Electronics

Detectors/Sensors/Instruments

Title: STTR Phase II: Diamond Nanoprobes for Atomic Force Microscopy - Imaging, Metrology, Material Property Measurement, Process Control, and Manipulation with Ultrahigh Performanc

Award Number: 0823002
Program Manager: William Haines

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $484,464

Investigator: John Carlisle, carlisle@thindiamond.com
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project will develop commercially viable atomic force microscope (AFM) probes fabricated from ultrananocrystalline diamond. The project will refine the processes developed in Phase I and bring contact and non-contact all-diamond probes to market. Probes using conducting diamond that are chemically and electronically tunable and have superb tribological properties will also be developed. This work will facilitate new industrial applications for AFM, including high-throughput imaging, metrology, and characterization of large quantities of materials, local electrical characterization for process control in micro/nanoelectronics, nanomechanical characterization of MEMS/NEMS devices, and ultraprecise hard mask correction for the micro/nanolithography industry.

Title: STTR Phase II: High Resolution Spectrometer-on-a-Chip Based on Nano-Optic Plasmonic Device

Award Number: 0823023
Program Manager: Juan E. Figueroa

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $500,000

Investigator: Byounghee Lee, blee@nanolambda.net
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project is to develop an ultra-compact, high-resolution and low-cost spectrometer-on-a-chip, based on plasmonic nanowire arrays. In response to the growing demands for miniaturized non-invasive spectroscopic sensor, there have been many efforts to miniaturize optical spectrometers using various conventional technologies. However they are not yet conducive to both dramatic miniaturization and also high spectral performance at low production cost. Unlike the bulky and expensive conventional diffractive optical devices, the proposed nano-optic device utilizes the wavelength-dependent plasmonic phenomena occurring on metal nanowire surfaces and the gaps between the metal nanowires. This single layered nano-optic filter array is expected to enable a high resolution spectrometer-on-a-chip, overcoming the limits of diffractive optics. This proposal is to design, and fabricate the nano-optic filter array structure using standard wafer processes, to integrate it with a custom designed CMOS detector array to form a spectrometer-on-a-chip. The anticipated outcome of this project are spectrometer-on-a-chip samples for customer test and evaluation, and demonstration of high spectral resolution (10nm) over 380nm ~780nm wavelength range in a compact size, less than 5 mm x 5 mm x 2 mm, at significantly lower cost. If successful the proposed ultra-compact high-resolution low-cost spectrometer-on-a-chip can be used in various applications such as high-resolution color sensing, multiple gas detection, and mobile/wearable health monitoring. Consumer electronics manufacturers, portable medical device vendors, and wireless sensor node suppliers can be all potential customers. As a key component to these markets, it is anticipated that the total addressable market for the proposed spectrometer-on-a-chip will be over $1 billion in around 2012. Considering the manufacturability of the proposed technology and the readiness of the markets, it is feasible to launch the first commercial product in 2010. The proposed activities will contribute to enhancing color quality and color consistency across consumer color devices, and has potential to contribute to advancing personalized point-of-care, environmental monitoring, and homeland security by enabling non-invasive, high-throughput, low-cost sensing. The proposed activities will provide further solid understanding of the phenomena occurring when a light interacts with nanostructured metal, and enhance the mass production capabilities of nano-structures. Successful completion of this project will also open up new application opportunities in the convergence areas of information, bio and nanotechnologies.

Title: SBIR Phase II: A High-Throughput Scanning Probe Microscope Using Micromachined Ultracompliant Probe Arrays with Embedded Sensors for Simultaneous Topography and Thermal Imag

Award Number:	0822810
Program Manager:	Cheryl F. Albus
Start Date:	August 1, 2008
Expires:	July 31, 2010
Total Amount:	$499,694

Investigator: Angelo Gaitas, angelo@picocal.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to produce a commercial prototype of a state-of-the-art high throughput scanning probe microscope (HT-SPM), which can be used for measuring topography and thermal parameters in nanotechnology, bio, and semiconductor applications. The scanning probe microscope has been a very successful tool, but emphasis has not been put on rapid data acquisition. The HT-SPM is an enabling technology that consists of a transformative and patented method for extracting topography which allows for higher throughput. The project leverages experience in atomic force microscope (AFM) probe micro-fabrication and industry. An immediate outcome of this SBIR project will be a fully functional and market ready HT-SPM. The broader impact/commercial potential of measurements in nanometer scale devices and structures have both scientific and industrial importance. Although the Atomic Force Microscope (AFM) is one of the most important tools for nanotechnology, there has not been any fundamental innovation in the way it operates for more than a decade. This project provides faster measurement as a result of a fundamentally different way of imaging. Faster characterization permits manufacturers to expedite problem isolation, leading to higher productivity and higher return-on-investment (ROI). The HT-SPM also benefits R&D, failure analysis and off-line engineering. The HT-SPM offers critical capabilities that will allow users too quickly and clearly measure topography/friction/temperature at the nanoscale and view critical characteristics. The HT-SPM fills a critical need in integrated circuits, nanotechnology, life sciences and other markets that rely on sub-micron microscopy, as it will provide users with a superior and inexpensive measurement system to aid in studying new properties.

Title: SBIR Phase II: Sub-100nm Infrared Spectroscopy Based on Atomic Force Microscopy

Award Number:	0750512
Program Manager:	William Haines
Start Date:	April 1, 2008
Expires:	March 31, 2010
Total Amount:	$493,057

Investigator: Kevin Kjoller, kevin@anasysinstruments.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project seeks to develop the prototype of a characterization system which can perform IR spectroscopy and imaging at sub-100nm spatial resolution and thus break the 5 micron resolution barrier that has limited IR spectroscopy for the last 50 years. This 50x breakthrough in spatial resolution is enabled by the proprietary technique of Photo-Thermal Induced Resonance (PTIR) whose feasibility has already been demonstrated in the Phase I work. IR spectroscopy is a critical analytical technique which itself comprises a $1 Billion/yr industry. However, its spatial resolution limitation has seriously limited researchers who need information on nanoscale chemical composition. The potential impact of nanoscale IR ranges from new materials discovery to interfacial property improvements in high value applications.

Title: SBIR Phase II: Picotesla Magnetic Sensor Using MgO-Based Magnetic Tunnel Junction Technology

Award Number: 0750584
Program Manager: Muralidharan S. Nair

Start Date: April 1, 2008
Expires: March 31, 2010
Total Amount: $498,295

Investigator: Benaiah Schrag, schrag@micromagnetics.com
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Abstract:

This Small Business Innovation Research(SBIR) Phase II research project will develop a compact, easy-to-use two-axis magnetic sensing module with picotesla sensitivity, based on the use of Magnesium Oxide (MgO)-based Magnetic Tunnel Junction (MTJ) sensor devices and associated electronics. The sensor module will have superior field sensitivity with excellent linearity and orthogonality, thanks to a specialized control circuitry which allows the sensors to operate under optimal magnetic conditions. The sensor module will operate under ambient conditions, with no extra infrastructure required, and will therefore be easily integrated into a number of emerging applications. The field sensitivity of the sensor module will be more than a factor of ten larger than any commercially-available thin film sensor, giving it a dominant technical edge for high -performance applications. This sensor module will be realized through the synergy of three key innovations: enhanced device performance derived from magnesium oxide tunnel barrier technology, active sensor compensation via on-board current-carrying striplines, and anisotropy engineering using specialized annealing processes. This research will create a new product family with greatly enhanced capabilities for use in many critical segments of the world sensor market, including remote sensing applications in the defense and homeland security segments, as a key component of non-destructive evaluation systems, and in emerging medical applications. It will expand the utility and availability of a number of powerful new medical technologies. This research will improve the understanding of the emerging spintronic technology of magnetic tunnel junctions, a class of devices which forms the central component of several important commercial products in the high-tech semiconductor and data storage industries.

Title: STTR Phase II: Coherent THz Sources and Amplifiers Using Carbon Nanotubes

Award Number:	0750559
Program Manager:	Juan E. Figueroa
Start Date:	February 15, 2008
Expires:	July 31, 2010
Total Amount:	$508,705

Investigator: Christian Drouet d'Aubigny, cdaubign@teravision-inc.com
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Phone: (520) 465-1909

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II research project will design and develop practical traveling-wave tube (TWT) amplifiers and oscillators at THz frequencies. During Phase II the research team will 1) optimize the design for low noise operation, 2) add a tuned feedback loop to the 0.345 THz TWT so the unit can function as a stand-alone oscillator, 3) based upon the experience gained at 0.345 THz, develop a detailed design for a TWT for higher frequency operation (e.g. 0.65, 0.82, and 1.5 THz where atmospheric absorption by water is at its minimum at THz frequencies), and 4) package a THz TWT for a wide variety of commercial uses. The proposed developments will increase the coherent output power available at frequencies above ~200GHz by orders of magnitude, while dramatically reducing the cost per milliwatt. The work will also provide a path for the realization of the first THz low-noise amplifiers. If successful the results from the proposed research will lead to the availability of signal sources and amplifiers capable of yielding orders of magnitude more coherent power in the THz regime than is currently available. The devices coming out of the effort will lead to THz components and devices that can be used in applications ranging from communications and remote sensing to medical imaging. . Potential end-users include NASA, aerospace companies, telecommunication companies, the security industry, companies engaged in the development of medical imaging systems, and the military.

Title: SBIR Phase II: Vapor Generator for the Calibration of Explosive Trace Detectors

Award Number:	0749979
Program Manager:	Cheryl F. Albus
Start Date:	February 1, 2008
Expires:	January 31, 2010
Total Amount:	$499,961

Investigator: Donald Hayes, dhayes@microfab.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to use digitally controlled vapor generators for calibration and test of explosive. Two systems will be created: a research oriented system, targeting manufacturers, for development of new explosive vapor trace detectors and production quality control and a portable system, intended for end users, for field testing and calibration. The use of digitally controlled ink-jet dispensing to precisely eject minute amounts of dilute explosive solutions and convert them into vapor has been demonstrated. We have also identified unique requirements of distinct vapor trace detector models and the actual needs of the marketplace. This project will: design and fabricate the two systems; generate the software control program; formulate explosive solutions customized for commercial explosive vapor trace detectors; develop test protocols for each system; evaluate the systems with commercial vapor trace detectors; and run reliability and repeatability testing. The research performed will also include: material compatibility studies; distribution of various explosive vapors by flow simulations and measurements; shelf life studies of the cartridges; and development of methods to calibrate the cartridges for explosive solutions. The broader impact/commercial potential from this technology will be a method to evaluate the development of the next generation detectors. This project will lead to products (vapor generator systems and associated consumables). These products will provide the means to compare the various explosive trace detectors and to identify the most accurate ones. Ultimately, the ability to further miniaturize the vapor generators will lead to units that are embedded into next generation detectors for real-time verification and calibration. The overall societal benefit of successfully developing vapor generator products will be improved protection of the public, both real and perceived, from terrorist threats while minimizing the cost and negative perception related to false alarms. Technological advances from this project will facilitate basic research on detection mechanisms for explosives, drugs and chemical threats. Researchers in government labs and academia will be able to use the vapor generator to evaluate and quantify improvements of promising detection methods. The technology also has spin-off opportunities in olfaction based medical diagnostics.

Title: SBIR Phase II: Automated Structural Health Monitoring Sensor

Award Number: 0724434
Program Manager: Muralidharan S. Nair

Start Date: September 15, 2007
Expires: August 31, 2009
Total Amount: $499,838

Investigator: An-Dien Nguyen, a.d.nguyen@lgrinc.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will support the development of a new automated structural health monitoring (SHM) sensor system capable of detecting cracks and measuring stress in advanced structures. Current electrically-based SHM instrument is bulky and expensive. With the increase of sensing points and structure size, the amount of cabling, weight, and cost for hardware increases dramatically. This instrument combines optical waveguides and fibers, and Bragg Gratings (BG) with a low-cost, rugged light source to yield a SHM instrument capable of continuous measurements in the field with high precision and sensitivity. Phase II research will develop a field-tested 8-channel BG-based SHM instrument for simultaneous crack detection and loading stress measurements in large structures.

This novel SHM instrumentation will offer significant cost saving by providing a low cost solution for crack detection in large airframe structures such as wings, fuselage, and lap joints, as well as in civil structures such as oil pipelines, bridges, freeways, plants and buildings. The new sensor technology will enhance public safety as a result of low-cost condition-based maintenance and effective warning systems due to the sensor instrument's accurate prognosis and early prediction of catastrophic failures in large public transportation and utility systems.

Title: SBIR Phase II: A Novel Imaging Device for Infrared and Terahertz Radiation Beams Utilizing Thermochromic Liquid Crystal Materials

Award Number:	0724505
Program Manager:	Juan E. Figueroa
Start Date:	September 15, 2007
Expires:	August 31, 2009
Total Amount:	$499,170

Investigator: Alex Murokh, murokh@radiabeam.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will construct a detector with the capabilities of broadband imaging in the far infrared to terahertz band. The far infrared (FIR) to terahertz (THz) band of the electromagnetic spectrum has recently opened up with the proliferation of sources in this regime. However, the detector systems available on the market for this spectral region are currently expensive and inflexible. The research is centered on the study of a specific material that will convert the thermal imprint of incoming THz radiation into a visible, wavelength dependent signature that is analyzable by a detector and specialized software. A scanning system based on this detector combined with a tunable source will be designed for use as a security/inspection system. The research will incorporate this detector, capable of imaging a wide spectrum of FIR-THz radiation sources with sensitivities better than current technologies at a fraction of the cost, into a scanner system that can scan small parcels, bags and humans to identify hazardous materials or contraband.

As researchers and industries increasingly exploit this previously inaccessible portion of the electromagnetic spectrum, the need for a better imaging diagnostic tool becomes ever more important. A less-expensive, more sensitive imaging detector of FIR-THz sources is necessary before real-world applications, such as in medicine, become widespread. The realization of this particular application will impact the security and non-destructive testing markets.

Title: SBIR Phase II: Photon-Assisted Hydrogenation Process Technology for Manufacturability and Improved Operability of HgCdTe Infrared Detectors

Award Number:	0724233
Program Manager:	William Haines
Start Date:	September 1, 2007
Expires:	August 31, 2009
Total Amount:	$499,901

Investigator: Ronald Hellmer, admin@amethystresearch.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will deliver an innovative hydrogen passivation technique for improving manufacturability and performance of HgCdTe infrared detectors. Photon-Assisted Hydrogenation (PAH) causes the substrate to be hydrogenated by simultaneous exposure to hydrogen gas and ultra-violet (UV) light which allows hydrogen to diffuse into and become a permanent part of the substrate. In Phase I the feasibility of PAH for the fabrication of high-performance near-infrared HgCdTe avalanche photodiode (APD) arrays on large-area silicon wafers was demonstrated. In Phase II PAH will be optimized for fabrication of HgCdTe infrared sensors from a variety of sources.

The PAH process will not only create a new product line of high-performance HgCdTe/Si-based APDs, but may also provide a means to effect significantly higher yields, and thus lower costs for all manufacturers of HgCdTe-based detectors. PAH technology will enable all HgCdTe infrared device manufacturers to grow on Silicon wafers, significantly reducing the cost of these high value systems, and making them more generally available for a broad range of currently unaffordable applications, including civil transport, aviation, medical and robotic vision systems. Derivatives of the this technique may be applied to the manufacture of a variety of other optoelectronic semiconductor devices requiring passivation to mitigate defects.

Title: SBIR Phase II: Three-Dimensional Microscopy of Surfaces by Grazing Incidence Diffraction

Award Number: 0724428
Program Manager: Juan E. Figueroa

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $493,370

Investigator: Thomas Ditto, 3d@taconic.net
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Abstract:

This Small Business Innovation Research (SBIR) Phase-II project is aimed at building a working three-dimensional microscope for industrial applications. This patented optics using holography will be grafted onto a two- dimensional inspection microscope now sold into the thread spinneret manufacturing industry. This research will seek to demonstrate that the expensive holographic master used in Phase I can be inexpensively mass replicated. Optical microscopy has almost always used refractive primary objectives, and 3D versions of classical refractive microscopes exploit the methods of triangulation, confocal focus accommodation, or interferometry. Here, a new concept into the technology of optical microscopy, primary objective gratings, is introduced. We have demonstrated that if an objective grating is fabricated using holography and is then configured at grazing incidence, it can be used as 3D profilometer. The demonstration microscope will be designed with features to show that it can be sold into the electronics surface mount technology inspection industry, a larger market than spinneret inspection.

This project will demonstrate the 3D capability to inspect solder paste and component insertions of sample circuit boards, and therefore will impact industrial inspection, and will provide robust field units for geology, archeology, anthropology, and paleontology. In medicine, this method has utility in endoscopy, and uses in surgery and dentistry is also foreseen. Generalized biological scientists will also be end users with the introduction of computer image processing, the availability of 3D profiles greatly expedites characterization and pattern recognition, because 3D data is immune to variations in surface shading typical of 2D image processing.

Title: SBIR Phase II: Sensory System for Autonomous Area-Wide Disease and Agriterror Detection and Reporting

Award Number: 0725388
Program Manager: Juan E. Figueroa

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $500,000

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Abstract:

This Small Business Innovative Research (SBIR) Phase II research project will fabricate nanosensory arrays using the Micro-Electro-Mechanical Systems (MEMS) technique. This electrochemical polymerization of biomolecule-friendly conducting polymers was developed and successfully tested to build functional, highly reliable nanosensors. This research will address key technical challenges in automating the fabrication of antibody-functionalized conducting nanowires that are individually addressable and scalable to high-density biosensor arrays for the detection of Huanglongbing (HLB). The resultant nanosensory-arrays will form the base for the development of small, effective, inexpensive, field worthy, autonomous and automated pathogen detection devices. These units will permit the unattended processing of a large number of field samples, thus increasing the temporal and geographical density of data collection, providing superior pathogen and agri-terror detection.

Current disease management techniques typically lack the data collection technologies needed to avert epidemics; diagnostic instruments are not amenable to unattended autonomous operation. Devices currently used are slow, expensive, bulky, and must interface with humans. Consequently, only few pathogen introductions are detected before causing widespread disease or epidemics. This research will increase the efficiency in detection of plant pathogens and agents of disease, allowing for preventative rather than crisis or remedial control actions. The development of this automated system can mitigate the estimated $300 billion loss due to agricultural pests.

Title: SBIR Phase II: Structurally Integrated Organic Light Emitting Device-Based Sensors for Dissolved Oxygen in Water

Award Number: 0724090
Program Manager: Juan E. Figueroa

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $499,976

Investigator: Ruth Shinar, rshinar@iastate.edu
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project aims to develop and commercialize a novel, next-generation photoluminescence (PL)-based, palm-size and miniaturizable dissolved oxygen (DO) sensor. DO sensors are primary monitors of water quality in industrial wastewater treatment. The new sensor is based on a pioneering platform for PL-based biochemical sensors where the excitation source is a pulsed organic light emitting device (OLED) pixel array that is structurally integrated with the sensor component. The individually addressable pixels and the sensor film are fabricated on either side of the glass substrate. The photodetector is "behind" the OLED array, monitoring the PL passing between the OLED pixels. This uniquely simple structural integration enables multi-sensor fabrication on a single, compact substrate, and should therefore yield field-deployable micro-sensor arrays for simultaneous detection of various analytes.

This sensor has applicability in water quality measurements in wastewater treatment, power, pulp and paper, chemical, food, beverage, brewing, and pharmaceuticals plants, fish farms, fresh water, coastlines, and the oceans. Current sensors suffer from key drawbacks that limit their utility and application. Electrochemical sensors require frequent calibration and maintenance, and are typically slow to respond. PL-based sensors are expensive due to intricate design. The proposed sensor will be reliable, require very little maintenance/calibration, and will be inexpensive, with a flexible design and size. The proposed device will be uniquely simple, initially palm-size and eventually micro-size, autonomous, fast, miserly on power consumption, and inexpensive. It will be structurally integrated and will operate in a pulsed PL-lifetime mode, eliminating the need for optical components and frequent calibration.

Title: SBIR Phase II: Efficient, High-Resolution Fast-Neutron Detector

Award Number:	0724503
Program Manager:	Juan E. Figueroa
Start Date:	August 1, 2007
Expires:	July 31, 2009
Total Amount:	$500,000

Investigator: Jay Cremer, ted@adelphitech.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop a fast-neutron imaging detector capable of high resolution and efficiency. Traditionally, fast neutron detection has required a thick, low resolution scintillator material. The proposed research will instead use light-channeling micro-capillaries filled with liquid scintillants. The capillary diameter and length that will yield optimal resolution and efficiency will be determined using a state-of-the-art image-intensified CCD camera capable of creating short time-interval images, in which noise can be identified and filtered out. The detector system will be tested using a new, revolutionary fast neutron source that is being fabricated and sold by the company. Because fast neutrons are highly penetrating, they have the possibility of imaging and interrogating large, high-density objects. The new high-resolution fast-neutron detector will be used with a high-brightness fast neutron source being developed under another program to form a fast-neutron radiographic system.

This system will serve the nondestructive testing interests of commercial and military aircraft, public utilities and petrochemical organizations. The detector and generator combinations will increase the safety, reliability and efficiency of nuclear and other power plant facilities. The discovery of fatigue cracks and piping integrity without the removal of insulation, and possibly the detection of aging in polymeric cabling materials will be possible. The imaging system will be portable, permitting imaging inside of thick steel, lead or even uranium for voids, corrosion and cracks. The proposed detector and neutron generator has a large market for screening for contraband, weapons, and explosives.

Title: STTR Phase II: Novel Deposition Rate Sensors for Real-Time Thickness Control of Plasma Spray

Award Number: 0724382
Program Manager: Muralidharan S. Nair

Start Date: August 1, 2007
Expires: July 31, 2009
Total Amount: $499,983

Investigator: Gregory Reimann, Reimann@gmail.com
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II research project will develop a robust, commercial ready sensor that enables the first viable implementation of real-time control for plasma spray, reducing the cost for existing spray applications and enabling advanced coating applications that require tighter tolerances. The sensing scheme, based on a high speed solid state array, is superior to existing sensors because it can sense individual particles across the entire plume and can filter out non-molten particles that don't contribute to the coating. For the first time, a sensor will provide the basis for real-time, closed loop control for coating thickness of plasma sprayed parts. The Phase II research will develop production models of the sensor and the related closed loop control module, as well as establish proof of concept for advanced versions of the sensor.

Plasma spray is a high-throughput, economical, low environmental impact process that can be used to custom engineer coating microstructures to meet specific performance requirements, primarily in the form of thermal barrier coatings for gas turbines used in power generation and aircraft engine applications as well as emerging applications such as the electrolyte coating for fuel cells. Currently, the plasma spray process is run open-loop with respect to the critical deposition physics that determine coating quality and is characterized by large variations in coating thickness and structure.

Title: SBIR Phase II: Ultra-Low Power Microcontroller Design

Award Number:	0724361
Program Manager:	Muralidharan S. Nair
Start Date:	August 1, 2007
Expires:	July 31, 2009
Total Amount:	$500,000

Investigator: Alexander Ishii, alexander.ishii@cyclos-semi.com
Company: Cyclos
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will investigate novel integrated circuit design technologies for the realization of ultra-low-power microcontrollers. The main objective of this project is to investigate the deployment of novel charge-recovery circuitry for the design of an ultra-low-power leading-edge commercial microcontroller core. The resulting charge-recovery core is expected to dissipate 25-30% less power than its conventional counterpart. In conventional circuit design, capacitors are switched abruptly between supply and ground, dissipating all their stored energy as heat across resistive devices. In charge recovery design, on the other hand, capacitors are switched gradually, returning any energy that remains un-dissipated back to the power supply. The significant potential of charge recovery to reduce power consumption has so far remained untapped in the commercial world, primarily due to the lack of support for such a new design style that deviates from established design practices.

The results of the proposed research are commercially applicable to the realization of a broad class of computer systems and consumer electronic devices that are subject to power efficiency requirements. Microcontrollers are essential elements of every System-on-Chip (SoC) and typically account for a substantial fraction of overall chip power, since they remain on most of the time. Embedded microcontrollers are key components of semiconductor chips for mobile devices such as cell phones and personal digital assistants. Generating a commercial microcontroller core with substantially reduced power consumption will lead to a broad variety of next-generation computer and communication systems with enhanced features, longer battery life, and improved performance.

Title: SBIR Phase II: Particle Metrology and Diagnostics using Microchannel Resonators

Award Number: 0724350
Program Manager: F.C. Thomas Allnutt

Start Date: July 15, 2007
Expires: une 30, 2009
Total Amount: $499,142

Investigator: Ken Babcock, ken@affinitybio.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II program develops an instrument capable of measuring micron-scale particles using their weight as the measured parameter. At the instrument''s core is a novel microfabricated sensor containing a vibrating microchannel. The target particles are suspended in fluid as they pass through the channel, causing channel vibration frequency to change with a sensitivity of less than a picogram.

The broader impact of this research will to provide a method for particle size analysis that in addition to size gives mass. Manufacturing processes in many industries could benefit from this type of instrument to improve their processes and thereby lower production costs as well as improving product quality when used in a quality assurance program.

Title: SBIR Phase II: Development of a Broad Spectrum Differential Mobility Aerosol Analyzer for Aerosol Size Distribution Measurements

Award Number: 0646182
Program Manager: Muralidharan S. Nair

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $500,000

Investigator: Fredrick Brechtel, fredbmi@sbcglobal.net
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Phone: (510)732-9723

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will support the continued development of a new Synchronous Differential Mobility Analyzer (SDMA) aerosol sizing and counting system that is simple to use, inexpensive, and allows rapid observations of ambient particle number size distributions over the 0.005 to 0.4 micron diameter range. The new technology will largely eliminate the cost, size, weight, and operator-expertise limitations of currently available sizing technologies. Prototypes of the particle sizing, growth and optical detection systems will be fabricated and the instrument will be tested side-by-side against standard instruments in the laboratory.

Broader impacts of the proposed research include satisfying the need for increased spatial and temporal coverage of ambient aerosol data while creating a measurement technique accessible to a more general group of users through reduced cost and ease of use. The broader application of the new technology will serve as an educational tool for students and investigators leading to more widespread understanding of how particle concentration varies with size in ambient, laboratory and industrial settings. Increased understanding of the variability of the ambient aerosol number size distribution will serve as important information for investigators in the areas of aerosol global climate and particulate pollution health impacts.

Title: SBIR Phase II: RFID Tags for Cardiopulmonary Monitoring in Clinical Setting

Award Number:	0646422
Program Manager:	Muralidharan S. Nair
Start Date:	March 15, 2007
Expires:	February 28, 2009
Total Amount:	$499,998

Investigator: Ronald Salesky, salesky@jerseymicro.com
Company: New Jersey Microsystems
211 Warren Street, M/S 31
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Phone: (973)297-1450

Abstract:

This Small Business Innovation Reseach (SBIR) Phase II research project will develop an RFID system with sensor tags. This work focuses on design and implementation of a custom CMOS integrated circuit which contains hybrid analog-digital circuits on a micro-power tag. The biomedical application is vital signs monitoring including heart and lung sounds. The sensor tag operates within an RFID environment. Micro-electromechanical systems technology is used to fabricate an optimized sensor together with CMOS circuitry on the RFID-compatible tag. Heart sounds are presented as time-varying waveforms and processed algorithmically for feature extraction. Micro-power designs are used throughout the planned system.

The commercialized product with disposable tag sensors can replace the jungle of wiring currently used with direct-wired sensors or, for wireless pods, the need to replace batteries frequently. The system provides a patient monitoring capability that is very convenient, highly-cost effective, capable of chronic use, and does not interfere with nearby heart pacers. The ease of application makes this system ideal as a teaching tool for medical students and specialists with both visual waveforms and sound presented to the operator simultaneously. The system will be used in hospitals, clinics, medical offices, and for outpatients in the home.

Title: SBIR Phase II: Atmospheric Pressure Microplasma Emission Spectrometer

Award Number: 0646415
Program Manager: Muralidharan S. Nair

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $500,000

Investigator: Chris Doughty, cdoughty@verionix.com
Company: Verionix
251 Granville Lane
North Andover, MA 01845
Phone: (617)905-0015

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop a miniature atmospheric pressure plasma spectrometer using a source which generates a highly confined, high-density discharge (kW/cm3). The source would be based on a high frequency ring resonator structure and would utilize low cost widely available IC power amplifiers and drivers, would have extremely low cost in moderate volume production, and would consume <2 W rf power, allowing for portable operation. The compact size of this discharge should allow straightforward coupling to fiber optic spectrometers, and intense optical emission.

This research will substantially add to the scientific knowledge base and lead to fundamental understanding of the physics and engineering of these high-power-density, small and highly non-equilibrium plasmas. The source technology to be developed here will enable the miniaturization of a variety of chemical and gas analysis technology. This technology, by dramatically lowering the cost (10-100x), form factor (100x), and portability of the analytical equipment will provide economic benefits to customers in industrial settings, enhance worker and workplace safety, and allow for wider environmental monitoring.

Title: SBIR Phase II: Electronic Pills for Medication Compliance

Award Number: 0646491
Program Manager: Muralidharan S. Nair

Start Date: February 15, 2007
Expires: January 31, 2009
Total Amount: $500,000

Investigator: Neil Euliano, neil@conveng.com
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Gainesville, FL 32608
Phone: (352)378-4899

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project shall evaluate the use of electronic pills for medication compliance monitoring. Medication compliance monitoring is critical in pharmaceutical clinical trials, geriatrics, and mental health /addiction medicine. The only proven method for accurately determining medication compliance is directly observed therapy where personnel are present during
ingestion by the patient. This technique is labor intensive, but effective. In vivo biotelemetry and monitoring is a rapidly growing field that may provide the next critical breakthrough in medical monitoring. This research will focus on the development of these two solutions, namely a UHF resorbable antenna printed on the outside of an existing capsule or pill with or without a chip designed to improve signal to noise ratio and provide ID capability. The antennas will be printed with standard ink-jet technology. A handheld RF communication device will sense the presence of the pill in the GI tract and positively confirm that the medication regimen was followed appropriately.

Electronic pill technology and R&D will help expand the rapidly growing field of in vivo telemetry. The development of biodegradable low power miniature circuits will be an important step to future bio-implantable chips and sensors. Additionally, the field of medication compliance is tremendously important in many areas of medicine. In particular, better compliance monitoring can greatly reduce the costs associated with FDA approval of pharmaceuticals as well as provide dramatically improved data for accurate determination of low probability side effects.

Title: SBIR Phase II: Balloon-Based Instrument for Measurements of Atmospheric Water Vapor and Methane

Award Number:	0646479
Program Manager:	Muralidharan S. Nair
Start Date:	February 15, 2007
Expires:	January 31, 2009
Total Amount:	$500,000

Investigator: Mark Zondlo, mzondlo@swsciences.com
Company: Southwest Sciences Inc
1570 Pacheco St Ste E11
Santa Fe, NM 87505
Phone: (505)984-1322

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop, test fly, and inter-compare a balloon-based sensor for measuring atmospheric water vapor and methane. The chemical sonde is based upon low power vertical cavity lasers, compact optical cells, and noise-lowering data analysis algorithms. Water vapor is the most important radiative gas in the atmosphere, but accurate measurements of it in the upper troposphere and lower stratsophere are limited to custom, one-of-a-kind instruments. Methane is the second most important anthropogenic greenhouse gas, photochemically breaks down into water vapor in the stratosphere, and is a useful tracer for troposphere-stratosphere exchange. In combination, the water vapor and methane balloon based sensor offers more accurate insight into atmospheric chemistry (e.g. recovery of the ozone layer), atmospheric dynamics, and the Earth's radiative budget.

Improved data on water vapor and methane in the upper troposphere and lower stratosphere will help to better understand and predict how climate will change in the future. The costs of action and inaction on climate change are expected to be large, and it is imperative that society implement policies that maximize environmental protection while minimizing economic costs. More accurate assessments of climate change will indirectly benefit the economy by giving society time to prepare and adapt to potential changes in future climate.

Title: SBIR Phase II: High Power Deep UV LED-Based Lamps

Award Number:	0620525
Program Manager:	Juan Figueroa
Start Date:	August 29, 2006
Expires:	August 31, 2008
Total Amount:	$499,704

Investigator: Thomas Katona, tkatona@s-et.com
Company: SET
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Columbia, SC 29209
Phone: (803)647-9757

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will result in solid-state high power UV LED based lamps for use in water/air/food sterilization/purification, bio-aerosol detection, bio-medical instrumentation, and laboratory measurement systems. Currently there are no portable, rugged, long-lifetime, non-toxic sources of ultraviolet radiation for integration into increasingly important UV water and air purification (particularly residential), bio-aerosol detection, and food sterilization systems. The predominant sources of UV radiation are low-pressure, medium-pressure and amalgam Hg based lamps. These high voltage lamps are large, non-directional, ozone-producing sources of radiation with radial emission from a tube source. This restricts the design flexibility of purification systems because of the geometrical constraints imposed by the lamp. High power deep UV LEDs require packaging designed to dissipate several watts of power, be stable under UV illumination, reflect UV light, and enhance UV extraction. The team proposes to develop manufacturing innovations in the packaging of high power UV LEDs to extend the range of applications that UV LEDs are suitable for including high power package/LED design, and the manufacturing processes required to fabricate these packages. Deep UV LED based lamps with output powers ranging from 50-100 mW are expected from this developmental effort.

If successful these Deep UV LED-based lamps will penetrate existing markets using UV radiation sources as the efficiency of the devices increases, as well as creating new markets previously unattainable due to the inherent limitations of current UV sources. The merits of UV radiation for sterilization/purification applications are beginning to be widely publicized. Several of the primary markets are: 1) Sterilization/Purification for Water, Air, and Food Preparation/Storage, 2) UV Spectroscopic Laboratory Analysis Equipment, 3) Bio-medical instrumentation, and 4) Biological weapons detection using UV fluorescence. This expertise will expand the technology base of the U.S. semiconductor manufacturing sector. In addition, low power point-of-use purification systems enabled by this technology will meet a crucial humanitarian need.

Title: SBIR Phase II: Development of an Imaging X-Ray Spectrometer

Award Number:	0620578
Program Manager:	Murali Nair
Start Date:	July 5, 2006
Expires:	February 28, 2007
Total Amount:	$644,000

Investigator: Michael Feser, mfeser@xradia.com
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Mayaguez, PR 00681
Phone: (787)834-5700

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project addresses the development of a novel real-time bio-aerosol machine for detecting and identifying harmful bio-aerosols present in the environment. The system will use the time of flight method to determine the aerodynamic size, and the Multiphoton Laser Induced Fluorescence (MLIF) method for the identification of the fluorescence spectrums. The novelty of the detection machine lies in the use of in-line, non-invasive techniques to measure these two important parameters. The system will consist of a compact laser source, a laser diode, a spectrometer, fiber optics couplings, a series of lenses and filters, pumps, flowmeters and pressure transducers. The sensor will be driven by two printed circuit boards and by computer software both uniquely designed for the proposed detector.

The need for the proposed instrument is of high priority in current times due to the extreme concerns about air quality issues and the high probability of terrorist attacks in large urban settings. The initial target markets for this product are "first emergency response" civilian agencies, medium to large size hospitals, and the armed forces.

Title: SBIR Phase II: An Improved Multi-Sensor Manufacturing System for Scrap Metal Sorting

Award Number:	0548698
Program Manager:	George Vermont
Start Date:	January 23, 2006
Expires:	January 31, 2008
Total Amount:	$499,991

Investigator: David Spencer, dbswte@aol.com
Company: wTe
7 Alfred Circle
Bedford, MA 01730
Phone: (617)275-6400

Abstract:

This Small Business Innovation (SBIR) Phase II project combines two technologies (XRF and Laser Induced Breakdown Spectroscopy) into a single processing system for high speed sorting of scrap metal. The proposed new technology has the potential to revolutionize the way nonferrous metals from recycling facilities are handled. Instead of disposing of the metals in a landfill or selling them as low priced metal mixtures, they can be used directly in commercial applications.

This project is aimed at validating small scale results on titanium and aluminum alloys from Phase I, and designing and constructing a prototype unit to demonstrate commercial feasibility.

Title: SBIR Phase II: Thick Film Planar Magnetooptic Garnet Faraday Rotators

Award Number: 0450470
Program Manager: Juan E. Figueroa

Start Date: September 15, 2005
Expires: August 31, 2007
Total Amount: $443,775

Investigator: Vincent Fratello, vjfratello@integratedphotonics.com
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Phone: (908)281-8000

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project addresses the device and market opportunity for thick magnetooptic garnet Faraday rotator films with planar anisotropy to be operated in the near infrared. Magnetic and electromagnetic field sensors could be developed at a variety of near-infrared wavelengths including the 800 nm, 1310 nm and 1550 nm bands. These sensors can be made much less expensively, in much smaller sizes and with much less weight than current technologies such as current transformers. They have a potential for immediate impact in reliability of electric power distribution through failure anticipation and prevention and conservation of electric power through monitoring and control. Planar materials have much higher switching speeds than conventional perpendicular Faraday rotators and as such would permit a magnetooptical approach to packet switching. Such films are an innovative solution to device problems that require high-speed, continuously-varying polarization rotation with applied field. The project will work on improving properties and performance of such thick planar films and incorporate them into devices. Specific materials tasks are directed to improving sensitivity, linearity and temperature range of operation.

If successful these sensors will have applications such as wheel and turbine rotation, electric power distribution, monitoring, metering and control, and battlefield sensors. The electric power application in particular has potential to revolutionize catastrophic failure prevention in the power grid and reduce power costs at a variety of levels by enabling autonomous reconfiguration. The lack of electrical connectors in fiber optic sensors for explosive, flammable and high-voltage environments represent a significant improvement in safety. New photonic devices not currently realizable will be enabled for telecommunications and military applications such as variable optical attenuators, polarization controllers and increased speed magnetooptic switches. Photonic devices include polarization controllers, variable optical attenuators, switches and new innovative devices. Smart ships and buildings would find utility both for conservation and efficiency.

