NIST
National Institute of Standards and Technology

SBIR

SMALL BUSINESS INNOVATION

RESEARCH PROGRAM

ABSTRACTS OF PHASE I and PHASE II

AWARDS FOR FISCAL YEAR 2017

INTRODUCTION

Abstracts of Awards for Fiscal Year 2017 SBIR Program

Note: Certain non-ASCII characters may not be represented accurately in this document. In cases where there may be doubt, please direct your questions to sbir@nist.gov.

Fiscal Year 2017 List of Awardees

Award Number	Company Name	Open Topics/Topic Areas	Phase
70NANB17H227	Cadre Research Labs, LLC	Systems	Phase I
70NANB17H255	ColdQuanta, Inc	Precision Measurements	Phase I
70NANB17H222	En'Urga Inc.	Collaboration and Partnership	Phase I
70NANB17H221	Infobeyond Technology LLC	Systems	Phase I
70NANB17H218	Low Thermal Electronics, Inc.	Precision Measurements	Phase I
70NANB17H224	MBSE Tools, Inc. d.b.a. ModGeno	Data and Modeling	Phase I
70NANB17H228	MetroSage, LLC	Data and Modeling	Phase I
70NANB17H219	Nikira Labs, Inc.	Systems	Phase I
70NANB17H225	SIFT, LLC	Systems	Phase I
70NANB17H240	Tetremer Technologies, LLC	Precision Measurements	Phase I
70NANB17H223	X-wave Innovations, Inc.	Data and Modeling	Phase I
70NANB17H226	XpressRules LLC	Systems	Phase I
70NANB17H231	AxNano, LLC	Lab to Market	Phase II
70NANB17H232	Bridger Photonics, Inc.	Advanced Sensing for Manufacturing	Phase II
70NANB17H233	Innoveering, LLC	Advanced Sensing for Manufacturing	Phase II
70NANB17H234	MicroXact Inc.	Advanced Sensing for Manufacturing	Phase II
70NANB17H235	Omega Optics Inc.	Advanced Sensing for Manufacturing	Phase II
70NANB17H236	OptoFluidics, Inc.	Biomanufacturing	Phase II
70NANB17H328	Quantum Diamond Technologies, Inc.	Advanced Sensing for Manufacturing	Phase II
70NANB17H237	Symbio Robotics, Inc.	Advanced Sensing for Manufacturing	Phase II
70NANB17H239	XCSpec	Cyber Physical Systems	Phase II

FY 2017 PHASE I AWARD

Topic: Systems

Subtopic: An Automated System for Firearm Evidence Identifications

Title: Development, Validation, and Implementation of CMC Algorithm into a Software Platform for Firearm Analysis

OU: Laboratory Programs

Firm: Cadre Research Labs, LLC
363 W Erie St.
Chicago, IL 60654

Principal Investigator: Ryan Lilien
Phone: (508) 443-1275
Email: Ryan.Public@CadreResearch.com

Award Amount: $92,100

Abstract: The research involves implementation of a comparison algorithm for firearm forensics. The Congruent Matching Cells (CMC) algorithm has been developed by NIST yet does not appear in any commercially available software. As requested in the call for proposals, we will implement the algorithm in the C++ programming language and validate CMC using two specified datasets. In addition, we will incorporate the CMC method into our already commercially available software for firearm analysis. Our software implements import, visualization, masking, database, and search functionality. In addition to the two specified datasets we will also evaluate CMC against two additional, larger, real-world datasets. We will also explore slight algorithm variants whereby CMC algorithm parameters can be adjusted (e.g., number/size of grid cells and the CCF, angle, and translation thresholds). Overall, we will advance the CMC method with real-world testing and will incorporate CMC into a fully functional software application ready for deployment to crime labs.

Commercial Applications: The research involves implementation of a comparison algorithm for firearm forensics. The Congruent Matching Cells (CMC) algorithm has been developed by NIST yet does not appear in any commercially available software. As requested in the call for proposals, we will implement and validate CMC. In addition, we will incorporate the CMC method into our already commercially available software for firearm analysis. Our software implements import, visualization, masking, database, and search functionality. Therefore, the CMC method will join a fully functional software application and be ready for commercialization as soon as the Phase I award is complete.

Topic: Precision Measurements

Subtopic: Atomic Vapor Cell Technology for Electric-Field Metrology

Title: Compact Vapor Cell Technology for Rydberg-Atom RF Metrology

OU: Communications Technology Laboratory

Firm: ColdQuanta, Inc
3030 Sterling Circle
Boulder, CO 80301

Principal Investigator: Daniel Farkas
Phone: 303-440-1284
Email: daniel.farkas@coldquanta.com

Award Amount:

Abstract: ColdQuanta seeks to develop compact vapor cells designed specifically for high-accuracy RF metrology with Rydberg atoms. Sensors utilizing these vapor cells can take advantage of Rydberg atoms' exceptional sensitivity to RF, microwave, and millimeter radiation between 1 and 1000 GHz. Featuring resolutions down to the uV/cm level, the accuracy of these devices will be at least ten times better than existing technologies (e.g. dipole probes). In addition, these sensors will be self-calibrating, allowing their accuracy to be attained in the field without relative standards or external calibration sources.

