U.S. Department of Energy

Small Business Innovation Research

And

Small Business Technology Transfer Programs

Phase II Abstracts

FY 2007

80000T06-II

***STTR Project: Broadly Tunable Quantum Cascade Laser Technology for Remote Sensing—**Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500; www.aerodyne.com
Dr. John Barry McManus, Principal, Investigator, mcmanus@aerodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-06ER86264
Amount: $749,700

Research Institution
Rice University
Houston, TX

Remote sensing of airborne chemicals by mid-infrared spectroscopy will greatly benefit by the development of new laser sources with improved tuning and power. The mid-infrared spectral region is ideal for measuring numerous gases with high sensitivity, because many gaseous chemicals have their strongest absorption features in this region, and there are atmospheric transmission windows. A new type of mid-infrared laser, the quantum cascade laser, is currently available at selected wavelengths, but they cannot be widely tuned. To measure different chemicals at significantly different wavelengths a widely tunable laser is needed. Also, higher power lasers help in many measurement situations, especially in remote sensing. In the proposed research, a small business and a university will jointly develop an improved mid-infrared quantum cascade laser based light source for spectroscopic remote sensing, along with associated optics and software. The improvement of the laser source will be in terms of the tuning range, tuning speed and output power as well as wavelength tuning speed, realized by an external cavity laser configuration with a quantum cascade gain medium. The laser design uses a technique that allows one to compensate for the effects of modest quality antireflection coatings and achieve wide and continuous tuning of the emission wavelength. During Phase I we developed and demonstrated the laser tuning technology at two different infrared wavelengths, exceeding our goals for tuning range (up to 155 wavenumbers) and continuous output power (50 milliwatts). We also tested remote sensing optics and instrumentation approaches with a narrowly tunable quantum cascade laser, measuring gas concentrations over a range path length greater than 280 meters. In the proposed Phase II work we will continue to develop the control techniques to produce an improved source with wide tuning and high power, beyond the substantial results of Phase I. The laser source will be more compact and rugged, with improved real-world performance and faster tuning. Optics and software will be developed to interface to the new laser source, resulting in a prototype instrument that will be field tested.

Commercial Applications and other benefits as described by the awardee: This new EC-QCL source will wide utility for remote sensing and chemical sensing problems in the military, industrial and research sectors. The ability to widely tune the laser allows measurement of multiple molecules, or the wide absorption spectra of complex molecules. Many of the gases of interest in military, industrial, medical and environmental problems have broad spectra that cannot be measured with a conventional narrowly tunable laser.

80001S06-II

Tunable Infrared Quantum Cascade Lasers for Active Electro-Optical Remote Sensing--Daylight Solutions, Inc., 13029 Danielson Street, Suite 203, Poway, CA 92064-8809; 858-391-0377; http://www.daylightsolutions.net
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DOE Grant No. DE-FG02-06ER84631
Amount: $750,000

Remote sensing of airborne chemicals from industrial or illicit emissions is greatly facilitated by looking for characteristic absorption patterns of mid-infrared (IR) light with wavelengths from 3 to 14 μm. The DOE can use this type of remote sensing to monitor and detect effluents from nuclear fuel cycle processes, for example. At present, there is no robust and reliable way to generate an intense beam of mid-IR light that can be tuned in wavelength to look for these absorptions and thus realize these remote sensing capabilities A high power, tunable mid-IR laser is being designed and built for use in remote sensing applications. State-of-the-art quantum cascade laser (QCL) technology is being incorporated in a miniaturized tunable laser cavity to provide a field-ready mid-IR light source to enable detection of airborne chemicals. Phase I helped extend QCL fabrication technology to develop materials suitable for incorporation in a miniaturized tunable laser cavity. Tunable near-IR diode laser technologies were extended to the mid-IR to enable design and construction of a miniaturized tunable mid-IR laser platform. Several prototypes were built that demonstrated *pulsed* tunable mid-IR lasers. Phase II will extend the Phase I platform technology to the *continuous wave* (CW) lasers necessary for remote sensing. Laser cavity design and quantum cascade (QC) device coatings will be optimized to allow continuous tuning of CW lasers. Design and development of CW QC devices throughout the entire mid-IR will be undertaken.

Commercial Applications and Other Benefits as described by the awardee: If tunable mid-IR lasers can be turned into commodity items, it will open up many new commercial applications. Monitoring of infrared absorptions as a function of light wavelength allows detection of airborne chemicals. Applications such as remote sensing of industrial emissions, stand-off detection of illicit chemicals, and medical breath diagnostics all could benefit from this laser. In addition, tunable mid-IR lasers will allow new applications in diagnostic imaging to be developed both for medical and industrial purposes. At present there are no practical technologies available that allow the creation of tunable IR light for commercial applications. This laser will solve that problem.

80004S06-II

Tools for Full Spectrum Analysis of Hyperspectral Data--Technical Research Associates, Inc., 3602 Woodlawn Drive, Honolulu, HI 96822; 858-926-7179; http://www.stormingmedia.us
Dr. Michael E. Winter, Principal Investigator, winter@higp.hawaii.edu
Dr. Edwin M. Winter, Business Official, edwinter@tracam.com
DOE Grant No. DE-FG02-06ER84642
Amount: $748,463

Hyperspectral sensor systems are currently under consideration for such applications as the detection of camouflaged and concealed targets, gas plume detection and identification, and terrain classification. Unfortunately, many of the data exploitation tools that can be used for the DOE mission of remote sensing of proliferation signatures are not user-friendly and do not full exploit all the spectral data available. The emphasis of this proposal is on monitoring the nuclear fuel cycle and other signatures of interest to the nonproliferation community. While most of the potential observables have significant features in the VNIR/SWIR reflection band (0.4 to 2.5 micrometers), some very important signatures, such as quartz minerals and disturbed soil are primarily in the thermal band. Currently, hyperspectral data from the VNIR/SWIR, the MWIR and LWIR are analyzed separately. The proposed approach will allow the analysis of the full spectrum to increase probability of proper identification and reduce false alarms. During Phase I, the requirements were analyzed and several additional segmentation techniques: Independent Component Analysis (ICA) and Non-Negative Matrix Factorization (NNMF) were implemented. These algorithms provide unique ways to investigate hyperspectral data that differ from either the orthogonal projections (Principal Components) or the linear unmixing endmember projections. In addition to the implementation of ICA and NNMF, the extension of the current Microcorder rule based spectral identification algorithm to the LWIR was investigated using data collected simultaneously by VNIR/SWIR and LWIR hyperspectral sensors. Under the Phase II project, software tools for the full spectrum analysis of hyperspectral data that will employ multiple endmember based and material identification procedures concurrently in both the reflection band and thermal bands will be developed. Besides ICA and NNMF, other full spectrum compatible analysis techniques will be implemented. Specifically, the current Microcorder algorithm will be extended to the LWIR, so that rules for spectral matching can be applied over the full spectrum from VNIR to LWIR. Included will also be a mixed pixel linear deconvolution method for separating the spectral components of mixed pixels. These tools will be integrated into a user-friendly analysis package with other existing software, and delivered with the software components level for integration into DOE hyperspectral analysis packages.

Commercial Applications and Other Benefits as described by the awardee: This software package will have uses for such applications as: detection of contaminants, military target detection, and exploration geology. In each case, remote sensing in one spectral region can detect certain target materials, but this task can be greatly enhanced by the use of the full spectrum. Contamination detection (EPA, local government, or military requires high probability of detection and identification with a low probability of false alarm. Bringing together the reflection and thermal bands offers the possibility of discriminating against false alarm sources. The emphasis of geological remote sensing has been in the reflection dominated portions of the spectrum, meaning that certain key minerals of economic importance are missed. The use of thermal infrared has been explored in some data collects using the Aerospace SEBASS and University of Hawaii AHI sensors. These exploratory investigations have led major exploration firms to sponsor the development of a commercial LWIR hyperspectral instrument. With the fielding of an LWIR HSI sensor, there will be a requirement for full spectrum analysis of data collected by reflection and thermal sensors over the same area.

80613S06-II

New Bright High Resolution Scintillators--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Mr. Kanai S. Shah, M.S., Principal Investigator, KShah@rmdinc.com
Dr. Gerald Entine, Business Official, Gentine@rmdinc.com
DOE Grant No. DE-FG02-06ER84640
Amount: $750,000

Proliferation of the weapons of mass destruction such as nuclear weapons is a serious threat in the world today. Gamma-ray detectors are an important component of systems used to prevent nuclear proliferation. The performance of such systems is currently limited by the characteristics of the available gamma-ray sensors.The goal of the proposed project is to investigate a new class of scintillators which has the potential to provide very high light output, fast response, high efficiency and excellent energy resolution and thereby, provide high performance gamma-ray sensors for nuclear non-proliferation. The Phase I project was aimed at performing a systematic investigation of the new class of scintillators and identifying compositions that are promising for further optimization in Phase II. Single crystals of the proposed scintillators were grown and their scintillation performance were evaluated. Energy resolution and proportionality measured. Excellent results were obtained and the feasibility of the proposed effort was adequately demonstrated. The Phase I project will be an extension of the successful Phase I during which optimization of the promising compositions identified in the Phase I research will be carried out. Larger crystals of selected compositions will be grown and their performance will be extensively characterized. A gamma-ray spectroscopy system based on the proposed detector will also be developed.

Commercial Applications and Other Benefits as descrbed by the awardee: Over and above the scientific use in nuclear non-proliferation, the new scintillators will be commercially applicable to nuclear, high energy, and space physics experiments, medical imaging, homeland defense, geological exploration, industrial imaging, X-ray instrumentation, and materials analysis.

80009S06-II

Nanostructured Composites for Space-Bound Housings--Mainstream Engineering Corporation, 200 Yellow Place, Rockledge, FL 32955; 321-631-3550; http://www.mainstream-engr.com
Mr. John Meyer, Principal Investigator, jam@mainstream-engr.com
Mr. Michael A. Rizzo, Business Official, mar@mainstream-engr.com
DOE Grant No. DE-FG02-06ER84633
Amount: $749,963

The current proposal addresses the problem of excessive weight of satellites. Successful weight reduction would result in decreased launch costs and increased maneuverability in space. Although, the particular DOE interest is for space bound electronics housings, the developed technology will enable a greater use of composites throughout the aerospace industry. This technology would permit composites to substitute for existing metals without compromising the necessary electrical and thermal conductivity properties. The combined objective of the Phase I and Phase II is to develop nanostructured carbon composites capable of conducting heat and electricity. Substituting the composite structure for metals allows the manufacture of lighter aircraft and satellites. Phase I experimentally examined the benefits of incorporating conductive- and strengthenhancing carbon nanofibers to aerospace grade resins with considerable success. Physical tests indicated that the nanofibers significantly improved tensile strength and electrical/thermal conductivity. These nanostructured resins can be utilized to create composite structures and used in satellites where electricity and heat must to be dissipated to protect equipment. The plan for Phase II is to further develop this technology and make it suitable for a lamination and manufacturing process. Further testing and optimization will be performed to guarantee the best combination of nanofibers, resin, carbon cloth, and molding process. The final product will be a prototype space-bound housing made of stronger and thermally/electrically conductive composites that will be approximately 40% lighter than aluminum.

Commercial Applications and Other Benefits as described by the awardee: A key benefactor will be the commercial- and military-based aerospace industry for which improved fuel consumption is imperative. Direct substitution of metallic elements within the aircraft with lightweight composites would result in substantial realized fuel savings. This project is a step towards reducing fuel dependency and helping to maintain affordable air travel.

80458S06-II

Cost-Effective Acoustic-Stirling Cryocooler with Flexibly Attached Remote Coldhead--Clever Fellows Innovation Consortium, Inc., 302 Tenth Street, Troy, NY 12180; 518-272-3565; www.cficinc.com
Dr. Philip S. Spoor, Principal Investigator, pspoor@cficinc.com
Mr. John A. Corey, Business Official, jcorey@cficinc.com
DOE Grant No. DE-FG02-06ER84646
Amount: $745,897

This project addresses the need for practical cryogenic refrigeration to realize benefits of high-temperature superconductivity in electrical power grid infrastructure. Present alternatives do not combine reliability, efficiency, cost & interface to support superconducting transformers, transmission lines and other devices in commercial service. Coolers of the new type, if achieved in the proposed Phase II – can do so. The novel coldhead, combined with oil-free acoustic-Stirling cooler baseline technology, does not require adaptation of cryostats and equipment and combines the reliability and efficiency of acoustic-Stirling with the universality and adaptability of coldfinger interfaces. This has been developed for miniature coolers and is to be extended by over 30X in this project, to capacities of direct usability in superconducting power systems. In Phase 1, we completed mechanical design for the new remote coldheads, evaluated production cost and reliability of coolers using that head, and executed performance simulation models. We validated those models against existing miniature remote-head cooler by test. We found that this cooler type, at volume expected with a universal interface (which it has) can approach or meet the cost goal, as well as the reliability, capacity, and efficiency required for superconducting power systems commercialization. In Phase II, we will build and test coolers designed in Phase I, suited for superconducting transformers and transmission lines. We will also submit one machine to long-term testing. Together, these will provide concrete demonstration of the performance, reliability, efficiency, weight and (to a limited degree) cost of this most promising cryogenics system for superconducting power systems.

Commercial applications & Other Benefits as described by the awardee: The proposers have already made a license and commercialization contract for our oilfree drive technologies, with Praxair, Inc, the largest air separation company in the Americas. With a remote coldfinger, that baseline technology becomes general purpose cryocoolers in the 100's to 1000's of watts class for superconductivity, industrial gas liquefaction and recondensation, power electronics cooling, and general scieentific cryogenics. In every case, these devices will deliver cold or liquid cryogen at less cost than traditional truck-and-store distribution (where applicable) and enable new uses where traditional distribution is unworkable (e.g., shipboard power electronics cooling).

80460S06-II

Large Capacity, Multi-Cylinder Cryocooler for High Temperature Superconductor (HTS) Applications--Infinia Corporation, 6811 W. Okanogan Place, Kennewick, WA 99336-1743; 509-737-2114; www.infiniacorp.com
Dr. Songgang Qiu, Principal Investigator, sqiu@infiniacorp.com
Mr. Tom D. Mitchell, Business Official, tmitchell@infiniacorp.com
DOE Grant No. DE-FG02-06ER84650
Amount: $749,968

High Temperature Superconductor (HTS) applications are emerging from the laboratory and industry experts expect dramatic growth for the foreseeable future as high temperature superconductor devices provide more efficient power transmission, generation and use. While substantial investments have been made to develop the technology and markets for high temperature superconductor devices, little attention has been paid to the critical enabling technology – cryocoolers that provide high efficiency, high capacity, high reliability, and long life with little or no maintenance requirements. The innovative multi-cylinder cryocooler (MCC) proposed by Infinia Corporation addresses the needs of high temperature superconductor devices in a costeffective manner and to a significantly higher degree than existing alternatives, such aspulse tube cryocoolers or maintenance-intensive Gifford-McMahon cryocoolers. Infinia's innovative but low-risk design configuration benefits from parts that are interchangeable with Stirling engine components designed for low cost mass production. The MCC concept developed during Phase I offers a unique integration of proven long-life, highreliability, maintenance-free flexure bearing and clearance seal technology used successfully with free-piston Stirling engines and cryocoolers (plus pulse tubes) together with high capacity double-acting alpha configuration Stirling machine technology. The proposed Phase II effort will design and fabricate a functional prototype MCC that will be tested to prove the performance and benefits identified during Phase I. As expressed in letters from world-class high temperature superconductor and cryocooler experts, Jim Maguire of American Superconductor, Ray Radebaugh of NIST and John Pfotenhauer from the University of Wisconsin, the proposed cryocooler concept is ideally suited to meet the demanding needs of high temperature superconductor equipment.

Commercial Applications and Other Benefits as described by the awardee: Infinia Corporation firmly believes that the proposed multi-cylinder free-piston Stirling cryocooler offers the best potential of any available technology to meet these demanding needs. HTS technology holds the promise of more efficient power distribution in densely populated communities, where a single HTS cable can replace several conventional cables, and more efficient naval vessels, which replace conventional motors and generators with HTS versions. The proposed cryocooler represents a vital enabling product for realizi ng these applications on a commercial scale.

80169S06-II

A Low-Cost Modular Optical Voltage Sensor for Power Transmission Applications--FieldMetrics Inc., 13352 82nd Avenue, Seminole, FL 33776-3126; 727-698-1742; www.fieldmetrics.net
Dr. Christopher Paul Yakymyshyn, Principal Investigator, yakymyshyn@fieldmetricsinc.com
Ms. Pamela Jane Hamilton, Business Official, hamilton@fieldmetricsinc.com
DOE Grant No. DE-FG02-06ER84649
Amount: $750,000

Updated abstract

Because investment in the United States power grid infrastructure has not kept pace with increased energy demands, existing power lines must operate close to conservative safety limits. Advanced instrumentation can simultaneously improve efficiency and maintain reliability by enabling true dynamic rating. Next generation sensors must be low-cost to allow widespread deployment and capable of providing critical power line parameter measurements to utility operators in real-time.
A low-cost modular optical voltage sensor has been designed for deployment on power lines over the full range of distribution and transmission voltages. The sensor is comprised of modular sections that are produced in high volume using advanced manufacturing techniques to dramatically reduce the cost as compared to conventional equipment.
The Phase I project addressed the design of the optical sensor to ensure accurate measurements under all operating conditions. Exceptional accuracy has been demonstrated at lower voltages, with a clear design path shown for extending the concept to 765 kV. Previous work explored the design of the modular impedance building block, which is the other critical enabling technology for the modular optical voltage sensor system.
The Phase II project will develop and implement a full-scale prototype manufacturing process to produce complete modular optical sensors for type testing. The stacked optical modular topology will support a voltage sensor capable of metering class accuracy, relaying class accuracy, transient and real time measurements for transmission applications up to 765 kV.

Commercial Applications and Other Benefits as described by the awardee: The proposed optical voltage sensor has a wide range of possible applications for the electric utility industry. The device offers a high-accuracy, low cost, environmentally friendly voltage measurement technology to replace conventional instrument transformers that have exceeded their design lifetime. An integrated power supply allows the inclusion of GPS timing, transient recording, revenue metering, power quality assessment and other specialty sensing needs within a single package that can exploit recent advances in broadband communications techniques to eliminate much of the cost and effort associated with installing conventional equipment having equivalent capabilities.

Previous Version

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dynamic rating. Next generation sensors must be low-cost to allow widespread deployment and capable of providing critical power line parameter measurements to utility operators in real-time.
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81257B06-II

Distribution System State Estimation--EnerNex Corporation, 170C Market Place Boulevard, Knoxville, TN 37922-2337; 865-691-5540; www.enernex.com
Dr. Thomas E. McDermott, Principal Investigator, tom@enernex.com
Mr. Jeffrey D. Lamoree, Business Official, jeff@enernex.com
DOE Grant No. DE-FG02-06ER84647
Amount: $524,740

Effective management of distribution systems requires analysis tools that can estimate the state of the system (the operating condition). This is achieved at distribution level by load prediction and state estimation methods. Recently state estimation algorithms have arisen from research activities, but they have yet to be adopted in practice. Utilities need an easier way to implement these new algorithms, and also need tools that can pull together all the data needed for the analysis. On a radial distribution system, load estimation and state estimation mean the same thing. A branch current state estimation algorithm was chosen to provide both of these functions. This algorithm is tailored to radial distribution feeders, because the state estimation techniques used on transmission systems don't work well on the distribution system. This algorithm is to be deployed on a large-scale data historian software system, which provides access to a large volume of measurements to support state estimation. The end result will be a state estimation template that is suitable for large-scale applications.
The framework for deploying advanced state and load estimation algorithms to utilities was specified. A suitable research-grade state estimator was also identified, and its interface to the deployment framework was tested. University research will produce better methods of load modeling from statistical data, of branch current state estimation, and bad data identification. A configurable mapping to measured data will be developed, and then deployed and tested at an electric utility.

Applications and Other Benefits as described by the awardee: Using the load estimation toolbox, researchers from universities or industry can develop new modules as add-ons to the industry-leading data historian software for electric utilities. The potential market share in the U.S. is 50-60%. This lowers market entry barriers and enables better operation of the electric power distribution system. In the future, the same basic framework will support additional data collection from automated meters and power quality monitors, leveraging the use of these measurements.

81146S06-II

Low-Cost SSPM-Based Digital Radiation Monitor--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Dr. James F. Christian, Principal Investigator, JChristian@RMDInc.com
Dr. Gerald Entine, Business Official, GEntine@RMDInc.com
DOE Grant No. DE-FG02-06ER84589
Amount: $749,996

Many facilities throughout the DOE Complex will reside in a safe storage or surveillance and maintenance (S&M) mode until such time that funding resources are available to perform decontamination and demolition. Long-term monitoring systems are required to ensure against a contaminant release and provide rapid response in the case of such an event. New or improved monitors or sensors are needed to record contaminant levels that would expose workers during deactivation and decontamination activities. The solid-state photomultiplier (SSPM) detector concept will be applied to the application to produce a sensor capable of long-term functionality with the ability to easily form sensor webs. The complimentary metal oxide semiconductor (CMOS) fabrication environment provides a low-cost, process controlled production method; scintillation detection provides a proven, high efficiency nuclear detection method at a low cost. The goal of this research is to develop a low-cost rate-eter based on a CMOS SSPM coupled to a scintillation crystal. We designed and fabricated SSPM array chips and coupled them to various scintillation materials to demonstrate their performance. The Phase-I experiments allowed us to determine the configuration that maintains low cost with maximum sensitivity. The early Phase-I prototype achieved an energy resolution of 22% for 511-keV photons detected with LYSO, and the modified Phase-I prototype will improve the detection efficiency by more than a factor of four. The Phase-II effort develops a compact, low-cost, sensor-network-compatible technology appropriate for monitoring DOE Legacy sites while providing state-of-the-art spectroscopic information. In the Phase-II program, we will optimize the design of the scintillation detector and CMOS solid-state photomultiplier device, and integrate the necessary components to construct a “rate-meter-on-a-chip”.

Commercial Applications and Other Benefits as described by the awardee: Companies and national labs that monitor radiation have a need for low cost digital rate-meters and dosimeters to improve monitoring, reduce liability, and improve record keeping ability. Nuclear, high energy, and atomic physics experiments using scintillator readout or direct detection of light can utilized improved SSPM’s.

81148S06-II

High Sensitivity, Low Cost Fluorescence Detection for Beryllium Particulates --AJJER, LLC,
4541 East Fort Lowell Road, Tucson, AZ 85712-1108; 520-321-7680; www.ajjer.com
Dr. Juan Carlos Lopez Tonazzi, Principal Investigator, jctonazzi@qwest.net
Dr. Anoop Agrawal, Business Official, aagrawal@qwest.net
DOE Grant No. DE-FG02-06ER84587
Amount: $749,865

The unique properties of beryllium (Be) have lead to many applications ranging from the aerospace and nuclear industry to manufacturing and electronics. Unfortunately, beryllium is a Class A EPA carcinogen and when inhaled into the lungs can cause the incurable and potentially fatal lung disease. The purpose of the SBIR Phase I was to demonstrate that fluorescence could be employed to improve the detection limit so that it may be used to measure beryllium at the ultra-low levels to improve worker safety. The goals were achieved in Phase I and the detection limit was shown to be better than 50 times the Phase I goals. The objective of Phase II is to capitalize on Phase I success and to demonstrate a system including a fluorometer which can be commercialized. The second goal of Phase II is to automate the system so that more than 240 samples can be processed/shift.

Commercial Applications and Other Benefits as described by the awardee: The work in this proposal will provide a simpler, inexpensive method to analyze beryllium that can be used on site if desired for fast quantitative results that will match the detection capability of ICP-MS. This will allow the industry and the Government laboratories to better protect their staff.

81037B06-II

***STTR Project: Imaging the Stratigraphy Around a CPT Penetration Using a Combined ERT and CPT Method—**Vista Engineering Technologies, LLC, 8203 W. Quinault, Building C, Suite 200, Kennewick, WA 99336; 509-737-1377; http://www.vistaengr.com
Dr. Wesley L. Bratton, Principal Investigator, bratton@vistaengr.com
Mr. Phillip C. Ohl, Business Official, ohl@vistaengr.com
DOE Grant No. DE-FG02-06ER86292
Amount: $664,327

Research Institution
Lawrence Livermore National Laboratory
Livermore, CA

The research proposed under this effort addresses the need for improved technologies for measuring key influencing factors that impact mass-transport rates in the shallow subsurface on a large scale. Many technologies are available to make discrete point maeasurements of key parameters, but few technologies are able to expand and assess those parameters on a larger scale or provide maps of those parameters in a cross-section. Mass-transport parameters are important on a large scale because the flow and transport occurs on a large scale. Key amoung the mass-transport calculaions is the ability to map out key fine grained layers that significanly influence groundwater flow. The proposed development project will develop, evaluate, and demonstrate a commercially viable method for mapping the stratigraphy of the subsurface around cone penetrometer (CPT) penetration or a monitoring well using electrical resistance measurements between an array of electrodes along the ground surface as well as electrodes mounted on the CPT probe itself. This will combine the point measurments capabilites of the CPT with the mapping potential of Electrical Resistance Tomography (ERT) to assess key parameters and specifically fine grained layering on an appropiate scale for mass-transport problems. This will also significantly reduce the uncertiainity on the stratigraphy between borehole test locations. Successful results from both numerical modeling computations and laboratory tests conducted during Phase I were obtained. This resutls demosntrated that sufficeint resolution can be obtained by combining surface electodes with CPT probe electrodes to produce images of the surface stratigraphy surrounding a CPT penetration. A key aspect that was considered was the mapping of thin fine grained layers. An important relevation that was determined in Phase I was the need for multiple electrodes on the CPT probe to generate sufficient data pairs for high resolution imaging. The Phase II effort will expand upon the Phase I resutls with additional numerical modeling to optimize the probe electrode spacing and measurement appraoches. Spacings between surface and CPT electrodes will be optimized along with the mesuerments strategies. The goal is maximize the number of unique measurements such that sufficeint data exists for the image inversion process. A CPT probe with 3 to 5 electrodes will be fabricated. The CPT electrode will be designed to both transmit electrical current as well as measure the electrical potential. This will be the first time that a CPT probe for transmiting ERT signals has been developed. The new CPT probe will be used in field tests to map the stratigraphy at a well characterized field site. This will allow a comparison of the CPTERT generated stratigraphy and stratigraphy generated using more standard approaches.

Commercial Applications and Other Benefits as described by the awardee: Current subsurface characterization techniques typically only provide a point measurement and are not able to map out resutls past the borehole location to determine wheter layers are continuous or pinch out away from the borehole. The proposed combined ERT-CPT appraoch will permit real-time mapping of the subsurfae straigraphy several to a hundred feet way from the borehole. This will provide a much improved image

of the subsurface, especially key flow controlling layers, that will singificantly improve the realiability of flow and transport models.

80672T06-II

***STTR Project: In-Situ Analytical System for Remote Determination of 90Sr Flux through the Aquifer—**Burge Environmental, Inc., 6100 South Maple Avenue, Suite 114, Tempe, AZ 85283-2872; 480-968-5141; www.burgenv.com
Dr. Scott R. Burge, Principal Investigator, burgenv@globalcrossing.net
Dr. Scott R. Burge, Business Official, burgenv@globalcrossing.net
DOE Grant No. DE-FG02-06ER86266
Amount: $747,802

Research Institution
Battelle Memorial Institute
Richland, WA

The long-term monitoring of ground-water contamination plumes to determine the fate of contaminants in the environment is expensive and labor intensive. Current baseline methods have resulted in monitoring programs that collect less data than is required to fully understand the fate and transport mechanisms of the contaminants. An automated field-deployable monitoring system using a preconcentrating column sensor will be used to monitor strontium-90 concentrations. The system will be capable of being deployed and operated in the field for several months measuring strontium-90 concentrations below the regulatory limits, 8 pCi/L. The system will provide more frequent data with less reporting delay at a lower cost than the baseline methods. A prototype analytical system was developed and tested. The system successfully detected strontium-90 below the regulatory limit and appeared to have the necessary attributes for deployment in the field. The Phase II will further reduce the risks of the technologies, and field deployment of four systems to allow for near real-time estimation of flux through the aquifer at 100-N area of Handford Site, Washington.

Commercial Activities and other Benefits as described by the awardee: The system has application at DOE sites with radiological contaminants (Hanford Site, Washington). The system will decrease monitoring costs, enhance the understanding of the fate of the radiologicals in the environment, and ultimately decrease the cost of groundwater remediation activities.

81151S06-II

Field Portable Gel Element Arrays for Microbial Community Profiling in Subsurface Sediments and Groundwater--Akonni Biosystems, Inc., 9702 Woodfield Court, New Market, MD 21774; 301-524-7867; www.akonni.com
Dr. Darrell P. Chandler, Principal Investigator, dchandler@akonni.com
Dr. Charles E. Daitch, Business Official, cdaitch@akonni.com
DOE Grant No. DE-FG02-06ER84412
Amount: $749,970

The objective of this project is to develop a simple-to-use, microarray-based environmental diagnostic test and device that will enable technicians and engineers to monitor microbial community structure and dynamics in groundwater and subsurface environments. The technical problem and product opportunity addressed by this Phase 2 project lies in integrating complex, environmental molecular microbiology operations into a fluidic architecture that can be mass produced at low cost and operated by any unskilled technician with a simple push of the button. We will meet these objectives by taking advantage of an exclusively-licensed gel element microarray intellectual property portfolio, and embedding the microarray and molecular techniques into an injection-molded, sample-to-answer fluidic development model. Based on results from the Phase 1 project, the basic biochemical and technical methods now exist for microfluidic nucleic acid extraction, purification, labeling, microarray hybridization and data analysis that are required to make practical use of microarray technology in the field. The specific objectives for the Phase 2 project are therefore to develop a standard operating protocol for a v2.0 gel element array; improve the efficiency of on-cartridge nucleic acid recovery from environmental samples; incorporate a flow-through nucleic acid amplification subcircuit into the development model to militate against low sample-to-answer detection limits; integrate the sample preparation, amplification and microarray sub-circuits into a unified, sample-to-answer model for automatically processing and analyzing sediment and aquifer extracts for rRNA gene signatures from metal- sulfate- and nitrate-reducing bacteria; establish a semi-automated decision logic for interpreting the array data; and evaluate the integrated model and standard operating procedure with environmental samples impacted by metals, radionuclides or organics before transferring the product to commercial production in Phase 3.

Commercial Applications and Other Benefits as described by the awardee: The anticipated public benefits of this project are therefore threefold. The scientific benefit of this project is to engender multi-disciplinary research and development in the fields of environmental microbiology, environmental engineering, biochemistry, chemistry, physics, manufacturing science and mechanical/electrical engineering. The educational benefit of the project is ultimately realized by teaching engineers, regulators and policy makers the value and use of molecular tests for environmental monitoring and process control. The societal benefits of the project are to create a low-cost, affordable diagnostic cartridge and controller device that will improve the nation's ability to clean up environmental hazards; inexpensively monitor environmental samples through time and space for microorganisms of interest or concern; and reduce the public (taxpayer) economic and societal cost of cleanup, restoration, or public health mitigation activities associated with environmental contaminants.

80465S06-II

Commercial High Resolution Optical Tweezers Packages for Single Macromolecule Analysis and Control--Nanobiosym, Inc., 200 Boston Avenue, Suite 4700, Medford, MA 02155; 781-391-7979; www.nanobiosysm.com
Dr. Anita Goel, Principal Investigator, agoel@nanobiosym.com
Dr. Anita Goel, Business Official, agoel@nanobiosym.com
DOE Grant No. DE-FG02-06ER84422
Amount: $749,150

The advent of methods to detect and manipulate single macromolecules like optical tweezers has unleashed a new frontier in biological physics, especially at the nanoscale. Despite rapid advances in optical tweezers technology, its full impact on biomedicine, nanomedicine, the nanobiotechnology and biopharmaceutical industries, and clinical research markets remains far from fully realized. To date, nearly all of the high resolution optical tweezers setups suitable for single molecule experimentation are locally built and thus limited to a handful of academic labs around the world. The biggest barrier to entry in this field remains the lack of adequate commercially available optical tweezers systems that would allow a broader user community to exploit these new tools for single molecule analysis and control. In this proposed SBIR effort, we seek to refine and commercialize our existing apparatus in order to bring ultra-high-resolution optical tweezers to a broader audience of researchers, for a variety of applications. We will do so by providing customers with customized design and assembly, installation and ongoing technical support, consulting, and training. The primary goal of our Phase I work was to demonstrate the feasibility of a high-resolution optical tweezers commercial package. This was accomplished via a first-generation instrumentation prototype interfaced with software components enabling computer control of various features. All proposed milestones were successfully achieved and feasibility of our high resolution optical tweezers package was demonstrated using single molecule biosystems under constant-force conditions. In Phase II, we will integrate remaining hardware upgrades into a low-maintenance, self-contained hardware package and further develop the control and noise reduction software. We will also develop an integrated graphical user interface to allow automated calibration and basic trapping control and functionality. By the end of Phase II, we will demonstrate a self-contained, low-maintenance, user-friendly system that allows pN force and nm position measurements of biomolecular dynamics. In tandem with the base model, we will also develop advanced modules for custom modules such as flow cells and nanopositioning stages. We will demonstrate the use of our integrated force-feedback system for precise measurements of force-dependent kinetics of macromolecules and molecular motors. We will also establish robust assays for single molecule analysis and control, such as single-molecule DNA assays with nanomedical applications**.**

Commercial Applications and Other Benefits as described by the awardee: Upon successful completion of all three SBIR phases, Nanobiosym will provide customers with custom design and construction of optical tweezers systems, as well as installation and ongoing technical consulting services. Nanobiosym will market these systems to both traditional domains (i.e., biophysics, nanobiology) and areas such as clinical and diagnostic lab spanning areas such as molecular diagnostics, pathology, oncology, drug discovery, and nanomanufacturing.

