Abstracts of Awards for Fiscal Year 2006 NIST SBIR Program

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**FY 2006 Phase I Award**

**Topic:** 9.05 Intelligent Control

**Subtopic:** 9.05.1-2 Applying AI Tools and Techniques to the Real-Time Control of Intelligent Systems

**Title:** Intelligent Agent Toolset for 4D/RCS Architectures

**NIST OU:** Manufacturing Engineering Laboratory

**Firm:** 21st Century Systems, Inc.
12152 Windsor Hall Way
Herndon, VA 20170

**Principal Investigator:** Dr. Plamen V. Petrov
**Phone:** 402-505-7885
**Email:** Plamen.Petrov@21csi.com

**Award Amount:** $74,998.33

**Abstract:** There is an increasing demand for systems with more autonomous operations interacting with other autonomous and human-based systems. What is needed is an architecture bundled with developer tools for the creation of intelligent real-time control systems that marry the talents of modern control theory, software technology, sensory processing, and semantic knowledge representations. It would be a step closer to mimicking the human cognitive capabilities in a blended software/hardware system. 21st Century Systems, Inc. is pleased to propose to research and develop an intelligent agent toolset for 4D/RCS architectures. Our proposed research will use the 4D/RCS cognitive architecture and will extend it with a model which allows its interaction and integration with an intelligent agent-based AI environment. We believe that intelligent agents are a natural fit for the problem at hand. The hierarchical RCS architecture defined in 4D/RCS can be described very closely by a multi-agent system. This effort will lead to the development of an overarching architecture that will bridge the gap between intelligent agents and RCS.

**Commercial Applications:** This effort will lead to the development of an overarching architecture that will bridge the gap between intelligent agents and RCS. There are many domains where this toolset can be used to improve manufacturing, production, and operations. In the case of manufacturing, we would target the manufacturers of industrial robots. This toolset would make it possible to make smarter and more flexible robots. The time and expense of acquiring large industrial robots for manufacturing and retooling is non-trivial. This toolset would make the robotic systems more flexible. Retooling and "tailoring" of the system's capabilities and actions would be quicker and much easier. The technologies germane to this toolset could also be applied to make autonomous systems smarter and more fault tolerant. Systems that operate in remote environments (space, underseas, etc.) require a large measure of autonomy in order to accomplish the mission successfully. The toolset technologies could be used to produce better remote systems (satellites, undersea vehicles, etc. \_ and unattended sensors (antennas, security sensors, waning systems, etc.). A longer term goal, requiring more research, is the realm of evolutionary swarm behaviors to develop an improved " swarm of swarms" controlling technology.

**FY 2006 Phase I Award**

**Topic:** 9.10 Optics and Optical Technology

**Subtopic:** 9.10.2-3 High Performance NIR Array Detectors for Advanced Sensors

**Title:** Low-Noise Detector Arrays for Raman Spectroscopy

**NIST OU:** Chemical Science and Technology Laboratory

**Firm:** Aerius Photonics
4160 Market St., Suite #6
Ventura, CA 93003-5622

**Principal Investigator**: Michael MacDougal
**Phone:** 805-642-4645
**Email:** macdougal@aeriusphotonics.com

**Award Amount:** $74,973.26

**Abstract:** We propose to demonstrate near infrared (NIR) InGaAs sensor arrays with 55% lower noise than arrays presently available to improve the sensitivity of current spectroscopy systems. The low noise performance will be enabled by the use of low-noise source follower per detector ROICs, which are also used in astronomy with HgCdTe for low noise measurements. With design improvements to current available ROICs, the new InGaAs sensor array is expected to achieve less than 20 electrons of read noise and quantum efficiency of greater than 80% at 77K. Such a sensor would directly lead to higher sensitivity than presently available at low light levels, thereby improving spectroscopic systems ability to detect signals that were previously masked. The end product will be a 12 x 1064 pixel 2D InGaAs array on a 20 um pitch with less than 20 electrons/pixel/frame at liquid nitrogen temperatures (~77K) and a 60 Hz frame rate, delivered in a cryogenic dewar.