In Phase I, ColdQuanta will focus on the interaction between the external RF electromagnetic field and the dielectric medium of the cell itself. Scattering of the RF field off of the cell (e.g. diffraction, reflection, and absorption) is a systematic effect that can change the electric field amplitude "seen" by the atoms. To quantify the impact of cell scattering on sensor accuracy, a full numerical model is needed. ColdQuanta will develop these tools to help understand which cell geometries and physical features minimize scattering and enhance electric field uniformity throughout the interior volume of the cell.

Commercial Applications: There are a host of commercial applications that would benefit from improved RF metrology, including studies and mitigation of passive intermodulation distortion in antennas; design, manufacturing, and calibration of smart antennas, phased arrays, and radar systems; nearfield measurements for microwave circuit design and testing; biological sensing through optically opaque materials; millimeter-wave detection and imaging of concealed weapons; and terahertz imaging for navigation during brownouts.

Topic: Collaboration and Partnership

Subtopic: NIST Technology Transfer

Title: Optical Device for Sorting Particles by Size

OU: Technology Partnerships

Firm: En'Urga Inc.
1201 Cumberland Avenue, Suite R
West Lafayette, IN 47906

Principal Investigator: Yudaya Sivathanu
Phone: (765) 497-3269
Email: sivathan@enurga.com

Award Amount: $100,000

Abstract: This Small Business Innovation Research Phase I project will evaluate the feasibility of an innovative optical sizer for estimating drop sizes in sprays that have very small drops. The technique is based on the NIST provisional patent (application number 62/358,264). The NIST invention sorts particles by size over the range of 10nm to 10μm. Drop sizing is achieved in these sprays using an intense standing wave optical field created in a laser-pumped resonant optical cavity, and sending the spray in a laminar flow through the optical field.

During the Phase I project, En'Urga Inc. will undertake three tasks. The first task will be to configure a laboratory system to evaluate the technical feasibility of the optical drop sizer. The second task will be to evaluate the laboratory system using spray experiments. The last task will be to design a commercial prototype system for the Phase II work. During the Phase II work, En'Urga Inc. will design and develop a prototype drop sizer. The drop sizer will be rigorously evaluated before commercialization of the system can commence.

Commercial Applications: The primary commercial application for the proposed drop sizer is in the quality audit of spray nozzles and fuel injectors used in automotive and aerospace applications. Conventional diffraction based drop sizers and phase Doppler anemometers cannot provide accurate drop size estimates in sprays that have very small drops. Many of the newer fuel injectors and spray nozzles are producing very small drops since they increase the fuel mixing and efficiency of the engines. The proposed sizer will enable injector and nozzle manufacturers to evaluate the drop size distribution in their very fine sprays ensuring rapid commercialization.

Topic: Systems

Subtopic: Low-Latency High-reliability Wireless Protocol for Advanced Manufacturing Applications

Title: Low-Latency High-reliability Wireless Protocol for Advanced Manufacturing Applications

OU: Engineering Laboratory

Firm: Infobeyond Technology LLC
320 Whittington Pkwy., Suite 117
Louisville, KY 40222

Principal Investigator: Bin Xie
Phone: (502) 371-0907
Email: Bin.Xie@InfoBeyondtech.com

Award Amount: $100,000

Abstract: Advanced manufacture requires low-latency and high-reliability wireless communications between the sensors/actuators and the central controller. However, the current wireless protocols cannot meet such stringent latency and reliability requirements. In this project, InfoBeyond advocates L2Wireless (Low-Latency High-reliability Wireless Protocol Using Cooperative Relaying and Network Coding) to address this problem. It can simultaneously address the stringent requirements on latency (close-loop sense-to-actuation time < 1ms) and reliability (transaction error < 10^{-9}) within a factory cell with at least 10 sensor/actuators. For this goal, L2Wireless modifies the MAC and PHY layers of IEEE802.11ac, which includes radio diversity, scheduling, baseband processing, RF band selection, antenna selection, modulation and error coding, etc. The key features are: (i) L2Wireless PHY layer is developed based on the PHY techniques of IEEE802.11ac with adjustments to adapt to the latency/reliability requirements and radio environments of manufacturing applications; (ii) L2Wireless MAC layer utilizes cooperative relay and network coding to ensure successful information exchange between the controller and sensors/actuators with constrained latency and reliability; (iii) Our preliminary results indicate that L2Wireless protocol is able to support the communications of sufficient number of devices within a work cell and simultaneously achieve the desired latency and reliability for advanced manufacturing applications.

Commercial Applications: L2Wireless provides an approach that enables wireless networks with close-loop sense-to-actuation time < 1ms and transaction error< 10^{-9} in the harsh radio environments. It can act as a drop-in replacement for wired industrial control networks. This brings networking flexibility through wireless connections among the devices in the plant. It allows the factory to easily maintain, modify, and update the network according to the dynamic manufacturing process. L2Wireless meets the NIST's goal to promote innovation and standardization in a way to enhance U.S. economic efficiency and improve the industrial competitiveness. L2Wireless will be commercialized into current industrial control systems and others.