Title: SBIR Phase II: Portable Sequential Injection (SI)-High Performance Liquid Chromatography (HPLC) Analyzer

Award Number: 0522319
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $500,000

Investigator: Garth Klein, garth@flowinjection.com
Company: FIAsolutions
14450 NE 29th Place, suite 113
Bellevue WA, 98007
Phone: (425)376-0450

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project is aimed at the development of a portable and fully automated chromatographic based analyzer. This analyzer will integrate several proven technologies to produce an automated instrument that is compact, robust and easily implemented for on-line, at-site, or field-ready use, especially where complex HPLC (High Performance Liquid Chromatography) analyses is needed. Based on both Sequential Injection (SI) protocol and HPLC instrumentation, this device will be fully automated and provide an integrated approach with respect to sample collection, pre-treatment, chemical modification, separation and detection of target analytes. This chemical analyzer will exploit several novel technologies including sequential injection, portable high-pressure syringe pumps and sol-gel HPLC columns in its development.

The proposed SI-HPLC instrument will find applications in on-line process control, at-site environmental monitoring or as a multipurpose field-ready analyzer for medical, law-enforcement and military use. Sequential Injection technologies make this analyzer ideally suited for use by untrained personnel or for remote autonomous analysis since sample handling and preparation can be completely automated. Initial targeted use for the SI-HPLC will be for online bioprocess control (e.g. pharmaceuticals) to provide real-time feedback for Quality Control or optimal product yield.

Title: SBIR Phase II: Novel Radial Magnetic Field Actuator for Fully Flexible Electromechanical Valve

Award Number: 0522170
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $462,429

Investigator: David Cope, dcope@engineeringmatters.com
Company: Engineering Matters Inc
375 Elliot St Ste 130K
Newton MA, 02464
Phone: (617)965-8974

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop a novel radial magnetic field actuator for fully flexible electromagnetic automotive engine valves. Electromagnetic valve actuators are rapidly emerging as the technical solution for improved emissions, fuel consumption and greater engine performance. Dramatic improvement in engine performance and reduction in environmental impact is possible with this technology. A fully electronically controlled inlet/exhaust valve actuating system eliminates camshafts and other mechanical components completely, thus (1) allowing optimization of the gas-exchange process across the whole engine speed and load range, and (2) eliminating the packaging restrictions placed upon an engine by conventional camshaft profiling.

The primary application of the actuator is automotive internal combustion engine valves. The ability to alter the lift and timing (opening and closing) of automotive engine valves will create more powerful engines that require less fuel and create fewer emissions. In fuel savings alone, an estimated 15% savings can be achieved, which equates to saving approximately 475 million barrels of oil per year for US consumption worth approximately $21 billion per year. Improving fuel economy is a worthy national goal: it will reduce America's dependence on imported oil, cut the carbon emissions that contribute to global warming, and increase automotive competitiveness.

Title: SBIR Phase II: Assessment of Manufacturing and Fatigue Damage Effects in Titanium Alloys Using Induced Positron Annihilation

Award Number: 0521901
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $446,385

Investigator: Jagoda Urban-Klaehn, klaehn@physics.isu.edu
Company: Positron Systems, Inc.
6151 N Discovery Way
Boise ID, 83713
Phone: (208)672-1923

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop a prototype Induced Positron Manufacturing Damage System (IPMDS) to be used to assess initial component quality, and manufacturing damage effects for Ti-6Al-4V and IN738 components. The IPMDS is based on the Induced Positron Annihilation technologies whose capabilities to assess alpha inclusion and fatigue damage effects have been previously demonstrated. The IPMDS is an innovative damage assessment tool that will be developed with support from Precision Cast Corporation (PCC) as a manufacturing quality control and damage assessment tool to be used to reduce costs in place of current destructive methods, which are expensive and do not provide adequate sensitivity to either manufacturing or operational damage effects. The IPMDS will contribute to extended use component designs, cost savings, and efficient operations for the titanium and nickel super-alloy industries.

Commercial applications of IPMDS will be targeted at the structural and turbine engine industries, which extensively utilize expensive titanium and nickel super-alloy components. The IPMDS has a high potential for becoming a critical and necessary inspection tool in these industries due to its potential for minimizing manufacturing variability, assessing operational damage, optimizing maintenance requirements, reducing costs, and improving safety. The IPMDS capability is expected to extend inspection applications to a wide range of industries where improved knowledge of manufacturing variability, induced damage effects, minimization of inspection and replacement costs, and component life extension are important

Title: SBIR Phase II: A Reversible, Colorimetric Hydrogen Safety Sensor Using Tailored Xerogels

Award Number: 0521760
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $499,999

Investigator: Kisholoy Goswami, kisholoy.goswami@innosense.us
Company: InnoSense LLC
2531 West 237th St, Ste 127
Torrance CA, 90505
Phone: (310)530-2011

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will optimize performance of an optical safety sensor for integration with the hydrogen economy infrastructures. Feasibility of the sensing approach was demonstrated by developing a sol-gel-titania-based indicator formulation, which showed complete reversibility, and response and recovery time of less than a minute with 4% hydrogen. Safety remains a top priority since leakage of hydrogen in air during production, storage, transfer and distribution creates an explosive atmosphere for concentrations between 4% (v/v) - the lower explosive limit (LEL) and 74.5% (v/v) - the upper explosive limit (UEL) at room temperature and pressure. Being a very small molecule, hydrogen is prone to leakage through seals and micro-cracks. The sensor will be further improved with regard to its dynamic detection range, response and recovery times, sensitivity, accuracy, resolution and reduced interference from temperature fluctuations, and atmospheric gases including humidity.

Hydrogen economy is new; public acceptance of hydrogen fuel would require the integration of a reliable safety sensor. Global energy consumption is projected to increase by 50% over the next 20 years. Failure to develop alternatives to oil would heighten growing reliance on oil imports, raising the risk of political and military conflict and economic disruption. The acceptance of hydrogen by the general public as an alternative fuel requires a safety sensor for mitigating the explosion risks due to hydrogen leakage at unacceptable levels

Title: SBIR Phase II: Ultrasensitive, Real-Time Explosives Sensor

Award Number: 0521652
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $483,725

Investigator: James Scherer, jjscherer@novawavetech.com
Company: Novawave Technologies
900 Island Dr Ste 101
Redwood City CA, 94065
Phone: (650)610-0956

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project seeks to develop a new, ultrasensitive laser based explosives detection system (EDS). The system will be capable of rapidly detecting and discriminating among common explosives materials in a timescale commensurate with that of existing passenger screening systems that are presently used in airports. The proposed EDS technology is based on a combination of a new, rapidly and widely tunable laser system with a novel optical cavity enhanced absorption method. The research effort comprises constructing and testing a bench top version of the system that is suitably configured for use in the middle infrared, where explosives can be detected via their characteristic spectral signatures. If successful, the instrument will be capable of significantly exceeding the sensitivity level of existing commercial EDS sensors, as well as potentially providing an orthogonal sensor platform.

The sensor will be suitable for passenger, baggage, and cargo screening applications, and will be engineered specifically for integration as a plug-in replacement or parallel technology to existing screening systems. In addition to advancing laser technology, the project has the potential to benefit society by assuring safer transportation to the general public. The ability to rapidly scan the middle infrared spectral region with high absorption sensitivity will enable the rapid detection of numerous trace chemical species including toxic industrial chemicals, chemical warfare agents, and industrial pollutants.

Title: SBIR Phase II: Oxygen Sensor for Aircraft Fuel Tanks

Award Number: 0522239
Program Manager: Muralidharan S. Nair

Start Date: July 15, 2005
Expires: June 30, 2007
Total Amount: $474,135

Investigator: Travis Martin, tmartin@dakotatechnologies.com
Company: Dakota Technologies Inc
2201 12th St N Ste A
Fargo ND, 58102
Phone: (701)237-4908

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will complete the development of an oxygen sensor that can be deployed inside aircraft fuel tanks. Such a sensor will be needed after the Federal Aviation Agency (FAA) mandates the use of nitrogen-enriched air to prevent explosions like the one that destroyed TWA flight 800. Currently available oxygen sensors cannot withstand the harsh environment and meet the accuracy, longevity, and cost requirements. The technical objectives are to completely characterize and understand the permeation properties of the polymer matrix; examine alternative formulations of the polymer; completely understand the photochemical, leaching, and spectroscopic properties of the phosphorescent dye, examine other candidate dyes, and conduct long-term testing. A flight test of the oxygen sensor is planned.

This research will ultimately benefit society by making air travel safer. It will also serve as a model for the interplay between fundamental science, applied science, and the engineering disciplines during product development. The work will open the door for development of other luminescent sensors that can be deployed in comparably harsh chemical environments, including the measurement of water in fuels and alcohols.

Title: SBIR Phase II: Sensor Technology Enabling Large Array Based Sensors

Award Number: 0450583
Program Manager: Muralidharan S. Nair

Start Date: June 1, 2005
Expires: May 31, 2007
Total Amount: $480,705

Investigator: Tony Ragucci, tony.ragucci@lynntech.com
Company: Lynntech, Inc
7607 Eeast Mark Dr. Ste 102
College Station TX, 77840
Phone: (979)693-0017

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project involves an innovative gas sensor (DiskFET) based on a commercially available hard drive mechanism, proprietary polymers for sensing, and a modified Field Effect Transistor (FET). The device as envisioned is small, handheld, lightweight, low power, and applicable to a diverse range of chemical sensing fields. The DiskFET operates by applying an electric field between a polymer coated rotating disk and stationary FET, which is "floating" a fixed distance above the disk surface, the field strength will be affected by the interactions of the analyte with the polymer coating on the disk. This change in field strength is measured by the FET. By combining the signal responses of all of these relatively non-specific sensors, a "fingerprint" for the analyte is constructed. Using Artificial Neural Network analysis, the concentration and identity of the analyte can be recognized based on a database of the sensor response characteristics.

Personal safety and air quality monitoring is on the rise. More and more workers are becoming conscious of the dangers of their work environments and are demanding adequate monitoring technologies as evidenced by the long-term, steady increase in chemical detector sales. This device will be used for the detection of chemicals such as Ammonia and VOC's with detection limits below current OSHA accepted levels.

Title: SBIR Phase II: Automated Foam Index Test Instrumentation

Award Number: 0450405
Program Manager: T. James Rudd

Start Date: April 1, 2005
Expires: March 31, 2007
Total Amount: $463,748

Investigator: John Stencel, john@triboflow.com
Company: Tribo Flow Separations, LLC
1525 Bull Lea Blvd
Lexington KY, 40511
Phone: (859)259-0011

Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to develop a prototype Automated Foam Index Test (AFIT) instrument for measuring foam indices of mineral admixtures used in concrete; and, a prototype AFIT instrument for controlling dosage of air entraining agents into mineral admixtures and concrete. AFIT instruments take advantage of the physical behavior of foams to identify bubble stability and breakup activity. The Phase I project confirmed concepts behind AFIT to measure air entrapment. The Phase II project creates a commercial-ready instrument. The Phase II research objectives are to (1) construct, test and then refine the tabletop AFIT and the automated sampling, control AFIT prototype instruments; (2) confirm correlations between the foam index/air content values from AFIT prototypes and visual/ASTM measurements; (3) install an AFIT at a partner company and verify its efficacy within a industrial setting; and (4) commercialize these instruments for the concrete industry.

Commercially widespread application of AFIT for the concrete industry would promote replacing cement with less expensive mineral admixtures up to specification limits of 30%. On a worldwide view, the potential cost reduction associated with this replacement is greater than $5 billion per year. Significant societal benefits also accrue. First, because cement production is approximately 10 times more energy intensive than the average of all other industrial activities, green house gas emissions worldwide are decreased significantly when cement is replaced by a less energy-intensive substitute. Second, because the primary mineral admixture used is coal combustion ash, and because it is now predominantly landfilled, environmental impacts and land usage issues are ameliorated.

Title: SBIR Phase II: Infrasonic Avalanche Identification

Award Number: 0449731
Program Manager: Muralidharan S. Nair

Start Date: April 1, 2005
Expires: March 31, 2007
Total Amount: $500,000

Investigator: Ernest Scott, scotte@imlinc.com
Company: Inter-Mountain Laboratories, Inc
555 Absaraka St
Sheridan WY, 82801
Phone: (307)674-7506

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project aims to produce a working prototype sensor array monitoring system that detects, identifies, and localizes the infrasound generated by snow avalanches. The goal of the project is to bring to commercial form automated monitoring systems that improve the safety and welfare of those impacted by avalanche activity. Avalanche-generated infrasound signals can propagate miles from their origin, and provide a basis for automated monitoring and warning systems. Previously developed single sensor infrasound monitoring systems can detect and identify avalanche-generated infrasound in an automated near real-time manner, but performance suffers when avalanche signal amplitudes are small and/or during high wind noise periods. By advancing and refining array-based signal processing algorithms, sensor array monitoring can provide spatial information that greatly improves avalanche signal identification in varying signal and noise conditions while also providing the geographic location of the avalanche signal origin.

Identification of avalanche occurrences will improve safety in avalanche prone terrain and minimize direct and indirect costs associated with avalanche activity. Automated notification of unexpected avalanche activity will provide a prompt for early response activities. Knowledge garnered through this project will advance the field of applied infrasonic sensor array monitoring, an infant science. Innovative hardware and software components that are designed and proven will be available for other infrasound monitoring applications such as tornadoes, volcanoes, flash floods, ocean storms, calving glaciers, aura borealis, ridgeline winds, explosions, and aircraft.

Title: SBIR Phase II: Development of an Optical Sensor for Instantaneous Detection of Bioaerosols

Award Number: 0450546
Program Manager: Muralidharan S. Nair

Start Date: March 1, 2005
Expires: February 28, 2007
Total Amount: $512,000

Investigator: Luis Alva, ctt@vitec2.com
Company: Caribbean Thermal Technologies
177 Balboa St.
Mayaguez PR, 681
Phone: (787)834-5700

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project addresses the development of a novel real-time bio-aerosol machine for detecting and identifying harmful bio-aerosols present in the environment. The system will use the time of flight method to determine the aerodynamic size, and the Multiphoton Laser Induced Fluorescence (MLIF) method for the identification of the fluorescence spectrums. The novelty of the detection machine lies in the use of in-line, non-invasive techniques to measure these two important parameters. The system will consist of a compact laser source, a laser diode, a spectrometer, fiber optics couplings, a series of lenses and filters, pumps, flowmeters and pressure transducers. The sensor will be driven by two printed circuit boards and by computer software both uniquely designed for the proposed detector.

The need for the proposed instrument is of high priority in current times due to the extreme concerns about air quality issues and the high probability of terrorist attacks in large urban settings. The initial target markets for this product are "first emergency response" civilian agencies, medium to large size hospitals, and the armed forces.

Title: SBIR Phase II: Development of an Automated Ballast Water Exchange Monitoring System Using 'Through-the-Hull' Acoustic Modems

Award Number: 0450355
Program Manager: Muralidharan S. Nair

Start Date: March 1, 2005
Expires: February 28, 2007
Total Amount: $497,767

Investigator: Kushal Talukdar, kushal@harrisacoustic.com
Company: Harris Acoustic Products Corporation
141 Washington St
East Walpole MA, 02032
Phone: (508)850-3101

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project is aimed at building the first prototype of an automated ballast water exchange (BWE) monitoring and reporting system. The system will use acoustic modems that use ultrasonic acoustic energy through metal structures as the means of communication. Wireless networking based on radio frequencies (RF) is not very effective within enclosed metal structures such as the hulls of ships. The acoustic modems can be used to overcome such limitations and can establish a local wireless network for data transfer among sensors located in various parts of the vessels. The through-the-hull communications technology is at a nascent but proven state. Existing modems transfer data at 20 bits per second. The Phase-I research showed that a data rate of 500 bits per second (or higher) would exceed the data throughput requirement for BWE monitoring.

Ballast water management is a global issue. The foreign micro-organisms not only destroy the bio-diversity in the native coastal eco systems but create problems for regional economies as well. The impact from the introduction of Zebra mussels in great lakes is estimated at over four billion dollars. Therefore developing an effective and inexpensive technology for monitoring the ballast water has a broader impact on the society. It has the potential to save economies that depend on coastal resources and ensure the preservation of the local eco-systems for future generations without placing excessive restrictions on international maritime trade.

Title: SBIR Phase II: Miniature Mass Spectrometer for Liquids Analysis

Award Number:	0450512
Program Manager:	Muralidharan S. Nair
Start Date:	February 15, 2005
Expires:	January 31, 2007
Total Amount:	$458,475

Investigator: John Grossenbacher, grossenbacher@griffinanalytical.com
Company: Griffin Analytical Technologies, Inc.
3000 Kent Ave
West Lafayette IN, 47906
Phone: (765)775-1701

Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to develop novel instrumentation based on electrospray ionization (ESI) coupled with mass spectrometry for identifying and quantifying chemical species in liquid-phase samples in the field. The goal of this project is to employ an existing Minotaur miniature mass spectrometer (MS) to develop a portable, easy-to-operate detector that will provide real-time and highly sensitive detection of a broad range of chemical compounds in liquid samples in the field. The objectives of the research are to construct, integrate, and optimize an innovative miniature ESI source into the instrument to receive liquid samples and introduce the target analytes to the detector, while minimizing interference from background matrix constituents, and to fully develop and qualify the analytical characteristics and ease-of-use of the instrument during field operations.

Commercially this development of the first field portable, miniaturized ESI-mass spectrometer will have commercial applications in several governmental and commercial sectors, and has the potential to impact society broadly by providing improved monitoring of water resources and protection of the public from chemical exposure resulting from hazardous material accidents or acts of terrorism. If successful, this research will lead directly to developments allowing for determination of compounds of biological origin, e.g. biomarkers, which will provide additional dimensions of information as to the content of analytical samples.

Title: SBIR Phase II: Advanced Phased Array Ultrasound Instrument for Nondestructive Evaluation (NDE)

Award Number: 0450553
Program Manager: Muralidharan S. Nair

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $481,841

Investigator: Vincent Lupien, vincent.lupien@acousticideas.com
Company: Acoustic Ideas Inc.
27 Eaton St
Wakefield MA, 01880
Phone: (781)621-8228

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project strives to develop an Advanced Ultrasonic Beamformer that is unparalleled in its scalability and signal processing features. The ultrasonic beamformer architecture will be unique in its breadth of features. The architecture was developed as the superset of features across several fields including medical imaging, medical therapy, bone density measurement, vascular imaging, and materials characterization. This approach provides each field with an instrument capable of operating outside the normal performance envelope, thereby presenting opportunities for the development of new uses of ultrasound. The benefits of this array include better frame rates, crisper images, and more accurate surgery.

The higher frequencies used in materials characterization, when brought to medical imaging, will allow array transducer to be used where only conventional, single element probes could used in the past, for example in intra-cardiac imaging for surgical instruments, and also for tumor ablation. By design, the proposed architecture encompasses the abilities of many different fields. Each field then enjoys performance capabilities beyond what is normally available, providing a general-purpose tool for research.

Title: SBIR Phase II: Reflectance Sensitive Image Sensor for Illumination-Invariant Visual Perception

Award Number: 0450554
Program Manager: Muralidharan S. Nair

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $499,997

Investigator: Vladimir Brajovic, brajovic@intriguetek.com
Company: Intrigue Technologies, Inc.
513 Harrogate Rd
Pittsburgh PA, 15241
Phone: (412)223-2443

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project proposes to develop an adaptive CMOS image sensor that estimates and largely eliminates illumination variations in sensed optical images thus reporting electronic images that are indicative of the reflectance of the viewed scene. By eliminating illumination-induced variations from the raw optical images the proposed sensor will eradicate the vision system's vulnerability to illumination variations and signal loss due to high dynamic range. The core innovation is in a signal processing technique for estimating the illumination field from sensed images. The technique efficiently implements as a dense on-chip massively parallel analog processor distributed among the photo-detectors to produce a reflectance sensitive image sensor. By compensating for illumination, the proposed image sensor inherently addresses the wide dynamic range problem, that routinely causes conventional cameras to over or under expose producing inadequate images. Even when illumination conditions do not saturate an image sensor, the vision system has to account for object appearance variations caused by illumination.

The proposed research has the potential to broadly impact computer vision performance and reliability. Most present and future vision applications including automotive, biometric, security, and mobile computing applications operate in unconstrained environments and have to cope with unknown and widely varying illumination conditions. Image sensors are rapidly finding their way into people's cars, cell-phones, personal digital assistants, medical and diagnostic equipment, automated drug discovery, cutting edge security, surveillance and biometric systems.

Title: SBIR Phase II: A Device for Measuring Electric Field Strength from Dropsondes and Radiosondes

Award Number: 0450497
Program Manager: Muralidharan S. Nair

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $499,970

Investigator: R. Paul Lawson, plawson@specinc.com
Company: SPEC, Inc.
3022 Sterling Circle
Boulder CO, 80301
Phone: (303)449-1105

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will provide research-aircraft and weather-balloon flight tests a new, novel device for measuring the electric field strength of thunderstorms and hurricanes. Electric field strength is a significant factor in the development of precipitation and lightning, and may even play a role in influencing the intensity of precipitation from thunderstorms. Research aircraft flights that typically measure electric field strength in thunderstorms and hurricanes are difficult and potentially dangerous because of the hazardous conditions, such as lightning, hail and turbulence. However, the new device, called an electric field module, can be contained in a device called a dropsonde and dropped through thunderstorms from aircraft flying above the storm, or attached to weather balloons called radiosondes that are released from the ground.

Since over 7,000 dropsondes and 400,000 weather balloons are routinely deployed each year, adding electric field measures to these devices represents a substantial commercial market. Measurements using the new E-field modules deployed by the SPEC Learjet research aircraft will be unique and open a new realm for analyzing the structure of electric fields in storms. A more realizable goal is improved aviation safety, by virtue of a better understanding of lightning discharges from clouds associated with thunderstorms, particularly anvil clouds, where commercial aircraft are often struck by lightning.

Title: SBIR Phase II: Multi-Coil Surface NMR Instrumentation and Software for 3-D Groundwater Imaging

Award Number: 0450164
Program Manager: Muralidharan S. Nair

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $500,000

Investigator: David Walsh, davewalsh@vista-clara.com
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8849 47th Pl W
Mukilteo WA, 98275
Phone: (425)353-8494

Abstract:

This Small Business Innovation Research (SBIR) Phase II research proposal aims to develop a commercial multi-Coil Magnetic Resonance Sounding (MRS) system for 3-D groundwater imaging and characterization. The principal innovations are the use of multi-coil arrays and the development of coherent signal processing methods to reconstruct 3-D images. The feasibility of this system concept through computer simulation, analysis, and by acquiring experimental (very low SNR) multi-coil NMR data has been established. It is now proposed to design and assemble a field-scale multi-coil MRS prototype instrument with surface coil diameters on the order of 50-100 meters, and to field test this prototype extensively with the U.S. Geological Survey and a groundwater -consulting firm. This multi-coil MRS system enables a critical performance improvement in the area of spatial resolution (3-D vs. 1-D) and at least an order of magnitude improvement in sensitivity (effective SNR).

Inadequate access to clean, safe, and reliable sources of drinking water is a primary cause of disease in the developing world. Inadequate access to groundwater resources, and inadequate understanding of the long-term effects of groundwater use, pose fundamental limitations on economic and agricultural development in much of the developed world, including the United States. As an inexpensive, low-energy, and non-invasive groundwater exploration method, the proposed technology could have significant positive impacts on world health, natural resource management, and economic development.

Title: SBIR Phase II: 2D Transducer Array for 3D High-Resolution Ultrasound Imaging

Award Number: 0450493
Program Manager: Juan E. Figueroa

Start Date: January 1, 2005
Expires: December 31, 2006
Total Amount: $488,109

Investigator: David Lemmerhirt, dlemmerh@soneticsultrasound.com
Company: Sonetics Ultrasound Inc
4890 Troon Ct
Ann Arbor MI, 48103
Phone: (734)260-4800

Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to develop Micro-electro-mechanical systems (MEMS) based, fully populated two-dimensional (2D) ultrasonic transducer array for three dimensional (3D) imaging in real time. Current 2D ultrasound systems employ a linear array of transducers to accumulate images. A planar array is universally acknowledged as the ideal approach for 3D image acquisition; however, multiple challenges must be overcome to make this practical, including: limitations in existing piezoelectric transducer technology, connecting an array with many elements (e.g., > 16,000) to front-end electronics, and processing large amounts of image data in real-time. The highly collaborative Phase II effort will build upon design and simulation results from the The system architecture will provide substantial flexibility in applying digital processing techniques, including adaptive beamforming, synthetic apertures, and phase aberration correction.

The developed technology could bring many new capabilities to medical imaging, including volumetric flow, and real-time 3D imaging for tumor evaluation, image-guided surgery, and fetal echocardiography. Some of these include a breakthrough planar array technology overcomes a key bottleneck in the state-of-the-art in ultrasound, with spillover contributions to non-ultrasound fields (e.g. other MEMS, sonar, other medical imaging, nondestructive testing).

Title: SBIR Phase II: A Novel Clamp-On Self-Powered Flowmeter

Award Number: 0422033
Program Manager: Muralidharan S. Nair

Start Date: November 1, 2004
Expires: October 31, 2006
Total Amount: $496,929

Investigator: Robert McKillip, Jr., bob@continuum-dynamics.com
Company: Continuum Dynamics, Inc.
34 Lexington Ave
Trenton NJ, 8618
Phone: (609)538-0444

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will produce a prototype low-rate fluid flow instrument for nuclear power plants that incorporates several novel features that permit its use as a clamp-on measurement device having minimal installation costs and complications. By utilizing waste heat on piping lines, and wireless data links, the flow sensor system avoids the requirement for an extended wiring system that interconnects and powers the instrumentation within the containment vessel. Accurate and reliable measurement of critical flow systems will ensure piping thermal stresses remain below design limits, for safe continued generation of electric power.

The broader impact of the proposed flow sensor should significantly enhance nuclear power plant system safety by providing a robust, self-contained, zero-maintenance, zero-power instrument for monitoring in-plant piping systems. In addition, the platform for the flowmeter instrument may serve as a basis for a new family of monitoring systems for nuclear power plants and other environments where instrumentation wire runs are costly or prone to failure.

Title: SBIR Phase II: Development of a Low-Cost Harsh Environment Vibration Sensor

Award Number: 0422069
Program Manager: Murali S. Nair

Start Date: September 15, 2004
Expires: August 31, 2006
Total Amount: $475,190

Investigator: Jonathan Geisheimer, jong@radatec.com
Company: Radatec, Inc.
75 Fifth St NW
Atlanta, GA 30308
Phone: (404)526-6048

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop an inexpensive sensor for measuring mechanical vibration and displacement of rotating machines using 5.8 GHz communications components. Current sensing technologies cannot operate in the high temperature and dirty environments often found inside these machines. Major problems often first develop in these unmonitored areas. By providing a new source of information, failures and degradation can be detected earlier.

The broader impacts of the proposed research result from the ability of engineers and scientists to more accurately characterize the internal workings of large rotating machinery (e.g. hydroelectric generator, power generation gas turbine, and DC motor) within the harshest environments. Designers and machine operators will have data in critical areas where failure modes most often occur, allowing for earlier warning of performance degradation and more accurate machine condition monitoring.

Title: SBIR Phase II: Composite Structural Damage Self-Sensing via Electrical Resistance Measurement

Award Number: 0422146
Program Manager: Murali S. Nair

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $498,010

Investigator: Jaycee Chung, jayceechung@sbcglobal.net
Company: Global Contour Ltd.
1145 Ridge Road West
Rockwall, TX 75087
Phone: (214)514-4085

Abstract

This Small Business Innovation Research (SBIR) Phase II project is aimed to capitalize on the Phase I success of an innovative self-sensing of composite structural damage utilizing the electrical conductivity of carbon (graphite) composite materials for structural health monitoring (SHM). The Phase II project is intended to provide a full-scale development (FSD) technology for composite a structural self-diagnostic (CSSD) system/technique. The necessary hardware/software and implementation procedures, such as microchip-based nodal electrical conductivity acquisition electronic circuitry, composite structural self-monitoring computer hardware and software will be incorporated in the CSSD device. The CSSD technology should prevent the catastrophic failures of aircraft and rotorcraft by predicting impending failures of flight-critical composite structural components. The system hardware/software will be demonstrated on new commercial passenger jet aircraft and military aircraft. The application of the CSSD technology should reduce the maintenance cost of the aircraft and rotorcraft due to automated structural health monitoring and diagnostic feature.

Title: SBIR Phase II: Low-Pressure Microplasma Gas Analyzer

Award Number: 0422076
Program Manager: Murali S. Nair

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $500,000

Investigator: Chris Doughty, cdoughty@verionix.com
Company: Verionix
251 Granville Lane
North Andover, MA 01845
Phone: (617)905-0015

Abstract

This Small Business Innovation Research (SBIR) Phase II research project will develop a miniaturized gas analyzer for use in industrial process control, fault detection and monitoring. The gas analyzer proposed here would be able to identify the chemical components of the gas and quantify their partial pressures down to part-per-million (ppm) levels. It will be sensitive to a range of gas species, and be small, have low power consumption and low cost.

The broader impact of this research project will be to advance the nation's scientific and intellectual knowledge base by developing and demonstrating novel plasma emission sources and their applications. It will advance the nation's economic competitiveness by enhancing industrial productivity and the ability of the US semiconductor capital equipment industry to compete worldwide.

Title: SBIR Phase II: A Sensitive Integrated Multi-Speckle Laser Interferometer for Industrial Applications

Award Number: 0422028
Program Manager: Murali S. Nair

Start Date: July 1, 2004
Expires: June 30, 2006
Total Amount: $499,934

Investigator: Bruno Pouet, bpouet@bossanovatech.com
Company: Bossa Nova Technologies LLC
606 Venice Boulevard
Venice, CA 90291
Phone: (310)577-8113

Abstract

This Small Business Innovation Research (SBIR) Phase II project describes an innovative Approach for development of a high sensitivity laser ultrasonic receiver for Application in industrial environment. A high sensitivity classic reference beam interferometer with the ability to efficiently overcome the limitation caused by the speckle light generated from the reflection from rough surface will be developed. The interferometer should be well suited for demanding industrial applications where low cost, sensitive and rugged receiver is needed. Because the proposed interferometer takes advantage of the high integration level of current state-of-the-art in electronic packaging, the system can be made very compact and will be the key element of an ultrasonic system. The robustness, high sensitivity and lower cost of this ultrasonic receiver is hoped to enable laser based ultrasonic inspection to become a cost effective and reliable solution.

The commercial market for this type of laser ultrasonic receiver is targeted at process control and in-service inspection applications where high reliability and low inspection cost is required. The steel industry has expressed strongly a desire to have a system dedicated to the in-process wall-thickness measurement of seamless tube.

Title: SBIR Phase II: Improved Magneto-Optical Imaging Films Employing Surface Plasmon Resonance

Award Number:	0349694
Program Manager:	Murali S. Nair
Start Date:	March 1, 2004
Expires:	February 28, 2006
Total Amount:	$498,774

Investigator: Jeff Lindemuth, jlindemuth@lakeshore.com
Company: Lake Shore Cryotronics, Inc
575 McCorkle Boulevard
Westerville, OH 43082
Phone: (614)891-2243

Abstract:

This Small Business Innovative Research (SBIR) Phase II research project is to develop an improved magneto-optical (MO) visualizer based on a laser-scanning polarimeter and a MO imaging film (MOIF) utilizing surface plasmon resonance. In Phase I, the feasibility of substantial improvements in spatial and magnetic field resolutions and imaging bandwidth over existing methods were demonstrated. In Phase II, the MO material quality and sensor design will be further optimized. The visualizer will be adapted to maximize the many advantages offered by the improved MOIF material. Software will be developed to provide automatic system control and conversion of the acquired image into the quantitative spatial magnetic field distribution. The capabilities of the prototype systems and sensors will be evaluated in terms of magnetic field resolution, spatial resolution and speed through the imaging of electrical current patterns and data storage devices.

Commercial market needs include sensors, instruments and systems for improved magnetic field imaging. Applications include magnetic character reading, magnetic code reading for security, superconductor research, spin valve and magnetic RAM research and manufacturing, integrated circuit electrical current imaging, structural composite stress imaging using magnetic and magnetostrictive materials, flaw detection in metals, biomedical tagging and identification of cancer and other cells, research and testing of MEMS actuators and devices.

Title: SBIR Phase II: Self-Imaging Transmitters for Remote Sensing

Award Number: 0349771
Program Manager: Murali S. Nair

Start Date: March 1, 2004
Expires: February 28, 2006
Total Amount: $458,011

Investigator: Iain McKinnie, iainm@ctilidar.com
Company: Coherent Technologies, Inc.
135 S. Taylor Ave
Louisville, CO 80027
Phone: (303)604-2000

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop and demonstrate self-imaging laser technologies for eyesafe remote sensing applications. Laser based remote sensing applications require a variety of output formats, including amplitude modulated (AM) and frequency modulated (FM) continuous wave (CW) lasers; and pulsed lasers. There are currently no eye safe technologies available with the adaptive waveform capabilities to satisfy these requirements. At eye safe 1.5-micron wavelengths, bulk solid-state lasers are not capable of high average power operation; and conventional fiber laser systems are not capable of handling high peak powers due to optical damage and nonlinear effects. A patent-pending diffraction limited self-imaging waveguide laser technology has been developed that use an adaptive waveform that has the potential to satisfy the average and peak power requirements simultaneously. There are two objectives for the Phase II research- 1) to design a self-imaging laser system with adaptive waveform capability, and 2) to demonstrate an adaptive waveform 1.5-micron laser transmitter. It is anticipated that >20 W of diffraction limited, eye safe average laser power will be achieved with adaptive waveform capability demonstrated. This eye safe self-imaging waveguide laser module is targeted as an enabling technology with broad reaching impact.

The specific markets include remote sensing markets of wind and aerosol detection and 3- D imaging. This technology should have a significant impact because current sensors are complex and costly. Other applications include hazard alerting for windshear, gust front, and turbulence detection; wake vortex detection, tracking, and measurement; and detection and tracking of hazardous bioaerosols.

Geoscience Instrumentation

Title: SBIR Phase II: Gamma Ray Detector for Geophysical Exploration

Award Number: 0522021
Program Manager: Murali Nair

Start Date: October 28, 2005
Expires: October 31, 2007
Total Amount: $479,410

Investigator: Gerald Entine, GEntine@rmdinc.com
Company: Radiation Mon Devices Inc
44 Hunt Street
Watertown, MA 02472
Phone: (617)668-6801

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project aims to produce a radiation detector technology that will be able to provide a completely new level of performance for demanding industrial applications. Three different scintillator materials - $LaBr_3$, $LaCl_3$ and $CeBr_3$ - have been shown in Phase I to provide outstanding results even when subjected to high temperatures. This trait makes these materials well suited for geologic well logging applications where radiation measurements must be in environments where temperatures exceed 175 C. The keys to furthering these materials are tailoring their chemical composition through dopants, producing ingots of larger sizes and packaging them to resist such environments.

Producing more accurate well-logging tools should be a direct outcrop of this project. These tools should in turn enable the geology researcher to more efficiently conduct experiments, and to reduce some of the uncertainties in the otherwise highly speculative field of oil exploration. The broader impacts of this program will encompass both a better understanding of this family of scintillator materials and their use in other applications for which temperature performance is not a key issue. Applications include nuclear science to medical imaging to security and monitoring.

Title: SBIR Phase II: Digital Correlator Imaging Spectrometer For Submillimeter Astronomy

Award Number: 0521830
Program Manager: Muralidharan S. Nair

Start Date: January 1, 2005
Expires: August 31, 2007
Total Amount: $434,230

Investigator: Steven Kaplan, steve.kaplan@hypres.com
Company: HYPRES, Inc.
175 Clearbrook Rd
Elmsford NY, 10523
Phone: (914)592-1190

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop technology to significantly improve digital-auto-correlator spectrometer bandwidths and clock rates. Astronomers are increasing their reliance on digital auto-correlators for receiving sub-millimeter-wavelength signals buried in noise. For larger red-shift sources, bandwidths of tens of GHz are required. Digital spectrometers are also required to manage communications spectrum for wideband wireless software-defined radio systems. These systems under development are based on a radically new wireless-communications paradigm: the analog wireless signal is converted directly to the digital domain at RF frequencies. Wideband superconducting digital-RF hardware will result in extremely robust systems, with revolutionary new opportunities for handling complex waveforms (e.g. the Wideband Networking Waveform).

Astronomers need compact spectrometers to study sources such as planetary atmospheres, molecular clouds, and extragalactic objects. Distant sources have very small signals that are red-shifted by as much as tens of GHz. Therefore, spectrometer bandwidth and sensitivity must be better than present instruments offer. Applying these technology elements to communications enables software-defined all-digital radio systems. Improvements in wireless communications are helping the U.S. to become more productive and socially active. Power efficiency and sensitivity will be orders of magnitude greater than conventional systems, while enabling software functionality and upgrades, at a fraction of the cost.

Title: SBIR Phase II: Advanced Unified Oceanographic Data Logger

Award Number: 0450461
Program Manager: Muralidharan S. Nair

Start Date: January 1, 2005
Expires: December 31, 2006
Total Amount: $495,716

Investigator: Thomas VanZandt, thomas.vanzandt@geosense.com
Company: GEOSense, LLC
409 N. Pacific Coast Hwy., #427
Redondo Beach CA, 90277
Phone: (818)388-2826

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project aims to complete the development of a fully-characterized, commercial prototype, Advanced Unified Oceanographic Data Logger (AUDL). This system aims to provide a new commercial standard for standalone data recording within existing and future oceanographic applications. The same technology will also provide best-in-class performance within the larger markets of terrestrial environmental monitoring. One key feature is that the AUDL will provide a nearly universal sensor interface. It will record data transparently from analog, serial-asynchronous, and digital sensors and instruments. This will enable GEOSense to target a wider range of applications and customers, with a single, low-cost system.

GEOSense will provide a commercial solution that significantly lowers the cost of technical data acquisition within a number of research and engineering applications. By reducing the overall cost of data recording, it is expected that the technology will enhance both the scientific return, and the educational opportunities, from limited research funds. It is hoped that the widespread application of this technology will increase the scope of expertise in oceanographic instrumentation.

