunications (DoITT), Silicon Harlem, and Calient Technologies in this technology translation effort from research discovery toward commercial reality.

University of California, Santa Cruz

Program: PFI:BIC

NSF Award No.: 1632158

Award Amount: $992,146.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Topic: Information Technologies (IT)

PFI:BIC: RouteMe2 -A Cloud-Integrated Sensor Infrastructure for Assisted Public Transportation Services

This project will create a smart service system (RouteMe2) that will help passengers with special needs use public transit safely and confidently. This research addresses the needs of a large community of people who rely on public transportation for independent mobility, and yet face difficulties using it. For someone with poor vision or blindness, some level of cognitive impairment, or for a senior citizen, taking a bus on an unfamiliar route can become a challenge and a source of anxiety. The problem is often one of scarce access to relevant information such as which bus to catch, which platform to wait on for a train, when to exit the vehicle and how to negotiate a transfer. The smart service system will facilitate and promote use of mass transit systems as passengers, or their assistants, will be able to pre-register a trip, possibly involving multiple legs and different means of transportation from multiple agencies. It is envisioned that during the trip, passengers will receive context-aware information that will help ensure that they are waiting for a bus or a train in the right location; they are entering the desired bus vehicle or train car, and that they exit the vehicle at the correct stop or station. Importantly, authorized users (family members, friends, or assistants) will be able to monitor the user's trip remotely, and receive warnings when an unexpected situation occurs (e.g., when a user is waiting for a train in the wrong platform, enters the wrong bus, or is stuck at a certain location). Anonymized data about travelers can be relayed to the transit agency for enhanced service; for example, a bus driver can be informed that a blind passenger is waiting for the bus at a certain stop. RouteMe2 will promote increased travel independence, and thus increased opportunities for education, employment, socialization, participation, and leisure. It is expected that designing this type of human-centered technology with a clear societal benefit, and interacting with the participants in the user studies will be an inspirational and rewarding experience for the students involved in this research.

This technology will rely on interconnected sensors that can track a passenger during a trip, and on services that can provide just-in-time information to passengers on smartphones. This project will develop and experiment with a sensor and information infrastructure specifically designed to assist individuals with special needs while taking public transportation. The RouteMe2 system will rely essentially on cloud services, complemented with location data from an infrastructure of economical, miniaturized sensors (iBeacons), as well as data from the smartphone carried by the user, such as data generated by its GPS and inertial sensors. Individuals from different communities of potential users of this system (senior citizens and people with visual or cognitive impairments) will contribute to system design by means of initial focus groups, and will test it with a series of carefully designed user studies.

This project is a partnership between the University of California, Santa Cruz (lead institution) with faculty and students from its departments of Computer Engineering, Computer Science, Computational Media and Environmental Studies with IBM Research as primary industrial partner (Almaden, CA; large business) participating with its Cloud, IoT & Systems Lifecycle Analytics Group. Other broader context partners are Santa Clara Valley Transportation Authority (San Jose, CA; special purpose district) and the Vista Center the Blind and Visually Impaired (Palo Alto, CA; non-profit organization).

University of Massachusetts Amherst

Program: PFI:BIC

NSF Award No.: 1632193

Award Amount: $999,880.00

Start Date: 09/01/2016
End Date: 08/31/2019

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Program Director:
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Topic: Information Technologies (IT)

PFI:BIC: CityWarn -A Smart, Hyperlocal, Context-Aware Hazard Notification Service System.

This project proposes to develop next generation warning systems that will improve how people make decisions about hazardous weather, such as thunderstorms, tornados and floods. Over the past two decades, cities have become a locus of population and economic activity. Currently, over 80% of the US population is concentrated in cities; furthermore, 80% of the Gross Domestic Product in the United States is produced in metropolitan areas. The concentration of people and economic activity makes cities even more vulnerable to extreme weather events. Given these trends, effective hazardous weather warning systems are critical. Hazard warning systems are service systems that aim to minimize deaths, injuries, property loss, infrastructure destruction, and service or business disruption. They include the sensors, forecasts, networking and communications, public safety personnel and decision-makers, warning information, and those who receive and respond to the warnings.

CityWarn addresses three important issues for hazard notification service systems: 1) Coordination and sharing. Public safety agencies, private sector firms and the general public, all have their own hazard warning needs, and over the years, sector-specific, and even hazard-specific warning systems have evolved that may not share important information in efficient and useful ways. 2) Data Explosion. There's an explosion of data from all sources, from fine scale meteorological observations and traffic data, to humans reporting weather on social media. This is challenging for decision-makers who must quickly make sense of all of this information; and 3) Smart phone penetration. There is now a proliferation of smart phones, plus a trend toward hyperlocal, user-selected information. Warning systems have the potential to personalize weather warnings in a way that can make warning response more effective.

CityWarn will deliver user-defined, dynamically changing alerts through a next-generation communications and networking platform. The platform is linked to a cutting edge radar system that provides high-resolution weather information on an urban scale of streets and neighborhoods. A mobile app delivers user-configured, weather information. Our integrated research will focus on Computing & Sensing, Behavioral Sciences, Engineered Systems and Testbeds. The Computing & Sensing thrust will develop new scalability, security, and functional advances within the communication and networking platform, and integrate high-resolution radar products and user-generated observations from the field. Through cognitive task analysis, usability studies, and live experiments, behavioral science researchers will learn how field-workers, such as utility workers, police, firefighters, stormwater personnel, use and share weather information in the context of their tasks and organizational constructs. Our engineered systems work will focus on aggregation and sharing of sensed information sources, automation of warning processes to address data overload problems, and user alert customization. By developing a common platform for use by industry and public sector players, we hope to break down silos between existing warning systems and increase inter-agency coordination and improve response time and quality. The main test bed will be a living lab in the Dallas Fort Worth metroplex where weather data will be disseminated to users during actual severe weather events.

Primary partners: University of Massachusetts, Amherst (lead): Electrical & Computer Engineering, Computer Science, Resource Economics; Colorado State University: Electrical & Computer Engineering; Oncor Electric Delivery Company (Large Business, Dallas, Texas); TruWeather Solutions (Small Business, Reston, VA). Other broader context partners are the City of Fort Worth (Government, Fort Worth, Texas);CommPower (Small Business, Camarillo, CA); and IBM (Large Business, Armonk, New York).

This award is partially supported by funds from the Directorate for Computer and Information Science and Engineering (CISE), Division of Information and Intelligent Systems (IIS).

University of Utah

Program: PFI:AIR - TT

NSF Award No.: 1602127

Award Amount: $199,412.00

Start Date: 05/01/2016
End Date: 10/31/2017

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Topic: Information Technologies (IT)

PFI:AIR - TT: Cost Effective Solutions for Storage and Access of Massive Imagery

This PFI: AIR Technology Translation project focuses on the potential to revolutionize how microscopy and medical devices are used and the science questions that they can answer. When image data size is no longer a restricting factor, new domains of study become possible relating the micro-scale to macro-scale, such as understanding the neural connectomics of the visual cortex. By removing the barrier of time, effort, and expertise to use large imagery, VisStore will enable scientists to scale their existing workflows. Such capability would open new investigations into fundamental biological processes, the origin and progression of diseases, and ultimately the drugs and procedures for curing them. Although initially tailored to life sciences applications, VisStore can be integrated in microscopy for new devices and emerging disciplines, such as precision medicine, material sciences and semiconductors. Furthermore, VisStore has the potential to ease the transition from current workflows to fully online cloud-based ones. Furthermore, VisStore and the hierarchical streaming infrastructure have the potential to become the de-facto standard for large volumetric images.

This Accelerating Innovation Technology Translation project will support R&D to build a prototype of VisStore, a plug-and-play device for easy storing, archiving, accessing, distributing, and processing massive volumetric images coming from microscopy or medical devices. It translates research discovery toward commercial applications in the microscopy market which continues to grow, topping $4.1 billion in 2014 with an anticipated CAGR growth of 7.1%, while the addressed cyber-infrastructures to reliably store, easily access, and efficiently process such data have not kept pace. This has led to a discrepancy between the quality of data that could be produced, and what actually is used, as scientists unnecessarily restrict image sizes to match computational capabilities. Brute force solutions for scaling to massive images are expensive, difficult to maintain, and require expertise usually out of reach for smaller institutions. VisStore is a combined software/hardware/cloud solution that enables ease of use for image data of any size. No more complicated than a USB drive, VisStore allows users to easily access, process, and distribute giga and terapixel 2D and 3D images within a workgroup, a company, or even globally distributed environments.

The technology behind VisStore enhances the state-of-the-art for handing massive image volumes. Modern software tools often stop scaling when data size exceeds main memory, and this has been a limiting factor for microscopy imagery. When dealing with image data, the hierarchical streaming software infrastructure implemented in VisStore essentially extends the memory hierarchy of a workstation to both an external network-attached hard drive (NAS), and even cloud-based storage. With each component acting as a cache, VisStore achieves performance through on-demand data access to proprietary file layout that minimizes the amount of data transferred between levels, enabling efficient scaling to images of any size. This will support development for: (i) automated ingestion and conversion of images coming from microscopy or medical devices; (ii) a simple user interface and tool to manage local and remote storage of data; and (iii) a tool to select and export data for integration with existing workflows.