**Commercial Applications:** The low noise InGaAs arrays to be developed under this program will be directly applicable to markets in Raman spectroscopy and astronomy. Within Raman spectroscopy, important markets include pharmaceuticals, forensic science, and polymers, among others.

**FY 2006 Phase I Award**

**Topic:** 9.03 Homeland Security

**Subtopic:** 9.03.1-6 Development of a Large-Area Solar Simulator Using Light Emitting Diodes

**Title:** Holographic Light-Emitting-Diode-Based Solar Simulator

**NIST OU:** Building and Fire Research Laboratory

**Firm:** Physical Optics Corp.
20600 Gramercy Place, Bldg. 100
Torrance, CA 90501-1821

**Principal Investigator:** Dr. Kang-Bin Chua
**Phone:** 310-320-3088
**Email:** sutama@poc.com

**Award Amount:** $74,992.00

**Abstract:** NIST is seeking a large area solar simulator to overcome the shortcomings of current solar simulators. To meet this need, Physical Optics Corp. (POC) proposed to develop a new Holographic Light-Emitting-Diode-Based Solar Simulator (HOLIOS) based on holographic gratings, holographic diffuser, high-power light emitting diodes with electronic drivers, collimating and projection optics, and photodetectors for monitoring output. HOLIOS can accurately simulate both solar irradiance under a wide range of air mass conditions, and atmospheric absorption by water, oxygen, ozone, and carbon dioxide molecules. It can irradiate a 1.5 m by 1.5 m area at irradiance levels that can be varied from <500 to 1300 w/sq. m, and the uniformity of the irradiance level among measurement blocks will be tunable within +/-2% over the 2.25 sq. m area. In Phase I POC will build a deliverable small-scale HOLIOS prototype capable of illuminating an area > 30 cm x 30 cm and of meeting all NIST requirements.

**Commercial Applications:** The proposed solar simulator not only addresses NIST requirement for a large-area solar simulator that overcomes the shortcomings of current solar simulators, but also has significant commercial applications in agriculture -- for artificial greenhouses in remote locations such as the arctic and space stations -- and in treatment of skin disorders.

**FY 2006 Phase I Award**

**Topic:** 9.11 X-ray System Technologies

**Subtopic:** 9.11.1-5 Imaging Variable Kinetic Energy (0.1 to 8 KeV) Electron Analyzer

**Title:** Imaging Variable Kinetic Energy Electron Analyzer

**NIST OU:** Materials Science and Engineering Laboratory

**Firm:** R. Browning Consultants
522 Chestnut St., #1
San Carlos, CA 94070-2146

**Principal Investigator:** Raymond Browning
**Phone:** 650-595-1528
**Email:** rb\_net@sbcglobal.net

**Award Amount:** $74,909.00

**Abstract:** The objective of this proposal is to create a prototype imaging variable kinetic energy electron analyzer in the range 0.1 to 8 keV for use with an X-ray excitation source. The imaging analyzer is to have a target imaging spatial resolution of 100 nm. The X-ray excitation source will be a synchrotron light source. The instrument can be described as an X-ray photoelectron spectroscopy (XPS) microscope XPM. The microscope will use a magnetic immersion projection lens and an electrostatic hemispherical electron analyzer.

**Commercial Applications:** XPS microanalysis could prove to be a significant analysis tool in the investigation of techniques for sub-micron semiconductor device physics, materials science, and nanoscale devices. Current XPS imaging systems are bulky and expensive. The tool proposed here could have widespread acceptance as a routing tool for microanalysis.