Title: SBIR Phase II: Ultra-fast Broadband Imaging Spectroscopy for Geosciences Applications

Award Number: 0422094
Program Manager: Murali S. Nair

Start Date: August 15, 2004
Expires: July 31, 2006
Total Amount: $400,732

Investigator: Qiushui Chen, qchen@bostonati.com
Company: Boston Applied Technologies, Incorporated
150-H New Boston Street
Woburn, MA 01801
Phone: (781)935-2800

Abstract

This Small Business Innovation Research (SBIR) Phase II project is aimed to capitalize on our Phase I success of ultra-fast tunable optical filter technology for the applications of hyperspectral imaging, environmental monitoring and optical communication. During Phase I period, the feasibility of ultra-fast tunable filters based on electro-optical effect have been demonstrated through prototyping. State-of-the-art filter characteristics have been achieved, including ultra-fast response (< 500 ns), wide tuning range (> 80nm at 1550nm), narrow line width (< 0.1nm) and broad working spectral band (from visible to middle infrared continuously). Based on the successful Phase I execution, the major effort of Phase II will be developing an advanced tunable filter platform. At which several commercial products are expected to emerge. Such as ultra-fast hyperspectral imaging systems suitable for geosciences and medical diagnostics, high frequency wavelength modulators for high sensitivity spectroscopic detection of trace-gas and wide-range fast-tuning optical filters for spectroscopy and wavelength-division-multiplexing (WDM) optical communication Hyperspectral imagery has many existing and potential applications in agriculture, forestry, emergency response/disaster management, insurance, national security, oil and gas exploration, medical imaging, and military surveillance.

The proposed components and system, featuring in lightweight, fast action, broad wavelength band, and low cost, is needed for airborne hyperspectral imagery. The tunable add/drop is promise to reduce network complexity and cost by eliminating expensive optical-electrical-optical conversion and reducing inventory of fixed-wavelength devices. A fast wavelength modulation, combined with synchronized detection, can form a very sensitive spectroscopic analytic instrument for trace-gas sensing. These gases usually have characteristic absorption lines in infrared (IR) band, where no other fast tunable filter existed. It has seen a growing demand from the largest application areas, such as chemicals, petrochemicals, power generation, national security and environmental monitoring.

Title: SBIR Phase II: Pipeline Integrity in Natural Gas Distribution and Transmission Systems

Award Number: 0422171
Program Manager: Murali S. Nair

Start Date: September 1, 2004
Expires: August 31, 2006
Total Amount: $499,984

Investigator: Paul Lander, paull@flowmetrix.com
Company: Flow Metrix, Incorporated
2 Clock Tower Place, Suite 425
Maynard, MA 01754
Phone: (978)897-2033

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will solve challenging problems in processing, tracking, and communicating vibration recordings from remote locations in pipelines to determine whether a pipeline has suffered an integrity breach. The solutions include design of new battery-powered, wireless-enabled, rugged field instruments for the harsh pipeline environment, and the development of advanced signal processing methods to characterize and interpret the complex acoustic energy in pipelines.

The broader impact of this research project will be to provide the industry with state-of-the-art, cost-effective equipment that will allow owners and operators to protect their investment in pipeline infrastructure and to meet the mandated pipeline integrity management regulations safely, efficiently and effectively. The societal impact will be increased personal safety through faster and more accurate inspection methods and the preservation of continued affordable energy transportation into the future.

Title: SBIR Phase II: Integrated Electric and Magnetic Free-Space Sensor for Geosciences

Award Number:	0349333
Program Manager:	Murali S. Nair
Start Date:	February 15, 2004
Expires:	January 31, 2006
Total Amount:	$499,607

Investigator: Andrew Hibbs, andy@quasarusa.com
Company: Quantum Applied Science and Research
5764 Pacific Center Blvd
San Diego, CA 92121
Phone: (858)373-0232

Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to integrate a new, free-space electric field (E) sensor with a recently introduced, miniaturized magnetic induction (B) sensor to form a compact six-channel sensor system. The proposed new E-field + B-field sensor should offer a completely new instrumentation capability for geosciences, providing for the first time measurement of all components of the electromagnetic (EM) field vector at low frequency in a single package without contact to the ground or any other physical object. The Phase II objectives are to develop a system prototype with sensitivity and bandwidth suitable for the majority of applications in geophysical surveying, lightning detection, electromagnetic sounding for detection of buried objects, and for general EM research. A side-by-side comparison with state-of-the-art conventional technology will be performed for magneto-tellurics and lightning detection in collaboration with academic and industry experts.

This technology should help develop products for the stand-alone electric and magnetic sensors, as well as a new class of bio-electrode that shares the same basic technology as the E-field sensor. Applications for the bio-electrodes are for human physiologic monitoring such as the electrocardiogram (ECG) and the electroencephalogram (EEG).

MEMS

Title: SBIR Phase II: Automotive Nanocomposites

Award Number: 0822808
Program Manager: Cheryl F. Albus

Start Date: July 1, 2008
Expires: June 30, 2010
Total Amount: $500,000

Investigator: Joel Dulebohn, jidulebohn@comcast.net
Company: Claytec Inc.
5901 Sleepy Hollow
East Lansing, MI 48823
Phone: (517) 862-3928

Abstract:

This Small Business Innovation Research (SBIR) Phase II proposal aims to commercialize a new mesoporous silicate nanoparticles for the reinforcement of thermoplastic polymers used in the manufacture of U.S. cars and light trucks. Whereas nanoparticles, in general, provide some polymer reinforcement benefits, they typically lack the ability to provide strength as well as stiffness. Also, they normally require extensive organic surface modification for dispersion in the polymer matrix. Organic modifiers limit nanoparticles thermal stability and compromise their suitability for nanocomposite manufacturing through cost-effective melt processing methods. The purely inorganic mesoporous silicates this project plans, circumvent all of the limitations caused by organic modifies by providing a unique combination of surface polarity, mesopore size, surface area, and pore volume which optimizes interfacial interactions between the particles and the polymer matrix for effective dispersion and reinforcement. In addition to providing stiffness at particle loadings, the mesoporous silicates provide strength, which allows the amount of polymer needed to produce an automotive part to be reduced in proportion to the added strength. The polymer savings alone allow users of the technology to reduce the weight of the vehicle, achieve stiffness, and improve fuel economy at no added cost. The broader impact/commercial potential of automotive nanocomposites can directly impact the US energy economy, as well as environmental quality. The combination of reduced vehicle weight and increased fuel economy translates into a reduction in petroleum consumption and green house gas emissions. The process for producing mesoporous silicate nanoparticles is neither energy-intensive nor environmentally harmful. Based on aqueous sol-gel chemistry, this project's nanoparticles are manufactured in yields at a temperature of with no harmful waste released to the environment.

Title: SBIR Phase II: MEMS for Secure RFID Applications

Award Number: 0823009
Program Manager: Muralidharan S. Nair

Start Date: July 1, 2008
Expires: June 30, 2010
Total Amount: $500,000

Investigator: Joshua Cross, jdc47@cornell.edu
Company: Cerberex Technologies, Inc.
507 East Buffalo Street, #2
Ithaca, NY 14850
Phone: (607) 227-9539

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will demonstrate a working ?alpha? prototype of a MEMS-based approach to security for RFID and other electronic security applications. MEMS resonators have very narrow bandwidths and high frequencies which vary from resonator to resonator. This natural frequency variation can be used to uniquely identify a resonator, and makes cloning a specific signal extremely difficult ? in essence creating a ?voiceprint?. This approach to RFID security overcomes the drawbacks of encryption which include more complex and expensive tags and the need to manage encryption keys. MEMS resonators for RFID tags are unique, secure, cost effective, CMOS compatible, and fast to read, with low power requirements and low overhead. This research project will demonstrate in a real environment with material temperature swings, working vacuum encapsulated MEMS chips with attached antennas, a low-cost prototype reader with maximum 10cm read range, and reader and system software to extract MEMS response signals to compare with stored signals for chip identification. This project will have broad impact on the security of identification of both people and goods. For example, the RFID tags used in the implementation of US passports were recently cloned which calls into question the security of those documents. Since MEMS resonators cannot be cloned, they can provide significant security assurance to economically validate a given passport. MEMS resonators can also be used to economically authenticate pharmaceuticals since counterfeit drugs are increasingly prevalent (the World Health Organization projects a $75 billion counterfeit market in 2010) and have caused deaths.

Title: SBIR Phase II: Control System Development for Microelectromechanical Systems (MEMS) Segmented Deformable Mirrors

Award Number:	0750521
Program Manager:	Gregory T. Baxter
Start Date:	March 1, 2008
Expires:	February 28, 2010
Total Amount:	$474,995

Investigator: Carl Kempf, carl.kempf@irisao.com
Company: Iris AO, Inc.
2680 BANCROFT WAY
Berkeley, CA 94704
Phone: (510) 849-2375

Abstract:

The Small Business Innovation Research (SBIR) Phase II project aims to develop an integrated control system for adaptive optics (AO) systems based on microelectromechanical systems (MEMS) deformable mirrors (DM). Under ideal circumstances, the resolution of an optical system is limited by the diffraction of light waves. Due to imperfections in optical components however, the limits are never achieved. AO is a technology that enhances the performance of optical systems such as telescopes and microscopes by reducing distortion. It can lead to significantly sharper images which can approach the theoretical diffraction limit. The increase in image sharpness also allows additional gains in contrast, thus allowing detection of faint objects. Although AO has been significantly used for improving the performance of telescopes, an AO system based on MEMS deformable mirrors for use in biomedical applications has not. It would significantly improve image quality and would likely find multiple applications. As such, it would lead to the adoption of AO in a variety of biological imaging settings and would be of benefit to scientists engaged in such research.

Title: SBIR Phase II: Advanced MicroDisplay Engine for Full Windshield Transparent Display

Award Number: 0724453
Program Manager: Juan E. Figueroa

Start Date: September 15, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Jianqiang Liu, jq.liu@compass-innovations.com
Company: Compass Innovations
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a revolutionary miniature projector engine for automotive full windshield display (FWD). The invention allows high quality images with rich graphics to be displayed directly on automobile windshields. The mini-projector engine can be integrated with a rearview mirror. It can be interfaced to the on-board electronics or other communication devices using standard protocols. Based on Micro-Electro-Mechanical Systems (MEMS) fabricated micromirror devices, the proposed display engine provides 4X faster display speed than state-of-the-art vector display devices. Its size is less than 1 in3 and consumes less than 1W of energy. It can be mass produced at low cost and is the most suitable for automotive applications.

If successful the outcome of this project will provide the most effective method to convey information to driver without causing distraction. Unlike traditional HUD, it can display information on the entire windshield. As augmented information display, it can effectively reduce road accidents and save thousands of lives every year! When implemented, even a small 10% of deployment, the market size for this display engine will be 6 millions of units annually in the 60 millions global vehicles market. It will generate hundreds of millions dollars of tax and hundreds of jobs for the United States and bolster the economy.

Title: SBIR Phase II: Wafer-Scale, Hermetic Packaging of Intelligent MEMS-Based Systems

Award Number:	0724340
Program Manager:	Juan E. Figueroa
Start Date:	September 1, 2007
Expires:	August 31, 2009
Total Amount:	$500,000

Investigator: Sonbol (Sarah) Massoud-Ansari, sonbol@mems-issys.com
Company: Integrated Sensing Systems
391 Airport Industrial Drive
Ypsilanti, MI 48198
Phone: (734)547-9896

Abstract:

This Small Business Innovation Research (SBIR) Phase-II project continues to address development of a novel packaging method for wafer-scale hermetic packaging of intelligent Micro-Electro-Mechanical Systems (MEMS). Packaging of MEMS along with their requisite electronics is one of the main technical barriers to commercialization of these devices. Packaging methods are often expensive, have long development cycles, and may adversely affect device performance and reliability. In cases where direct media access is required and the MEMS device needs to operate in harsh environments, protecting the electronics from the media provides a huge challenge. The proposed packaging approach consists of extending the MEMS device and etching a deep cavity into the substrate to house the electronics. A wafer-level hermetic bonding method will then be used to cap the electronics while allowing electrical connection between the electronics and the device. This Phase II project will focus on development of hermetic lead transfer using buried metal layers, and expansion of the packaging method to include wireless applications. Wired and wireless pressure sensor/electronics testbeds will be fabricated to verify overall system integration and evaluated both internally and by external customers.

The potential commercial value of this Small Business Innovation Research proposal will be in several areas. The most immediate area will be revenue from sale of foundry services for packaging and integration of MEMS and their associated electronics. Through its existing Foundry Services Division, ISSYS will provide a packaging platform for wired and wireless MEMS sensor/electronics subassemblies. The second source of revenue is product sales, where off-the-shelf MEMS pressure sensor subassemblies (wired and wireless) will be sold to customers in various medical and industrial fields. The long-term vision is use of this packaging platform for a variety of MEMS-based devices. According to Yole Development, the worldwide MEMS market is forecast to grow from $5.1 Billion in 2005 to $9.7 Billion in 2010. The main product families in this market are inkjet heads, pressure sensors, microphones, accelerometers, gyroscopes, optical MEMS, microfluidics, RF MEMS and micro-fuel cells. The proposed packaging technology will be highly beneficial to pressure sensors, microphones and microfluidic devices, with a combined market forecast of $2.5 Billion in 2010.

Title: SBIR Phase II: Microelectromechanical (MEMS) Mirror Arrays for Bioimaging Applications

Award Number: 0548508
Program Manager: F.C. Thomas Allnutt

Start Date: February 7, 2006
Expires: January 31, 2008
Total Amount: $511,290

Investigator: Tom Tsao, ttsao@umachines.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will advance the state of the art in MEMS deformable mirror arrays. The research will address the key technology bottlenecks in the production of affordable, high performance adaptive optics systems. The objective is to further expand the proof of concept and to successfully fabricate and package the MEMS arrays.

The mirror arrays will play a key part in the understanding, diagnoses, and treatment of the leading causes of progressive vision deterioration and blindness in humans. Having improved retinal resolution will allow physicians to detect diseases and prescribe treatment earlier than current technologies allow. This will allow for increased preservation of eyesight and increase in lifestyle. Further, improved resolution will allow for increased research into various pathologies for additional scientific and medical advancement in a more efficacious time frame.

Title: SBIR Phase II: Lead Zirconate Titanate (PZT) Multimorph Micro-Opto-Electro-Mechanical Systems (MOEMS) Deformable Mirror

Award Number:	0522321
Program Manager:	Juan E. Figueroa
Start Date:	September 1, 2005
Expires:	August 31, 2007
Total Amount:	$499,798

Investigator: Michael Helmbrecht, michael.helmbrecht@irisao.com
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2680 Bancroft Way
Berkeley CA, 94704
Phone: (510)849-2375

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project aims to deliver a dramatic advance in microelectromechanical system (MEMS) deformable mirror performance. Deformable mirrors are the key active component in adaptive optics (AO) systems that provide vastly improved resolution through turbulent air, water, and biological samples. The lack of low- cost, high-deflection (stroke), and low-voltage deformable mirrors has prevented the widespread deployment of AO in a range of fields including biotechnology, ophthalmology, and national security. Phase I successfully demonstrated a new actuation approach for shaping MEMS deformable mirrors. The new approach combines piezoelectric actuation with MEMS deformable mirror technology. The piezoelectric actuators are a true breakthrough as deformable mirror actuation voltage may be reduced from 100-200 volts down to 10-20 volts - a full order of magnitude reduction. The use of smaller, less expensive, safer, and more reliable low-voltage electronics opens the door for a host of applications. The goal of Phase II is to build on the Phase 1 actuator designs to manufacture complete deformable mirror arrays with groundbreaking high stroke, low voltage, low cost, high speed, coupled with superb optical quality.

The high resolution and contrast enhancement enabled by adaptive optics (AO) using deformable mirrors is poised to dramatically advance astronomy, ophthalmology, biology, and national security. Yet for the full potential to be realized, miniature deformable mirrors with high stroke, low voltage, and low cost are critical. If successful the proposed mirror will address the key requirements vital for moving AO into mainstream scientific laboratories and commercial markets. This will have enormous social and commercial impact. Biological microscopes that have far higher resolution, ophthalmoscopes that can image single cells in a living retina, laser microsurgery with precise beam control, and telescopes that can image through atmospheric turbulence will push the boundaries of science. The health and well being of millions will be directly improved as commercialization moves early eye disease detection, customized vision correction, and new medical treatments into doctor offices across the nation. Free space optical communication, and long-range surveillance applications will also reap the benefits of this technology.

Nanostructured Materials

Title: STTR Phase II: Low-Cost Nanoparticles for Enhanced Heat Transfer

Award Number: 0823112
Program Manager: William Haines

Start Date: August 15, 2008
Expires: July 31, 2010
Total Amount: $480,409

Investigator: Yanming Liu, y.liu@amadinc.com
Company: Advanced Materials & Devices Inc
4451 Lynnfield Way
Reno, NV 89519
Phone: (775) 826-8868

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project is to develop and commercialize copper nanofluids for heat transfer enhancement applications. The low cost nanoparticle production methods developed will produce quality nanoparticles for this application. Success of this STTR project will benefit a wide range of applications for heat transfer enhancement including: electronics, HVAC, transportation, textile and paper manufacturing, and energy production systems. The project will also provide educational impact by offering opportunities for student recruitment, research and training, and curricula design at the University of Nevada, Reno.

Title: SBIR Phase II: Chemical Aerosol-flow Synthesis of Nanometals

Award Number:	0823029
Program Manager:	William Haines
Start Date:	August 15, 2008
Expires:	July 31, 2010
Total Amount:	$499,986

Investigator: Yuri Didenko, info@utdots.com
Company: UT Dots, Inc.
115 Paddock Dr.
Savoy, IL 61874
Phone: (217) 390-3286

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop new scale up methods for the synthesis of surface stabilized metal nanoparticles from aerosol. The advantage of chemical aerosol-flow synthesis is in its simplicity in procedure and experimental setup, low cost and scalability. The method allows for the synthesis of high quality nanoparticles in continuous flow regimen. Phase I results proved feasibility of the method for the synthesis of high quality silver nanoparticles with high yield. This Phase II project will focus on increasing manufacturing capabilities to decrease the cost of nanoparticles significantly. Low cost, printed electrical conductors are expected to be a rapidly growing market for flexible electronics and solar cells. Reducing processing temperatures and material costs are key enablers to these growing applications. The low cost production of nanometals will contribute to these trends.

Title: SBIR Phase II: High-Efficiency Nanocomposite Photovoltaics and Solar Cells

Award Number: 0822652
Program Manager: Juan E. Figueroa

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $492,740

Investigator: Valery Rupasov, anteosinc@aol.com
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Phone: (508) 754-3548

Abstract:

This Small Business Innovation Research (SBIR) Phase II project is focused on development of an innovative technology for fabrication of high-efficiency thin film nanocomposite photovoltaic materials and solar cells taking advantage of the recently discovered effect of carrier multiplication in semiconductor nanocrystals. The proposed concept employs smart design of the solar cells providing fast and effective spatial separation of electrons and holes photo-generated in the nanocrystals. The proposed reach nanotechnology platform solves the challenging problem of electrical communications with nanoscale objects, such as nanocrystals, nanorods, nanowires, nanotubes, etc. It can be employed for development of many other nanocomposite optoelectronic devices having numerous commercial and military applications. If successful the development of new generation of high-efficiency photovoltaic materials and solar cells based on the demonstrated technology will have broad impact on the entire solar energy industry resulting in considerable energy savings and environmental protection. The technology has great commercialization potential and niche market. The proposed all-inorganic, high-efficiency, thin film, flexible nanostructured photovoltaic materials and solar cells, which can operate in extreme environment conditions and offer significant mass and volume savings, are ideally suitable for numerous applications, including power generating residential rooftops, power supplies for utility grid, emergency signals and telephones, water pumps, activate switches, battery chargers, residential and commercial lighting, etc.

Title: SBIR Phase II: Development of Cadmium-Free, Water-Soluble and Multicolor Quantum Dots by Chemical Doping

Award Number: 0823040
Program Manager: William Haines

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $500,000

Investigator: Lin Song Li, lsli@oceannanotech.com
Company: Ocean NanoTech, LLC
700 Research Center Blvd
Fayetteville, AR 72701
Phone: (479) 871-0707

Abstract:

This NSF Small Business Innovation Research (SBIR) Phase II project is to synthesize cadmium-free, water-soluble, and multicolor quantum dots (QDs) by chemical doping. The project will focus on the synthesis of high quality doped ZnSe QDs using a newly developed phosphine-free approach. From these cadmium free doped derivatives with high quality blue, green, and red emissione will be produced. Then the doped core/shell QDs will be processed to make them water-soluble and biocompatible through proprietary methods for biomedical applications. Successful development of the proposed techniques will result in a new generation of biolabels and make significant advances in biomedical applications of such cadmium-free doped QDs. The "green" nature of the production methods, mineral precursors, natural surfactants, non-toxic and nonvolatile solvents and cadmium free QDs, will assist to maintain a sustainable environment, in addition to delivering high performance end products to the public.

Title: SBIR Phase II: Dual Substrate MEMS switch

Award Number:	0750536
Program Manager:	Juan E. Figueroa
Start Date:	April 1, 2008
Expires:	March 31, 2010
Total Amount:	$511,945

Investigator: Jaquelin Spong, jackie@imtmems.com
Company: Innovative Micro Technology
75 Robin Hill Rd
Santa Barbara, CA 93117
Phone: (805) 681-2800

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop manufacturing capabilities for MEMS electrical switches with a novel dual substrate design approach. The approach consists of dividing the switch components between two substrates, with the moving portion on an upper substrate, and the stationary contacts on a lower substrate. The moving portion will be formed from a stress-free layer of single crystal silicon, and so has no tendency to warp or distort. Using two substrates allows the contacts to be fully exposed throughout processing, and cleaned just before the substrates are bonded together to form the switch, thereby minimizing the contact resistance of the switch. Because the contacts are exposed, they can be effectively cleaned just prior to sealing in the hermetic seal between the two wafers, thereby reducing the contact resistance of the junctions. This Phase II effort will take the improved design into volume manufacturing to produce higher power, higher frequency, lower contact resistance and/or smaller footprint switches than competing ones while being produced at lower costs. If successful, the approach described here will be used to produce MEMS cantilevered switches for a broad range of applications, from DC power handling applications to RF and radar applications. Because of their high current-carrying, high frequency characteristics with small size and low cost, the MEMS switches may serve as viable replacements for FET switches or micro relays in a wide range of devices. The approach may also be applicable to other sorts of MEMS devices, such as sensors and actuators, which may have a movable component suspended over a substrate which interacts with a fixed component on the substrate. This approach may therefore fundamentally alter how these devices are manufactured, and open up a wide range of applications not presently served by MEMS devices.

Title: SBIR Phase II: Advanced Materials for Hybrid Electrochemical Capacitors

Award Number: 0750183
Program Manager: Cheryl F. Albus

Start Date: February 15, 2008
Expires: January 31, 2010
Total Amount: $467,171

Investigator: Christopher Rhodes, chris.rhodes@lynntech.com
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College Station, TX 77840
Phone: (979) 693-0017

Abstract:

The Small Business Innovation Research (SBIR) Phase II project involves the development of a nanostructured electrode material for high energy and power density hybrid electrochemical capacitors also called ultracapacitors or supercapacitors. Symmetric electrochemical capacitors that consist of two identical electrodes currently utilize flammable, non-aqueous electrolytes to improve the energy density. Hybrid or assymetric configurations that utilize different electrodes result in significantly higher energy densities and can operate in aqueous rather than non-aqueous electrolytes. The objectives of the Phase II project are to optimize the material's synthesis, further characterize the material, perform electrochemical testing to evaluate the energy density, power density and cycle life of the material, optimize the electrode fabrication process and electrolyte composition, and develop a low-cost, large-scale manufacturing process to produce the material. The anticipated result of the project is the development of a new, commercially viable electrode material that enables hybrid electrochemical capacitors with improved energy density, lower cost, and improved safety over current technologies. The development of low cost, high performance electrochemical capacitors has a substantial impact on the development of electric and hybrid vehicles, consumer and industrial electronics, and telecommunications devices. The broad impact of this technology is to enable the manufacturing of next generation electrochemical capacitors that will have higher energy densities, lower cost, and improved safety compared with current electrochemical capacitors. Hybrid electrochemical capacitors that have high energy densities as well as power densities result in improved performance power systems for numerous medium, high, and pulse-power applications. The ability of the hybrid ultracapacitor to operate in benign aqueous electrolytes reduces the cost of the device and has significant environmental and safety impacts, since current non-aqueous electrolytes are flammable and can emit toxic gases.

Title: SBIR Phase II: Spatially-Resolved Swept-Laser Spectroscopic System for Gold Nanoparticle Sensing

Award Number:	0724231
Program Manager:	Juan E. Figueroa
Start Date:	November 15, 2007
Expires:	October 31, 2009
Total Amount:	$499,939

Investigator: Kevin Hsu, khsu@micronoptics.com
Company: Micron Optics Inc
1852 Century Pline
Atlanta, GA 30345
Phone: (404) 325-0005

Abstract:

This Small Business Innovation Research (SBIR) Phase II project is to develop a spatially-resolved bio-sensing technology based on spectroscopic swept-source optical coherence tomography (S-SSOCT) and gold nanoparticles as bio-sensors at 1060nm spectral region. The proposed system will advance contrast-enhanced molecular imaging of diseased tissue. The project will explore several contrasting agents for imaging applications, among these are; the traditional florescence and absorption dyes, to the latest semiconductor quantum dots and metallic nanoparticles. The recently engineered gold nanoparticles possess superior light scattering and absorbing characteristics as well as long-term stability, and when bound to antibodies, can enable high-contrast molecular and cellular imaging of various diseases. The advancement of biotechnology and nanotechnology will benefit greatly from the ability to perform spatially-resolved and sensitive imaging of diseases in molecular and cellular levels through contrast enhancing agents. One expected outcome of this project is to make it possible to track the effectiveness of pharmaceuticals, treat disease, monitor responses to therapies, as well as to provide novel pairing of therapeutic and diagnostic processes. A particular goal of this project is to advance cancer diagnostic technology by developing a high-speed, high-resolution bio-medical imaging modality using gold nanoparticle as bio-conjugated sensors. This market is driven by synergy between various imaging methods (optical, nuclear, and magnetic) and new types of imaging agents.

Title: SBIR Phase II: Integration of Nanostructured Electrodes with Organosilicon Electrolytes for High Energy-Density Supercapacitors

Award Number:	0724469
Program Manager:	Rathindra DasGupta
Start Date:	September 15, 2007
Expires:	August 31, 2009
Total Amount:	$496,384

Investigator: Robert West, rwest@silatronix.com
Company: Silatronix
University Research Park, Inc
Madison, WI 53719
Phone: (608)441-2700

Abstract:

The Small Business Innovation Research (SBIR) Phase II project proposes the development of ultracapacitor devices that combine the use of nanostructured carbon electrodes with organosilicon electrolytes. These innovative ultracapacitor devices are expected to provide higher working voltages than existing devices, yielding significantly increased energy and power density. This Phase II project will use laboratory results to develop prototype devices and address issues associated with scale up and development of procedures for creating prototype devices. These ultracapacitor devices will be characterized for long-term use by evaluating their physical properties and stability.

The size of the ultracapacitor market, already surpassing $200M, continues to grow at a compound annual growth rate of more than 15%. The development of improved ultracapacitor energy storage devices should accelerate this growth by facilitating the commercial development of low-emission vehicles, which should reduce the overall demand for energy. Organosilicon-based electrolytes should improve the overall safety profile of ultracapacitor devices due to their low flammability and low vapor pressures. The improved safety and improved physical characteristics will expand opportunities for the use of ultracapacitors as robust energy storage devices in consumer electronics and industrial applications. This work will also assist in the development of a trained workforce by involving graduate students and postdocs in the research and development effort.

Title: SBIR Phase II: Nanostructured Materials and Process for Improved Electrochromic Device Performance

Award Number: 0724375
Program Manager: William Haines

Start Date: September 15, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Douglas Weir, dweir@sage-ec.com
Company: SAGE Electrochromics Inc
One Sage Way
Faribault, MN 55021
Phone: (507)331-4902

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project is to develop full size electrochromic (EC) window glazings with superior performance and durability due to the incorporation of sputtered nanocomposite thin film materials. These window glazings can be electronically darkened to control solar light and heat in buildings and vehicles. The new materials and processes will be tested for prototype glazings followed by the development of a robust manufacturing process with optimum product yield and reliability. Numerical simulation techniques will be used to model how process input variables impact product attributes with a goal of minimizing device variation and optimizing performance.

The performance and reliability improvements achievable from this SBIR project are essential for widespread acceptance of electronically tinted windows. The improved transmission properties and more neutral coloration obtainable with nanostructured materials are highly desired commercial features. A successful project will lead to widespread adoption of EC windows and enable annual energy savings of up to 0.7 quad to occur sooner. This corresponds to a reduction in carbon emissions of ~10.5 million metric tons per year. In addition to architectural windows, deposition technologies for nanostructured films can improve the performance of transportation windows, flat panel displays, and alternative gate oxides for advanced CMOS technology.

Title: SBIR Phase II: Developing Advanced Ultracapacitors Using Carbon Nanomaterials and Environmentally Friendly Electrolytes

Award Number:	0724468
Program Manager:	Rathindra DasGupta
Start Date:	August 1, 2007
Expires:	July 31, 2009
Total Amount:	$499,993

Investigator: Wen Lu, wenl@adatech.com
Company: ADA
8100 Shaffer Parkway
Littleton, CO 80127
Phone: (303)792-5615

Abstract:

The Small Business Innovation Research (SBIR) Phase II project seeks to develop advanced ultracapacitors for hybrid electric vehicles (HEV). The proposed research combines the unique properties of carbon nanotube (CNT) electrodes with those of environmentally friendly ionic liquid electrolytes to develop ultracapacitors possessing high performance (energy and power densities) and long life for HEVs. The proposed research will focus on optimization of CNT materials, production of selected CNT electrodes on a larger scale, and fabrication and evaluation of packaged prototype ultracapacitors.

Advanced vehicular ultracapacitrs are extremely useful in achieving better fuel economy, decreasing harmful emissions, and reducing the nation's reliance on foreign sources of petroleum. More generally, ultracapacitors are essential components in consumer electronics (ex: notebook computers, cell phones, pagers, video cameras), medical electronics (ex: drug delivery units), and military and defense systems (ex: spacecraft probes, missile systsms). In addition to ultracapacitors, research in the proposed project will also have a broad impact on the applications of carbon nanomaterials to other electronic and electrochemical devices.

Title: SBIR Phase II: Quantum Dot / Fluoropolymer Composites: A New Approach for Enhancing Performance in Light Sources

Award Number:	0646322
Program Manager:	Juan E. Figueroa
Start Date:	March 1, 2007
Expires:	February 28, 2009
Total Amount:	$499,997

Investigator: Earl Wagener, ewagener@bellsouth.net
Company: Tetramer
657 S Mechanic Street
Pendleton, SC 29670
Phone: (864)653-4339

Abstract:

This Small Business Innovation Research (SBIR) Phase II project describes an innovative approach to encapsulating nanocrystals (quantum dots and rare earth doped inorganics) using functionalized perfluorocyclobutyl (PFCB) polymers. This project will expand the range of ligands synthesized in Phase I specifically designed to enhance the encapsulation of nanocrystals currently being developed for commercialization in the rapidly growing light emitting diodes, displays, planar infrared amplifiers and photovoltaic markets. In Phase I, the company developed a significant competitive advantage by increasing nanocrystal loading to unprecedented levels with uniform distribution and little or no loss of performance. Further competitive advantages over current encapsulating polymers such as silicones, epoxies, and polycarbonates are Tg's above 250 0C, optical clarity at 800, 1330 and 1550 nm, and no free radicals or by-products during polymerization. This encapsulating performance creates an excellent competitive advantage since it meets a critical enabling need in the field of nanophotonics. The technical objectives for this project are 1) Synthesize 7 new functionalized polymers 2) Work with nanocrystal and device manufacturers to commercialize new nanocrystal composites for the markets shown above 3) Down select and scale up the best materials for commercialization. The Tetramer team has over 50 years of successful specialty polymer commercialization.

If successful the results of this project will enhance scientific and technical knowledge in the very active field of quantum dot and rare earth doped inorganic nanocrystals. In particular, the interaction between the unique functionalized PFCB polymers and the nanocrystal surface will provide new fundamental technical insights for the origins of performance of these materials in LED's, displays, infrared amplifiers, and photovoltaic devices. Improvement of devices in these markets has the potential for strong societal and commercial impact. For example, light emitting diodes replacing incandescent lighting alone could decrease national energy consumption by 29%, while more efficient, lower cost solar cells would reduce the US dependence on foreign oil. Use of these new encapsulating materials will enable new device designs for these high priority markets. This in turn will lead to improved cost performance therefore accelerating commercialization and the subsequent societal benefits of reduced energy usage and improved communications.

Title: SBIR Phase II: Titania-Loaded Silicone with High Refractive Index for Light-Emitting Diode Encapsulation

Award Number: 0646439
Program Manager: Juan E. Figueroa

Start Date: February 15, 2007
Expires: January 31, 2009
Total Amount: $500,000

Investigator: Jong Kim, TroyResearch@nycap.rr.com
Company: Troy Research Corporation
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Phone: (518)271-2044

Abstract:

This Small Business Innovation Research (SBIR) Phase II project addresses the development of a new class of materials, namely polymeric nanomaterials with a very high refractive index, which will closely match the refractive index of inorganic semiconductors. The encapsulant materials consist of titania-nanoparticle-loaded silicone and epoxy. Titania (TiO2) has a refractive index of 2.68 and the admixture of TiO2 with a polymer would result in an increase of the refractive index. The well-known problem of excessive optical scattering will be overcome by proper use of surfactants and an encapsulation structure that employs thin films, with a thickness that is less than the average distance between scattering events.

If successful the development of a new high-index encapsulant will have a tremendous impact on SSL technology because virtually all SSL devices made of inorganic semiconductors are packaged and encapsulated. A successful completion of the program will result in a worldwide paradigmatic shift in the packaging and encapsulation of optoelectronic devices. The broad deployment of efficient LED technology for general lighting applications would also result in electrical energy savings in the TWh range per year within the United States alone.

Title: SBIR Phase II: Supercritical Fluid Processing of Polymer/Clay Nanocomposites

Award Number:	0646447
Program Manager:	William Haines
Start Date:	January 1, 2007
Expires:	January 31, 2009
Total Amount:	$498,536

Investigator: Steve Horsch, steveedwh@hotmail.com
Company: nSEC
6942 Lakemont Circle
West Bloomfield, MI 48323
Phone: (313) 550-8523

Abstract:

This Small Businesss Innovation Reseach (SBIR) project will address a major technological barrier to producing superior nanocomposites by overcoming the
difficulty of dispersing nano-fillers uniformly in a host matrix to derive the maximum surface area advantage. When effective filler dispersion is coupled with improved polymer-clay interactions, a significant technological gap in the field of polymer nanocomposites can be addressed. The company, nanoSEC has licensed, developed, and 'validated' (lab scale) a supercritical fluid-based dispersion (SCFP) technology, that produces significant clay dispersion using a simple, versatile, environmentally friendly process that utilizes the unusual properties of supercritical CO2. During Phase I, the clay dispersion conditions were optimized and showed significant property improvements in the resultant nanocomposites that were appreciably better than those in literature. During Phase II, these technical accomplishments will be translated towards commercial success by: (1) producing and benchmarking pilot-scale polystyrene/clay, polyethylene/clay, polypropylene/clay nanocomposites for mechanical and barrier property improvements, with applications in automotive and food packaging industries; (2) scaling up the pilot production process to produce 200 lbs/week of dispersed clay in Year 1, and to produce 1 million lbs/year of polymer-clay nanocomposites (at 10% clay loading) by Year 3; (3) developing specific joint development agreements with business customers for faster adaptation of nanoSEC's technology in actual products.

Commercially, nanoSEC's technology addresses a key need in nanocomposites, which could single-handedly revive the packaging technology applications of nanocomposites. Several companies have expressed strong interest in joint development agreements. Working closely with Wayne State, and end users like Ford, Daimler Chrysler, and GE Plastics will enable nanoSEC to advance both on research and commercial sides to produce a revenue of close to $ 8 million by the end of 2008. The Phase II project will enable pilot-commercial scale validation for rapid development and nanoSEC's location in the state-of-the- art NextEnergy building in Detroit, and the familiarity of the participants with the automotive and food packaging industry will enable unique applications to be achieved in a timely manner. The 'top down' strategy to partner with end users will enable fast implementation upon validation.

Title: SBIR Phase II: Synthesis and Processing of High Performance Polymer Nanocomposite Foams

Award Number: 0620502
Program Manager: James Rudd

Start Date: August 31, 2006
Expires: August 31, 2008
Total Amount: $500,000

Investigator: Guojun Xu, xu96@yahoo.com
Company: NIL
1109 Millcreek Lane
Columbus, OH 43220
Phone: (740)522-6617

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop and scale-up a new group of light-weight, high-strength and fire-resistant polymeric foams by using innovative nanotechnology. The project explores the synthesis of nanocomposites using both plate-like and fiber-like nanoparticles with high carbon dioxide (CO2) affinity. Polymer blends including a minor phase with high CO2 solubility are used as the matrix material. To improve fire-resistance, surfactant-free and water-expandable polymer/clay nanocomposites are also prepared by suspension polymerization of inverse emulsion. Since low molecular weight surfactants are not needed, there is no fire hazard problem. These polymer blend nanocomposites are then used to produce high performance foam products aimed at both insulation and structural applications. The presence of nanoparticles in polymer blends allows better control of cell morphology and foam density in the manufacturing processes. Ultra-low-density foams with thermal insulation properties better than the existing insulation materials and high-density microcellular foams with mechanical properties close to those of solid polymers are achieved. The materials and processing conditions will be optimized to obtain better foamability and mechanical properties of these novel nanocomposites foams.

Commercially, nanocomposite reinforced foams have the potential in structural applications to replace solid polymers. The U.S. market for polymer foams was more than 7.4 billion pounds in 2001. Currently, their applications are limited by poor mechanical strength, surface quality, thermal stability and fire retardance. Furthermore, traditional chlorofluorocarbon (CFC) blowing agents cause ozone depletion and will be banned by 2010. As environmentally benign blowing agent CO2 is used to replace CFCs, the success of this project will be extremely valuable for environmental protection. A successful implementation of this novel technology can lead to significant impact on energy saving, material saving, and environmental protection that are critical to our nation's economy and societal health.