The project engages the Moran Eye Center, the Associated Regional and University Pathologists, Inc. (ARUP) laboratories and the Oregon Health & Science University to develop and tests a prototype acquiring giga- and teravoxel images and test its commercial value to translate this technology from research discovery towards a commercial reality. In particular, the graduate and undergraduate students supported by the project will be directly involved in these entrepreneurial activities. They will cooperate directly with the early adopters of the technology at the collaborating institutions and receive hands-on experience in how to identify and resolve their pain points and ultimately translate the raw technology into a product with commercial value.

Vanderbilt University

Program: PFI:AIR - TT

NSF Award No.: 1543098

Award Amount: $199,656.00

Start Date: 09/01/2015
End Date: 02/28/2018

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Program Director: Barbara H. Kenny

Topic: Information Technologies (IT)

PFI:AIR - TT: High-precision, Low-cost GPS Cloud Service

This PFI: AIR Technology Translation project addresses the void between expensive, survey-grade outdoor GPS-based localization technologies and low-cost, lower-accuracy techniques, such as the ones found in smartphones. The technology is based upon a novel GPS-based methodology that marries the precision found in industrial-grade methodologies with the low costs of off-the-shelf consumer-grade components. Current competing solutions (RTK, D-GPS, etc.) suffer from high cost, technical complexity, and other constraints, making them inaccessible to a large market segment of potential users. The lack of affordable and accurate solutions restricts the availability of further innovations and better product offerings by companies and developers in location-aware markets that would be otherwise inclined to use such solutions, including applications such as sports tracking, self driving cars, drones, and do-it-yourself land surveying. Successful completion of this project will result in a robust and scalable prototype, providing accuracies approaching those of professional-grade positioning in a viable consumer-grade price range. This will enable further innovation in this field, and it may lead to new application areas that have not yet been conceived due to limitations of the current state of the art.

The project addresses a number of known technology gaps as it translates from research discovery toward commercial application, including 1) developing a novel approach for combining inertial and GPS measurements without a stationary calibration phase, 2) making the technology robust in challenging GPS environments such as dense urban areas and forests, and 3) devising a new approach to "Localization as a Service" by integrating the algorithms in a scalable cloud platform, utilizing a potentially crowd-sourced network of low-cost base stations for increased robustness and accuracy. Some of these contributions are novel research areas themselves and some are based on known techniques, but each one is made possible due to the interplay between the contributions as a whole and the basic GPS-based localization research upon which this translation project is built. The result of overcoming these technical hurdles and integrating them into a cloud-based platform will be an easy-to-use, low-complexity localization service that can provide professional-grade accuracies at a fraction of the cost of existing commercial solutions.

In addition to producing an industrial-grade prototype, the team members involved in this project, including a postdoctoral researcher and a graduate student, will receive invaluable entrepreneurial and academia-to-industry technology translation experiences, not only through continued interactions with potential customers, but also by navigating the business and legal landscape of licensing the existing IP from Vanderbilt University, developing strategic partnerships with businesses who desire to integrate this product into their own, and learning how to best utilize the resources available, both from academia and from industry.

Virta Laboratories, Inc.

Program: SBIR Phase II

NSF Award No.: 1555816

Award Amount: $748,227.00

Start Date: 04/01/2016
End Date: 03/31/2018

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: Anomaly and Malware Detection using AC Power Analysis

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be an improved cybersecurity posture among industries that rely on mission-critical computing systems that are difficult to patch and/or monitor. Many technical failures on these systems, including information breaches, equipment malfunctions, and malware infestations, stem from longstanding problems that go undetected. This project develops nonintrusive measurement and analytics tools that give IT operators operational visibility into high-assurance assets, increasing confidence in their correct operation. This project will reduce losses due to unscheduled maintenance across industries, improve the trustworthiness of embedded and semi-embedded systems such as software-based medical devices, and reduce the business risk of breaches and malware damage at organizations that rely on hard-to-manage devices. This project also advances the state of the art in detecting rogue software execution and other anomalies through nonintrusive side channels, such as observing power signals collected on a wall outlet.

This Small Business Innovation Research (SBIR) Phase II project aims to extend operational visibility of IT departments into mission-critical computing equipment using a novel combination of nonintrusive signal collection and machine learning. From infusion pumps to Internet routers to retail point-of-sale terminals, organizations rely on fixed-purpose computing systems. With this reliance comes three key risks. First, the effects of unscheduled interruptions to critical systems ripple outward to other business areas. Second, critical systems are often incompatible with constantly changing mainstream tools such as host-based antivirus and intrusion-detection systems. Third, critical systems often lag behind other systems patch levels because they are rarely taken out of service for patching. This project addresses these challenges by providing nonintrusive monitoring for critical systems in situ, reducing the risk of unscheduled downtime due to abnormal behavior. The company's monitoring hardware and software observe software execution from the vantage point of the power line, requiring no modifications to monitored systems and extending the ability of operators to understand what critical systems are doing.

VisiSonics Corporation

Program: SBIR Phase II

NSF Award No.: 1430908

Award Amount: $1,413,878.00

Start Date: 10/01/2014
End Date: 04/30/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Three Dimensional Headphone Audio for Music, Gaming, Entertainment and Telepresence

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project extends to wherever headphones are used to listen to sound. The first commercial markets targeted by the technology being developed are gaming, virtual reality and consumer entertainment. These are areas in which the US has strong market and technology leads. By the end of the project, the company intends to have developed software that can be licensed to major players in these areas, reaching tens of millions of users. Beyond these markets, there are many applications for spatial audio in human-computer interfaces to deliver spatial information along with the intended semantic message. Several niche markets also exist, such as data presentation/exploration via sonification and specifically designed auditory interfaces for vision-impaired users. Overall it is expected that the proposed R&D work will advance the state of the art in science and technology and will be of substantial value to society as a whole due to high usability, fidelity, naturalness, and portability of the developed spatial audio solutions.

This Small Business Innovation Research (SBIR) Phase II project seeks to develop highly realistic and computationally efficient software for synthesis of personalized spatial audio, for applications that include virtual reality, gaming, and prostheses for the blind. Current algorithms are either perceptually unsatisfactory or have very high computational load. Approximate modeling of sound propagation, reverberation, and diffusion, along with tradeoffs between complexity and quality, will be explored using perceptual distortion metrics combined with the skills of professional listeners. The software will be optimized for use on mobile, console and embedded platforms. Additionally, a method to personalize the software to individual listeners, which was previously developed and tested in laboratory conditions, will be further refined and ruggedized for use in realistic environments. The expected outcomes will include a high-quality and efficient audio rendering library, a portable personalization apparatus, and several demonstrations that highlight the capabilities of the technology.

VOCALID, Inc.

Program: SBIR Phase II

NSF Award No.: 1555608

Award Amount: $913,299.00

Start Date: 04/01/2016
End Date: 09/30/2018

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Topic: Information Technologies (IT)

SBIR Phase II: VocaliD - Infusing Unique Vocal Identities into Synthesized Speech

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to offer custom crafted digital voices for text-to-speech applications. Each one of us has a unique voiceprint - an essential part of our self-identity. Though the quality of text-to-speech technology has improved, voice options remain limited. For the 2.5 million Americans (and tens of millions worldwide) living with voicelessness who rely on devices to talk, access to a custom digital voice is a game changer. It's the difference between a functional solution and being heard, uniquely, as oneself. Enhanced opportunities for social connection increase quality of life, independence, and access to educational and vocational resources that can narrow the gap between those with and without disability. This immediate unmet societal need, coupled with the increasing proliferation of devices that speak to us and for us, creates a compelling, timely and significant commercial opportunity for high quality, personalized digital voices that can be produced at scale. By leveraging the company's crowdsourced human voicebank and proprietary voice matching and blending algorithms the technology has the potential to empower everyone to express themselves through their own voice.

This Small Business Innovation Research Phase II project builds on the company's NSF-funded research and Phase I results that support feasibility and commercialization of a customized voice building technology. The text-to-speech market, encompassing assistive technologies, enterprise and consumer applications, is currently valued at around $1B and is rapidly growing and ripe for innovation. To create custom voices, the company leverages the source-filter theory of speech production. From those who are unable or unwilling to record several hours of speech the company extracts a brief vocal sample - even a single vowel contains enough 'vocal DNA' to seed the personalization process. Identity cues of the source are then combined with filter properties of a demographically and acoustically matched donor in the company's voicebank. The result is a voice that captures the vocal identity of the recipient but the clarity of the donor. Phase II technical objectives address the need for 1) customer-driven voice customization, 2) quality assurance of crowdsourced recordings, 3) voice aging algorithms, and 4) targeted donor recruitment algorithms. These advances will help secure the assistive technology beachhead and spur innovations for broader applications such as virtual reality, personal robotics, and digital persona for the Internet of Things.

Waltz Networks, Inc.