80468S06-II

An Experimental/Computational Platform for the Analysis of Metabolite Profile Data--

Genomatica, Inc., 5405 Morehouse Drive, Suite 210, San Diego, CA 92121; 858-362-8550; www.genomatica.com
Dr. Stephen James Van Dien, Principal Investigator, svandien@genometica.com
Dr. Christophe Heinz Schilling, Business Official, cschilling@genometica.com
DOE Grant No. DE-FG02-06ER84416
Amount: $747,527

Advances in bioinformatics and genome research have generated a rapid expansion in the availability of information at all levels of biological investigation. One of the goals of the Genomics:GtL initiative of the Department of Energy requires the development of a computational infrastructure for systems biology to interpret this information at the whole cell level, and to predict the behavior of these complex systems in response to their environment. This proposal is aimed at developing a combined experimental/in silico platform to improve upon the predictive capabilities of such models using metabolite profile (metabolomics) data. Specifically, infrastructure is being developed within existing metabolic modeling software to manage, visualize, and analyze metabolomics data in the context of the genome-scale model. This framework will then be validated using microbial strains in development for bioprocessing applications. We will demonstrate that metabolomics data in conjunction with modeling technology can improve the ability to predict cell behavior, and thus streamline the strain development process. In Phase I of this project, we first used qualitative metabolomics data to improve the quality of existing genome-scale models by finding gaps in the network and identifying candidate genes with functions to fill these gaps. Next, quantitative concentration data was used in conjunction with thermodynamic considerations to probe intracellular metabolism and improve the ability to predict cell physiology. Two computational methods were implemented in house and tested with available datasets, allowing us to predict reaction directionalities, identify potential bottleneck sites, and predict potential sites for regulation. In Phase II, Genomatica's modeling software will be expanded to contain a module dedicated to calculating, managing, and comprehensively integrating quantitative metabolomics data within the existing modeling infrastructure. A database of thermodynamic data will also be constructed, for use in conjunction with this "Metabolomics Module" for the application of the new simulation methods developed in Phase I. Finally, we will perform a research demonstration of the capabilities of performing such integrated analysis using engineered *E. coli* strains as a case study.

Commercial Applications and Other Benefits as described by the awardee: This project will leverage metabolite concentration data to expand in silico models of metabolism and improve the ability to predict cell behavior using these models. Furthermore, it will establish a general methodology for extracting useful biological information from metabolomics data. Collectively, this work will serve to increase the capabilities of the modeling technology as a whole and more specifically the use of modeling to guide rational strain engineering for the production of chemicals and fuels from renewable feedstocks. Finally, success of this program will advance one of the core aims of the GtL initiative: the establishment of a comprehensive computational infrastructure for systems biology research.

80486S06-II

CAPS-Based Particle Single Scattering Albedo Monitor--Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500; www.aerodyne.com
Dr. Andrew Freedman, Principal Investigator af@aerodyne.cim
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-06ER84411
Amount: $750,000

Measuring the radiative forcing of aerosols is currently the focus of the Department of Energy Atmospheric Sciences Program. Aerosol particles affect the radiative balance of the earth directly, by scattering and absorbing solar and terrestrial radiation, and indirectly, by acting as cloud condensation nuclei. It is now recognized that the atmospheric loading of aerosols generated through human activities can exert an influence on the earth's radiation budget comparable in magnitude with greenhouse gases. However, the uncertainties in the current understanding of aerosol direct and indirect forcing "limit the ability to quantify human influences on climate change". We are developing a particle single scattering albedo monitor that combines extinction and scattering measurements in one instrument with rapid time-response, active temperature/relative humidity control, and high sensitivity. This monitor will employ Aerodyne's proprietary Cavity Attenuated Phase Shift spectroscopy technology in order to produce a far simpler, smaller, lower cost alternative to cavity ring downbased systems and more traditional instruments with no loss in sensitivity or accuracy. The Phase I project focused on a proof-of-principle demonstration of the proposed technique. A laboratory prototype was constructed and calibrated. Both particle extinction and absorption coefficients were measured simultaneously using monodisperse polystyrene latex particles ranging in size from 0.1 to 8.0 microns in diameter. A baseline precision for the extinction measurement was ~0.3 Mm-1 in 60 seconds integration time. The monitor response to scattering as a function of particle size was flat from 0.1 to 2 microns, but falls off to 75% of full response at 8 microns. Modeling indicates that this falloff in response is caused by use of a highly non-ideal integrating volume. The Phase II project will focus on developing a robust and improved field prototype instrument which will be compared to a number of commercially available instruments which measure particle scattering and absorption. Once its performance capabilities has been established, the prototype sensor will be used on a number of field campaigns involving measurement of aircraft exhaust and urban air pollution.

Commercial Applications and Other Benefits as described by the awardee: Successful development and marketing of this monitor will yield a significant level of direct commercial sales from the atmospheric sciences and environmental pollution research and development communities. The comparatively low cost and ease of use of this sensor will allow almost routine measurement of the scattering properties of atmospheric aerosols, something precluded by the cost and complexity of current instrumentation.

80083S06-II

Field-Worthy UV Backscatter Lidar for Cirrus Studies--Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077; 978-689-0003; www.psicorp.com
Dr. David M. Sonnenfroh, Principal Investigator, sonnenfroh@psicorp.com
Dr. B. David Green, Business Official, green@psicorp.com
DOE Grant No. DE-FG02-06ER84427
Amount: $749,945

Cirrus clouds are an important element in atmospheric radiative transfer and impact climate and climate change. The spatial coverage and frequency of cirrus clouds has been increasing in recent years. New instrumentation is needed to measure the occurrence and spatial extent of these clouds to develop a database for climate modelers. We propose to develop and field demonstrate a compact ultraviolet backscatter lidar that will utilize a state-of-the-art, all solid state ultraviolet laser for the transmitter and will provide better sensitivity and new capability to monitor subvisual cirrus clouds, as compared to the existing MicroPulse Lidar. We successfully demonstrated the requisite output energy and pulse repetition rate from an aircooled ultraviolet laser that will serve as the heart of the new lidar. We carried out modeling to show the expected increase in sensitivity arising from operating in the ultraviolet compared to the MicroPulse Lidar. We also developed a conceptual design for the field prototype Ultraviolet Backscatter Lidar, which will be fabricated and tested in Phase II. In the Phase II project, we will finalize the design for the field prototype Ultraviolet Backscatter Lidar. We will then fabricate the sensor, extensively test it in-house, and then field demonstrate it at the Southern Great Plains Atmospheric Radiation Measurement site. We intend this demonstration to include intercomparisons with the MicroPulse Lidar and the Raman Lidar that are already deployed and operated at the site.

Commercial Applications and Other Benefits as described by the awardee: This program will demonstrate a new, highly compact lidar system for the remote monitoring of cirrus clouds. Such a sensor fulfills an important near term need for a highly autonomous sensor for widespread use by monitoring networks. Other potential applications of the technology would be monitoring of lower atmosphere natural and hazardous aerosols, and tropospheric ozone and sulfur dioxide.

80072S06-II

Implantable Biofuel Cell--Lynntech, Inc., 7607 Eastmark Drive, Suite 102, College Station, TX 77840; 979-693-0017; www.lynntech.com
Dr. Season Wong, Principal Investigator, season.wong@lynntech.com
Dr. G. Duncan Hitchens, Business Official, duncan.hitchens@lynntech.com
DOE Grant No. DE-FG02-06ER84420
Amount: $750,000

Implantable medical devices including pacemakers, nerve stimulators, drug delivery pumps, and biosensors offer tremendous patient benefits, however batteries currently used to supply power to these devices have a large footprint and a limited lifetime, requiring periodic surgical replacement. In addition, the development of miniature implantable devices is constrained by the size and energy density of current implantable battery technologies. Biofuel cells have a tremendous opportunity to provide much higher energy densities and smaller footprints than batteries for powering implantable medical devices, leading to less intrusive implantable devices with longer lifetimes. Biofuel cells can specifically extend the lifetime of implantable devices and reduce or eliminate the need for additional surgery required for battery replacement. Lynntech is developing an innovative miniature biofuel cell that uses two enzymatic systems at the anode and cathode and is powered by glucose and oxygen found in the human blood stream. Both the biofuel cell materials and by-products are non-toxic and bio-compatible to the human body. The overall goal of the Phase II project is to develop a working prototype biofuel cell that provides a high power density, long-term stable operation, and can be implanted in the human body. During the Phase I work, Lynntech successfully developed and tested enzymatic anode and cathodes and developed bio-compatible polymer coatings to enhance cell performance and stability. A working biofuel cell operating on glucose and oxygen was fabricated, and the cell demonstrated an open circuit potential of 0.5 V and power densities up to 300 μW/cm2. During the Phase II project, Lynntech will optimize the biofuel cell components (e.g., enzymatic electrodes and bio-compatible polymers) to enhance the power density and long-term stability of the biofuel cell. The Phase II project will also design, fabricate, and test a prototype miniature biofuel cell that can be implanted in the human body. The design will allow the biofuel cell to be easily implanted into a blood vessel with minimal disruption of the blood flow. The miniature prototype biofuel cell will be tested in serum and defribinated blood to demonstrate the ability of the biofuel cell to operate *in vivo*.

Commercial Applications and Other Benefits as described by the awardee: Summarize the future applications or publicbenefits if the project is carried over into Phase III and beyond. Do not repeat information already provided above. The development of this technology has broad commercial impact on a large sector of the biomedical industry based on its ability to provide power to a wide range of implantable devices including pacemakers, implantable cardioverter defibrillators, nerve stimulators, biosensors, glucose monitors, and other implantable devices. A significant impact of the technology is to reduce the size and extend the lifetime of implantable devices. In addition to implantable devices, enzymatic biofuel cells could provide a versatile, renewable power supply for portable electronics and other applications using readily available carbohydrate fuels and non-precious metal catalysts.

80495S06-II

Novel, Needle-Shaped Scintillator for Emission Transmission Tomography--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Dr. Vivek V. Nagarkar, Principal Investigator, vnagarkar@rmdinc.com
Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-06ER84433
Amount: $749,996

With the ever-increasing number of human disease models, particularly in smaller animals, high resolution emission/transmission tomography techniques have become extremely important. Such advanced imaging requires advanced detectors, and although detector technologies have improved significantly in recent years, the current state-of-the-art scintillator technology remains the primary performance-limiting factor. The main barriers to using existing modalities in studies of laboratory animals remain poor spatial resolution, low sensitivity, and high cost. To address the multiple limitations of the current technology, we propose to develop a new scintillator formed by the co-evaporation of rare earth halides onto suitable substrates. This new scintillator will simultaneously provide high spatial resolution, excellent stopping efficiency, high light output and fast response, and will do so at reduced cost. Our fabrication approach will allow the synthesis of thick scintillators in large area formats that otherwise would be prohibitively expensive, even for use in important y-ray/X-ray imaging modalities. Our phase I research accomplished all of its stated goals and successfully demonstrated the feasibility of growing microcolumnar fils of rare earth halide scintillator material using our vapor deposition approach. Furthermore we demonstrated that such films possess all of the excellent properties of their crystal counterparts and render beneficial effects in achieving high spatial resolution of 10 1p/mm or higher for radiographic and radionuclide imaging. Initial commercialization efforts in Phase I succeeded in attracting several potential customers very interested in evaluating the phase II films, and each has indicated that if the films meet expectations that they will probably incorporate them into existing and/or new products. The proposed Phase II research will build upon the solid foundation laid by the Phase I work, with the intention of fabricating large area scintillators of the required thickness, with excellent emission properties. The microcolumnar structure of the films will be controlled to enhance scintillation yield, while maintaining very high spatial resolution. The scintillator films thus produced will be subjected to thorough evaluation at RMD, at our collaborator's facility, and at our potential customer's sites to confirm their superiority over existing scintillators. In parallel we will pursue commercialization efforts through publishing and exhibiting the product at trade shows, and further introducing it to our existing customer base.

Commercial Applications and Other Benefits as described by the awardee: The proposed novel scintillator is expected to have widespread use in small animal and human SPECT/CT imaging systems in particular, and in nuclear medicine systems in general. Additionally, it will have applications in the areas of high speed and ultra-high speed X-ray imaging, nondestructive testing and homeland security. The demand for fast, high-resolution, high-sensitivity radiation sensors is rapidly growing. As such, the proposed development holds a very high potential for successful commercialization.

80498S06-II

An Efficient, Solid State Detector for Nuclear Medicine--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Dr. Michael R. Squillante, Principal Investigator; MSquillante@rmdinc.com
Dr. Gerald Entine, Business Official; GEntine@rmdinc.com
DOE Grant No. DE-FG02-06ER84430
Amount: $750,000

Nuclear medicine techniques such as Positron Emission Tomography and Single Photon Emission Computed Tomography have become powerful new tools in imaging biological processes in small laboratory animals. Performance of these systems is limited by the properties of the detectors available at present. The goal of the proposed project is to investigate a new solid state detector which appears to be very promising due to its high efficiency, high signal to noise ratio and possibility of excellent energy resolution. Large crystals of the new material will be grown, detectors will be fabricated and their properties will be extensively examined in our study. The Phase I project was aimed at demonstrating the feasibility of applying the new solid state detectors towards small animal imaging. Single crystals of the proposed material were grown and the detector performance was evaluated. Energy and timing resolution studies were conducted. During the Phase II project, larger crystals of the proposed solid state detector material will be grown, position sensitive detectors will be built and performance evaluation studies will be carried out. Finally, multiple detectors will be tiled to create PET modules with very high spatial resolution for small animal imaging and these PET modules will be evaluated.

Commercial Applications and Other Benefits as described by the awardee: Over and above the use in nuclear medicine, the new detectors will be applicable to particle physics, homeland defense, geological exploration, industrial imaging and nuclear remediation.

80507S06-II

Lightweight, High-Precision Instrument for Balloon Sonde CO2 Measurements--Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041; 650-965-7772; www.lgrinc.com
Dr. Douglas S. Baer, Principal Investigator; d.baer@lgrinc.com
Dr. Douglas S. Baer, Business Official; d.baer@lgrinc.com
DOE Grant No. DE-FG02-06ER84419
Amount: $676,208

More accurate determination of CO2 in the atmosphere is required to reliably quantify the sources and sinks of carbon in the environment. Current CO2 analytical instrumentation is relatively large, heavy and requires significant amounts of electrical power to operate. As a result, *in situ* CO2 measurements can presently be recorded on weight-bearing vehicles (e.g., aircraft) that fly infrequently and thus cannot report measurements with high spatial or temporal resolution. LGR will develop, test and deploy inexpensive, low-power CO2 sensors (weight < 100 grams), based on absorption spectroscopy techniques, capable of reporting CO2 with an uncertainty of less than 1 ppmv in the troposphere and tropopause. These instruments will be designed to report CO2 measurements while onboard balloon sondes over extended periods. In Phase I, LGR designed, built and tested a novel compact CO2 sensor based absorption spectroscopy. The instrument demonstrated a measurement precision of 1 ppmv over a range of concentrations typical in ambient air and in industrial processes. In Phase II, LGR will develop, test and deploy several CO2 sensors on board balloons for measurements in the troposphere and tropopause at a DOE Atmospheric Radiation Measurement site. The Phase II instrument will weigh about 100 grams and operate on a lightweight battery. Commercial applications of the proposed instrument include atmospheric studies of carbon sources and sinks, industrial process control (chemical and petrochemical refineries), pollution detection.

Commercial Applications and Other Benefits as described by the awardee: By significantly increasing the speed, accuracy and precision of CO2 measurements in the field and on balloons, the new instrument will significantly enhance studies of global warming and facilitate controlled multi-year studies and comparisons between geographically distant field sites. These studies will enable detailed monitoring of mass and energy exchange which is needed to determine the chemical composition of the atmosphere and the productivity of the biosphere. The instruments will thus help quantify in detail the global carbon cycle on local and large spatial scales and enable atmospheric chemists to generate reliable models of climate change and carbon sequestration.

80510S06-II

Real-Time Infrared Greenhouse Gas Sensor--NovaWave Technologies, Inc., 900 Island Drive, Suite 101, Redwood City, CA 94065-5150; 650-610-0956; www.novawavetech.com
Dr. Hans-Jurg Jost, Principal Investigator; hjjost@novawavetech.com
Dr. James J. Scherer, Business Official; jjscherer@novawavetech.com
DOE Grant No. DE-FG02-06ER84424
Amount: $749,927

Improved greenhouse gas monitors are presently required to improve our understanding of atmospheric dynamics and climate change. In particular, highly accurate and robust sensors that are capable of monitoring fluxes and concentrations of key greenhouse gases such as methane are needed. The proposed sensor is based on a novel mid-infrared laser source. This laser will possess many desirable qualities, including high reliability, excellent beam quality, compact size, low power consumption, and room-temperature single-frequency operation. This laser will be combined with a rugged, miniaturized gas sampling system to enable long-term measurements of trace gas fluxes and concentrations in field settings. During Phase I, the mid-infrared laser source will be constructed and fully characterized. The source will be used in conjunction with a compact gas sampling system to demonstrate the fast and accurate determination of methane concentrations in atmospherically relevant gas mixtures. Additionally, preliminary designs for a fully automated Phase II sensor will be produced. The Phase II work comprises constructing an improved laser and integrated sensor prototype systems. The system will be rigorously tested under both laboratories as well as field conditions to demonstrate system efficacy for autonomous greenhouse gas monitoring for extended periods of time. The Phase II work will also demonstrate the efficacy of the core sensor technology platform for numerous other gas sensing applications.

Commercial Applications and Other Benefits as described by the awardee: The commercial applications of the proposed sensor are numerous, including trace gas monitoring at AmeriFlux and FLUXNET sites, greenhouse gas monitoring for emissions compliance, hydrocarbon leak detection, and in a variety of industrial process control settings.

80417B06-II

Field-Deployable Gas Analyzer for MMV Applications--Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041; 650-965-7772; www.lgrinc.com
Dr. Anthony O'Keefe, Principal Investigator; a.okeefe@lgrinc.com
Dr. Douglas Baer, Business Official; d.baer@lgrinc.com
DOE Grant No. DE-FG02-06ER84606
Amount: $728,099

In response to recent evidence confirming that anthropogenic CO2 emissions are disturbing the natural carbon cycle and resulting in global warming, DOE has pioneered a Carbon Sequestration Program to capture and store CO2 and other greenhouse gas emissions in geological sites. However, despite initial research that suggest that leakage rates may be low, there have been no definite long-term studies, and a recent review on carbon sequestration has identified MMV as a critical component of future activities, stating that "a more expansive program aimed at monitoring underground CO2 injections in a wide variety of geological settings is essential." In order to address these issues, researchers require instrumentation that is highly sensitive (< 0.5 ppm CO2), capable of covering a broad area (> 15 square miles), and able to distinguish between leakage of stored CO2 and natural, biological CO2 fluctuations (via carbon isotope measurements). In this Small Business Innovative Research effort, Los Gatos Research proposes to employ its patented Off-Axis Integrated Cavity Output Spectroscopy technology to develop a field-portable gas analyzer for carbon sequestration monitoring, mitigation, and verification (MMV) applications. This instrument will be capable of providing *in-situ*, highly accurate quantification of CO2 concentration (< 0.5 ppmv), isotope ratio (δ13C < 1.0 ‰), and CH4 concentrations without calibration to monitor surface leaks above geological formations and distinguish between biogenic and injected carbon sources. In Phase I, Los Gatos Research demonstrated technical feasibility by fabricating a carbon isotope ratiometer that accurately measure δ13C to better than 1.0 ‰ and CO2 concentration to better than 0.5 ppmv after only 100 seconds of measurement time. Moreover, the instrument was capable of retaining this high specification over a wide CO2 dynamic range spanning from 300 – 6000 ppmv, allowing for measurements of both ambient air and soil gases. The analyzer's capabilities were empirically demonstrated by extracting and quantifying methane and carbon dioxide concentrations from soil at various depths, detecting and distinguishing a simulated CO2 leak, and deploying the instrument at the University of Utah for independent performance verification. In Phase II, LGR will develop and deliver three complete gas analyzer systems that are capable of quantifying the carbon isotope ratio (13C/12C) of CO2, the concentration of CO2, and the concentration of CH4 at ambient and subsurface levels. After thorough testing under real-world conditions, the instruments will be deployed at a DOE Carbon Sequestration Field Site, a biological natural carbon sequestration site, and an Ameriflux complex, coupled system site respectively. Subsequent to these deployments, the primary instrument will be delivered to the National Energy Technology Laboratory (NETL) or another facility of DOE's choosing for further application in carbon sequestration programs.

Commercial Applications and Other Benefits as described by the awardee: During Phase III, LGR will sell the carbon isotope ratiometer into a variety of markets, including environmental research, industrial process control, and medical diagnostics. Preliminary estimates suggest annual revenue exceeding $3M/year by 2012.

80620S06-II

A Low-Energy Low-Cost Process for Stripping Carbon Dioxide from Absorbents--AIL Research, Inc., P.O. Box 3662, Princeton, NJ 08543; 609-799-2605; www.ailr.com
Dr. Thomas Tonon, Principal Investigator; ttonon@ailr.com
Dr. Andrew Lowenstein, Business Official; ail@ailr.com
DOE Grant No. DE-FG02-06ER84592
Amount: $748,064

If CO2 could be scrubbed from the flue gas of power plants and safely sequestered, the country's most important source of electricity—fossil-fired power plants—could operate without emitting significant amounts of greenhouse gases. Although technology for scrubbing CO2 from flue gas is commercially available, it is far too expensive and requires too much energy to be widely deployed. The proposed work focuses on reducing the costs and energy requirements for the stripper of a CO2 scrubber, with the objective of making CO2 scrubbing an affordable technology for controlling emissions. The proposed work will reduce the capital cost for a CO2 scrubber by converting the expensive metallic heat exchangers that are fundamental to its operation to plastic designs. It will also significantly improve the thermal efficiency of the scrubber by replacing the conventional reboiler and stripper column with a unique heat and mass exchanger that is again based on a plastic heat exchanger. Performance data from a proof-of-concept experiment confirmed that the proposed technology could effectively strip the CO2 from an MEA absorbent at a significantly lower temperature than would be required by a conventional stripper. By lowering the temperature for stripping, the proposed change to the stripper when combined with additional benefits attributed to the plastic heat exchangers would reduce the derating of a power plant that used an MEA scrubber from 35% to 20%. The application of the plastic heat exchangers would reduce capital cost for the MEA scrubber by 24%. Further reductions in capital cost and plant derating are possible if the proposed technology is applied to advanced absorbents that are being developed elsewhere. The Phase II work will scale up the plastic heat exchanger technology that was proven in Phase I to a module that will have most of the design features of a full-scale deployable system. The module will be tested under controlled laboratory conditions using several thermally-regenerated absorbents. A preferred absorbent will be identified. Engineering analyses that follow DOE Guidelines will determine the potential reductions in energy use and capital cost that may be realized for the proposed technology.

Commercial Applications and Other Benefits as decribed by the awardee: The primary benefit for the proposed technology will be to allow the country to use its vast reserves of coal in existing and planned power plants without contributing to the accumulation of CO2 in the atmosphere. Furthermore, since CO2 is increasingly being used to recover "stranded" oil reserves, the proposed technology, by lowering the cost for CO2, will play an important part in extending the country's oil resources.

80801S06-II

Early Remote Risk Assessment Survey Technology--Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088; www.poc.com
Dr. Sergey Sandomirsky, Principal Investigator, sutama@poc.com
Mr. Gordon E. Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-06ER84613
Amount: $749,993

The Department of Energy is seeking development of risk assessment methodologies and simulation models to quantify and mitigate accidental release of carbon dioxide and other noncarbon dioxide greenhouse gases from geologic formations. Current monitoring technologies cannot reveal concealed fractures in overburdened formations, which are the most probable path for carbon dioxide leaks. To address this need, Physical Optics Corporation is proposing a new Early Remote Risk Assessment Survey Technology, which identifies potential zones of carbon dioxide leakage before geologic sequestration is initiated. This technology is based on differential absorptionlidar and designed to detect anomalies with multiple gases ("geogas"), including methane, carbon dioxide, helium, argon, and hydrogen on the surface of the earth. Such anomalies can reveal potentially hazardous concealed zones of high permeability. In Phase I a laboratory prototype of differential absorption lidar operating at three wavelengths was designed, assembled, and tested in laboratory conditions. Experiments demonstrated feasibility in detecting methane, argon, and carbon dioxide, individually and in mixtures. In Phase II, efforts will be concentrated on system optimization, including increasing the optical power of the laser light source; optimizing the receiving optics; designing a push-broom scanning mechanism; and developing geolocation, georegistration, and mapping software tools. Successful completion of this development will lead to a fully operating technology system for remote mapping of potential hidden fracture zones for planning geological carbon dioxide sequestration and minimizing the risk of subsequent carbon dioxide leaks from the ground.

Commercial Applications and Other Benefits as described by the awardee: The proposed technology can identify, from an aircraft, surface geogas anomalies that indicate deep penetrating concealed faults and fractures, which are the major risk sources for accidental carbon dioxide release; this cannot be done by any other technology with comparable cost and speed. The proposed technology will allow the Department of Energy, at an early stage, to minimize risk in selecting sites for geologic carbon dioxide sequestration. The proposed device will be compact and affordable for multiple users, including government agencies and private companies engaged in environmental monitoring, pipe leak inspection, earthquake prediction, nonproliferation control, etc.

80805S06-II

Efficient Treatment of Toxic Metal Contaminated Wet Scrubber Wastewater from Coal-Fired Power Plants--Lynntech, Inc., 7607 Eastmark Drive, Suite 102, College Station, TX 77840; 979-693-0017; www. lynntech.com
Dr. Hariprasad Gali, Principal Investigator, hari.gali@lynntech.com
Dr. G. Duncan Hitchens, Business Official, duncan.hitchens@lynntech.com
DOE Grant No. DE-FG02-06ER84607
Amount: $750,000

Coal-fired electricity generating plants use flue gas emission control technologies to contain green house gases and other materials that pollute the environment. Although these control methods bring the plant into compliance with emissions regulations, they have also been shown to increase the capture of toxic mercury, which accumulates in the installation's wastewater, creating a serious environmental hazard that cannot easily be dealt with using existing methods to treat wastewater. New methods to remove mercury from coal plant wastewater are needed urgently. Lynntech has developed a new nanoporous inorganic-organic hybrid material for the selective removal of mercury from wastewater, where mercury is removed by ion-exchange. The Phase I research demonstrated that the new material has significant potential for commercial use. Laboratory tests indicated that the material has favorable characteristics for meeting new EPA restrictions on mercury discharge levels in wastewater. In addition, the sorbent's ability to remove mercury at high flow rates was demonstrated. In key performance criteria, the new material substantially exceeded the performance of the most advanced commercial material for mercury removal and the new material's processes advantages are complemented by its low manufacturing cost. Wastewater samples collected from operating coal-fired power plants were used in evaluating the material's performance. The aims of the Phase II project include: design and fabrication of treatment system for pilotscale demonstration, and carrying our engineering feasibility tests at an operating coal-fired power plant. To achieve these goals, Lynntech will collaborate with a leading engineering company specializing in mercury control technology and with a major chemical company regarding manufacture the sorbent material.

Commercial Applications and Other Benefits as described by the awardee: Summarize the future applications or public benefits if the project is carried over into Phase III and beyond. Do not repeat information already provided above. The technology developed in this project offers enormous benefits over the existing technologies for mercury removal from power plant wastewater. This technology will be very useful for removing mercury from industrial, mining, and municipal wastewater, crude oil, liquid condensate, nuclear waste, dental wastewater, etc.

80440S06-II

Intelligent Control of Advanced Power Generation Systems Using Model-Free Adaptive Control Technology--CyboSoft, General Cybernation Group, Inc., 2868 Prospect Park Drive, Suite 300, Rancho Cordova, CA 95670-6065; 916-631-6313; www.cybosoft.com
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DOE Grant No. DE-FG02-06ER84599
Amount: $717,948

For the U.S. to reach its future energy objectives, visions to build ultra-clean and highly efficient energy plants of the future have to be realized. More robust and flexible process control technologies must be developed to build an intelligent control system that can yield a fully automated operation and be adaptive to changing process needs and fuel availability. It must be safe, reliable, and easy to install, maintain, and operate. The overall objective of a multi-phase SBIR effort is to research, design, develop, test, evaluate, benchmark, and bring to production an intelligent control system for controlling the new generation of boilers for energy plants using CyboSoft's innovative yet industry proven Model- Free Adaptive control technology. CyboSoft accomplished all Phase I feasibility study objectives; and we are 100 percent confident in stating that MFA is the most suitable technology for this application and MFA control products can be instrumental in controlling the advanced boilers including Supercritical boilers, CFB boilers, and Supercritical CFB boilers for future energy plants to achieve maximum energy efficiency, near-zero emissions, fuel-flexibility, and multi-products. CyboSoft is applying for the Phase II grant with these objectives: (1) refining the boiler models and MFA boiler controllers, (2) enhancing MFA Toolbox software to allow collaborators Alstom Power and Siemens PG to test MFA with their MATLAB boiler models, (3) developing a special CyboCon MFA Advanced Boiler Control software package, and (4) On-site testing and demonstration of the intelligent MFA control system to control Supercritical and CFB boilers. We expect to have shippable commercial products by the end of the Phase II project. CyboSoft has the experience and expertise to solve tough industry-wide control problems, and develop successful commercial products. We believe the key is to team up with good partners that already have a large market share. We have secured good partners for both Supercritical boiler and CFB boiler markets. All we have to do is to focus on achieving Phase II objectives and deliver what our partners and their customers want. Then, the success of the MFA advanced boiler control products is almost assured.

Commercial Applications and Other Benefits as described by the awardee: The quality of fuels is degrading, and clean fuels are becoming scarce. By using MFA control, the conventional fuels, combustible byproducts, and waste fuels can be burnt more efficiently and hence more cleanly. Effective automatic control system represents the simplest way of reducing greenhouse gas emissions from combustion, which translates to a healthier and safer environment.

80020S06-II

Hybrid Ceramic/Metallic Recuperator for SOFC Generators--Acumentrics Corporation, 20 Southwest Park, Westwood, MA 02090; 781-461-8251; www.acumentrics.com
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DOE Grant No. DE-FG02-06ER84590
Amount: $740,060

Solid oxide fuel cells (SOFCs) are one of the most efficient and cleanest power generating systems being developed. A key component in the SOFC generator is the cathode air heat exchanger or recuperator. The function of the recuperator is to ensure that the cathode air, and thereby the cells, are at sufficient temperature to permit ion mobility, and to improve overall SOFC system efficiency by reducing stack losses. At present, commercially available metallic recuperators contribute a significant cost to the overall cost of an SOFC generator and a highly effective, low cost, long life alternative is needed. The work to be conducted under this application will focus on the development and demonstration of a "hybrid" recuperator which combines a high temperature ceramic section with a low temperature metallic section to reduce the overall cost of the unit while achieving the high effectivenss and long life required an SOFC generator. This arrangement will take advantage of the high temperature, low fouling capability of a ceramic heat exchanger core while allowing lower grade metallic materials, with high extended surface area, to be used in medium to low temperature regions. By incorporating the ceramic and metallic sections into a single unit, costly interconnect ducting and fittings along with associated support structure and insulation will not be required significantly reducing the cost over non-integrated solutions. In phase I, a single pass ceramic monolith was manufactured and tested to determine its heat transfer performance, evaluate plenum sealing methods and its ability to withstand temperature gradients and thermal cycling. The monolith was integrated into a multi-pass cross-flow recuperator configuration using metallic first and second passes and an integrated recuperator effectiveness of greater than 80% was obtained. In phase II, the ceramic monolith will be further refined to enhance heat transfer performance and implement a low cost sealing/attachment arrangement. Custom single pass molds will be produced. Precommercial prototypes will be produced to conduct performance and durability testing and to establish manufacturing techniques and costs. A ceramic cross flow – metallic counter flow hybrid arrangement will also be evaluated.

Commercial Applications and Other Benefits as described by the awardee: Development of the "hybrid" recuperator will significantly reduce the cost of a key component in Solid Oxide Fuel Cell generators. It is estimated that a cost reduction of $100/kW compared with state-of-theart metallic recuperators can be achieved with this technology. This in turn will increase the economic and commercial viability of this low emissions, high efficiency power generation technology. There is also a high likelihood that this technology will also be utilized in other high temperature applications such as metal melting furnaces, glass furnaces, chemical process reactors, forge furnaces, etc.