Topic: Precision Measurements

Subtopic: Precision 10 kV Programmable Voltage Source

Title: Precision 10 kV Programmable Voltage Source

OU: Physical Measurement Laboratory

Firm: Low Thermal Electronics, Inc.
PO Box 210
2612 FM 66
Itasca, TX 76055

Principal Investigator: David Fitzgerald
Phone: (254) 687-9700
Email: dave@lowthermal.com

Award Amount: $97,500

Abstract: Low Thermal Electronics, Inc. proposes to design a stand-alone, programmable voltage source capable of supplying precision voltages in the range of zero to 1,000 volts direct current (DC), with options for scaling up to 10,000 volts, and with a total expanded uncertainty (k=2) of less than 10uV/V for the 10,000 volt version. This instrument will improve state-of-the-art measurements in high resistance, high voltage, and potentially other research and metrology applications that require precision voltages above 1,000 volts. It will also provide improved performance and cost savings when compared to currently available commercial multi-function calibrators in the range of zero to 1,000 volts DC.

Commercial Applications: A stand-alone, programmable 1,000 volt DC voltage source with uncertainties in the single digit ppm range is not commercially available today. A stand-alone, programmable 10,000 volt source of sufficiently low uncertainty to advance state-of-the-art measurement is also not commercially available. A cost effective, single instrument that can satisfy both of these requirements is needed to improve measurements and high voltage sourcing in the areas of precision high voltage and high resistance measurements. Low Thermal Electronics intends to manufacture a commercially available instrument in the United States that satisfies these requirements.

Topic: Data and Modeling

Subtopic: Modeling and Simulation Analysis for Manufacturing Systems

Title: A Model-Based Solution to Improve the Accessibility and Affordability of Manufacturing System Simulations

OU: Engineering Laboratory

Firm: MBSE Tools, Inc. d.b.a. ModGeno
5120 Oakwood Circle
Cumming, GA 30028

Principal Investigator: George Thiers
Phone: (770) 312-7812
Email: george.thiers@modgeno.com

Award Amount: $100,000

Abstract: The vision is to provide decision-makers with effective, fast, and inexpensive analysis tools to answer "What-If" and "What-Should" questions about manufacturing systems. Value Stream Mapping (VSM) is a modeling methodology with widespread contemporary use in manufacturing, and our strategy is to start with VSM as a deployment beachhead for the eventual deployment of a more generic manufacturing system modeling and analysis tool. In Phase I, we propose to add modeling rigor and computational analysis to VSM; our goal is to demonstrate the feasibility of using Value Stream Maps to answer routine value stream questions about throughput, capacity, cycle time, and inventory using automated generation of discrete-event simulation models. A Phase I demonstration will start from the VSM tool environments of Microsoft Visio and Excel, and automatically generate discrete-event simulation models in a COTS language and tool.

Commercial Applications: A potential commercial application of Phase I research results is to significantly enhance the utility of a popular manufacturing process improvement tool, Value Stream Mapping (VSM). If successful, Phase I research results will enable complementing VSM's usage as an ad-hoc modeling and intuitive analysis tool with a rigorous underlying modeling foundation, enabling a suite of standardized analyses for answering routine questions about throughput, capacity, cycle time, and work-in-process inventories. The value proposition of this innovation is greatly improved analytic capabilities which are easily accessible to VSM users.

Topic: Data and Modeling

Subtopic: Interactive Software Tools for Processing QIF-formatted Part Models to Generate Realistic and Accurate Measurement Plans and Programs in Standard Digital Languages

Title: Interactive Software Tools for Processing QIF-formatted Part Models to Generate Realistic and Accurate Measurement Plans and Programs in Standard Digital Languages

OU: Engineering Laboratory

Firm: MetroSage, LLC
26896 Shake Ridge Road
Volcano, CA 95689

Principal Investigator: Jon M. Baldwin
Phone: (415) 336-2244
Email: jmbaldwin@metrosage.com

Award Amount: $99,500

Abstract: The QIF standard shows the promise of offering an environment where best-in-class metrology applications can be linked to yield solutions that are automated, optimized, adaptive, and traceable, maintaining the agility required to ensure U. S. global competitiveness. While the QIF standard has reached a substantial level of comprehensiveness and maturity, the embodiment of the standard in actual, commercial-grade software applications remains in its beginning stage because many developers of metrology applications software are waiting to see whether the QIF standard is sufficiently mature to warrant adoption. We propose a project to demonstrate QIF maturity and to facilitate future development of commercial applications of QIF by means of a three-faceted program: (1) Development and commercialization of a QIFbased software application that will enable the automated generation of optimized CMM inspection plans and programs. (2) Development and dissemination to the user and developer communities of free, open source tools for QIF instance file generation and maintenance. (3) Production of a report of recommendation of extension of the QIF Rules schema in future additions.

Commercial Applications: The research proposed herein will find valuable commercial application in the manufacturing industries primarily by promoting the application of the QIF standard to provide a means for automated production of known-good, economically optimum measurement plans for CMM based measurement, thereby improving the profitability and competitive posture of U.S. manufacturing companies. Additionally, it will promote the further use and development of QIF-based software tools by providing end users and developers with a suite of free, open source tools for creating, maintaining and validation of QIF instance files.

Topic: Systems

Subtopic: High Speed Large Field-of-View Optical Microscope

Title: Large Field of View Microscope for Rapid, High-Resolution Imaging

OU: Information Technology Laboratory

Firm: Nikira Labs, Inc.
1931 Old Middlefield Way
Mountain View, CA 94043

Principal Investigator: Manish Gupta
Phone: (650) 906-0274
Email: manish.gupta@nikiralabs.com

Award Amount: $100,000

Abstract: In this SBIR effort, Nikira Labs Inc. proposes to develop a high-resolution (< 1 micron) microscope that can rapidly (< 30 seconds) image a large field of view (> 1 cm2). The technology will provide both bright-field and fluorescence imaging and be capable of retrofitting into a wide variety of existing microscopes at a low retail price. This work will complement the microscopy efforts that are ongoing at the National Institute of Standard and Technology (NIST).