Title: SBIR Phase II: Commercial Scale Production of High Quality and Affordable Fe3O4 Nanocrystals for Nano-Biomedicine

Award Number: 0620323
Program Manager: Murali Nair

Start Date: August 8, 2006
Expires: July 31, 2008
Total Amount: $499,997

Investigator: Yongcheng Liu, ycliu@nn-labs.com
Company: NN-Labs
513 Harrogate Rd
Pittsburgh, PA 15241
Phone: (412)223-2443

Abstract:

This Small Business Innovation Research (SBIR) Phase II project intends to finalize commercial production protocols for high quality, highly stable, bio-compatible, bio-accessible, and yet affordable Fe3O4 nanocrystals and related magnetic beads. Current state-of-the-art methodology for making Fe3O4 nanocrystals for biomedical applications has many critical deficiencies including poor ability to control size, broad size distribution, difficult/complicated surface chemistry, high cost and low solubility in solutions. This technology will produce high quality of Fe3O4 nanocrystals. The company's products have excellent control of size and size distribution and offer super stability and friendly surface chemistry so that they are completely dispersible in solutions due to their simple processing and manufacturing technique. Their terminal groups are ready to conjugate various bio-molecules so that they can be used in various biomedical applications.

The primary application for this technology will concentrate on the life science research. Specific applications include (1) Magnetic bio-separation, (2) Magnetic resonance imaging (3) Drug delivery, and (4) Biomedical treatment. The biomedical applications related to the Fe3O4 magnetic nanocrystals cover many aspects of biomedical fields, ranging from diagnostics, detection, therapy, separation, and pollution control. The environmentally benign nature of this technology helps to achieve a sustainable environmentally-aware business paradigm.

Title: SBIR Phase II: Lithium Reservoir Nanocarbons for Lithium Ion Batteries

Award Number:	0548708
Program Manager:	Rosemarie Wesson
Start Date:	January 27, 2006
Expires:	January 31, 2008
Total Amount:	$462,455

Investigator: Ronald Jacobsen, rljacobsen@mlpc.com
Company: Applied Sciences, Inc
141 W. Xenia Ave.
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop Li-ion battery anodes that exploit the unique morphology of low cost carbon nanofibers (CNF). Primary efforts will focus on reduction of irreversible capacity, through a variety of nanofiber surface modification techniques, characterization of the upper limits of anode discharge rate, and development of a new type of compound anode material that combines CNF with elements that form high energy alloys of lithium. The latter effort has the potential to combine the high rate capability of CNF with the higher operation voltage of alloys in a manner that synergistically increases the reversible capacity of both components of the compound anode.

Safe, rechargeable, inexpensive Li-ion batteries are enjoying a growing customer base in diverse markets from consumer electronics to space vehicles. The unique morphology of carbon nanofibers and the fact that these materials can readily be transitioned into an existing client base of Li-ion battery producers and users, holds great promise for this cutting-edge research.

Title: STTR Phase II: Benign Thin Film Composite Particles for Protection from UVA/UVB - Rays

Award Number:	0548739
Program Manager:	George Vermont
Start Date:	January 9, 2006
Expires:	December 31, 2007
Total Amount:	$448,225

Investigator: Karen Buechler, buechler@aldnanosolutions.com
Company: ALD NanoSolutions, Inc.
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Broomfield, CO 80020
Phone: (303)318-4145

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project provides for the commercialization of surface-passivated composite titania/zinc oxide particles for benign protection from UVA and UVB radiation. The composite particles are manufactured via novel atomic layer deposition (ALD) technology. These materials are targeted at use in sunblock skin care formulations; the inert coating will allow easy dispersion of the particles in a variety of formulations, and will prevent direct contact between active titania or zinc oxide and the skin. The major health problem of sun-induced skin cancer could be helped with the introduction of new, more effective UVA/UVB protection in a wider variety of skin care products.

This Phase II project will focus on refining the material design, production at larger scale, and proving the effectiveness of these composites in formulations for UVA/UVB transmittance and sun protection factors.

Title: SBIR Phase II: Quantum Confined Atom Based Nanophosphors for Future Efficient Lighting

Award Number: 0521948
Program Manager: T. James Rudd

Start Date: September 15, 2005
Expires: August 31, 2007
Total Amount: $424,693

Investigator: Rameshwar Bhargava, rbhargava@nanocrystals.com
Company: Nanocrystals Technology Limited Partnership
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Phone: (914)923-1142

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will involve quantum confining a single atom in 2 to 5 nm size nanocrystal of ternary semiconductor, from which new and efficient nanophosphors will be developed. The band-gap engineering of nanophosphors allows improvement in the luminescence characteristics such as absorption and emission spectra, half-width, efficiency, life-time, etc. Indeed the role of conventional activators (rare-earths and transition metal impurities) in nanophosphors can be re-evaluated for different applications. Specifically, ternary wide band gap semiconductors such as ZnCdS with dopants like Ag, Cu, Mn offer very efficient broad-band visible spectra that is close to white light. The possibility of band-gap engineering in nanocrystals of ternary semiconductors, similar to that catapulted the optoelectronic devices from III-V semiconductors, opens the door to design of new nanophosphors that match well with the excitation spectra of LED's and compact fluorescent lamps. This development would lead to a new class of white light sources in this Phase II project. By developing different nanophosphors that can be excited by blue/UV LEDs, it successfully demonstrates that nanophosphors can significantly enhance the performance of not only white LEDs but also can improve the performance of compact fluorescent and arc lamps.

Commercially this technological breakthrough of engineering of nanophosphors when used with current efficient lamps, is expected to enhance the efficiency of LED's by 40% and lamps by 15%, respectively. These improvements in overall power efficiency of these lamps, will significantly lower the cost of energy used and it is projected will help to save energy costs equivalent to $25 billion by 2025.

Title: SBIR Phase II: Carbon-Coated Nano-Structured Electrodes for Next-Generation Lithium-Ion Batteries

Award Number: 0522287
Program Manager: Rosemarie D. Wesson

Start Date: July 1, 2005
Expires: June 30, 2007
Total Amount: $476,850

Investigator: Timothy Spitler, tspitler@altairinc.com
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204 Edison Way
Reno NV, 89502
Phone: (775)858-3742

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will demonstrate superior power-delivery, rapid-charge, and long cycle-life performance of prototype carbon-coated, nanoparticle-based electrodes for use in inherently safe, moderate-to-large sized lithium ion batteries of various commercial designs. The primary innovation is the use of optimally sized, arranged and assembled carboncoated nanoparticles that preserve the intrinsic performance characteristics of the bare nanocrystalline materials when fabricated into thin-film electrode structures for use in advanced power sources. Phase I focused on improving performance of nanostructured aggregates of 20nm lithium titanate (n-LTO, used in anode service) via carbon coating for better electrical and ionic connectivity. Phase II will develop appropriate carbon-coated nanomaterials for cathode service designed to match the n-LTO anode performance; providing matched Li-ion host anode-cathode pairs for next-generation performance

There are demonstrated market for fast-charge, long-life batteries in a broad range of consumer applications. Markets require that it be possible to reliably and economically recharge remote devices, including portable computers; hand tools, lawn mowers and medical devices; electric cars, motorcycles and mopeds in a matter of minutes rather than hours, and faster discharge rates translate immediately to higher power per unit weight.

Title: SBIR Phase II: Carbon Nanotubes Field Effect Transitors (FET) Platform for Electronic and Sensors Applications

Award Number: 0450648
Program Manager: T. James Rudd

Start Date: April 1, 2005
Expires: March 31, 2007
Total Amount: $499,999

Investigator: Jean-Christopher Gabriel, jcgabriel@nano.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to design and develop a molecular nano-sensor platform for researchers developing new chemical and bio-sensors. The principal component of these devices will be an array of single-wall carbon nanotube transducers on a silicon chip. The product itself will be a sensor development kit comprised of a set of sensor chips, an electronics module with a standard PC interface, adaptors for gas and liquid sensing, data reduction and analysis software, and directions for product use. General guidelines for the additional of specialized functionalization chemistry and biology to the sensor chip will be included. The project objectives include developing a set of 5-10 different chip architectures for gas, liquid and biosensing together with modules for sensing in both gases and liquids. The CMOS mask design will include as many as ten different architectures suitable for different types of experiments and functionalization layers. The sensor chips themselves will be manufactured on 4-inch silicon wafers and set into a standard CERDIP package that fits into the top of the electronics module. Signal processing electronics and software systems will be designed and integrated to deliver digital sensor output to LabView(TM) on a PC. The research involved in meeting these goals encompasses the design, prototyping and experimental testing of each component of the development platform. At the culmination of Phase II, the molecular nano-sensing platform will be validated by collaborative users in UCLA, UC Berkeley and UC Irvine, and positioned for market introduction.

Commercially this novel nanosensing platform will enable research and product development in molecular level phenomena related to chemical reactions and catalysis, chemical
and biological sensing, and photonics. The work described in this proposal will produce a valuable new nanoelectronics research tool that will ultimately result in new discoveries and products in sensing and diagnostics. Researchers seeking to develop new direct electronic detection sensing applications and conduct charge transfer experiments at the molecular level lack a robust, inexpensive experimental platform. In most cases researchers must develop their own experimental apparatus, interfaces and software. For those wishing to take advantage of the sensitivity and flexibility of nanoelectronic arrays, fabricating the devices is a formidable and cost prohibitive challenge. This project seeks to provide a state-of-the-art nanotechnology-based solution in an ultra sensitive and flexible detection platform.

Title: SBIR Phase II: High Performance Thin Film Transistors on Plastic Fabricated from Dense Thin-Films of Oriented Semiconductor Nanowires

Award Number: 0450585
Program Manager: T. James Rudd

Start Date: March 1, 2005
Expires: February 29, 2008
Total Amount: $999,554

Investigator: David Stumbo, dstumbo@nanosysinc.com
Company: Nanosys Inc
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Phone: (650)331-2106

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a revolutionary new high-performance thin-film-on-plastic technology that will provide single-crystal silicon, thin film transistor (TFT) performance. This technology is based on a novel thin-film semiconductor on plastic composed of a dense film of parallel nanowires with electronic properties comparable to single-crystal silicon that can be deposited at low temperatures. In Phase I, the feasibility of this innovative technology was successfully demonstrated and key device design and material processing parameters to address underlying device performance were identified. Specific developments included (1) nanomaterial deposition (2) contact technology (3) doping processes and (4) device architecture. Phase II research will build on the knowledge gained in Phase I, and focus on further optimization of device performance and the development of roll-to-roll manufacturing processes. The output of Phase II will be a prototype array of transistors on plastic. In addition, this fundamental concept can be applied to nanowire materials other than silicon, allowing the production of thin films of material that presently are impossible to produce over large areas on any substrate, including semiconductors relevant to communications (GaAs, InAs), optically active materials (GaN, InP), piezoelectric or ferroelectric materials ($SrTiO_3$), or materials of mixed composition with newly engineered properties.

Commercially, this research will impact greatly the development of high performance TFT devices on plastic for commercial, military, and homeland security markets. These high-performance, flexible semiconducting films have the potential to replace amorphous and polycrystalline silicon in important large-area electronics applications such as displays and also radio frequency identification tags (RFID'S).

Title: SBIR Phase II: Dye Co-Sensitizer Combinations for Increasing the Efficiency of Dye-Sensitized Titania Nanoparticles in Solar Cells

Award Number:	0450532
Program Manager:	T. James Rudd
Start Date:	February 15, 2005
Expires:	January 31, 2007
Total Amount:	$511,977

Investigator: Russell Gaudiana, rgaudiana@konarka.com
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Lowell MA, 01852
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Abstract:

This Small Business Innovation Research(SBIR) Phase II project aims to commercialize lightweight, flexible, affordable solar cells and modules that efficiently generate electricity from sunlight or indoor room light. These cells are based on dye-sensitized titania which is coated on a flexible substrate at high speed in a continuous coating, laminating process. The overall objective of Phase II is to raise the cell efficiency from its current 7% to 10% or higher, thereby raising the module efficiency from 5% to over 8%. To accomplish this, the ability of the sensitizing dyes to harvest a much larger number of available photons and convert them into electrons must be increased. In Phase I of this program, a new class of sensitizing dyes that cover a larger portion of the solar spectrum, have larger absorptivity than the currently used ruthenium-based dyes was discovered. In addition, materials that have similar molecular structures to those of the new sensitizing dyes, and act as co-sensitizers by boosting electron injection from the dye to the titania, are co-adsorbed with the dyes on the surface of the titania. It is anticipated that the combination of these materials will bring the cell and modules performance to the desired level.

Commercially, the project will result in an inexpensive, efficient, flexible photovoltaic (PV) technology that can be integrated into consumer products. Therefore a renewable source of energy could be used to power products, minimizing the battery capacity and disposal requirements, and ultimately delivering power to building structures, avoiding emissions associated with fossil fuels. Security is a broad benefit on two levels. First, grid instability demonstrated by widespread blackouts in 2003 emphasizes the need for distributed power in our national grid. Secondly, growing homeland security concerns underscore the importance of wireless networks of sensors, cameras, and other monitoring systems for building and border security. Photovoltaics are uniquely suited to serve these distributed applications

Title: SBIR Phase II: Nanotube-Based Electronic Pressure Sensor

Award Number:	0422198
Program Manager:	T. James Rudd
Start Date:	October 1, 2004
Expires:	September 30, 2006
Total Amount:	$499,260

Investigator: Lian Zhang, lian@monano.com
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977 Commercial Street
Palo Alto, CA 94303
Phone: (650)846-2519

Abstract:

This Small Business Innovation Research (SBIR) Phase II program focuses on developing carbon nanotube-based electromechanical pressure sensors. To translate the change in pressure into an electrical signal, current solutions (MEMS devices) use membranes with sensors made out of doped silicon. Silicon, however, is prone to effects of temperature changes and as a result, such devices require additional electronics for temperature compensation and more stringent packaging. They also have sensitivity limitations. The device in this work will use carbon nanotubes as strain gauges. Because nanotubes have higher sensitivity (higher gauge factor) and better temperature stability, this will result in development of devices that are easier to manufacture (fewer manufacturing steps), have superior precision, and require less stringent packaging, leading to less expensive end-product. This work will combine chemistry for synthesis of materials and microfabrication to explore important properties of a novel nano-material carbon nanotubes. Key technical innovations will include precise placement of nanotubes on thin membranes, novel approaches to avoiding membrane damage during nanotube integration, forming nanotube circuits on membranes for electromechanical pressure sensors and other integration issues.

If successful, the project will lead to the first application of carbon nanotubes in high-end electronic devices, enabling the development of nano-electromechanical systems (NEMS), which convert mechanical effects into electrical signal. Such devices, which would include pressure sensors, accelerometers, gyroscopes and acoustic sensors, could address the unmet needs in a wide range of applications, such as in automobiles, safety, medical, military and process control. Specifically, in the automobile market, a nanotube-based pressure sensor could serve as a tire pressure measuring device and could result in over $180million in annual savings for such end users as the automotive industry.

Title: SBIR Phase II: Nanocomposite Solar Cells

Award Number: 0422147
Program Manager: T. James Rudd

Start Date: September 15, 2004
Expires: August 31, 2006
Total Amount: $499,990

Investigator: Erik Scher, escher@nanosysinc.com
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Palo Alto, CA 94304
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop an innovative solar technology that combines nanotechnology with conducting polymer photovoltaics to achieve light weight, flexible solar cells that surpass current solar cell efficiencies, but can be manufactured at a fraction of the cost. Phase I, successfully demonstrated the feasibility of this innovative technology and identified key device design and material requirements to address underlying loss mechanisms limiting the nanocomposite photovoltaic performance. Specific developments included (1) controlled nanocrystal surface chemistry (2) novel nanocrystal synthesis (3) film morphology control and (4) reproducibility and control of the entire process from synthesis to device measurement. Phase II research will build on the knowledge gained in Phase I, and focus on the development of optimized optical and electronic materials and the development of an advanced stacked-intra-layer recombination device architecture. The output of Phase II will be a prototype of an optimized, light-weight, low-cost, flexible solar cell with efficiency greater than 10%; amenable to large-scale, low-temperature manufacturing by roll-to-roll.

Commercially this technology has the potential to meet the market needs to enable solar energy to become an integral and critical power generation source world-wide, providing societal benefits in the areas ranging from environment to national and economic security. Commercial applications exist for high performance, low-cost solar cells that can provide an alternative power generation source. Specific examples of use include on-grid building integrated electricity generation systems; on-grid wholesale power generation; remote off-grid power generation; portable power generation; and power generation for long-term aerospace applications.

Title: STTR Phase II: Novel Nanocoated Ferromagnetic Materials

Award Number:	0422220
Program Manager:	T. James Rudd
Start Date:	August 1, 2004
Expires:	July 31, 2006
Total Amount:	$469,030

Investigator: Karen Buechler, buechler@aldnanosolutions.com
Company: ALD NanoSolutions, Inc.
11711 Chase Ct
Westminster, CO 80020
Phone: (303)460-9865

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project will build on the great successes of the Phase I program by proving that the nanocoating of fine ferromagnetic particles is possible on the large scale and that such nanocomposite particles have commercial uses. The Phase I program proved that atomic layer deposition (ALD) of an alumina film can provide these properties.The objectives of the Phase II program are to prove the scalability of the process as well as to work with supporting companies to develop specific products for commercial markets. A pilot scale facility will be constructed to increase the scale of production to provide the kilogram quantities of material that most partners require for product development. This facility will be optimized to provide the best quality coatings at the lowest production cost. It is anticipated that at the close of the Phase II program, the company will have developed at least one market for full scale production with 2-4 markets still being developed. The ALD nanocoating of individual ultrafine particles to control individual ultrafine particle surface chemistry is enabling technology that is unparalleled compared to more conventional CVD, PVD, PE-CVD, or wet chemistry solution processing. The process allows for individual ultra-fine particles to be nanocoated, rather than coating aggregates of ultra-fine particles. It is independent of line of sight and provides for chemically bonded films to the substrate particle surface. It is easily scalable. It is a forgiving process where the nanocoating thickness is controlled by self-limiting surface reactions (not flux, temperature, or time of processing like CVD, etc.). Films are pin-hole free and conformal.   Commercially, fine iron particles are used in a variety of applications such as metal injection molding, radar absorption, localized drug delivery carriers, electronic devices etc. Most of these applications would benefit from a smaller initial iron particle size and reduced oxidation sensitivity. Thus nanocoating of ultrafine particles provides many opportunities. It is now possible to produce ultrafine particles with designed electrical, magnetic, optical, mechanical, rheological, or other properties.

Markets for such functionalized ultra-fine powders include microelectronics, defense, hardmetals, cosmetics, drug delivery, energetic materials, and polymer/ceramic nanocomposites, among others.

Title: SBIR Phase II: Direct Conversion of Heat to Electricity with Nanowire Antenna Arrays

Award Number: 0422219
Program Manager: T. James Rudd

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $488,855

Investigator: Lin Simpson, LSimpson@itnes.com
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Littleton, CO 80127
Phone: (303)420-1141

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop enabling nanotechnology that collects and converts infrared radiation (IR) from heated sources into DC power using nanowire antenna arrays with monolithically integrated rectifying diodes (IR-AAID). The innovation uses scaleable (square meters), self-organizing, and inexpensive electrochemical processing with low cost materials to engineer antenna/diode systems to convert light from heat sources. IR-AAID can convert heat to electricity at over 40 percent efficiency and be adapted to different emitters simply by changing the antenna geometry. The best IR thermo-photovoltaic modules typically operate at less than 5 percent efficiency, cost more than $300 per Watt, require up to 2000 degree Kelvin emitter temperatures to match available bandgaps, and require expensive materials with chemically tailored compositions, that are temperature sensitive, to match specific energy applications. In Phase I, the team demonstrated the feasibility of forming nanometer scale IR collecting antenna/diode structures over large areas, developed unique measurements to independently evaluate antenna and diode performance, demonstrated materials and diode structures that will provide the required IRAAID performance, generated DC power from light with IR-AAID devices, and demonstrated 6 percent conversion efficiency with non-optimized diodes. For Phase II, the team will develop robust processing to form inexpensive (less than $2 per Watt), IR-AAID prototypes to efficiently convert light to DC power.

Commercially, since IR-AAID does not require prohibitively expensive advanced lithography or direct serial nano-patterning, this effort will produce low-cost nanowire arrays with high density over relatively large areas, for heat collection. These applications will vary from portable power packs that use low temperature heat, to the generation of electricity from high temperature nuclear and conventional heat sources where noise or other environmental concerns are an issue. The enabling IR-AAID features are ideally suited for heat recovery applications, a $100B resource that is virtually untapped at present due to the limitations and costs of existing technology.

Title: SBIR Phase II: Nanofluidic Reference Electrode with an Invariant Liquid Junction Potential

Award Number: 0422237
Program Manager: Winslow L. Sargeant

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $494,988

Investigator: Scott Broadley, sbroadley@broadleyjames.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II is for the development of nanofluidic-flowing liquid junction (NFLJ) reference electrodes using nanochannel glass arrays developed by the Naval Research Laboratory. While consuming electrolyte at less than 2 ml/yr, the NFLJ reference electrodes will allow a flow at velocities of over 0.1 cm/sec to impede back diffusion of sample solution into the electrode. A variety of challenging test sample solutions, potentiometric measurements made with NFLJ references varied < 0.5 mV with response times of less than 60 seconds while measurements made with conventional reference electrodes varied up to 20 mV with response times of over one hour have already been completed. The NFLJ reference electrode's exceedingly small electrolyte consumption makes possible handheld NFLJ pH sensors with significantly higher precision and longer operational life. The high impedance of NFLJ reference electrodes, when using modern commercial pH electrodes, has no measurable effect on the precision, response time, or span of the pH measurement. The nanochannel glass nanofluidic-flowing liquid junction (NFLJ) adds a new dimension to the design and construction of reference electrodes.

The unique ability of the NFLJ design to separate flow volume and flow velocity will provide scientists with a tool for investigating reference electrode behavior as a function of flow, velocity, and resistance. It should help to develop a more fundamental understanding of mass transfer effect on liquid junction potentials. Initial results indicate that velocity is the critical parameter in stabilizing the potential.

Title: SBIR Phase II: Highly Efficient, Long Lifetime, and Inexpensive Nanocrystal Light Emitting Diodes (LEDs)

Award Number: 0349730
Program Manager: T. James Rudd

Start Date: March 1, 2004
Expires: February 28, 2006
Total Amount: $468,743

Investigator: Yongqiang Wang, awang@nn-labs.com
Company: NanoMaterials and NanoFabrication Laboratories
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Fayetteville, AR 72704
Phone: (479)871-0707

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will advance the performance of light emitting diodes based on semiconductor nanocrystals (NanoLEDs) to the same level of that of organic/polymer light emitting diodes (OLEDs). The key parameters of NanoLEDs targeted for this Phase-II program are 2000 hours operation lifetime, above 200 Cd/m2 brightness, and 0.5-2% external quantum efficiency. The Phase-II program will improve the performance of the NanoLEDs through a unique design of the nanocrystal thin layer in the devices. This design enables the ligands of all nanocrystals to be inter- and intra-particle cross-linked, which results in the thermally stable nanocrystal thin films required for high performance devices. The three dimensionally cross-linked ligands are short and have quasi-conjugated electronic structures, instead of the traditional long aliphatic ligands. This choice aims to dramatically improve the charge injection and charge transport in the NanoLEDs. New types of nanocrystals to be used will diminish the re-absorption and energy transfer in the densely packed nanocrystal thin films identified in literature. With the committed support from a state agency and extensive collaboration with mainstream industry it is expected to commercialize this technology in the display and lighting industry within five years.

The commercial potential of NanoLEDs is enormous. NanoLEDs possess nearly all of the advantages of OLEDs, but with readily tunable and narrow emission profiles. OLEDs are currently being used in active commercial development. The commercial goal in the Phase-II is to boost the performance of the NanoLEDs to at least the same level of that of the polymer LEDs, the low end of OLED devices. The first generation of NanoLEDs will be used in portable electronic devices. When the lifetime of NanoLEDs is extended over ten years, they will be used for other display technologies and in the lighting industry. NanoLEDs will one day change the way we see the world. Based on industry estimation, the near-term market for flexible LEDs, including NanoLEDs, will be $5 billion in 2005. After they are adapted to the mainstream of the flat panel graphics and lighting applications, the market size is going to be at least tens of billions.

Photonics

Title: STTR Phase II: High Resolution, High Brightness Display for Virtual Reality

Award Number: 0822965
Program Manager: Ian M. Bennett

Start Date: September 1, 2008
Expires: August 31, 2010
Total Amount: $492,628

Investigator: Michael Bass, bass2703@comcast.net
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Phone: (407) 718-2843

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II research project focuses on new GaAs-based, low voltage technology for high definition head mounted displays (HMDs), suitable for advanced applications in immersive virtual reality and 3-D imaging. Applications for this technology include battery powered augmented reality HMDs, full color, high resolution HMDs with 3-D imaging potential, and low cost, low voltage indicators and backlights for battery powered electronics. Displays derived from this GaAs technology have superior color gamut, high brightness, resolution and efficiency compared to other approaches. The results obtained from the STTR Phase I project indicate that low cost HMD-based optical systems can be designed using these high resolution microdisplay chips at supply voltages as low as 1.5 volts. Compared to display systems based on GaN LED and OLED technology which require voltages of up to 4 volts, this technology presents a path for continued advancement to 3-D imaging systems that could reach the resolution of the human eye. This technology should impact low cost HMDs displaying low-information content data such as maps, text or line graphics that require long battery life for markets that include first responders, factory and inventory workers, and consumer appliances. The technology can be advanced to much higher resolution microdisplays and improved optics for the high-information content marketplace such as immersive virtual reality for education, medical imaging and surgery, games and videos. Commercial emphasis will be placed on the low voltage operation for battery compatibility, a key advantage for augmented reality HMDs; and one which may lead to fundamental changes in battery powered electronics having indicator lights and/or displays.

Title: SBIR Phase II: Electronic Orientation and Navigation System for People with Visual Impairments

Award Number:	0822972
Program Manager:	Muralidharan S. Nair
Start Date:	July 1, 2008
Expires:	June 30, 2010
Total Amount:	$500,000

Investigator: Michael Manning, michael@manningrf.com
Company: ManningRF, LLC
2718 Winningham Rd.
chapel hill, nc 27516
Phone: (919) 967-5438

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will design, build and test a new type of orientation and navigation (O&N) system for people with visual impairments. While GPS-based solutions show promise in outdoor environments, there are currently no widespread O&N devices that are designed for use in indoor environments. This makes it difficult for people with visual impairments to navigate through indoor public spaces. The purpose of this research will be to complete development of a new type of radio frequency identification (RFID) system, in which intelligent, variable-range active RFID beacons are programmed with information about their locations and placed through indoor environments like schools, shopping malls and museums. This information will be accessible to people with visual impairments via a small RFID receiver worn on the user?s belt. Information will be conveyed to the user via a text-to-speech interface. Results from field testing have demonstrated that the device helps people with visual impairments to navigate through an unfamiliar environment. Phase II research will complete development of the communications protocols and interface techniques that give the system its unique capabilities for delivering speech-based information to people with visual impairments. There are 10.4 million people with visual impairments in the U.S., and this research will lead to an inexpensive commercial product that will greatly enhance their ability to navigate in unfamiliar surroundings. The market for this technology includes those who will purchase the RFID receivers and the RFID beacons. This includes people with visual impairments, as well as the owners and tenants of public spaces, such as office buildings, schools, malls, museums and government facilities. Also, because of the simplicity of the interface, the system will be useful to Orientation and Mobility educators working with young children to develop spatial concepts.

Title: STTR Phase II: Hybrid Integrated Optoelectronic Systems

Award Number: 0750506
Program Manager: Juan E. Figueroa

Start Date: March 1, 2008
Expires: February 28, 2010
Total Amount: $500,000

Investigator: Lisa Dhar, lisadhar@inphase-tech.com
Company: InPhase Technologies
2000 Pike Road
Longmont, CO 80501
Phone: (217) 369-7409

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project will combine advanced two-chemistry photopolymer science and 3D maskless lithography to demonstrate a solution to a ubiquitous barrier to the broader impacts of optical and optoelectronic technologies. This research will strive for a universal integration platform capable of seamlessly hybridizing electronic, micro-mechanical, opto-electronic and optic devices on a single chip to implement complex 3D systems in an environmentally robust package. Over 90% of the development cost of optoelectronic components for telecom is estimated to be packaging and the limited market penetration of MEMs products is universally blamed on packaging difficulties clearly showing the need for the proposed platform. In this program the team will optimize the photo polymerizable monomer system and adapt a multi-beam direct-write lithography platform in order to demonstrate and optimize a new class of 3D routed waveguides. Anticipated results are a new class of polymer material and an associated maskless lithography technique to support research, education and commercial production of a wide range of miniature mobile devices that are currently confined to laboratory benches. If successful the proposed multi-disciplinary materials and lithography research program has the potential to revolutionize public access to complex microdevices that are currently restricted to laboratories or expensive military systems. By providing a platform for inexpensive, robust miniaturization of systems that seamlessly incorporate optics, MEMs and electronics, a wide range of communication, medical and sensing systems become technically and economically feasible.

Title: SBIR Phase II: Wavelength-Selective Lasers for Photonic Integrated Circuits

Award Number:	0724237
Program Manager:	Juan E. Figueroa
Start Date:	October 1, 2007
Expires:	September 30, 2009
Total Amount:	$499,998

Investigator: Alan Sugg, arsugg@vegawave.com
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1275 W. Roosevelt Rd Ste 112
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Phone: (630)562-9433

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will address the commercial need for novel, wavelength-selective laser diodes for 10 Gigabit Ethernet applications. The distributed feedback lasers currently used in 10 Gigabit Ethernet transceivers are fabricated using an expensive, low-yield, epitaxial re-growth process. The drawbacks of this method are the high cost of the capital equipment and of the manufacturing process. In addition, the lower yields encountered with the multiple regrowths required to fabricate complex photonic circuits make cost-effective integrated photonic components difficult to achieve. A novel laser diode design and high-yield manufacturing method that will enable the fabrication of low-cost wavelength-selective and tunable laser diodes for optical communications has been developed. This research will refine the design and fabricate both discrete and integrated devices for 10 Gigabit Ethernet applications.

The major scientific and technical benefit of this work is an improved method for fabricating lasers and other optoelectronic devices. The work should also result in arrays of novel, wavelength selectable lasers suitable for use in high-speed data communications applications. The main societal impact will be the increased availability of low-cost, high-speed data communications, which is a significant contributor to economic development. Making lower cost lasers will enable a significant reduction in the cost of transceivers, which will increase the rate at which high speed Ethernet penetrates the data network.

Title: SBIR Phase II: Compressing and Measuring Ultrashort Laser Pulses in Imaging and Spectroscopy

Award Number: 0724370
Program Manager: Juan E. Figueroa

Start Date: September 15, 2007
Expires: August 31, 2009
Total Amount: $500,000

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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop two novel ultrashort-laser-pulse devices. Each will solve an important problem for researchers that use exciting new ultrashort-laser-pulse techniques for imaging, micro-machining, surgery, telecommunications, chemical-reaction control, time-domain spectroscopy, and many other applications. Such applications work best with the shortest pulse - but currently operate with much longer ones because such pulses naturally lengthen as they pass through the many optical components on the way to their final destination. Pulse compressors, which use four prisms (or two prisms and a mirror), solve this problem, but they are unwieldy and have a tendency to introduce other distortions, making them difficult to commercialize. This research will develop an elegant, easy-to-use single prism pulse compressor, which is much simpler, more compact, and much less expensive, and is also naturally immune to the problematic distortions of current two- and four-prism designs.

The pulse compressor will greatly benefit multi-photon microscopy - in use in over 1000 biological labs worldwide, and where it will significantly improve image sensitivity and resolution. Micromachining efforts and new ophthalmologic surgical techniques that now use ultrashort pulses also require the shortest possible pulses. In addition, telecommunications and chemistry researchers who shape their pulses into potentially extremely complex waveforms, currently cannot measure them, but this spectral interferometer, which can also measure complex shaped pulses, will fill this need, as well.

Title: SBIR Phase II: New Ceramic Sub-Microchannel Plates

Award Number: 0724478
Program Manager: Juan E. Figueroa

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $500,000

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Abstract:

This Small Business Innovative Research (SBIR) Phase II research project proposes to develop and commercialize advanced high- resolution ceramic microchannel plates (s-MCPs) for applications in low- and night vision devices, scientific detectors and biomedical imaging. Conventional glass-fiber MCP technology has reached its fundamental limits in spatial and temporal resolution, fixed pattern noise, high count rate capabilities, thermal performance, yield and reproducibility, stability and lifetime. This is a unique approach based on nanoporous ceramics, which allows reaching ultra-high sub-micron resolution. Due their ceramic nature, the proposed s-MCPs are capable of processing temperatures up to 1000 degrees celsius, enabling direct integration of advanced photocathodes for expanded spectral range and sensitivity, and are also expected to have greater lifetime than those produced with existing methods. In addition ceramic s-MCPs can be produced at a much lower cost than glass MCPs. A robust ceramic structure with the required dimensions and resistance has been developed. The remaimimg challenge is to fabricate functional s-MCP prototypes from this structural material, along with validation of s-MCP performance.

The expected result of the proposed work is a manufacturing technology for production of commercially viable sub-microchannel plate intensifiers with better performance, longer lifetime and lower cost. This could open up new opportunities in the development of the next generation particle and photon detection systems for the infrared, UV, x-ray and gamma ray astrophysics applications. Spin-off applications for ceramic MCPs include "lobster eye" optics for x-ray detectors as well as gas avalanche detectors. Commercial applications include detectors for high-energy physics, scientific instrumentation, biomedical imaging, commercial satellite mapping, vision augmentation, as well as consumer night vision products.

Title: SBIR Phase II: A New Class of Complex Ferroelectric Liquid Crystal Mesogens for Advanced Electro-Optic Devices

Award Number:	0646460
Program Manager:	William Haines
Start Date:	June 15, 2007
Expires:	May 31, 2009
Total Amount:	$499,999

Investigator: Yongqiang Zhang, zhang@displaytech.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to exploit novel dimer ferroelectric liquid crystals (FLCs) to develop a new class of materials for electro-optics (EO) and non-linear optics (NLO) that offer previously unobtainable properties. This will enable advanced optoelectronic products across multiple markets, from lasers for projection television to 100GHz integrated electro-optic modulators and switches for optical interconnects and telecommunications. For over 100 years, predominant liquid crystal molecules have been variants on simple rod shapes. This innovation exploits new dimers - a side-by-side pair of conventional rod-shaped FLC molecules connected by a pi-conjugated bridge engineered to be part of a strong NLO chromophore. It is difficult and expensive to build integrated optoelectronic devices using lithium niobate, today's dominant NLO material. Organic poled-polymer NLO materials offer significant advantages for integration, but suffer performance and stability limitations due to being thermodynamically unstable and non-centrosymmetric (required to be NLO active). FLCs are intrinsically non-centrosymmetric and thermodynamically stable, offering an ideal scaffolding for creating high densities of strong, oriented, NLO chromophores. Our Phase II objectives are to develop and demonstrate prototype materials for projection television laser light sources and electro-optic modulation, and to design a product that will be used in projection television lasers.

Commercially, this SBIR Phase II project will advance the scientific and technological understanding of a new class of dimer ferroelectric liquid crystals, and will produce the first commercially significant liquid crystals not based on simple rod-shaped molecules. Consumer products will include higher image quality, lower cost, rear projection televisions and practical, bright, micro-projectors for portable electronics. Integrated electro-optic devices enabled by the NLO materials will help to expand the bandwidth of computer and telecommunication networks, and of interconnects within coming generations of faster computers.

Title: SBIR Phase II: Voltage Tunable Micro-Ring Resonators: Low-Cost, Reconfigurable Optical Add-Drops

Award Number:	0646357
Program Manager:	Juan E. Figueroa
Start Date:	April 1, 2007
Expires:	March 31, 2009
Total Amount:	$499,953

Investigator: Scott Davis, davis@vescentphotonics.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project entails the design and building of polarization independent, fiberdized, wavelength selective switches using patent pending EO-waveguide micro-ring technology developed and demonstrated as a result of work carried out under Phase I. The approach is electro-optic, rather than thermo-optic, and operates with negligible power consumption (< 30 microwatts per ring demonstrated in phase I), fast switching (< 100 microseconds demonstrated), larger index modulation (dn > 0.01 demonstrated, more possible) and importantly, will enable active polarization dependent loss (PDL) compensation. This will replace thermo-optically tuned ring resonators, which have provided only limited tunability (dn/dt =~ 1.5 x 10-5/oC), slower tuning times (> 3 milliseconds typical), high polarization dependency (no active PDL compensation possible), and are prohibitively power consumptive (~~ 0.5 Watts per ring).

In the last century the low power transistor replaced the power hungry vacuum tube, thereby ushering in the age of integrated electronics. In a similar fashion, low-power LC-waveguides have the potential to replace high-power thermo-optics (providing a power savings of >10,000), thereby opening up applications and markets for integrated optics. In phase II we will transition our phase I feasibility demonstration into a fully functioning and packaged prototype. As computing power and bandwidth continue to grow (e.g., streaming media), low-cost electro-optical filtering and switching systems will be required to satisfy pending fiber-to-the-home and "last mile" deployment needs. Since 2002, United States and European deployment of long-haul dense wavelength division multiplexing (DWDM) systems have been almost entirely constructed from reconfigurable optical add-drop multiplexers (ROADM). A typical deployed system works by reading incoming optical signals and converting them to electrical signals, which can then be routed. Conversion back to optical is performed by an array of tunable lasers. This brute force method, while providing useful performance, is cost prohibitive for small network deployment. According to Infonetics, a leading market research firm, the ROADM-enabled equipment market size nearly reached $600 million in 2005, tripling earlier forecasts. Over all growth will be determined by affordability and reliability of ROADMs technology, especially within the metro and access space. The technology outlined in this proposal if successful will contribute a new and inherently agile all optical solution by reducing cost while maintaining performance and reliability. In addition to ROADMs, the voltage tunable micro-rings will enable a wide array of useful devices, ranging from spectral filters, to optical cross-connects, to routers, to name only a few.