80747S06-II

Novel Supports and Materials for Oxygen Separation and Supply--Eltron Research Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263, www.eltronresearch.com
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DOE Grant No. DE-FG02-06ER84600
Amount: $750,000

Existing coal gasification and combustion processes employ air as the oxidant which leads to nitrogen oxide formation and dilute product/waste streams which are difficult and expensive to separate. The proposed technology will provide a more economical, non-cryogenic, and non-membrane means for separating, storing, and releasing pure oxygen for use in coal gasification and oxycombustion, leading to the elimination of nitrogen oxides and product/waste streams which are more concentrated and easier to separate, and lowering the cost of CO2 capture in these facilities. This project addresses the application of mixed metal oxide materials on novel supports capable of separating oxygen from air and releasing that oxygen so it can be used in coal gasification and related processes such as IGCC. The material technology developed here will be more resistant to attrition than ceramic supports and will possess large surface area, large oxygen storage capacity, long term stability, and will not contain costly noble metals. A number of mixed metal oxide materials with large oxygen storage capacities were identified in Phase I and were shown capable of releasing large amounts of that stored oxygen under ambient pressures and moderate temperatures. These materials, when supported on sintered metal fiber filters, demonstrated improved oxygen production at lower temperatures. The ability to coat the supports with various ceramics and glass in order to improve surface area was also successfully demonstrated and these coatings were shown to be stable up to 700oC and had good attrition resistance. Phase II will investigate the compositional optimization and continued development of materials for the uptake and release of pure oxygen. In addition, optimization of the coating process for the ceramic and glass coatings on the supports, as well as that for the mixed metal oxide materials will be undertaken. Kinetic data will be obtained for the uptake and release of oxygen from preferred materials. Using the kinetic data, as well as other information, design, fabrication and testing of a bread-board reactor will be performed and the system, as well as the process utilizing it, will be optimized.

Commercial Applications and Other Benefits as described by the awardee: Cryogenic separation of oxygen is extremely expensive and remains the main obstacle to making several more environmentally friendly fossil fuel utilizing processes (coal gasification, oxycombustion) commercially possible. By utilizing pure oxygen instead of air in these processes, a much more concentrated, easily separated, carbon dioxide gas stream is produced and NOx emissions are eliminated. Since there is a global push for reduction, sequestration, and utilization of greenhouse gases, most notably carbon dioxide, and because this technology would reduce costs associated with carbon dioxide separation in coal gasification, and related processes utilizing a pure oxygen feed, it would be of significant economic and technical benefit to the nation and world community.

81332T06-II

***STTR Project: H2 Separation Membranes—**TDA Research, Inc., 12345 W. 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
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DOE Grant No. DE-FG02-06ER86290
Amount: $750,000

Research Institution
Colorado School of Mines
Golden, CO

Recent advances in the area of metal membranes have shown that Pd aloy composite membranes are not susceptible to the embrittlement and poisoning problems that have prevented widespread industrial use of Pd for high temperature H2 separation from coal-derived synthesis gas. However, there is still a need to prepare thin membranes on porous stainless steel substrates to provide the robustness and ruggedness required in industrial processes. However, several issues related to the use of PSS supports must still be addressed. The surface roughness of the steel supports must be reduced to make a defect-free thin Pd alloy film, and a diffusion barrier must be in place to prevent metal migration at the tube-film interface (e.g., diffusion of iron from the steel into the Pd membrane). TDA Research, Inc. (TDA), in collaboration with Colorado School of Mines (CSM) is developing a simple and effective technique to modify the surface of stainless steel supports that would allow preparation of very thin Pd alloy films. In Phase I, TDA and CSM developed various thin Pd alloy membranes films supported onto porous stainless steel substrates and demonstrate their potential for hydrogen separation. We showed that the performance of these membranes are not affected by the major constituents of the synthesis gas (CO, CO2 and H2O) and tolerates sulfur poisoning, while achieving favorable flux and selectivity.
In Phase II, we will continue to optimize these membranes, scale-up their production and demonstrate their effectiveness in the presence of other contaminants of the cola-derived synthesis gas.

Commercial Applications and Other Benefits as described by the awardee: Recently, there has been interest in utilization of Pd membranes to separate hydrogen produced in hydrocarbon reforming, the water-gas shift reaction, and coal gasification for power generation in fuel cells. Such applications have the potential to reduce energy consumption, capital costs or the number of unit operations compared to conventional systems.

80532S06-II

Novel Surface Modification Method for Ultrasupercritical Coal-Fired Boilers--Inframat Corporation, 74 Batterson Park Road, Farmington, CT 06032-2597; 860-487-3838; http://www.inframat.com
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DOE Grant No. DE-FG02-06ER84604
Amount: $750,000

The efficiency of conventional pulverized coal power plant cycles is strongly related to operating temperature and pressure. Ultrasupercritical (USC) coal-fired boilers are being developed to operate with higher steam temperatures and steam pressures. However, the increasing temperatures and corrosive environment cause more severe oxidation and corrosion in USC boiler components, particularly, the surface damages on the fireside in waterwall and superheater/rehearter. New surface modification technology is needed to solve the corrosion problem. The overall objective is to develop an innovative process for forming an ultrafine-grained alloy coating at a competitive cost, and to evaluate and optimize coating materials and structures for high-temperature corrosion and erosion resistance. The overall apprach is to develop a novel surface coating technique for producing desirable ultrafine structured coatings with high quaillty and long durability. The technique is affordable and marketable. The Phase I work has well demonstrated that the innovational process is capable of producing a superior coating with the desirable aspects of merits of nanometer grains, high adherance and full density. The extensive experiemetal tests were performed to evaluate coatings' performance under corrosion and erosion conditions, and promising coating system are identified. Proposed Phase II program will focus on continuation of efforts to demonstrate the improvement and optimization of manufacturing process, evaluation of coating characteristics, and performance of long-term exposure properties. Technical benefits identified in the Phase I feasibility program need to be evaluated in greater depth and further refined in Phase II, specifically with emphasis on long term corrosion exposure of coatings in simulated boiler environment and or field testing.

Commercial Applications and Other Benefits as described by the awardeee: The potential application will include supercritical and ultrasupercritical boiler components, coal gasification system, SOFC system, hot-section components of steam turbine, land-based gas turbine engines and aerocraft engines, and other industry components involved in oxidation and corrosion at elevated temperatures. The process technology is scaleable and marketable, and will definitely promote the overall global competitive advantages of US economy at large.

80540S06-II

Robust, Low-Cost Membranes for Hydrogen Production from Coal-Derived Syngas--Aspen Products Group, Inc., 186 Cedar Hill Street, Marlborough, MA 01752; 508-481-5058; www.aspensystems.com
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DOE Grant No. DE-FG02-06ER84594
Amount: $750,000

The production of hydrogen from coal offers the potential for increased power generation efficiency, reduced pollutant emissions and the production of valuable chemical products from coal. This project will develop a novel, low-cost, hydrogen membrane with improved durability for the production of high-purity hydrogen from coal-derived syngas. The use of such membranes in water gas shift membrane reactors for hydrogen generation from coal via gasification offer the advantages of 1) generating more hydrogen in a single shift reactor, 2) simplifying or completely eliminating downstream hydrogen separation and purification processes and 3) producing a high-pressure carbon dioxide-rich stream that can be sequestered to reduce greenhouse gas emissions. The objective of the project is to develop hydrogen permeable membranes that possess high hydrogen permeability, high hydrogen selectivity, high tolerance to impurities and low materials cost. This will enable application of the membrane technology to coalderived syngas streams that contain sulfur and halides. In the Phase I program, defect-free metal membranes with thicknesses of less than 100 microns were fabricated. The permeabilities of the membranes in the presence of hydrogen and common coal-derived syngas impurities were measured. Stable membrane performance in the presence of these impurities was demosntrated. In the Phase II program, additional membrane compositions will be prepared and evaluated. Membrane fabrication techniques will be scaled up to produce membranes sized for practical applications. A water gas shift membrane reactor operating on coalderived syngas will be designed and demonstrated.

Commercial Applications and Other Benefits as described by the awardee: An immediate application for the membrane is to use it in water-gas shift membrane reactors for high-purity hydrogen generation from coal and other sulfur-containing fuels such as diesel and jet fuel. This will enable lower-cost hydrogen production for the Hydrogen Economy and operation of PEM fuel cells on many of today's conventional and readily available fuels. Larger-scale application of the technology will allow the production of hydrogen from coal to be more energy-efficient, cost-effective and environmental friendly. Because the technology can also be applied to hydrogen production from other fossil fuels, widespread application of the technology has significant potential to improve the Nation's energy security and reduce greenhouse gas emissions.

80587S06-II

Proton Conducting Solid Oxide Fuel Cells--Ceramatec, Inc., 2425 South 900 West, Salt Lake City, UT 84119-1517; 801-978-2176; www.cerametec.com
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DOE Grant No. DE-FG02-06ER84595
Amount: $749,648

Proton conducting electrolyte offers the opportunity for very high efficiency fuel cell operation compared to oxygen ion conducting electrolyte. The poor stability of the proton conducting material in typcial fuel gas composition has hampered technology development. This project addresses the stability issue to demonstrate long term stable fuel cell operation using hydrocarbon fuel. Dopant selection is being targeted for improved conductivity to achieve high performance. Composite approach is employed to the existing proton conducting material to improve stability. A variety of dopants were evaluated to map the conductivity and ion transference number of proton conductors. A composite was evaluated and shown to have good stability in syngas atmosphere. Limiting factors were identified to improve performance and efficiency. Further optimization of composition to improve conductivity at a lower temperature is planned. Additionally, the specific composite compositions required to improve stability in air and fuel atmosphere will be optimized. Fabrication techniques will be developed for low resistance stacks. Prototype fuel cell short stacks will be tested to demonstrate improvements in materials characteristics.

Commercial Applications and Other Benefits as described by the awardee: This project will result in developing high efficiency solid oxide fuel cells that use hydrogen or hydrocarbon based fuels for stationary and mobile power sources. The fuel cells can also be operated as a simplified steam electrolyzer for hydrogen production wittout a need for steam condensers. A spin off application from the materials set developed could be used as hydrogen separation membranes and in electro-synthesis of value added hydrocarbon chemicals.

80107S06-II

High Power Density Li-Ion Batteries with Good Low Temperature Performance--NEI Corporation, 400 Apgar Drive, Suite E, Somerset, NJ 08873; 732-868-1906; www.neicorporation.com
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DOE Grant No. DE-FG02-06ER84561
Amount: $749,986

Conventional and plug-in hybrid electric vehicles (HEVs) require economical and safe rechargeable Liion batteries that have high power, good cyclability and long calendar life, as well as good low temperature performance. Plug-in HEV batteries also need to have high energy density. The performance of currently available Li-ion batteries significantly degrades at sub-zero temperatures and does not meet the requirements. Working in collaboration with a National Laboratory and a University, and two industrial partners, we are developing safe and high performance electrode materials to fulfill the requirement of the two HEV applications. Utilizing these electrode materials in conjunction with high performance liquid electrolytes will lead to Li-ion batteries that will have good low temperature performance. In addition, it will overcome the lithium plating problem, which is commonly found in conventional Li-ion batteries. A further goal of the program is to drastically raise the Wh/$ ratio from the current level of ~ 6 Wh/$. In Phase I, a nanocomposite cathode material was produced by a simple and economical synthesis process, and was demonstrated to have good low temperature performance. These nanocomposite cathodes in Li-ion cells (capacity: 9 – 12 mAh) exhibited excellent cycling stability. Additionally, important powder properties that control the rate capability of the nanocomposite cathode were discovered. In Phase II, the synthesis process for producing nanocomposite cathode materials will be optimized and the electrode materials will be implemented in Li-ion batteries with higher Wh/$ ratios for use in conventional HEVs. Additionally, a cathode material, suitable for plug-in HEV Li-ion batteries, will be developed. High performance prototype Li-ion batteries that will avoid the lithium plating problem at low temperatures and fast charge rates will be fabricated and tested.

Commercial Applications and Other Benefits as describde by the awardee: Low cost Li-ion batteries that are safe in large-format are needed in HEV applications. In addition, Li-ion batteries are ubiquitous in both consumer and industrial sectors. All of these applications have nearly identical needs – more energy, higher safety, faster charges and high power (in some cases). The proposed program will advance the state of the art in Li-ion battery technology.

80120S06-II

Nano-Structured Carbon/Silicon Composite for High Energy, Long Cycle Life Lithium-Ion Batteries--TIAX, LLC, 15 Acorn Park, Cambridge, MA 02140; 617-498-5655; www.tiaxllc.com
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DOE Grant No. DE-FG02-06ER84580
Amount: $749,868

Battery-powered electric vehicles (EVs) require energy storage devices with high specific energy, but currently available lithium-ion systems can not meet the energy and power goals for EVs. Lithium-ion cells are needed that provide at least 150 Wh/kg), 230 Wh/l, 300 W/kg, and 460 W/l, have a life of 1000 cycles at 80 percent depth of discharge; have a calendar life of at least 10 years, and are made with materials costing less than $10/kg. A high capacity, long cycle life nanostructured silicon/carbon composite anode material made using low cost materials and processes is being developed to meet this need. In Phase I, the synthesis of nano-scaled silicon material was demonstrated, together with the life cycle benefit derived by silicon-based anodes in composites with carbon. Also in Phase I, the potential impact of nanostructured silicon/carbon composite anodes on Li-ion cell energy was modeled, demonstrating that such a composite with suitable performance characteristics could enable attainment of the above-listed performance targets. In Phase II the composite of nano-scaled silicon with carbon will be developed, and its performance will be demonstrated in scaled-up Li-ion batteries.

Commercial Applications and Other Benefits as described by the awardee: The proposed low cost material will have broad commercial applicability in small portable power lithium-ion batteries for consumer electronics and power tools as well as in large lithium-ion batteries for electric vehicles and hybrid electric vehicles.

80158S06-II

Novel, Redox-Stabilized Li-Ion Cell--Farasis Energy, Inc., 23575 Cabot Boulevard, Suite 205, Hayward, CA 94545; 510-732-6600; www.farasis.com
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Mr. Keith D. Kepler, Business Official, kkepler@farasis.com
DOE Grant No. DE-FG02-06ER84534
Amount: $750,000

Current commercial Li-ion cells are protected by several layers of safety devices, primarily to prevent catastrophic thermal runaway events resulting from improper use. Unfortunately, these safety devices are difficult to scale up for large cells, are not very effective at stabilizing multicell packs and are generally not reversible once activated. A Li-ion cell will be developed that incorporates an internal, low cost, voltage activated, reversible safety mechanism that can handle the high currents required to stabilize large cells. The development and initial optimization of the components of the cell safety mechanism were completed under Phase I. The mechanism was incorporated into full Li-ion cells for further evaluation and to demonstrate the feasibility of the concept. The components of the cell safety mechanism will be further optimized and new process innovations will be developed. The mechanism will be scaled up in collaboration with a major subcontractor and the technology will be demonstrated in 18650 Li-ion cells.

Commercial Applications and Other Benefits as described by the awardee: If successful, the proprietary safety product that will be developed under this SBIR project will lead to the increased safetly of Li-ion battery cells and systems. Cells incorporating the technology will meet the needs of a wide range of advanced applications in the automotive, telecommunications and military supply industries. Some of these applications include electric and hybrid electric vehicles including automobiles, scooters and bikes, satellites, stationary backup power, and portable power applications like cell phones, computers and PDA’s for both civilian and military use.

81250S06-II

Low-Cost Porous Carbons for Ultracapacitors--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
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DOE Grant No. DE-FG02-06ER84578
Amount: $750,000

Ultracapacitors have the potential to be high-power energy sources for electric and hybrid vehicles. Current ultracapacitors based on porous carbon electrodes are too expensive for vehicle application, mainly due to the cost of the carbon. What is needed is an inexpensive porous carbon for the ultracapacitors that perform as well as the expensive carbons that are currently being used.Porous carbons will be produced from sugars to make electrodes for ultracapacitors that are inexpensive, stable and have high capacitance and rapid charge-discharge response. A production process will be developed with goal of producing thousands of tons of carbon per year. Porous carbons were synthesized and characterized. The carbons were tested in laboratory test cells and we carried out an engineering analysis to evaluate the cost and performance of the porous carbon materials. As a result of this work, a continuous process to make inexpensive carbons from sugars was developed. The production process developed in Phase I will be optimized for large-scale production. The best carbons will be tested in ultracapacitor devices suitable for use in vehicle applications.

Commercial Applications and Other Benefits as described by the awardee: In addition to electric and hybrid vehicles, ultracapacitors are used in many consumer electronic devices such as cell phones, cameras, etc. Inexpensive porous carbons are needed to decrease the cost of ultracapacitors for all these applications.

81277S06-II Cyc24-2

High-Volume Fabrication of Hydrogen Sensor Using Intrinsically Safe Optical Sensor Platform--

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DOE Grant No. DE-FG02-06ER84541
Amount: $749,994

The U.S. DOE Hydrogen Program is working to overcome technical barriers with respect to using hydrogen in the emerging economic sectors. One key mission of the Program is to address safety concerns related to the use of hydrogen across the hydrogen economy infrastructures, and establishing codes and standards. Developing a superior technology for manufacturing intrinsically safe, highly reliable, and low-cost hydrogen sensors will play an import role toward assuring safety compliance. In this project, InnoSense LLC (ISL) will fine-tune technologies for the high volume fabrication of intrinsically safe, all-optical hydrogen sensors that ISL has previously developed. The purpose of the manufacturing project is to eliminate individual calibration of sensors by making many identical sensors in one batch. Our ultimate aim is to develop manufacturing processes for both components and complete system for the hydrogen economy infrastructures. During Phase I, we have investigated two manufacturing technologies and established that our fabrication protocols allow the development of multiple sensors in a single batch, and these sensors perform reversibly and reproducibly over many cycles. Our Phase II project goal is to optimize the manufacturing technology. Parameters that will be optimized in Phase II include fine-tuning coating formulations, refinements in the application of coating formulation, refinement in curing processes, and storage and conditioning of sensors. By developing quality control and quality assurance protocols, the manufacturing process will be formalized.

Commercial Applications and Other Benefits as described by the awardee: According to U.S. DOE Energy Information Administration International Energy Outlook 2004 Report, world energy consumption is projected to increase by 54% from 2001 through 2025. The President's Energy Policy recommended that the Energy Department promote the development of hydrogen as a primary fuel for cars and trucks, as part of our effort to reduce dependence on oil import. Hydrogen is a domestically produced energy source, thus can reduce our reliance on fuel import. Some challenges, however, need resolution – particularly the one that concerns safety. Since hydrogen can neither be seen nor smelled, a reliable hydrogen sensor is a necessity for storing, transporting and distributing hydrogen.

80911S06-II

Low-Cost Manufacturing of Sheet Molding Compound Bipolar Plates for PEM Fuel Cells--

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DOE Grant No. DE-FG02-06ER84558
Amount: $749,040

Nanotek Instruments, Inc., in collaboration with National Composite Center and Wright State University, proposes to research, develop, and commercialize an innovative class of low-cost sheet molding compound (SMC) bipolar plates and related mass-production processes. The bipolar plate is known to significantly impact the performance, durability, volume/weight, and cost of a fuel cell system. The proposed SMC composition consists of a thin nanocomposite core layer sandwiched between two sheets of flexible graphite (FG). The nanocomposite is composed of a thermoset resin and a conductive nano-filler, such as graphitic nano-fibers (GNFs), nano-scaled graphene plates (NGPs), carbon blacks, and their mixtures. NGPs may be considered as much lower-cost, two-dimensional counterparts of carbon nano-tubes and are a particularly desirable nano-filler due to their exceptional electrical, mechanical, and gas permeation resistance properties. The nanocomposite core layer imparts desired structural integrity to the plate while the FG sheets contribute to electrical conductivity, flexibility, resistance to corrosion and gas permeation. Both the nanocomposite core and FG sheets can be very thin (each of < 0.125 mm), resulting in ultra-thin bipolar plates and much more compact and lightweight fuel cell systems. Phase-I studies have demonstrated that thin FG-SMC bipolar plates can possess conductivity much higher than 100 S/cm (a DOE target). The area specific conductivity is typically greater than 400 S/cm2, exceeding another DOE target of 100 S/cm2. Theoretical estimations or experimental measurements also indicate that other technical and commercial targets either have been reached or are within reach with the proposed FG-SMC technology: cost of $6/kW (when in mass production), weight of < 1 kg/kW, H2 permeation flux of < 2 × 10–6 cm3/(cm2·s) (at 80oC, 3 atm), corrosion rate of < 1 μA/cm2, flexural strength of > 4 MPa, and flexibility (% deflection at mid-span) of 3 to 5. Phase-I work has also successfully demonstrated the feasibility of an SMC fabrication process that entails continuously sandwiching a nanocomposite core between two flexible graphite sheets to obtain a laminated SMC precursor composition (containing an uncured or partially cured resin), which is collected on a winding roller. Such an SMC laminate may be later uncoiled from a roller and cut to fit into a matched-die mold for final shaping and curing. Alternatively, fluid flow channels can be created in the two outer surfaces of a SMC laminate through in-line embossing and curing to produce bipolar plates. This roll-to-roll process is continuous and amenable to automation and, hence, is well-suited to mass production of low-cost bipolar plates. Phase-II activities include finalizing the R&D and pre-commercialization tasks, which include (1) process scale-up (e.g., to construct a pilot-scale roll-to-roll apparatus that can be readily scaled up to become a commercial-scale system); (2) complete performance characterization and analysis of FG-SMC bipolar plates for the establishment of product specifications (e.g., the strength, flexibility, electrical conductivity, gas permeation, and corrosion rates of the bipolar plates will be experimentally measured, and compared with theoretical predictions), (3) market validation and expansion (e.g., to proactively conduct direct marketing activities in selected market sectors); (4) business development, marketing, and sales (e.g., preparation of FG-SMC bipolar plate samples that will be evaluated by potential customers, investors, and strategic partners); and (5) sourcing of materials, components, and sub-systems.

Commercial Applications and Other Benefits as described by the awardee: The automobile fuel cell bipolar plate market size is expected to be approximately $0.74 billion per year by 2011. The market size for motorcycles, other specialty vehicles, and portable device sectors is $0.092 billion, $0.050 billion, and 0.039 billion, respectively. The total worldwide bipolar market size will be $0.921 billion by 2011. Additional potential applications of conductive SMC include electromagnetic interference (EMI) shielding, thermal management (heat dissipation) for microelectronic devices, and battery electrode materials.

80916S06-II Cyc24-7

Fuel Cell Membrane Measurement System for Manufacturing--Scribner Associates Incorporated, 150 E. Connecticut Avenue, Southern Pines, NC 28387-5528; 910-692-5966; www.scribner.com
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DOE Grant No. DE-FG02-06ER84574
Amount: $686,206

Successful adoption of fuel cells by the automotive market demands reducing the cost and increasing the quality and consistency of proton exchange membrane materials. Tools and procedures to measure the through-thickness resistance of fuel cell membranes, a keystone property, are required to support high-volume production and quality control programs. The overall objective is to develop an automated, high-throughput membrane measurement system to enhance manufacturing quality control, increase manufacturing efficiency, and decrease membrane cost. A novel electrode design compatible with bare membranes is the cornerstone of this advanced measurement technology, permitting rapid, reproducible and accurate measurements that are required for a quality control device. Technical feasibility of a high-throughput membrane measurement system was demonstrated in the Phase I program wherein the company developed a novel, proprietary electrode that facilitates accurate, repeatable measurement of the through-thickness resistance (or conductivity) of bare, as-manufactured membranes. The use of bare membranes in combination with a true four-electrode approach significantly advances measurement of this critical membrane performance property, facilitating significant time and cost savings, and making feasible the potential for a high-throughput analysis tool. The research team developed robust, user-friendly test hardware for rapid, reproducible measurement of key membrane properties and principal measurement process variables were identified. In Phase II, the research team will develop a high-throughput membrane measurement system for manufacturing quality control by developing: (*i*) an easy-to-use automated cell fixture with integrated, optimized, high-durability electrodes, (*ii*) application-specific control and measurement electronics and user-interface software, and (*iii*) robust measurement protocols for high accuracy and repeatable operation. A collaborating membrane manufacturer will evaluate a prototype of the membrane measurement system using production materials and established protocols.

Commercial Applications and Other Benefits as described by the awardee: Manufacturing measurement technologies enhance product quality and lower costs through increased production yield while improving the consistency of materials within the supply chain. Lower fuel cell membrane cost will accelerate market entry and growth of this technology, notably into the crucial but cost-sensitive automotive sector. Improved membrane manufacturing will accelerate achievement of the societal and economic benefits associated with implementing a hydrogen-based energy system including energy security, improved public health and environmental protection. Modified test systems, that are by design more versatile, will find application in membrane and solid electrolyte research and development.

80141S06-II

Enhanced Distillation via Membranes for Elimination of Trapped Water--Compact Membrane Systems, Inc., 325 Water Street, Wilmington, DE 19804; 302-999-7996; www.compactmembrane.com
Mr. Kenneth J. Pennisi, Principal Investigator, kpennisi@compactmembrane.com
Mr. Stuart Nemser, Business Official, snemser@compactmembrane.com
DOE Grant No. DE-FG02-06ER84530
Amount: $750,000

Distillation is a major chemical unit operation and consumer of significant energy. Often water or other intermediate boiling component can become trapped within the distillation column and accumulate. This causes various operating difficulties such as flooding, slugging, cycling, instability d off-spec product. The technology to be developed in this program will improve distillation operating efficiency in systems that are prone to water trapping. This will be done by using a chemically resistant non-porous water venting membrane. Three separate initiatives were successfully completed including the fabrication of chemically and thermally resistant membrane modules with goal permeation properties. These membrane modules were then successively used for separating water from target distillation products. Extensive modeling simulated distillation water trapping and economic analysis of representative systems quantified the economic and energy value of water trapping. There are three key objectives of this Phase II proposal. The first is to demonstrate that the proposed technology can be used to significantly reduce the concentration of water in a specific process when water trapping is occurring. The second key objective is to demonstrate that the technology has the necessary mechanical strength and chemical resistance to provide stable performance over extended periods of exposure to process materials at the process temperature and pressure. The third key objective is to demonstrate the relative economic benefits of the technology for removing trapped water from commercial processes in comparison to other available techniques.

Commercial Applications and Other Benefits as described by the awardee: Water is a ubiquitous substance and is a common cause of component trapping problems in distillation columns. Therefore this program will enhance the distillation process in many situations when distillation trapping is a major problem. This membrane technology has additional value in many other distillation applications where removal of water is difficult (e.g. azeotropes).

80126S06-II

Interior Surface Modified Novel Zeolite Adsorbents for Preferential CO2 Adsorption at High Relative Humidity--Lynntech, Inc., 7607 Eastmark Drive, Suite 102, College Station, TX 77840; 979-693-0017; www.lynntech.com
Dr. Alan Cisar, Principal Investigator, alan.cisar@lynntech.com
Dr. G. Duncan Hitchens, Business Official, duncan.hitchens@lynntech.com
DOE Grant No. DE-FG02-06ER84549
Amount: $750,000

Minimizing energy penalties and associated capital costs are the major concerns of current gas separation and purification technologies. Virtually all of transportation and nearly two-thirds of electricity energy is supplied from fossil fuel combustion, which is the major contributor of carbon dioxide in the environment. This is expected to be the case for at least two or more decades. Cost-effective and energy-friendly mesoporous adsorbents that can adsorb carbon dioxide and carbon monoxide efficiently at various pressures and temperatures in presence of high humidity, ideally suitable for pressure swing adsorption/temperature swing adsorption technologies, are urgently needed. The modification of adsorbents via surface amination and organosilanation enhances carbon dioxide adsorption capacities and also makes mesoporous based adsorbents more moisture tolerant. Phase I activities consisted of investigating chemical synthesis routes for surface modification with stable amine-group and perfluoroalkyl group attachments and testing. Future Phase II activities for this project will address issues of optimization and market analysis, to promote the commercial viability of this product and to meet the DOE goals for CO2 adsorption. In Phase I of this project, interior surface modification experiments were conducted via alkoxysilane based chemical reaction scheme. Primary amines attached alkyl silanes and effect of the size of the alkyl groups were researched to improve the adsorption capacity via increasing the number of attached amine groups into the interior surface. Chemical routes for the synthesis of secondary and tertiary amines based precursors were also researched. In addition, attachment of perfluoroalkyl groups to the interior surfaces of adsorbents was researched which added a hydrophobic character to the adsorbents. Finally, dynamic adsoprtion capacities of the synthesized adsorbents were determined via adsorption isotherms. As a result, Lynntech demostrated the preferential CO2 adsorption character of the interior surface modified Zeolite 13X adsorbents in the presence of high relative humidity. During the Phase II effort, the surface modifications and their processes will first be thoroughly optimized for the CO2 adsorption in the presence of high humidity. Then, the, long-term testing of the optimized adsorbents in a PSA/TSA will be performed in addition to determination of the failure modes and evaluation of the potential for regeneration. Lastly, a preliminary market analysis and identification of commercial partners will be performed.

Commercial Applications and Other Benefits as described by the awardee: Preferential adsorption of CO2 in high relative humidity due to interior surface modification will bring down the large capital costs that are asscociated with the current gas separation and purification technologies to a resaonable and affordable price. And also integration of these novel adsorbents with PSA and/or TSA systems will reduce the emission of harmful gases generated during the fossil fuel combustion process which will make these systems more appealing for many current and future commerical and military applications.

80860T06-II

***STTR Project: Stabilizing Hydraulic Fluid by Removing Water—**Compact Membrane Systems, Inc., 325 Water Street, Wilmington, DE 19804; 302-999-7996; www.compactmembrane.com
Dr. Sudipto Majumdar, Principal Investigator, smajumdar@compactmembrane.com
Mr. Stuart Nemser, Business Official, snemser@compactmembrane.com
DOE Grant No. DE-FG02-06ER86268
Amount: $750,000

Research Institution
New Jersey Institute of Technology
Newark, NJ

In the electrical power industry, steel production and aluminum production industry flame retardant phosphate ester hydraulic fluids are used to minimize fires. While these fluids minimize fires, they are unstable and performance suffers which leads to loss in productivity. Compact Membrane Systems will, using novel chemically resistant high flux membranes, remove the chemical reactants that make these hydraulic fluids unstable. This will be done on-line to enhance stability in real time which will minimize degradation and enhance productivity. Overall Phase I program was very successful and achieved all objectives including CMS developed composite membrane modules with excellent chemical and thermal resistance in combination with the desired flux and separation properties to stabilize a range of hydraulic esters. Laboratory testing at representative temperatures (e.g. 70-85ºC) showed that real time use of the CMS membranes dramatically enhanced the long term stability of the hydraulic ester. Working closely with industry leaders we have completed an engineering and economic analysis that indicates CMS membrane systems could be introduced in a low cost and cost effective manner. Given the strong interest of industry leader in our technology/product we will work closely with industry. First we will fabricate larger scale prototype hollow fiber membrane system with goal membrane properties similar to membrane transport properties used in Phase I. These prototype membrane modules will then be evaluated extensively in the laboratory and then with our industrial partner in actual field tests.

Commercial Applications and Other Benefits as described by the awardee: This is a platform technology for removing small undesirable molecules (e.g. oxygen, water) from organic liquids. This application focuses on stabilizing flame retardant phosphate ester hydraulic fluids for power plants, steel plants and aluminum plants but many other petrochemical streams (e.g. oxygen removal from monomers, removal of gases from transformer oil) will also benefit.

80865S06-II

Dielectrophoretic Extraction of Water Enhanced by Nanostructure Technology--Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088; www.poc.com
Dr. Michael Reznikov, Principal Investigator, sutama@poc.com
Mr. Gordon E. Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-06ER84568
Amount: $749,991

Dewatering is a widely used process in many industries, such as in food fabrication, paper production, and pharmaceutical and biochemical processing. Current thermal dewatering technologies offers better productivity than mechanical- or physical-property based techniques, but they consume large quantities of energy and require extensive space and capital investment because the entire mass of material to be dewatered must be heated to an elevated temperature. Large-scale energy savings in many industrial dewatering processes can be achieved by applying energy directly to the water, while avoiding heating of the remaining materials. To decrease the energy consumed for dewatering, enforced moisture evaporation in a gradient electric field is proposed, followed by removal and condensation of vapor, with recovery of latent heat that can be returned to the material. In Phase I, electrically enforced evaporation was investigated through the fabrication of a prototype to measure water evaporation rate at the same supplied power with and without applied high voltage. It was found that the evaporation rate (the loss of weight per unit of time) with applied high voltage is 80 percent higher than without applied voltage. The Phase II development of large-scale prototypes will include: optimization of electrostatically enforced evaporation and latent heat recovery for one of the most energy- consuming applications—paper mills; design of an industrial-scale module prototype; development of fabrication technology for the integrated heat pump (thermoelectric or compression) and heat pipe; and system design of a prototype module for installation in the drying part of a paper machine. Several modules will be fabricated, tested on a preliminary basis on site, and then beta tested on a pilot paper machine at a subcontractor facility.

Commercial Applications and Other Benefits as described by the awardee: The benefits of the proposed technology include energy savings in dewatering processes used for material drying in the production of paper, food, pharmaceuticals, chemicals, coal, and gases. Due to lower temperature during water extraction, this approach can be especially valuable for drying temperature-sensitive products in biotechnology. Because water is extracted in an evaporation process, the proposed technology can be used for energy-saving distillation of seawater. The other benefit of this technology is the recuperation of latent heat, which decreases the environmental impact, especially in the case of nuclear industrial distillers (thermal discharge).