Program: SBIR Phase II

NSF Award No.: 1556120

Award Amount: $899,999.00

Start Date: 04/01/2016
End Date: 09/30/2018

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Program Director: Peter Atherton

Topic: Information Technologies (IT)

SBIR Phase II: High Frequency Network Traffic Optimization

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is that it will dramatically increase the efficiency of communications networks. Commercially, the ability to dynamically, adaptively and optimally route traffic on data networks will lead to network cost savings ranging from 60% - 70% for network service providers. Critically, the project leverages the recent industry shift towards software-defined networking (SDN) that is projected to become a $45 billion market by 2020. The excitement behind SDN is driven primarily by the promised performance benefits of better traffic control. By bringing to market its provably optimal, dynamic and adaptive traffic control algorithms, the company will be uniquely positioned to capitalize on this market opportunity. The immediate resulting social impact will be that end users will have access to faster, cheaper and more robust data networks. In the longer term, efficient software control of networks will enable rapid innovation in networking leading to new network applications that have not even been envisioned yet. The project also enhances technological and scientific understanding by commercially verifying the company's solution to a longstanding open problem in networking - namely, whether an easy to deploy, dynamic, adaptive and optimal routing algorithm can be found.

This Small Business Innovation Research (SBIR) Phase II project focuses on delivering commercial, smart, traffic control algorithms that can unlock the full capacity of modern communications networks. Today, due to unprecedented traffic growth, network operators face major challenges in the form of efficient resource utilization. The problem is that the inherent randomness of data traffic has led to network designers over-provisioning networks to the point where they run at 30% - 40% utilization on average. The company's competitive advantage is a new algorithm that allows it to optimally manage traffic variations by adjusting network routes in real time while retaining the scalability and simplicity of today's protocols. The goal in this project is to build on the beta tests from Phase I by developing an enterprise-grade, cloud-based network control application that is ready for general market launch. To this end, the company will start with small commercial deployments at selected test partners. Feedback from these deployments will be used to iron out any issues before general market launch. By the end of the project, the company anticipates generating significant revenue from initial customers as it continues to innovate and maintain its current lead in developing SDN control plane software.

Whova

Program: SBIR Phase II

NSF Award No.: 1430725

Award Amount: $1,399,999.00

Start Date: 10/01/2014
End Date: 03/31/2018

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Topic: Information Technologies (IT)

SBIR Phase II: Automated People Information Discovery and Mining

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project results from its potential to transform professional networking from passive to pro-active. People-information is valuable for business professionals in sales, marketing, recruiting, fundraising, M&A and business development, to establish connections, generate leads, and generally maximize opportunities. This project will further commercialize big data analysis techniques to quickly capture, filter, and analyze people related information from the whole Internet, and present such information to users via mobile and web services for various use cases such as networking at events, etc. These services will enable mobile users to plan in advance whom they should meet at events, and equip them with much deeper insights regarding their prospects than are currently available, so that they can generate business more efficiently.

This Small Business Innovation Research (SBIR) Phase II project is intended to further develop and commercialize the company's big data analysis and mining technology for people-information, with specific emphasis on making professional networking at events/meetings more productive and efficient. It provides a real-time, instant, "people research" capability on mobile devices to enable effective networking at business events, trade shows, conferences and private/Meetup meetings. It goes beyond existing "name-based" keyword search provided by commonly-used search engines, and is complementary to social network sites, which rely purely on subjective information provided by users themselves. Based on the company's current collaboration with large event organizers and their marketing/sales teams, the project will further extend the event mobile solution for enterprise customers by providing an organizer self-service (SaaS) platform, integrating with their CRMs, and leveraging Beacon technology to track attendee activities and interests in trade shows. In addition, it will include more advanced features to motivate individual users to use the app more frequently, including outside such events. Finally, it will build a platform with APIs to allow OEM partners to generate and use the people-information in activities such as recruiting, marketing, etc.

INTERNET OF THINGS (I)

Arable Labs, Inc.

Program: SBIR Phase II

NSF Award No.: 1660146

Award Amount: $749,954.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Internet of Things (I)

SBIR Phase II: Advanced Bioeconomic Forecasting Enabled by Next-Generation Crop Monitoring

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase I project will be to empower farmers to capture a greater share of revenue from the marketing of their crops. Agriculture is a significant engine to the U.S. economy, and farming itself is vital to creating economically vibrant rural areas. Farmers are often at a disadvantage when it comes to capturing good prices from their crops because there are significant information asymmetries in the marketing supply chain. We have developed a combination of hardware and analytics that greatly improves crop forecasts at dramatically more accessible prices, which allows farmers and their trusted buyers to make more informed marketing decisions. Whereas improved agronomy could raise yields by 5-10%, improved marketing could raise revenue >25%, especially for high value crops. In addition to the narrow application of sensing hardware and analytics for forecasting, the data collected by our platform can also be used by growers to make decisions that improve operational performance of complex agribusinesses and improve the agronomy of the farm. These tools make it easier to compare performance of crops to improve yields and reduce resource costs. Together this technology continues to raise productivity and profitability per farmer.

This Small Business Innovation Research (SBIR) Phase I project integrates a completely novel plant and weather sensing platform with analytics that synthesizes data into actionable forms that can drive agribusiness decisions. We have bundled a suite of capabilities into a single hardware unit that includes sensing, communications, GPS, mounting, and solar power, which dramatically reduces the cost and increases the simplicity of collecting agricultural data. These data are uniquely designed to monitor crop performance and its sensitivity to weather and management. Data synthesis is a critical pain point in transforming raw numbers into insights for growers to act upon. By creating an integrated hardware platform, the data is poised to provide useful advice that allow a farmer to act on emerging situations, anticipate upcoming events, and even predict the future. Our research objective here will be to generate probabilistic forecasts that use the unique data from our hardware to estimate key crop growth parameters and project forward for an operational yield forecast. This coupling between highly informative quantitative in-field data and sophisticated parameter estimation and forecast techniques could dramatically improve marketing decisions and help farmers capture better prices for their products.

IOTAS, Inc.

Program: SBIR Phase II

NSF Award No.: 1655520

Award Amount: $727,647.00

Start Date: 04/01/2017
End Date: 09/30/2018

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Topic: Internet of Things (I)

SBIR Phase II: Automated Pairing and Provisioning

This Small Business Innovation Research (SBIR) Phase II project will be focusing on automatic pairing and provisioning of Internet of Things (IoT) for the Multi-Family-Home (MFH) industry, to help them increase revenue potential by digitizing their apartments. It is estimated that the Smart Home Automation industry will reach $71B by 2018. If installation and setup of IoT devices could be automated and simplified then the MFH industry could roll out Smart Apartments quickly and in large scale. Being able to gather data and insights on buildings could lead to increased revenue from more efficient use of labor and materials and through better management of energy. It also gives them the opportunity to create new revenue streams from software and services targeted at the data output. The MFH industry can also get insights on their entire building portfolio versus a single building and more efficiently manage their entire portfolio. The MFH industry implementing Smart Home Automation technology has huge societal benefits by integrating with smart grids and utility demand response programs. The potential energy savings of 18M Smart Apartments could be hundred thousand gigawatt hours or $7.3B in savings.

This Small Business Innovation Research (SBIR) Phase II project seeks to enable the deployment of a scalable and maintainable infrastructure through the use of mechanisms including automatic pairing, tiered authentication, and network isolation in low cost, resource-constrained Internet of Things (IoT) devices. The problem with existing IoT pairing methods is that they are targeted at Single-Family-Home deployments and the number of nodes that needs to be paired are relatively minimal. However, this is not a scalable model when trying to address the needs of the Multi-Family-Home (MFH) industry. In the multi-family dwelling, the sheer density of nodes creates new problems. The technical challenge that remains for this phase is to ensure that all the devices will easily pair and to differentiate the nodes so that they authenticate and provision to the right apartment in a dense, RF noisy environment. Developing a cost effective, scalable solution for this high-density scenario is a key component to fulfilling the value proposition of mass deployment in the Multi-Family-Home industry. The anticipated result of this project is to solve the issue of pairing large quantities of end nodes and authenticating them appropriately to the correct apartment.

Matrix Sensors, Inc.

Program: SBIR Phase II

NSF Award No.: 1632269

Award Amount: $759,710.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Internet of Things (I)

SBIR Phase II: Reliable Low-cost, Low-power Methane Sensors for Explosive Limit Detection

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project in the long term has two main components. First, the development has potential to reduce the country's overall energy consumption by funding the development of low cost air quality sensors for energy efficient buildings. And second, the project will enhance the safety of our natural gas infrastructure with a low cost, low power methane (natural gas) sensor technology. This work will develop a methane (natural gas) sensor prototype with 10x lower cost, size and power consumption than current solutions. The proposed methane sensor will meet several currently unmet needs. These include enhanced public safety by enabling methane leak detection for natural gas distribution systems, and protecting first responders by enabling more and better methane detection in hazardous environments.