Title: SBIR Phase II: Novel Monolithically Integrated Wavelength-Range-Selectable and Widely-Wavelength-Tunable Semiconductor Lasers with High Functionalities

Award Number:	0646478
Program Manager:	Juan E. Figueroa
Start Date:	March 15, 2007
Expires:	February 28, 2009
Total Amount:	$500,000

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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is focused on the use of new technology for the development of a novel wavelength selectable or wavelength tunable laser. Such lasers are central to next-generation photonic technologies and optical networks, and have a wide range of applications including instrumentations, optical sensing, medical, military, imaging, and high bandwidth DWDM optical networks. The company has recently developed a powerful integrated super-high-resolution compact curved diffraction grating (SCG) on InP chip with the highest spectral resolution and the smallest size. Applying to lasers, SCG allows combining the simple-control and high-performance advantage of "external cavity laser" with the high ruggedness and low-cost advantage of monolithic integration. The Proposed wavelength-selectable or tunable lasers will result in extended tunable laser capabilities, not achievable currently, such as simpler control electronics, direct modulation capability up to 2.5Gb/s, 10Gb.s modulation with integrated modulator, ultra-compact laser module size, lower power consumption, and lower costs via monolithic integration.

The proposed wavelength-selectable or wavelength-tunable SCG lasers will involve a number of new technological approaches such as the high-resolution Integrated Curved Diffraction Grating, Cavity-Grating Frequency Offset detector, and other integrated functionalities (e.g. integrated shutter/amplifier, integrated modulator etc). These are combined capabilities that can only be realized with chip-scale monolithic integrations, and are not available currently. IF successful the proposed solution, a single wavelength selectable SCG laser, will replace the use 40x fixed wavelength DFB lasers to cover the 40 DWDM ITU Wavelength Channels. Thus the proposed solution, WS-SCG laser, will reduce the DWDM laser inventory by 10-40x while having substantially simpler control electronics, more compact module size, lower power consumption, and higher functionalities than those of current tunable lasers, and could be engineered to give higher output and higher spectral purity. The potentially new capabilities of SCG lasers will open up many application areas including: (1)DWDM/CWDM/OCDMA Networks; (2) WDM On Chips; (3) Instrumentations; and (4) Optical sensing and medical equipments. Applications to these areas require wavelength selectable or tunable lasers with higher output, higher spectral purity, wider wavelength tunability, and lower cost.

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Title: SBIR Phase II: Development of a New High Intensity Pulsed Light Source System

Award Number:	0645824
Program Manager:	Juan E. Figueroa
Start Date:	March 1, 2007
Expires:	February 28, 2009
Total Amount:	$500,000

Investigator: Raymond Schaefer, rschaefer@phoenixsandt.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is to conduct further research on the erosion properties of electrode materials under high-current pulsed operation, and demonstrate extended lifetime for a new pulsed lamp, making it economically practical. With increased lifetime, the new lamp can become the industry standard for UV water treatment and enable a new photolytic paint stripping process. Materials used for pulsed power electrodes were originally formulated for continuous or alternating current at low peak current. In Phase I a tungsten composite fabricated with a specific process eroded at one-sixteenth of the erosion of the standard electrode material. Phase II continues the research on this tungsten composite and its fabrication processes to demonstrate low erosion, with the objective of demonstrating increased lamp life that meets requirements for commercialization.

If successful the proposed research will enhance scientific understanding of the erosion of electrode materials under repeated high-current pulsed cycling. New electrode materials will expand the use of pulsed power and provide better alternatives to thoriated tungsten, which is banned in Europe because of its radioactivity. The primary goal is to enable a new commercial pulsed lamp. The lamp will replace mercury lamps, reducing mercury use and exposure of the public. The lamp also will enable commercial photolytic paint removal, replacing chemical and abrasive techniques that are labor intensive, create dust and debris, and generate toxic byproducts. The photolytic process will provide a lower cost and cleaner method of removing lead paint. This will allow abatement to replace "interim measures" currently in vogue, and support national goals to eliminate childhood lead poisoning. The commercial market for the new lamp encompasses all of UV water treatment and a wide range of paint removal applications.

Title: SBIR Phase II: Electro-Optic Photonic Bandgap Materials and Devices

Award Number: 0522177
Program Manager: T. James Rudd

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $499,821

Investigator: Yingyin Zou, kzou@bostonati.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop electro-optic photonic bandgap (EO-PBG) Materials and Devices. During the Phase I project the feasibility of the proposed electro-optic PBG technology has been demonstrated. High quality EO film, La-modified PMN-PT (PLMNT), was successfully deposited using a unique metal-organic chemical liquid deposition (MOCLD) technique, a low cost and efficient manufacturing process. A large EO coefficient was achieved from PLMNT films. An innovative metallic/dielectric PBG structure was designed and studied for device applications. An electro-optic filter/modulator was developed. A two-dimensional PBG structure was demonstrated for efficient wavelength tuning through simulation. In Phase II based on this Phase I work, new generation tunable PBG material and devices, such as filters and modulators with state-of-the-art performance, will be brought to the marketplace.

Commercially photonic bandgap materials promise to give similar control of the flow of photons as there is over electrons in a semiconductor material but with even greater flexibility because there is far more control over the properties of photonic bandgap materials than the electronic properties of semiconductors. Given the impact that semiconductor materials have had on every sectors of society, photonic bandgap materials could play an even greater role in the 21st century, particularly in the optical-communications industry. Not only can this material be made into common PBG passive components, such as cavities, waveguides, or couplers, but also the active and dynamic ones, such as high-speed modulator and tunable filters. These advanced devices will have great applications in industrial, space, and military sectors

Title: SBIR Phase II: Efficient Light Out Coupling from AlGaN Light Emitting Diodes

Award Number: 0522067
Program Manager: T. James Rudd

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $499,961

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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop novel graded-index (GIN) structures for blue/UV light emitting diodes (LEDs). Solidstate LEDs (SSLs) are among the most efficient converters of electrical energy into light and additionally have the advantages of long lifetime, excellent reliability, low power consumption, light weight, small size and excellent resistance to mechanical shock and
vibration. These significant benefits over conventional lighting explain why, according to a recent study, the average growth rate for the SSL market is expected to be around 200% per year for the next five years.Since LEDs are narrow-band emitters, they must be coupled to an efficient downconverting phosphor in order to achieve the broad emission necessary for the generation of white light. However, even for a perfect phosphor, high efficiency will not be achievable unless there is also efficient out-coupling of radiation from the LED into the phosphor and from the phosphor to air. The resulting losses associated with outcoupling are due to the difference in refractive indices (n) of adjacent material layers that cause Fresnel Reflections and total internal reflection (TIR). In Phase I the research team has developed unique material structures and electrophoretic (EP) deposition process that are expected to realize high out-coupling efficiencies from LEDs at low costs. During Phase I, the feasibility of the EP deposition process has been successfully demonstrated and the advantage of an index-matching structure has been shown to significantly (~50%) improve the light extraction efficiency in LEDs. This fact was demonstrated both experimentally and theoretically using ray tracing simulations. In Phase II the work will focus on refining these structures for blue/UV LED's to develop the efficient down- converting technology for enabling the new solid state lighting systems.

Commercially if SSL technology can achieve this projected goal, the lighting industry would be revolutionized. Potentially an efficiency of 200lm/W is possible, more than 2X better than that of fluorescent lamps (80lm/W), and more than 10X better than that of incandescent lamps (15lm/W). If current lighting, with an aggregate efficiency of roughly 50lm/W (in between the efficiencies of fluorescent and incandescent lamps), were replaced by semiconductor lighting with an aggregate efficiency of 150lm/W (somewhat less than the target), then the electricity currently used for illumination would decrease by a factor of three, from 2,350TWh to 780TWh. This would represent a decrease in global electricity use of 13%, and a decrease in global energy use and associated carbon emissions of 2.3%. In the U.S., the potential reduction in electricity consumption due to lighting is expected to be as high as 50% by the year 2025

Title: SBIR Phase II: Development of High Performance Ultraviolet Single Photon Detectors

Award Number: 0521973
Program Manager: Juan E. Figueroa

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $500,000

Investigator: Petre Alexandrov, unitedsic@unitedsic.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project aims to carry out the major R&D work to fully develop a 4H-SiC Single Photon Avalanche Detectors (SPADs) capable of ultra-sensitive and reliable room temperature single photon counting in the ultraviolet (UV) range with high efficiency for a wide range of applications. Existing commercial semiconductor UV avalanche photo detectors (APDs) suffer from high-dark count due to the fundamental material limitation. Unlike other wide band gap semiconductors, 4H-SiC has intrinsically more than an order of magnitude disparity in the electron and hole impact ionization coefficients, making it ideally suited for APDs and SPADs which require, as a key performance parameter, ultra low excess noise. The major research efforts will be focused on the novel design of the 4H-SiC SPADs and the development of the processing technology to manufacture the SPADs in both single element and in linear array forms. The goals are to achieve drastically improved dark count rate, quantum efficiency, and photon counting rate in comparison to the results achieved in Phase I.

Success of the project will have significant impact to the scientific understanding of cryptography for secure UV free-space communication, of fundamental quantum mechanics of single photon-molecular interaction, and of astronomy and space exploration. The results of the project are expected to lead to commercial products including hand-held or field-portable compact UV analyzers with single-molecule unmatched sensitivity, UV spectroscopy and fluorescence systems for pharmaceutical /drug development, and biowarfare agent detection. Ultra-sensitive UV and Deep UV detectors will find immediate applications in both civilian and defense industries for radar and missile detection systems, for scientific and measurement instruments and OEM, for non-invasive underground oil and mine detection and profiling, for safety protection industry (food protection, utility and power system protection/electrical arc detection, engine and fire/flame sensing and control) and for UV imaging/UV camera as well as radiative and space applications

Title: SBIR Phase II: Vertical Electroabsorptive Modulated Laser (EML) Source for High-Speed Interconnects

Award Number: 0450619
Program Manager: Muralidharan S. Nair

Start Date: June 15, 2005
Expires: May 31, 2007
Total Amount: $428,440

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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to fabricate and commercialize a Vertical Electro-absorptive Modulated Laser (V-EML) for high-speed (up to 40Gbps) optical interconnects for chip-to-chip, board-to-board, and intra-rack optical applications. Compared to current electrical data buses using copper interconnects or conventional fiber optic links, the V-EML will enable the fabrication of higher speed, lower cost, lower power consumption and smaller optical transmitters for multi-channel fiber optic data buses in computer and communication networks. This technology virtually removes the modulation speed limit of VCSEL optical transmitters. At the same time it maintains high channel density at low cost. The low power consumption of the V-EML (~20 mW) and its potential low cost in volume (~$1.0) will provide a solution to the interconnect speed and power barriers in multiprocessor computers and servers. An array spacing of 50 to 100 microns will be possible with V-EMLs. This means that an 8x8 array with 2.5 Tbps of capacity has less than 1.0 mm2 of footprint. This offers substantial space savings over the existing copper interconnect technology and creates another strong incentive for transition.

This technology could provide societal benefits from the commercialization of this technology by enabling faster and more widespread deployment of broadband services. The potential for ultra-fast delivery of audiovisual information is enormous as the V-EML technology helps to remove data-com bottlenecks. Educational and scientific benefits of the V-EML development arise in the area of supercomputers with sufficient computing power for complex scientific simulations. Applications include climate modeling for better predictions, molecular level modeling such as protein folding in medicine, ecosystem modeling in agriculture, and large-scale analysis of business information and economic statistics. These computers could then operate much faster and much more efficiently when interconnect speed limits are increased.

Title: SBIR Phase II: Wavelength-Division-Multiplexed Surface-Emitting Lasers with Two-Dimensional Photonic Lattice Outcouplers

Award Number: 0450560
Program Manager: Juan E. Figueroa

Start Date: February 15, 2005
Expires: January 31, 2007
Total Amount: $498,766

Investigator: Nuditha Amarasinghe, vamarasinghe@photodigm.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II Project proposes to develop a commercially viable monolithic Wavelength Division Multiplexed (WDM) two-wavelength Grating-Outcoupled Surface-Emitting semiconductor (GSE) laser emitting near 1310 nm. Phase I demonstrated the concept of WDM GSE lasers in a cross-grating configuration emitting two wavelengths separated by 9 nm from a common two-dimensional photonic lattice (2D-PL) aperture that can be efficiently coupled to multi- and single-mode fiber. A low-cost package that can couple 2, 4 and 8 independent wavelengths from one or more 2D-PL GSE lasers directly to a single fiber without multiplexers will also be developed on this program. The knowledge required to develop these lasers requires expertise in materials, optics, gratings, nanostructures, semiconductor processing, thermal transfer, high-speed electronics, packaging, systems and telecommunications. Combining the desirable traits of both edge emitting lasers (high power, reliable material, low voltage, use of proven) and vertical cavity surface-emitting lasers (low cost, wafer level testing, simple packaging, high integration ability), the advanced research proposed is an innovative photonics technology that has broad applications in telecommunications, information processing, data communications, fiber to the business and home, scientific and medical instrumentation, and computations.

A broader impact of this project is the realization of very high data rates at very low cost, and the elimination of barriers to deploying fiber to the desktop and to (or closer to) the home, enabling ultra high bandwidth connections for business, distance learning, entertainment, and computing. Each wavelength of the 2D-PL GSE laser can presently be modulated at 3.125 Gbps and has the potential for 10 Gbps, enabling data rates of 6.25 to 80 Gbps over a single fiber from a single transmitter package. This research effort will provide an enhanced educational experience for students working on this project. Students will gain an increased understanding of materials, optics, gratings, nanostructures, semiconductor processing, thermal transfer, packaging, electronics, and telecommunications through both experimental and theoretical work.

Title: SBIR Phase II: Photonic Crystal Coherent Thermal Emission for Sensors

Award Number: 0450397
Program Manager: Juan E. Figueroa

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $495,949

Investigator: Irina Puscasu, ipuscasu@ion-optics.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to fabricate a photonic crystal, thermal mid-IR source with low divergence and low dispersion at about 0.1% the cost of competing technologies.
Phase 1 research resolved fine structure of the emission spectrum from 2-D photonic crystals showing that the high intensity, large bandwidth peak had many submodes with strong polarization and angular dependence. In a series of designed experiments the intensity and central wavelength of these submodes were varied with geometrical alterations of the photonic crystal, and theoretically were correlated to surface plasmon resonances. A computer model was developed that matched experimental data. Results imply optimization of photonic crystal structure in Phase 2 could isolate a single sub-mode resulting in very low dispersion, very low divergence emission that could be coherent. The project will support high-end computational research at a university for complex electro-magnetic modeling of photon - surface plasmon interactions. Improved structures predicted by these calculations will be fabricated at an NSF supported nano-fabrication facility. We will examine effects of altered symmetry, periodic defects, and detailed shaping of electrostatic fields.

All existing choices for coherent radiation in the mid-infrared spectral region are too expensive for widespread vapor detection. Examples are wavelength shifting of high power pulsed lasers using non-linear optical effects or quantum cascade lasers (now $5,000 each). The proposed source could sell for less than $10. Additionally, it could significantly reduce the cost of sensitive spectroscopic instrumentation allowing detection of vapors well below 1ppm concentration and application to widespread use as toxic vapor detectors for commercial, residential, and homeland defense applications. Compared to other technology, these detectors are temperature insensitive, rugged, and free of interference effects with zero maintenance and zero drift. This work will contribute towards understanding photon surface plasmon interactions within 2D photonic crystals. The field has huge implications for the microelectronics and optics industry as optical and electronic functions are combined onto single chips for applications to optical computing, communications, etc.

Title: SBIR Phase II: Ultimate Sensitivity Photodetector

Award Number: 0450605
Program Manager: Juan E. Figueroa

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $355,974

Investigator: Eric Harmon, harmon@lightspintech.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to develop a solid state photodetector with ultimate sensitivity and wide dynamic range at room temperature, capable of efficiently seeing signals from a single photon to trillions per second, featuring high speed, zero dead-time, high reliability/reproducibility, solid state robustness/compactness, and a large photosensitive area. The Phase I project proved the practicality of compatibly combining these features, and demonstrated compound semiconductor materials 1000 times quieter electrically than silicon. The project plans to model, design, layout, fab, package, test, and analyze a series of prototypes, resulting in a complete photodetector prototype for detailed evaluation and customer review; and will engage students in for-profit industrial R&D.

This project aims to revolutionize the $10 billion industrial sector for ultra-low-light analytical instruments by obsolescing bulky glass, high voltage, photomultiplier vacuum tubes ($500 million) and microchannel plates ($400 million); improving scientific instruments dependent on them; enabling altogether new instruments; and making new applications of the instruments affordable and accessible.
This product has been sought as the holy grail of photodetection for fifty years. It could make detecting light with ultimate sensitivity so practical, affordable, and ubiquitous that important scientific research and industrial instruments needing to sense extremely low light levels could be microminiaturized to eliminate bulky, thousand volt, multi-thousand dollar, high-voltage vacuum tubes, written operating plans, and the expertise & proven track record of its managers.

Title: SBIR Phase II: Liquid-Crystal Waveguides for Optical Integrated Circuits

Award Number: 0450463
Program Manager: Juan E. Figueroa

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $499,565

Investigator: Mike Anderson, anderson@vescentphotonics.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will reduce mechanical external-cavity diode lasers to a centimeter-sized waveguide chip using a novel giant electro-optic effect. The device, a waveguide external-cavity semiconductor laser (WECSL), will be environmentally robust, compact, entirely electro-optic and capable of continuous, mode-hop-free tuning over 100 nm in fewer than 5 milliseconds. The laser will also exhibit a side-mode-suppression ratio of 40 dB and a (fast) linewidth of ~200 kHz. In Phase II we will demonstrate advanced prototype WECSLs, develop critical manufacturing processes, and perform basic environmental qualifications. We will also conduct research allowing the laser to sweep over a 50 nm band at a rate of 5 kHz.

The low-cost technology platform of WECSLs, and their precision performance specifications could enable laser-based sensors to assume a prominent role in commercial applications. In biophotonics, tunable lasers can replace broadband light sources and enhance the performance of optical coherence tomography instruments that measure the tissue layers in the human retina and the vascular system. Distributed fiber sensing arrays greatly benefit from tunable lasers that probe Bragg sensors spaced along the fiber. Distributed fiber sensors needing low-cost tunable lasers are being developed for chemical and biological sensing, pressure sensing, and vibration, strain and temperature sensing for a wide variety of monitoring applications such as homeland security; civil structures such as buildings, bridges, and dams; oil wells and pipelines; electrical power lines; aircraft and spacecraft; and all-optical shipboard sensing.

Title: SBIR Phase II: Efficient Multi-Spectral Holographic Filters

Award Number: 0450478
Program Manager: Juan E. Figueroa

Start Date: January 15, 2005
Expires: December 31, 2006
Total Amount: $499,190

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Phone: (626)357-9600

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will commercialize the holographic multi-spectral filter technology developed during the SBIR phase I project. The objective of this project will be the industrial fabrication of holographic multi-spectral filters by using the methods developed and demonstrated during the phase I SBIR research. There is a strong scientific and public push in astronomy to look deeper into the universe to discover and observe fascinating phenomena such as the birth of stars and exo-planets. In observations of celestial bodies from ground telescopes, the signal is faint and surrounded with unwanted optical noise from the atmosphere. The hydroxyl (OH) radicals present in the atmosphere emit light in hundreds of narrow lines that dominate the inter-line sky emission by many orders of magnitude. The multi-spectral rejection filter demonstrated in phase I discriminates the narrow spectral features of the OH emission lines from the atmosphere which increases the image sharpness by increasing the signal to noise ratio.

The narrow band grating filter technology is a core platform that has a scientific and economic impact on ground-based astronomy as well as in laser diode systems. To date $3.8 Billion has been spent deploying and maintaining the Hubble Telescope. An estimated $2.2 Billion is required to see it to its final scheduled retiring date of 2010. It is believed that the introduction of the these multi-line filters combined in some cases with adaptive optics, can boost the performance of ground based telescopes so that they can approach the performance of space telescopes at a price more than 1000 times lower.

Title: SBIR Phase II: Development of Chiral Fiber Polarizer

Award Number:	0450551
Program Manager:	Juan E. Figueroa
Start Date:	January 1, 2005
Expires:	December 31, 2006
Total Amount:	$499,997

Investigator: Dan Neugroschl, dann@chiralphotonics.com
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Clifton NJ, 7012
Phone: (973)594-8888

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a new class of in-fiber chiral polarizers based upon chiral fiber gratings. A double helix variation of the effective refractive index will be formed by twisting fibers with a noncircular core as they pass through a miniature oven. These chiral fiber polarizers will be created from specially prepared glass performs in a low-cost, versatile, continuous process, which will not require coherent irradiation of photosensitive glass commonly used to produce fiber Bragg gratings. Chiral polarizers are true fiber devices and do not require any substrates, bulk components, or rigid package. Their pitch profile will be engineered to minimize insertion loss for the passing polarization and maximize the extinction of the orthogonal polarization over a broad spectral range. The design will implement a multi-core optical fiber to match the low numerical aperture of standard fiber with the numerical aperture of the chiral polarizer at its input and output while maintaining a high numerical aperture in the polarizing zone. Chiral polarizers will have broad application in single polarization transmission, polarization mode dispersion compensation, and test and measurement instrumentation. Polarizers are also key elements in sensors relying on optical interference such as gyroscopes and current sensors.

Polarization and frequency selective chiral fibers have applications ranging from telecommunications to sensing. The use of external modulators for high bandwidth fiber telecommunication requires that the incident wave be linearly polarized. This necessitates use of a polarizer since laser sources used in telecommunications generally have random polarization. Further, any use of polarization maintaining fiber requires that polarized light be launched into the fiber. Polarizers are also key components in polarization mode dispersion compensation systems. Since chiral polarizers may be fabricated from refractory or radiation resistive glasses and involve only mechanical deformation of glass they may function in harsh environments with high levels of radiation, high temperature, or corrosive chemicals. The fabrication techniques developed for chiral fiber polarizers will spur the development of other devices based on chiral fiber gratings. These devices, ranging from sensors and filters to in-fiber lasers will become building blocks for a new platform for passive and active in-fiber devices. The understanding of glass behavior under extreme shear stress will push the frontier of glass forming technology and stimulate new applications. Understanding polarization-selective light scattering within the nonresonant band will open the way for new devices based upon microstructured fibers.

Title: SBIR Phase II: Compact, High-Power, Terahertz (THz) Radiation Source

Award Number: 0422057
Program Manager: Murali S. Nair

Start Date: September 15, 2004
Expires: August 31, 2006
Total Amount: $500,000

Investigator: Hans Bluem, hans_bluem@mail.aesys.net
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Medford, NY 11763
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project will develop a tunable, compact, high-power Terahertz (THz) radiation source. The unique discriminator of the source is the projected power level, which is orders of magnitude greater than available semiconductor sources, should enable for the first time both wide field of view (FOV) imaging and high-throughput spectroscopic interrogation from a compact package. The Phase II program will complete the final design of the THz source developed in Phase I and described in the final technical report, fabricate a prototype device and demonstrate its performance at a THz research laboratory. The goal of the project is to demonstrate that the concept can deliver tens of watts of THz power from a device that is sufficiently robust and compact to be transportable and operate in the field. The THz spectral region combines many desirable features for spectroscopic and imaging applications. However, higher-powered, compact sources, such as that here, are needed to deliver practical throughput rates and the signal-to-noise ratio required for many commercial applications.

The major medical imaging applications being developed are the detection of breast and basal cell carcinomas. Pharmaceutical industry applications include drug discovery and quality assurance, DNA analysis and proteomics. In the homeland security and defense arenas, the potential applications include standoff chemical and biological agent and explosive detection. THz systems are finding increasingly widespread use in scientific and University R&D environments for non-destructive evaluation and medical applications.

Title: SBIR Phase II: Integrated Dense Wavelength Division Multiplexing (DWDM) 3D Micro-Opto-Electro-Mechanical Systems (MOEMS) Optical Switch for Dynamically Reconfigurable Network

Award Number: 0422155
Program Manager: Murali S. Nair

Start Date: September 1, 2004
Expires: August 31, 2006
Total Amount: $499,925

Investigator: Roger Helkey, helkey@calient.net
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Phone: (805)562-5501

Abstract:

This Small Business Innovative Research (SBIR) Phase II project will integrate Dense Wavelength Division Multiplexing (DWDM) with Micro-electro-mechanical systems (MEMS) optical switching to make the critical network element needed for reconfigurable, transparent, high capacity fiber optic networks. This technological advancement will facilitate the transition from today's point-to-point opaque networks with optical to electrical to optical (OEO) electrical switches to transparent, dynamic all optical networks. The design involves free space optical design, fiber optic design, MEMS design and optical coating design in order to make a wavelength switch which has low loss, low polarization independent loss, low temperature sensitivity, low vibration sensitivity, properly shaped pass bands (flattop with good adjacent channel rejection) and low crosstalk.

The design will be developed, constructed and tested in Phase II, significantly advancing the field of optical switching from where it is today. This integrated wavelength switch should have numerous applications in commercial and government networks. The capacity is huge: 4 fibers with 40 wavelengths each carrying 40 Gbit/s of data results in 6 Terabit/s switching capacity. This allows continued growth in the Internet, and enables a much lower cost solution to higher capacity wavelength services. Continued expansion of access to information requires continued expansion of worldwide core optical networks.

Title: SBIR Phase II: Diode-Pumped, High-Power, Cr:LiSAF-Based Ultrafast Laser and THz Source

Award Number: 0422089
Program Manager: Murali S. Nair

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $499,954

Investigator: Evgueni Slobodtchikov, slobodtchikov@qpeak.com
Company: Q Peak, Inc.
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Bedford, MA 01730
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Abstract:

This Small Business Innovation Research (SBIR) Phase II will develop the ultrafast laser system that could represent a significant advance in the technology of directly diode-pumped, solid state, ultrafast sources. In the initial Phase I effort, a record cw power level (> 2W) from diode-pumped Lasers were demonstrated through the use of an innovative, side-pumped design. In Phase II, this design will be further improved and utilized as the basis for a regenerative amplifier to generate high peak powers. The output of a passively mode-locked, diode-pumped laser should provide the seed pulses for the regenerative amplifier. The overall ultrafast source should be simpler, smaller and ultimately less expensive than present, power-equivalent, sapphire-based ultrafast laser systems. As a demonstration of the utility of the proposed technology, a time-domain terahertz (THz) spectrometer will be constructed, based on an optical-rectification THz source and an electro-optical detector, both driven by the laser system. The directly diode-pumped ultrafast laser represents an enabling technology, allowing ultrafast and THz systems to emerge from the laboratory and into the widespread scientific and industrial applications

The proposed ultrafast laser and THz spectrometer both could have the potential for significant scientific and commercial impact. With the lower cost (on the order of 50%) made possible by the simplicity of design, a wider range of research groups in academia and industry will be able to obtain ultrafast sources and THz instrumentation. The lower cost, simplicity, higher reliability and smaller size of the systems will also greatly expand and accelerate the use of ultrafast lasers and THz radiation in biotechnology, medical imaging, precision micro-machining, industrial process control and security systems.

Title: SBIR Phase II: All-Optical Method to Detect and Diagnose Optical Faults in Advanced Optical Networks

Award Number: 0419104
Program Manager: Murali S. Nair

Start Date: July 15, 2004
Expires: June 30, 2006
Total Amount: $499,226

Investigator: Paul Melman, melmanp@newtonphotonics.com
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Phone: (617)928-1221

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a prototype optical network monitoring system based on the enabling technology demonstrated in Phase I. Optical networks must be continuously supervised to ensure high availability and reliability. Advanced networks will use optical routing for cost savings and provisioning flexibility. This trend obsoletes current optical signal quality monitoring techniques. The proposed system, designed specifically for these advanced networks, utilizes an all-optical, in-channel detection method. It not only monitors performance but also performs on-line diagnosis of optical faults. This system operates in a real network environment including the presence of polarization mode dispersion, a phenomena which has frustrated other monitoring approaches.

This technology is targeted to develop advanced networks that cost 50% less to deploy and maintain than existing systems. This represents an enormous cost savings for telecommunications carriers and ultimately all data communications consumers. The demand for telecommunications bandwidth continues to grow rapidly. The market for optical networking equipment and strong growth is predicted.

Title: SBIR Phase II: The Interfractor - A New Optical Dispersive Component

Award Number: 0420331
Program Manager: Murali S. Nair

Start Date: July 15, 2004
Expires: June 30, 2006
Total Amount: $500,000

Investigator: Stephen Senturia, sds@polychromix.com
Company: Polychromix, Inc.
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to develop a new type of optical dispersion element that combines a relief grating with appropriately optimized dielectric films to achieve both high dispersion and high efficiency into one diffraction order, independent of polarization. Grating efficiency is critical for wavelength management in modern fiber-optic telecommunication systems that employ dense wave-division-multiplexing (DWDM) transmission. Dynamic gain equalizers, reconfigurable channel blockers, programmable optical add-drop modules, and wavelength-selective switches all require spatial separation of the wavelengths from an input fiber, typically with a diffraction grating, which is also typically the largest source of insertion loss. Further, because the polarization of the optical signal of any particular wavelength within a fiber may change over time, the net power loss through the device must be independent of polarization. It is very difficult to achieve high grating efficiency in both polarizations. The proposed technology achieves this goal with a proprietary combination of diffractive and thin-film interference effects, and can be fabricated to be robust Over the wide temperature range required of DWDM components

The proposed use of this optical dispersion element will be to improve the insertion loss in Free-space optical wavelength-management products, such as dynamic gain equalizers and Reconfigurable channel blockers, now being deployed in modern fiber-optic telecommunication Systems. This technology will implement in other products to change in its own wavelength-management products as soon as the product can be manufactured.

Title: SBIR Phase II: Low-Voltage Poling of Waveguides in Nonlinear Optical Materials

Award Number: 0349758
Program Manager: Murali S. Nair

Start Date: January 1, 2004
Expires: December 31, 2005
Total Amount: $499,981

Investigator: Philip Battle, battle@advr-inc.com
Company: AdvR, Inc
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Bozeman, MT 59718
Phone: (406)522-0388

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop the processing steps for the fabrication of highly quality periodically poled waveguides in potassium titanyl phosphate (KTP). Periodically poled waveguides enable highly efficient, quasi-phase matched (QPM), nonlinear optical wavelength conversion of continuous wave and high-peak power quasi- continuous lasers. The fabrication process, established during the Phase I effort, utilizes low-voltage pulses combined with a novel electrode configuration to periodically pole channel waveguides embedded in a KTP chip. The use of standard off-the-shelf KTP channel waveguides will significantly increase yields, allow greater design flexibility, and decrease manufacturing expenses while providing a large QPM conversion efficiency that will enable a range of commercially significant applications. Specific products include the frequency doubling of pulsed and continuous wave infrared diode lasers for use in bio- analytical instrumentation and fluorescent spectroscopy, waveguide-based difference frequency mixing modules for generating tunable, narrow band near-infrared sources for environmental monitoring, spectroscopy at hard-to-reach wavelengths, and all-optical switching in communication networks.

This project should result in efficient frequency doubling of diode lasers, which will Have beneficial impacts in medical, environmental, and scientific applications. In the Medical field, the availability of small, low power consumption, cost-competitive visible Lasers will enable the creation of portable bio-analytical instrumentation (e.g. a bedside flow cytometry system). In the environmental field, small inexpensive spectroscopically useful infrared sources will enable new and improved remote sensing systems. Additionally, the KTP waveguide technology developed in this effort is expected to contribute to advanced research in a variety of fields including ultra short pulse wavelength conversion, development of waveguide optical parametric devices, and the efficient generation of correlated photon pairs for quantum optical studies.

Robotics

Title: SBIR Phase II: Extended Performance Red VCSELs

Award Number: 0823022
Program Manager: Juan E. Figueroa

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $485,794

Investigator: Mary Brenner, mhibbsbrenner@photonicdevelopment.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will demonstrate significantly improved output power, temperature range of operation, and reliability of red VCSELs. Commercialization of red VCSEL technology has been plagued by the limited temperature range and output power of the devices and unknown reliability characteristics. The Phase I project demonstrated the 1) feasibility of improving output power and temperature range through a number of techniques, 2) that the fundamental limit of the temperature range is at least as high as 125°C, and 3) dramatically improved reliability. The Phase II approach proposed here breaks away from traditional models for fabricating VCSELs and consists of a variety of growth and fabrication methods allowing us to provide a high thermal conductivity path from the active region to the package. The goals and expected technical results are to demonstrate > 0.5mW single mode, and >1mW multi-mode useful output power at 670nm at 85°C, and the same power output power objectives for 655nm at 65°C on a reproducible basis. This project will also demonstrate greater than 10,000 hours device lifetime at 85°C continuous operation. Project activities consist of design, wafer growth and fabrication, performance testing, and reliability testing. To date, the only commercially available VCSELs have been at 780nm to 850nm, due to the substantial materials challenges at other wavelengths. This proposed effort is applicable to a variety of VCSEL wavelengths (similar thermal issues exist at 1310nm to 1550nm), as well as other optoelectronic devices. Commercially, a significant enhancement in red VCSEL performance can enable the migration of plastic fiber based home and auto networks to higher data rates, faster and higher quality laser printing, longer distance and more precise motion control sensing, new types of portable or wearable medical sensing, and improved robustness and cost of radiography equipment. The success of this project not only creates a significant business opportunity for a red VCSEL supplier, but also enhances the competitiveness of customers by making available a valuable new technology. The reduction in power consumption and improvement in medical technology costs address particularly important societal issues.

Title: SBIR Phase II: High-Speed Atomic Layer Disposition System for Compound Semiconductor Thin Films

Award Number: 0750076
Program Manager: Cheryl F. Albus

Start Date: January 1, 2008
Expires: December 31, 2009
Total Amount: $499,908

Investigator: Prasad Gadgil, pgadgil@atomic-precision.com
Company: Atomic Precision Systems Inc.
301 Rosemont Drive
Santa Clara, CA 95051
Phone: (408) 244-5845

Abstract:

The Small Business Innovation Research (SBIR) Phase II project will develop a novel high-speed Atomic Layer Deposition technology comprising an ALD reactor and associated thin film processes for GaN thin films required for fabrication of high-brightness Light Emitting Diode (HBLED). The proposed effort is based on successful demonstration of operation of the ALD reactor in phase-I SBIR project at 5x speed of commercially available ALD reactors. The unique ALD reactor concept can process atomically thin films and also micron thick films in one chamber. Furthermore, point-of-use, safer and low-cost generation of chemical precursors combined with low temperature processing promises low defect density thin films of a variety of compound semiconductors including GaN. Low defect density, low cost GaN thin and thick films are building blocks of an HBLED. An HBLED bulb that consumes 15 Watts, lasts 10+ years and costs a few dollars can effectively replace a fluorescent tube consuming 30 Watts and an incandescent bulb consuming 100 Watts. The proposed ALD technology promises to reduce process cost, and improve the HBLED quality critical to realize ultra-large scale production of affordable HBLEDs for worldwide lighting applications leading to 50% potential electricity savings and tremendous associated environmental benefits.

Title: SBIR Phase II: Methodology for Applying Haptic Robotics to Agile Manufacturing

Award Number: 0646448
Program Manager: Muralidharan S. Nair

Start Date: April 1, 2007
Expires: March 31, 2009
Total Amount: $500,000

Investigator: William Townsend, wt@barrett.com
Company: Barrett Technology Inc
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Cambridge, MA 02138
Phone: (617)252-9000

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project addresses safety, user - interface, and performance challenges uncovered in Phase I while adapting a haptic robot to the manufacturing environment for medium-production-run paint spraying. Haptics is an exciting field, but industry adoption has been slow. Yet without haptics in applications like medium-run paint spraying, the two alternatives (fully automated or fully manual) are unappealing. Robots are prohibitively expensive to program for short runs, and fully manual operations endanger worker health.

The technologically revolutionary haptics field has not yet revolutionized manufacturing. Some manufacturing tasks lack good alternatives, especially in medium run production, where one must choose between high-cost, time-consuming robot programming versus poor worker health. Physical robot-craftsperson interaction will benefit these middle applications, if safe and intuitive.

Title: SBIR Phase II: Robotic Material Removal System

Award Number: 0646438
Program Manager: Muralidharan S. Nair

Start Date: February 1, 2007
Expires: January 31, 2009
Total Amount: $500,000

Investigator: Steven Somes, ssomes@adelphia.net
Company: Western Robotics Co
8840 Eagle Road
Willoughby, OH 44094
Phone: (440)256-2004

Abstract:

This Small Business Innovation Research (SBIR) Phase II project explores the innovation of a robot that, like biological creatures, operates by applying and sensing contact forces. Today's position-controlled robots have limited applicability to many manufacturing tasks, especially those related to material removal and surface finishing. Emulating a human's free-hand motion capability greatly advances robot capability. Such a robot could trace part contours to smooth and polish. It could feelfor part edges to discover a part's location, and compare measured geometry to a modeled ideal to detect finishing requirements. The robot could follow finishing strategies, acquiring needed information by touch as it worked.

Applications for force capable robots are ubiquitous across industry. Virtually all parts made from casting, forging, machining, or molding require some degree of surface finishing to arrive at a final desired shape and smoothness. Other prospective applications include: mechanical assembly, sorting and packaging irregular objects, and dual-arm manipulation of heavy and bulky items.

Semiconductor & Other Materials

Title: STTR Phase II: 3D Lithography of Thick Photopolymers for Imaging and Photonic Crystal Waveguides

Award Number: 0822695
Program Manager: Juan E. Figueroa

Start Date: August 15, 2008
Expires: July 31, 2010
Total Amount: $499,990

Investigator: Jacob Kuykendall, jlkuykendall@zenwa.net
Company: Zenwa Inc
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Sudbury, MA 1776
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project will culminate in a new form of 3D lithography capable of fabricating imaging arrays and photonic-crystal waveguides that are cheaper, higher performance, lighter, more flexible and have capabilities not currently possible with current ?stack and draw? manufacturing. For example, by directly fabricating these parts at the micron scale, perturbations such as global scaling (to implement magnifying arrays), global rotation (to implement image inverters) or local scaling (to implement modal tapers or integrated lenslets) can be created in a single process step. Unlike current methods which must draw out a minimum of km from a preform, here single parts can be cm in length. The imaging arrays have significant commercial potential as replacements for current endoscopes, fiber face plates and image inverters. They also enable new markets including inexpensive eye monitoring for clinical and public safety applications, wearable gaze-tracking for human-computer interface for paralysis victims, and ultra lightweight heads-up displays for military and consumer entertainment. The team will develop both the lithography and materials to create these all-polymer imaging cables. The transport and manipulation of optical images is ubiquitous but nearly uniformly implemented with delicate, rigid lens trains. Discrete imaging devices such as fiber bundles are sufficient for modern digital displays and cameras and are naturally robust, but currently limited by cost and capability. By enabling flexible, lightweight transport of discrete images, the results will impact ? Education, Medical and Biological Research and Macular Degeneration. The Phase I including supplementary funding has partially funded 7graduate, 1 post-doc and two undergraduate students. An exchange of graduate students with Dublin Ireland extended this impact. The lithography system has been used in multiple undergraduate class projects and for multiple cross-disciplinary graduate research programs. Disposable endoscopes with high resolution, small diameter and large field of view exceed current capabilities at much lower costs. Zenwa has signed a collaborative agreement with the Smith-Kettlewell Eye Research Institute to develop a lightweight customized image delivery system to restore sight to the severely vision impaired.