80866S06-II Cyc24-9

Intelligently Vibrating Dewatering Machinery--Quality Research, Development, and Consulting, Inc. (QRDC, Inc.), 125 Columbia Court, Suite 6, Chaska, MN 55318-2348; 952-556-5206; www.qrdc.com
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Mrs. Shohreh Pirzad, Business Official, spirzad@qrdc.com
DOE Grant No. DE-FG02-06ER84573
Amount: $749,921

This proposal addresses the significant need for improvements in the efficiency and effectiveness of physical separation technologies used in processing industries. The mining industry alone uses approximately 33 billion kW-hr per year (costing $1.65 billion at $0.05 per kW-hr) of electrical energy for physical separations. Although vibrating machines are not the single most energy intensive step in a processing plant, they are often a major bottleneck in the process. Improvements to this area offer tremendous potential in both energy savings and production enhancements. Additionally, in processing plants, the vibrating machines are among the most costly in maintenance and worker health and safety. The goal is to significantly reduce energy usage and maintenance costs while noticeably improving efficiency, effectiveness, capacity, and worker health and safet**y** in vibration-based physical separation systems. Our innovative approach is based on our recently developed vibrating machine using miniaturized intelligent engines with PZT-based actuators and award winning energy managing techniques. The vibrating machine uses an advanced sensory system to continuously monitor the process and make appropriate adjustments to improve production. In Phase I, we developed a full scale single-panel laboratory prototype with one-fourth of the full load capacity. The system was fully tested for its function and energy consumption under controlled and dry conditions. Two miniaturized PZT-based engines were used. The total power consumption for the manually controlled prototype was measured to be less than 40 W for operation above idle, this result is an impressive 82% less power consumption than conventional systems. In Phase II, we will design and fabricate a full-scale multiple panel prototype with 100% load capacity. It will be tested and evaluated under both dry and wet conditions in the field. The full system will have two main components, hardware and software. The hardware will be similar to the Phase I prototype but with four times more load capacity. For full automation of the system, self monitoring, and self adjustment, an advanced controller software will be developed and integrated into the system. The proposed machines will have significant energy savings (50 to 75%) as compared to conventional machines. In addition, considerable performance improvement, enhanced throughput (10%), reduction in maintenance cost (50%), and immeasurable improvement in worker health and safety.

Commercial Applications and Other Benefits as described by the awardee: Commercial application of this technology is in the processing industries, such as mining, sand and gravel, oil/gas, food, biomass, aggregates, agricultural, and pharmaceutical. Vibrating machines are used for dewatering, screening, sizing, mixing, compacting, and conveying.

80683S06-II

Printed Solar Cell Using Nanostructured Ink--Nanosolar, Inc., 2440 Embarcadero Way, Palo Alto, CA 94303; 650-565-8891; www.nanosolar.com
Dr. Chris Eberspacher, Principal Investigator, chris@nanosolar.com
Dr. Brian M. Sager, Business Official, bsager@nanosolar.com
DOE Grant No. DE-FG02-06ER84556
Amount: $750,000

Solar cells made using Copper-Indium-Gallium-diSelenide (CIGS) as a light absorbing material offer the potential for the production of a device free of silicon and yet with the potential for an efficiency and durability similar to that of conventional silicon-based devices. Solar cells made from a CIGS absorber layer are more than 100X better at absorbing light than an equivalent absorber layer made from silicon, and so CIGS solar cells can be constructed as thin film devices, with less material usage, and potentially less cost, than conventional silicon-based solar cells. A thinner absorber layer also results in less cell fragility, providing an opportunity to reduce the packaging surrounding the solar cell, which would otherwise be required to protect a fragile cell. Lesser packaging further reduces solar module cost. If CIGS-based solar production was cost-effective, these attributes would substantially drive down the cost of solar panels. However, a central challenge in cost-effectively constructing a large-area CIGS-based solar cell or module is that the elements of the CIGS layer must be within a narrow stoichiometric ratio on nano-, meso-, and macroscopic length scale in all three dimensions in order for the resulting cell or module to be highly efficient. Achieving precise stoichiometric composition over relatively large substrate areas is difficult using traditional vacuum-based deposition processes. For example, it is difficult to uniformly deposit compounds and/or alloys containing more than one element by sputtering or evaporation. Both techniques rely on deposition approaches that are limited to line-of-sight and limited-area sources, tending to result in poor surface coverage. Line-of-sight trajectories and limited-area sources can result in non-uniform three-dimensional distribution of the elements in all three dimensions and/or poor film-thickness uniformity over large areas. These non-uniformities can occur over the nano-, meso-, and/or macroscopic scales. Such non-uniformity also alters the local stoichiometric ratios of the absorber layer, decreasing the potential power conversion efficiency of the complete cell or module. A semiconductor printing technology has been developed that overcomes these challenges by printing nanoparticulate CIGS precursor materials onto low-cost metal foil substrates, and performing a rapid thermal processing to convert the nanoparticulate coating into a CIGS absorber layer By locking in the appropriate stochiometry into the nanoparticulate precursor material, spatial uniformity is ensured in the coated layers, while printing at high speed and high throughout further minimizes solar cell cost. In a Phase I SBIR project, it was successfully demonstrated that an efficient solar cell could be coated onto a foil using the printing technology described above. The goal of this Phase II SBIR project is to construct such foil-based solar cells with further increased power conversion efficiency. The chemical composition of the light-absorbing layer will be modified to improve the optoelectronic performance of the device. The chemically modified devices will be measured to determine their performance characteristics.

Commercial Applications and Other Benefits as described by the awardee: A successful outcome of this Phase II SBIR project will be to support the development of a thin-film, low cost, solar cell that can be deployed on the roofs of both residential homes and commercial buildings as well as utility-scale solar power plants. Such deployment will decrease the current U.S. dependence on foreign energy sources.

80691S06-II

Improved Fullerenes for OPV--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
Dr. Michael D. Diener, Principal Investigator, mikee@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-06ER84577
Amount: $750,000

Describe the problem or situation being addressed - be sure that the DOE interest in the problem is clear. This project aims to develop materials that will speed the economic viability of bulk heterojunction organic photovoltaics (BHJ OPV). These devices have the potential to be far less expensive that current inorganic devices because they can be mass-produced by inexnpensive printing and rol-to-roll processes. Economically viable PV will allow the US to replace some fraction of its current, CO2-producing electrical generating capacity with emissions-free solar electricity. However, the efficiencies of the BHJ devices must show additional improvement before their widespread commercialization can occur, and such improvements will require new materials. The overall goal of this project is to demonstrate that TDA's new class of fullerene derivatives can be used as n-type organic semiconductors in combination with existing p-type conducting polymers for thin film OPV devices that have superior performance to existing materials. In the Phase I project, we developed two new synthetic strategies resulting in two new classes of fullerene derivatives suitable for OPV. Key OPV performance parameters for the three initial target fullerene compounds synthesized were assessed at the National Renewable Energy Laboratory (NREL), and the new materials demonstrated their promise. In Phase II, we will apply the new synthetic methods to produce related fullerene derivatives and complete the optimization of devices based on the new fullerenes. The search for fullerene derivatives will be guided by more detailed modeling of electronic properties of potential target fullerene derivatives, and by assessing the performance of the new fullerene derivatives in PV devices as they are made.

Commercial Applications and Other Benefits as described by the awardee: The new fullerenes will be the n-type component of organic photovoltaics (low-cost solar cells).

80855S06-II

Catalytic for Chemical Manufacture--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
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Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-06ER84576
Amount: $750,000

Statement of the problem or situation that is being addressed Sulfuric acid is produced in greater volume than any other industrial chemical, and is used primarly in the manufacture of phosphate fertilizers. Sulfuric acid is made by by first burning sulfur to produce SO_2, further reacting the SO_2 over a catalyst to produce SO_3, and then absorbing the SO_3 into water to produce the acid. The conversion in the catalytic process is limited by equilibrium, and if the process can be operated at a lower temperature, the conversion of SO_2 to SO_3 could be increased. TDA has developed a novel low temperature catalyst for the oxidation of sulfur dioxide for sulfuric acid manufacture.

General sttement of how this problem is being addressed TDA's catalyst operates 50-80°C lower than commercial catalysts, which gives greater per-pass conversion of sulfur dioxide to sulfur trioxide. Increaseing conversion reduces the amount of feedstock used, increases the energy efficiency of the sulfuric acid plant and significantly lowers sulfur emissions.

What was done in Phase I In the Phase I project, TDA synthesized and tested a series of catalysts and compared their activity with several commercially available catalysts. TDA's catalyst significantly outperformed the commercial catalysts at the lower temperatures and was stable in a preliminary lifetime test. Our economic analysis indicates that the slightly increased cost of the new catalyst is more than offset by its benefits.

What is planned for the Phase II project In Phase II we will further improve the the catalyst, examining both the composition and preparation method. We will then design and build an automated test system that can run unattended for weeks at a time, since good catalyst lifetime is of utmost importance. Test data will first be used to provide feedback to the catalyst optimiztion task, and then to test the catalyst's durability. Finally, we will determine the cost of manufacturing the catalyst followed by an economic analysis of using the catalyst for sulfuric acid manufacturing..

COMMERCIAL APPLICATIONS

TDA's low temperature sulfur dioxide oxidation catalyst can substantially lower energy use in sulfuric acid manufacture while increasing throughput and lowering sulfur emissions. TDA is collaborating with a major catalyst and chemical manufacturer to further develop the catalyst in the Phase II project, eventually leading to large scale implementation.

Old Abstract

Sulfuric acid is produced in greater volume than any other industrial chemical, and is used primarily in the manufacture of phosphate fertilizers. Sulfuric acid is made by first burning sulfur to produce SO_2,

and then by further reacting the SO_2 over a catalyst to produce SO_3, and then absorbing the SO_3 into a water stream to produce the acid. The conversion in the catalytic process is limited by equilibrium, and if the process can be operated at a lower temperature, the conversion of SO_2 to SO_3 could be increased. TDA has developed a novel low temperature catalyst for the oxidation of sulfur dioxide for sulfuric acid manufacture. Sulfuric acid is the largest commodity chemical manufactured worldwide (176 million tons in 2006). TDA's catalyst operates 50-80°C lower than commercial catalysts, which gives greater per-pass conversion of sulfur dioxide to sulfur trioxide, increases the energy efficiency of the sulfuric acid plant and lowers sulfur emissions. In the Phase I project, TDA synthesized and tested a series of catalysts and compared their activity with several commercially available catalysts. TDA's catalyst significantly outperformed the commercial catalysts at the lower temperatures and was stable in a preliminary lifetime test. Our economic analysis indicates that the slightly increased cost of the new catalyst is more than offset by its benefits.

Commercial Applications and Other Benefits as described by the awardee: TDA's low temperature sulfur dioxide oxidation catalyst can substantially lower energy use in sulfuric acid manufacture while increasing throughput and lowering sulfur emissions. TDA is collaborating with a major catalyst and chemical manufacturer to further develop the catalyst in the Phase II project, eventually leading to large scale implementation.

Old Text

TDA has developed a low temperature catalyst for commodity chemical manufacture. The catalyst can operate at 50-80oC lower than conventional catalysts for the same reactions. Because of the lower temperature operation, the process is more energy efficient and emissions from the plant are also reduced considerably. In the Phase I project, TDA has synthesized and tested a series of catalysts and compared the catalytic activity with those of commercially available catalysts. At the lower temperatures of interest, TDA's catalysts outperform the commercial catalysts significantly. A preliminary durability test performed on the catalyst shows that the catalysts appear to face no deactivation issues. In addition, an economic analysis carried out by TDA has shown that the cost of improving the catalyst is minor compared to the benefits derived from using it commercially.

Commercial Applications and Other Benefits as described by the awardee: TDA's low temperature catalyst can substantially lower energy use in the chemical industry. TDA is collaborating with a major catalyst and chemical manufacturer to further develop the catalyst in the Phase II project. A successful catalyst development can lead to commercialization and large scale implementation in the chemical industry.

81060S06-II

Nano-Porous Catalyst for Refinery Alkylation--Exelus, Inc., 99 Dorsa Avenue, Livingston, NJ 07039; 973-740-2350; www.exelusinc.com
Mr. Mitrajit Mukherjee, Principal Investigator, mmukherjhee@exelusinc.com
Mr. Mitrajit Mukherjee, Business Official, mmukherjhee@exelusinc.com
DOE Grant No. DE-FG02-06ER84533
Amount: $750,000

The phase-out of MTBE from the US gasoline pool has created an excess supply of isobutylene. Substituting ethanol for MTBE has also resulted in a rise in the vapor pressure of gasoline blends and increased the need for high-octane, low vapor pressure blendstocks. This SBIR project aims to create a safe and economical solid acid catalyst suitable for refinery alkylation using isobutylene or mixed butene feeds. The catalyst is designed with a unique nanometer-scale pore structure to improve its performance with these feeds.In Phase I, this new family of alkylation catalysts was synthesized and tested to demonstrate their enhanced properties and performance. Significant benefits were found at commercially viable reaction conditions. Phase II aims to build on this success by optimizing the performance of the catalyst while reducing its cost. The long-term stability of the catalyst will also be demonstrated.

Commercial Applications and Other Benefits as described by the awardee: This technology will improve refining efficiency and increase gasoline supply while still enabling refiners to meet clean-fuel regulations by producing a high-value gasoline blending component from excess, low-value material. This technology also replaces dangerous liquid acid catalysts, improving safety and reducing the vulnerability of alkylation units.

81063S06-II

A Novel Mixed Metal Oxide Supported Catalyst System for Improved Fuel Cell Oxygen Reduction Reactions--Lynntech, Inc., 7607 Eastmark Drive, Suite 102, College Station, TX 77840; 979-693-0017; www.lynntech.com
Dr. Anuncia Gonzalez-Martin, Principal Investigator, anuncia.gonzales-martin@lynntech.com
Dr. G. Duncan Hitchens, Business Official, duncan.hitchens@lynntech.com
DOE Grant No. DE-FG02-06ER84548
Amount: $750,000

For fuel cell technology to become viable, electrocatalysts must efficiently utilize precious metals in order to achieve low precious metal loadings. In addition, the catalysts must have a long operating life to keep replacement costs down. Current catalysts based on platinum loaded on high surface area carbon supports have not demonstrated the long term stability necessary to meet future demands. The objective of this project is to develop an oxide based support. This support will demonstrate enhanced stability, conductivity, and greater catalytic activity than the current state of the art. In the Phase I, a catalyst with a novel oxide based support was developed. This catalyst has performance that surpasses commercial state-of-the-art carbon supported platinum catalysts with similar platinum loadings. This catalyst demonstrated enhanced performance and excellent activity at lower humidity levels than current catalysts. For the Phase II, the catalyst formulations will be redesigned with the goals of reducing the precious metal content and increasing the surface area and conductivity of the catalyst and support. These changes will lead to additional gains in platinum utilization.

Commercial Applications and Other Benefits as described by the awardee: Summarize the future applications or public benefits if the project is carried over into Phase III and beyond. Do not repeat information already provided above. The benefit of this research is to lower the cost of the catalytic component of proton exchange membrane fuel cells in two ways, by lowering the levels of the costly precious metals, and by extending the lifetime of the fuel cell systems that using these catalysts. These fuel cell systems could be used for transport power (both cars and trucks), for portable power systems that would furnish longer remote operation time for portable devices such as cell phones, laptop computers, or camera systems, and for stationary power systems.

80321S06-II Cyc24-6

Novel Platform for Enhanced Membrane Reactors for Homogeneous Catalysis--Compact Membrane Systems, Inc., 325 Water Street, Wilmington, DE 19804; 302-999-7996; www.compactmembrane.com
Dr. Stuart Nemser, Principal Investigator, snemser@compactmembrane.com
Dr. Stuart Nemser, Business Official, snemser@compactmembrane.com
DOE Grant No. DE-FG02-06ER84529
Amount: $750,000

Statement of Problem – Membrane reactors have been proposed for a number of syntheses. However, to be competitive with conventional technologies, membrane reactors must be shown to have better selectivity, permeability and stability. How this program is being addressed – Compact Membrane Systems (CMS) will introduce a novel platform with key features for broad membrane reactor utilization. Membranes have enhanced permeability and stability. These unique features of CMS membranes compared to existing membranes (e.g. polyvinyl alcohol) and other unit operations (e.g. molecular sieve dryers) will allow CMS membranes to be successful where other systems have not. What was done in Phase I – Overall Phase I program was very successful and achieved all objectives including working with leading membrane reactor scientists, CMS first fabricated a chemically resistant membrane reactor based on novel composite membranes. Next CMS synthesized specific esters using the novel CMS membrane reactor and demonstrated large improvements in reaction rate (e.g. 6X), yield and subsequent ease of downstream separation compared to no membrane reactor and significant improvements (e.g. 4X) compared to other membrane reactors. Using basic data from membrane reactor and membrane performance our engineering and economic evaluation on representative chemical processes showed the CMS membrane reactor significantly enhances chemical synthesis productivity, yield and ease of separation. Results suggested 35% energy savings. Economics were attractive for both Greenfield or retrofit applications. What is planned in Phase II – First we will fabricate larger prototype hollow fiber membrane reactors with the needed chemical and thermal resistance in combination with the needed flux and separation properties. Next working with industry leaders we will demonstrate enhanced homogeneous catalysis on specific esterification processes. The final major initiative will be working with industry to do field testing in combination with economic evaluation.

Commercial Applications and Other Benefits as described by the awardee: This program addresses a broad platform of chemical reactions that can be enhanced by membrane reactors. Applications identified that would be enhanced by these membrane reactors product well over 5 billion pounds of product annually and save over 50 trillion BTU/yr of energy.

81088S06-II Cyc24-8

Highly Efficient Organic Light-Emitting Devices for General Illumination--Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088; www.poc.com
Dr. Paul Shnitser, Principal Investigator, sutama@poc.com
Mr. Gordon E. Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-06ER84567
Amount: $749,987

Lighting devices consume 8.3 percent of all energy produced in this country. Even a small improvement in lighting efficiency will save millions of barrels of oil or similar quantities of other fossil fuels used for the production of power. Organic light emitting devices have striking advantages for general-purpose illumination - they are thin, flat, and lightweight, and also take up very little space. However, before they can become viable alternatives to conventional luminous sources, including inorganic light emitting devices, organic light emitting device prices and performance standards, including energy efficiency, must be improved. White organic light emitting devices today have an efficiency of only 25-60 lumens per watt, while a lighting efficiency over 100 lumens per watt is needed for significant energy savings. One of the most significant factors responsible for their low efficiency is total internal reflection at the interfaces between layers. Because of this less than 20 percent of generated photons can escape into the air and be available for lighting. To improve the external efficiency of organic light emitting devices, what is proposed is light scattering on a random surface relief structure fabricated between the bases of organic light emitting devices and their active layers. The multilayer surface relief structure includes a polymer material with a high refractive index, matching that of the electroconductive anode, and a polymer with low refractive index. The light scattering at the interface between these layers significantly improves the probability of photons penetrating through this interface even when their angles of incidence exceed the angle of total internal reflection. Those photons that reach the low-refractive-index layer also exit the glass base without experiencing total internal reflection. The proposed structure eliminates light leakage to device boundaries by preventing excitation of waveguide modes. The first phase effort experimentally and theoretically proved a new approach to organic light emitting device design based on the fabrication of random surface relief on the internal layers. It was demonstrated that the light scattering by this relief enhances photons' probabilities of escaping, thus improving efficiency by factor of 1.5, and additional improvements in the external efficiency are achieved by easing total internal reflection for photons coming to this interface after reflection from the cathode layer. In the second phase, a low-cost roll-to-roll mass production technology will be developed for fabricating flexible and rigid substrates that will be fully compatible with subsequent organic light emitting device manufacturing. The second phase will involve cooperation with an organic light emitting device manufacturer, which will produce devices on the new substrates for the demonstration of their technical and commercial benefits.

Commercial Applications and Other Benefits as described by the awardee: The development of flexible substrates for highly efficient organic light emitting devices will contribute to fast preparation for mass production, and will reduce costs, thus making these devices more attractive to customers and promoting their acceptance by the general public. All these factors will result in the energy savings and reducing dependence on foreign oil.

81092S06-II

WOLEDs Containing Two Broad Emitters--Universal Display Corporation, 375 Phillips Boulevard, Ewing, NJ 08618-1428; 609-671-0980; www.universaldisplay.com
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Ms. Janice K. Mahon, Business Official, jkmahon@universaldisplay.com
DOE Grant No. DE-FG02-06ER84582
Amount: $750,000

In 2001, lighting is estimated to consume 8.2 quads (approximately 762 TWh), or about 22% of the total electricity generated in the U.S., so new high-efficiency solid-state light sources, such as light emitting diodes (LEDS) and organic LEDs (OLEDs), are needed to help reduce the ever increasing demand for energy. An OLED is potentially an inexpensive diffuse source that may compete most directly with conventional incandescent light sources; however, improvements in the overall efficiency of these devices are still required before they become commercially viable products and attain expected goals in terms of cost ($3 per 1000 lumens) and performance (150 lumens per watt).
This proposed research will utilize novel OLED fixtures enabling highly efficient stable, organic, solid-state, lighting sources to replace short lifetime 12 lm/W incandescent sources, and hence reduce overall energy consumption in the U.S. Additionally, the research will support future work to attain OLEDs having 150 lm/W power efficacy. In this Phase, a white OLED containing only two emitters was demonstrated with an efficacy of 34 lm/W at a forward luminance of 800 cd/m2. The device had a CIE = (0.38, 0.37), a CRI of 71, and a correlated color temperature of 3,900 K and met the targets of the Phase I program. During Phase II, we will demonstrate white OLEDs with a simple architecture containing only two emitters and/or as few organic materials as necessary will be developed to enable low-cost white OLED lighting sources. These devices will have color rendering indexes (CRI) of >75, and efficacy of 60 lm/W at 1,000 cd/m2.

Commercial Applications and Other Benefits as described by the awardee: Today, OLED technology is the leading emerging technology for flat panel displays (FPDs), with recent product introductions in cell phones. Many of these features that are desired for FPDs are also making OLED technology of great interest to the solid-state lighting community. For example, OLEDs are bright and colorful lambertian emitters with excellent power efficiency at low voltages. Therefore, OLEDs having high recombination efficiency materials in conjunction with flexibility and OVPD will mean that this technology can also become costeffective in general lighting applications.

81275S06-II

Fast Neutron Imaging Scintillator with Low Sensitivity to Gamma Radiation--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Dr. Irina Shestakova, PhD, Principal Investigator, Shestakova@rmdinc.com
Dr. Gerald Entine, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-06ER84403
Amount: $749,999

The advent of higher flux neutron pulsed sources has allowed development of time-sensitive neutron diffraction techniques, important for obtaining information about function in areas such as biological matter and water saturation in radiography. However, the detectors available for neutron radiation are still inadequate, primarily limited by the available scintillators. Scintillators which can simultaneously provide high spatial resolution, high neutron detection efficiency, low gamma sensitivity, and fast response time do not exist, and are needed to realize the full potential of the new high flux sources such as the Spallation Neutron Source at ORNL. To address these limitations of the current neutron scintillator technology, we are developing a structured scintillator that promises to fulfil the demanding requirements. The structure of the scintillator will serve to channel light to a digital optical detector promoting very high spatial resolution, even for thick scintillators needed for high detection efficiency. The proposed scintillator will be inexpensive, will have low gamma sensitivity, and a very fast response of 2 ns well suited for time resolved diffraction studies, tomographic imaging and other time-sensitive applications. The Phase I research was highly successful and has demonstrated feasibility of producing such a scintillator. These scintillators have demonstrated high spatial resolution, and fast decay time with excellent luminescence under neutron excitation. We have exhaustively evaluated the produced samples and demonstrated their application for neutron imaging in series of tests at the University of Massachusetts Lowell Research Reactor and SNS, Oak Ridge National Laboratory. The technology used in Phase I studies will be further developed to optimize the scintillator compositions and parameters of the process. A development of special neutron sensitive glass to produce neutron sensitive capillary array substrates arrays will be undertaken. This new development will improve the overall neutron stopping power of the proposed sensors. Large area prototype sensors will be fabricated and evaluated at neutron beam facilities of our collaborators at UMLRR and Oak Ridge National Laboratory to demonstrate their efficacy for incorporation into the advanced high resolution neutron detectors.

Commercial Applications and Other Benefits as described by the awardee: The proposed scintillator is expected to find widespread applications in neutron radiography and neutron crystallography. Detectors based on the proposed scintillator could be employed at any neutron source facility and would help advance basic research in material science, protein mechanisms research, as well as drug design. Further applications could be found in non-destructive testing and secuity scanning at entry ports and strategic facilities. Therefore, the proposed development holds a very high potential for commercialization.

81289S06-II

High Resolution, High-Count-Rate Silicon X-Ray Detector--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Mr. Kanai S. Shah, M.S., Principal Investigator, KShah@rmdinc.com
Dr. Gerald Entine, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-06ER84404
Amount: $750,000

X-ray detectors with high energy resolution, high sensitivity and high count-rate performance are required in electron beam systems. In many studies conducted with electron beam systems, the characteristics of available X-ray detectors limit the system performance. The proposed project aims to investigate a novel low capacitance design of high purity silicon detectors that offers high energy resolution, high efficiency, high count-rate operation and easier fabrication. This should be very beneficial for X-ray detection studies with electron beam systems. The Phase I project was aimed to demonstrate the feasibility of producing high resolution, high purity silicon detectors with low capacitance. Demonstration of high resolution detection of Xrays with the new detector was achieved in the Phase I project. The Phase II project will aim to advance the promising high resolution, high purity silicon detectors with low capacitance. Optimization of detector design and processing aspects as well as electronic readout and data acquisition aspects is planned in the Phase II project.

Commercial Applications and Other Benefits as described by the awardee: The proposed detectors will be very useful in X-ray detection studies conducted with electron beam systems. Additional applications include nuclear and particle physics, astronomy, synchrotron studies, health physics, nuclear non-proliferation, and non-destructive studies.

81291S06-II

Scaleable Carbon Nanotube Field Emitters for Scanning Electron Beam Instruments--Xidex Corporation, 8906 Wall Street, Suite 105, Austin, TX 78754-4542; 512-339-0608; www.xidex.com
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DOE Grant No. DE-FG02-06ER84408
Amount: $750,000

Currently there is a need for significant improvement in the spatial resolution, signal-to-noise ratio, and processing speed of scanning electron beam instruments used by many industries, including the driver of the global economy, the semiconductor industry, as well as the emerging nanotechnology industry. Xidex Corporation proposes to demonstrate the utility of nano-sized high-aspect-ratio cylindrical carbon-nanotube (CNT) field emitters for Scanning Electron Microscopes (SEMs) and Transmission Electron Microscopes (TEMs) that can be fabricated commercially. Prospects for success are driven by Xidex's unique, repeatable fabrication process for CNT emitters and very promising Phase I results. During Phase I Xidex developed and demonstrated optimal CNT emitter designs, demonstrated the feasibility of fabrication processes for manufacturing CNT emitters, and demonstrated achievement of key figures-of-merit for the proposed optimal CNT field emitters. Our CNT emitters were evaluated in a modified commercial scanning electron microscope (SEM) tool and briefly operated the SEM to image a sample, thereby demonstrating a proof-of-concept for operating an SEM instrument with a CNT emitter, a task that had originally been scheduled for Phase II. During Phase II Xidex will design commercial-grade carbon nanotube based field emitters with design guidance derived from the Phase I results and findings. The company also plans to demonstrate a scaleable commercially-feasible fabrication processes for making commercial-grade carbon nanotube based field emitters suitable for use with commercial SEM and TEM instruments. Results will be confirmed by measuring key figures-of-merit of the commercial-grade CNT emitters manufactured in Phase II and evaluating their use in a commercial scanning electron beam instrument. Xidex plans to manufacture carbon nanotube field emitters on metal substrates (wires) that can be integrated into SEM and TEM electron guns. The wire with CNT tips will be attached to existing filament-holders which are available commercially. The product offering directly addresses a long standing problem. Electron optical columns have improved significantly in the last 10-15 years, however, the field emission source itself has basically not changed. Electron guns may require some redesign to take full advantage of our new CNT electron emitters. SEMATECH has offered to facilitate the required working relationships with SEM and TEM vendors to rapidly affect any required redesigns and adjustments.

Commercial Applications and Other Benefits as described by the awardee: Societal benefit will accrue from use of imaging systems with improved resolution performance in materials science, biology, medical research, and forensics. Ultra high resolution imaging of nanoscale structures for materials science and engineering applications will benefit directly from our work. Ebeam tools are also used in the semiconductor industry for engineering development and production quality control in fabs. The CNT emitter technology may also enable development of new multi-beam array tools needed for e-beam lithography, and could extend to miniaturization of e-beam columns. Use of a stable autocollimated coherent e-beam delivered by a CNT emitter, together with future MEMS fabricated electrodes of micron-scale dimension could further reduce electron optics aberrations.

81357S06-II

Sensitive X-Ray Fluorescence Detection for Higher Energies--HD Technologies, Inc., 455 S. Frontage Road, Suite 214, Burr Ridge, IL 60527; 630-230-0013; www.hdtechinc.com
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DOE Grant No. DE-FG02-06ER84398
Amount: $748,000

Recognizing the count rate and energy resolution limitations of the solid state detectors as the bottleneck of x-ray fluorescence detection at synchrotron sources, we propose to further develop highly sensitive and efficient multilayer array analyzer detectors. The proposed detector will benefit x-ray spectroscopy and micro spectroscopy experiments at synchrotron sources, especially at the third generation sources, such as the Advanced Photon Source at Argonne National Lab and Advanced Light Source at Lawrence Berkeley Lab. The proposed analyzer detector will improve the performance of our previous design of multilayer detectors by a factor of 6 to 10 times. Utilizing diffraction from graded multilayers, the selection of energy photons is achieved through an array of multilayer analyzers and the signal are collected with high rate non-energy resolving detectors, resulting a detector with very high count rate. The proposed new development of the multilayer array analyzer detector will cover a large solid angle with superb energy resolution, and will be able to approach higher energies . Phase I feasibility studies have demonstrated that multilayers with high efficiency and narrow reflectance can be fabricated. In addition, we have shown that superb background rejection can be achieved with a double multilayer configuration. Phase II project will optimize the multilayer array analyzer design. In particular, a full-scale array detector and two modular detector units will be fabricated to cover an energy region from 3 KeV up to 20 KeV. These detectors will be characterized and compared with the currently available detector systems. Phase II project will also evaluate the dual multilayer analyzer configuration to largely improve the background rejection of the system.

Commercial Application and Other Benefits as described by the awardee: The proposed multilayer detector will be 50 times more efficient than the state-of-the-art solid-state detector in fluorescence detection at intense beamlines. In addition, its energy resolution will be 2-3 times better than the solid-state detector. Not only the detector will make more efficient use of synchrotron beamlines, but also it will largely enhance our ability of detecting fluorescence in very dilute systems and under other unfavorable conditions. These include study of metal centers in biology under physiological conditions (in vivo). From an economic point of view, the best investment in the research field of x-ray spectroscopy is not multi-million dollar beamlines, but better fluorescence detection systems. The detector will be commercialized as generally used high sensitive detectors at synchrotron sources around the world. The technology developed for synchrotron application may be used in microanalysis using other type of radiation.

81360S06-II

Sensitive High Speed Detector for Synchrotron Applications--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6801; www.rmdinc.com
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DOE Grant No. DE-FG02-06ER84402
Amount: $749,993

Third generation synchrotron sources, such as the Advanced Photon Source (APS), are outstanding facilities for X-ray diffraction and scattering of non-crystalline biological materials. However, their full potential has not been exploited because of the lack of detectors that can provide multiple frames of detailed structural information on the required millisecond time scale at extremely high count rates available at these sources. Development of such detectors could prove invaluable in a variety of synchrotron based applications such as time resolved X-ray diffraction. These applications require X-ray detectors with high spatial resolution, large area, high-sensitivity, and millisecond time resolution. Unfortunately, detectors that fulfill all of these requirements are currently unavailable. To address these limitations we propose to develop a novel X-ray imaging detector that can simultaneously provide millisecond time resolution, high spatial resolution, large imaging area, high sensitivity, and wide dynamic range at a substantially reduced cost compared to current detector systems. The detector will be based on two new technologies: a very bright, high resolution, scintillator that offers unique advantages for high speed imaging, and a novel readout that provides millisecond time resolution with significantly improved signal to noise ratio than the current detectors. For X-ray energies typically used in time resolved X-ray diffraction analysis, this detector will provide high detective quantum efficiency even when operated at high frame rates, and improved image quality than is currently possible. During Phase I we made major progress toward these goals, demonstrating feasibility of developing such a detector. Our tests conducted at the APS, Argonne National Laboratory, show that the sensitivity of the Phase I prototype system, even in this preliminary, non-optimized form, is a factor of 2.5 higher than that of the state-of-the-art detector and is close to what is needed for a majority of applications. Furthermore, the data quality at high frame rates is shown to be adequate for these demanding applications. In terms of scintillator development, the major technological breakthrough during Phase I was that we could, for the first time, demonstrate fabrication of a novel semiconductor scintillator in a structured form needed for high resolution imaging. The Phase I data clearly shows that we have not only accomplished the Phase I goals, but have exceeded them in almost all respects. The Phase II research is a logical extension of the Phase I work, the goal of which is to fabricate a low cost, large area, high speed detector for time resolved X-ray imaging of biological and other industrial specimens. The Phase II research will focus on the photodetector development, optimization of the scintillator performance, fabrication of a prototype, and its thorough evaluation at the ANL Synchrotron. Substantial efforts towards commercialization of this technology will be made.