This Small Business Innovation Research (SBIR) Phase II project will develop the world's most porous materials, Metal-organic frameworks (MOFs) as a sensing material. MOFs have been an active topic in material science research for over a decade, but they have yet to find a commercial application. This project promises to be the first commercialization of this exciting new class of materials. Nearly 40,000 different MOF structures have been identified to date. The crux of this work is to use a combination of computer models and laboratory experimentation to optimize a MOF structure that selectively and rapidly absorbs methane gas. The end goal of this project is to develop a commercial prototype methane sensor 'on a chip' that consists of a solid state mass transducer with the MOF coating that has been tuned for sensing methane.

Multicore Photonics, Inc.

Program: SBIR Phase II

NSF Award No.: 1660213

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Internet of Things (I)

SBIR Phase II: Fiber Optic Based Nitrogen Oxides Sensor

The broader impact/commercial potential of this SBIR Phase II project will be the enhanced ability to monitor NOx optically using a unique approach that is fundamentally different from voltage biased solid electrolyte diffusion technology deployed commercially today. NSF Phase I activities brought to light the shortcomings of existing sensor technology, including slow response time and up to 90% "garbage data" that OEMs and regulatory authorities have to work around. Phase II efforts include improvement of Phase I prototypes where near instantaneous NOx detection to ~200 ppm was observed. NOx are a major pollutant and precursor to acid rain, surface ozone and smog formation. Worldwide regulatory bodies are driving NOx regulations to increasingly stringent levels, thus presenting even greater challenges for real-world emissions. Addressing these regulations, industry must deploy after-treatment technologies including selective catalyst reduction systems and lean NOx traps. Both of these technologies will benefit from a less expensive, more robust, and faster responding NOx sensor. With continued success, the new NOx sensor has the potential to significantly reduce emissions levels through a more accurate and much faster detection than current NOx detection techniques thus allowing the internal combustion engine to directly employ detection feedback to enhance emission controls.

This Small Business Innovation Research (SBIR) Phase II project will continue the prototyping and characterization of an optical based Nitrogen Oxides (NOx) sensor technology not based on oxygen sensor derivatives found in the market today. We will further optimize the design and materials needed for a novel thermo-catalytic NOx sensing mechanism through continued experimentation and testing. Increasing the number and type of catalytic sensing elements and integrating them into existing OEM packaging will allow us to measure NOx as well as other gases including ammonia (NH3). Sensor calibration equations and response lookup-tables will help validate our new method for NOx detection with successful results creating the foundation of a new category of sensors based on this differential detection architecture. Current automotive NOx sensors do not meet response time, accuracy and price requirements as used in the industry where such parameters are critical. The Phase II will optimize the optical sensing mechanism, and planned designs of experiment will help refine this technology into a reliable and robust device. Besides NOx and NH3, our "inorganic taste buds" also derive carbon monoxide and unburned hydrocarbon concentration as a byproduct of the measurement process, thus providing additional utility for any combustion emissions control application.

One Million Metrics Corporation

Program: SBIR Phase II

NSF Award No.: 1660093

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Richard Schwerdtfeger

Topic: Internet of Things (I)

SBIR Phase II: Predicting Musculoskeletal Injury Risk of Material Handling Workers with Novel Wearable Devices

This Small Business Innovation Research (SBIR) Phase II project has the objective of demonstrating that discrete, belt mounted internet-connected wearable devices used by industrial workers can detect high risk lifting activities, promote safe lifting practices and behavior change, and predict the risk of musculoskeletal injuries due to unsafe lifting. Each year over 600,000 workers suffer a musculoskeletal injury due to lifting related activities, which cost US companies over $15bn annually. Worker injuries affect employee morale, absenteeism, productivity loss and employee turnover, all of which are challenges to the efficient running of a company and are a unnecessary cause of human suffering. By developing a wearable device that can detect high risk lifting activity and provide immediate feedback to workers, safer lifting practices can be promoted and a reduction in the number of unsafe lifts registered, leading to a reduction in injuries.

The project includes three main technical objectives: i) the development of machine learning algorithms to detect lifting events from sensor data, and to measure risk related metrics associated to those lifting events. When a lift is considered high risk, real-time feedback will be provided to the worker; ii) the deployment of the device in an industrial setting at several customer sites for 12 months, with the number of high risk lifts performed by workers quantified over time to measure the ability of the system to drive behavior change in the workforce; and ii) the development of a model that can predict the likelihood of musculoskeletal injures based on the risk metrics measured. It is expected that the outcomes of the project demonstrate a significant reduction in the risk of suffering musculoskeletal injuries, paving the way for a clear return on investment value proposition for the industrial companies and their insurance carriers who are potential customers.

Radiator Labs, Inc.

Program: SBIR Phase II

NSF Award No.: 1659038

Award Amount: $749,403.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Internet of Things (I)

SBIR Phase II: Low-cost, Wireless, Energy Harvesting Environmental Sensors

This Small Business Innovation Research (SBIR) Phase II project focuses on the development of a low-cost, wireless, and energy harvesting environmental sensor, and a data aggregation / visualization platform to enable effective communication of data to users and control systems. This project addresses major barriers in our main market, the application of IoT to the buildings sector, where complexity is encountered in the placement and powering of sensors in monitoring locations where access is limited. By reducing the up-front and maintenance costs of wireless sensor networks, the project allows cost-effective building sensor data collection of unprecedented longevity and density. These rich data sets in turn enable myriad benefits, including more effective building management controls and in-depth automated energy evaluations. The commercial availability of a low-cost, wireless, energy-harvesting environmental sensor would enable high-granularity sensing, feedback, and control to several additional markets including industrial, agricultural, and any other market application that would benefit from monitoring where power or access is in short supply.

This Small Business Innovation Research Phase II project focuses on developing a low-cost, wireless, energy-harvesting environmental monitor using commercially available components and standard processes. An energy harvesting sensor of this type is not available commercially, and is uniquely enabling for building energy auditing and controls, supporting a new generation of automation and systems integration while eliminating the cost of extensive powered sensor installation or battery maintenance. This device was developed through Technology Readiness Level (TRL) 7 in Phase 1 of the SBIR program, in parallel with supporting data infrastructure, including dynamic cloud databases, data access via API methods and a beta data visualization platform. Phase II of the program aims to expand the scope of the low-cost, wireless, energy-harvesting environmental sensor from a network of low-power, short-range devices to a plug-and-play building-wide sensing solution, which includes the incorporation of additional hardware elements, including routers to extend the range of the low-power devices, and the development of automated data analysis strategies to extract valuable building information for the end-user.

SEMICONDUCTORS (S) AND PHOTONIC (PH) DEVICES AND MATERIALS

Active Layer Parametrics, Inc.

Program: SBIR Phase II

NSF Award No.: 1632322

Award Amount: $749,987.00

Start Date: 08/01/2016
End Date: 07/31/2018

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Activation and Mobility Profiling for High-mobility Semiconductor Materials

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to accelerate advancement in high-mobility materials. These materials are being increasingly used in the electronics device industry. This project's goal is to enable better devices by providing complete data on the effects of manufacturing processes and better enabling their optimization. Innovative electronic device structures such as faster computer chips, and more powerful RF circuits require development of smaller and smaller devices employing more advanced materials. The innovation that is being advanced through this Phase II program directly impacts this development.

This Small Business Innovation Research (SBIR) Phase II project will develop a deployable system to directly measure high-resolution mobility, resistivity, and carrier concentration profiles for high-mobility semiconductor materials. Current electrical profiling methods provide partial data for these material systems that form the basis of the multi-billion dollar semiconductor logic device and RF/power chip industries. The objectives of this Phase II program are to further demonstrate a prototype by developing and integrating high-reliability sub-systems to build a beta-level measurement tool with nm-level resolution. This is expected to reduce the semiconductor wafer area needed to evaluate high-mobility materials, and develop the measurement capability to target all high-mobility materials with potential applications in IC and RF/power industries.

Applied Novel Devices

Program: SBIR Phase II

NSF Award No.: 1660078

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Thin Crystalline Technologies for Advanced Power Transistors

This Small Business Innovation Research (SBIR) Phase II project seeks to de-risk the volume manufacturability and reliability of thin crystalline power MOSFETs fabricated with a novel exfoliation technology demonstrated in Phase 1. The broader impact/commercial potential of this project is to enable lower cost and better performance for power devices in switching or transferring electricity under varying power requirements across the voltage spectrum in a variety of applications ranging from consumer, to communications, automotive and industrial applications. In all of these applications, the ON resistance of the power MOSFET and IGBTs can be reduced and the switching speed and performance further improved by reducing the device thickness. Additionally, in consumer and mobile applications, reducing the form factor of the power MOSFET devices can enable slimmer and lighter products. A significant broader impact of this technology will be the reduction of expensive and environmentally hazardous waste treatment processes associated with wafer grinding technology used in the power MOSFET industry. While the power MOSFETs developed using this technology can have broad commercial and societal impact, the use of this thin crystalline technology can have even broader impact across all modern semiconductor devices such as LED, PV, flexible CMOS and passive devices.