Title: SBIR Phase II: VLSI Clocking Using BDS Technology

Award Number: 0822830
Program Manager: Muralidharan S. Nair

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $499,989

Investigator: Mihai Banu, mihaibanu@ieee.org
Company: MHI Consulting LLC
22 Sulfrian Road
New Providence, NJ 7974
Phone: (908) 464-6893

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project intends to demonstrate a unique circuit method for GHz clock distribution inside CMOS chips, which provides state-of-the-art performance and is modular, scalable, and reusable. The theoretical foundation of this technology is the Bi-Directional Signaling (BDS) principle implemented over on-chip transmission lines. The project covers the design, fabrication, and evaluation of a comprehensive test chip aimed at validating key aspects of this new method such as the practical accuracy of a long distribution system, the realization of inexpensive high-quality integrated transmission lines, and the design of low power high precision active circuits for local clock generation. If laboratory tests confirm the expected performance and features, this method will be the basis of a valuable new VLSI Very Large Scale Integration (VLSI) technology. The demonstration of scalable and reusable circuit Intellectual Property (IP) for clock distribution will cause a major simplification in the VLSI design methodology with substantial benefits to the manufacturers of integrated circuits. The semiconductor industry will be able to produce faster processing, lower power, and lower cost VLSI components for systems such as computers and communication devices.

Title: SBIR Phase II: Novel Deposition of Silicon Carbide Boules

Award Number: 0750064
Program Manager: William Haines

Start Date: April 1, 2008
Expires: March 31, 2010
Total Amount: $522,000

Investigator: Joshua Robbins, josh.robbins@sicsystems.com
Company: SiC Systems, Inc.
400 Corporate Circle, Unit B
Golden, CO 80401
Phone: (303) 216-2656

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a novel processing technique to form silicon carbide (SiC) boules for wafer production. The technique uses high-purity gas precursors and has the potential to economically produce large diameter SiC boules with low contamination levels and reduced defect levels. In this project, SiC boule growth using gas-phase precursors will be developed for commercialization of 150 mm SiC wafers. SiC is a wide bandgap compound semiconductor with high thermal conductivity, high breakdown electric field strength, thermal stability and chemical inertness. SiC-based electronics are of great interest because they can significantly outperform conventional semiconductors under high-temperature, high-power, high-radiation, and corrosive conditions. Potential products based on SiC include engine control eletronics, turbine engine sensors, power switching devices, microwave electronics, and many others.

Title: STTR Phase II: Germyl Silanes - Enabling Precursors for Chemical Vapor Deposition of Advanced CMOS Substrates, CMOS-Integrated MEMS, and Nano-Scale Quantum-Dot Silicon Phot

Award Number:	0750479
Program Manager:	William Haines
Start Date:	April 1, 2008
Expires:	March 31, 2010
Total Amount:	$481,557

Investigator: Matthew Stephens, mstephens@voltaix.com
Company: Voltaix, Inc
197 Meister Avenue
North Branch, NJ 8876
Phone: (908) 231-9060

Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project will demonstrate pilot scale manufacture of germyl silane precursors and their use to create prototype semiconductor devices and thin films under low temperature and selective growth processing conditions. The project addresses a critical need for precursors and processes that deposit such films under low temperature conditions with throughput rates that are significantly higher than those offered by existing processes. The potential market for devices made with these technologies is predicted to exceed several billion dollars per year and exhibit double-digit growth rates over the next five years. Ge-rich SiGe films will enable higher clock speeds in microprocessors, lower power consumption in cell phones, silicon-based photonics, and more efficient solar cells.

Title: SBIR Phase II: Ultra High Thermal Conductivity Aluminum/Graphite Composites from Low Cost Natural Graphite

Award Number: 0750180
Program Manager: Cheryl F. Albus

Start Date: February 1, 2008
Expires: January 31, 2010
Total Amount: $499,994

Investigator: James Cornie, jcornie@mmccinc.com
Company: Metal Matrix Cast Composites, LLC
101 Clematis Avenue
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Phone: (781) 893-4449

Abstract:

The Small Business Innovation Research (SBIR) Phase II project will develop and present for commercialization natural graphite (NG) reinforced Al (AlGr). In this project, inexpensive natural graphite flake (NGF) will be manufactured into a preform and pressure infiltrated with Al-Si alloys to form composites with thermal conductivities (TC) from 600 W/mK to 750 W/mK and corresponding thermal expansion (CTE) from 7 to 4 ppm/K. CTE is specified by controlling volume fraction of NGF. TC is 1.5 to 1.9 times oxygen free high conductivity (OFHC) Cu at 25% of the mass and comparable volumetric cost to Cu with customized CTE enabling thermally efficient direct die attach. High TC results from reaction of Si from the alloy with NGF surfaces to form low thermal impedance SiC interface. These properties result from innovative preform architecture. In addition, quasi-isotropic TC values (~700 W/mK) are achievable through further preform design. For every 10C decrease in operating temperature, the life of an electronic device is doubled. Conversely, more efficient cooling schemes enable devices to be manufactured with higher performance at higher power densities and in smaller spaces. The materials developed in this project would enable such performance enhancements, and at lower cooling costs. The proposed technology would reduce the dependence on copper for electronic thermal management applications and would find serious application in space and military radar and communication systems as well as laser diode heatsinks, heat spreaders for notebook computers and other consumer electronics.

Title: SBIR Phase II: Diffractive Electrode Structure for on Chip Embedded Passive Components.

Award Number: 0724467
Program Manager: William Haines

Start Date: October 1, 2007
Expires: September 30, 2009
Total Amount: $499,027

Investigator: Ronald Kubacki, kubacki@ionic.com
Company: Ionic Systems Inc
2161 Otoole Ave Ste H
San Jose, CA 95131
Phone: (408)435-2680

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a method for tuning the capacitance of on-chip capacitors. The Phase I effort demonstrated an optical diffractive electrical electrode structure that permits the penetration of deep ultra-violet (DUV) radiation into an underlying dielectric. This was used to precisely tune dielectric constant and capacitance. The DUV radiation incites a photochemical reaction altering the dielectric constant of the spacer material in the capacitor.

This project, if successful, will enable compact, precision capacitors embedded on chip to replace external discrete capacitors in electrical circuits. Moving passive components on chip in the same fabrication process is a reduction of manufacturing effort. By precisely trimming electrical values with resistor trimming equipment a significant simplification of the manufacturing process may be achieved. The successful results of Phase II will result in the demonstration of a molecularly engineered nanocomposite for use in millimeter and micro wave monolithic integrated circuits that can be photo-optically tuned for precise value to embed precision capacitors on chip. Incorporation of this technology can result in reduced size and cost for a wide variety of high frequency applications.

Title: SBIR Phase II: New N-Type Polymers for Organic Photovoltaics and other Electronic Devices

Award Number: 0724875
Program Manager: William Haines

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Silvia Luebben, silvia@tda.com
Company: TDA Research, Inc
12345 W 52nd Ave
Wheat Ridge, CO 80033
Phone: (303)940-2301

Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to develop a new family of n-type conjugated semiconducting polymers for use in plastic photovoltaics and other organic electronic devices. New n-type semiconducting polymers with good solubility, environmental stability, and high charge carrier mobility are needed to fabricate efficient organic solar cells and other electronic devices. During the Phase I project several n-type semiconducting polymers were fabricated via simple reactions. In Phase II the polymers will be optimized to improve their solubility and charge mobility. Partnership with a major developer of organic photovoltaics will allow the materials to be optimized for use in organic solar cells.

The further development of these n-type semiconducting polymers will result in the manufacture and sale of these materials as specialty chemicals to the organic electronic industry for the fabrication of a variety of organic devices including photovoltaic devices, thin film transistors, organic light emitting diodes, and others. The novelty of this chemistry over the chemistry of current n-type organic semiconductors has the potential for significant academic and scientific value and could lead to a cascade of new discoveries and technology advancements, in addition to the primary objective of creating a new business.

Title: SBIR Phase II: Ultra Low Cost, p-i-n OLED Lamps for Specialty Lighting

Award Number: 0724204
Program Manager: Juan E. Figueroa

Start Date: July 15, 2007
Expires: June 30, 2009
Total Amount: $497,242

Investigator: Melissa Kreger, melissak@add-vision.com
Company: Add-vision
1600 Green Hills Rd. Suite #100
Scotts Valley, CA 95066
Phone: (831)438-8192

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will analyze the limiting factors in performance and commercialization obtained through printed polymer organic light emitting diode (P-OLED) research and development as well as customer engagement. Utilizing this basis, a set of materials, device and process development tasks have been devised. These include continued lifetime improvements and development of an encapsulation process. During Phase-I, the impact of light-emitting layer morphology and cathode interactions on device performance was identified. This has allowed a prioritization of these issues for final development. Technical objectives include exceeding the commercialization threshold and achieving greater than 1000 hour product lifetimes with a flexible encapsulation process adaptable to small and large scale manufacture. This includes advanced light-emitting polymers (LEP) formulations, cathode development, and device structure optimization to meet performance milestones along with encapsulation adhesive, getter materials and lamination process trials and optimization.

If successful the outcome of this project includes benefits for mobile electronic product designers and consumers using low cost and low energy manufacturing in the U.S. display and lighting industries. Furthermore, the science and engineering work compliments R&D efforts in related materials technologies. The proposed technology is uniquely attractive among OLED lighting technologies currently under development in that it allows for low manufacturing set-up and operating expenses, and therefore early commercial adoption. Because of this cost structure, which is radically different from conventional, high capital, glass-based OLED processing, there is a significant early commercialization opportunity in mobile backlighting products and other specialty lighting applications. In these product areas, the proposed technology''s voltage, brightness, DC drive, and form factor makes it preferable to existing inorganic approaches. The low capital cost structure and dependence on advanced materials technology also provides opportunities for distributed manufacture in the U.S. away from the centralized Far East display manufacturing base. Outside of the organic display and lighting industries, this research would enhance the scientific understanding for other emerging printable and organic electronics technologies including organic photovoltaics, thin film transistors and memory, where low cost manufacturing of high-efficiency devices are paramount for commercial success.

Title: SBIR Phase II: Thick Film Garnet Materials for In-Plane Propagation Magnetooptic Devices

Award Number: 0646272
Program Manager: William Haines

Start Date: April 1, 2007
Expires: March 31, 2009
Total Amount: $500,000

Investigator: Vincent Fratello, vjfratello@integratedphotonics.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project addresses the device and market opportunity for in-plane propagation of light in-planar anisotropy magnetic garnet films for high sensitivity, high speed magneto-optic sensors, switches and modulators. Traditional perpendicular propagation devices require perpendicular magnetic fields and magnetization processes. These are limited in speed and sensitivity by the current materials and the energy required to magnetize the garnet in the perpendicular direction. In the plane of the film, there is almost no energetic barrier to domain rotation. In this project, Integrated Photonics, Inc. (IPI) proposes to reduce that barrier to near zero to make devices of unprecedented sensitivity and speed. The goal is to attain pico-tesla field sensitivities in sensors and gigahertz device frequencies. The latter will enable small, low-power magneto-optic light modulators that are truly a disruptive technology by comparison to current large dimension electro-optic technologies. In Phase I, a materials growth and characterization capability was established and limitations on speed and sensitivity were removed by optimizing material parameters. In Phase II the process will be optimized to achieve the highest optical quality for commercial devices and sensor, switch and modulator devices will be realized in collaboration with customer-partners.

Commercially, in-plane propagation in planar thick film Faraday rotators would enable unique new devices. High speed magneto-optic modulators open the door to system integration architecture for wideband communications and software defined radios. In-plane propagation materials have much higher switching speeds than conventional perpendicular Faraday rotators and as such would permit a magneto-optical approach to packet switching. Reduced costs would permit wide deployment in FTTP. High speed, low field magneto-optic switches are attractive for military applications. In-plane propagation magnetic field sensors can be optimized to give unprecedented high sensitivity speeds much higher than can be attained with conventional perpendicular propagation. These sensors would have applications such as wheel and turbine rotation, electric power distribution, monitoring, metering and control and battlefield sensors. The electric power application in particular has potential to revolutionize catastrophic failure prevention in the power grid and reduce power costs at a variety of levels by enabling autonomous reconfiguration. The lack of electrical connectors in fiber optic sensors for explosive, flammable and high voltage environments represents a significant improvement in safety. Smart ships and buildings would find utility both for conservation and efficiency.

Title: STTR Phase II: Improved Boron Nitride Materials for Enhanced Thermal Management

Award Number: 0646556
Program Manager: William Haines

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $500,000

Investigator: John Ferguson, john.ferguson@aldnanosolutions.com
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II project builds upon the successful Phase I results to develop surface modified boron nitride (BN) filler materials for electronic thermal management applications. Novel Atomic Layer Deposition (ALD) nanocoating is used to selectively functionalize edges only or edges/basal planes to improve wetting of BN platelets with resin encapsulants. The improved wetting allows for reduced viscosity of BN/resin mixtures during processing so that increased BN filler particle loadings can be achieved, resulting in higher thermal conductivity electronic packages. These improvements are best realized using an ultra-thin (nm thick), conformal, pin-hole free, chemically bonded silica nanofilm selectively placed on the edges of primary BN platelets. Coating the edges of platelets only provides for a low cost impact since edges being nanocoated represent less than 10% of the available platelet surface area. Higher BN loadings in filled composites allow for improved heat dissipation in electronic packaging materials, particularly in the case of glob top coatings and potting compounds. Proposed Phase II R&D is focused on working with potential customers to develop applications of particle ALD surface modified BN fillers for their specific moulding compound systems. Film chemistry and thickness will be developed for their specific applications.

Commercially, the ALD nanocoating of individual ultrafine particles to control their surface chemistry is enabling technology that is unparalleled compared to more conventional CVD, PVD, PE-CVD, or wet chemistry solution processing. The process allows for individual ultra-fine particles to be nanocoated, rather than coating aggregates of ultra-fine particles. It is independent of line of sight and provides for chemically bonded films to the substrate particle surface. It is easily scalable. It is a forgiving process where the nanocoating thickness is controlled by self-limiting surface reactions (not flux, temperature, or time of processing like CVD, etc.). ALD films are pin-hole free and conformal. The potential impact of successful large scale processing extends far beyond this proposed microelectronics packaging application. It is now possible to produce ultrafine particles with designed electrical, magnetic, optical, mechanical, rheological, or other properties. Markets for such functionalized ultra-fine powders include microelectronics, defense, hardmetals, cosmetics, drug delivery, energetic materials, and polymer/ceramic nanocomposites, among others.

Title: SBIR Phase II: A New Production Method for Ta Fibers for Use in Electrolytic Capacitors with Improved Performance and Packaging Options

Award Number: 0646417
Program Manager: William Haines

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $500,000

Investigator: William Nachtrab, wnachtrab@supercon-wire.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project is intended to develop a new process for manufacturing tantalum (Ta) metal fibers for use in producing tantalum capacitors, and advance this process to the stage of commercialization. This technology, which has been demonstrated in Phase I, could lead to capacitor products having higher performance and greater volumetric efficiency than any currently available. The use of fibers in place of metal powder allows the production of thin anode bodies leading to improved packing options and component performance. The innovation underlying the technology is bundle drawing of Ta filaments in a copper matrix. A composite consisting of Ta filaments in a copper matrix is drawn is a series of reduction steps until the filaments are less than about 10 microns in diameter. The drawn wire is rolled to produce ribbon-type filaments that are 1 micron or less in thickness. The copper composite matrix is chemically dissolved without attacking the Ta to produce metallic Ta high surface area, ribbon-fibers. The fibers are formed into thin mats, which are sintered to produce porous metal strips from which high surface area capacitor anodes are made. A significant aspect of this approach is that fiber morphology can be varied over a wide of fiber thicknesses unlike powder. This allows the morphology of the fibers to be optimized for the particular voltage rating and use requirements in order to maximize the performance of the capacitor.

Commercially, nearly all medical, automotive, military and many consumer electronic devices utilize Ta electrolytic capacitors due to their outstanding performance, reliability and volumetric efficiency. Solid electrolytic capacitors are currently made from Ta metal powder. Several million pounds per year of Ta powder are consumed in manufacturing Ta capacitors for these applications. The trend in electronics is toward high powder
components and increased miniaturization. Combined with the need to lower materials
and manufacturing costs, these considerations have created an opportunity for new
method of producing solid electrolytic capacitors. Fiber metal technology has the potential to both lower manufacturing costs, improve capacitor performance, and improve
packaging options, which could enable the development of new product that are either
currently very difficult or very expensive to make using current technology base on metal powder.

Title: SBIR Phase II: A Novel Microwave Technique for Rapid Thermal Processing of Silicon Carbide Wide Bandgap Semiconductor

Award Number: 0646184
Program Manager: William Haines

Start Date: March 1, 2007
Expires: February 28, 2009
Total Amount: $500,000

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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a unique solid-state microwave technique capable of reaching ultra-high temperature (up to 2150 deg C) and ultra-fast thermal processing of large wide band gap semiconductor wafers. It is widely recognized that the existing post-implant anneal process is a bottleneck limiting the performance and reliability of wide band gap semiconductor devices. This technique lowers the sheet resistance and surface roughness of the implanted semiconductor, enabling the fabrication of higher performance, more power efficient devices at lower cost. As part of the Phase I research, the microwave annealed samples showed a record low sheet resistance and surface roughness in both p-type and n-type implanted SiC. The Phase II research is to extend microwave-based rapid thermal processing (RTP) to other wide band gap materials such as GaN and to allow for RTP of larger sized wafers. The prototype system will be upgraded from a single-heating-head system to a system with an array of multiple heads and multiple sensors. Computer-based automated control will be developed to regulate wafer temperatures uniformity and stability. The research is anticipated to show feasibility of microwave-based RTP in commercial use for large SiC wafers. The technology improves post-implant anneal process to minimize sheet resistance and surface roughness of SiC and GaN, which consequently reduces the device power consumption and lowers the thermal budget. Lower surface roughness improves SiC sub-micron device reliability, consequently improving yield and reducing manufacturing cost.

Commercially, this is an enabler technology that will make better and lower-cost compound semiconductor devices in areas such as power devices, light emitting diodes (LEDs), high temperature and high frequency electronics. The societal and commercial impact of the technology can be enormous. LED technology, for example, can potentially reduce the percentage of energy required for lighting in the U.S. from 22% to 7%, saving $17 billion per year and reduce CO2 emissions by 155 million tons. Manufacturers of LED devices are looking for enabler technologies such as RTP to reach this goal. Recognizing the technological and the commercial significance of the research, Cree, GE Research and ARL are supporting the research effort by providing the technological expertise, test wafers, access to equipment, and other in-kind services.

Furthermore, the technology can be extended to other applications such as RTP of ultra-shallow junction for nano-scale CMOS devices, wafer bonding, MEMS as well as processing of SiC nano-materials.

Title: SBIR Phase II: Germanium Liquid Crystals for Perfect Displays

Award Number: 0522304
Program Manager: James Rudd

Start Date: December 13, 2005
Expires: October 31, 2007
Total Amount: $400,000

Investigator: Michael Wand, mdwand@gmail.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop germanium-containing ferroelectric liquid crystals (Ge-FLC's), a fundamentally new class of LC materials that enable migration of microdisplays into camera and automotive applications with billion-dollar available display markets. Ge-FLC mesogens synthesized during Phase I demonstrated breakthrough layer shrinkage properties that will solve the longstanding bistability problem in FLC's, thereby raising the achievable brightness of FLC-based projection displays to commercially viable levels. Phase II research tasks include: (1) the synthesis and characterization of a library of approximately 100 new Ge-FLC compounds, (2) the formulation from this library of FLC mixtures engineered for three specific approaches to bistable switching, and (3) development of alignment layers conforming to the device physics requirements of the three bistable approaches. These tasks support the overall project objective of demonstrating robust engineering-prototype bistable FLC devices with characteristics appropriate for commercial microdisplay products.

Commercially, the project furthers the emerging technology of silicon-based microdisplays with very large potential commercial impact. The company's previous success commercializing SBIR-funded technology into a rapidly-growing $40-million business provides a foundation for growth into billion-dollar markets for camera and automotive microdisplays enabled by the Phase II innovation. Success in these markets will generate outstanding returns for the company's shareholders, and will provide higher-performing, lower-cost electronic cameras and safer and more convenient automobiles to U.S. consumers.

Title: SBIR Phase II: Integration of Advanced Power Electronics through the Packaging of High Temperature Silicon-Carbide (SiC) Based Multichip Power Modules (MCPMs)

Award Number: 0522272
Program Manager: T. James Rudd

Start Date: August 1, 2005
Expires: July 31, 2007
Total Amount: $441,918

Investigator: Alexander Lostetter, alostet@apei.net
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop highly miniaturized power converters by developing a functional, scaled-down hardware prototype of a high-temperature multichip power module (MCPM). To achieve this goal, the company has taken advantages of the key benefits of silicon carbide (SiC) semiconductors which include high-temperature operation, high switching frequencies, low switching losses, and high power densities. While Phase I of the project was focused upon successfully proving the feasibility of high-temperature MCPM's, Phase II will be focused on developing full prototype modules. The Phase II project will further develop high-temperature packaging techniques and investigate long term reliability issues associated with high-temperature operation. At the conclusion of Phase II, the company will deliver two high-temperature MCPM modules. The first prototype delivery will be a fully functional 4-hp 3-phase motor drive MCPM capable of 250 degrees C operation, and the second prototype will be a 30 kW 3-phase motor drive that demonstrates an order of magnitude miniaturization over modern state-of-the-art silicon based systems. Since current silicon electronics are typically limited to approximately 150 degrees C maximum temperature of operation, the high-temperature research proposed in this project has the potential to greatly enhance scientific understanding of high-temperature failure mechanisms, thermal induced electronic packaging stresses, and long-term interconnect reliability issues, in addition to technical advancement of state-of-the-art power electronics systems.

The commercialization of SiC based MCPM's has the potential to find benefit in nearly every electric motor drive, power supply, or power converter conceivable. The application of such MCPM's could save electrical energy consumption worldwide, due to the improved electrical efficiency of SiC power switches alone. Furthermore, an immediate commercialization application is possible in the development of high-temperature geological petroleum exploration instrumentation and also in industrial motors. Other long term benefits would be found with application to complex weight critical power systems (such as in spacecraft), high-temperature systems (such as fuel cell electronics or electric vehicle motors), and other high efficiency power systems.

Title: SBIR Phase II: Miniature Cooling System for Laptop Computers

Award Number: 0522126
Program Manager: T. James Rudd

Start Date: August 1, 2005
Expires: July 31, 2007
Total Amount: $500,000

Investigator: Daniel Schlitz, dschlitz@bellsouth.net
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a compact, light-weight and noiseless cooling system for laptop computers. The product will be an air cooled, micro-channel heat sink with an electro-hydrodynamic (EHD) pump integrated within the channels. Research will focus on the development of a heat sink with a large parallel array of micro-channels to provide optimal thermal resistance. The second major area of development will be the EHD air flow device; a modification to the corona wind technique will be used to provide air flow through the heat sink. Other tasks include power supply development, system integration, manufacturing process development and reliability improvement. As the speed and performance of laptop computers increases, the power density in the microprocessors rises and they dissipate more heat. The proposed project addresses the fact that laptop computer cooling systems will be required to dissipate upwards of 40 Watts while maintaining the microprocessor below 85 degrees C.

Commercially, the proposed cooling system is being developed for the growing laptop computing market. More than 235 million personal computers will be sold in 2007; roughly one-third of which or about 80 million will be laptop computers. The proposed product's small size and excellent heat dissipation capabilities will enable laptop computer manufacturers to incorporate faster processors while simultaneously reducing the overall size and weight of their products. Besides cooling applications, electro-hydrodynamic pumping technology can be used as a means of providing precise control of small amounts of liquid. This has application as an insulin delivery mechanism for diabetics and in the so-called laboratory-on-a-chip.

Title: SBIR Phase II: Iptymer Low-k Dielectric Materials

Award Number: 0450507
Program Manager: T. James Rudd

Start Date: April 15, 2005
Expires: March 31, 2007
Total Amount: $500,000

Investigator: Lawrence Hancock, lhancock@nomadics.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project will develop and introduce new low-dielectric constant polymers as a new dielectric material for the fabrication of interconnect systems in integrated circuits. The continuing drive for denser integrated circuits and faster interconnects requires the development of new interlayer dielectric materials. The proposed materials rely on newly defined, so called Iptymer molecular design concepts, to create intrinsic free volume within the material. This approach is distinctly different than the current methods under investigation that introduce extrinsic pores into a material to lower its dielectric constant. The standout thermal stability, mechanical strength, and processability of Iptymer materials will enable facile integration into semiconductor fabrication processes. The research objectives of the Phase II program will introduce and supply Iptymer materials into semiconductor fabrication process development programs. This effort builds on Phase I results that demonstrated scaled synthesis of key Iptymer monomers and polymers and validated the dielectric performance, mechanical strength and processability of Iptymer polymers. The Phase II program will demonstrate pilot production of Iptymer materials that possess a dielectric constant less than 2.0 and have superior mechanical and thermal integrity. In addition integration of Iptymers in semiconductor fabrication processes will be demonstrated.

Commercially, the impact of reliable low-k dielectric materials is considerable. Higher bandwidth processing and communication for the same cost will be possible with improved materials. Present day microprocessors have a range of clock speeds determined from post-fabrication testing. Superior low-dielectric materials will not only increase the ultimate clock speeds, but will also improve the yield of the highest speed devices. Every country, economic group, and industry will benefit from such advances. The societal benefits realized through the extension of electronic tools into areas where their use is now impractical or not affordable will be tremendous. Widespread availability of computers throughout primary and secondary education will reap tremendous gains in education.

Title: SBIR Phase II: Lead-Free Solder Process

Award Number: 0450408
Program Manager: T. James Rudd

Start Date: April 15, 2005
Expires: March 31, 2007
Total Amount: $501,925

Investigator: Holly Garich, hollygarich@faradaytechnology.com
Company: Faraday Technology, Inc
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Abstract:

This Small Business Innovation Research Project (SBIR) Phase II project will advance the development of an electrochemical process, addressing the need for elimination of the use of lead-based finishes and solders in the printed circuit board, electronics packaging and semiconductor industries. This technology utilizes pulsed electrolysis to deposit a lead-free tin solder with the desired grain size, matte finish and control of internal stresses, to avoid whisker growth which can lead to component failure. The Phase II objectives/research tasks include: 1) pilot-scale facilities design and modification for electro-deposition of lead-free solder onto full size printed circuit boards and wafers, 2) demonstration and optimization of the process to deposit lead-free solder for chip and wafer scale packaging, 3) development of analysis methods to characterize deposit properties and evaluate the correlations between the process and deposit properties, 4) demonstration of qualification and reliability tests for tin whisker evaluation and characterization of corresponding acceleration factors, and 5) comparison of the data to that obtained by other alternatives lead-free materials, e.g. tin-silver. The anticipated results of the Phase II program are a marketable manufacturing process/manufacturing tool in the form of an electrochemical module incorporating the lead-free process.

Commercially the project addresses the needs of the printed circuit board and semiconductor industry, to minimize chemical waste and environmental impact and at the same time increase cost-effectiveness.

Title: SBIR Phase II: High Resolution Infrared Imager

Award Number: 0450487
Program Manager: Juan E. Figueroa

Start Date: March 15, 2005
Expires: February 28, 2007
Total Amount: $484,140

Investigator: Conor Rafferty, conor.rafferty@nobledevice.com
Company: Noble Device Technologies Corporation
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to leverage new materials technology to drive a revolution in infrared imaging. Silicon imagers are widely used, from supermarket scanners to the ultra-sensitive charge-coupled devices (CCDs) used in astronomy. Germanium is photo-sensitive over a wider spectrum, from visible to well into the infrared. Combining this new spectral capability with fine-line silicon manufacturing brings high resolution, high reliability and lower costs to infrared imaging, enabling new applications, especially in dentistry and medicine. Short-wave infrared (SWIR) imagers today using exotic materials have limited resolution and are too costly for widespread use. This SBIR Phase II project proposes to design a prototype silicon-imaging array for use with integrated germanium pixels.

The proposed project has broad impact. The short-wave infrared (SWIR) spectral range from 800 to 1600 nanometer (nm) holds considerable scientific and applied interest. The human eye does not focus wavelengths past 1.4 micron, so that infrared imaging using active illumination with bright flashes is possible without endangering safety. The most promising immediate application is dental imaging, where the transparency of tooth enamel at 1300 nm allows improved diagnostics through infrared imaging.

Title: SBIR Phase II: High Surface Area Tantalum Powder for Capacitor Applications

Award Number: 0450598
Program Manager: T. James Rudd

Start Date: February 15, 2005
Expires: January 31, 2007
Total Amount: $500,000

Investigator: Harvey Gershenson, kappastl@aol.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will scale-up a new technology for producing high-surface area tantalum powders for the electronic capacitor industry. The existing technology is over 30 years old and cannot keep pace with the needs of smaller electronics, which require tantalum particles in the nanometer size range. In addition, environmental factors are driving the industry away from the fluorinated precursors that are presently used to make tantalum. The proposed technology employs the Sodium Flame Encapsulation (SFE) technology to address this problem by producing nano-tantalum powders encapsulated in sodium chloride. In-situ encapsulation allows for control of morphology and prevents oxidation of the nano-tantalum by air or moisture. The technology has been shown to produce state-of-the-art capacitor materials with an environmentally-friendly process. Nonetheless, the present process is a two step process involving post-processing of the nanopowders into the agglomerated structure needed by capacitor manufacturers. This program will specifically develop the flame technology so that the post-processing step is unnecessary. In this way powders can be produced with the appropriate morphology such that they only need to be washed and re-encapsulated to be a drop in replacement for existing materials. The results will be a less expensive, higher efficiency, higher surface area material that is produced by a green technology.

Commercially, this technology will enable smaller, more versatile electronics by ensuring that the tantalum capacitor industry can continue to reduce its package size in line with the rest of the industry.

Title: SBIR/STTR Phase II: A Semiconductor Device for Direct and Efficient Conversion of Radioisotope Energy

Award Number: 0450338
Program Manager: T. James Rudd

Start Date: February 1, 2005
Expires: January 31, 2007
Total Amount: $510,050

Investigator: Larry Gadeken, larrygad@betabatt.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will fabricate a prototype betavoltaic battery in a form factor the size of a quarter coin. The goal will be to generate approximately 100 microwatts of electrical power in a volume less than half a cubic centimeter from a tritiated energy source. Research conducted for the Phase I portion of this project established the feasibility of constructing a semiconductor device that directly and efficiently converts the energy released from radioactive decay directly into electric current. Three dimensional (3D) diodes were constructed in macroporous silicon by placing p-n junctions along the walls of all the pores. These junctions formed the betavoltaic conversion layer for beta particles (electrons) emitted by gaseous tritium (the radioisotope of hydrogen with a half life of 12.3 years) that was distributed throughout the pore space. Measurements of the current-voltage responses for this novel 3D geometry demonstrated an order of magnitude efficiency increase compared to conventional 2Dplanar diodes. In the 3D diode nearly every decay electron entered the p-n conversion layers. The focus of the Phase II research will be to enhance the performance of the 3D diodes to maximize conversion efficiency. Also, the source energy density will be increased markedly by developing a tritiated solid that can be easily and routinely dispersed in the pore space. This research will lead to the development of a practical nuclear battery.

Commercially, betavoltaic batteries will be useful in a wide variety of sensors and devices used for remote and extended missions in many inaccessible locations. Successful commercialization of this nuclear battery with its order of magnitude increase in useful life is to increase significantly the utilization of self-powered devices and sensors. Stringent efforts will be made to ensure the radiological safety of these nuclear batteries at every step in the development, manufacturing and commercialization processes.

Title: SBIR Phase II: Power-Aware Statically Speculative Microprocessors

Award Number:	0450165
Program Manager:	Muralidharan S. Nair
Start Date:	February 1, 2005
Expires:	January 31, 2007
Total Amount:	$500,000

Investigator: Csaba Moritz, andras@bluerisc.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will develop energy-aware compiler techniques to reduce power and energy consumption in microprocessors, without affecting performance. A key principle behind this approach is to use speculative information available at compile time to reduce power and energy consumption. The key qualifier is speculative: the information does not have to be provably correct. Speculative information that turns out to be correct will enhance energy reduction; if it is incorrect, the worst that will happen is that a penalty (in terms of energy) will have to be paid. The use of such speculative compile-time information opens up a largely unexplored dimension in compilers and computer architectures, to target energy efficiency.

Over the past few years, energy consumption by computers has emerged as a major area of intellectual and commercial activity. These techniques if successful will permit substantial savings in energy consumption. The outcome of the proposed effort will not merely be a set of products, but also a vastly increased understanding of the means by which compile-time information can be exploited for energy savings. With the increasing prevalence of battery-powered computing devices such as PDAs, mobile telephones, and notebooks, power-aware computing is becoming increasingly important commercially.

Title: SBIR Phase II: Microdisplays Based on III-Nitride Wide Band Gap Semiconductors

Award Number:	0450314
Program Manager:	T. James Rudd
Start Date:	February 1, 2005
Expires:	January 31, 2007
Total Amount:	$479,672

Investigator: Zhaoyang Fan, zyfan@3N-Tech.com
Company: III-N Technology, Inc
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project's goal is to bring the demonstrated Gallium Nitride (GaN) microdisplay technology to industrial maturity and to final commercialization levels. The project's goal will be accomplished by further optimizing the microdisplay device structural design and fabrication process based on the demonstrative results obtained in Phase I. Based on high-efficiency semiconductor micro-light-emitting diode (microLED) array technology, the GaN microdisplay is the first of its kind based on semiconductor LEDs. Specifically, by the hybrid integration of GaN microLED arrays with Si CMOS driver circuits through flip-chip bonding, active matrix addressable GaN microdisplays will have a compact size and will be able to support more information content and movie display due to their high pixel filling factor, uniformity, luminance, and power efficiency. The unique intrinsic properties of GaN microLEDs - high brightness (> 10 microwatt optical output power for microLEDs of 18 micrometer in diameter), wide viewing angle (~ 160 degrees), fast response time (< 1 ns), and high thermal and vibrational resistance, make GaN microdisplays a perfect solution for environmentally demanding applications such as head-up displays (HUD) in modern vehicles and aircrafts, head-mounted displays (HMD) for firefighters and other rescue operatives, and hand-held mini-projectors for field applications.

Microdisplays have a small size (typically less than 1 inch diagonal) with a resolution from low end to above XVGA format. They are magnified by optics to form enlarged virtual or projected images for viewing by a user. Microdisplays can be used in a variety of devices such as head-mounted displays, video headsets, camcorder viewfinders, projection TV, head-up displays, etc. and have many commercial applications. GaN microdisplay, with its superior performance over other microdisplay technologies, is especially suitable for environmentally demanding applications that require high brightness, high reliability, and wide operating temperature range. With a slight modification of the material composition, GaN microLED arrays developed here can vary the emitted wavelength from the green to the ultraviolet range, which is very suitable for fluorescence analysis used in new type chemical-biology agent detector array or DNA/protein microchips. The GaN microLED array also has the potential for applications such as optical links and parallel computing. Other applications also include spatially resolved optical studies of biological, medical, and health care systems. The research will also enrich the general knowledge of wide bandgap semiconductor micro- and nano-photonics

Title: SBIR Phase II: Yb:KGW for High Power and Ultrafast Lasers

Award Number: 0450570
Program Manager: Juan E. Figueroa

Start Date: January 1, 2005
Expires: December 31, 2006
Total Amount: $499,979

Investigator: Barry Wechsler, bwechsler@novaphase.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project focuses on developing methods to improve the power and performance of an exciting new diode-pumped solid-state laser crystal. Laser crystals are superior to any other candidate material in the emerging and rapidly developing field of ultrafast lasers by their ability to generate high power femtosecond pulses. The proposed program will involve crystal growth in order to select the material with optimum operating performance and power handling capabilities. Issues to be addressed include the optimum concentration in the crystals, the uniformity of dopant incorporation during crystal growth, the preferred orientation of the crystal for laser rod fabrication, and methods to improve the quality and reliability of these crystals.

The first commercial ultrafast laser system based on this technology was recently introduced. In order to ensure the rapid development of this new technology and the myriad applications in material processing, medicine and basic science it will undoubtedly enable, considerable development effort is required. This research effort is directed toward bringing the material system on which the laser is based to a point of performance, reliability and producability necessary for the commercial success of this new device.

Title: SBIR Phase II: Novel Fluoropolymer Material

Award Number: 0422104
Program Manager: T. James Rudd

Start Date: December 1, 2004
Expires: November 30, 2006
Total Amount: $499,997

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Phone: (405)372-9535

Abstract:

This Small Business Innovative Research (SBIR) Phase II project is to develop a novel material to enable improved performance of surface enhanced Raman spectroscopy (SERS). Availability of this material could result in the manufacture of pollution monitoring, industrial process monitoring, and defense-related products for the identification and quantification of analytes of importance to these markets. Currently available Raman spectroscopy systems provide detection of a broad range of analytes and have met with commercial success but are limited in sensitivity due to the inherent weakness of the Raman scattering phenomenon. They are also limited in their ability to differentiate analytes in complex matrices. SERS offers a means of overcoming these limitations but has been plagued by poor repeatability and limited availability of suitable substrates. Suspending noble metal particles in an inert matrix could allow their functionalization for analyte sensitivity.