Commercial Applications and Other Benefits as described by the awardee: Besides being ideally suited for time-resolved studies, the proposed detector will also find widespread use in other areas of pre-clinical and clinical imaging, biological imaging, high speed computed tomography, non-destructive testing, and basic physics research. Due to its high performance, compact nature, and low cost, the proposed detector will be ideally suited for homeland security applications, ranging from baggage scanning to detection of biological agents without contaminating the detector system.

81361S06-II

High Count Rate, Pixelated APDs for Direct X-Ray Detection--Voxtel, Inc., 12725 SW Millikan Way, Suite 230, Beaverton, OR 97005; 971-223-5646; www.voxtel-inc.com
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DOE Grant No. DE-FG02-06ER84406
Amount: $750,000

Synchrotron radiation (SR) has become a widespread tool across a broad spectrum of forefront science. However, with advances in the brightness of synchrotron radiation sources, a wide gap has developed between the ability of these sources to deliver high photon fluxes and the ability of detectors to measure the resulting photon, electron, or ion signals. In a number of cases, expensive beamlines are limited by the lack of suitable fast X-ray imaging systems. Fortunately, due to advances in CMOS microelectronics, SR detectors are possible that have massive integration of parallel electronics on a pixel by pixel basis, enabling a three to four orders of magnitude improvement of data rates and 'smart processing' of information on-chip. Highly sensitive, high count rate detectors will greatly benefit measurements in the areas of Mossbauer experiments, time resolved X-ray diffraction (XRD), microscopy, fluorescence, and absorption studies, among others. A rad-hard, sub-nsec, pixelated, thinned (10 μm), monolithic, Si avalanche photodiode (APD) array is being developed for time-resolved photon counting measurements of spatial intensity distributions. The SR detector's APD elements are coupled, at the pixel level, to integrated ultra low noise amplifiers, pulse discrimination, and photon counting circuits. The detector contains an array of 200 x 200 fully depleted, APD elements, each 1000 x 1000 micron2 in size. The APDs have been engineered for low avalanche noise, which, when combined with the low noise amplifiers, allow superior signal to noise and improved detectors efficiency over a range of X-ray energies. Features that enable new science at 358 MHz and higher count rates include, two-level pulse discrimination and dual, 16-bit counters, which allows two-condition photon counting. In Phase I, prototype back-illuminated APDs of varying thickness and pixel dimension were fabricated using SOI silicon wafers engineered for high gain, low dark current, and low excess noise avalanche gain. Unlike bulk CMOS, SOI CMOS transistors are isolated from both the substrate and one another, which makes them inherently radiation hard and impervious to single event upset (SEU). Using the results of detailed TCAD modeling and simulation, we optimized the design of the APD array and used the design to procure SOI wafers, custom engineered with fully electrically activated dopants. The SOI process flow was used to fabricate and back-thin the silicon APDs. A 2.5 GHz bandwidth amplifier and pulse detection circuit was also demonstrated. The demonstration of these key components led to the design of a 100 x 100 mm2 pixel architecture, including low noise amplifier, two level discriminator, and two, user-enabled 16-bit counters. The fully functional prototype will be fabricated in Phase II.

Commercial Applications and Other Benefits as described by the awardee: Highly-efficient, back-illuminated APD detectors have a wide variety of applications that in addition to synchrotron Xray science include: astronomy, fluorescence microscopy, electron microscopy, semiconductor test, soft X-ray spectroscopy, hybrid image intensifier tubes, DNA sequencing, as well as laser radar (LADAR) assisted autonomous navigation and cruise control.

81362S06-II

High Rate X-Ray Fluorescence Detector--XIA, LLC, 31057 Genstar Road, Hayward, CA 94544; 510-401-5760; www.xia.com
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DOE Grant No. DE-FG02-06ER84407
Amount: $750,000

X-ray fluorescence analysis is widely used, both in basic and applied research and in commercial process monitoring and quality control operations. The most important of the x-ray research is carried out at the four national synchrotron radiation research laboratories that the DOE supports. Unfortunately, for most of the experiments that involve fluorescence, the detector system limits the rate at which data can be collected. In the proposed effort, we will combine our digital processing electronics with a novel silicon drift detector (SDD) design to make a compact, modular, large area detector that provides a significantly better combination of resolution and throughput than the currently available detector systems, all with greater serviceability at a lower overall cost. As a proof of principle, we obtained a representative SDD, and made measurements with our digital processing electronics to show that we can achieve excellent results. We then showed that we can produce a version of our electronics that will fit within the detector housing, creating a very clean total package, with much higher noise immunity than currently available solutions. The goal of the Phase II research is to develop a complete multi-element detector array, including seven SDD detector modules, full processing electronics, and associated cooling and power supplies. WE will develop host software to control the new processor through USB2. Finally, we will develop an ultra high speed readout system through high speed serial links and PXI Express, and extend the software support to that system.

Commercial Applications and Other Benefits as described by the awardee: It is very clear that improved detectors could substantially increase the research productivity of fluorescence x-ray experiments at the DOE's modern synchrotron facilities. Synchrotron research is a major component in the DOE's commitment to maintaining excellence in scientific research in the US. By taking advantage of the higher throughputs available in the proposed detector array, synchrotron research scientists can achieve higher scientific throughput, ultimately producing more quality research and saving money for the DOE. The proposed detector can also have significant application in the commercial x-ray market, where high throughput also equiates to time and money saved. XIA LLC does quite a bit of work with the X-ray fluorescence (XRF) and Energy Dispersive Spectrscopy (EDS) markets; based upon our sales growth over the past two years, those markets are in a period of rapid growth. Many XRF manufacturers face a challenge of combining one company's detector system with processing electronics from another detector; the availability of a truly high performance detector system with all the processing included has great potential.

80921B06-II

***STTR Project: Life Prediction of SiC/SiC Composites in Advanced Nuclear Reactors—**Hyper-Therm High-Temperature Composites, Inc., 18411 Gothard Street, Unit B, Huntington Beach, CA 92648; 714-375-4085; www.htcomposites.com
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DOE Grant No. DE-FG02-06ER86276
Amount: $749,998

Research Institution
Oak Ridge National Laboratory
Oak Ridge, TN
Some Generation IV nuclear reactor designs call for employing high reactor core temperatures to improve the thermodynamic efficiency of the power generation and to efficiently produce process heat. Materials are required that are capable of sustaining temperatures approaching 1000ºC and are also stable under neutron irradiation for the life of the reactor. The outer containment of the control rod material is one such application, where the sheath material is subjected to large thermal gradients and thermal cycling in addition to the high temperature, high radiative flux environment. Silicon carbide fiberreinforced silicon carbide matrix composites that are stable under these high neutron fluxes have been identified and a preliminary database of mechanical and thermal properties is being generated. In addition to these properties, the evolution of the mechanical and thermal properties over time must be understood such that end of life properties can be used in designing control rod sheaths. However, the intended lifecycle of SiC/SiC control rod sheaths is thirty years. Therefore accelerated test methods must be developed to simulate the material condition after thirty years. A strong understanding of the aging mechanisms within nuclear grade SiC/SiC composites must be gained to develop accelerated test techniques. The technical objective of the Phase I effort was to develop a means of life prediction for nuclear grade SiC/SiC that will allow determination of the effect of low oxidizing partial pressures (~10 μatm) at elevated temperatures on SiC/SiC over long periods of time. Accelerated stress rupture testing was used to evaluate the composite material. Data was accumulated as a function of temperature and oxygen partial pressure to assess equivalent aging conditions. Calculations were performed and test data generated that identifies three aging regimes: passive oxidation, active oxidation, and creep related strain. The bases for an empirical and a micromechanical reliability model were established for predictive capabilities. The Phase II program will advance the state of technology of nuclear grade SiC/SiC to make these composites the primary choice for fabricating highly irradiated, high temperature (T>900ºC) load bearing components for future reactors. Technology advancements that are targeted include developing an end of life (thirty year) mechanical and thermal property database based on accelerated aging of the material. The validity of the accelerated aging will be demonstrated through a significant set of stress rupture data examining the effect of temperature and oxygen partial pressure. A reliability model will be completed to offer probabilistic failure estimates. The proposed continued development of nuclear grade SiC/SiC composites is an enabling materials technology that provides a needed advancement in high temperature materials for irradiated environments.

Commercial Applications and Other Benefits as described by the awardee: Continued developments of such materials benefits the Department of Energy efforts on developing Generation IV fission reactors, and also benefit the longer range development of fusion power. Both of these energy generation approaches will substantially reduce dependence on foreign sources of fossil fuels as well as reduce greenhouse gas emissions.

80926S06-II

Refractory Composites for Reactor Applications (PSI-7266-290)--Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077; 978-689-0003; www.psicorp.com
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Dr. B. David Green, Business Official, green@psicorp.com
DOE Grant No. DE-FG02-06ER84630
Amount: $749,960

Next generation nuclear reactor cores will operate at temperatures near 1000ºC to increase fuel utilization efficiency. Martensitic steels traditionally used in reactor construction and Alloy 800H planned for the Next Generation Nuclear Plant demonstrator do not possess the mechanical strength or oxidation resistance to reliably and safely function in systems that operate at these temperatures. Carbon-carbon and silicon carbide ceramic composite structural materials being considered for in-core structural applications have high strength at high temperature, but do not perform well under off-normal high temperature (emergency) oxidation conditions. Fiber reinforced ceramic composites will be modified with refractory metals to substantially increase their oxidation resistance and retain high temperature strength. The Phase I program successfully demonstrated carbon fiber reinforced refractory enhanced silicon carbide composites that retained strength of more than 140 MPa after rapid oxidation at 1000ºC. The helium erosion resistance of the composites was comparable to state of the art SiC/SiC materials and they retained thermal conductivities in excess of 10 W/m-K. The Phase II project will expand the development of the refractory composite materials to increase post oxidation strength to more than 140 MPa and maintain thermal conductivity to 10 W/m-K after helium aging at 1000°C for up to 3000 hours. The composite fabrication process will be scaled up to demonstrate that successful compositions can be fabricated with properties that vary by no more than 10% in any part of a component. The project will culminate with the delivery of prototype control rod guides and sheaths fabricated from the best composition developed during the program.

Commercial Applications and Other Benefits as described by the awardee: Successful development of a family of high temperature, oxidation resistant refractory composites will enable full-scale commercial development of Next Generation Nuclear Plants. These high efficiency systems will produce both electricity and hydrogen to enable the United States to reduce its dependence on fossil fuels and reduce imports of foreign energy products while minimally impacting the environment. Additional commercial applications for high temperature, oxidation resistant refractory composites include ducting for high temperature exhaust systems including catalytic converters and incinerators. Developing high temperature catalytic converters for diesel engine systems will reduce particulate emissions and help maintain clean air standards. High temperature exhaust ducting in incinerators will allow more complete combustion of waste products and minimize toxic emissions.

80327S06-II

On-Line Monitoring of Accuracy and Reliability of Instrumentation and Health of Nuclear Power Plants--Analysis and Measurement Services Corporation, 9111 Cross Park Drive, Building A-100, Knoxville, TN 37923; 865-691-1756; www.ams-corp.com
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Mr. Darrell W. Mitchell, Business Official, mitchell@ams-corp.com
DOE Grant No. DE-FG02-06ER84626
Amount: $749,609

The nuclear power industry continues to depend largely on antiquated methods and hands-on maintenance of its equipment and for plant aging management and health monitoring. As such, over the last few years, DOE has solicited new research and development to develop and apply advanced maintenance technologies for the current and next generation of nuclear power plants. The Phase I project responded to this DOE interest. The on-line monitoring technologies that were identified in the Phase I project, and the commercial product to be developed during Phase II will help establish the accuracy and reliability of nuclear power plant instrumentation and will also, and as importantly, help in condition monitoring and management of aging of critical equipment and processes in the current and next generation of reactors. The Phase I project involved an experimental hands-on research and development effort consisting of five technical objectives; all of which were completed fully with excellent outcome. As a result, the feasibility of an on-line condition monitoring system for nuclear power plants was established in Phase I and the foundation was laid for development of the system in Phase II. The project will result in development of an integrated on-line condition monitoring system which will be implemented during Phase II in a nuclear power plant. Two host utilities have formally agreed to allow this implementation in their nuclear power plants and have provided official letters of support to that effect. The main features of the system are: provides a means to verify the accuracy and reliability of process instrumentation; provides plants with the means to automatically assess the condition of critical plant equipment and processes; offers a practical tool to optimize plant maintenance activities and improve efficiency, reduce costs, and contribute to plant safety; provides the foundation for an automated condition monitoring system to be embedded in the design of the next generation of reactors.

Commercial Applications and Other Benefits as described by the awardee: The product of Phase II effort will have immediate applications in nuclear power plants. Two utilities have formally committed themselves to the project, several others have provided strong expression of interest, and one has stated verbally that it intends to purchase the product of the Phase II project. The Phase II product will help with both the safety and economy of nuclear power plants. During Phase I, a utility partner in the project estimated that the potential benefits of the Phase II product can add up to over $25,000,000 per year for a 1200 Mwe nuclear power plant. In addition to the nuclear industry, the product of this project can help other power and process industries. Also, and more importantly, the Phase II development will have a great impact on continuous surveillance and monitoring needs of homeland security and protection of government facilities and defense installations.

80336S06-II

Real-Time Fiber Optic Neutron Spectrometer--Luna Innovations Incorporated, 1703 South Jefferson Street, SW, Suite 400, Roanoke, VA 24016; 540-769-8430; www.lunainnovations.com
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Mr. Michael E. Pruzan, Business Official, submissions@lunainnovations.com
DOE Grant No. DE-FG02-06ER84628
Amount: $749,898

To meet future energy needs for efficient production of electricity and hydrogen, advanced nuclear reactor designs have been proposed, which require improved neutron sensors for adequate design and subcomponent evaluation, and for safe reactor operation. These new sensors must outperform present fission chamber detectors and wire dosimetry with higher signal to noise ratios and faster response times. Overall objective: Fiber-optic sensors and interrogation systems are being developed to provide reliable real time monitoring of neutron flux and fluence and energy distribution in multiple locations near or inside the reactor core. Phase I Results: The feasibility of a fiber-optic neutron spectrometer was demonstrated. Combinations of four sensor types were identified, each with unique responses to neutron flux, dose in two energy ranges, above and below 0.3 MeV. Type I sensors showed very high sensitivity to thermal neutron dose with no sign of saturation or reduced sensitivity at higher fluence levels up to 2.56 x1017 n/cm2. Phase II Plans: Neutron probes with improved energy resolution will be developed for high-temperature operation. A system for rapidly analyzing and displaying neutron probe information will be tested in a research nuclear reactor.

Commercial Applications and Other Benefits as described by the awardee: Miniature fiber-optic neutron probes can be distributed widely within nuclear reactors to help ensure uniform fuel depletion. These probes can help validate computer models for activities, such as control rod rotations, which can quickly alter neutron intensities and energies. To minimize clean-up costs of aging nuclear reactors, a network of these neutron probes could provide early warning of fast neutron leaks. Finally, neutron spectrometers can be used to more accurately monitor structural neutron damage and predict embrittlement.

80721B06-II

High Temperature Quantum Well Thermoelectric Materials--Hi-Z Technology, Inc., 7606 Miramar Road, Suite 7400, San Diego, CA 92126-4210; 858-695-6660; www.hi-z.com
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DOE Grant No. DE-FG02-06ER84538
Amount: $750,000

A very large amount of waste heat (10 quads/year) is being continually generated by large industrial plants. This renewable source of energy can be tapped to replace more than 7% of the nation's imported oil using new thermoelectric materials that can convert this heat into electricity. However, new thermoelectric materials are required that are more efficient to make this conversion process economical. In Phase I the alternating Si/SiGe Quantum Films were upgraded in performance to yield ZTs greater than 5 which indicates efficiencies >20% can be obtained at relatively low temperatures such as a TH of 300EC and TC of 100EC. Higher efficiencies of >30% at the elevated temperatures are anticipated. These very encouraging values were verified by UCSD and NIST. Very low thermal conductivity single crystal Si was developed that should greatly limit bypass heat losses. One side of the Si wafer remains 100% dense so the QW can be successfully deposited. Thermal stability annealing tests (both isothermally at 1000EC for Si/SiGe and at a TH of 300EC for a couple in gradient operation exhibited no signs of degradation. Phase II will emphasize fabricating many more of the films that exhibited very encouraging α and ρ values to obtain more verification. Also thermal conductivity and efficiency will be obtained as a function of temperature. Joining development for the N and P legs into couples and modules will become a major task along with extensive life testing. Different bonding techniques will be pursued for the low temperatures (up to 300EC) versus the higher temperatures (up to 1000EC).

Commercial Applications and Other Benefits as described by the awardee: Commercial use of this technology will be with industrial users such as with steel mill furnaces and Al plants that have a considerable amount of waste heat at various operating temperatures that are being thrown away. Another major area is cars and trucks where 2/3 of the fuel going into the vehicle goes into waste heat. Some of this heat can be converted into electricity to increase vehicle efficiency. The payoff is in making industrial plants and vehicles more efficient so fuels are conserved, pollution is reduced, resulting in a more efficient operation. Further the public health is less endangered and the nation is less dependent on foreign imports.

80730S06-II

Scalable Nanostructured Thermoelectric Generation System for Industrial Waste Heat Recovery--Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088; www.poc.com
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Mr. Gordon E. Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-06ER84566
Amount: $749,988

Every year, an estimated 7 quadrillion British thermal units—about 15% of the total energy consumed in the United States—is lost in liquid and gaseous waste streams from industry. Energy from low- to medium-grade waste heat (50-250 deg. Celsius) cannot be efficiently recovered by conventional heat exchanger technologies because of its distributed nature and insufficient temperature difference, while thermoelectric generation technologies are not yet economically viable. Improved waste heat recovery systems can potentially recover1.8 quadrillion British thermal units of energy, a major goal of the United States Department of Energy. This problem will be solved by implementing a new advanced thermoelectric generation technology based on flexible large-area tiles fabricated from nanoengineered thermoelectric materials. Cascading these tiles results in a thermoelectric waste heat recovery system with a heat-to-electricity conversation efficiency three times better than that of current technology.
In Phase I, the system design was developed and its feasibility demonstrated through computer simulation and a series of proof-of-concept experiments. Key fabrication steps were validated through fabrication and testing of material samples that showed enhancement in the thermoelectric conversion efficiency of the nanoengineered materials. Analysis of results indicates that this technology is feasible and can produce electricity at 30 cents per Watt, making it a viable alternative energy technology.
POC plans to optimize the design of the advanced thermoelectric generation system, mature the fabrication process for the nanoengineered thermoelectric materials, and complete the development of a fully functional prototype that will meet Department of Energy waste heat recovery applications. This prototype will be tested at a National Laboratory to demonstrate its conversion efficiency and economic viability. The work will be done in close collaboration with industrial partners to commercialize this technology.

Commercial Applications and Other Benefits as described by the awardee: This system can provide remote, highly reliable, low-power sources for pipeline and telecommunication infrastructure monitoring. Other applications include space power production and wearable devices. Another major application lies in the auto industry, where fuel-efficient and hybrid automobiles will benefit from the recovery of vehicular coolant/exhaust heat. This technology also augments solar/geo/waste power generation. Widespread use of remote “mesh” sensor networks also contributes to the need for such systems.

80293S06-II

Manufacturing of CMC Combustor Liners for Gas Turbine Generators--MATECH Advanced Materials, 31304 Via Colinas, Suite 102, Westlake Village, CA 91362-4586; 818-991-8500; http://www.matechgsm.com
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Dr. Edward J. A. Pope, Business Official, ed@matechgsm.com
DOE Grant No. DE-FG02-06ER84550
Amount: $750,000

Current CMC systems do not meet the long cycle life requirements (>100,000 hours) of stationary gas turbine engines used in electricity production. Using CMCs would permit higher efficiency power generation. MATECH/GSM proposes to further develop our recent advances in preceramic polymer chemistries (developed in the DOE Phase I SBIR program) to fabricate high yield yttrium aluminum garnet (YAG) and Refractory Alloyed YAG (RAYAG) structural ceramic fibers and matrices.
In the phase I program, high temperature oxide ceramic fibers were demonstrated that can withstand up to 1600C temperatures. The Phase II effort will optimize and develop these new ceramic fibers for commercialization.

Commercial Applications and Other Benefits as described by the awardee: It is predicted that improving the thermodynamic efficiency of gas turbine generators through the use of CMCs will save nearly 300 billion BTU a year in natural gas and save over $1.3 billion dollars per year for utility customers.

80296S06-II Cyc24-3

In-Situ Functionally Graded Oxide Matrix Composite for Gas Turbine Applications--UES, Inc., 4401 Dayton-Xenia Road, Dayton, OH 45432-1894; 937-426-6900; www.ues.com
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Ms. DeeDee Donley, Business Official, ddonley@ues.com
DOE Grant No. DE-FG02-06ER84581
Amount: $749,920

Ceramic matrix composites (CMCs) are currently under evaluation in industrial gas turbine engines, since CMCs are generally lighter and more thermally stable than their metallic counterparts. This allows for higher operating temperatures and reduced cooling, thereby contributing to higher fuel efficiency and lower NOx and CO emissions, which is essential based upon the increasing public awareness of global warming/climate change. State-of-the-art oxide-based composites require a TPS coating to mitigate the thermal gradients endured by the material during exposure; this coating can delaminate or erode, leading to exposure of the composite. Further, the underlying composite contains a mullite-based fiber, which is prone to environmental attack during exposure in a moist combustion environment. The vision is to produce a non-silica-containing composite with a TPS that is integral and fabricated insitu. This oxide-based composite design is resistant to environmental attack on the hot side, and supports a low thermal gradient on the cold side to minimize thermal stresses. In the Phase I work, the viability of producing a compositionally graded oxide matrix composite was demonstrated. This composite was exposed in a simulated combustion environment for 100 hours, the results of which provided invaluable information that has led to a clear direction for the Phase II program.
In the Phase II work, two different composite design options will be evaluated for improved properties of the functionally graded oxide matrix composite and the optimal design will be down-selected based on mechanical and thermal property data. Subscale components of the functionally graded composite material will be fabricated and tested in a subscale test facility. Successful testing of the subscale components will lead to fabrication and testing of a full scale component at the end of the Phase II program.

Commercial Applications and Other Benefits as described by the awardee: A successful Phase II program will provide the needed foundation for commercialization of the functionally graded oxide matrix composite. This composite technology offers a novel concept for use in high temperature gas turbine engines. The current materials being considered for this use suffer environmental degradation during exposure to moisture-containing combustion environments. The composite technology is much more resistant to this type of degradation, which is its distinct advantage. The introduction of an alternative material for use in gas turbine applications will have significant economic and environmental effects. The advantages afforded by these materials will benefit all users of gas turbine engines, from industrial to consumer, in the form of lower costs and a cleaner environment. The market for industrial gas turbine engine applications is expected to grow over the next decade, due to the closing of ageing coal plants and the need for increased global power demands, particularly in Asia. These materials also have potential use in propulsion-related applications for industrial, military and commercial sectors.

81079S06-II

Development of High Speed Multispectral Imaging for Sorting Automotive Plastics--National Recovery Technologies, Inc, 566 Mainstream Drive, Suite 300, Nashville, TN 37228-1223; 615-734-6400; www.nrtsorters.com
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DOE Grant No. DE-FG02-06ER84559
Amount: $750,000

Manufacturers are increasing the use of lightweight materials, such as aluminum and plastics, in the manufacture of automobiles and other vehicles in order to improve fuel efficiency. About 15 million vehicles annually are discarded and processed through shredding by recycling companies for extraction of recyclable materials. Today almost all metals are recycled whereas most non-metallic components of the vehicle, approximately 25% by weight including vehicle plastics, are not recycled and are landfilled. Methods and technologies are needed to enable recycling of these materials, including automobile plastics, in order to conserve resources and reduce energy usage. It is proposed to develop a new high-speed electronic detection and sorting technology capability of identifying durable automobile plastics as they flow dry in bulk quantities on a conveying system and to sort the plastics into marketable polymer fractions. This new detection and sorting system will be applied to the recovery and recycling of automotive plastics derived from end-of-life automobile shredder plants. In Phase I a bench scale prototype sensing system was designed, constructed, tested, and evaluated. Using the bench scale system the Phase I research established technical feasibility for construction of a high speed multispectral imaging system suitable for use in a sorting environment. In Phase II it is planned to design, engineer, construct, test, and evaluate a prototype high speed multispectral imaging system integrated with a materials sorting system for automated identification and sorting of polymers from a mixed-polymer stream of plastics. It is intended that the prototype sorting system will be suitable for demonstrating sorting of mixed plastics derived from end-of-life automobiles at small scale commercially viable processing rates.

Commercial Applications and Other Benefits as described by the awardee: Significant public benefit will result from successful development of the proposed technology. The new technology will enable an increased ability to recycle used automotive plastics thereby conserving energy, conserving increasingly limited resources, and reducing flow of materials to landfill while providing a plentiful new source of manufacturing materials to industry. Additionally the new technology will provide a powerful analytical tool that can have broad impact through wide-spread applications in other recycling applications such as recycling of electronic waste (or e-waste), other industries, research instrumentation, and other sectors such as the military and homeland security.

81181S06-II

Laser Ultrasonic Inspection of Adhesive Bonds Used in Automotive Body Assembly--Intelligent Optical Systems, Inc., 2520 W. 237th Street, Torrance, CA 90505-5217; 310-530-7130; www.lasson.com
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DOE Grant No. DE-FG02-06ER84545
Amount: $749,999

Adhesive bonding is widely used in automotive production, especially for body assembly. It is critical to be able to measure the strength of adhesive bonds during manufacture in a nondestructive, effective and rapid manner. There is no current means for inspecting these bonds in real time.We will apply the technique of laser ultrasonics for real time adhesive bond inspection during body assembly. Laser ultrasonics offers high measurement speed without contacting the part. We demonstrated the feasibility of single-side inspection for mapping the adhesive, measuring adhesive thickness and also for measuring bond strength. We plan to design and assemble a prototype inspection system, and test it on a full scale auto body. At the conclusion of this work, a full specification for a turnkey system will be delivered.

Commercial Applications and Other Benefits as described by the awardee: An adhesive bond inspection system would allow greater use adhesives in auto body manufacture, thereby adding strength and reducing weight.

81220S06-II

Biosolvents for Coatings, Resins and Biobased Materials--Vertec Biosolvents, Inc., 1441 Branding Lane, Suite 100, Downers Grove, IL 60515-5624; 630-960-0600; www.vertecbiosolvents.com
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DOE Grant No. DE-FG02-06ER84584
Amount: $734,000

Biologically based products derived from renewable resources have the potential to replace petrochemical feedstock based products as well as reduce the emission of hazardous pollutants. However, in order to penetrate large markets and overcome the entrenched barriers to change, the bio-based products have to provide superior performance and economics together with the environmental benefits. We intend to develop and commercialize products with superior performance for major industries in coatings and paints that have traditionally relied on petrochemical based solvents. The DOE's initiative of the advanced lignocellulose-based biorefinery would need additional co-products and means to utilize its residual fractions for value added use. This interest by DOE is listed in Topic 30 a. of the Phase 1 solicitation and this proposal was funded for this interest area. The primary technical approach and objective for this proposal is: Develop and commercialize high performance coatings formulations using biosolvents with resins and bio-based materials for large volume applications such as polyesters and polyacrylates. Successful development would address large market opportunities, alleviate critical emissions problems that are facing this important industry and make major advances towards growing the markets and commercialization of bio-based products. For Phase 1, the primary technical objective was to establish the initial feasibility of biosolvent based formulations for high performance coatings with polyester and polyacrylate resins. The work has progressed very well and the results have shown that the biosolvent blends can be very effective. In addition, the key regulatory challenges faced by the industry and their costs were identified and a preliminary economics model of the comparative costs was developed. Based on the promising results from the Phase1 project Vertec has recently executed development agreements with two major coatings manufacturers to further support the project in Phase2 and lead it to commercial development. Based on the promising results of the Phase 1 project, the primary technical approach and objective for the Phase 2 project is: optimize, pilot and lead to commercial development, two or three high performance coatings formulations using biosolvents with resins and bio-based materials for large volume applications in polyacrylates, polyesters or epoxies.

Commercial Applications and Other Benefits as described by the awardee: Successful development and commercial implementation would address large market opportunities, alleviate critical emissions problems that are facing this important industry and make major advances towards growing the markets and commercialization of bio-based products.

80173S06-II

Solar Desalination Technology for Mid-Sized Applications--AIL Research, Inc., P.O. Box 3662, Princeton, NJ 08543; 609-799-2605; http://www.ailr.com/
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Dr. Andrew Lowenstein, Business Official, ail@ailr.com
DOE Grant No. DE-FG02-06ER84525
Amount: $749,676

Secure sources of clean, freshwater are essential to the welfare of communities throughout the world. Unfortunately, both in this country and abroad, freshwater supplies are increasingly being contested. Faced with threats to growth, economic development and the health of their citizens, governments are battling over the rights to freshwater supplies. Desalination, particularly if it is powered by a sustainable source of energy, can alleviate this critical shortage. The proposed work will dramatically reduce the cost of water from a desalination plant that runs on renewable energy. The novel desalination cycle operates similarly to a conventional multi-stage flash evaporation plant, but all stages operate at atmospheric pressure. This change allows the expensive metallic heat exchangers and vacuum vessel used in the conventional plant to be replaced with inexpensive plastic heat exchangers within a simple enclosure. A novel configuration for the solar collectors that uses low-cost evacuated-tube collectors provides most of the thermal energy for producing water. Performance data from a proof-of-concept experiment confirmed that the proposed technology could achieve a very high thermal efficiency. Using the experimental data to calibrate a computer model of the process and then using the model to design a larger plant showed that Gain Output Ratios (GOR, a measure of efficiency) over 20 could achieved. This efficiency is about twice that for a conventional thermal desalination plant. The projected cost of water for a mid-sized plant that met 64 % of its thermal input from solar and the balance from a fossil fuel could produce water at a cost of $3.91 per 1000 gallons. This cost is less than half that of the projected cost of water from competing desalination concepts that are powered primarily by renewable energy; it is competitive with the cost of water from conventional desalination plants. The Phase II work will build and test a larger model of the novel desalination concept and operate the model in the field with thermal energy provided by solar collectors. Long duration operation of models will identify the O&M requirements for future commercial plants. The installed cost for a commercial desalination plant will be developed from a detailed manufacturing cost analysis of the plastic heat exchangers that form the core of the plant. The proposed technology will be introduced to one or more industrial companies that now design, build and operate thermal desalination plants.

Commercial Applications and Other Benefits as described by the awardee: The primary benefit for the proposed technology will be to allow economic growth in parts of the country that do not (or will not in the future) have secure water supplies. The proposed technology will also improve agricultural and industrial productivity, including the enhanced recovery of oil and natural gas, by greatly reducing the volume of wastewater that often can have very high disposal costs and adverse environmental impacts.

80849B06-II

Novel Interconnection Process for Lightweight Flexible Photovoltaic Modules--Midwest Optoelectronics, LLC, 2600 Dorr Street, Toledo, OH 43607; 419-724-3710; www.mwoe.com
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Dr. Liwei Xu, Business Official, xu@mwoe.com
DOE Grant No. DE-FG02-06ER84555
Amount: $746,325

Midwest Optoelectronics received a Phase I SBIR grant from the US Department of Energy towards developing its patent-pending concept [R5] for the series interconnection of thin film solar cells that have been pre-fabricated on plastic or other insulating substrates. In this improved manufacturing process, all series interconnection steps are done after the thin film solar cell is fabricated. This is in contrast with traditional monolithic interconnection processes, in all of which at least one of the steps required for interconnection is performed before the deposition of the thin-film semiconductor material.

Commercial Applications and Other Benefits as described by the awardee: The new process will allow MWOE to perform the interconnection at a single point near the end of the production line. It would also allow manufacturers to ship the solar cells to a different location for interconnection and module assembly, if required. The process uses ink-jet and laser processing for the interconnection, and when fully developed, will be substantially automated. The process is being designed to be compatible with low-cost, continuous, roll-to-roll photovoltaic manufacturing processes.

80775S06-II Cyc24-4

High Performance, Low-Cost Nanostructured Mirror Surfaces--NanoSonic, Inc., 1485 South Main Street, Blacksburg, VA 24060; 540-953-1785, http://www.nanosonic.com
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Mrs. Lisa B. Lawson, Business Official, llawson@nanosonic.com
DOE Grant No. DE-FG02-06ER84557
Amount: $750,000

Solar thermal energy conversion is currently the lowest-cost source for environmentally-friendly, renewable solar energy; however, to make this technology cost competitive with conventional power generation, the capital investment must be reduced with additional advantages gained through increased component longevity or increased system efficiency. The Phase I effort demonstrated not only feasibility, but also significant progress for the construction of large area nanocomposite reflectors and the fabrication of flexible mirrors. Having demonstrated feasibility and prototype performance, Phase II will build on these gains to create greatly enhanced mirror products. The primary focus of this program will be the further development of materials which will improve solar thermal conversion's efficiency, reduce its cost, and increase the longevity of installed capacity. Through breakthrough contributions in novel nanostructured coating materials, processing, and bulk material alternatives, the contractor is positioned to assist the solar thermal energy industry through a variety of fabrication cost reductions, efficiency enhancements and longevity improvements for both the reflectors/mirrors and the heat collection elements. The project will develop and implement new materials and processes; these techniques will decrease installation costs, as well as increase the longevity and efficiency of solar thermal energy conversion plants. The efforts in Phase II would provide for improvements to existing technology; with respect to reflectors, it would apply equally to all currently implemented form factors: parabolic trough, flat panel, and parabolic dish. The expertise and success in the construction of multilayer nanocomposites is ideally suited for the construction of lower-cost and higher-efficiency mirrors (reflecting surfaces, reflection enhancement coatings, dielectric mirrors, and environmental resistance coatings for anti-soiling and hydrophobicity) These materials can be applied to large areas with closed or open geometries using environmentally benign techniques. This is in direct contrast with existing technologies for coating applications; CVD and PVD, for example, require specialized chambers and nonambient conditions. In addition, the contractor would support the construction of multilayer energy converters or absorbers (antireflection layers, metal/lossy dielectric stacks for enhanced absorption through multiple scattering, graded metal/dielectric composites and micro-textured surfaces). The advanced materials solutions created within this Phase II would lead to more affordable implementation of solar thermal energy and provide a strong commercialization potential for the contractor.