 **FY 2006 Phase I Award**

**Topic:** 9.01 Advanced Biological and Chemical Sensing Technologies

**Subtopic:** 9.01.1-1 Broadly-Tunable CW Terahertz Single-Port Source

**Title:** Tunable CW THz Source

**NIST OU:** Electronics and Electrical Engineering Laboratory

**Firm:** Structured Materials Industries, Inc.
201 Circle Dr. North, Unit 102/103
Piscataway, NJ 08854-3723

**Principal Investigator:** Dr. Catherine E. Rice
**Phone:** 732-302-9274
**Email:** cerice@structuredmaterials.com

**Award Amount:** $75,000.00

**FY 2006 Phase I Award**

**Topic:** 9.04 Information Technology

**Subtopic:** 9.04.2-4 Gigabit/second Random Number Generator

**Title:** Gigabit/second Random Number Generator Using White Noise Generated by Delayed Optical Homodyne

**NIST OU:** Physics Laboratory

**Firm:** Structured Materials Industries, Inc.
201 Circle Dr. North, Unit 102/103
Piscataway, NJ 08854-3723

**Principal Investigator:** Jie Yao, Ph.D.
**Phone:** 732-302-9274
**Email:** jieyao@structuredmaterials.com

**Award Amount:** $75,000.00

**Abstract:** As more and more information is stored digitally and transmitted over the Internet, data and communication security becomes an ever more severe problem facing the military, the government and the financial industry, both for the United States and for all other developed countries. The need for data encryption technology is most urgent. One of the key technologies involved is the generation of truly random numbers. Having worked extensively on the random noise behavior of light-emitting devices, researching and developing both broad-band light-emitting diodes and low-noise semiconductor lasers for many different areas of applications, SMI proposes Gigabit/second Random Number Generator using the white phase noise generated by delayed optical homodyne. Preliminary experimental data from the proposed device design already shows the true randomness of the output signal stream. With the unique advantages of being a truly random noise generator at Gigabits per second speed, the proposed device maximizes the information entropy of the encrypting key, and provides optimal security to the precious data requiring high security.

**Commercial Applications:** Potential commercial applications exist in military and government data storage security, military and government communication encryption, data and communication encryption and security for the financial industry, private data security, and so on.

**FY 2006 Phase II Award**

**Topic:** 9.01 ADVANCED BIOLOGICAL AND CHEMICAL SENSING

**Subtopic:** 9.01.1-3 Instrument for Characterization of Environmental Soot

**Title:** Development of a High Sensitivity Laser-induced Incandescence Instrument for Characterizing Soot and Carbonaceous Particles

**NIST OU:** Chemical Science and Technology Laboratory

**Firm:** Artium Technologies, Inc.
150 W. Iowa Ave., #202
Sunnyvale, CA 94086-6184

**Principal Investigator:** Dr. William Bachalo
**Phone:** 650-941-4233
**Email:** wbachalo@aol.com

**Award Amount:** $269,508.00

**Abstract:** A high sensitivity laser-induced incandescence system is proposed for the detailed characterization of environmental soot. The Phase I effort has clearly demonstrated the feasibility of (1) reducing the lower detection limit of soot volume fraction and increasing the overall measurement range by at least 2 orders of magnitude from what is currently achievable, and (2) providing PM particle size measurement capability. The prototype instrument to be developed in Phase II will be capable of real-time PM measurement over any engine transient operation. It will also have orders of magnitude more sensitivity than the gravimetric technique. The wide dynamic range and lower detection limit of the LII make this technique a potentially preferred standard instrument for particulate matter measurements.

**Commercial Applications:** The primary application for the LII system is for monitoring the soot particulate emissions for vehicles (diesel and gasoline). Artium believes that the LII instrument could be used for enforcing EPA regulations on particulate emissions. A version of the instrument can also be used for R&D purposes. Specifically, this instrument will help engine manufacturers develop low emission engines and development of products by emissions control equipment manufacturers. Regulators looking for better measurements to develop new emissions regulations will find the LII system to be attractive. It will provide them with real time analytical capabilities for exhaust gas particulates, particularly diesel soot emissions. It is also expected that the LII method can be developed into a field portable compact rugged system that can make roadside measurements of diesel exhaust, be used in test centers for monitoring vehicle emissions, or installed on stationary power plants and operated remotely.