The use of free floating and matrix-bound noble metal particles as SERS substrates has been demonstrated by other researchers but has not yet provided the reliability that is required for industrial and military applications. SERS has remained an "almost-commercial" technology for a number of years. It is believed that this material is a platform technology for the widespread investigation and commercialization. These enhancements and the increased understanding and control of the SERS effect provide should result in dramatic improvements in the sensitivity, selectivity, and cost of monitoring and detection systems for many Raman-active analytes of military and industrial importance.

Title: SBIR Phase II: High Conductivity Photoprintable Conducting Polymers for Polymeric Electronics

Award Number: 0420397
Program Manager: T. James Rudd

Start Date: November 1, 2004
Expires: October 31, 2006
Total Amount: $500,000

Investigator: Brian Elliott, belliott@tda.com
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Wheat Ridge CO, 80033
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project will develop organic dispersible and photoprintable conducting polymers based on polyethylenedioxythiophene (PEDOT). PEDOT is the conducting polymer of choice for electronic displays and devices due to its high conductivity, stability and transparency as a thin film. However, it is only available as an aqueous dispersion, and no one else has been able to render PEDOT dispersible in organic solvents. It is important to make PEDOT dispersible in organics because water is incompatible with many semiconductor processing steps. This SBIR project will develop printable conducting polymers that are initially organic dispersible, can be cast a thin films, and conducting patterns can be made permanently fixed by selectively exposing the film to ultraviolet light. The material that is not exposed to the light can be easily removed. This project will develop printable PEDOT-based conducting polymers that contain no water, and that can be used in the production of electronics such as organic light emitting diode (OLED) displays.

This project hopes to increase knowledge of organic dispersible conducting polymers. Sample size quantities of organic dispersible conducting polymers developed in this project will be made available to researchers by sale through a major chemical distributor. This will promote a more rapid dissemination of the base technology and quicken the pace of additional discoveries and applications using our materials. The benefits of this research to society include a reduced environmental impact due to electronics manufacturing. The printing technology presented in this proposal results in fewer chemical waste streams than inorganic electronics production. Inorganic electronics fabrication facilities produce large amounts of toxic waste including arsenic and heavy metals. The lack of ground water pollution from toxins in the decomposition process is a plus for municipalities who struggle with this issue today. Furthermore, this printing technology will result in a reduction in the cost and a greater variety of electronic devices available to consumers. This technology should have a positive impact in areas where weight sensitivity represents a gating factor.

Title: SBIR Phase II: Geiger Mode Avalanche Photodiodes for Photon Counting from 0.9 Micrometers to 2.0 Micrometers

Award Number: 0422110
Program Manager: Murali S. Nair

Start Date: August 1, 2004
Expires: July 31, 2006
Total Amount: $355,578

Investigator: John Dries, jcdries@sensorsinc.com
Company: Sensors Unlimited, Inc
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is to develop an InGaAs/InP avalanche photodiodes for use in Geiger mode photon counting with wavelength response extended from the conventional cutoff wavelength of 1.7 microns to 2.1 microns. Commercial InGaAs/InP avalanche photodiodes developed for linear operation in optical fiber communication systems have limited quantum detection efficiency and relatively high dark count rates when operated in Geiger mode, and are unable to detect radiation from important laser sources such as Tm/Ho near 2 microns. Using our experience as manufacturers of commercial linear-mode avalanche photodiodes and our epitaxial growth facility, we will design and fabricate avalanche photodiodes optimized specifically for Geiger-mode operation. The goal will be to obtain enhanced quantum detection efficiency, reduced dark count rate, and extended wavelength response to 2.1 microns. The two primary impacts of this work will be to enhance the understanding of the physics of Geiger-mode avalanche photodiodes, and to provide the broader research community with improved detectors that will significantly enhance the usefulness of photon-counting techniques in the near-infrared spectral region. Although the basic theory of Geiger-mode operation of avalanche photodiodes is several decades old, there continues to be a significant quantitative discrepancy between the quantum detection efficiency predicted by the theory and the quantum detection efficiency observed experimentally. Part of this study will pursue this discrepancy, not only to design improved devices but also to better understand the fundamental performance limits.

By developing improved near infrared photon-counting detectors this study will take a major step toward making such detectors commercially available to the larger research community, which will enable photon-counting techniques to be more widely applied in the near-infrared spectral region.

Title: SBIR Phase II: Ultra-Broadband Ferrite Circulators/Isolators

Award Number: 0349610
Program Manager: T. James Rudd

Start Date: March 1, 2004
Expires: February 28, 2006
Total Amount: $500,000

Investigator: Hoton How, hotonhow@hotech.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project addresses the development of Innovative Ultra-Broadband Ferrite Circulators/Isolators. A conventional 3-port ferrite stripline junction circulator involves a low-Q ferrite stripline resonator so that at the circulation frequencies standing-wave resonant modes are excited dumping microwave energy from the input port to the output port but not the isolation port. Operation of a conventional ferrite circulator is nonreciprocal, and the transmission bandwidth is roughly proportional to the inverse of the Q-factor of the resonator, due to the standing-wave nature of the excited resonant modes. A new picture of ferrite-circulator operation utilizing traveling-wave coupling of microwave signals at the circulation frequencies haa been discovered. This is in contrast to the operation of the conventional circulators employing standing waves for coupling. As such, ultra-broadband operation of the circulators results, whose bandwidth has been measured in Phase I to cover from 1.6 to 16 GHz for a prototype device. It is not possible to acheive this bandwidth with a conventional circulator. This leads to a new generation of ferrite circulators or isolators.

Using the LTCC technology facilitates mass production in large quantities. As such, generic microwave circulators and isolators can be fabricated at low costs suitable for universal applications covering across many frequency bands. Ferrite-circulator operation does not require a ferrite resonator anymore. This requirement has been constantly enforced by the operation of a conventional circulator for more than 50 years. There is always a tremendous need for circulators or isolators which are able to provide signal-path separation or protection over many frequency bands, as demanded by the measurement of a broadband signal and by a narrow electromagnetic pulse.

Title: SBIR Phase II: Multimodal High-Conductivity Filler for Epoxy Molding Compounds

Award Number: 0349517
Program Manager: T. James Rudd

Start Date: February 15, 2004
Expires: January 31, 2006
Total Amount: $499,422

Investigator: Jared Sommer, jsommer@alum.mit.edu
Company: Sommer Materials Research
587 North Main Street
North Salt Lake, UT 84054
Phone: (801)397-2000

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will focus on developing more efficient semiconductor packaging materials, which is one of the key challenges of the electronics industry where increasing power and reduced size of integrated circuits is creating heat dissipation challenges. Most epoxy molding compounds used to encapsulate semiconductors contain fused silica (55-70% by volume) to maintain a compatible thermal expansion coefficient and impart moisture resistance. However, the resulting thermal conductivities of the composite compounds are very low (<1 W/mK). The low thermal conductivity of the epoxy molding compound increases the operating temperatures, which in turn decreases the reliability and processing speed of microprocessors. As semiconductor clock speeds continue to increase and chip sizes decrease, the need for higher thermally conductive molding materials has become a stark necessity. In Phase I of this project multi-modal distributions of high-conductivity diamond powder where optimized to obtain high packing densities (over 72% by volume) in epoxy molding compounds. The resulting thermal conductivities of diamond/epoxy composites were almost 8 times higher than conventional silica-filled epoxies and almost 30 times higher than the epoxy matrix. The thermal expansions of silica and diamond filler are similarly low, thus allowing better matching to silicon. In this Phase II project significantly higher thermal conductivities are to be achieved by optimizing the epoxy/hardener system with the diamond filler to improve bonding and thereby improving the heat transfer mechanism. The diamond filler will be used as a direct substitute for commercially available silica filler, requiring little or no modification of existing equipment or processing. The diamond/epoxy molding compound will effectively act as a heat-spreader. The diamond filler will allow higher switching speeds, thinner oxide gates and increased reliability of electronics. The project team will work with an epoxy molding compound (EMC) manufacturer to introduce the diamond filler into the commercial market towards the end of Phase II.

Commercial markets for this EMC technology include high-performance aerospace, automobile and microelectronic packaging applications, where heat dissipation from the packaging material outweighs the increased material cost. The increased thermal conductivity offered by the diamond filler will benefit the business and scientific community by increasing computing speed and hardware reliability. Studies indicate that heat dissipation and associated thermal problems are the most critical factors in determining the efficiency and reliability of electronic devices. In terms of scientific and educational value, EMC's incorporating the optimized diamond filler will exhibit the maximum thermal conductivity obtainable and serve as the upper-limit benchmark in thermal conductivity for the composite material.

Title: SBIR Phase II: Crystalline Ferroelectrics Combined with Transistor Technology

Award Number:	0349729
Program Manager:	T. James Rudd
Start Date:	January 15, 2004
Expires:	December 31, 2005
Total Amount:	$500,000

Investigator: Zhiyong Zhao, zzhao@ngimat.com
Company: CCVD, Inc dba MicroCoating Technologies (MCT)
5315 Peachtree Industrial Blvd.
Atlanta, GA 30341
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project will focus on developing tunable microwave devices that utilize ferroelectric thin films for their electronic properties. Specifically, barium strontium titanate (BST) thin films are being used to develop new classes of tunable microwave devices, including phase shifters, delay lines and frequency-agile filters. Currently, these ferroelectric devices suffer from two drawbacks: easily formed planar devices demand very large tuning voltages on the order of 100 Volts , while easily tuned parallel plate devices require sophisticated processing techniques. These problems have inhibited the development of commercially viable components. The current project proposes combining silicon based circuitry with ferroelectric devices on the same substrate. For example, a silicon charge pump circuit can be integrated on-chip to provide high tuning voltages for a ferroelectric phase shifter. The voltage will be isolated to the chip and less than 3 Volts would be needed to externally drive the device. Combining silicon semiconductor technology with ferroelectrics will enable development of devices which take advantage of ferroelectric's dielectric properties and overcome the current roadblocks in the way of commercializing these devices.

Commercially, a great deal of interest has emerged in the use of ferroelectric thin films in the wireless industry because of the material's ability to dramatically improve the functionality of existing devices. For example, a ferroelectric duplexer is possible which has one third the size of existing duplexers, while using 40% less power. Today's multiband handsets use up to four filters, so the potential for ferroelectrics is tremendous. A key wireless handset manufacturer identified at least six applications for tunable devices inside their telephones. Overall, the wireless telecommunications market has spawned the need for small, low power, high bandwidth microwave components. Over $50 billion of wireless handsets were sold in 2002, with $6 billion being spent on RF semiconductor components. With the trend towards highly functional wireless appliances like PDA's, the demand for wireless components will continue skyrocketing.

Spintronics

Title: SBIR Phase II: High-Temperature Magnetic Rotary Encoder Based on a Spintronic Sensing Array

Award Number: 0522160
Program Manager: Muralidharan S. Nair

Start Date: July 1, 2005
Expires: June 30, 2007
Total Amount: $434,090

Investigator: Gurpreet Singh, singh@micromagnetics.com
Company: Micro Magnetics Inc
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Phone: (508)672-4489

Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will continue the development of an incremental magnetic rotary encoder based on magnetic tunnel junction (MTJ) sensor technology. This device uses sensitive MTJ devices to sense the magnetic field created by a patterned magnetized scale, and converts the resulting information into an accurate reading of angular position. The dual advantages of high-temperature operation (up to 200 degrees C) and contamination resistance will separate this device from the optical encoders that currently dominate the market for motor encoders. Current motor encoders are rarely capable of operation above 115 degrees C, a problem that requires motors in many market segments to operate in non-optimal configurations, costing end users in terms of time and efficiency. In addition, optical methods are sensitive to dust in the measurement path.

This development effort will create a new measurement technology with greatly enhanced capabilities for use in many critical segments of America's manufacturing sector. The creation of cost-effective encoders capable of operation at high temperatures will increase efficiency and enable further progress in a number of areas where hot environments are unavoidable, such as in the turbines of power-generating windmills. This research will advance the state of understanding of the emerging spintronic technology of magnetic tunnel junctions, a class of devices which forms the central component of a number of important commercial products in the high-tech semiconductor and data storage industries.

Title: SBIR Phase II: Reduction Of The Critical Current In Spin Transfer Switching Through Anisotropy Engineering

Award Number: 0646327
Program Manager: William Haines

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $497,550

Investigator: Alex Panchula, alex.panchula@grandisinc.com
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Milpitas, CA 95035
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will address the critical steps needed to manufacture a fast, non-volatile, magnetic random access memory (MRAM) based on spin transfer torque (STT-RAM). STT-RAM which uses spin polarized current to switch individual bits is predicted to have better scaling properties than conventional MRAM which uses magnetic fields. This Phase II project will focus on sub-100nm device manufacturability, device performance testing, and circuit design to develop a set of results which will enable the creation of a 1 Mb demonstration chip. The STT-RAM test chip is needed to prove the technology for customers. The results obtained from this project will include the development of arrays of sub-100nm bits, with the appropriate thermal stability, read/write characteristics and distributions. Also addressed will be the reliability of reading and writing such small devices. The project will develop processes for manufacturing sub-100nm structures. Finally, a simulation of read and write circuitry based on STT-RAM will be produced allowing for tape-out of a 1 Mb test chip.

Commercially, as microelectronics scales to smaller sizes and higher speeds, more features are added to typical consumer electronic devices and the demands on memory continues to grow. These demands and the inherent limitations of existing technologies create opportunities for new memory technologies to fill. As a leading candidate for a future universal memory that incorporates all the desired characteristics; non-volatility, high speed, low power, unlimited rewriting capability, extendibility to future semiconductor nodes; STT-RAM is in a strong position to take advantage of these opportunities.

Wafer & Sensor Production/Lithography

Title: SBIR Phase II: Single Crystal Silicon Flexible Display Backplane

Award Number: 0822770
Program Manager: Juan E. Figueroa

Start Date: August 1, 2008
Expires: July 31, 2010
Total Amount: $475,557

Investigator: Etienne Menard, etienne.menard@semprius.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project focuses on fabrication of flexible display backplanes using transfer printed electronics. The display industry has been successful at fabricating amorphous silicon (a-Si) thin film transistor (TFT) backplanes on rigid glass. However, a-Si TFT manufacturing does not easily translate to flexible substrates due to handling issues and the high temperature process of a-Si deposition. In transfer printing, a novel elastomeric stamp is used to pick-up specially designed circuits from the parent wafer and transfers the circuits to the desired target substrate. The parent wafer is fabricated using a standard silicon IC foundry and the single crystal silicon transistors have much better performance than the a-Si counterparts. The SBIR Phase I project demonstrated chip transfer printing process yields of 99.9% and chip placement accuracies better than +/- 5 ìm. Phase II objectives include design, fabrication and characterization of flexible backplane prototypes and further optimization of transfer printing by increasing throughput and demonstrating rework methods. The anticipated result is a manufacturing approach to flexible electronics that is cost competitive, low temperature and well suited to handle flexible substrates. The competitive advantage of the proposed approach is the fact that all the demanding fabrication process steps necessary to fabricate high performance electronic systems are performed on the ?mother? substrate and not on the final plastic substrate. If successful the inherent mechanical or chemical instabilities of the receiving plastic substrate do not limit the choice of semiconductor manufacturing processes for fabricating devices. The ability to manufacture flexible display backplanes to the demanding standards of the display industry will open up a broad market of opportunity in flexible electronics far beyond displays, including configurable X-ray sensors, RFID tags, and wearable electronics and biosensors. In displays, backplanes using the proposed technology will be utilized by all major display manufacturers and many specialty manufacturers.

Title: SBIR Phase II: High Performance Cooling Devices through Wafer Scale Manufacturing

Award Number: 0750189
Program Manager: William Haines

Start Date: February 1, 2008
Expires: January 31, 2010
Total Amount: $505,487

Investigator: Andrew Miner, miner@romny-scientific.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will create high performance coolers using waferscale semiconductor manufacturing by building on the material processing foundations demonstrated in Phase I. Phase I work has demonstrated that high quality materials can be formed in a method that can be extended to high volume production. This Phase II effort will implement this manufacturing technique at a wafer scale, integrating Phase I materials into initial devices for customer evaluation and sale. The broader impacts of widespread deployment of efficient thermoelectric coolers include reduction in energy consumption and more efficient use of available energy by widespread use of high performance thermoelectric power generation from waste heat; and broad improvements in general quality of life by high performance compact coolers that allow continued advancement of products in the microelectronics and optoelectronics industries.

Title: SBIR Phase II: Development of Efficient Short-Wavelength Radiation Sources For Next-Generation Lithography

Award Number: 0724183
Program Manager: Rathindra DasGupta

Start Date: September 15, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Joseph MacFarlane, jjm@prism-cs.com
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Abstract:

The Small Business Innovation Research (SBIR) Phase II project will pursue the development of novel plasma technologies for creating highly efficient, short-wavelength radiation sources for use in next-generation semiconductor chip manufacturing. The development of radiation sources that efficiently emit light at wavelengths near 13.5 nm is crucial to the expected emergence of EUV lithography as the primary technique used in manufacturing integrated circuits and DRAM near the end of this decade. Laser-produced plasma experiments will be conducted to validate and refine the novel high-efficiency, low-debris EUV light source designs developed in our previous work. Comparisons between experimental data and simulations performed using state-of-the-art simulation tools will facilitate the development of light sources with high 13.5 nm conversion efficiencies. This project will lead to lower cost, more efficient, and more robust EUV lithography light sources for use in the manufacturing of next-generation semiconductor chips.

Short-wavelength radiation sources are applicable to a wide variety of research areas, and have significant value in commercial applications, basic research, and defense research and technology. Such sources are valued not only for use in EUV lithography, but also in medical research, instrumentation, and technology. While this project will focus on the development of plasma-based technologies for creating highly efficient light sources for EUV lithography, it is likely that techniques and capabilities developed under this project will further the development of plasma light sources applicable to other major areas of research and technology.

Title: SBIR Phase II: Fabrication of Conformal Antennas for Airborne SatCom Using Kinetic Metallization

Award Number: 0724502
Program Manager: Muralidharan S. Nair

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Ralph Tapphorn, rtapphorn@inovati.com
Company: Innovative Technology Inc
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Phone: (805)571-8384

Abstract:

This Small Business Innovative Research (SBIR) Phase II research project will develop direct write copper conductors onto doubly curved dielectric substrates using the Kinetic Metallization (KM) process. There is a need for new processes and methodologies to enable low profile RF systems on current and planned airborne platforms. Low profiles antennas are achieved through integration with structural elements. The concept is referred to as aperstructures, and in this Phase II research the scientific and engineering foundation necessary for robust aperstructures will be laid. Principally, research to establish process-property relationships will be conducted, as well as an investigation of novel material systems. The envisioned result of this research is conformal antennas integrated into the load bearing structures of the application platform. Conformal antennas represent a significant stride forward in the ability to communicate in high bandwidth applications. They also offer lower profiles, lighter weight and greater mission flexibility.

Originally airborne platforms were identified as high benefit early adopters. Targeted markets in the Navy and Air Force have already been identified with customers awaiting the Phase II results to transition the KM process to the manufacture of antennas. Ship systems, land systems, and non-military opportunities such as automobiles and skyscrapers will also gain from the development of this research.

Title: STTR Phase II: Fully Embedded Optical Interconnects based on Optical Bus Architecture for Large Size Printed Circuit Boards

Award Number: 0724096
Program Manager: William Haines

Start Date: September 1, 2007
Expires: August 31, 2009
Total Amount: $500,000

Investigator: Alan Wang, alan.wang@omegaoptics.com
Company: Omega Optics
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II research project is to develop a commercial board level optical interconnect using bus architecture. Conventional copper links on printed circuit boards fail to provide sufficient bandwidth for data transfer above 10 Gbit/sec. Optical interconnections are widely viewed as an alternative to higher throughput. However, existing photonics-related approaches suffer from issues of packaging, reliability and manufacturing cost. In this project, Omega Optics and the University of Texas at Austin seek to develop a fully embedded board level optical interconnect for enhanced bandwidth, while reducing the difficulties of optoelectronic packaging and device reliability. Phase I results demonstrated 150 GHz bandwidth with 51 cm interconnection distance.

Instead of utilizing surface mounted optical components this approach separates the fabrication of the optical layer with the electrical parts and laminates it inside printed circuit boards, between which the interconnection is setup through in-layer vias. This fully embedded technology seals all the optical components and provides a seamless interface with electrical layers, therefore it eliminates the concerns of external optoelectronic devices for end users. The revolutionary breakthrough over copper links sought through this research would benefit the entire computer industry and enable the continued progression of bandwidth and interconnect distance.

Title: SBIR Phase II: R-CEL for DUV Lithography

Award Number:	0724417
Program Manager:	William Haines
Start Date:	September 1, 2007
Expires:	August 31, 2009
Total Amount:	$500,000

Investigator: Zhiyun Chen, zchen@pixelligent.com
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387 Technology Drive Suite 3122
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is to develop a product for a reversible contrast enhancement layer (R-CEL) using semiconductor nanocrystalline materials. The R-CEL technology, if successfully developed, will enable finer resolution optical lithography postponing the need for more expensive techniques such as electron beam or x-ray lithography. R-CEL technology will help to extend the diffraction limit facing optical lithography by enabling double exposure techniques to be used for pattern definition.

The use of R-CEL with double exposure will increase the capability of optical lithography thus enabling the extension of Moore's Law without the need to switch to more expensive alternatives. It will also help restore the technological competitiveness of domestic vendors in the lithography industry. The SBIR project will also advance the understanding of semiconductor nanocrystal characteristics including detailed absorption and recombination processes and the effect of nanocrystal surface conditions on dispersion with polymers. This information will be valuable in other semiconductor nanocrystal UV applications including optical storage, UV light sources and detectors.

Title: SBIR Phase II: Novel Hybrid Rapid Thermal Processing (HRTP) Systems for Annealing of Advanced Silicon Devices

Award Number: 0725021
Program Manager: William Haines

Start Date: August 1, 2007
Expires: July 31, 2009
Total Amount: $500,000

Investigator: Syamal Lahiri, slahiri1@sinmat.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project focuses on development of a novel high-temperature system for processing of advanced silicon devices. Currently used rapid thermal processing (RTP) systems result in substantial dopant profile broadening because of their relatively large time constants. The development of a novel Hybrid Rapid Thermal Process (HRTP) system which combines the advantages of RTP and laser annealing will be accomplished through this project. The advantages of HRTP anneals was demonstrated in the Phase I of the project. In the Phase II project extensive thermal simulation studies will be performed to understand, optimize and scale up the process.

Rapid Thermal Processing (RTP) systems are a critical part of semiconductor manufacturing operations and are used to form gate oxides, silicides and annealed ion implanted dopants for formation of ultra-shallow junctions. The market-size for these applications exceeds $500 M/year. With the rapid miniaturization of the devices, there is a strong need to develop higher ramp rate and higher temperature annealing systems to achieve the formation of ultra-shallow junctions. The proposed HRTP system is expected to fill this niche. The HRTP system can also be usedin thermal annealing of wide band gap semiconductors such as GaN and SiC as they require extremely high temperature, which cannot be achieved by traditional systems.

Title: SBIR Phase II: Enhanced Plasma deposition Process for MgO-Based Magnetic Tunnel Junctions with 500% Magnetoresistance

Award Number:	0724913
Program Manager:	Cheryl F. Albus
Start Date:	July 15, 2007
Expires:	June 30, 2009
Total Amount:	$499,883

Investigator: Benaiah Schrag, schrag@micromagnetics.com
Company: Micro Magnetics
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Fall River, MA 02720
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop the process to fabricate magnesium-oxide (MgO) based magnetic tunnel junction (MTJ) sensor devices, which are simultaneously ultra-sensitive at high frequencies, small in size, with high output, and extremely low power consumption. The dual advantages of high sensitivity and low power consumption will separate these sensor devices from traditional Hall-effect and magnetoresistive sensor products, which are power hungry and typically not suitable for many high-performance and battery-powered sensing applications. This innovative approach combines the high resistivity tunneling and enhanced signal strength derived from magnesium oxide tunnel barrier technology.

The broader impact anticipated if this project is realized is a new class of MgO-based sensors with high sensitivity and low power consumption, and the development of a reliable fabrication process suitable for mass production. This project will advance the state of understanding of the emerging spintronic technology of magnetic tunnel junctions, a class of devices which forms the central component of a number of important commercial products in the high-tech semiconductor and data storage industries. Finally, the collaboration of physicists, electrical engineers, materials scientists, and students will result in a broader multidisciplinary training and education for all the participants in the field of spintronics.

Title: SBIR Phase II: Microfluidics Device for Real-time Process Control of Copper Plating Baths

Award Number: 0646935
Program Manager: Muralidharan S. Nair

Start Date: April 1, 2007
Expires: March 31, 2009
Total Amount: $500,000

Investigator: Holly Garich, hollygarich@faradaytechnology.com
Company: Faraday Technology Inc
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Phone: (937)836-7749

Abstract:

This Small Business Innovation Research (SBIR) Phase II program will advance the monitoring of copper plating baths, responding to the stated need to design, develop and prototype innovative sensors and systems for testing and characterization in both industrial and laboratory settings, for specific use as a process control device. This technology couples the theories of microfluidics and alternating current voltammetry for a powerful monitoring tool. The anticipated result of this research project is a marketable, commercially viable sensor with the capability to accurately and precisely measure concentrations of all components of the copper plating bath. In addition, application of the proposed method is anticipated to significantly reduce the waste generated by semiconductor and printed circuit board industries.

This work addresses the needs of the printed circuit board and semiconductor industries, which are important aspects of the US commercial economy and will play an increasing role in the US as well as world society. In addition to providing tight process control and therefore a better quality product, the proposed sensor is anticipated to be more environmentally friendly than current technologies due to the decrease in sample size and analysis time requirements, resulting in lower chemical and power consumption, an objective of the 2005 International Technology Roadmap for Semiconductors.

Title: SBIR Phase II: A Quality Monitor for Enabling Water Recycling in Semiconductor Processing - The Particle Scout

Award Number: 0646557
Program Manager: Muralidharan S. Nair

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $500,000

Investigator: Bingrong He, bingrong@uncopiers.com
Company: Uncopiers, Inc.
6923 Redbud Drive
Manhattan, KS 66503
Phone: (785)293-4917

Abstract:

This Small Business Innovation Research (SBIR) Phase II Project concerns Ultrapure Water (UPW), the life blood of the semiconductor industry. The proposed instrument seeks to satisfy the ITRS requirements on two counts: 1. full flow inspection, and 2. detection of sub-100nm liquid-borne particles. 1. A typical semiconductor fab uses about 3 million gallons of UPW every day, and the ITRS, in its attempt to conserve the precious resource, water, mandates that 90% of UPW be recycled/reused by 2010. The recycled UPW loop will need full flow monitoring, which the proposed Particle Scout will do. 2. The purity of UPW directly affects the chip yield, because the final operation on wafers is UPW rinse and any contaminants present in the UPW contaminate the wafers it rinses. As the industry moves to sub-100 nm nodes the ITRS particle detection requirements fall to sub-50 nm.

Particle Scout" for monitoring in real-time the particulate purity of recycled UPW for use in Semiconductor processing successfully overcomes a critical technological barrier facing the IC manufacturing industry today. Beyond IC manufacturing industry it will find applications in all enterprises where UPW is used: Power generation, Nuclear Reactors, Pharmaceutical industry, Biotechnology, Space exploration, and processing of Advanced high purity chemicals.

Title: SBIR Phase II: Trapping Particle Detector for On-Line Monitoring

Award Number:	0646388
Program Manager:	William Haines
Start Date:	March 15, 2007
Expires:	February 28, 2009
Total Amount:	$500,000

Investigator: Chris Doughty, cdoughty@verionix.com
Company: Verionix
251 Granville Lane
North Andover, MA 01845
Phone: (617)905-0015

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop improved particle detectors for monitoring of semiconductor manufacturing tools. This detection technology will increase count rates for greater than 0.2 micron diameter particles by 100 to 1000 times improving correlations between the particle detector and wafer by greater than 10 times. For smaller particles this detector will enable detection, ultimately to the nanoparticle regime (less than 25 nanometers). The intellectual merit of this proposal is that it will advance the state of knowledge in the field of engineering and physics of microplasmas. It will broaden knowledge of plasma scaling and of the behavior of particles in plasmas. The project will involve the following tasks: Optical detector hardware development ; Trap development for capturing particles; Data analysis, Control system and Software interface development and ; Field testing of prototypes. This project will provide currently unavailable detection technology for monitoring particles.

Commercially, this project will improve the performance of semiconductor process tool manufacturer's products by enabling cost-effective, real-time monitoring. The broad economic benefit of this program will be to enhance the competitiveness of domestic semiconductor manufacturers where particle issues account for approximately 11% of manufacturing tool down time and are a major cause of scrap and yield losses. For the future nanotechnology industry as a whole this detector will enhance workplace and public safety by enabling monitoring of nanoparticle levels and production processes.

Title: SBIR Phase II: Extrusion Manufacturing Process for Ultrahigh Bandwidth, Low Attenuation Graded-Index Polymer Optical Fibers

Award Number: 0646397
Program Manager: Juan E. Figueroa

Start Date: February 15, 2007
Expires: January 31, 2009
Total Amount: $500,000

Investigator: Whitney White, white@chromisfiber.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will advance the technology for reliably manufacturing low attenuation, ultrahigh bandwidth, graded-index, perfluorinated polymer optical fibers (GI-POF) by a low cost continuous extrusion process. Currently there is an unmet need for an easy-to-use, rugged medium that allows the migration of data communications to speeds of 10 Gigabits per second, and beyond, in rapidly growing applications such as data centers, supercomputing and consumer electronics. This project will result in a production quality process for manufacturing plastic fibers having bandwidth equal to the best multimode glass fibers, but with a simple "plug-and-clamp" installation process, and tolerance of bend radii fivefold tighter than that allowed by glass fibers. The project will address three areas to develop the technology into commercially viable products: 1) Advanced extrusion process development to greatly improve fiber bandwidth distribution and attenuation, while doubling production speed; 2) Investigation to prove-in new polymers that can increase the fiber operating temperature up to 85 deg C; 3) Investigation and development of a unique, readily manufactured multi-core fiber design that can offer customers almost unlimited bandwidth, as well as greatly improved attenuation in tight bends.

If successful the production technologies developed in this project will result in the possible recapturing of American leadership in POF manufacturing while stimulating American-based production of the manufacturing capital equipment used in this industry. Similarly, American companies using POF to develop next-generation short-distance communication systems will also benefit, as they will enjoy better access to information and custom products based on GI-POF. The results of this project will help improve the "ecosystem" for many areas of datacom manufacturing in the US. Also, by enabling a product that makes installation of high-bandwidth cabling much simpler and less expensive, the Phase II project will be of considerable benefit to schools, hospitals, and other institutions which have many needs for high-bandwidth communication, but often do not have large budgets to support such systems. The scientific benefits of the Phase II project are likely to be the simplified and lower-cost construction of massively parallel computing facilities, and increased commercial interest in chemical synthesis techniques for amorphous fluoropolymers and their precursor chemicals.

Title: SBIR Phase II: Gentle Atomic Level Chemical Mechanical Smoothening (CMS) of Gallium Nitride Substrates

Award Number: 0646586
Program Manager: William Haines

Start Date: February 15, 2007
Expires: January 31, 2009
Total Amount: $499,900

Investigator: Syamal Lahiri, slahiri1@sinmat.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop and scale-up an industrially robust and low cost chemical mechanical smoothening (CMS) process to produce atomically polished gallium nitride (GaN) on silicon substrates for high power and high frequency applications. As GaN is mechanically hard and chemically inert, traditional surface polishing processes have resulted in significant surface damage which negatively affects the electrical performance. In contrast, the CMS process forms a soft layer on GaN surface which can be removed by nanoparticles. In the Phase II of this project, the company plans to further optimize and scale-up the CMS process. In conjunction with the compound semiconductor chip manufacturers and academic partners, the company's plan is to further validate the polishing technology by fabricating and testing the performance of high electron mobility transistors. The research team members are internationally recognized experts and are in an excellent position to execute the research plan and attain the project goals.

The commercialization of the proposed polishing technology is expected to significantly impact GaN based semiconductor technology used for high frequency, high power microwave devices in wireless mobile communication and radar defense systems. This process will accelerate commercialization of GaN on silicon technology by increasing yield and reducing manufacturing costs.

Title: SBIR Phase II: Molecular Transfer Lithography with Real-Time Alignment

Award Number:	0646183
Program Manager:	William Haines
Start Date:	February 15, 2007
Expires:	January 31, 2009
Total Amount:	$500,000

Investigator: Charles Schaper, cschaper@transferdevices.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a comprehensive automated nanolithography and alignment system for integrated electronics and photonics manufacturing. Transfer Devices, Inc. is the pioneer, and has significant intellectual property, in transfer lithography. The product driver for this application is the MxL (molecular transfer lithography) template. It is a consumable, one-time-per-use item that forms patterns by bonding patterned resist layers onto a substrate surface, with subsequent water dissolution of the template. MxL is a non-imprint, non-photolithography process that solves the defect propagation problem of contract printing, and is applied for large area, conformal printing at low costs and high throughput. The proposal seeks to optimize the replication of MxL templates, and coordination with an advanced adaptive alignment system, to achieve unprecedented overlay and high resolution patterning for high throughput next generation lithography of integrated circuits and photonic devices. The reason for the success of the proposed solution is a technologically superior solution of that of alternative approaches by combining low-cost, environmentally friendly processing with defect free conformal printing over large areas at high throughput rates. MxL (molecular transfer lithography) is a patent protected unique process using a water dissolvable sacrificial polymer template. This advanced process is coordinated with an adaptive alignment scheme to produce state-of-the-art registration with sub-50 nm features at sub-20 nm placement capability.

Commercially, the proposed process and technological solution will significantly advanced the capability to manufacture nano-technological devices for a wide range of applications including integrated circuits, solar wafers, displays, data storage, MEMS, as well as emerging areas in photonics, high brightness LED's, optoelectronics, life sciences, and nanotechnology. The project will be implemented commercially into the lithography marketplace, which by 2009 has a total market size of roughly $20B including equipment technology, masks, and consumables.

Title: SBIR Phase II: Large-Scale Manufacturing Process for Uniform Semiconductor Nanowires

Award Number:	0620589
Program Manager:	James Rudd
Start Date:	September 13, 2006
Expires:	August 31, 2008
Total Amount:	$297,784

Investigator: Francesco Lemmi, flemmi@nanosysinc.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop an innovative manufacturing technology for inorganic semiconductor nanowires for use in high-performance thin-film electronics products. In Phase I, the company successfully demonstrated the feasibility of this innovative manufacturing method to yield large volumes of high quality, uniform nanowire nanostructures of the quality and quality required to enable the application of these materials in high performance thin-film electronics. Specifically, the company: (1) setup a prototype nanowire manufacturing reactor capable of large-volume production; (2) identified critical process parameters affecting materials quality and methods to optimize them; and (3) established control over the process parameters enabling the precise fabrication of nanowires. Phase II research will build on the knowledge gained in Phase I, and focus on further development and optimization of this system into a fully automated, manufacturing system capable of pilot scale production of nanowires for commercialization in high performance electronics applications including displays and phased array antennas.

Commercially, the project represents an innovative approach to a manufacturing process technology for large-scale production of high quality inorganic semiconductor nanowires, and will enable wide-spread production of low-cost high-performance electronics fabricated by roll-to-roll manufacturing. Applications of these materials exist in novel electronic devices and systems including specific uses in displays, RFIDs, phased array antennas and sensors.

Title: SBIR Phase II: High-Speed, Low-Cost Maskless Lithography

Award Number: 0620566
Program Manager: Juan Figueroa

Start Date: September 6, 2006
Expires: August 31, 2008
Total Amount: $429,287

Investigator: Richard Yeh, yeh@alcestech.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will research and develop a maskless lithography tool based on the results of the feasibility study. The company has a unique and proprietary approach to achieve higher throughput and lower cost than currently available maskless lithography tools. The approach will employ Line Light Modulator (LLM) to pattern wafers with a linear array of 2048 beams. The patent-pending LLM is a novel and efficient light engine that converts a single light source into a large linear array of beamlets. Using a large array of beamlets increases the power handling capability of the system which increases the exposure throughput. The result is a one to two order of magnitude improvement in throughput compared to existing maskless lithography tools. Our tool also takes advantage of the new 405nm diode laser. The 405nm diode laser offers a combination of power, cost, and speed not available in other UV laser sources. In the feasibility study, we have demonstrated the ability to pattern photoresist with <1um resolution using the LLM. In Phase II, we will develop and fully characterize a prototype tool that will achieve a 1um resolution, 50nm position accuracy, and a throughput of 65mm2/sec (two minutes per 4" wafer).

As high volume semiconductor production has mostly moved overseas, the US semiconductor industry relies more on prototyping and initial manufacturing of innovative, cutting-edge technology. Lowering the cost to pattern wafers at these volumes helps keep US companies competitive by enabling rapid and cost-effective innovations. Cost is especially important for the small- to medium-sized companies that neither have the capital for high cost mask sets, nor require the most advanced resolutions of modern conventional lithography tools. The proposed tool addresses this need for fast and cost-effective semiconductor lithography with good throughput, resolution, and seamless integration with current lithography processes. The proposed project will provide researchers with an affordable tool to quickly fabricate new and existing designs. These low cost lithography tools will also be useful in fabrication and MEMS laboratory courses. A maskless lithography tool will make it practical for students to design and fabricate devices instead of simply using masks made for the course.

Title: SBIR Phase II: Optical-Maskless-Lithography Equipment

Award Number:	0620456
Program Manager:	Juan Figueroa
Start Date:	August 31, 2006
Expires:	August 31, 2008
Total Amount:	$499,943

Investigator: Rajesh Menon, rmenon@nano.mit.edu
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is a major step in the development of an optical-maskless lithography technology that is capable of high resolution, high throughput, flexibility, low cost, and extendibility. Current lithography technologies suffer from the problems of high tool costs, high mask costs, and inflexibility in the case of optical-projection lithography, and high tool costs, very low throughputs, and high complexity in the case of scanning electron- beam lithography. The company's Zone-Plate-Array-Lithography (ZPAL) technology will mitigate these issues, while providing unprecedented flexibility in nanopatterning. This project covers two major thrusts: one the manufacture of zone-plate arrays containing over 1000 zone plates, each with a numerical-aperture (NA) greater than 0.85, second the development of a high-accuracy alignment sub-system that can achieve overlay accuracy of 20nm with potential extendibility below 5nm. A successful completion of the first thrust of this project will result in large arrays of high-NA zone plates installed in the prototype lithography system, enabling high resolution and high throughput. A successful implementation of the alignment sub-system in the prototype tool will meet specifications of accuracy unmatched by alternate technologies.