In Phase I, we will demonstrate technical feasibility by fabricating two optical microscopes that utilize Fourier Ptychographic Imaging (FPI) via highly controlled, inhomogeneous illumination sources. The first imaging system will target high-performance applications, whereas the second system will be more cost-effective for educational applications. In both cases, the illumination source will be improved to increase the imaging speed, and the camera will be optimized for lower noise and cost. Image analysis and reconstruction software will be developed in a platform-portable language to allow for retrofitting on existing systems. The Phase I prototypes will be characterized to determine their resolution, field of view (FOV), imaging speed, and depth-of-focus. Finally, Phase II instruments will be designed to include fluorescence and phase imaging.

Commercial Applications: In Phase III, Nikira Labs Inc. will commercialize the FPI microscope for numerous markets including educational institutions, biomedical diagnostics, and industrial applications. A preliminary market estimate suggests 5-year global revenues of $8 – $16M, $15 – $30M, and $2 – $4M respectively for these market segments. Moreover, these attractive markets are expected to continue to grow with a predicted compound annual growth rate (CAGR) of 7.5% from 2016 to 2021. Contingent upon the SBIR funding, Nikira Labs Inc. is poised to take advantage of this growth.

Topic: Systems

Subtopic: Sources of and Triggers for Cybersecurity Failures

Title: ISABEL - Integrated Secure Automated Bug Extraction List

OU: Information Technology Laboratory

Firm: SIFT, LLC
319 1st Ave N., Suite 400
Minneapolis, MN 55401

Principal Investigator: David J. Musliner
Phone: (612) 325-9314
Email: musliner@sift.net

Award Amount: $99,322.27

Abstract: The ISABEL program will create symbolic execution signatures to classify bugs in the NIST Bugs Framework. Using the symbolic execution signature ISABEL will find a program

input to trigger the bug using fuzz testing. ISABEL will integrate its bug categorization and bug triggering capability with a software development environment using a flexible framework that will allow both open source and commercial software to use ISABEL features. One of the key ISABEL outputs summarizes the bug categories, when they were created and when they were eliminated against the organizations software

development timeline. This will allow organizations to see which of their processes are most effective for catching various categories of bugs. ISABEL gives the software development organization actionable intelligence on how to improve their software development process. ISABEL will provide better insight into the science of software development for the entire industry.

Commercial Applications: The ISABEL technology will create an open source framework that allows organizations to use the NIST Bug Framework to improve their software development process. The flexible framework will support both an open source and a commercial set of products for the symbolic execution and fuzz testing components. ISABEL components will be integrated into premier software development systems for additional license fees. Supporting both an open source solution and commercial version will increase market penetration and ensure an economic engine to support and improve the ISABEL technology.

Topic: Precision Measurements

Subtopic: Innovative Manufacturing of Nanoscale Calibration Spheres

Title: Rational Design of sub-100 nm Polystyrene Particles with a Low Coefficient of Variation in Size

OU: Physical Measurement Laboratory

Firm: Tetremer Technologies, LLC
657 S. Mechanic St.
Pendleton, SC 29670

Principal Investigator: Michael Schreuder
Phone: (864) 646-6282
Email: Michael.schreuder@tetramertechnologies.com

Award Amount: $99,952.70

Abstract: In this Phase I SBIR program, Tetramer Technologies will develop new, commercially attractive, highly monodisperse polystyrene latex standards in a variety of sizes (i.e. 30 nm to 100 nm) via emulsion polymerization processes that employ a surfactant and that are surfactant-free. Surfactant free emulsions will be stabilized through the use of ionic comonomers in the emulsion polymerization. The focus of the study will be to elucidate the inter-relation of processing parameters on the resulting particle size and coefficient of variation

of the size. Specifically, once 100 nm particles with a coefficient of variation of 2% has been achieved (duplicating NIST SRM 1963a), the ratios of reagents, stirring time, and rate of reagent addition will be translated to generating particles with a size of 30 nm with a coefficient of variation 2% or less. Sizing measurements will be performed with a variety of tools including, both scanning electron microscopy and transmission electron microscopy, dynamic light scattering, and atomic force microscopy (AFM) to assess the products of the research. In addition, the cross-referencing of the techniques with one another will used to establish effective metrological practices for sizing the particles.

Commercial Applications: The products of this research will be utilized as size calibration standards in the 20 – 100 nm range. The need for calibration standards at this size range are experiencing an ever increasing growth with the expansion of nanotechnology into commercial products. Specifically, optical sizing equipment, semiconducting measurement tools, and electron microscopy are just a few of the measurement tools that require a NIST traceable 20 – 100 nm standard to calibrate them.