 **FY 2006 Phase II Award**

**Topic:** 9.03 HEALTHCARE AND MEDICAL PHYSICS

**Subtopic:** 9.03.1-5 An Optical Coherence/Multi-photon Fluorescence Microscope for Imaging of Tissue Engineered Medical Products (TEMPs)

**Title:** Design and Realization of a Dual Function OCM/MPM for Imaging TEMPS

**NIST OU:** Materials Science and Engineering Laboratory

**Firm:** Distant Focus Corporation
60 Hazelwood Dr., Suite 230B
Champaign, IL 61820-7460

**Principal Investigator:** Rick Morrison
**Phone:** 217-384-8350
**Email:** morrison@distantfocus.com

**Award Amount:** $269,593.02

**Abstract:** Regenerative medicine is an emerging, interdisciplinary field that will result in new engineered medical products. The introduction of a high-resolution, non-destructive imaging technique that is capable of penetrating deeply into the highly-scattering scaffold medium has the means to accelerate the development and commercial utilization of these novel materials. Multi-photon microscopy (MPM) is based on the detection of the fluorescence emitted by endogenous or exogenous markers. Optical coherence microscopy (OCM) delivers information on the sample's scattering properties. These modalities provide different imaging contrast mechanisms. It is highly desirable to combine both imaging functions into a single instrument. We propose to design and construct a dual function OCM/MPM platform based on expertise developed building a similar system for a biophysics research program at the University of Illinois.

**Commercial Applications:** The unique configuration of the proposed setup, and the opportunity to obtain both anatomical and functional imaging information will make the combined microscope a very useful and attractive imaging tool that could be widely exploited by the scientific community. Particular useful applications can be found in the field of tissue engineering. Other possibilities exist in the field of plant biology to study for example the localization and interaction of different proteins attached to fluorescent proteins in different plants in relation to their development. The combined microscope would also be of potential interest to major microscope vendors that already market two photon microscopes.

**FY 2006 Phase II Award**

**Topic:** 9.09 MICROFABRICATION AND MICROMACHINING

**Subtopic:** 9.09.2-2 Very High Accuracy Probe for Micrometer Scale Structures

**Title:** Very High Accuracy Probe for Micrometer Features

**NIST OU:** Manufacturing Engineering Laboratory

**Firm:** InsituTec, Inc.
2750 East WT Harris Blvd., Suite 103
Charlotte, NC 28213

**Principal Investigator:** Dr. Marcin Bauza
**Phone:** 704-599-0895
**Email:** marcin.bauza@insitutec.com

**Award Amount:** $269,593.02

**Abstract:** The Phase II objective is to provide NIST with a modular gauge head unit equipped with InsituTec's standing wave probe technology. The complete gauge head unit will be retrofitted to the NIST M48 which is one of the most precise measuring machines in the world. This unit will enable NIST to achieve the agency's program goal in dimensional metrology which is to provide microscale measurement capacity to a level suitable for calibration services. At the end of the program, NIST will have a working measuring machine with the ability to measure challenging microscale features such as channels or holes <50 µm wide at a depth up to 4 mm. These types of features are difficult if not impossible to reach using previous probing technologies. The gauge head will be capable of functioning in touch triggering modes and the measurement capability will be further enhanced by the ability to change the vibration amplitude at the end of the probe tip. Additionally, the force probes will have programmable nano-Newton contact force, scanning and touch triggering mode functionality, repeatability better than 5nm, 2D laterally and depth measurement capability.

**Commercial Applications:** The market for microscale probing technology is significant due to a vast number of products designed with microscale features. Our standing wave probing technology, as far as we are aware, is the only tool in the world to provide accurate measurements for high aspect ratio feature on the order of 100:1. There are other companies working in this field to develop nanoscale measurement tools. However, the competitive technologies are still fraught with problems and based on published data InsituTec is clearly the leader in this area. InsituTec's objective is to transition this technology into a commercially viable tool for industry and ultimately be a valuable resource for improving microscale manufacturing. InsituTec has already established dialogue and relationships with leading companies in the automotive markets, aerospace, optics, and three internationally recognized standards laboratories. All of these areas have expressed interest in our technology and commercialization of the tool via InsituTec.