This Small Business Innovation Research (SBIR) Phase I project addresses challenges to further scaling of Power MOSFETs which are one of the key building blocks of the electronic revolution over the last few decades. While the feature size of transistors has been constantly shrinking, the substrate thickness has been increasing. These substrates are currently mechanically thinned to minimize the negative impact of this increased thickness on performance and form-factor. There are significant challenges to continue this trend and the thin crystalline technology and device architecture proposed here can enable continued scaling of device metrics over the next decade with favorable cost structures. During phase I, functional power MOSFETs were demonstrated with this thin crystalline technology to establish the feasibility of this technology for power devices. This phase II effort will focus on the following specific technical challenges to bring it to market. (1) Develop power MOSFETs with improved switching characteristics using the thin crystalline technology (2) High voltage high current characterization of the thin crystalline power MOSFETs (3) Process yield and reliability characterization of package thin crystalline power MOSFET parts and (4) Convert existing process line to use thin crystalline exfoliation technology in high volume manufacturing flow.

Arizona State University

Program: PFI:AIR - TT

NSF Award No.: 1602135

Award Amount: $200,000.00

Start Date: 04/01/2016
End Date: 09/30/2017

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Program Director: Barbara H. Kenny

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

PFI:AIR - TT: Low Temperature High Performance Metallization using Reactive Ink Chemistries

This PFI: AIR Technology Translation project focuses on translating reactive ink science and technology to fill the need for low temperature, high performance and low-cost photovoltaic metallization. The development of reactive inks for solar cells is important because of the savings incurred by reducing the total amount of precious silver and also because the outstanding electrical properties these inks have shown can significantly enhance photovoltaic performance while reducing the overall cost of solar energy.

The project will result in a proof-of-concept demonstration that reactive silver inks can replace costly high temperature pastes and low-temperature nanoparticle pastes in solar cell metallization. This reactive silver ink has the following unique features: resistivity comparable to metallic silver, 3.7 micro-ohm-cm, and contact resistances of 1.8 ohm-cm2 on silicon heterojunction cells, even when printed below 90°C. These features enable solar cell field factor (FF) higher than 70% and Power conversion Efficiencies higher than 18%, with much finer control of the finger width and silver consumptions an order of magnitude lower when compared to the state-of-the-art solar cell heterojunction market space.

This project addresses the following technology gap as it translates from research discovery toward commercial application. The further reduction of the contact resistance to values below 1.2 ohm-cm2 is required to propel solar cell efficiencies above 20%. The project will approach this by optimizing the ink chemistry and developing adhesion promoters. While SiO2 particles could be easily incorporated like traditional silver pastes do to enhance adhesion, these glass frits require high temperatures (>350 deg. C) to form Ohmic contact. The proposed project will look into implementing Sn- and Sn/Pd-based promoters, commonly used in electrochemical and electroless deposition of noble metals on polymers and oxide surfaces. The goal is to print the entire metallization layer, metal plus the adhesion promoter. This reduces capital equipment costs, speeds production, simplifies synthesis, and reduces metal contamination across the cell.

In addition, personnel involved in this project, two graduate students, will receive hands-on experience developing products for commercial applications while working closely with industry partners. They will also receive technology transfer experience by learning about Phase I SBIR funding opportunities and other entrepreneurial training through the Arizona Technology Transfer Office.

The project engages two important partners: Techniq Inc. (advanced metallization experts) and Simplexity Product Design (printer designers) to allow for pilot testing environment, guided commercialization and the joint development of high throughput, low cost capital equipment.

Bert Thin Films, LLC

Program: SBIR Phase II

NSF Award No.: 1660161

Award Amount: $749,998.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Low Cost Copper Contacts with Built in Barriers for Crystalline Silicon Solar Cells

This Small Business Innovation Research Phase II project aims to develop copper based pastes for the metallization of silicon solar cells. Photovoltaics (PV) offer an opportunity for clean and affordable energy and over the past decade the PV industry has seen annual compound growth rates of over 50%. Although revenues are high, the profit margins for many manufacturers have substantially diminished, necessitating the need for cutbacks throughout the value chain. One area marked for cost reduction, is in the metallization of the solar cells, which now commands nearly 10 percent of the world's supply. Having the cost of photovoltaic panels tied to a precious metal with price volatility can lead to higher prices for renewable energy; thus replacing silver with copper is a significant opportunity for the industry. Thus the outcomes of this project would be a product for making solar energy more affordable. The project also includes creating two new full time positions in Kentucky in Advanced Research and Manufacturing. This proposal will enhance scientific understanding of the copper-silicon contact formation and durability of the material during operation.

The technological feasibility of the copper pastes with an inherent diffusion barrier was demonstrated on standard and bifacial solar cells in Phase I. Phase II will further improve the screen printable pastes to industry standards. To achieve the high electrical performance required in this market, the project will investigate the copper-silicon interface to investigate the mechanisms involved during contact formation, and the chemical nature of the copper-silicon interface. This information will be used to optimize the chemical composition and thermal treatment of the pastes to improve electrical performance and cell lifetime. The pastes will be optimized for industrial operating equipment to provide the manufacturer with a product that can be dropped in, with minimal changes to the production line. Phase II will also involve scale up of the core materials in the pastes to be able to engage customers in further printing trials. Through the assembly and testing of prototype solar cell modules, the durability of the copper contacts will be demonstrated. The outcomes of this proposal will be screen printable copper pastes that can be direct drop in replacement for the silver pastes; thereby enhancing the profit margins of the solar cell manufacturer.

Brown University

Program: PFI:BIC

NSF Award No.: 1430007

Award Amount: $808,000.00

Start Date: 08/01/2014
End Date: 07/31/2017

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

PFI:BIC A Wireless Networked Biophilic Lighting System for the Delivery of Lighting for Enhancing Secondary School Student Performance

Adequate sleep is crucial for students to maintain the best possible performance in the classroom. However, a natural biological tendency among teenagers to stay up later in the evening combined with early morning start times at most schools can result in a lack of sleep among middle and high school students that can impact their classroom performance. Research has shown that various properties of indoor lighting can influence the human cycle of sleep and wakefulness, known as circadian rhythm. This Partnerships for Innovation: Building Innovation Capacity (PFI:BIC) project from Brown University aims to better understand those light properties and design a dynamic, intelligent lighting system that can effectively shift the circadian phase of students to help them remain alert and focused during the school day.

The project aspires to advance smart lighting by developing a wireless networked biophilic lighting system that will deliver lighting tunable in terms of spectral band(s), intensity, directionality, duration, and season. An essential first step will be to determine the efficacy of this system in suppressing the production of melatonin, a hormone that mediates the circadian cycle. Working with Digital Lumens, the team members will design and integrate several of these wirelessly networked LED systems that are equipped with sensors and actuators. They will then test them in the Sleep Labs of Brown University/ Bradley Hospital, via the monitoring and control of the lighting conditions, and analyze the physiological responses in real time. The "prescriptions", in the form of control algorithms and wireless networked control and sensor modules, will be the basis for field-tests in a local school, conducted in cooperation with school administrators, teachers, parents, and students.

The project will be undertaken by an interdisciplinary collaboration between the laboratories of Professor Jimmy Xu, from Brown University's School of Engineering, and Professor Mary Carskadon, from the Department of Psychiatry and Human Behavior at Brown University's Warren Alpert Medical School. The industrial partner is Digital Lumens (Boston, MA), a small business pioneer in the development and implementation of next-generation LED lighting solutions.

Carbice Nanotechnologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1660259

Award Amount: $746,975.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: A Novel Heat Dissipation Product for Chip Testing and Internet of Things

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project comes from addressing the thermal challenges brought about by the significant increase in transistor density that semiconductors have experienced over the past few decades. This trend has enabled many advancements ranging from high performance servers to Internet of Things devices. Still, with every advance in chip technology, the difficulty of chip cooling continues to increase. Three major thermal interface material (TIM) market segments exist: polymer composites, metallic materials and phase-change materials. Commercial carbon nanotubes (CNTs) will create a fourth market segment that will supplant existing TIMs, initially in the chip testing market and eventually extending into servers, high performance computing and Internet of Things devices. CNT researchers and small businesses have made little progress towards a commercial TIM product. Among other factors, this failure is driven by poor positioning in the crowded low-cost TIM space, which is currently dominated by thermal greases and pads. Progress towards a viable solution lies in the strategic alignment of product features with industry pain points. This Phase II SBIR aims to develop a means to scale the ability to produce CNT based TIMs as well as to further improve their performance.

The technical objectives of this SBIR Phase II project are to: 1) scale up of the CNT TIM manufacturing process to achieve a production capacity of 200,000 sq. in of product annually and to 2) enhance the conductivity of the CNT array by a factor of 3x or more to facilitate entry into the TIM1 and TIM2 market. This project will ultimately develop processes that will translate into achieving production scale CNT based thermal interface materials for the first time in the world. Scale up will be achieved through a combination of physical vapor deposition and chemical vapor deposition processes developed on tools designed specifically for CNT production. In Phase I of this research effort, two commercial products aimed at the semiconductor chip testing market were developed and validated through collaboration with leading chip manufacturers. In addition to the chip testing market segment, in Phase II products will be developed for entry into the TIM1 and Internet of Things markets.