Topic: Data and Modeling

Subtopic: Non-Destructive Testing Qualification of Complex Parts with Digital Image Correlation and Digital Signatures

Title: 3-D Digital Image Correlation Based Non-Destructive Testing System for Qualification of Additive Manufacturing Parts

OU: Engineering Laboratory

Firm: X-wave Innovations, Inc.
555 Quince Orchard Road
Gaithersburg, MD 20878

Principal Investigator: Dan Xiang
Phone: (301) 200-8128
Email: dxiang@x-waveinnovations.com

Award Amount: $100,000

Abstract: NIST's seeks a high resolution DIC technology for qualification of complex AM parts. To meet this critical need, X-wave Innovations Inc. proposes to develop a 3-Dimentional Digital Image Correlation (3-D DIC) based NDT system. The proposed effort builds upon the success of XII in developing a variety of NDT technologies (including DIC system) for advanced materials evaluation. The success of the proposed effort will result in not only a novel 3-D DIC NDT technology, but also a system that is accurate, fast, and easy to use. This system should be suitable for field applications to qualify AM parts and inspect defect type, size, and location in those parts.

Commercial Applications: The 3-D DIC based NDT system has many market applications in different industries, such as air and space vehicles, replacement parts in naval fleets, oil and gas industry, and power generation. In the commercial sector, we anticipate that the resulting technology may have immediate applications in the growing bank of commercially available AM machines, as many of these suffer from a lack of quality assurance and characterization of final AM components resulting from these systems. Academic institutes and universities for advanced mechanical, aerospace and structural research and development should also benefit from this new technology.

Topic: Systems

Subtopic: Policy Machine/Next Generation Access Control Implementation

Title: XpressRules-PM: Commercial Implementation of PM/NGAC

OU: Information Technology Laboratory

Firm: XpressRules LLC
9515 North Wieber Dr.
Spokane, WA 99208

Principal Investigator: Ronald C. Turner
Phone: (509) 467-0668
Email: Ron.Turner@XpressRules.com

Award Amount: $100,000

Abstract: This proposal represents a response by XpressRules to a two-fold demand from the information security marketplace. The business requirement (for true policy governance) is that asset owners and steward themselves-and not IT—become directly accountable for the life cycles of their rules and policies. The technical requirement (for an adequate data model) is that the policies themselves embody sufficient semantic content so as to enable effective "pre-emptive analytics"—the ability for policy analysts to discover logical leaks and gaps before a policy is deployed. For attribute based access control (ABAC) NIST center-staged the human manager by defining and demonstrating natural language policy (NLP) in its Guide to ABAC (SP 800-162). In addition, the NIST standardization and current implementation of Policy Machine/New Generation Access Control (PM/NGAC) provides the semantics-rich graph-based data model required for robust policy analytics. The goal of this proposal is to exploit and commercialize both of these NIST initiatives with XpressRules-PM, a product with (1) an adaptive NL human-computer interface (HCI) that empowers business users—in their own words—to manage policies and the policy authoring environment and (2) a dynamic graph-based policy representation that allows for effective policy analytics.

Commercial Applications: XpressRules-PM fills an immediate need in the company's existing market of pharma (protection of clinical trials artifacts), healthcare (granular access control of

patient data in the electronic health record), credit cards (safe automation of customer-controlled card management), accounting (automated audits), banking (enforcement of separation of duty), government (privacy and compliance), and insurance (reliable privacy throughout the payments work flow). Strategically, the core business rules (BR) engine in XpressRules-PM will enable the company to compete effectively in massive cybersecurity and to collaborate with global BR players.

FY 2017 PHASE II AWARD

Topic: Lab to Market

Subtopic: NIST Technology Transfer

Title: Bimetallic Zero Valent Iron Composites for In Situ Remediation

OU: Technology Partnerships

Firm: AxNano, LLC
527 Bridge Street
Danville, VA 24541

Principal Investigator: Alexis Wells Carpenter
Phone: (336) 217-5171
Email: alexis.carpenter@triadgrowthpartners.com

Award Amount: $299,994

Abstract: The EPA estimates that one out of every four Americans lives within three miles of a hazardous waste site. Recent advanced materials developments have driven increased use of In Situ Chemical Reduction (ISCR) remediation in the US and globally. Nanoscale Zero Valent Iron (NZVI) holds great potential for ISCR due to its low cost and high capacity for degrading halogenated compounds. However, two major technical challenges prevent wide-spread NZVI adoption: 1) agglomeration, which prevents transport in the subsurface; and 2) passivation, which decreases reactivity to contaminants. During a NIST Phase I program, AxNano, in collaboration with University of Arkansas, proved the feasibility of a novel, three-component composite composed of bimetallic NZVI on a carbon-based substrate (RemRxTM CSI) for in situ remediation of trichloroethylene. RemRxTM CSI achieved 10x greater transport than NZVI particles alone, and 4x greater transport than NZVI particles on activated carbon. Removal of TCE by the RemRxTM CSI was 30% greater than by the NZVI particles alone. Having proven feasibility in a laboratory setting, Phase II will focus on prototyping, scale-up manufacturing and pilot scale field testing of RemRxTM CSI. This SBIR program will produce a novel, low-cost remediation with broad-spectrum efficacy to meet market and society needs.

Commercial Applications: The global environmental remediation technology market is forecasted to be $80.5B by 2019. In situ methods are the fastest growing areas in the remediation space. While Nanoscale Zero Valent Iron (NZVI) has widely recognized potential for In Situ Chemical Reduction, current products have yet to perform as desired. AxNano is developing RemRxTM CSI, a NZVI-based composite that exhibits longer shelf-life, larger sphere of

influence, and greater efficacy to target and destroy contaminants. Initially, we will target the $34B chlorinated solvent-contaminated groundwater remediation market. RemRxTM CSI can also remediate other contaminants to capture additional segments of the $60B remediation market.