Commercial Applications and Other Benefits as described by the awardee: This project will create state-of-the-art flexible, lightweight and durable mirrors; an enabling technology for widespread implementation of solar thermal energy as a distributed or remote energy source. Metal Rubber™ would be pursued as an enabling technology for widely available, lowcost distributed power generation and remote power generation based on solar dish concentrator mirrors. The work primarily performed in support of this technical goal would be in the enhancement of the spectral performance of the mirrors. Furthermore, the contractor would develop shaped memory polymer mirrors for easy transport and installation, particularly in remote areas.

80951S06-II

Passive Wireless Humidity Sensor for Building Monitoring--Boston Applied Technologies, Incorporated, 6F Gill Street, Woburn, MA 01801; 781-935-2800; www.bostonati.com
Dr. Hua Jiang, Principal Investigator, hjiang@bostonati.com
Dr. Yingyin Kevin Zou, Business Official, kzou@bostonati.com
DOE Grant No. DE-FG02-06ER84526
Amount: $750,000

People spend more time indoor now. Concerns about the impact of indoor environmental quality on human health, comfort, productivity, energy efficiency, building security, and respiratory disease control are rapidly increasing and capablibility of detecting biological attack is also in government and public interests. Therefore, low-cost, reliable and easy-deployment sensor systems are needed for monitoring and control of building environmental parameters as well as for homeland security and military purpose. This project aims to develop an integrated passive wireless RF sensing system to monitor humidity. The sensing platform and fabrication technology to be developed can be extended to a networked system for monitoring building environment. By changing sensing materials, various conditions can be monitored, such as temperature, pollutant, flow rate, gases and bioagents. The system can be embedded into wallpapers since its multilayer thick film structure are low-cost, maintenance-free, very long lifetime and totally passive. Multiple-point data can be collected wirelessly through Ethernet for controlling purpose. The feasibility of proposed passive wireless environmental monitoring system has been completely demonstrated through a humidity sensor prototyping and system-level testing. Several wireless humidity sensors had been prototyped by employing planar inductor and capacitor resonant sensing platform and various functional materials including very reliable porous ceramics. It was also proved that multiple sensors could share single reader, which extended the proposed sensor applications for multi-point or multi-parameters distribution information sensing. The Phase II project is to develop wireless sensor systems for commercial applications. Detailed objectives include: production-level prototyping of wireless wallpaper humidity and temperature sensors, a readout system for multiple passive sensors, and a wireless sensor network implemented with industry standard Zigbee or Ethernet protocols.

Commercial Applications and Other Benefits as described by the awardee: This technology to be developed laid the groundwork for more sensors that could be easily incorporated in wallpapers. These wireless passive sensors will be very useful for remote query environmental parameters and advance control strategy for increasing occupant comfort, decreasing energy consumption, and controlling technologies against potential chemical and biological agent attacks in buildings. The direct market of the variety of sensors is multi-billion dollar; however, the impact of sensors to human life, to the society, to the economy of the nation, is far beyond the dollar value.

81343S06-II Cyc24-5

Composite Hollow Fiber Membrane for Natural Gas Treatment--PoroGen Corporation, 6C Gill Street, Woburn, MA 01801; 781-391-7073; www.porogen.com
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Dr. Benjamin Bikson, Business Official, bbikson@porogen.com
DOE Grant No. DE-FG02-06ER84571
Amount: $750,000

U.S. production of natural gas is about 24 trillion scf/year; total worldwide production is about 100 trillion scf/year. About 17% of all domestic raw natural gas must be treated to remove carbon dioxide before it can be passed to the pipeline. Membrane technology has gained acceptance in the natural gas processing field due to favorable economics, compact system sizes, reliability and low operating costs. However, commercial membranes suffer from low selectvity and are succeptable to degradation. Robust membrane with improved performance is needed to reduce natural gas processing costs. The overall objective of this combined Phase I and Phase II projects is to develop a novel hollow fiber membrane for carbon dioxide removal from natural gas streams. The membrane will be contaminant resistant and exhibit high selectivity for carbon dioxide removal. The membrane process will provide a step change reduction in natural gas sweetening cost. In Phase I of this project, PoroGen has established technical feasibility of forming a novel composite membrane capable of selective CO2 permeation over methane and demonstrated economical feasibility to use the composite hollow fiber membranes for natural gas sweetening. In Phase II of this project the membrane performance will be optimized, a pilot scale membrane module constructed and tested, and commercial scale hollow fiber membrane module developed.

Commercial Applications and Other Benefits as described by the awardee: Successful development of the proposed membrane technology will enable cost effective removal of carbon dioxide from low grade natural gas streams. The proposed technology will also enable efficient CO2 separation in tertiary oil recovery applications.

81347S06-II

Bioethanol Production with Mixed-Matrix Membranes--Membrane Technology and Research, Inc., 1360 Willow Road, Menlo Park, CA 94025-1524; 650-328-2228; www.mtrinc.com
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Ms. Elizabeth G. Weiss, Business Official, egweiss@mtrinc.com
DOE Grant No. DE-FG02-06ER84552
Amount: $749,753

The separation and concentration of bioethanol from fermented biomass by distillation is a highly energy-intensive operation. In this project, ethanol-selective pervaporation membranes are being developed to perform the separation. The pervaporation process uses zeolite-polymer (mixed-matrix) membranes to perform the separation. These membranes provide ethanol separation factors that are two- to threefold higher than distillation. By using these membranes, the energy consumption of bioethanol separation is reduced by 30 to 50%. Capital cost savings in construction of the separation plant will also be achieved. In the Phase I program, mixed-matrix membranes were made and shown to have the permeances and selectivities required to provide significantly improved bioethanol separations. Membrane production was scaled up to the bench scale. A small spiralwound module was made and operated successfully. The membranes will be scaled up to the small industrial scale. Four-inch diameter modules with a membrane area of 4 m2 will be made. These modules will be tested and optimized in the laboratory using pilot-scale equipment. The pilot plant will then be demonstrated at an operating bioethanol plant to validate its reliability and efficiency.

Commercial Applications and Other Benefits as described by the awardee: This process is applicable to many bioethanol fermentation separations. However, the simple flow scheme and low-maintenance operation make this process particularly applicable to small bioethanol plants such as cellulose-based bioethanol plants.

80941S06-II Cyc24-1

Membrane Structures for Hydrogen Separation--Genesis Fueltech, Inc., 528 South Cannon, Spokane, WA 99204; 509-534-5787; http://www.genesisfueltech.com/
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Mr. Joseph Phillip Piffer, Business Official, phillip@genesisfueltech.com
DOE Grant No. DE-FG02-06ER84535
Amount: $748,000

The Phase I project addressed the need for a low cost hydrogen permeable membrane, where the purity of the permeated hydrogen is high enough for PEM fuel cell usage. The Phase I work involved forming a thin palladium alloy on a permeable metallic support, where the alloy film was free of porosity or defects. Phase I work was successfully completed with the fabrication and demonstration of a pore-free palladium alloy film, demonstrated in a small purifier module. The Phase II project will consist of extending the Phase I work. The supported membrane will be further developed and fully tested in a scaled-up, integrated purifier module. Tasks will include the determining how thin the membrane can be formed, optimization of the fabrication methods, and whether alternative alloys can provide superior results. Purifier modules will be tested for output and durability in Genesis methanol reformers to establish their suitability for commercialization.

Commercial Applications and Other Benefits as described by the awardee: Genesis believes there are near-term markets in building reformers for remote power applications, military power generation, as well as fuel cell transportation (hydrogen refueling stations, on-vehicle reformers for public transportation buses). While Genesis' reformers are nearly ready for commercialization, the high cost of the hydrogen. purifiers make the units cost-prohibitive. A successful result from this Phase II project will enable the broad commercialization of integrated fuel cell systems. Furthermore, the secondary applications of the purifier itself will benefit other industries as well – from purification for gas chromatographs, to industrial scale applications requiring purified hydrogen.

81301S06-II

Phased Array Ultrasonic NDE of Plasma Facing Components--Acoustic Ideas, Inc., 27 Eaton Street, Wakefield, MA 01880-2448; 781-621-8228; www.acousticideas.com
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Dr. Vincent Lupien, Business Official, vincent.lupien@acousticideas.com
DOE Grant No. DE-FG02-06ER84440
Amount: $750,000

Realizing the promise of nuclear fusion depends in part on effective plasma facing components (PFCs) that can withstand the intense heat loads, forces and neutron bombardment of long pulse high power reactor operation. PFCs in the next generation large scale fusion reactor, ITER, involve Beryllium armor and a Stainless Steel strongback joined to a Copper heatsink. A single reactor such as ITER will require thousands of PFCs. Imperfections in the joints of just one in-service PFC has potentially disastrous consequences to reactor operation; it is therefore imperative to assure quality by nondestructively evaluating the integrity of PFC joints during manufacture, especially given the relatively high incidence of joining defects that is probable with a novel manufacturing process. A suitable NDE approach must accommodate the complex geometries of the components, provide 100% inspection of the joints, yield resolutions of one millimeter or less, and operate as part of the manufacturing process. No prior NDE technique has been identified which is capable of meeting all these requirements. A revolutionary new NDE technique known as phased array ultrasound is an excellent candidate for inspection of PFC joints. This technique has all the advantages of conventional ultrasound, with powerful added capabilities such as: (i) programmable adjustment of focusing depth to achieve the best possible resolution at the desired spot; (ii) versatile adjustment of the beam angle through electronic control for forming images, avoiding obstructing geometry or redundant inspections at several angles; (iii) formation of focused ultrasound beams even when traversing multiple layers of dissimilar materials having complex geometry; and (iv) high speed production inspection through electronic scanning of the active aperture across the face of the transducer array. These abilities of phased array ultrasound meet therequirements of PFC joint inspection. In Phase I, the feasibility of using phased array ultrasound for inspecting PFCs was demonstrated (i) by experimental detection of joining defects in representative PFC specimens using phased array transducers; and (ii) by detailed design and numerical validation of a more advanced phased array transducer customized to the actual 3D geometry of the PFCs. Based on demonstrated feasibility, the objective of Phase II is to develop a prototype phased array system, appropriate for in-line production inspection of PFCs. The new array design obtained and validated in Phase I will be manufactured and tested. Phased array instrumentation capable of driving this advanced design will be developed. The instrument and probes will be demonstrated on PFC mockups representative of the different stages of production, leading the way to implementation in a production setting in Phase III.

Commercial Applications and Other Benefits as described by the awardee: The technology developed under this Phase I SBIR Project will serve a long-standing unmet need for inspection of dissimilar metal bonds with complex geometry. Such scenarios arise not only in various components of fusion reactors, but also in nuclear fission reactors, petrochemical plants, aerospace vehicles and manufacturing industries

81315S06-II

Tungsten Alloy Divertor Concept with Helium Jet Cooling--Plasma Processes, Inc., 4914 Moores Mill Road, Huntsville, AL 35811; 256-851-7653; http://www.plasmapros.com
Mr. John Scott O'Dell, Principal Investigator, scottodell@plasmapros.com
Ms. Angela Hattaway, Business Official, ahattaway@plasmapros.com
DOE Grant No. DE-FG02-06ER84446
Amount: $750,000

Helium cooled refractory metal heat sinks are being considered for the divertor sections for several fusion energy reactor concepts. Recent EU results have shown considerable promise for jet impingement type helium cooling techniques for high heat flux applications. However, because of the small size of the units (1.5-2 cm), a large number of these heat sinks would be needed for the divertor section of a reactor. Recently, a mid-size helium jet-cooled configuration with good heat flux accommodation potential has been designed comprised of concentric tungsten tubes in a "T-shaped" configuration. During this investigation, advanced net shape refractory metal forming techniques are being developed to enable the fabrication of this improved helium cooled tungsten divertor concept. During the Phase I investigation, critical fabrication techniques were developed. Using these techniques, impingement cooled and straight bore tungsten heat sinks were fabricated and tested. Preliminary high heat flux testing demonstrated the ability of a tungsten heat sink with helium impingement cooling to reduce its average surface temperature by ~20% as compared to the average surface temperature for a straight bore tungsten heat sink under the same heat flux. Building on the successes of the Phase I investigation, a mid-size helium impingement cooled divertor configuration will be developed and fabricated to withstand heat fluxes up to 10 MW/m2. To determine the Phase II design, initial scoping studies will be conducted to determine trade-offs between easy of fabrication, thermal induced stresses/strains, and thermal performance. Manufacturing techniques will be optimized and improvements will be thoroughly characterized using metallographic and material properties testing techniques. Using the optimum design configuration, a prototype helium impingement cooled divertor heat sink will be fabricated for quantitative high heat flux testing.

Commercial Applications and Other Benefits as described by the awardee: Helium in combination with an all refractory metal heat sink, affords higher operating temperatures with large changes in gas temperature which can result in increased power conversion efficiency. Compared to other helium cooling techniques, such as the porous heat exchanger configuration, the proposed jet-impingement cooling method could significantly simplify the fabrication of helium cooled refractory metal heat sinks and improve long term reliability and performance. The techniques developed to produce the helium jet cooled tungsten divertor concept will be used on commercial components varying from x-ray targets, crucibles for semiconductor crystal growth, rocket hardware, and wear and thermal protection coatings.

81017S06-II

A Novel Low-Cost Method of Manufacturing Nb3Sn Multifilamentary Superconductors with Multiple-Tin-Tube Sources--SupraMagnetics, Inc., 214 Canal Street, Plantsville, CT 06479; 860-426-1961

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DOE Grant No. DE-FG02-06ER84447
Amount: $738,083

This project will develop and demonstrate an economical Nb**3**Sn conductor manufacturing process based on the multiple-tin-tube (MTT) sources. This will be accomplished by replacing sub-elements having a tin core with sub-elements having tin coating. Greater current density Jc and lower magnetization losses are expected. A potential impact of ~ 20% to 30% conductor cost savings will be realized in comparison to the current state-of-the-art internal-tin core Nb**3**Sn process. In the Phase I, we successfully developed the MTT process and fabricated prototype Nb3Sn conductors demonstrating feasibility. In the Phase II project, optimization of the MTT process on intermediate size billets will be performed. The data will be used to assemble and manufacture a scale-up prototype conductor in the Phase II project. The material produced in the Phase II program will be available for testing and building prototype cables and test magnets at the DOE national laboratories.

Commercial Applications and Other Benefits as described by the awardee: The improved cost-performance for this new MTT Nb3Sn conductor will have an immediate benefit for high field magnet applications. Fusion reactors require confinement of the hot plasma comparable to temperatures found on the sun that will potentially provide unlimited energy for mankind. The successful demonstration of a prototype fusion machine based on an advanced cost effective Nb3Sn conductor will have enormous economic and social benefits to the public. The application of NMR is on the verge of technological explosion with requirements for uses in chemical research, biochemistry, pharmaceutical chemistry, polymer science, petroleum research, agricultural chemistry, and medicine. Giant strides by researchers are being made in understanding of cells, proteins, DNA, and drug interactions to name a few. Any advances in the development of higher performance-cost effective superconductors will help bring these powerful research tools into wider use for the general benefit of the public.

81105S06-II

A Kalman Filter for n > 1 Resistive-Wall-Mode Identification and Feedback Control Modeling--

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DOE Grant No. DE-FG02-06ER84442
Amount: $750,000

While the resistive-wall-mode (RWM) should be stabilized beyond n=1 mode, the edge-localized-modes (ELMs) noise is prevalent for high performance tokamak plasmas. Although a Kalman filter, which discriminates the ELM-noise from n = 1 RWM, has been developed, no Kalman filter has been constructed to include n >1 RWM mode, which will become the performance-limiting instability under n=1 RWM controlled plasmas. The goal of this project is to develop a Kalman filter that discriminates non-RWM (e.g. ELMs) from n > 1 RWM mode, in addition to n = 1 RWM mode. Since a Kalman filter, which discriminates ELM-noise from n=1 RWM mode, was successfully developed, this work will be an extension of the previous achievements including the n > 1 RWM modes. During Phase I, we developed a state-space model that serves as the basis for constructing Kalman filter which is compatible with n=1, and n > 1 RWM modes. Specifically, the n > 1 RWM mode states have been included to the state-space model in addition to the n =1 RWM mode states. The compatibility of these additional states to the n=1 Kalman filter has been assessed. During Phase II, we will construct a state-space model-based Kalman filter compatible with $n \geq 1$ RWM modes. Specifically, the Kalman filter compatible with low-n (e.g. n = 1,2, and 3) RWM modes will be constructed based on noise characteristics from experimental data, as well as on noise modeling. The model validation will be performed in real-time experiments, followed by more advanced controller algorithm development.

Commercial Applications and Other Benefits as described by the awardee: The project is beneficial to provide ELM-discrimination to n > 1 RWM mode, as well as to n=1 RWM mode. As the n > 1 RWM needs to be stabilized on top of n=1 RWM suppression for high performance plasma, the algorithm for ELM-noise discrimination from these low-n RWM modes will be conducive to RWM feedback control.

81113S06-II

Compression of Compact Tori for Cureent Drive and Heating--Woodruff Scientific, LLC, 301 Minor Avenue North, #429, Seattle, WA 98109-5415; 206-697-9401; www.woodruffscientific.com
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DOE Grant No. DE-FG02-06ER84449
Amount: $700,000

Several critical issues stand in the development path of spheromak to a reactor. An important one is the production of strong magnetic fields by use of a low current source. The usual formation of spheromaks by use of a coaxial electrode source suffers from low current amplifications: one important limitation of injecting helicity bearing plasma into a spheromak is encountered as a pressure-limit. In Phase II we propose a new means for generating strong magnetic fields from a low current source, by repetitive injection of helicity-bearing plasma that also undergoes an acceleration and compression, obviating injection limits set by magnetic pressure at the boundary of the target plasma. The new experiment will be supported by computational efforts and analytic modeling. During Phase I we completed computational and analytic studies of the compression and acceleration of two compact tori in support of an experiment at the University of Washington. We used advanced computations run at NERSC and benchmarked against analytic theory to determine the best means for the acceleration, and compression of a compact torus plasma. Our study included detailed simulations of magnetic reconnection. In Phase II we will build an experiment to produce strong magnetic fields in a spheromak by repetitive injection of magnetic helicity from a low current coaxial plasma source, accelerated and compressed by means of a traveling wave adiabatic compression scheme that was previously applied to a mirror plasma. The compression section could also be used to compress an FRC to high temperatures. In Phase III, we would seek industrial partners to build a high field, high temperature spheromak concept as a pre-cursor to a spheromak-based burning plasma experiment.
The aim would be to skip the proof-of-principal stage and go straight to performance extension, based on existing results, and our ability to accurately simulate plasma behavior with existing computational models.

Commercial Applications and Other Benefits as described by the awardee: Energy from fusion, if economic, would be world altering. This technology has the potential of ending a country's dependence on foreign energy sources (oil, coal, gas). The worldwide energy market is measured in the trillions of dollars, and only grows further as the world's population increases and industrializes. A power plant based on this technology, if feasible, would look like existing nuclear facilities (except with a different reactor core).

81168B06-II

Development of a Traveling Wave Accelerating Structure for a Superconducting Accelerator--

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DOE Grant No. DE-FG02-06ER84464
Amount: $700,000

Superconducting rf technology has been recommended recently as the basis for the International Linear Collider, (ILC) accelerating structures. The principal goal of this proposal is development of a new experimental device - the Superconducting Traveling Wave Accelerator (STWA), a technology that may prove of crucial importance to the ILC. The present state of the art in superconducting structures has obtained a gradient of 35 MV/m; the STWA technology in this proposal will further increase the gradient by a factor of 1.20-1.40. We plan to design, develop and demonstrate the Superconducting Traveling Wave Accelerating Structure under the scope of this project. Traveling wave SC accelerating structure need arises from demand for a high accelerating gradient. Proposed STWA structure operates at the same surface magnetic and electrical field magnitudes as the TESLA cavity surface to avoid undesirable superconductivity break down. Operation is with an RF feedback system consisting of a loop waveguide and coupling system. Transit factor increases result in accelerating gradient enhancement by a factor of 1.4 Project includes superconducting structure design and development of the tuning system. Ph.II will apply this design to fabrication of the Superconducting TW Accelerating Structure to be tested at the cryostat of FNAL. The overall goal of the Phase I R&D program was to study traveling wave (TW) superconducting (SC) accelerating structure for ILC that allows an increased accelerating gradient and, therefore reduction of the length (and hence the cost) of the collider. The Phase I objectives have been met. The theoretical studies were performed in order to optimize the proposed design by minimizing the surface fields inside the cavity of the structure, to make the design compatible with existing technology, and to determine the maximum achievable gain in the accelerating gradient. The experimental program for the Superconducting Traveling Wave Accelerating (STWA) structure has been developed. The Phase II SBIR project proposed here by Euclid TechLabs LLC has as its goal theoretical studies, development, and preliminary engineering design of the high-gradient STWA structure suitable for ILC application. As the first step in the study physical principles and technological feasibility of the STWA structure, the experimental program includes engineering design, manufacturing, surface processing and high gradient testing of the single-cell STWA model with a high-power feedback waveguide.

Commercial Applications and Other Benefits as described by the awardee: The main goal of the project is a development of the superconducting accelerating structure with the increased gradient for the linear collider. This structure will allow the total length of the linear collider to be reduced by 20-40% with a corresponding reduction in construction costs. The proposed structure is an inexpensive solution that permits the use of currently available accelerator components.

81171S06-II

Fast Ferroelectric L-Band Tuner for ILC Cavities--Omega-P, Inc., 199 Whitney Ave., Suite 200, New Haven, CT 06511; 203-458-1144; www.omega-p.com
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DOE Grant No. DE-FG02-06ER84472
Amount: $650,000

The interntional accelerator R&D community is focused on development of the next eletron-positron collider ILC based on superconducting RF technology. ILC is expected to achieve a center-of-mass energy of 0.5 TeV, with a possible upgrade to 0.8 TeV. The fast ferroelectric tuner for ILC cavities to be developed in this project is for adjustment during each RF pulse of cavity coupling so as to compensate for unavoidable microphonics and Lorentz force detunings and to reduce the total RF power needed and, as a result, to reduce the refrigeration power needed to remove waste heat from the cavities. It can be shown that use of such fast tuners can help to preserve the quality of the accelerated electron and positron beams, and save up to 6 MW of AC power for the 0.5 TeV ILC, and up to 13 MW for the 0.8 TeV upgrade. A waveguide magic-T with two coaxial phase shifters containing ferroelectric elements is to be designed and built, such that application of a dc voltage pulse across the ferroelectric elements causes a near-instantaneous change in dielectric constant, a shift in phase, and a resulting change in cavity coupling. In this way, the cavity can remain on resonance at the operating frequency and maintain precise phase, and both the cavity filling and decay times can be shortened to reducing the overall RF power needed to energize the cavities, and the total refrigeration power needed to dispose of the waste cavity heat. Design of a coaxial phase shifter for the L-band tuner for ILC cavities was accomplished. This included determining specifications for a ferroelectric ring and alumina rings, design of a coaxial impedance transformer, design of a waveguide-to-coax coupler, thermal considerations, and temperature stabilization requirements. In addition, an alternative planar design that appears simpler than the coaxial design was invented. Arrangements were established with Euclid Concepts LLC for supply of the ferroelectric rings, with Advanced Engineering Systems, Inc. for fabrication of the phase shifter, and with Fermi National Accelerator Laboratory where high-power tests of the tuner will be carried out. Engineering design for the L-band coaxial phase shifter for the tuner will be accomplished, and the phase shifter fabricated to Omega-P specifications. This design will incorporate metallized ferroelectric rings supplied by Euclid Concepts LLC. Tests of the tuner will be carried out at Fermi National Accelerator Laboratory in collaboration with Fermilab staff.

Commercial Applications and Other Benefits as described by the awardee: ILC is to have about 10,000 superconducting cavities, each of which would require a fast ferroelectric tuner of the type to be developed under this grant, should the tuners operate as expected, and should the technical performance justify the initial cost of the tuners. If each tuner can be built in mass production for $500, one sees that a potential market for these devices could be in the range of $5 milliion. But applications can be envisioned in other accelerators, including industrial machines, so the potential market could be even larger.

81374S06-II

Fast Kicker Driver for International Linear Collider Damping Rings--Diversified Technologies, Inc., 35 Wiggins Avenue, Bedford, MA 01730; 781-275-9444; http://www.divtecs.com/
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DOE Grant No. DE-FG02-06ER84459
Amount: $699,877

The overall objective of this effort is to develop solid-state kicker drivers which can meet the very demanding requirements of the International Linear Collider (ILC), and also address a wide range of other kicker driver applications in existing and planned accelerators, synchrotrons, and other particle physics systems. The ILC will use "damping rings", and the cost of each damping ring strongly depends on the speed of the kickers. Solid-state technology is now at a point where it is fast enough to meet the demands of kicker drivers, including those for the ILC. DTI will develop and demonstrate two approaches: the first using commercially available MOSFETs, and the second employing Step Recovery Diode (DSRD) technology. Comparison of the performances of the HV MOSFET and the DSRD, in which the latter exhibited pulse lengths of 2-to3 nanoseconds, resulted in the selection of the DSRD for the final stage of the pulse generator. Measurements confirmed that HV MOSFET technology, as opposed to IGBT technology, was most appropriate for generating the 25-nanosecond pump pulses that drive the pulse compression circuitry and the DSRD switch. Appropriate DSRD diodes for the damping ring kicker driver do not exist. The semiconductor processing and packaging methods for the required high-current, high-voltage DSRD diode stacks will be developed by working with a major US high-voltage semiconductor diode manufacturer. The pump circuit and pulse compression network required for the build of a prototype kicker pulse generator will be developed concurrently with the development of the DSRD semiconductor processing. The performance of a composite system designed to deliver 5kV, 2 nanosecond pulses to a 50 Ohm load according to the ILC pulse protocol will be demonstrated in the 2nd half of year two.

Commercial Applications and Other Benefits as described by the awardee: The major thrust of this proposed effort is to develop and demonstrate the technologies which will move the ILC into reality – by enabling the precise kicker operation needed to handle the desired ILC bunch spacing and energy. The secondary benefit of this effort will be the development of reliable, solid-state kicker pulsers which can meet the needs of a wide range of existing and planned accelerators and colliders around the world.

80384S06-II

Superconducting RF Photocathode Gun for Low Emittance Polarized ELectron Beams--
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DOE Grant No. DE-FG02-06ER84450
Amount: $699,997

Polarized electron beams are important to high energy physics and nuclear physics experiments. At present, linear colliders and nuclear science machines use DC polarized sources, as these are proven to provide polarized beams with good cathode lifetimes and acceptable emittances. However, linear colliders, including the future International Linear Collider, require emittance damping rings that can be large and expensive. A gun that can produce low emittance polarized beams with a reasonable cathode lifetime can reduce or even eliminate the damping ring requirement. A superconducting radiofrequency electron gun using a gallium arsenide photocathode has the potential to produce polarized electron beams with very low emittances while still providing for long cathode lifetimes. The project intends to show that the cathode lifetimes in a superconducting radiofrequency gun can rival the lifetimes achieved in the existing DC guns and that a gun system can be designed with very low electron beam emittances. The Phase I project focused on demonstrating that a cathode lifetime test can be performed in a cost effective manner in Phase II. The Phase I effort also showed through simulations that low emittances can be achieved and that ion backbombardment, which limits the lifetime of cathodes in DC guns, can actually be less than in DC guns. The Phase II project will complete the design of the modifications to the existing cavity and cryostat to be used for the lifetime testing. This testing will be performed near the end of the project. Phase II will also explore the preliminary design of a superconducting radiofrequency gun that would be suitable for use with the International Linear Collider.

Commercial Applications and Other Benefits as described by the awardee: In addition to the above applications, other future applications of the resultant accelerating structure exist within the advanced light source arena. In addition to energy recovery linac facilities for basic research, the electron source could be used in other radiation sources to produce high-power, coherent radiation spanning THz to UV and perhaps beyond, through various mechanisms such as coherent synchrotron radiation and FELs. Finally, the source could find application in defense and as the front end of high-power electron accelerators for materials processing and sterilization.

80385S06-II

An Ultra-Low-Emittance, L-Band, Flat-Beam PWT Photoinjector--DULY Research Inc., 1912 MacArthur Street, Rancho Palos Verdes, CA 90275-1111; 310-548-7123; www.dulyresearch.com
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DOE Grant No. DE-FG02-06ER84460
Amount: $650,000

The International Linear Collider (ILC) needs a polarized electron source capable of producing an electron beam with 85% polarization when illuminated by a circularly polarized laser requires an ultra high vacuum (UHV). Survival of an activated Gallium Arsenide photocathode that can produce such a beam requires an ultra high vacuum. The beam must also have an ultra low vertical emittance and a large ratio of the transverse emittances. The current design of the ILC polarized electron source is based on a dc gun and a subharmonic buncher, followed downstream by a large, expensive damping ring. The proposed approach in this SBIR project is to use an L-band, normal-conducting, polarized electron gun of the Plane-Wave-Transformer (PWT) design that would meet the ILC specifications. Detailed numerical simulations and tradeoff studies based on vacuum, rf, magnet, beam dynamics, thermal hydraulic and mechanical considerations have been performed in Phase I for a short, L-band, PWT photoinjector. A baseline design has been selected for implementation in Phase II. After completion of the detailed mechanical design of a 1.3 GHz, 2-cell PWT gun and an UHV loadlock, we will fabricate and assemble the entire system. Tests will be performed at the Fermi National Accelerator Laboratory in Phase II and Phase III for the dual purpose of demonstrating the survivability of the GaAs photocathode in an UHV rf gun, and generating a low emittance beam from the PWT gun.

Commercial Applications and Other Benefits as described by the awardee: The successful demonstration of the L-band PWT gun as a viable electron source could potentially save the ILC construction on the order of $100M by eliminating the complicated and expensive damping ring. In other applications, the PWT gun could be used as a high brightness electron injector for linear accelerators, synchrotrons, FELs and other light sources. The PWT gun in combination with a high-intensity laser could also be a Compton source for production of ultrafast, copious X-rays for applications in biotechnology, medicine, industry and research.

80386S06-II

Laser Systems Development for the International Linear Collider (ILC) Photoinjector--

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DOE Grant No. DE-FG02-06ER84469
Amount: $654,004

The International Linear Collider is a proposed 40 km-long electron accelerator that will enable the exploration of the high-energy frontier in particle physics. During this SBIR project we will address technical issues related to the front-end of this accelerator-- the electron source. This electron "gun" for ILC is a laser-driven photocathode, and the primary unproven part of this technology is the development of a laser with the required pulse characteristics and average power. In this project we will develop a laser system capable of generating pulse bursts of coherent ~800 nm light, with ~5 μJ energy in each pulse, emitted at a 3 MHz repetition-rate, and with 2820 pulses in each individual burst. The technical approach pursued is to develop an oscillator-amplifier laser system based on titanium-doped sapphire in the required wavlength range. The ILC laser power requirements also dictate that we use a cryogenically-cooled laser medium and 50-100W of "pump" light to power the amplifier. These capabilities have recently been developed at KMLabs, but a laser with the required characteristics has not yet been demonstrated. To test the feasibility of a high repetition rate, cw-pumped amplifier laser system at 3 MHz, we constructed a test bed at repetition rates between 10-250 kHz. We used this test bed to measure single pass gain, mode quality and energy, and to test the architecture that would be used in phase II of this project. We plan to design, construct, test, and install a fully functional prototype titanium-doped sapphire oscillator-amplifier laser system. We will work to meet the specifications of the ILC laser as much as possible. We expect to obtain 1ns output pulses at 3MHz repetition rate, ~5μJ energy in each pulse, with 2820 pulses in each macro bunch.

Commercial Applications and Other Benefits as described by the awardee: This pulsed laser system developed for the ILC will also represent a tunable, short-pulse laser system with unprecedented repetition-rate and average-power characterstics. In addition to its use at ILC, this laser will find use in both basic science, for high-fidelity studies of materials and molecular dynamics, and indutrial and medical applications such as precision laser machining.