Carbon Technology, Inc.

Program: SBIR Phase II

NSF Award No.: 1632566

Award Amount: $750,000.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: High Quality Carbon Nanotubes for Radio Frequency Applications

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project can be found across the semiconductor industry with its initial market in wireless communications. Due to the extraordinary properties of carbon nanotubes (CNTs), applications include low noise amplifiers (LNAs), mixers, and RF power amplifiers (PAs). Looking forward, carbon nanotube transistors (CFETs) can reshape analog radio frequency electronics, enabling the higher data rates and improved capacity demanded by next generation wireless systems due to their intrinsic linearity and associated low out of band interference . CFETs are highly efficient, dissipating less unwanted power than current state of the art technologies while handling high power levels. This translates into more battery life for mobile devices with lower cooling costs. With more linear RF transistors, many billions of dollars of spending on additional base stations, larger batteries, and radio spectrum can be avoided, at great savings to consumers and industry. More speculatively, the creation of reliable grwoth techniques for CFETs and associated manufacturing processes may offer an excellent sensor platform or better ways to form on chip interconnects. The key problems being investigating of in situ growth of high performance nanotubes are applicable to the fabrication of CNT based devices for many electronic applications.

This Small Business Innovation Research (SBIR) Phase II project will develop electronic devices for radio frequency applications using carbon nanotubes (CNTs). CNTs are a one dimensional material with diameters in the nanometer range. CNTs have unique and highly desirable properties ranging from superior mobility to current carrying capability to thermal stability. Calculations show CNT amplifiers will be inherently linear with noise suppressed to the lowest possible quantum limit. These properties allow for electronic devices that will perform better than existing technologies, such as silicon and gallium arsenide. Just as importantly, the cost for making these devices will be dramatically lower due to the relatively simple method for material synthesis and device fabrication. This work will enable wafer scale arrays of high density in-situ tubes to be grown on silicon enabling the development of carbon electronic components a manner comparable to silicon devices. This work will enable cost effective wafer scale growth of devices which exploit the groundbreaking linearity that CNTs can deliver.

Colorado State University

Program: PFI:AIR-RA

NSF Award No.: 1538733

Award Amount: $772,000.00

Start Date: 09/15/2015
End Date: 08/31/2018

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

PFI:AIR-RA: Advanced Thin-Film Photovoltaics for Sustainable Energy

This PFI: AIR Research Alliance project focuses on the translation and transfer of higher efficiency Cadmium Telluride (CdTe) photovoltaic (PV) technologies that are derived from the expertise and discoveries in advanced materials processing and devices from the Next Generation Photovoltaics Center (NGPV), a NSF funded Industry and University Co-Operative Research Center. CdTe PV is currently competitive for generating electricity in many parts of the world (e.g. 7-9 cents/kWhr from utility scale projects without subsidy) and the costs are decreasing rapidly. However, the objective of this work is to advance the CdTe technology to the point where solar is a competitive source of energy in all regions for individual home owners and a variety of applications which are now considered too expensive to be done electrically. To achieve this, the work proposed under this award will enable a significant increase in device efficiency while also addressing manufacturing methods to reduce costs. This could have a direct impact on further developing the U.S. based CdTe industry with the potential for significant economic growth and job creation. In addition, results from this research will lead to cost-effective opportunities to displace greenhouse-gas emitting technologies with PV technology and corresponding benefits to the environment.

The innovation ecosystem that will be enhanced includes all the leading groups in CdTe PV technology space. The proposed project will be led by Colorado State University (CSU), which has a long history of successful CdTe PV research and is a founding member of the NGPV. The primary research partner and third-party investor will be First Solar, Inc., the largest U.S. manufacturer of solar panels. CSU will also be joined by the Center for Renewable Energy Systems at Loughborough university in UK (CREST), the U.S. National Renewable Energy Laboratory (NREL), and material supplier 5N Plus. Students will gain entrepreneurial and technology translation experience through working with industry on their research projects and formal student training in innovation, entrepreneurship, and technology transfer.

This project addresses the following technology gaps as it translates from research discovery toward commercial application. The project will advance CSU's state-of-the-art deposition systems and pursue two separate routes to higher-efficiency manufacturing-friendly cells. The first route will be to advance the research on unique device structures to move them to commercialization, and the second will be to develop PV devices with a higher bandgap suitable for multi-junction cells. In addition, detailed characterization of these advanced devices will be performed. The proposed effort will have a clear line of sight to mass production and has the potential to significantly increase the efficiency of both single-junction and multi-junction CdTe-based solar cells.

CubeWorks, Inc.

Program: SBIR Phase II

NSF Award No.: 1632483

Award Amount: $740,612.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Millimeter-Scale Wireless Sensor Node for Intracranial Pressure Monitoring

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project allows for the realization of a commercial millimeter-scale intracranial pressure (ICP) monitoring product that can help neurosurgeons in treating patients with hydrocephalus. While the goal of this SBIR Phase II project is the development of said ICP monitor, the technology can also be translated to the development of 'smart dust', opening up the next generation of computing paradigm. This will mark a significant milestone towards massive-scale realization of internet of things, dramatically accelerating the technology adoption and research impact of millimeter-scale wireless sensor nodes. The technology adoption can be introduced to multiple markets including, but not limited to, medical, industrial, and consumer spaces. This would open up many new commercial opportunities that were previously limited by energy consumption and size, heralding a new era of computing in an unprecedented form factor and lifetime.

This Small Business Innovation Research (SBIR) Phase II project focuses on the development of a millimeter-scale intracranial pressure (ICP) monitoring for improved treatment of hydrocephalus. Hydrocephalus is a condition in which cerebrospinal fluid (CSF) builds up in the brain's ventricle area, causing head enlargement, epilepsy, and death. The only practical treatment for hydrocephalus is surgical implant of medical shunts, which relieves excess CSF to other parts of the body. The biggest problem with existing shunts is that they lack any embedded monitoring feature. Once the shunt is installed, there is no way to measure the internal pressure outside of hospital settings. The proposed monitor enables a 'smart shunt' solution, which continuously records ICP information inside the shunt for many years. This data is read out wirelessly and can be used to prevent shunt failures and improve the treatment of this lifelong disease.

Dimien, LLC

Program: SBIR Phase II

NSF Award No.: 1534767

Award Amount: $909,126.00

Start Date: 08/15/2015
End Date: 01/31/2018

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Smart Solar Control Film

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will reduce energy consumption in buildings and automobiles via 'smart' solar control window films. The effects of solar heating are frequently experienced on sunny warm days when the inside temperature of a car can exceed 130°F in minutes. The same solar heating that is such a nuisance in summer is very much desired in winter. The national problem is that buildings consume more than 41% of all energy produced (more than 50% directly for heating, cooling, and lighting) which leads to an estimated 2,236M metric tons of greenhouse gases. Additionally, 80% of buildings that exist today will exist in 20 years, many of which are inefficient and outdated. This necessitates a retrofittable smart solar control film. The consequence of installing smart solar control film is that the sun's warmth can be harnessed when it is needed and reflected away when it is unneeded. Installing these highly transparent films will have significant energy savings in space heating, cooling, and lighting. If smart solar control films are implemented, the Department of Energy estimates as much as 1.0 quadrillion BTUs ($10B in cost savings) can be saved annually.

This Small Business Innovation Research (SBIR) Phase II project focuses on commercializing a family of doped nanoceramic materials that exhibit near-room temperature metal-to-insulator phase transitions. Slight changes to the composition of matter produce remarkably tunable thermochromic transitions over a broad range of temperatures, filling a key technological gap for their deployment as a smart solar control window film. No visible change occurs during the transition from the low-temperature/infrared transparent (insulating-like phase) to the high-temperature/infrared reflective (metal-like phase), and vice versa. The nanomaterials are also of sufficient stability, optical clarity, and compatible with commonly used polymers found in film. Phase II efforts address optimizing the composition of matter for peak performance and developing a unique in-line nanomanufacturing process compatible with scalable production and achieving more precise control. In order for these materials to perform correctly they need to be of the correct elemental composition and be in the form of nanoparticles of the correct size. The films will be optimized and then thoroughly tested in the laboratory and in the field for their performance, stability, optical clarity, and a wide variety of application-specific performance requirements.

Electroninks, Inc.

Program: SBIR Phase II

NSF Award No.: 1534755

Award Amount: $719,027.00

Start Date: 09/01/2015
End Date: 08/31/2017

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Reactive Silver Inks for High Performance Printed Electronics

The broader impact/commercial potential of this Small Business Innovation Research Phase II project will be to greatly enhance the capabilities of printed electronics via high performance conductive materials. This will be accomplished by the development and commercialization of novel silver and copper ink chemistries that are used in a number of device applications ranging from display bezels and interconnects, to high performance OLED electrodes, to ink specifically developed for high speed printing and smart packaging applications. The commercial impact of such developments will be the significant adoption and use of printed electronics material palettes across multiple consumer electronic device platforms. This will ultimately lead to more efficient device manufacture with a simultaneous improvement in performance. The printed electronics market is rapidly growing with progress hinging on fundamental material improvements.