Topic: Advanced Sensing for Manufacturing

Subtopic: Absolute Interferometry with Nanometer Precision

Title: Absolute Distance Interferometer for Manufacturing Metrology Applications

OU: Physical Measurement Laboratory

Firm: Bridger Photonics, Inc.
2310 University Way
Bozeman, MT 59715

Principal Investigator: Michael J. Thorpe
Phone: (406) 585-2774
Email: thorpe@bridgerphotonics.com

Award Amount: $299,926

Abstract: Bridger Photonics, Inc. proposes to develop an absolute length metrology sensor that will simultaneously provide >1,000 measurements per second, <10 nm precision, and >0.5 m maximum measurement distance. Bridger's solution is will fill a gap in precision measurement technology for applications that require rapid monitoring of macroscopic distances such as positioning and calibration of surface metrology systems (CMM, AFM, SEM), aspheric and freeform optics manufacturing, wafer positioning and optic alignment for the semiconductor industry, and part mapping and positioning for laser materials processing applications. Bridger's solution will enable several measurement scenarios that are not possible using traditional interferometry such as resolving reflections from multiple surfaces, performing thickness measurements, tracking discontinuous steps, and measuring high-relief or rough surfaces.

Commercial Applications: The proposed distance measurement technology has several commercial applications in precision manufacturing. Bridger anticipates the initial applications will be surface characterization for improved manufacturing of aspheric and freeform optics, and closed-loop process control and rapid part mapping for the laser materials processing industry. Other applications include alignment, and calibration of advanced optical assemblies for the semiconductor manufacturers and manufacturers of imaging interferometers. Other potential applications involve providing calibrated and traceable positioning for advanced manufacturing and research activities that use coordinate measurement machines, atomic force microscopes, and scanning electron microscopes.

Topic: Advanced Sensing for Manufacturing

Subtopic: High Temperature In Situ Pressure Sensor

Title: High Temperature High Resolution in-situ Differential Pressure Sensor

OU: Material Measurement Laboratory

Firm: Innoveering, LLC
100 Remington Boulevard
Ronkonkoma, NY 11779

Principal Investigator: Nicholas Tiliakos
Phone: (631) 219-3483

Email: nick.tiliakos@innoveering.net

Award Amount: $299,867.43

Abstract: Chemical manufacturers require high accuracy/high sensitivity pressure sensors to efficiently monitor the various manufacturing systems and processes in the chemical plant, to ensure any changes proceed in a safe and reliable manner, adhering to expected standards and practices. NIST also has a need for highly accurate pressure measurements, especially determining the thermo-physical properties of fluids. Such measurements must be made at the highest standard possible since they affect the development of theoretical models utilized by industry. Since the market is currently limited in the availability of such pressure sensors, i.e. possessing a combination of high accuracy/high temperature capability with excellent accuracy, NIST is seeking a high temperature, in situ, pressure sensor that can achieve better performance than the current state-of-the-art. The Innoveering team will build upon it's Phase I work, which showed promising results for its an innovative, compact High Temperature High Resolution (HTHR) in-situ differential pressure (DP) sensor utilizing piezo-resistive elements to sense differential pressure as well as an over-pressure protection feature to ensure reliable and safe operation. Our team brings together experts in the design/fabrication/testing and application of harsh environment pressure sensors, MEMS microfabrication techniques as well as packaging/welding techniques for these types of high pressure high temperature sensors.

Commercial Applications: Potential commercial applications for our HTHR DP sensor range from machinery health monitoring, smart process plan control/monitoring, monitoring of processes in chemical plants, oil refineries/petrochemical sector, to power plant monitoring. Our HTHR DP sensor will be at the cutting edge of CSOTA pressure sensing capabilities, providing a need not currently available, meeting all NIST's requirements while also accomplishing this in a very small factor and in a cost effective product. Our HTHR sensor also has the ability to behave like a smart transmitter by not requiring pressure compensation with extraneous electronics.

Topic: Advanced Sensing for Manufacturing

Subtopic: High-Density Cryogenic Probe Station

Title: High Density Semi-Auto Closed Cycle Cryoprober II

OU: Physical Measurement Laboratory

Firm: MicroXact Inc.
6580 Valley Center Dr.
Radford, VA 24141

Principal Investigator: Vladimir Kochergin
Phone: (614) 917-7202
Email: vkochergin@microxact.com

Award Amount: $299,959.37

Abstract: High density wafer scale cryogenic probing solution for testing at 4.5K temperatures or below is needed for testing and characterization of devices and circuits employing superconducting electronic components (such as used for quantum processing, high speed classical processing, magnetic field sensors, etc.) as well as for testing of various particle and light detectors for astronomy, aerospace, defense and homeland security applications. MicroXact Inc. is proposing to continue the development of a semi-automated, closed cycle, wafer scale high density cryogenic probe station for testing at below 4.5K to 300K. In Phase I MicroXact finalized the performance specifications, developed mechanical model and design, and verified system performance via simulations. Detailed commercialization and transition to marketing strategy was also developed. In Phase II MicroXact will fabricate, assemble and test the prototype high density closed cycle semi-automated cryogenic probe station first in-house and then will deliver and install the prototype at the NIST facility for verification and evaluation. Upon completion of Phase II, a prototype closed cycle refrigerated high density cryogenic probe station will be delivered to NIST for testing and verification. The solution developed on this SBIR project will be commercialized immediately after Phase II completion.