80796B06-II

New RF Design of Externally Powered Dielectric-Based Accelerating Structures--Euclid TechLabs, LLC, 5900 Harper Rd. #102, Solon, OH 44139; 440-519-0410; www.euclidtechlabs.com
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DOE Grant No. DE-FG02-06ER84463
Amount: $650,000

Euclid Techlabs LLC, in collaboration with the Accelerator R&D group of ANL submits this proposal to develop a new rf coupling system for the high gradient dielectric loaded accelerator (DLA). The principal goal of this project is to develop a broadband coupling section of an X-band DLA structure to allow high gradient (> 100 MV/m) acceleration demonstration experiments. The new coaxial-type DLA coupler design proposed in this project avoids vacuum gaps between the dielectric sections and thus eliminates any points for potential rf breakdown. It allows us to build a new type of dielectric-based accelerator structure that provides accelerating gradients exceeding 100 MV/m. The coaxial type of the DLA coupler will be designed, developed and high power tested. In this project, instead of using a TE-TM mode converter plus a tapered dielectric matching section, we propose a coaxial-type coupler which can provide simultaneously the required mode conversion as well as the impedance matching transition without using a tapered dielectric and without rf breakdown at the dielectric-vacuum gaps. Our new coupling approach employs a double-input design to eliminate parasitic modes. An X-band broadband coaxial-type coupler allows us to implement a variety of engineering solutions that do not depend on stringent tolerance requirements. Under Phase I of the project, we have fabricated and experimentally tested an X-band traveling wave gapless DLA structure using a coaxial type rf coupler. This prototype accelerator uses alumina as the loading material and operates in the X-band frequency range. Another accomplishment of the Phase I project is the design and fabrication of an X-band power combiner, which is integrated into the coaxial type rf coupler serving as a single- to dual-port transition. The overall structure, including the rf input/output coupler and dielectric loaded accelerating section, was characterized. We have also developed a model for a coaxial type rf coupler for a dielectric based accelerator using high dielectric constant MCT-20 ceramic, with permittivity of 20. Further optimization, fabrication and high power testing of the high permittivity device is planned for Phase II of the project. In this project, a coaxial rf coupler based prototype gapless dielectric based accelerating structure loaded with alumina will be experimentally tested at high power. Design, fabrication and bench tests of the proposed coaxial coupler have been completed in Phase I of the project. With the experience gained in Phase I, we will develop a high gradient MCT-20 dielectric accelerating structure to produce the highest accelerating gradient dielectric based accelerator ever and determine its breakdown field strength. One high power rf test of the gapless DLA structure using the new technology of brazed dielectric tubes will be completed as well. We plan to carry out a beam experiment on gapless DLA structures at the NRL compact X-band accelerator facility (contingent on its availability for the project). Phase II will culminate in a seriesof high power tests at the Naval Research Lab magnicon facility and SLAC X-band klystron facility.

Commercial Applications and Other Benefits as described by the awardee: The coaxial-type, ceramic-based coupling section for the dielectric based accelerator is a key enabling technology for high gradient Dielectric Loaded Accelerator operation. The coupler section proposed in this project will remove a major roadblock to the Dielectric Loaded Accelerator as a high-gradient accelerator that is able to sustain 100 MV/m-scale accelerating gradients.

80799S06-II

Two-Channel Dielectric Wakefield Accelerator--Omega-P, Inc., 199 Whitney Ave., Suite 200, New Haven, CT 06511; 203-458-1144; www.omega-p.com
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DOE Grant No. DE-FG02-06ER84473
Amount: $649,999

A rectangular dielelectric wake field electron accelerator is described with attributes not found in other wake field accelerators. These attributes include continuous coupling between one channel in which drive bunches travel, and the second channel in which accelerated bunches travel, without need for discrete transfer structures; large step-up or transformer ratio in wake field amplitude in the acceleration channel, as compared to amplitude in the drive channel; and rectangular geometry that affords relative ease in precision fabrication of dielectric elements and possible improved beam stability, as compared to conventional cylindrical wake field structures. These factors combine to offer the possibility for achievment of high acceleration gradient as required for a future multi-TeV electron-positron collider. A rectangular two-channel dielectric wake field accelerator is to be built for a proof-of-principal experiment in a collaboration with scientists at Argonne National Laboratory. A scaled-up X-band bench-test model will be built first to assess the effects of wall slots intended to damp higher-order modes. One or more 80-GHz structures will be built for testing at Argonne, using a single 50 nC drive bunch that is expected to generate accelerating fields of about 80 MeV/m. Theory and computations are being carried out to provide a full understanding of the influence of transverse wake forces acting on round and elongated oval cross section bunches. The five-zone rectangular dielectric wake field accelerator structure was analyzed to select tentative designs for an X-band bench-test prototype, and for an 80-GHz structure to be tested at Argonne National Laboratory. The design is characterized by a high transformer ratio that can be greater than 10:1, and by a high acceleration gradient of the order of 80 MeV/m when driven by a single 50 nC bunch. Excitation of higher-order modes has been shown to lead to transverse wake forces similar to those in conventional accelerators, but a number of strategies have been found that may mitigate against these. The X-band bench-test prototype structure will be built and tested to discover if design modifications are needed to account for the influence of wall slots. Then the optimized 80-GHz two channel dielectric wake field accelerator module will be built in a form that is compatible with the Argonne Wake Field Accelerator facility, and collaborative experiment carried out with Argonne scientists. Analysis of means to minimize effects of transverse wakes will be pursued.

Commercial Applications and Other Benefits as described by the awardee: The principal application for the two-beam rectangular dielectric wake field accelerator concept described in this proposal would be for evolution of a multi-TeV collider for high-energy physics experiments. Success in this goal could lead to need for hundreds of modules, each of which could have a commercial value of the order of $100,000. The total market could thus amount to several tens of millions of dollars. However, since the accelerator is modular, it could in principle be built for much lower final energy, as required in medical radiology, industrial processing, and low-energy advanced accelerator research and development. The compact nature of the accelerator should make it competititve with other accelerators used in commercial applications.

80823B06-II

***STTR Project: Development and Demonstration of 6-Dimensional Muon Beam Cooling—**

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DOE Grant No. DE-FG02-06ER86282
Amount: $750,000

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Fermi National Accelerator Laboratory
Batavia, IL

Ionization cooling, a method for shrinking the emittances of a particle beam, is an essential technique for future particle accelerators that use muons. Muon colliders and neutrino factories, examples of these future accelerators, depend on the development of robust and affordable techniques for ionization cooling.This is the overall objective of the combined Phase I and Phase II projects. This proposal is to develop an experiment to prove that effective six-dimensional (6D) muon beam cooling can be achieved using an ionization-cooling channel based on helical and solenoidal magnets in a novel configuration. This Helical Cooling Channel (HCC) experiment will be designed with simulations and prototypes to provide an affordable and striking demonstration that 6D muon beam cooling is understood, thereby overcoming a critical roadblock to intense neutrino factories and high-luminosity muon colliders. In Phase I we invented and developed a novel design of a helical solenoid magnet and emittance matching sections, which we have used to perform simulations of MANX, a 6D muon cooling demonstration experiment. We have adapted a simulation/reconstruction/analysis program that was developed for MICE, a 4D muon cooling experiment. We have made plans for the prototyping of a section of the helical solenoid magnet to test its magnetic, mechanical, and thermodynamic properties. A collaboration was formed to carry out the experiment. The simulation/reconstruction program started in Phase I will be extended and exploited to optimize experimental parameters by improving beam cooling statistical significance, understanding systematic errors, and exploring engineering simplifications and their ramifications. Phase II includes participating in the engineering of the HCC and emittance matching magnet systems, constructing and testing a three-coil prototype superconducting helical solenoid, and working with the Fermilab Muon Collider Task Force to develop a collaborative experimental proposal.

Commercial Applications and Other Benefits as described by the awardee: The applications of the new techniques that will be developed and demonstrated by this project involve very bright muon beams for fundamental research using muon colliders, neutrino factories, and muon beams with new characteristics. The most important application will be an energy frontier muon collider which achieves high luminosity by virtue of small emittance rather than large muon flux. The small emittance in all dimensions that is possible as demonstrated by this project will allow high-frequency ILC RF structures to be used for such a collider and also for a high intensity muon beam that could supply a storage ring used as a neutrino factory.

80826S06-II

Microbunching Free Electron Laser--TKO Research, Inc. (dba STI Optronics), 2755 Northup Way, Bellevue, WA 98004-1403; 425-827-0460; www.stioptronics.com
Mr. Stephen C. Gottschalk, Principal Investigator, scg@stioptronics.com
Mr. Stephen C. Gottschalk, Business Official, scg@stioptronics.com
DOE Grant No. DE-FG02-06ER84487
Amount: $550,000

The Phase I research showed that microbunching undulators in the THz range are technically feasible and can be built in a cost effective way. During phase I we achieved all technical objectives. These were to 1)perform magnetic analysis of the microbunching undulator design by coupling GENESIS with magnetic finite element analysis; 2) perform analysis of THZ waveguide impact on undulator design; 3) Perform engineering design analysis of the microbunching undulator and 4) coordinate with the UCLA collaborators on the final design specifications for the microbunching FEL. Analyses showed that a long microbunching undulator should saturate in 1.8m at a THz wavelength of 200 microns with a seed power of 1-2 kW and e-beam energy of 10 MeV. A short, 50-cm long (16 periods) undulator can be used to study THz IFEL microbunching at high seed level. It should provide a homogeneous modulation for the whole electron beam. The technical approach for the undulator is to use 6th order pole shaping to achieve two plane focusing. The optimized pole shape has advantages for other SASE FEL's and even standard FEL's due to the two plane focusing it creates.

There are several technical objectives for Phase II. This will be a collaborative effort between STI and UCLA. The main goals are 1) Refine the magnetic analysis based on engineering details; 2) Engineer, design, build and deliver two undulators, chicanes and THz waveguides to UCLA for future research 3) Test both the short and long THz waveguides with the 60cm and 2 meter microbunching undulators. These tests entail performing beam propagation measurements and comparing resonant FEL amplification with theoretical predictions.

Commercial Application and Other Benefits as described by the awardee: Future DOE accelerators could use these devices. In addition the United States Navy has a need for the undulator subsystem. Terahertz source can also be used by the Department of Homeland Security purposes. There are no commercial suppliers of these microbunching free electron lasers.

Original Abstract

Tabletop plasma laser accelerators require bunched electron beams as inputs. A terahertz free electron laser is an ideal source of a bunched beam. The addition of a terahertz waveguide permits efficient bunching with low input power. This is also a source of high power, terahertz radiation that has many applications. The overall approach is to develop, test and build two bunching undulator systems with THz waveguides, ancillary magnets and fully turn-key operation specifically targeted to this application.

Commercial Application and Other Benefits as described by the awardee: Future DOE accelerators could use these devices. In addition the United States Navy has a need for the undulator subsystem.

Terahertz source can also be used by the Department of Homeland Security purposes. There are no commercial suppliers of these microbunching free electron lasers.

80198S06-II

Amorphous NEA Silicon Photocathodes-A Robust RF Gun Electron Source--Saxet Surface Science, 3913 Todd Lane, Suite 303, Austin, TX 78744; 512-462-3444; www.saxetsurfacescience.com
Dr. Gregory A. Mulhollan, Principal Investigator, mulhollan@saxetsurfacescience.com
Dr. Gregory A. Mulhollan, Business Official, mulhollan@saxetsurfacescience.com
DOE Grant No. DE-FG02-06ER84475
Amount: $650,000

RF guns using thermionic cathodes are not able to supply the high phase space densities that are required for the operation of a short wavelength FEL. Energy recovery linacs and other cw accelerators mandate the use of RF photoinjectors for generation of the low emittance, high current, high peak charge electrons used in collisions with hadron beams and for electron cooling of hadron beams. The ultraviolet laser systems needed for most RF gun compatible photoemitters are more difficult to manage than those in the visible. Amorphous silicon shows great promise as a negative electron affinity visible wavelength photocathode suitable for RF gun systems. Advantages of amorphous silicon include a high degree of immunity to charged particle flux, low thermal emittance, bandgap tunability when grown as a germanium alloy and low production cost. Amorphous silicon can be grown on a variety of substrates including those transparent at its bandgap enabling transmission mode as well as reflection mode photocathodes to be fabricated .The Phase I research program was geared toward measurements on amorphous silicon with the following objectives: activation procedure, photoresponse and neutral and charged particle interactions. Amorphous silicon surface preparation as well as *in vacuo* treatment was established to achieve negative electron affinity performance. Photoresponse was measured as a function of wavelength and lifetime as a function of background gas and ion exposure. The NEA amorphous silicon photoemitter quality will be improved by best of practices growth using RF PECVD. This will improve the electron diffusion length and thereby the yield. Those characteristics relevant to RF gun operation: emission angle and current density will be measured. Optimization of other features for best RF gun use, including substrate diffusion blocking and simplified preparation methods, will be undertaken.

Commercial Applications and Other Benefits as described by the awardee: The cw accelerators such as energy recovery linacs, for which the product of QE and laser energy is the factor limiting the available current, will find amorphous silicon based RF photoinjectors very inviting. In addition, SASE FELs and other uses that require the lowest possible source emittance are also potential customers. Reliable, low cost photocathode driven RF gun systems could become ready replacements for the diode and triode guns used on medical accelerators (typically S band 5-20 MeV) for production of clinical photon beams and therapy electron beams. An integral photon source can be packaged with a transmission mode photocathode to allow both much better capture efficiency over the presently employed DC gun sources and beam control without requiring a high voltage pulser.

80781B06-II

***STTR Project: Computer Optimized Design of 3D Charged Particle Devices—**Calabazas Creek Research, Inc., 690 Port Drive, San Mateo, CA 94404-1010; 415-661-1562; http://www.calcreek.com
Mr. Robert Ives, Principal Investigator, rli@calcreek.com
Dr. Purobi Phillips, Business Official, purobi@calcreek.com
DOE Grant No. DE-FG02-06ER86267
Amount: $749,962

Research Institution
North Carolina State University
Raleigh, NC

Advance 3D design of charged particle devices involves more parameters than can be effectively explored with manually driven computer simulations. Consequently, the time and cost to optimize designs exceeds available resources. Even 2D designs could be improved if effective, automated processes were available to explore a larger range of parameters. Computer optimization can efficiently explore a far greater parameter space than can be achieved manually. This program will develop powerful and efficient optimization procedures and tools to dramatically reduce the design cost of charged particle devices while improving performance. The Phase I program developed computer optimization procedures and tools and applied them to Pierce and sheet beam electron guns. Results indicated that greater performance levels can be achieved much faster and less expensively than is possible with manual design. The Phase II program will extend the optimization procedures and tools to generalized 3D devices. The program will enhance the speed and performance of the 3D simulation code and develop an intuitive, user-friendly, graphical user interface. The program will include testing and verification of the procedures and results.

Commercial Applications and Other Benefits as described by the awardee: This new design tool will dramatically reduce the design cost and improve the performance of charged particle devices. It will also allow development of new devices that would be impractical using manual design.

80787B06-II

***STTR Project: Particle Tracking in Matter-Dominated Beam Lines—**Muons, Inc., 552 N. Batavia Avenue, Batavia, IL 60510; 757-870-6943; www.muonsinc.com
Dr. Thomas J. Roberts, Principal Investigator, tjrob@muonsinc.com
Dr. Rolland P. Johnson, Business Official, rol@muonsinc.com
DOE Grant No. DE-FG02-06ER86281
Amount: $750,000

Research Institution
Illinois Institute of Technology
Chicago, IL

Most computer programs that calculate the trajectories of particles in accelerators assume that the particles travel in an evacuated chamber. The development of muon beams, which are needed for muon colliders and neutrino factories and are usually required to pass through matter, is limited by the lack of user-friendly numerical simulation codes that accurately calculate scattering and energy loss in matter. This is the overall objective of the combined Phase I and Phase II projects. Geant4 is an internationally supported tracking toolkit that was developed to simulate particle interactions in large detectors for high energy physics experiments, and includes most of what is known about the interactions of particles and matter. Geant4 has been partially adapted in a program called G4beamline to develop muon beam line designs. We propose to continue the development of G4beamline to enhance its graphical user-interface and add other features to the program to facilitate its use by a larger set of beam line and accelerator physicists. In Phase I the graphical user interface of G4beamline was enhanced for greater effectiveness in beam line design and the program environment was extended to Windows XP and Mac OS users. The program is now being developed and debugged by a larger number of accelerator physicists studying muon cooling channel designs and other applications. Additions of space-charge effects and muon polarization enhancements in G4beamline have been investigated. Additional development/debugging as user needs grow, Support of computer farm use for more complex simulations, especially those that require iterative optimization of parameters, Space Charge additions, Polarization interactions, very low energy physics (< 100 eV), working more closely with the Geant4 collaboration to contribute aspects relevant to beam lines with matter, hiring of additional personnel to develop and test G4beamline.

Commercial Applications and Other Benefits as described by the awardee: New discoveries and inventions in muon beam cooling in the last five years have greatly increased the probability that muon colliders and neutrino factories will be the discovery machines of the future. A sophisticated tracking code to develop these machines will permit designers to accurately and realistically improve their performance, enhancing the likelihood that one or more of them will be built.

80790S06-II

Modeling Accelerator Beam Dynamics Including Superconducting RF Cavities--Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
Dr. Peter H. Stoltz, Principal Investigator, pstoltz@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-06ER84485
Amount: $649,925

Modern accelerator designs include superconducting rf cavities. Computer modeling is a main way for scientists to unders tand accelerators, but including sufficiently accurate models of superconducting rf cavities is difficult, especially models that include cavity misalignment. We will combine maps of the superconducting rf cavity fields generated using a self- consistent electromagnetic calculation with an existing particle tracking code. The existing particle tracking code will then be capable of modeling modern accelerators, including effects of, for example, misalignment s. We modeled an ILC- relevant cavity with a detailed electromagnetics code, we developed a tool for converting the detailed electromagnetic results into a map appropriate for particle tracking codes, and we tested the map in a particle tracking code on an ILC- relevant geometry. We plan to develop a full- featured, stand- alone software library from the map generation tool, we plan to develop interfaces with the library to electromagnetic and mapping codes, we plan to develop a catalog of results for cavity maps of various misalignment s and higher - order mode levels, we plan to use the coupled electromagnetic and mapping codes to study the effects of misalignments and higher -order modes on beam dynamics in ILC- relevant structures, we plan to create interfaces to other codes, we plan to create a web- driven front end, and we plan to investigate plun- and- play frameworks.

Commercial Applications and Other Benefits as described by the awardee: The ILC is a multi- billion dollar project, and we believe we will be able to successfully consult on ILCprojects if the Phase II of this project is funded.

80734S06-II

Single Cavity Amplifier for the International Linear Collider--Diversified Technologies, Inc., 35 Wiggins Avenue, Bedford, MA 01730; 781-275-9444; http://www.divtecs.com/
Mr. John Kinross-Wright, Principal Investigator, kinross@divtecs.com
Mr. Michael A. Kempkes, Business Official, kempkes@divtecs.com
DOE Grant No. DE-FG02-06ER84458
Amount: $699,792

The International Linear Collider (ILC) will be the largest and most expensive accelerator built to date. The RF subsystems - encompassing all of the equipment from external, grid power to the delivery of the RF to each of the 20,000 accelerating cavities - represent one of the largest single cost items in the ILC design. The baseline ILC approach requires 600 large power supplies and modulators to drive a multiple beam klystron (MBK) operating at 10 MW peak, then distributing RF power through a complex network of waveguide components, to power multiple cavities in a parallel topology. These RF systems are currently estimated to cost ~$1.2B. They have a key effect on operations, system reliability and uptime, and operating cost. DTI proposes to design and assess a single cavity amplifier (SCA) for the ILC. In this approach, a single amplifier system will drive each accelerating cavity in the ILC. This requires many more discrete systems, but the simplicity of each SCA, combined with the manufacturing learning curves available through the production of 20,000 identical SCAs, appears to offer significant (30 - 70%) overall cost reductions to the ILC RF systems. The performance and reliability of this approach should be superior to the baseline approach. The latest RF specifications for the ILC were carefully reviewed to establish the requirements for the SCA transmitter. Numerous microwave amplifier tubes were surveyed to select the best candidate for prototype transmitter testing in Phase II. The possible high voltage topologies suitable for driving the selected tube were reviewed. The conclusion from this work is that a 1.3 GHz Inductive-Output Tube (IOT) can be combined with a proven DTI solid-state switch cathode pulsing circuit to deliver a compact, high performance transmitter. A preliminary design was completed. This design will be cost effective and mass producible. The basic design created in Phase I will be carefully detailed for construction. The manufacturing costs for the first article as well as 20,000 units will be estimated. The prototype transmitter will then be constructed and tested with the IOT. Use of the pulsed cathode high voltage system will deliver at least 100 kilowatts of peak power from the existing tube. Performance and reliability of the transmitter will be carefully established based on the measured data.

Commercial Applications and Other Benefits as described by the awardee: This design will make high power RF available at low cost, and is applicable to any large, RF system, including other accelerator designs, food processing, wastewater treatment, semiconductor manufacturing, and military systems such as radars and directed energy systems.

80737S06-II

A Choppertron RF Source for High Gradient Accelerator Research--Haimson Research Corporation, 3350 Scott Boulevard, Building 60, Santa Clara, CA 95054-3104; 408-988-6007
Dr. Jacob Haimson, Principal Investigator, haimson@aol.com
Ms. Beverly L. Mecklenburg, Business Official, blmecklenburg@aol.com
DOE Grant No. DE-FG02-06ER84468
Amount: $724,096

A critical issue for multi-TEV linear colliders is the present inability to demonstrate acceptable microwave performance with accelerating gradients of greater than 80 MV/m at RF pulse widths of 100 to 200 nanoseconds. The DOE sponsored U.S. High Gradient Collaboration has determined that U.S. efforts should be focused on identifying the highest achievable practical accelerator gradient and on establishing a preferred working frequency. While the results of studies at CERN, Switzerland and elsewhere have indicated that the desirable working frequency lies in the range of 10 to 20 GHz, and with the 30 GHz program at CERN now terminated, high power test facilities essential for conducting high gradient accelerator research are presently available only at 11.4 GHz in the U.S. (SLAC). Guided by the demonstrated ability of spatially modulated beams to generate high peak power at short wavelengths, this grant application proposes the design, fabrication and testing of a high efficiency, deflection modulation power amplifier (Choppertron), and the construction of a unique test facility so that research and high power tests can be performed on existing advanced design and on new design 17 GHz high gradient accelerator structures. The Phase I research effort investigated novel means of combining a charge enhancement technique with a spatially modulated, high power 500-550 kV electron beam; performed detailed microwave and beam optics analyses; and established the design parameters of a high efficiency 20 MW 17 GHz Choppertron. The design of this power amplifier was based on the use of both an existing HV electron source and an RF drive source, so that during Phase II the new tube can be expeditiously fabricated and then high power tested at the MIT Plasma Science and Fusion Center. Design parameters of a 50 MW Choppertron, requiring a higher voltage electron source, were also established during this Phase I effort. During Phase II, final engineering design and manufacturing documents shall be developed for the 20 MW Choppertron beam centerline components, the solenoid assembly, the evacuated rectangular waveguide transmission and diagnostic components, and the components required for interfacing the existing subsystems with the upgraded test facility. After fabrication and installation of the equipment, a further Phase II objective is to measure the focused and deflected beam characteristics and then evaluate the high power performance of this new 17 GHz Choppertron.

Commercial Applications and Other Benefits as described by the awardee: It is anticipated that the Phase II efforts, if successful, will result in the development of a new, high Efficiency, short wavelength microwave source suitable for high gradient accelerator research and for high peak power commercial applications.

80194S06-II

SiC Semiconductor Switches for Klystron Modulators--GeneSiC Semiconductor Inc., 25050 Riding Plaza, Suite 130-801, South Riding, VA 20152; 571-265-7535; www.genesicsemi.com
Dr. Ranbir Singh, Principal Investigator, ranbir@ieee.org
Dr. Ranbir Singh, Business Official, ranbir@ieee.org
DOE Grant No. DE-FG02-06ER84466
Amount: $650,000

The extremely challenging speed (>3 MHz) and voltage (>5 kV)specifications of Damping Ring (DR) Kicker Modulators for the planned International Linear Collider (ILC) require the development of revolutionary new semiconductor switch technology. In addition, the robustness and reliability of capacitor charging circuits used in 140 kV Marx bank ILC Klystron modulators are enhanced significantly with the availability of sub-50 nanosecond, 12 kV semiconductor switches through a 3-10X reduction in the series connected stages. This voltage specification is beyond the theoretical limit that can be achieved with contemporary Silicon technology, is within the room temperature corona limit, and is compatible with commercially available capacitors. These challenging specifications are enabled by fully exploiting the superior electrical and thermal properties of the emerging power semiconductor material of choice: Silicon Carbide. The inherent high voltage and high frequency capability of SiC makes this project relevant and timely. In the Phase I, a novel SiC device invented recently – the SuperJFET was found to offer the best solution for the challenging requirements. Extensive analytical and 2D device simulations were conducted to accurately model SiC SuperJFET devices and their performance was verified. Test structures were fabricated in a commercial semiconductor foundry to demonstrate critical fabrication steps like reactive ion etching and passivation that enable the realization of these high voltage SiC devices. Fully isolated power modules were designed and fabricated that allows reliable packaging of 12 kV SiC devices. In this Phase II SBIR program, five batches of SiC SuperJFET devices will be designed and fabricated with successively increasing voltage capabilities to meet the program objectives. A high volume Silicon Carbide foundry will allow economical production of SuperJFET devices for successful commercialization with partners.A comprehensive test plan meeting military standards will be implemented.

Commercial Applications and Other Benefits as described by the awardee: Many government and commercial markets have been identified including: (A) Utility Industry: These advanced high power electronic components enable precise reactive compensation, control, and tuning of all circuits, promising unprecedented increases in the efficiency and cost-effectiveness of electricity infrastructure. By increasing AC/DC conversion efficiency, advanced interconnection technologies widen the practical end use of fuel cells, photovoltaics, wind power, batteries, superconducting magnetic storage, adjustable speed drives, and efficient power supplies. (B) Medical Imaging, Industry and Agriculture: High voltage devices are required in medical accelerators for cancer treatment and industrial systems for food irradiation and hospital waste sterilization; (C) Navy Applications: HV devices are suitable for solid state power conditioning systems for high power management as well as high energy weapon systems.

80195S06-II

Short Pulse, Multistage Generator for 200MW RF Sources--Sparktronics, Inc., 23765 Madison Street, Torrance, CA 90505; 310-529-8649; http://www.sparktronics.com
Dr. Joseph Yampolsky, Principal Investigator, jyampolsky@sparktronics.com
Dr. George F. Kirkman, Business Official, gkirkman@sparktronics.com
DOE Grant No. DE-FG02-06ER84477
Amount: $700,000

Short Pulse, Multistage Generator for 200MW RF Sources. Sparktronics, Inc. Future linear collider applications require higher frequency and higher power RF sources. One application requires 150 to 200MW at 12GHz with 130nsec pulse length, in the near term power is needed at this level for testing accelerating structures and components. The power modulator requirement is >450kV with high current square pulse shape. Power modulators are typically limited in risetime therefore pulslengths of 1usec are used followed by RF compression. In order to improve efficiency and reduce the overall system complexity and cost we propose a power modulator to drive RF sources with faster rise time and shorter pulses. The modulator is based on the Tunable Multistage Blumlein concept developed by Sparktronics. This modulator is capable of producing pulses with <30nsec rise time which allows square pulses to be produced with high efficiency. Applying this to>100MW RF source will greatly reduce or eliminate the need for RF pulse compression. It may be possible to directly produce a 200MW RF pulse at 130nsec and 100Hz. A prototype modulator was developed and tested at 110kV, 100nsec pulse length with 30nsec risetime and pulse flat top of 1%. Phase I has demonstrated the feasibility of this concept and produced a design to be developed in Phase II. Phase II will develop and test a tunable multistage generator at 400kV – 500kV, 130nsec pulse length, <30nsec risetime. The completed modulator will be made available for testing with 200MW RF sources.

Commercial Applications and Other Benefits as described by the awardee: The result of the proposed work will make new RF power sources available for testing components of future accelerators. Similar modulators may be utilized in fusion energy research and defense applications. Commercial applications include food processing and radar applications.

80552S06-II

Wind-and-React Magnet Insulation with Low Radiation-Induced Outgassing--Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026; 303-664-0394; www.ctd-materials.com
Dr. Matthew W. Hooker, Principal Investigator, matt@ctd-materials.com
Ms. Lori Pike, Business Official, lori@ctd-materials.com
DOE Grant No. DE-FG02-06ER84456
Amount: $649,977

Superconductors such as Nb3Sn and MgB2 are being considered for use in several government and commercial magnet systems. These materials require high-temperature reaction processes at temperatures on the order of 600 to 700°C, and after heat treatment are brittle and difficult to manipulate. Electrical insulation materials that can withstand the high-temperature process are being developed to allow the superconductor and insulation to be co-processed at elevated temperatures, thereby enabling more efficient magnet fabrication and reducing manufacturing risk. Ceramic-based insulation materials are being developed for direct application onto superconducting wires prior to heat treatment. This will enable more cost-effective wind-and-react fabrication processes to be employed in magnet fabrication. Other benefits of the technology include high dielectric strengths, good mechanical performance, and resistance to radiation. The Phase I work included resin formulation and processing, application process development, and electrical, mechanical, and thermal characterization of the insulation material. A process for applying thin, ceramic-based electrical insulation directly onto continuous lengths of wire was demonstrated. The Phase I also included the preliminary design of an experiment to assess the irradiation-induced gas evolution of the insulation materials. The first year of the Phase II project will continue the development and optimization of the insulation materials and processes, as well as the design and fabrication of a cryogenic dewar system to be used in a low-temperature irradiation study. The second year of the project will involve production scale-up, prototype coil fabrication, and irradiation testing of the insulation materials at an accelerator facility.

Commercial Applications and Other Benefits as described by the awardee: In addition to supporting U.S. high energy physics programs, the insulation systems developed in this program will be useful in the production of next-generation MRI magnets, as well as superconducting motors, generators, and transformers. These materials also have applications in oil and gas recovery and nuclear power generation.

80567S06-II

Plasma Synthesized Doped Boron Nanopowder for MgB2 Superconductors--Specialty Materials, Inc., 1449 Middlesex Street, Lowell, MA 01851-1111; 978-322-1961; http://www.specmaterials.com
Dr. James V. Marzik, Principal Investigator, jmarzik@specmaterials.com
Dr. James V. Marzik, Business Official, jmarzik@specmaterials.com
DOE Grant No. DE-FG02-06ER84478
Amount: $649,922

Controlled chemical doping of magnesium diboride (MgB2) has been shown to substantially improve superconducting properties to the levels required for high field magnets, but consistent dopant concentrations and homogeneity are difficult to accomplish through the usual route of solid state reaction and diffusion. Furthermore, a high quality source of doped boron needs to be established to advance the state of the art and to ultimately commercialize MgB2 superconductors. Gas phase plasma synthesis of boron powder in which dopants and boron are atomically mixed in the plasma will produce batches of nano-sized doped boron powder. Initial experiments using plasma synthesis methods proved satisfactory to prepare carbon-doped boron powders suitable for the fabrication of high performance MgB2 conductors. At 20 K, critical current density (Jc) values of 105 A/cm2 are obtained at 2 Tesla and at 5 K, Jc values of 105 A/cm2 are obtained at 4-5 Tesla. A systemmatic investigation of several dopants including carbon, titanium, and silicon carbide will be carried out. MgB2 wires will be fabricated by the powder-in-tube method and their superconducting properties measured. In Phase I, the plasma synthesis method was further investigated for producing doped boron nanopowder suitable for use in commercially viable MgB2 superconductor wire. Boron powder doped with carbon and titanium, was converted to MgB2 superconducting pellets and multifilament powder-in-tube (PIT) wires and the superconducting properties were measured.The effect of parameters such as dopant level, powder particle size, and wire processing temperature on the superconducting properties was investigated. Carbon doped MgB2 was fabricated into 19-filament wires and yielded upper critical magnetic field of 37T, equal to the highest values yet attained for bulk MgB2 materials. Small boron particle sizes (<100nm) enabled excellent superconducting properties at low wire processing temperatures (<700C°). In Phase II, carbon, titanium and silicon carbide will be investigated as dopants and optimum compositions will be defined. The effect of powder particle size, purity, dopant concentration, and chemical homogeneity on the superconducting properties of MgB2 will be systemmatically investigated. Fundamental plasma processing parameters for the optimal synthesis of boron nanopowders will be developed. The improvement and optimization of doped boron nanopowder as a feedstock for the powder-in-tube MgB2 wire manufacturing process will be an ultimate objective of this program.

Commercial applications and other benefits: Chemically doped MgB2 superconducting magnets can perform at least as well as NbTi and Nb3Sn in high field magnetic fields and still offer an improvement over the latter in terms of operating temperature. These characteristics make doped MgB2 an effective material for high magnetic field applications, such as particle accelerators, confined fusion and medical MRI devices. Cheaper and more efficient medical MRI devices could lower examination costs, find potential health problems earlier, and thus benefit society as a whole. Other potential commercial applications for this material are electric industry devices, thus lowering the cost of delivered electricity.