**FY 2006 Phase II Award**

**Topic:** 9.08 MICROELECTRONICS MANUFACTURING

**Subtopic:** 9.08.3-1 STEP AP210-based Stackup Design and Warpage Analysis Tool for Printed Circuit Board Manufacturing

**Title:** A Multi-Representation Architecture for STEP AP210-based PCB Stackup Design and Warpage Analysis

**NIST OU:** Electronics and Electrical Engineering Laboratory

**Firm:** InterCAX, LLC
2402 Lively Trail
Atlanta, GA 30345

**Principal Investigator:** Russell Peak
**Phone:** 678-369-0628
**Email:** Russell.Peak@InterCAX.com

**Award Amount:** $269,592.99

**Abstract:** This effort creates foundations for highly automated simulation tools that predict warpage in printed circuit boards and assemblies (PCAs/PCBs) and chip packages. Our technique, MHS, provides core capabilities to automate warpage and other problems that were impractical until now. MHS extends a multi-representation approach the PI first conceived at Georgia Tech for CAD-CAE interoperability. This method defines and combines key ingredients in a novel way: rich product models based on open standards, idealization capture, advanced analytical modeling and finite element meshing, and a modular architecture based on knowledge patterns. Phase II accelerates this work towards commercialization by exploring effective meshing and idealization refinements, completing validation vs. physical measurements, and benchmarking performance with challenge problems: dual-sided PCAs with 20+ complex devices.

Commercial Applications: Evaluating and correcting PCA/B warpage during design offers major improvements in electronics manufacturing yield and reliability. Integrating warpage analysis tools with established ECAD and MCAE tools benefits product development speed and efficiency. Our new warpage tools will provide significant advantages to U.S. manufacturers (PCB fabricators, package assembly and test houses, and contract manufacturers), potentially saving $100M/year. This effort will provide highly automated warpage simulation tools initially aimed at PCBs, PCAs, and chip packages. We will offer these innovative capabilities both as rich applications and as turnkey engineering web services for small or low frequency users. The new comprehensive warpage solution could also become part of larger product lifecycle management (PLM) systems for electronics OEMs and their subcontractors.

 **FY 2006 Phase II Award**

**Topic:** 9.07 MANUFACTURING SYSTEM INTEGRATION

**Subtopic:** 9.07.3-4 High-Resolution, Two-Dimensional Electronic Neutron Detectors for Imaging

**Title:** High-resolution, Two-dimensional Neutron Imaging Detector

**NIST OU:** Physics Laboratory

**Firm:** NOVA Scientific, Inc.
Sturbridge Technology Park
10 Picker Rd.
Sturbridge, MA 01566-1251

**Principal Investigator:** W. Bruce Feller
**Phone:** 508-347-7679
**Email:** bfeller@novascientific.com

**Award Amount:** $300,000.00

**Abstract:** NOVA Scientific proposes a high-resolution neutron imaging detector having a specialized neutron-sensitive electron amplified detection stage integrated with a cross-strip electronic readout capable of centroid averaging. Phase I efforts demonstrated spatial resolutions of 15 µm with high detection efficiency and moderate counting rates. The Phase II proposed program will carry out further detector enhancements with construction of neutron-sensitive 40 mm MCPs having 5 µm pores on 6 µm centers and a specialized bias angle to enhance detection efficiency. The MCP glass will be specially formulate to minimize gamma noise events. Integrated with a more advanced electronic readout, the system objectives are < 10 µm spatial resolution and MHz counting rates along with a reduced sensitivity to gamma ray photons. Using an MCP collimator add-on to remove scattered neutrons, the system will be demonstrated on a NIST neutron beamline and the hardware delivered for future studies. Applications include high-resolution neutron radiography for fuel cells and nondestructive testing, neutron scattering, SANS experimentation, neutron beam diagnostics, and materials research. The detector system will strongly support the diagnostic capabilities of the Neutron Imaging Facility (NIF) at NIST and assist in reestablishing U.S. leadership in neutron imaging technology.