Commercial Applications: Due to the unique technical advantages over competing technologies, the high density cryogenic probe station under development will find a number of applications in NIST testing sensors and electronic components for industrial materials analysis, nuclear security, concealed weapons detection, astrophysics as well as for testing classical and quantum processors employing superconducting elements. A similar need for such a solution exists at DoD, where a number of DoD laboratories and OEMs are using various sensors operating at cold temperatures as well as developing signal processing hardware employing superconducting elements.

Topic: Advanced Sensing for Manufacturing

Subtopic: Design of Fiber-coupled Waveguide Difference Frequency Generation Devices

Title: Fiber Pigtailed On-Chip Mid-infrared Difference Frequency Generation in Silicon

OU: Material Measurement Laboratory

Firm: Omega Optics Inc.
8500 Shoal Creek Blvd.
Austin, TX 78757

Principal Investigator: Swapnajit Chakravarty
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Award Amount: $299,240

Abstract: We propose a fiber-pigtailed strained silicon platform for tunable difference frequency generation (DFG) in mid-infrared (MIR) with tunable continuous wave near-infrared (NIR) sources. Stress exerted by silicon nitride induces second-order nonlinear susceptibility c(2) on underlying centro-symmetric silicon. NIR light is coupled into silicon and MIR light is coupled out of silicon using sub-wavelength grating couplers respectively. Phase I research showed feasibility of low fiber insertion loss and low propagation loss silicon waveguides on the silicon-on-insulator platform at NIR pump and signal and MIR idler wavelengths. Quasi phase matching (QPM) will be employed with periodically patterned strained silicon nitride induced c(2) to generate efficient DFG. Preliminary QPM designs indicates potential to achieve conversion efficiency 11.67%W-1 in periodic tensile strained and 47.15%W-1 in periodic tensile and compressive strained silicon nitride with c(2) ~ 40pm/V in a silicon waveguide of effective length 1.3cm. Periodic DC electric field induced c(2) effects will also be studied. Two-photon absorption (TPA) and particularly TPA induced MIR free carrier absorption will be controlled by experimentally demonstrated p-i-n geometries that reduce silicon free carrier lifetime from nano-seconds to picoseconds. The DFG source will be integrated with previously demonstrated silicon based slotted slow light absorbance sensor for commercialization success.

Commercial Applications: Frequency-mixed MIR can be generated over a much wider wavelength range than that possible from a single quantum cascade (QCL) or interband cascade laser (ICL). Tunable silicon chip integrated MIR sources are very desirable for Omega Optics' MIR silicon based on-chip absorption spectroscopy applications by slow light enhanced chemical sensing and biosensing. The generalized design of the proposed versatile technology implies possible implementation in multiple areas and markets such as food, air and water quality, health, environment and national security via integration with demonstrated silicon passive sensors. Research will enable a CMOS compatible tunable MIR source for diverse applications.

Topic: Biomanufacturing

Subtopic: Measurement Tools to Advance the Development and Manufacturing of Biologic Medicines

Title: Horizon: Validation of an Improved Method for Rapid Characterization of Protein Aggregates in Biologic Drugs for Increased Quality and Safety

OU: Material Measurement Laboratory

Firm: OptoFluidics, Inc.
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Philadelphia, PA 19104

Principal Investigator: Robert Hart
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Award Amount: $299,987.45

Abstract: Optofluidics proposes to complete the development of the Horizon technology and carry out validation via a comprehensive multi-site study. The technology is a subvisible particle analyzer pioneered during Phase I. The technology is designed to fill two critical gaps in biopharmaceutical product development: (1) Scientists can count and image particles with current tools, but they cannot easily identify them which hampers their ability to minimize or eliminate them. (2) Early on in product development where sample volumes are extremely limited, particle analysis is rarely carried out, despite the desire to do so. This is because of the large volume requirements and the slow nature of current techniques. The Horizon technology addresses these problems with a new imaging technique that can differentiate between important classes of particles. The analysis uses a tenth the volume of current techniques, is at least 10 times faster and is fully automated. The proposed research will involve internal validation followed by a multi-site study to show robustness and demonstrate the utility of the technique on real pharmaceutical samples at GSK. Horizon will speed up biopharma product development time and improve the quality and safety of biotherapeutics by enabling routine particle identification.

Commercial Applications: The proposed Horizon instrument will revolutionize the bioprocess analytical market by allowing researchers to conduct high throughput sub-visible particle screening studies at the earliest of formulation stages, a much-needed capability for the rapidly growing $160B biopharm industry. Targeted customers are biopharmaceutical formulation labs who are frustrated with their current sample hungry particle analysis tools, since they prohibit early stage particle research and do not enable the specific detection of protein aggregates, the most common and important particulate in bioformulation. After it is validated in the biopharmaceutical analytical vertical, we will expand to other niche markets including spray dried pharmaceutical analysis.