It is widely recognized that nanostructures of complex geometries are indispensable to create functionality and enable a nanotechnology revolution. At present, the tools that are available for the creation of such nanostructures are highly limited in flexibility, resolution, cost and throughput. The tools based on ZPAL have the potential to create a new paradigm in the development and manufacture of nanostructures by sharply reducing the development-cycle time and manufacturing costs. Being maskless, this technology provides flexibility by enabling the designers of nanostructures to quickly realize their designs in hardware for prototyping and even low-volume manufacturing. The company's tools have the potential to enable industries in a wide spectrum of industries such as micro-electro-mechanical devices (MEMs), nano-electro-mechanical devices (NEMs), nano-electronics, nano-magnetics, integrated optics, photonics, biochips, microfluidics, to name a few. Initial target customers are manufacturers of application-specific-integrated circuits (ASICs), compound semiconductors and photomasks. In the ASIC industry alone, the tools have the potential to enable savings of over $3B per year. Furthermore, this technology can provide the cost-effective, flexible solution required to revive and grow this important segment of the semiconductor industry.

Title: SBIR Phase II: Micro-Coax Manufacturability Study

Award Number: 0620136
Program Manager: Juan Figueroa

Start Date: August 10, 2006
Expires: July 31, 2008
Total Amount: $500,000

Investigator: Sean Cahill, seanc@bridgewave.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project deals with the ever-increasing burden placed on the microelectronics industry as computational speeds increase. While the number-density-speed of transistors doubles every 18-24 months (a phenomenon known as Moore's Law), the ability to retrieve and store data from external sources is not increasing nearly as quickly. The performance improvement rate of key computing tasks such as simulation, signal processing and database searches is becoming limited by off-chip bandwidth. Approaches such as "flip-chip bumping" are not a panacea, because despite their small size, these structures leak signals to one another; a significant performance detriment. The company has developed a novel MicroCoax interconnect technology to address these problems, utilizing existing semiconductor manufacturing infrastructure. The research objectives are to gain insights into MicroCoax fundamentals and understand application specific issues within market segments that are most impacted by current technological limitations. Research will focus on continuing exploration of MicroCoax material set, process flow, integration, and reliability, along with specific application to three distinct market spaces namely, MMICs, High-speed Digital/Optoelectronics, and high-frequency test.

Electronics technology impacts nearly every person on earth in some way. Even folks living in remote places are subject to natural disasters, which may be predicted by atmospheric and geological simulation and warning systems, allowing timely evacuation. Goods distribution and logistics are increasingly dependent on computationally intensive database search and tracking. Medical diagnosis and treatment rely increasingly on signal processing for imaging and therapeutics. High-bandwidth wireless systems allow for recovery of communication infrastructure following floods and hurricanes. All of the aforementioned technologies have high-speed electronic systems at their core, and MicroCoax can affect them all. High-bandwidth systems are quite expensive today, in large part because of interconnects based on machined waveguides and significant labor content associated with such approaches. If successful the proposed technology, MicroCoax, can eliminate much of the cost, making such systems more commercially viable and ubiquitous. While a disruptive technology such as MicroCoax will be invisible to the average user, electronics designers and will be able to expand their application horizons due to elimination of prohibitive cost constraints. Electronics, semiconductor, communications and related industries will stall without continued innovation in packaging and interconnect strategies. The economic implications are significant, as worldwide electronics sales number somewhere around US$1.3 trillion at this time.

Title: SBIR Phase II: Single Step Chemical Mechanical Planarization of Copper/Ultra Low k Interconnects

Award Number: 0620428
Program Manager: Juan Figueroa

Start Date: July 26, 2006
Expires: July 31, 2008
Total Amount: $496,673

Investigator: Deepika Singh, singh@sinmat.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project proposes to develop and commercialize a single step chemical mechanical polishing (CMP) process for fabrication of next generation of copper based interconnects that join millions of transistors on a chip. The current state of the art copper CMP process is complicated and requires multiple steps to meet the defect quality and planarity requirements. Furthermore, existing processes create high stresses during polishing, which may not be compatible with the fragile low dielectric constant materials are now being introduced by the semiconductor industry. To address these challenges the research team proposes to develop the "soft polishing layer" concept for gentle removal of copper that does not damage the fragile dielectric layer. The use compatible chemistries and nanoparticles in the slurry allows successful development of a flexible, defect-free, single step process to fabricate copper based interconnects that will result in substantial cost savings to the semiconductor chip manufacturers. During Phase II, the company will partner with the leading edge CMP companies and chip manufacturers to address industrial scale integration issues related to development and commercialization of the single step slurry.

With the impending introduction of new fragile ultra low k materials, CMP processes are expected to become more complicated and expensive, to achieve the necessary levels of performance. The successful implementation of the single step CMP process is expected to meet or exceed the technical performance levels of the 45 nm manufacturing node while decreasing the CMP manufacturing costs by up to 80% which translates to over $ 4 billion savings for the chip industry (10 X savings for the chip industry for every "X" dollar of slurry revenue). The reduction in costs is largely due to the simplification of the manufacturing process, higher throughput, increased yield, less use of capital equipment and manpower, and reduction in consumable costs. The successful completion of this project will help maintain and grow the country's leadership in nanotechnology, a key area for future health and vitality of the nation. This project will help increase the number and quality of manufacturing jobs in the country.

Title: SBIR Phase II: Direct Measurement of Wafer Temperature in White/UV LED Manufacture

Award Number: 0450516
Program Manager: T. James Rudd

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $449,635

Investigator: Jeffrey Bodycomb, jeffreyb@technologist.com
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Abstract:

This Small Business Innovation Research (SBIR) project will develop a highly accurate temperature measurement system that can be used in optimizing the growth of high brightness light emitting diodes for solid state lighting applications. This product does not currently exist due to technical difficulties in measuring the substrate or gallium nitride (GaN) epilayer in a region where they absorb energy. During Phase I of this program the company showed possible solutions to this problem that it can implement as the work progresses to Phase II. This SBIR Phase II program will address scientific and technical issues that has hindered the adoption of the Reflectivity Compensated Pyrometry (RCP) in the growth of GaN light emitting diodes (LEDs), the basis of solid state lighting sources. This program will result in a commercial instrument for directly measuring surface temperature during manufacture of visible and UV LEDs. Typical temperature variations during the growth of GaN-based LEDs results in a product which, even over a 2dimensional substrate, requires the LEDs to be separated into those with similar characteristics. Existing temperature measurements do not allow the accurate measurement of the substrate or the GaN epilayer because they are transparent at the measurement wavelength of ~1 micron.

Commercially, this project will increase manufacturing productivity in wide-bandgap materials and LED manufacture by providing better process control data. The improved manufacturing yields of LED's enabled by this work will lead to more widespread adoption of LEDs for solid state lighting with the accompanying economic and environmental benefits. For example, the use of LEDs has already saved the US economy nearly 10 TWh per year (equivalent to one large power plant) of energy in the niche applications implemented so far.

Title: SBIR Phase II: An Ultra-High-Speed Cleaning Process for Electronic Device Manufacturing

Award Number: 0522329
Program Manager: T. James Rudd

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $499,992

Investigator: David Boyers, dboyers@phifersmith.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop process technology for removing photoresist from semiconductor wafers at high speed while not damaging underlying materials. This process technology can be readily integrated into existing single wafer wet processing tools. The development of higher performance semiconductor devices with smaller feature sizes has driven the adoption of copper and low-k dielectric materials that are susceptible to damage by traditional oxygen plasma based resist removal processes. While other low temperature plasma processes are being explored as low damage alternatives, appreciably lower resist removal rates (1,000 to 2,000 A /min) are a significant limitation. In response to this challenge the company successfully developed a new ozone-water based single wafer process chemistry which does not damage low k dielectric materials such as Black Diamond (TM), and does not corrode copper. In phase I this process achieved an etch rate greater than 8,000 A /min. The phase II research will concentrate on the early integration of the process hardware and process technology into a commercial single wafer spin processing system, the further development of process capabilities using 300 mm customer wafers, and the placement of three systems at customer sites for evaluation.

Commercially, the successful completion of this research program will culminate in the development of a new single wafer process technology for use in the manufacture of the high-density semiconductor devices with feature sizes below 90 nm. Nearly all of the new manufacturing capacity is built for 300 mm wafer fabrication at the leading edge technology node. In addition to direct sales of $60 to $120 million per year of new wafer processing equipment incorporating this technology, this project will enable the productivity benefits and reduction in unit manufacturing costs provided by the early migration to the next technology node. In addition, the innovative copper compatible cleaning chemistry developed here holds promise for corrosion free cleaning and surface treatment of copper in other electronic device manufacturing applications. Finally, this process uses an environmentally benign "green" chemistry.

Title: SBIR Phase II: Novel Wafer Fabrication Technology for Semiconductor Sensors

Award Number: 0522039
Program Manager: T. James Rudd

Start Date: September 1, 2005
Expires: August 31, 2007
Total Amount: $465,833

Investigator: Rabi Bhattacharya, rbhattacharya@ues.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project is directed toward the development of cadmium zinc telluride (CdZnTe) single crystal films by using an ion beam layer separation process from bulk single crystals. The separated layers will be transferred and bonded on to silicon (Si) wafers for applications as substrates for epitaxial growth of mercury cadmium telluride (HgCdTe) films. HgCdTe films are of interest in infrared detectors. The ion beam layer separation process will allow the fabrication of a large number of films from a single bulk crystal, thus providing an economical wafer production technology for infrared detector materials. High-energy (MeV) light ions will be used to produce a buried damaged layer in the bulk crystal. Thermal annealing at elevated temperatures may generate lateral crack enabling the layer separation. Phase I has shown the feasibility of this approach. Phase II research objectives are to optimize the process parameters for wafer-scale separation without breaking and develop the process to transfer the separated films on to Si wafers. The wafers thus fabricated will be used for epitaxial growth of HgCdTe and fabrication of IR detectors. CdTe and (Cd,Zn)Te alloy crystals have been grown by various techniques including zone refining, vertical gradient freeze (VGF), liquid encapsulated Czochralski (LEC) methods, horizontal and vertical Bridgman techniques. Due to variable yields, none of these methods have produced enough material with the quality needed for today's infrared (IR) detector applications.
The proposed method has been developed to overcome these limitations.

Commercially, the proposed technique has the advantage of producing many good quality substrates from a single bulk crystal by ion beam slicing, thus providing an economic way of producing reliable and reproducible quality material. Also, large area CdZnTe substrate for the growth of HgCdTe will be possible by stacking smaller slices in a floor tile pattern on cheaper Si substrates. Bonding with Si substrate will also allow the integration of IR detectors with electronics on a single chip. IR photodetectors and focal plane arrays are of interest in many industrial and scientific applications including environmental monitoring, chem-bio detection, medical and space sensors.

Title: SBIR Phase II: Hydrothermal Growth of Ultra-High Performance Nd:YVO4 Laser Crystals

Award Number: 0421946
Program Manager: T. James Rudd

Start Date: August 1, 2005
Expires: July 31, 2007
Total Amount: $409,807

Investigator: Henry Giesber, hgiesber@apcrystal.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will focus on the development of a commercial process for the growth of Neodymium Yttrium Vanadate (Nd: YVO4) single crystals for use in solid-state lasers. This research will generate the commercially viable conditions for growth of large boules of single crystals suitable for use in diode pumped solid-state lasers. The hydrothermal method is a low temperature growth technique that leads to crystals containing less thermal strain, much fewer defects and greater homogeneity than conventional methods. These defects combine to cause considerable optical loss and concomitant reduction in performance. The hydrothermal technique has slower growth kinetics and requires chemical development for economically viable growth. In the Phase I project, preliminary growth conditions that lead to suitable single crystals were identified. These conditions include approximate thermal ranges, a variety of starting materials, seed crystals and mineralizer concentrations. In the Phase II project growth conditions will be systematically optimized to provide suitable transport rates and crystal quality. Once an acceptable growth is developed, the resulting boules will be evaluated for performance efficiency and loss.

Commercially benefits will emerge as the company introduces new higher performance crystal materials to the market that cannot be grown by existing crystal growth methods. In addition, new laser materials will be donated to Clemson University for design of new laser devices and cavities supporting the University's participation in the emerging photonics Coalition of the Carolinas that includes Clemson, the OptoElectronics Center at UNC-Charlotte, COMSET at Clemson University, and the Carolina MicroOptics Consortium.

Title: SBIR Phase II: Development of High Performance, Environmentally Benign Lapping Fluids for Hard Disk Drive Manufacturing Applications

Award Number: 0450441
Program Manager: T. James Rudd

Start Date: May 1, 2005
Expires: April 30, 2007
Total Amount: $522,000

Investigator: John Lombardi, ventanaresearch@msn.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop novel, water soluble, environmentally benign, aspartate co-aspartamide copolymers for use as aluminum titanium carbide (AlTiC) Giant Magnetoresistive (GMR) Read Write Head lapping fluid additives. Efforts will be directed towards refining the composition of these copolymers such that they exhibit maximum adsorption & electrostatic charging effects upon AlTiC surfaces. This will enable rapid removal of AlTiC swarf formed during lapping producing GMR Heads of superior surface quality and uniformity compared to those manufactured currently. Furthermore, the adsorption properties of these copolymers upon AlTiC ceramic GMR Head surfaces as well as their metallic sensor layers will also be characterized in greater detail using Zeta Potential & Electrochemical Techniques. An optimized procedure for synthesizing these copolymers will be established enabling them to be economically produced in bulk quantities. Finally, the company will work closely with hard drive manufacturers and will integrate the aqueous lapping fluids formulated from these copolymers into its current GMR Head manufacturing operations.

Commercially and from an industrial standpoint, lapping fluids formulated from these copolymers will enable the last vertically integrated domestic hard drive manufacturer to produce GMR Read Write Heads more economically & efficiently thereby enhancing the company's competitiveness within the marketplace. Future data storage technologies may also benefit from these fluids since they will in all likelihood still require high precision lapping or a related super finishing technique to polish their drive components.

Title: SBIR Phase II: Advanced Detectors for X-Ray Diagnosis

Award Number:	0450483
Program Manager:	Juan E. Figueroa
Start Date:	March 1, 2005
Expires:	February 28, 2007
Total Amount:	$500,000

Investigator: Michael Squillante, MSquillante@RMDInc.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to produce a new, high-resolution x-ray detector for fluorescence measurements of lighter elements. For x-rays generally near 30 keV and below, there exist several tradeoffs between today's choices of lithium drifted silicon (Si/Li)) detectors and high purity germanium (HPGe) detectors. Si/Li) detectors offer simple spectral decomposition but have limited active volumes. Conversely, HPGe detectors can offer larger sizes, but pulse height analysis is complicated by short x-ray penetration and overlapping escape peaks. The technical goal is to develop a detector from high purity silicon, with a contact structure that allows for increasing detection volumes without high capacitance -antithetical to high-count rates. The work will entail device design and computational modeling, developing new electrical contact fabrications on high purity silicon, manufacturing numerous test detectors and evaluation under various conditions, including temperature.

The impact of this technology could be how the detectors will be utilized and the basic science learned through the fabrication process. These detectors are used in many applications for the identification of completely diverse samples. Just a few examples include materials science, surface science, environmental analysis, industrial process and quality control, forensic sciences and archaeology, and geological and extraterrestrial exploration. In virtually any of these applications, a new detector providing greater counting efficiency yields more productive and definitive results.

Title: SBIR Phase II: High-resolution, high-precision 193-nm photomask phase metrology system

Award Number:	0450620
Program Manager:	T. James Rudd
Start Date:	February 1, 2005
Expires:	January 31, 2007
Total Amount:	$500,000

Investigator: Andrew Merriam, merriam@actinix.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to design and construct an ultra-high-resolution, high-precision phase-shift integrated measurement system suitable for metrology of advanced phase-shifting photomasks. A number of semiconductor manufacturers now expect to progress from the 90 nm through the 45 nm nodes using an exposure wavelength of 193 nm. Advanced photolithographic techniques are necessary to print these sub-wavelength features. Phase-shifting photomasks, i.e. those in which the optical
thickness, as well as the opacity is controlled, are a key reticle enhancement technology. Fast and accurate metrology of critical-layer phase-shift masks is becoming necessary both for process control and repair validation, but the enabling tools do not yet exist. The goal of this Phase II program is to integrate the actinic high-repetition rate laser built in Phase I into an interferometric laser microscope involving the design, construction, and integration of a stable
phase-shifting interferometer and laser microscope, and the incorporation and optimization of phase-shifting interferometry signal processing algorithms. The integrated optical system will enable phase metrology on advanced photomasks, with the measurement precision and spatial resolution required by the International Technology Roadmap for Semiconductors (ITRS), mask makers and mask users.

Commercially, the primary beneficiary of the Phase II photomask phase metrology system is the semiconductor optical lithography industry. The ITRS 'roadmap' for the 90-nm node and beyond requires measurements of photomask optical path difference with sub-0.4 degree precision. This metrology must be performed at spatial resolution scales consistent with feature sizes of the respective technology nodes, and for both isolated and densely-packed structures. No commercial metrology tools yet exist which satisfy these demands. The Phase II high-precision metrology system will enable manufactures to characterize, predict, and control mask-loading effects and other repair and process control issues essential to the reliable fabrication of phaseshifting masks. It is also likely that the integrated phase metrology system will find utility in the area of nano-MEMS testing and other nano-scale interferometry.

Title: SBIR Phase II: Non-Contact/Zero-Stress Surface Polishing Process for Copper/Low Dielectric Constant Semiconductors

Award Number: 0421638
Program Manager: T. James Rudd

Start Date: November 1, 2004
Expires: October 31, 2006
Total Amount: $516,963

Investigator: E. Jennings Taylor, jenningstaylor@faradaytechnology.com
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Phone: (937)836-7749

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will advance the development of a non-contact electro-polish process, addressing the need for a non-contact/stress-free polishing method for planarization of Cu/low-k interconnects required for the fabrication of nanochip integrated circuits. This technology utilizes pulsed electrolysis and a moving electrolyte front to effect complete electrochemical removal of copper overplate from a semiconductor wafer. The Phase II objectives/research tasks include: 1) design and fabrication of a module for the non-contact electro-polish process, 2) demonstration and optimization of the process on full size wafers, 3) development of a theoretical model defining a process library for the non-contact electro-polish process, and 4) characterization of the polishing performance and relationship to the mechanical properties of the materials used.

Commercially, the anticipated results of the program are a marketable manufacturing process/manufacturing tool in the form of an electrochemical module incorporating the non-contact electro-polish process. This product/process technology is enabling to other emerging industries such as MEMS and/or NEMS. In general, the project addresses the needs of the semiconductor industry, which is an important aspect of the US commercial economy and will play an increasing role in the US as well as world society. Furthermore, the process minimizes chemical waste and environmental impact.

Title: SBIR Phase II: MatchBox Display Systems

Award Number: 0422099
Program Manager: Murali S. Nair

Start Date: October 1, 2004
Expires: September 30, 2006
Total Amount: $499,935

Investigator: Chongchang Mao, cmao@setechinv.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project, matchbox projection systems, addresses a major opportunity in the multi-billion dollar projection display market. . The main goal for the phase II project is to develop a Matchbox projector based on one liquid crystal on silicon (LCOS) panel using the field sequential color (FSC) method. The development includes the fabrication of full custom and mixed signal integrated circuit (IC), LCOS panel, optical light engine, and mechanical assembly. The silicon backplane will contain 1280 x 768 frame buffer pixels that remove charge sharing and charge inducement noise, increase charge storage memory time, enhance display brightness, and increase image contrast ratio. The data loading will use frame-at-a-time approach, allowing an image to be displayed at full contrast while the next image is buffered onto the backplane. LCOS panel assembly process will be developed for implementing panels with high thickness uniformity, high contrast ratio, fast switching, and high reliability. The optical engine design will focus on compact FSC system. The display market is multi-billion dollar market with a wide range of products.

The commercial and military markets rely on highly specialized display products such as microscope and head mount displays. The LCOS system hopes to enable low power, high-resolution products in the market place.

Title: SBIR Phase II: A New Class of Ferroelectric Liquid Crystals for High Performance Optical Phase Modulation

Award Number: 0422196
Program Manager: T. James Rudd

Start Date: September 15, 2004
Expires: August 31, 2006
Total Amount: $499,994

Investigator: Michael Wand, wand@displaytech.com
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Phone: (303)772-2191

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a new class of ferroelectric liquid crystal (FLC) materials and novel operating mode to produce fast, analog, electro-optic phase modulation. This innovation exploits two recent developments in liquid crystal science: a new liquid crystal phase made from novel bent-core "banana" molecules, and electrostatically controlled analog modulation of high polarization FLCs. The new modulators will offer the fixed-optic-axis phase modulation capability of a nematic liquid crystal in combination with the much faster speed and lower drive voltage of a ferroelectric. Present day FLCs modulate light through electrically driven optic axis rotation. Phase modulation range is limited to less than 180 degrees unless complex multi-element device designs are used. What's so novel about the new FLC is that it modulates light through changes in its index of refraction; the direction of the optic axis remains fixed. Furthermore that modulation can be analog, unlike conventional FLCs, which are binary. This enables simpler device structures and phase ranges greater than 360 degrees. The new FLC should be compatible with liquid-crystal-on-silicon technology (LCOS), allowing the ability to construct inexpensive wavelength-tunable devices and wavefront modulators for diverse application including telecommunications, holographic and conventional optical data storage, and microdisplays.

This production on an electro-optic technology could be useful in an existing market (microdisplays), and could enable large new markets in the near future (active optics, optical data storage, telecommunications). Advantages over alternative technologies due to the nature of a lower cost manufacturing processes, and the ability to easily implement complex functionality because of the integration of this electro-optic technology with standard CMOS VLSI technology. Society could benefit through job creation, enhanced telecommunications, and improved data storage technologies.

Title: SBIR Phase II: Ge-Free Strained Silicon Via dTCE Bonding (Differential Thermal Coefficient of Expansion Bonding)

Award Number:	0421948
Program Manager:	T. James Rudd
Start Date:	July 15, 2004
Expires:	June 30, 2006
Total Amount:	$499,997

Investigator: Rona Belford, belford@hargray.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II project will develop a process that integrates wafer bonding technology with a novel straining process to create a new ultra fast silicon substrate: Strained-Silicon-On-Insulator (SSOI). This substrate can undergo normal IC fabrication and resulting circuits will be 30% faster at half the power required for comparative non-strained- SSOI architectures. The process is a direct approach and entirely surpasses the nearest competition as there is no germanium in any part of the processing. As a result the strained silicon is free from the high concentration of treading dislocations (>105 cm-2) always present when strained-silicon is grown on "strain-relaxed" silicon germanium virtual substrates. The silicon strained by the proposed method is maintained within its mechanically elastic region and thus is free from structural imperfections. The proposed method engages wafer bonding procedures already in place within the industry and modifies those processes to give a combined result of wafer bonding and SOI straining within a single step. The direct approach and single process makes the technique very inexpensive. The discipline evoked is fundamental surface science which involves investigation of both physical properties such as surface energies along with chemical aspects such as maintaining surface hydration and active surface species required for wafer bonding.

Commercially, the substrates available via this effort will make possible ultra fast silicon electronics. The proposed process also allows for non-intrusive radiation-hardening, giving initial commercial outlet in the military sector. Further markets include mainstream silicon-based electronics; effectively new host materials with speeds more characteristic of materials such as gallium arsenide and most salient, very low power electronics.

Title: SBIR Phase II: A Simple and Practical Solid-State 157nm and 193nm Coherent Light Source for Applications in Lithography Development

Award Number: 0349601
Program Manager: T. James Rudd

Start Date: March 1, 2004
Expires: February 28, 2006
Total Amount: $465,249

Investigator: Sterling Backus, sbackus@kmlabs.com
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Phone: (303)544-9068

Abstract:

This Small Business Innovation Research (SBIR) Phase II project will develop a new generation of fully-coherent, solid-state, vacuum-Ultraviolet (UV) light sources at 157nm and 193nm, to support the next generation of semiconductor fabrication and metrology, as well as for applications in basic research. Currently available UV excimer sources have limitations such as poor spatial coherence, making them unsuitable for metrology. Therefore, the most promising route to generate fully-spatially-coherent VUV sources is to up convert light from the visible-infrared region of the spectrum, where coherent laser sources already exist. However, a significant technical obstacle towards this goal is the lack of reliable solid-state nonlinear-optical crystals that work in the deep-UV. Unavoidable residual absorption at wavelengths <200nm can lead to long-term damage of nonlinear optical crystals, requiring constant replacement. Furthermore, for frequencies <193nm, no suitable nonlinear optical crystal currently exists. Therefore, gaseous nonlinear-optical media are an attractive alternative to crystals for generating light at wavelengths <200nm. This SBIR Phase II project will use four-wave mixing in gas filled hollow waveguides to develop a tabletop VUV laser capable of generating 10's of mW, and possibly 100's of mW of light at 157nm and at 193nm, in a fully coherent beam, at the very high (10kHz) repetition rates necessary for applications in metrology.

This project has the potential to have a very broad impact on the semiconductor and electronics industries, as well as in basic science. Progress in both the complexity and the speed of microprocessors, DRAM memory, and other integrated electronics has been driven by the ability to make increasingly dense IC's, with ever-smaller feature sizes. This has been enabled by the development of higher-resolution lithographic "steppers" and the use of ever-shorter wavelengths of light for lithography. Because no bright, tabletop, sources currently exist, most short-wavelength materials, nano- and chemical science must take place at synchrotron sources, where access is limited and the sources are not optimized. Therefore, significant gains in productivity could occur with the availability of such a source.

Title: SBIR Phase II: Nanoporous Silica Slurries for Enhanced Chemical Mechanical Planarization (CMP) of Low k Dielectrics

Award Number:	0349609
Program Manager:	T. James Rudd
Start Date:	March 1, 2004
Expires:	February 28, 2006
Total Amount:	$464,889

Investigator: Deepika Singh, singh@sinmat.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project aims to develop unique chemical mechanical planarization (CMP) slurries based on nanoporous silica particles that will meet or exceed CMP needs of low k dielectrics for the 80 nm and beyond semiconductor manufacturing nodes. The integration of low k dielectrics (dielectric constant 2.2 < k < 3.3) with copper metal lines is expected to considerably reduce RC (resistance x capacitance) delay for > 10 GHz CMOS expected devices in the next 3-5 years. One of the key issues plaguing the semiconductor industry is the chemical mechanical planarization (CMP) of copper/tantalum/low k dielectric materials. The low k dielectrics are fragile and are susceptible to both delamination and scratching (increased defectivity). Standard slurries employing hard abrasives may not meet the requirements for sub-80 nm CMOS devices which are expected to employ low k dielectric materials. The program proposes to develop & commercialize gentle CMP slurries based on nanoporous silica particles which exhibit reduced hardness and better stability. Combined with unique chemical formulations, these slurries are expected to achieve lower defectivity (surface scratching) and lower stress polishing than standard slurries. In this Phase II project extensive experiments will be conducted both in-house and with our partners (semiconductor chip manufacturers) to optimize performance and integration issues.

Commercially this research activity has significant impact not only in the semiconductor manufacturing areas, but also in may other areas such as biotechnology and nanotechnology, which are the key areas identified by the government for the future viability of US business. First and foremost it will ensure US can maintain its lead in CMP, even though semiconductor manufacturing jobs have been migrating overseas. As CMP slurries is the largest value added application of the nanoparticle technology (> 50%) excellence in this area will provide employment to nanotechnology graduates in the near future and could be a direct application of the skills they have acquired. This research will lead to the creation of faster electronic devices, which will in turn benefit the society to become more economically productive. The development of nanoporous particle technology can have applications in several other areas including controlled drug delivery systems.

Wireless Networks

Title: SBIR Phase II: Clock-on-Demand: High Performance, Ultra Low Power

Award Number: 0822542
Program Manager: Muralidharan S. Nair

Start Date: July 1, 2008
Expires: June 30, 2010
Total Amount: $500,000

Investigator: Farokh Eskafi, farokh@tagarray.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project is to develop a prototype and proof of concept for the tag and reader that uses an innovative low power Clock-on-Demand (CoD) and baseband/ media access controller (MAC) calibration algorithm to be used with ultra wideband communication systems. The new CoD and algorithm are motivated by application of ultra wideband to the RFID (Radio Frequency Identification) market. In this prototype, the CoD and the baseband/MAC layer algorithm are implemented in standard CMOS for tag and the UWB receiver and narrowband receiver with discrete components for reader. The low power requirement is achieved by the CoD and by dividing the time into epochs and epochs into slots. The CoD only runs until the tag transmits its impulse in the relevant slot, and the reader decodes the ID representations of all tags by the slot number. Therefore, if an epoch is divided into 210 slots, an impulse by tag represents 10 bits of the information. The robustness is achieved by having an UWB impulse transmitter in the tag and by repeating the impulse in different epochs. RFID is an exponentially growing market. However, the technology that supports its expansion is not able to provide robust communication and signaling between a tag and a reader. Furthermore, today?s technology only supports a low tag density (10s of tags/sec), while the applications that will fuel the exponential expansion of the RFID market, like point-of-sale, inventory management, shelf management, etc., require 100s and 1000s of tags/sec.

Title: STTR Phase II: Low-Cost Portable Telerehabilitation System for Intelligent Stretching and Remote Assessment of Hypertonic Arm Joints

Award Number: 0750515
Program Manager: Muralidharan S. Nair

Start Date: March 1, 2008
Expires: February 28, 2010
Total Amount: $485,564

Investigator: Yupeng Ren, yupeng.r@gmail.com
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Wilmette, IL 60091
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Abstract:

This Small Business Technology Transfer Research (STTR) Phase II research project seeks to develop technologies needed for rehabilitation of post-stroke patients with neurological impairment. For those patients, physical therapy followed by timely examination is the cornerstone of the rehabilitation. However, not all patients receive sufficient therapy due to limited access to expert healthcare services. There is a need for a tele-rehabilitation system that can stretch the spastic/contractured joints under accurate control at a remote location and provide remote access to expert healthcare services. This Phase II research will focus on improving the technology and making it suitable for the market by improving the design of the tele-rehabilitation system for multi-purpose applications to treat/evaluate multiple joints in the arm. It will make the portable device stand-alone with built-in capabilities of passive stretching, voluntary movement exercise, and tele-assessment of joint range of motion, stiffness, spasticity, and catch displayed in an intuitive way. Finally, a clinical test of the tele-rehabilitation system on stroke survivors will be conducted. This portable and low-cost stretching device is suitable for home use, making frequent and convenient treatment accessible to a large number of patients. It can potentially have broad impact on rehabilitation of stroke and other neurological impairments. The intelligent stretching concept was developed to insure safe and effective treatment and it will also be useful in other applications dealing with human-machine interface.

Title: SBIR Phase II: Location Aware Computing Using Near Field Electromagnetic Ranging

Award Number: 0646339
Program Manager: Muralidharan S. Nair

Start Date: March 15, 2007
Expires: February 28, 2009
Total Amount: $499,508

Investigator: Hans Schantz, h.schantz@q-track.com
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Abstract:

This Small Business Innovative Research (SBIR) Phase II research project seeks to transform the Real-Time Location Systems (RTLS) industry by bringing to fruition a simple, inexpensive, yet highly accurate approach to location awareness: Near-Field Electromagnetic Ranging (NFER) technology. RTLS is an important and rapidly growing segment within the Radio Frequency Identification (RFID) industry. In today's world of just-in-time commerce, Supply Chain Management (SCM) requires inexpensive real-time location data to improve efficiency and maintain competitiveness. Established technologies like the Global Positioning System (GPS), UltraWideBand (UWB), and traditional time-of-flight ranging have proven unable to perform satisfactorily within complicated, real-world, indoor propagation environments.

The anticipated result of this research effort will be a pilot installation of a NFER tracking system in a warehouse. It is predicted that: "RTLS and wireless LAN technologies, combined with innovative applications, will fundamentally change the way businesses manage and track high-value assets." Accelerated development of a technology that can meet this market need will bolster the American economy and increase American competitiveness.

Title: SBIR Phase II: Adaptive/Cognitive Software Radio Architecture for Gbps+ Wireless Networking

Award Number: 0620588
Program Manager: Errol Arkilic

Start Date: August 4, 2006
Expires: July 31, 2008
Total Amount: $500,000

Investigator: David Fogelsong, david@silvuscom.com
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Abstract:

This Small Business Innovation Research(SBIR) Phase II project will develop interference-mitigating technology for wireless networks. The traditional 802.11 WLAN systems that have been used for data communications are becoming ubiquitous. The next generation of these systems will be relied upon for video distribution, metropolitan networking, as well as a host of other applications that are as yet undefined. They must achieve aggregate network throughput rates in excess of one Gbps while operating in the unlicensed ISM bands. This, however, must be done in the face of ever increasing interference in the bands that in turn pose a serious threat to continued market growth. The current effort will address the interference problem by successfully combining novel spectrum sensing and cognitive approaches (observe, learn, react) with a host of powerful PHY, MAC, and combined PHY-MAC protocols. This effort will look to heavily leverage a new tool in the arsenal, namely that of multiple antennae enabled nodes that are included in the major Wi-Fi and WiMax standards.

The FCC revolutionized the wireless industry by opening up the unlicensed ISM bands. These bands reduce the barrier to entry for companies to introduce wireless services to niche markets without the expense and delays associated with obtaining a proprietary licensed band. The price paid for utilization of the ISM bands is interference. Traditionally these bands have been sparsely occupied, however, with ever increasing adoption of WLANs, and the emergence of WiMax and metropolitan networking in this band, interference is going to increase in significance. If successful, the current effort will allow high utilization of the ISM bands for high throughput high fidelity applications, and will help ensure low price wireless access to the society at large.

Title: SBIR Phase II: Multi-Frequency Low-Multipath Small Antennas for High Accuracy GPS

Award Number: 0450524
Program Manager: Muralidharan S. Nair

Start Date: March 15, 2005
Expires: February 28, 2007
Total Amount: $500,000

Investigator: Francesca Scire-Scappuzzo, fscire@psicorp.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II research project will consist of the design, development, and manufacturing of a novel low-multipath GPS antenna for high accuracy applications. This antenna prototype utilizes two key technologies: (1) a new design of GPS antennas using high-technology materials and manufacturing methodologies, that enables low-multipath, gain control, multi-frequency, tunability, and size reduction; and (2) a novel geometry of the metal ground plane to further rejects multipath interference. At the end of Phase II the anticipated results include, multipath error mitigation uniformly at L-Band, gain improvement at low elevation angles up to 10 dB with respect to choke ring antennas, multi-frequency operation at GPS and GALILEO frequencies, and at least 33% smaller size than other commercial low multipath antennas.

Because multipath interference reduction significantly improves GPS accuracy, the proposed multi-frequency GPS antenna will benefit the international scientific community that relies on high precision GPS for new advances in Earth and atmospheric sciences. In particular, the novel substrate antenna will allow accurate real-time GPS measurements, otherwise impossible, in support of the NSF funded EarthScope program, that is intended for the study of the structure and evolution of the North America continent using a network of GPS receivers.

Title: SBIR Phase II: Athermal Multiplexers Based on Reflective Arrayed Waveguide Grating Devices

Award Number: 0450072
Program Manager: Juan E. Figueroa

Start Date: January 1, 2005
Expires: December 31, 2006
Total Amount: $500,000

Investigator: Luis Gravede-Peralta, luisgrave@hotmail.com
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Abstract:

This Small Business Innovation Research(SBIR) Phase II project will optimize Performance and demonstrate reliability of temperature insensitive silica-based arrayed waveguide grating (AWG) multiplexers developed under SBIR Phase I award. In Phase I we have successfully demonstrated that the temperature sensitivity of silica-based AWGs can be eliminated by a combination of a reflective device with a unique external mirror that rotates with temperature at a constant rate. The rotation of the external mirror compensates for the temperature induced index change of silica waveguides and the resulting peak wavelength shift of individual channels, making the device athermal. This has been accomplished without penalties in the device performance. The goal of Phase II is to develop compact 40-channel, 100 GHz, totally passive athermal AWGs with Gaussian or flattop passband profiles that is manufacturable in large volume. Special attention will be given to the reliability certification of athermal AWGs as specified by Telcordia standards. During Phase II we will distribute reliable prototypes to our partners and potential customers for field tests. The research and development program carried out under this Phase II project will result in robust manufacturing process of reliable athermal AWGs ready for commercialization.

This project is focused on producing a highly reliable, temperature insensitive, AWGs based on silica-on-silicon technology. AWGs are planar optical devices that are considered key components in dense wavelength division multiplexed (DWDM) optical Networks. The novel approach to the manufacture of silica based AWGs, relying on high-technology silicon IC foundries, results in high quality devices that are produced at low cost, in high volume, and without a large front-end investment. The innovative design results in complete suppression of the temperature sensitivity of silica based AWGs. This approach eliminates the need for electric power and external temperature control of AWGs, resulting in a more robust, and considerably less expensive device package.

Title: SBIR Phase II: Adaptive Phased Arrays for Broadband Wireless Access

Award Number: 0422037
Program Manager: Muralidharan S. Nair

Start Date: November 1, 2004
Expires: October 31, 2006
Total Amount: $496,968

Investigator: Joseph Carey, joe.carey@fidelity-comtech.com
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Abstract:

This Small Business Innovation Research (SBIR) Phase II project will culminate in the demonstration of the smallest, most economical phased array system yet developed for addressing the problem of how to traverse the "last mile" between a broadband network and the home. During the course of the project, the state of the art in phased array antenna technology will be advanced and networking algorithms will be developed to take advantage of this innovative technology.

The broader impact of this research project is to fulfill the challenge to economically deliver wireless Internet access to rural communities. This steerable technology provides a greater than 50 percent increase in coverage and a cost savings of up to 55 percent. These cost and coverage improvements would help meet the needs and bring the benefits of broadband Internet into areas of the country that remain underserved.