The objectives of this Phase II research project are to demonstrate scalability of reactive silver ink chemistries, formulations for productization standards, and development of reactive copper ink chemistries. The reactive silver ink chemistry has begun to receive significant traction with customers. This program plans to achieve scalability of this high performance ink by novel purification of silver salts to achieve a high conductivity at large scales with industrially relevant processes. Next the inks will need to adhere to specific productization standards. This includes modifications of the chemistry for various printing processes ranging from low viscosity (10 cPs) up to high viscosities for high-volume printing techniques (1000 cPs and higher). Also, modifications to the chemistry for various testing criteria such as adhesion, abrasion, and environmental tests such as humidity and heat cycling will be made. Finally, reactive copper chemistries will be further developed. Copper inks that can be processed thermally in the ambient environment represent both a significant challenge as well as a vast opportunity in the printed electronics market. We have developed novel chemistries based on various low molecular weight reducing agents and short-chain surfactants that both reduce the copper quickly under thermal cycling while protecting the surface from oxidation.

Endectra, LLC

Program: SBIR Phase II

NSF Award No.: 1632467

Award Amount: $749,732.00

Start Date: 08/15/2016
End Date: 07/31/2018

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Novel Solid-State Cerenkov Detector for Portable and Wearable Neutron Radiation Sensors

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is the potential to bring a disruptive neutron detector technology to market, filling an urgent demonstrated need for real time, portable and wearable radiation detectors. Successful commercialization of the innovative Cerenkov BoroSilicate Glass (CBSG) technology will serve a broad customer base in the nuclear detection and verification industry. Market research indicates large scale potential, in the billions of dollars. This market is currently well served with gamma ray and x-ray detection devices, but the capabilities for portable and wearable neutron detectors are not as well established. The proposed technology will close this gap and is anticipated to have a very broad impact. The Cerenkov detector technology can also be transformative in enabling new kinds of directional arrays for neutron imaging and portal detectors, helping to make the nation's borders more secure against illicit nuclear materials and providing improved tools for nuclear safeguards and verification.

This Small Business Innovation Research (SBIR) Phase II project aims to commercialize an innovative neutron detector module based 100% on solid-state technology. The overall objective of the project is to build on the successful Cerenkov BoroSilicate Glass (CBSG) detector prototyping in Phase I/IB to develop a small, low cost, modular neutron detector which can be integrated with existing gamma detector technologies to 1) form a comprehensive, scalable, networked solution to the problem of Special Nuclear Material detection; 2) enable inexpensive in-house and third party integration of neutron detection technology into radioisotope identification devices and personal radiation dosimeters; and 3) allow for further testing and advanced product development relating to directional neutron detector networks, direct fast neutron detectors, and neutron spectroscopy. The research objectives include a thorough quantitative assessment of the detector front-end material response to neutron radiation and evaluation of its optoelectronic characteristics. In particular, in collaboration with a specialty glass manufacturer, the isotopic composition of glass front-end will be optimized for fast neutron detection. The anticipated result is a novel and disruptive neutron detection approach.

NGCodec, Inc.

Program: SBIR Phase II

NSF Award No.: 1632567

Award Amount: $750,000.00

Start Date: 09/15/2016
End Date: 08/31/2018

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: A Hardware FPGA Implementation of H.265/ HEVC Low Latency Video Encoder Algorithms for Professional Applications

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to promote and improve the use of high quality video in products that the general public works with every day. From high resolution auto dashboard cameras, to low latency video streams from flying drones, to wireless laptop docking stations, to higher quality coverage of news and sporting events, to better and faster delivery of video over the Internet, every application requires the high quality, low latency, flexible, power efficient video encoders that will be developed in this project. The uses of video are increasing every day. Video instruction manuals are replacing printed instruction manuals. Video is replacing still images in on-line advertising, social media and billboards. It is predicted that over 90% of all Internet traffic will be video data in the next few years. Enabling all these applications requires the latest technology in video compression such as the techniques developed in this project.

This Small Business Innovation Research (SBIR) Phase II project tackles the problem of creating a real time video encoder, using the latest H.265 compression technology, running in hardware on an FPGA (Field Programmable Gate Array). An FPGA is a type of chip on which the logic is configurable - it can be programmed to implement any function. It represents a mid-point between a dedicated integrated circuit, which is very expensive to develop, and can never be changed or enhanced once it is fabricated, and a pure software solution which is very flexible but requires bulky and power hungry equipment (i.e. computers) as an underlying platform. The research conducted under this grant will devise, test, and implement algorithms that are amenable to realization on an FPGA, that operate in real time, and that yield a high quality result in terms of the visual quality of the compressed video with respect to the number of bits used. The goal, at the conclusion of this research, is the demonstration of a functional HEVC/H.265 encoder running on an FPGA which has cost, flexibility, power and performance advantages over other encoders.

Northwestern University

Program: PFI:AIR - TT

NSF Award No.: 1500222

Award Amount: $200,000.00

Start Date: 09/15/2015
End Date: 06/30/2017

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

PFI:AIR - TT: BaTiO3 Photonic Crystal Electro-optic Devices for 50 GHz Applications

This PFI Accelerating Innovation Technology Project focuses on the development of a prototype Photonic crystal (PhC) electro-optic modulator for ultra-high bandwidth optical systems. This is important because in the future, communication and cyber systems will require optical subsystems with ultra-high transmission rates due to the connectivity requirements of data centers, residential systems, mobile smartphones, and smart network communications. The optical modulator is a key piece of optical systems and at present is the component that limits the data transmission rates. This project focuses on developing a working, packaged prototype optical modulator based on barium titanate (BaTiO3) ferroelectric oxide thin films with a bandwidth of 50 GHz, which is 25% higher than the current state of the art technology based on Lithium niobate (LiNbO3).

Lithium niobate (LiNbO3) has been established as the electro-optic material of choice for optical modulators due to its relatively high electro-optic (EO) coefficient. However, it has a high dielectric constant at microwave frequencies, which limits the bandwidth of conventional modulators to 40 gigahertz (GHz) or less. Approaches based on silicon, indium phosphide and polymeric materials have been widely investigated to solve this major challenge and although progress has been made, a number of significant challenges in speed and power required remain. This project takes an alternative approach by using BaTiO3 ferroelectric oxide thin films with experimentally demonstrated electro-optic (EO) coefficients more than an order of magnitude higher than that of LiNbO3. In this project, packaged EO modulators with photonic crystal waveguide structure will be developed. Devices will be fabricated using vapor phase epitaxial deposition, and both conventional photolithography and focused ion beam milling. The BaTiO3 thin film platform has numerous competitive advantages over other platforms for optical modulator applications such as (1) Large EO coefficient, ten times higher compared to those of LiNbO3 devices dominating optical modulator markets; (2) Low driving voltage thus low power consumption; (3) Ultrahigh bandwidth higher than 50 GHz demonstrated with potential reaching sub-THz regime; (4) potential for integration with Si electronics leading to ultrahigh compact electro-optical components at low cost. By using a BaTiO3 thin film platform with non-linear photonic crystals, significant improvements in bandwidth, operating voltage, and size are expected compared to conventional devices. A working packaged, prototype 50 GHz bandwidth modulator, 1mm long, will be demonstrated. The project will involve training of graduate students and postdoctoral scholars in photonic crystal design as well as offering experiences with technology transfer through the development and demonstration of the prototype.

PixelEXX Systems, Inc.

Program: SBIR Phase II

NSF Award No.: 1660145

Award Amount: $750,000.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Advancing Beyond the Photodiode - Deep Submicron Pixels for Next-generation Image Sensors

This Small Business Innovation Research Phase II project focuses on developing compact camera modules with lower noise and improved contrast using a submicron pixel imaging sensor array. The commercial potential of this project centers on developing compact cameras for endoscopes, navigational and robotic surgical systems and more. Embedding these cameras in endoscope systems, and even the surgical tools themselves, permits new treatments across a broad range of medical specialties that otherwise are not possible. Switching to the minimally invasive forms of some common surgeries could save an estimated $14 billion in healthcare spending. Oncology, urology, gastroenterology, women's health and pediatric medicine are just some of the specialties that will significantly benefit from these ultra-compact cameras. A broader impact will ultimately come from utilizing submicron pixels in unique ways in high density arrays. The sensor's small size and fast response times offer unique opportunities for spatial and temporal oversampling. The resulting large numbers of pixels can be employed in a compact multi-aperture arrangement to deliver significantly enhanced color mapping over traditional semiconductor imaging arrays, multispectral imaging, 3-dimensional image reconstruction, motion free auto-focusing, or some combination of the above, providing unique applications in medical imaging, defense, robotics, and consumer electronics.