Topic: Advanced Sensing for Manufacturing

Subtopic: Quantitative Magnetometry of Single Nanoparticles with High Throughput

Title: High-Throughput Single-Nanoparticle Magnetic Analysis Platform Using Diamond Magnetic Imaging

OU: Center for Nanoscale Science and Technology

Firm: Quantum Diamond Technologies, Inc.
28 Dane Street
Somerville, MA 02143

Principal Investigator: Colin Connolly
Phone: 617-440-4484
Email: cconnolly@quantumdiamondtech.com

Award Amount: $300,000

Abstract: Magnetic nanoparticles are widely-used tools over a range of industries, but have particularly powerful biomedical applications for clinical and research diagnostics, clinical therapy, and basic life science research. Many of these applications require consistent sources for magnetic nanoparticles with narrow distributions of magnetic properties, but no technology is now commercially available for manufacturers or users to quantify single-particle magnetic properties with sufficient throughput to provide cost-effective, efficient quality control.

Quantum Diamond Technologies has developed a high-throughput magnetic nanoparticle analysis platform using magnetic imaging with quantum defects in diamond. Our system can quantitatively analyze, with high sensitivity and precision, thousands of magnetic nanoparticles in parallel in a matter of minutes with a simple benchtop system. Following our Phase I feasibility study, in this work we will construct an automated prototype for rapid measurements of single-particle magnetization curve data, including magnetic susceptibility, magnetic remanence, and coercivity, key parameters for magnetic particle analysis. We will validate our prototype through comparisons to high-resolution micrographs and conventional bulk magnetic particle measurements. QDTI's high-throughput, single-particle analytical capability will fill a major gap in current instrumentation, with a low-cost, small-footprint device.

Commercial Applications: Magnetic particle products for immunoassays comprise a $1 billion market. A lack of cost-effective commercial technology for high-throughput single-particle analysis impedes robust quality control, which hinders reproducibility and stymies novel innovative uses for magnetic particles. A benchtop particle analysis system with low cost and high throughput will enable particle manufacturers to perform needed testing and reporting of magnetic particle uniformity and monitor lot-to-lot variation, adding value to their particle product offerings and providing a means for competitive differentiation and industry standardization. Particle users will benefit from a low-cost means to directly probe distributions of particle parameters critical to application performance.

Topic: Advanced Sensing for Manufacturing

Subtopic: Object Identification and Localization via Non-Contact Sensing for Enhancing Robotic Systems in Manufacturing Operations

Title: Visual Part Identification, Localization, and Manipulation with Deep Networks

OU: Engineering Laboratory

Firm: Symbio Robotics, Inc.
1368 Park Ave.
Emeryville, CA 94608

Principal Investigator: Jonathan L Long
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Award Amount: $299,587.16

Abstract: During Phase I, Symbio Robotics conducted initial development of a robust, real-time, high-performance, low-cost perception engine made possible by recent advances in deep learning. This system identifies parts in 2D or 3D images and determines their six degree-of-freedom poses, producing a full description of a scene in a fraction of a second. For this technology to be practically useful in manufacturing, thresholds of accuracy and reliability must be met, and perceptual inferences must be integrated with robust manipulator actions. In Phase II, Symbio will develop our system into a practical, complete sensory picking solution. The keys to executing this plan will be integration of information across multiple sensors and multiple images, learned grasp and motion planning, and new methods of robotic data collection. Building a multi-robot testbed will enable rapid iteration and real-world image and haptic data acquisition.

Commercial Applications: Rising global labor costs have spurred a new wave of interest in industrial automation. The future generation of industrial automation systems must be highly flexible and adaptable to greater variability and faster product cycles. To meet these demands, manufacturers and systems integrators will require robust, fast, and low-cost perception systems which will serve as a core part of factory automation. Recent advances in perception have opened a new regime of accurate and robust performance, with the as yet unfulfilled potential to transform all sensory-driven parts of manufacturing.

Topic: Cyber Physical Systems

Subtopic: Novel Methods for Determining Commercial Building Envelope Airtightness

Title: Air Movement Efficiency Monitor

OU: Engineering Laboratory

Firm: XCSpec
300 Riviera Circle
Larkspur, CA 9439

Principal Investigator: Peter Peterson
Phone: (415) 203-4341
Email: pop@xcspec.com

Award Amount: $298,975

Abstract: The Air Movement Efficiency Monitor is composed of small, inexpensive Microelectromechanical system (MEMS) sensors, connected wirelessly to the Internet, and distributed through a building to measure pressure readings at key points. We consider this a "FitBit" for a building's air-movement efficiency, employing many of the sensors used by a fitbit – temperature, humidity, acceleration. We expand on that concept and incorporate new emerging sensors from the drone and wearables industries, allowing our system to capture high-resolution absolute and differential pressure data, along with information from the fan shaft speed. These various sensors are deployed on a multi-sensor module and connected wirelessly to the system – exposing this previously hidden information at an affordable cost, with a small form factor and low power profile. This information is continuously monitored and can be used for a number of applications including: duct leakage, air balancing and fan efficiency measurement. The aggregated data is curated using flow network model simulations to calculate envelope leakage and duct leakage for the building, along with alerts or alarms to maintenance, building occupants or building managers. This "Performance" based approach to building efficiency provides a EM&V basis for more sustainable energy savings.

Commercial Applications: Commercial buildings are plagued by uncontrolled air movement and leakage through the buildings shell and air distribution ducts. Uncontrolled airflow leads to major increases in energy and operating costs. Existing methods to determine duct leakage are expensive and disruptive to the occupants. The Air Movement Efficiency Monitor is an in-situ monitor that can be installed with minimal disruption to the building occupants and left to collect continuous time-series data on building and duct leakage. This information is used to determine the ROI for energy upgrades to existing buildings, leading to improve energy performance and lower operating costs.