**Commercial Applications:** High-resolution neutron imaging will provide improved diagnostics of transport across hydrogen fuel cell membranes, permit enhanced experimentation for neutron scattering, small angle scattering, materials research, and nondestructive testing of high density components. It will provide the NIST Neutron Imaging Facility (NIF) with state-of-the-art neutron radiographic capabilities.

 **FY 2006 Phase II Award**

**Topic:** 9.05 INFORMATION TECHNOLOGY

**Subtopic:** 9.05.5-9 Multi-user Collaborative Tools for Immersive Scientific Visualization

**Title:** Multi-user Collaborative Tools for Immersive Scientific Visualization

**NIST OU:** Information Technology Laboratory

**Firm:** Open Tech, Inc.
2000 Kraft Dr., Suite 1101
Blacksburg, VA 24060

**Principal Investigator:** Daniel Larimer
**Phone:** 540-239-1863
**Email:** dlarimer@opentechinc.com

**Award Amount:** $269,593.02

**Abstract:** Open Tech will create an interactive multi-user collaboration product for immersive and desktop scientific visualization. This product will leverage our Virtual Reality Windowing Library to enable an easy to use collaboration interface that includes user lists, radars, maps, avatars, white boards, and virtual presentations. The product will also contain a software framework that enables developers to create new collaborative applications that will also run on immersive clusters and may include complex simulations and user interactions.

**Commercial Applications:** Open Tech has identified an opportunity to use virtual Reality to enable distributed teams to collaborate more effectively than they can today. Using virtual reality all members of the team can interact with a shared world in which they can view the hand gestures of the other users, draw on an white board and point to items in a 2D or 3D "Power Point" presentation. When combined with video and voice communication this collaboration technology has the potential to change the way every day businesses collaborate. Open Tech can market this product to any business with a need for more effective collaboration.

**FY 2006 Phase II Award**

**Topic:** 9.13 TECHNOLOGIES TO ENHANCE FIRE SAFETY

**Subtopic:** 9.13.3-6 Distributed Multi-Nodal Voice/Data Communication for Firefighters

**Title:** Distributed Automatic Reconfigurable Transponder (DART)

**NIST OU:** Building and Fire Research Laboratory

**Firm:** Williams-Pyro
200 Greenleaf St.
Fort Worth, TX 76107-1471

**Principal Investigator:** Kartik Moorthy
**Phone:** 817-872-1500 x125
**Email:** kartik.moorthy@williams-pyro.com

**Award Amount:** $300,000.00

**Abstract:** Williams-Pyro, Inc. (WPI) has designed and successfully demonstrated a proof-of-concept of the Distributed Automatic Reconfigurable Transponder (DART) that will be capable of achieving distributed multi-nodal voice/data communication for fire fighters. In Phase II we will focus on developing a fully functional system that reduces communication failure while maintaining a robust and flexible system. Specifically, WPI proposes to develop a fully functional AccuTag™-based DART, which consists of a series of distributed nodes that will relay voice transmission and data to the incident commander located outside the building. The DART system will be based on state-of-the-art technologies, allowing several distributed DARTs to communicate between individual team members inside the structure as well as with the incident commander located outside the structure. This system will allow faster, more accurate information transmission, resulting in timely fire detection and safer firefighting.

**Commercial Applications:** Commercial applications of the proposed AccuTag™-based Distributed Automatic Reconfigurable Transponder (DART) vary widely, with possibilities including police and fire departments; emergency management services; petroleum companies; water, gas, and electric utilities; mining companies; and transportation companies such as railroads, taxicab operations, and airlines. The firefighting market is the initial focus of our commercialization efforts (worth approximately $500 million, and WPI's estimated market share after five years on the market is expected to reach approximately 5 percent). The opportunities within this market are large, with approximately 30,000 fire departments, 50,000 public safety agencies, and more than a million firefighters nationwide. In addition to the large size, the market offers other promising factors such as great need.