The miniaturization of camera systems calls for the continuous shrinking of pixel sizes. At a certain point, however, the maximum photo-electrons a pixel can hold becomes limited, yielding low signal-to-noise ratios and poor dynamic range. This project develops a novel optical sensor that maintains sensitivity down to hundreds of nanometers. As the size of this sensor decreases, the maximum measurable light intensity can remain constant and the signal-to-noise increases, bringing significant improvements to images' dynamic range and color/feature rendition. This result stands in stark contrast to the behavior of conventional pixels where maximum intensity threshold scales down with pixel size and noise increases with decreasing pixel size. Reducing these image sensors to practice requires transitioning from gallium arsenide based devices to silicon. The work focuses on 1) finalizing design parameters, fabrication, and characterization of the electrical properties and optical response of the system and 2) fabrication and characterization of a linear photodetector array for the creation of both linear images and 2-D images assembled from linear images to characterize the noise, contrast and other image quality parameters of the prototype.

Solchroma Technologies, Inc.

Program: SBIR Phase II

NSF Award No.: 1660204

Award Amount: $749,998.00

Start Date: 04/01/2017
End Date: 03/31/2019

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Vivid Pixel array for Reflective, Full-color Digital signage

This Small Business Innovation Research (SBIR) Phase II project evaluates the feasibility of constructing vivid, full-color, reflective display modules for large-area outdoor digital signage driven by dielectric elastomers suitable for pilot testing. Completion of Phase II objectives is expected to have the following impact: Commercially, the availability of new signage products will create significant economic impact through partial capture of the $14.2B domestic billboard and sign manufacturing market. Up to 10% of US zoning codes are estimated to prohibit LED-based (light emitting diode) signage while potentially permitting a reflective digital signage technology, expanding the domestic market up to $5.6B, with a 10x impact worldwide. Environmentally, greenhouse gas reduction is expected as an alternative to LED-based technology; up to 40x reduction in energy consumption is anticipated relative to LEDs. Additionally, billboard wrap waste will be reduced by replacing printed signage. Scientifically, the use of dielectric elastomers as a class of materials in products would be promoted through addressing technological and manufacturing hurdles currently limiting market translation. Societally, increased impact from timely public service announcements on digital billboards displayed during natural disasters, when catching fugitives from the FBI's Most Wanted lists, and with Amber/Silver alerts are expected through large-area digital sign proliferation.

In phase II, electroactive polymer-based proof-of-concept display modules will be constructed and tested, ready for pilot testing with initial customers. The low-cost display design uses unique electro-hydraulic driving principles to enable exceptional refractive index matching within the optical stack for highly vivid and reflective full-color generation. In phase I, a functional proof-of-concept pixel array module was fabricated using scalable processes. To achieve pilot readiness, improvements in performance, resolution, and calibration to meet advertiser standards are needed, as well as environmental qualification for outdoor operation, development of industry-conscious software control, and qualification of supply chain inputs to enable further production at scale. Phase II research will address these technical challenges by introducing process refinements and quality control standards, conduct color calibration using existing techniques, perform industry-relevant environmental testing, work with vendors to source soft-tooled components, and develop module and multi-module control software. The result of phase II efforts will be a calibrated and rugged one square foot, full-color, 16mm pitch, reflective display module ready for scaling to pilot production following phase II.

TexasLDPC Inc., dba Symbyon Systems

Program: SBIR Phase II

NSF Award No.: 1632562

Award Amount: $750,000.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Area and Energy Efficient Error Floor Free Low-Density Parity-Check Codes Decoder Architecture for Flash Based Storage

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project will be high performance error correction for flash memory. Error correction plays a critical row in making digital devices reliable. Shrinking semiconductor geometries results in more errors. This has created a special problem for flash memory where the need for more rigorous error correction is approaching a practical limit with the widely used Bose Chaudhuri Hocquengham error correction. Low Density Parity Check (LDPC) is a recognized solution that can approach the theoretical limits of what is possible. This LDPC based technology can improve lifetime of flash by without the added cost of the existing BCH solution. This technology helps Flash Memory enterprises to use higher density flash to improve storage capacity and cut the storage product costs. Without the superior performance, small size and low power consumption of the LDPC technology, the migration to low cost high capacity flash memories will be seriously slowed. In the absence of a comparable alternative approach, there will be serious limitations on the performance of a vast array of products that depend on highly reliable and economical flash storage.

This Small Business Innovation Research (SBIR) Phase II project will use a variety of techniques to minimize the area and power requirements and enhance the performance of Low Density Parity Check (LDPC) error correction codes for flash memory. Many of these techniques are applicable to a wide range of error correction applications in digital communication and storage from WiFi to hard disk drives. The need for better error correction is crucial for flash memory but there is a widening demand for improved error correction. For example larger memories require better error correction to insure the system failure rate is low. In the next two years the company expects to develop a Verilog version of the LDPC decoder that is easily integrated with a flash controller. The project will work with potential customers/partners to ensure the code works with controllers. In the long run these techniques can be adapted to a wide range of applications as the need for more reliable data continues to rapidly expand.

Ubiquitous Energy, Inc.

Program: SBIR Phase II

NSF Award No.: 1431010

Award Amount: $915,999.00

Start Date: 09/01/2014
End Date: 05/31/2017

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Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: Transparent Molecular Photovoltaic Devices

This Small Business Innovation Research (SBIR) Phase II project will enable unprecedented freedom for architectural photovoltaic adoption by maintaining the aesthetics of existing building materials and the quality of natural indoor lighting. This unique approach offers to achieve levelized photovoltaic energy costs of 0.05-0.1 $/kWhr by (1) producing 10-40% of DC building electricity at the point of utilization, eliminating the need for DC-AC-DC power electronics, (2) simultaneously reducing building cooling demands 10-30% through rejection of infrared solar heat, increasing the effective PV efficiency by over 5% (absolute), and (3) piggybacking on the materials, installation, framing, customer acquisition, and maintenance of the existing building envelope, reducing non-module costs by over 50%. This project will also result in a core knowledge from which future generations of transparent photovoltaic devices and materials will be designed. Visibly transparent photovoltaics are also amenable to seamless energy harvesting within non-window surfaces such as electronic displays and mobile electronic accessories, enhancing the functionality of those products without impacting aesthetics or functionality.

This Small Business Innovation Research Phase I project develops a transformational visibly transparent photovoltaic device. Building-integrated photovoltaics are a promising energy pathway to capturing large areas of solar energy and increasing US building efficiency at the point of utilization. However, the widespread adoption of such technologies is severely hampered by the cost and aesthetics associated with mounting traditional photovoltaic cells on siding and windows. In this project, these challenges are overcome by exploiting the excitonic character of molecular and organic semiconductors that lead to oscillator bunching to produce photovoltaic architectures with selective absorption, i.e. exhibiting visible minima and ultra-violet (UV) and near-infrared (NIR) maxima, uniquely distinct from the band-absorption of traditional inorganic semiconductors. By using excitonic molecular semiconductors with structured absorption in the UV/NIR these devices are simultaneously optimized for high power conversion efficiency, visible light transmission, and color rendering index.

Uniqarta, Inc.

Program: SBIR Phase II

NSF Award No.: 1632387

Award Amount: $764,240.00

Start Date: 09/01/2016
End Date: 08/31/2018

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Program Director: Richard Schwerdtfeger

Topic: Semiconductors (S) and Photonic (PH) Devices and Materials

SBIR Phase II: IC Integration Technologies for Flexible Hybrid Electronics

The broader impact/commercial potential of this Small Business Innovation Research (SBIR) Phase II project is to address one of the primary barriers to the emergence of flexible electronics - the inability to assembly and interconnect thinned integrated circuits (ICs) onto flexible substrates in a reliable, cost-effective, high volume manner. Flexible electronics has been the subject of many industry journals, trade shows, technical conferences and market research reports. All describe a new age of ubiquitous electronics with devices embedded in the structures and items around us. Flexible electronic devices, unlike today's devices that are rigid and boxy, can conform to natural, curved shapes that exist in the real world. However, flexible electronics have yet to have their predicted economic and social impact. A major reason is because the electronics industry has not yet found a reliable, low-cost method for assembling thin, flexible ICs onto flexible circuit boards. Today's 'pick-and-place' assembly technology cannot handle ICs thin enough to be flexible. Until a new method is developed and adopted, the potential of flexible electronics will likely not be realized.

This Small Business Innovation Research (SBIR) Phase II project will advance the integrated circuit (IC) aspects of a flexible hybrid electronics technology to a level at which these devices can be produced reliably and in volumes in a production-relevant environment. While most of the components of flexible hybrid electronics technology relating to printed electronics methods have been adequately researched and developed, little has been done on the integration of solid-state semiconductor devices onto highly flexible, organic substrates. Partial results have been reported in the literature, however, no attempt has been made to provide a comprehensive, wafer-to-end product approach suitable for commercial applications. This project will address this gap by focusing on all the steps for IC integration, including the preparation for assembly of ultra-thin, flexible semiconductor dies, their attachment onto a flexible circuit board using laser-enabled assembly technology, and their reliable electrical interconnection. The anticipated end results will be a complete flexible hybrid electronics integration technology developed to a level of pilot production readiness.

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