80578S06-II

An Extrudable Low-Cost Nb3Sn PIT Conductor for Applications to HEP Magnets--

SupraMagnetics, Inc., 214 Canal Street, Plantsville, CT 06479; 860-426-1961
Dr. Leszek Richard Motowidlo, Principal Investigator, LMOTO@cox.net
Dr. Leszek Richard Motowidlo, Business Official, LMOTO@cox.net
DOE Grant No. DE-FG02-06ER84482
Amount: $649,957

This project will develop and demonstrate an economical hot extrudable powder-in-tube (PIT) Nb3Sn process for use in magnets for future High Energy Physics (HEP) accelerator research. In the Phase I and Phase II program, a new low-cost intermetallic powder will be developed and implemented with an advanced high performance powder-in-tube (PIT) Nb3Sn design for hot extrusion and drawing. The goal of Phase II is to optimize the extrusion parameters and demonstrate scale-up feasibility for large scale applications in HEP and the commercial sector. In the Phase I, we successfully developed the phase pure intermetallic powder and fabricated prototype Nb3Sn conductors demonstrating feasibility. In addition, we have prepared and hot extruded multifilament billets by the PIT approach. Analysis of the cost-performance of this approach, suggest that this technology will meet the DOE goals. In the Phase II project, further optimization of the hot extrusion approach for multifilament Nb3Sn billets will be performed. The powder manufacture and advanced PIT designs will be fabricated on intermediate size billets. The data will be used to assemble and manufacture a scale-up prototype conductor in the Phase II project. The material produced in the Phase II program will be available for testing and building prototype cables and test magnets at the DOE national laboratories.

Commercial Applications and Other Benefits as described by the awardee: The improved cost-performance for this new PIT Nb3Sn conductor will have an immediate benefit for high field magnets in HEP applications. Particularly, second generation LHC Interaction Region Magnets including both quadrupole and dipole magnets will require bigger apertures and higher peak fields. Another important application for Nb3Sn superconductors are fusion reactors. The successful demonstration of a prototype fusion machine based on an advanced cost effective Nb3Sn conductor will have enormous economic and social benefits to the public. The application of NMR is on the verge of technological explosion with requirements for uses in chemical research, biochemistry, pharmaceutical chemistry, polymer science, petroleum research, agricultural chemistry, and medicine. Giant strides by researchers are being made in understanding of cells, proteins, DNA, and drug interactions to name a few. Any advances in the development of higher performance-cost effective superconductors will help bring these powerful research tools into wider use for the general benefit of the public.

80809S06-II

Diamond Detectors--Coating Technology Solutions, Inc., 36 Munroe Street, #1, Somerville, MA 02143-2009; 617-625-2725
Dr. Roy Gat, Principal Investigator, roy@generalcvd.com
Dr. Roy Gat, Business Official, roy@generalcvd.com
DOE Grant No. DE-FG02-06ER84455
Amount: $650,000

Charged particles accelerators are key tools in the study of fundamental properties of matter and energy. The accelerators often cost billions of dollars but are only as effective as the detectors in them. Man made (CVD) diamond provides a relatively new material with unusual radiation hardness and high charge carrier mobility that make it superior to existing silicon solid state detectors in both dosimetry and analysis of collision products. This proposal aims to utilize man-made diamond to cost effectively manufacture detectors to improve the utilization of charge particle accelerators. Novel process for manufacturing high quality man made diamond specifically for detector applications is proposed. The proposed process is anticipated to be cost efficient relative to existing approaches. In Phase I, we achieved near state of the art performance and an indication for a simple method for improving performance. In phase II, new state of the art will be reproduced and established, deposition and post deposition processes will be enhanced and two geometries of prototype high performance diamond detectors will be built and tested.

Commercial Applications and Other Benefits as described by the awardee: Recently, in increasing numbers of cases, charged particle radiation therapy was effective in destruction of cancerous growths, prolonged life and even led to recovery. Diamond detectors exhibit tissue equivalence- a critical requirements for accuracy in dosimetry for human irradiation. This property directly improves survival rates for cancer patients. High quality diamond offers unusual ability to provide electronic functionality at extremely high temperature, it will likely find applications in high temperature electronics such as in power management and conversion applications and other high power density electronics such as in millimeter wave telecommunication and radar systems.

80813S06-II

Advanced Photodetector for Dark Matter Studies--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
Dr. Gerald Entine, Ph.D., Principal Investigator, GEntine@rmdinc.com
Dr. Gerald Entine, Ph.D., Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-06ER84474
Amount: $650,000

Optical detectors are a very important component of existing as well as future particle physics experiments including those being developed for dark matter studies. Performance of experimental systems used in dark matter studies is limited by the properties of the optical detectors available at present. The goal of the proposed project is to investigate new, robust, large area avalanche photodiodes (APDs) for detection of scintillation light emitted by liquid xenon for eventual use in dark matter studies. During the proposed project, the new APDs will be built and evaluated which will include detection of scintillation light from liquid xenon.
The Phase I project was aimed at demonstrating the feasibility of applying the new APDs towards dark matter experimentation. The proposed photodetector was built and tested. The performance of the new APDs in detecting scintillation light from liquid xenon was evaluated. Noise, energy resolution and temporal response were measured. The Phase II project will be aimed at optimizing the performance of the new, robust APDs for dark matter detection. Reduction in noise for large sizes and further improvement in UV response is planned. Extensive evaluation of large APDs in LXe scintillation detection studies is planned.

Commercial Applications and Other Benefits as described by the awardee: The proposed low cost, robust, high gain APD with large areas will have major impact on a variety of particle physics experiments. This includes eventual implementation for detection of scintillation light from LXe in project(s) aimed at search for dark matter. Over and above the use in particle physics, the new detectors will be applicable to nuclear medicine, space research, homeland security, environmental monitoring and material science studies.

80408T06-II

***STTR Project: Interactive Physics Data Analysis Using Streaming Grid Technology—**Deep Web Technologies, LLC, 301 North Guadalupe, Suite 201, Santa Fe, NM 87501; 505-820-0301; www.deepwebtech.com
Dr. Geoffrey Fox, Principal Investigator, gcf@indiana.edu
Mr. Abe Lederman, Business Official, abe@deepwebtech.com
DOE Grant No. DE-FG02-06ER86271
Amount: $748,957

Research Institution
Indiana University
Bloomington, IN

Physics analysis of the huge volumes of data expected from the LHC by a broad range of institutions requires a light weight highly interactive approach that is fully compatible with basic LHC Grid systems and has modest network and computing requirements on the user. The same requirements are seen in a wide range of data analysis and data mining problems from Biology, Chemistry, Earth and Environmental Science and Homeland Security. We have developed a general distributed data analysis architecture with collaborative clients linked by a publish-subscribe system to analysis engines (Rootlets) typically located near the data samples for which they are responsible. This supports streaming low bandwidth data to the user and a federated metadata framework to identify those Rootlets needed for a given analysis job. Phase I developed the concept and architecture and a proof of concept that was successfully demonstrated at SC06. The architecture is hierarchical and can scale to large world wide systems and can be used not just for ROOT as in our prototype but other data analysis systems. We also demonstrated a Grid-based information retrieval system that can help user choose the data needed in their analysis. We will build a deployable version of our proof of concept and test it a widening range of CMS and LHC data analysis examples. This production physics analysis system builds on existing LHC Grid technology with the new capabilities linking four key technologies; ROOT from CERN and Clarens, NaradaBrokering and federated information retrieval from Caltech, Indiana and Deep Web Technologies respectively. We will demonstrate the generality of the approach by also applying it to the statistics package R and applying it Cheminformatics.

Commercial Applications and Other Benefits as described by the awardee: Data analysis is a broadly important area and more and more fields are seeing the data deluge require distribute analysis systems. Commercial applications of this technology include Homeland security to support distributed surveillance sensors and the Pharmaceutical/Biotechnology industries for distributed high throughput screening. Sensor nets in earth and environmental science and distributed information retrieval also can benefit from our distributed hierarchical analysis architecture.

80987S06-II

Development of Real-Time Dynamic Super-Element Partitioning--Alpha STAR Corporation, 5199 East Pacific Coast Highway, Suite 410, Long Beach, CA 90804; 562-985-1100; http://www.alphastarcorp.com
Dr. Frank Abdi, Principal Investigator, fabdi@alphastarcorp.com
Dr. Kay Matin, Business Official, kmatin@alphastarcorp.com
DOE Grant No. DE-FG02-06ER84658
Amount: $749,998

The ever-increasing size of computational structural mechanics (CSM) simulations in energy and other key national industries imposes a pressing need for commensurate increases in computational speed to keep costs and computation times in check. Alpha STAR Corporation (ASC) proposes a three-pronged approach to ultra-large-scale CSM simulations and ultra-high speed computing. First, ASC will enhance and demonstrate the high-performance computing (HPC) approach developed in Phase I using real-time dynamic super-element forced partitioning. In a perturbation/trade study type analysis, this capability can reduce computation time by a 2 to 3 order of magnitude. Next, making use of the Team's unique experience with reconfigurable computing, we will extend the Phase I algorithms to computational structural modeling and simulation on non-Von Neumann computer architectures. The focus will be on developing robust software for ultra-rapid evaluation of ultra-large scale structural problems using parallel processing software and field programmable gate array (FPGA) chips. The third emphasis will be development and demonstration of a unique single-element formulation for closely solving the stress field in the region of a circular hole in a tension loading. This finite element can be integrated into a larger commercial finite element analysis (FEA) codes providing higher-accuracy solutions with fewer total degrees-of freedom. The methodology also lends itself to a distributed or parallel processing configuration; using super-element "sub-structuring" style analysis partitioning. Our Team will consist of Alpha STAR Corporation, Long Beach, CA, Continuum Analysis Technologies Incorporated (CAT), sub-contractor Dr. O.O. Storaasli (Oak Ridge National Laboratory, Knoxville, TN) and consultant Dr. J. Sobieski (Distinguished Research Associate, NASA Langley Research Center). This Team has successfully delivered advanced engineering software, including *NASA Software of the Year Award (1999), R&D 100 Award 2000, U.S. Senate Tibbetts Award 2001, and CAIB Team Award 2004* for the GENOA advanced structures strength and life prediction virtual testing suite. GENOA made intimate use of the GPS fast matrix solver, developed by Dr. Storaasli at NSA/LaRC, to greatly speed the analysis process.

Commercial Applications and Other Benefits as described by the awardee: The proposed effort will produce powerful, affordable software for rapid ultra-large scale engineering problem analysis. This will greatly reduce the excessive times/costs currently associated with configuration changes and design analyses of automotive and aerospace vehicles. Our final HPC algorithms for ultra-large scale system of equation solvers will be applicable to a wide range of physics and engineering disciplines.

81274S06-II

A Model Management System for Numerical Simulations of Subsurface Processes--Vista Computational Technology, LLC, 7754 Hathaway Lane, Fort Collins, CO 80528-8912; 970-231-9579; http://www.vistacomputational.com
Dr. David W. Zachmann, Principal Investigator, dzach@mesanetworks.net
Dr. David W. Zachmann, Business Official, dzach@mesanetworks.net
DOE Grant No. DE-FG02-06ER84661
Amount: $748,111

Numerical models related to subsurface fluid flow, contaminant transport and chemical and biological reactions play key roles in several DOE program areas. Decision makers and stakeholders dealing with groundwater issues need to determine, of the large number of models available, which models have the potential to produce useful information. At present, decision makers have no systematic, information technology based method for identifying simulation models that meet a set of specified requirements for use on a given project. The goal of the combined Phase I and Phase II parts of this project is to create a Model Management System for use first in the area of numerical simulations of subsurface science phenomena and subsequently in other physical science areas. To accomplish this goal requires the development of several innovative techniques for creating and managing metadata. Development of a preliminary ontology for subsurface science simulations Models. Construction of a model metadata vector with a sufficiently rich structure to enable a detailed description of each model and quantitative comparisons of different models using a cosine metric. Creation of a prototype relational database of mathematical models that simulate subsurface flow, heat transport and chemical and biological reactions. Initial development of a web site that enables users to use a “model choice wizard” to assist in identifying models appropriate for use on a particular problem. Initial beta testing of the prototype Subsurface Sciences Model Management System and web site. Continue development of the Subsurface Sciences Model Management System. Augment the current cosine based model comparison metric with a Latent Semantic Analysis metric. Add a wiki (a set of web pages for community editing) to the model management system to provide a forum for model users to discuss models and share data assemble and post sample data sets for several of the most frequently used models. Develop a generic model management framework that can be applied several areas of the physical sciences. Continue development of tools for creating and managing metadata and prepare to market these tools.

Commercial Applications and Other Benefits as described by the awardee: A web based model management framework that we will use in several physical sciences areas in Phase III.A fully developed model management system for subsurface science related codes. A marketable suite of metadata management tools

80411T06-II

***STTR Project: An Interdisciplinary Software Environment for Earth Sciences**—3DGeo Development Inc. 4633 Old Ironsides Drive Santa Clara, CA 95054-1846; 408-450-7840; www.3dgeo.com
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DOE Grant No. DE-FG02-06ER86263
Amount: $750,000

Research Institution
Stanford University
Stanford, CA

The objective of this Phase II project is to develop a software environment, prototyped in Phase I, to manage computational and visualization intensive interdisciplinary projects in the Earth sciences. Complex technologies in the oil and gas industry are today creating tremendous resource, integration, and data challenges. The Phase II project is partly an attempt to address these challenges. The proposed Phase II system will consist of a Gridenabled platform with an advanced graphical user interface providing *tip-of-finger* access to a diverse set of tools and applications in the oil and gas industry. All application modules will abide by a new uniform data format developed in Phase II. The value proposition realized at the conclusion of the present project will be the inclusion within the G-INSP framework of a large set of advanced earth sciences applications from Stanford University, and specialized features for collaboration and remote visualization developed jointly by the two STTR partners. In addition to standard applications, such as depth imaging and reservoir simulation, the Phase II system will include tools for automatic model updating and optimal control of oil and gas full-field models. These are fundamental components of the Instrumented Oil Field. In this regard, the proposed environment can be considered as a primary platform for the Instrumented Oil Field.

Commercial Applications and Other Benefits as described by the awardee: We believe the outcome of the Phase II project will be a major evolutionary advance over existing practice in the oil and gas industry. It will be an important step toward the efficient utilization of applications, and computing and data resources for the oil and gas industry, and will contribute to exploration and production of energy in challenging areas such as the deep Gulf of Mexico.

81124S06-II

Dynamically Reconfigurable Network Interface Framework--Acadia Optronics, LLC, 1395 Piccard Drive, Suite 210, Rockville, MD 20850; 301-332-2900; www.acadiaoptronics.com
Mr. Edward Walter Hagley, Principal Investigator, edwardhagley@acadiaoptronics.com
Dr. Jesse Wen, Business Official, jessewen@acadiaoptronics.com
DOE Grant No. DE-FG02-06ER84513
Amount: $749,958

As network speeds increase beyond 10 Gb/s, software-based implementations of network functions are unable to keep pace. There exists the need for network interfaces that can be easily reconfigured at the hardware level to provide the user with any desired functionality from real time intrusion detection to remote visualization. This effort seeks to develop a framework for an adaptable Network Interface Controller (NIC) based on reconfigurable hardware to remove the bottlenecks present in current network/computer system architectures. In Phase I, a feasibility study of the framework, including consideration of potential target physical devices and development of sample applications, was performed. The primary objectives of this study were to clearly define a virtual network machine, produce a network application program interface, and to generate code samples for further development. The Phase I research was expanded to include studying the host operating system and performing initial hardware prototyping, as a prelude to a larger Phase II effort In Phase II, the Phase I feasibility study and preliminary hardware demonstrations will be transitioned into a complete system ready for commercialization. The initial VNM/NAPI framework baseline specification will be significantly expanded and will be used in conjunction with a specialized hardware offload NIC to demonstrate a comprehensive hardware prototype. Finally, a client configuration application which demonstrates local and remote reconfiguration of the network interface and its plug-in modules will be produced.

Commercial Applications and Other Benefits as described by the awardee: The proposed NIC framework will remove the end-user bottlenecks present in high-speed data transmission by allowing users to transition from software-based network implementations to much faster on-card hardware-based solutions. The framework, comprised of a virtual network machine, a network application program interface, and an easy-to-use client configuration tool for end-users, will provide an extremely flexible platform for a variety of applications ranging from high-speed client interfaces to supercomputing. Such a framework is ideally suited to meet the specialized needs of the DOE community and other government agencies in the areas of high-performance networking, security, storage area networks, and supercomputing. Eventually, it is anticipated that corporations may deploy cards with such a framework to secure their networks and apply network policies at the hardware level.

80219S06-II

Dynamic Path Scheduling Through Extensions to Generalized Multiprotocol Label Switching (GMPLS)-Implementation & Demonstration--Lambda OpticalSystems Corporation, 12100 Sunset Hills Road, Suite 100, Reston, VA 20190-3233; 703-689-9500;
http://www.lambdaopticalsystems.com
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DOE Grant No. DE-FG02-06ER84515
Amount: $750,000

In current IP networks, service is initiated at the time of service request. Upon a receipt of a service request, the network checks to determine if capacity is available to satisfy the needs of the service request. If sufficient capacity is available, service is initiated while if sufficient capacity is not available, the service request is rejected. This mode of operation introduces problems for some types of scientific users who require network service at a specific data rate at a specific time in the future and specific duration, for example at the occurrence of some scientific phenomena. The technology required to implement these enhancements involves two major developments: 1.) algorithms to perform path generation for scheduled service, 2.) enhancement to the GMPLS signaling and routing protocols to include time based service. These developments will be performed in terms of the IETF GMPLS network infrastructure. The algorithms will be implemented within a GMPLS Path Computation Element (PCE) architecture as recently specified in RFC 4655. The existing GMPLS signaling protocol, RSVPTE), and the routing protocol, OSPF-TE, will be enhanced with time based signaling objects enabling the reservation of resources for future service and the activation of service at the required time. Phase I formulated new scheduling algorithms and the specification of GMPLS protocol enhancements to support scheduling. The work resulted in 1.) innovative scheduling algorithms using min-plus algebra that will efficiently compute the time based schedule paths and 2.) specification of both the signaling and routing objects for all applicable GMPLS protocol messages. It was concluded that the implementation of these enhancements is feasible. Phase II will involve the development of a proof of concept prototype that will demonstrate these enhancements in a realistic hardware-software environment. We have co-ordinated with the Naval Research Laboratory in Washington, D.C. to perform the demo using ATDNET nodes. It is also planned to standardize the proposed modifications to the GMPLS protocols and the PCE infrastructure by working with telecommunications carriers and the IETF/ITU standards community. The specific PCE scheduling algorithms will remain proprietary and provide us leverage in marketing our products.

Commercial Applications and Other Benefits as described by the awardee: To commercialize technology, it is planned to develop a portable implementation of both the PCE and GMPLS protocols that use the LINUX operating. We envision selling these products to both government and commercial network operators.

80754T06-II

***STTR Project: Integrated Scalable Parallel Firewall and Instrusion Detection System for High-Speed Networks—**GreatWall Systems, 635 West Fourth Street, Suite 200, Winston-Salem, NC 27101; 336-918-4665; http://www.grwall.com/
Dr. Errin Wesley Fulp, Principal Investigator, fulp@wfu.edu
Mr. Robert Estes Anderson, Business Official, randerson@greatwallsys.com
DOE Grant No. DE-FG02-06ER86274
Amount: $749,900

Research Institution
Wake Forest University
Winston-Salem, NC

This project aims to develop a new scalable network Intrusion Protection System (IPS) that can manage increasing traffic loads, higher network speeds, and strict Quality of Service (QoS) Requirements.Intrusion Detection Systems (integrated firewall and intrusion detection system) inspect arriving packets for malicious content (signatures) as defined by a security policy. Unfortunately, comparing packet headers and payloads against a policy can be complex and time-consuming. This becomes more problematic as polices and network speeds continue to increase. As a result, the IPS and, more important, the network it protects can be quickly overwhelmed and susceptible to Denial of Service (DoS) attacks. New IPS architectures that can support increasing network speeds and traffic loads as they minimize the impact of DoS attacks are needed, as described by the *letters of support* from ORNL, BNL, and LANL for this project. This project aims to develop a new scalable network IPS architecture that consists of an array of processors, configured in parallel, that collectively enforce a security policy. Unlike current data parallel designs that distribute the packets and duplicate the policy rules (load balancing), this proposed system will use a function parallel design that distributes the policy rules across the processors and duplicates the packets. This design has several unique advantages, including lower delays, scalability, and ability to maintain Quality of Service (QoS).During Phase I, methods for optimally reorganizing and distributing the policy rules across the function parallel firewall were developed. These software tools can be used to improve the performance of legacy firewalls as well as the proposed parallel firewall. A prototype function parallel firewall system was also developed, tested, and analyzed. Experimental results showed the proposed architecture is more than *m* times faster than an equivalent data parallel system, where *m* is the number machines in the parallel array. These promising results provide a strong foundation for the Phase II project. The Phase II project will develop a parallel Intrusion Detection System (IDS). Concepts used for the parallel firewall will be used to develop the IDS, such as distributing policy rules across the parallel system. The parallel IDS will then be integrated with the firewall to create a high speed IPS. The system will be developed on the more scalable blade server architecture, which consists of multiple compute blades interconnected through a high speed midplane. Additional firewall language support will also be added to the optimization and distribution software tool.

Commercial Applications and Other Benefits as described by the awardee: The proposed device is vitally needed at the various sites connected via the DOE Ultra-ScienceNet, specifically at ORNL, BNL, and LANL. This need is clearly stated in the attached letters of support. Furthermore, any corporation (i.e. banks, insurance, airlines, manufactures, internet multimedia content providers, managed network service providers, etc.) that must move large amounts of critical data in real time across the network would benefit from this technology.

80762S06-II

Achieving a High Level of Scalability in Federated Information Retrieval--Deep Web Technologies, LLC, 301 North Guadalupe, Suite 201, Santa Fe, NM 87501; 505-672-0007; www.deepwebtech.com
Mr. Abe Lederman, Principal Investigator, abe@deepwebtech.com
Mr. Abe Lederman, Business Official, abe@deepwebtech.com
DOE Grant No. DE-FG02-06ER84659
Amount: $499,078

A federated search engine that is capable of searching, aggregating and ranking more than a small fraction of the scientific content that is produced by and of interest to the research community at large and DOE researchers in particular does not exist. Thousands of sources of valuable content exist but a solution has not been developed that ensures that scientific discoveries already made can be easily found and leveraged to further advance science. We are developing sophisticated tools that instrument and monitor the performance of a highly complex distributed Web Services-based application. We will be implementing and testing a number of key performance enhancements to Explorit that will enable to scale to searching thousands of sources by thousands of users. In Phase I of this SBIR project we instrumented our existing Explorit federated search product and identified a number of performance bottlenecks. We laid the groundwork for turning Explorit into a highly scalable federated search engine. In Phase II of this project we will address the challenges of enhancing our state-of-the-art federated search engine so that it is highly scalable and can support searching thousands of sources in parallel by thousands of users. In Phase II we will develop and utilize sophisticated performance monitoring tools to accomplish our scalability goals.

Commercial Applications and Other Benefits as described by the awardee: National laboratories, major research-oriented universities, and the research departments of large Corporations including pharmaceutical and biotech companies, oil and gas companies, legal research firms and financial institutions are potential markets for our high-performance scalable federated search engine. In particular two of DWT's current commercial clients have a need for a highly scalable federated search product.

81255S06-II

rDistributor - Remote Distribution of Complete Application Environments--rPath, Inc., 1121 Situs Court, Ste 290, Raleigh, NC 27606-4165; 919-851-3984; http://www.rpath.com
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DOE Grant No. DE-FG02-06ER84505
Amount: $737,344

The objective of this project is to enable use of any available grid resources by running applications inside a virtual machine hosted on the physical grid systems. Grid resource providers install system virtualization software on the physical grid systems, providing a uniform virtual grid environment. Researchers package their application with the application's execution environment and distribute the complete application image in a virtual machine format. Applications packaged in this way are able to run unchanged on any virtual grid resource, regardless of the underlying physical grid environment. In Phase I of the project, the Solenoidal Tracker at RHIC (STAR) application from Brookhaven National Laboratory, a large scale nuclear physics application, was packaged in a virtual machine format. The virtual machine was then run on a virtual grid provided by Argonne National Laboratory. Phase I was successful in proving the capabilities of virtual grid computing, but the overall process required several manual steps and was closely tied to the virtual grid environment as provided by Argonne. In Phase II the project will automate the manual steps in the current process, allowing researchers to go directly from application packaging to job submission on the virtual grid. Additionally, applications packaged as virtual machines will be able to “contextualize” themselves based on information provided by the grid environment, allowing a single, generic application image to be run anywhere on the virtual grid. Finally, application environments will be enhanced to measure and track their resource consumption so that they can report resource usage back to the grid environment. The ultimate success of this project will result in a commercial product that delivers a new model of distributed computing to enterprise customers. This new model will split the traditional roles of the operating system, hardware support and application support, in two. Hardware will be deployed in clusters running server virtualization software, while applications run in virtual machines each with their own complete operating environment. The result is a more flexible hardware infrastructure that can be upgraded or expanded independent of the applications. Likewise, applications can be developed and tested in their own environment and then deployed as virtual machines anywhere in the virtual infrastructure. This new model of computing will deliver enterprise customers greater flexibility in their distributed computing infrastructure while increasing the utilization of those same resources. Enterprises will be able to rapidly promote applications from development to production by reducing the amount of testing required to validate the application across multiple production platforms. Finally, enterprises will be able to quickly respond to changes in application demand by deploying more application images to available virtual infrastructure.

Commercial Applications and Other Benefits as described by the awardee: Large scale grid computing is critical to researchers in Nuclear Physics, High Energy Physics, Climate Modeling, Genomic Research, and many other scientific pursuits. Grid organizations such as the Open Science Grid (OSG), TeraGrid, and the Enabling Grids for e-Science (EGEE) have assembled thousands of systems across widely distributed computing facilities. However, the inherent heterogeneity of those assembled systems – different operating systems, system libraries, compilers, etc. – pose a significant challenge to researchers who wish to run their applications on any available grid resource.

81126S06-II

Low Noise SQUID Array Amplifiers for High Speed Applications--HYPRES, Inc., 175 Clearbrook Road, Elmsford, NY 10523-1109; 914-592-1190; http://www.hypres.com
Dr. Masoud Radparvar, Principal Investigator, masoud@hypres.com
Mr. Steve Damon, Business Official, sdamon@hypres.com
DOE Grant No. DE-FG02-06ER84499
Amount: $749,776

Digital signal processing electronics are needed to replace analog circuitries for high-speed applications such as nuclear physics instrumentation. Superconducting electronics are ideal candidates for these applications as their speed of operation can easily approach 40 GHz utilizing small scale integrated circuit fabrication technology. However, the output voltage levels in super-conducting logic gates are too low to be instrumented with conventional electronics for further processing. This SBIR project addresses the development of a low noise Superconducting QUantum Interference Device (SQUID)-based amplifier and associated cooled semiconducting-based amplifier chips as interface between high-speed superconducting processing electronics and room temperature digital processing peripheral electronics. SQUIDs are ultra-high speed devices which are extremely sensitive detectors of magnetic flux and can be used as low noise amplifiers. They dissipate very low power and, as a result, can be also integrated with detectors where low power dissipation and high speed are critical. A novel approach for implementing a SQUID amplifier for high performance applications is being proposed as part of this SBIR program. HYPRES has already developed an analog SQUID array amplifier chip, which exhibits a sensitivity better than 2pA/root Hz and bandwidth in excess of 10 MHz. To improve upon the bandwidth, a novel SQUID amplifier architecture was proposed and demonstrated under the Phase I project. The SQUID amplifiers were integrated with the outputs of a high performance Analog to Digital Converter (ADC) operating close to 24 GHz clock frequency. This ADC was subsequently interfaced with room temperature electronics and was utilized to directly digitize a 10 MHz signal without the use of Intermediate Frequency down converter or any amplification before digitization. The low noise SQUID amplifiers integrated an array of SQUIDs in series utilizing Josephson Transmission Lines (JTLs). The SQUID stack in each amplifier was followed by a high-gain semiconductor amplifier, which accepts an input of ~2mV and generates an output of ~1V that can be read by standard semiconductor logic circuits for further processing. Since bandwidth associated with JTLs is on the order of tens of GHz, this SQUID array amplifier can easily possess switching speed approaching several tens of pico-seconds. However, further increases in voltage are difficult to obtain without decreasing the output bandwidth. In the Phase II program, we propose to design, develop, and demonstrate a novel differential input version of the SQUID array amplifier, which increases its gain by a factor of two while maintaining its high bandwidth. In addition, since the input is differential, the amplifier has a high common mode rejection enabling its use for amplification of very small signals. This amplifier chip will be integrated in a cryopackage with a semiconducting-based amplifier to facilitate its instrumentation with room temperature processing electronics. The superconductor digital pre-amplifier converts pulse-streams into mV-level waveform suitable for read-out by the cooled single-stage semiconductor amplifier.We will design the two-stage amplifier chip module to be compact and cost effective, requiring minimal support electronics suitable for integration in multi-channel systems.

Commercial Applications and Other Benefits as described by the awardee: The availability of such a low noise high speed SQUID amplifier chip would result in their use for many high-speed digital systems, such as analog to digital converters (ADCs) and digital receivers. Such a SQUID coupled to a large transformer (100 nH), will make an amplifier with sub-pico ampere sensitivity possible for many

applications. The sensitive / low speed version of the SQUID chips has commercial applications in non invasive medical diagnostic instrumentation or as SQUID amplifiers for readout of cryogenic detector arrays. We are confident that the funding of this program at HYPRES will expedite the development of a system that significantly enhances capabilities in low noise high frequency applications.

81208B06-II

***STTR Project: SiC Power MOSFET with Improved Gate Dielectric—**Structured Materials Industries, Inc. 201 Circle Drive North, Unit # 102, Piscataway, NJ 08854; 732-302-9274; www.structuredmaterials.com
Dr. Nick Sbrockey, Principal Investigator, sbrockey@structuredmaterials.com
Dr. Gary S. Tompa, Business Official, gstompa@structuredmaterials.com
DOE Grant No. DE-FG02-06ER86288
Amount: $750,000

Research Institution
Cornell University
Ithaca, NY

DOE has a need for improved devices used in conjunction with the detectors and instrumentation in high energy physics applications. Silicon carbide (SiC) based electronics are potentially well suited for use in these high temperature and intense radiation environments. However, present technology SiC devices suffer from poor reliability and limited high temperature performance, due to the lack of suitable gate dielectric materials and the associated fabrication techniques. SMI is developing gate dielectric materials for SiC devices based on high dielectric constant (high-k) materials. The use of these high-k materials allows increased transistor gate thickness, without sacrificing device speed or performance. This allows lower electric fields in the vicinity of the transistor gate and reduced leakage currents. Similar technology has been applied to silicon device manufacturing, to allow continued scaling down of transistor dimensions. In this SBIR effort, SMI is applying high-k materials to SiC device manufacturing, to produce transistor devices that are more reliable and have better high temperature performance. In Phase I, SMI developed processes to deposit oxide thin films with high dielectric constants and low leakage currents, on both silicon and silicon carbide substrates. We demonstrated excellent electrical properties for test devices on silicon carbide. We demonstrated technical feasibility of fabricating MOSFET devices with high-k gate dielectrics in silicon carbide. In Phase II we will integrate our high-k film structures into actual SiC device manufacturing. We will develop the production worthy tools and processes technology for both the high-k film deposition and the SiC MOSFET fabrication. At the end of Phase II, we will have developed and demonstrated optimized SiC MOSFET devices, with significantly improved performance and reliability over present devices.

Commercial Applications and Other Benefits as described by the awardee: SiC based electronics will also fill needs in a wide variety of other commercial, military and scientific applications. This includes high-temperature, high-voltage and high-power devices in automotive and aerospace systems, light-emitting diodes (LED's) which operate in the blue to ultraviolet range, and high frequency devices for communication and radar systems.

80231S06-II

100 Watt Laser Synchronous Photoinjection--Aculight Corporation, 22121 20th Avenue SE, Bothell, WA 98021-4408; 425-482-1100; http://www.aculight.com
Dr. Roy Mead, Ph.D, Principal Investigator, roy.mead@aculight.com
Dr. Dennis D. Lowenthal, Business Official, dennis.lowenthal@aculight.com
DOE Grant No. DE-FG02-06ER84491
Amount: $750,000

Electron accelerators are used to expand our knowledge of nuclear physics and basic materials science, for high performance synchrotron radiation sources used in physics, chemistry, and semiconductor development, and in specialized radiation sources at the forefront of medicine. To achieve the best performance, specialized lasers are used to produce electrons for these accelerators, and better, more capable lasers can greatly increase the usefulness of accelerators in these varied fields. The lasers must be precise and reliable, and lasers much more powerful than currently available are needed to fully enable the capabilities of these accelerators. The goal of the project is to develop a powerful and reliable laser ideally suited for use in electron sources for accelerators. The laser will use novel fiber-laser technology that is better suited to meeting the specific requirements of electron sources than previously-available technologies. The most difficult technical problem to be solved in the project was how to produce laser pulses lasting less than one-tenth of one billionth of a second, at rates beyond a billion times per second, in a way that could be precisely synchronized in time with cycles of electron accelerator systems. In the Phase I effort of this project, we successfully demonstrated a way to do this, combining commercial electronics technology with technologies used in optical fiber communications. The solution we demonstrated is robust and reliable, and will make integration of the laser with an accelerator easier than with lasers available before. The Phase II effort will combine this new laser pulse generation method with advanced optical fiber amplifier technology and nonlinear optics technology, to produce the high power laser needed for electron accelerators. The laser system will be thoroughly tested, and then delivered and installed at an electron accelerator facility. We will then work with the accelerator staff to gain the most utility from the laser, and find ways to improve future lasers dedicated to this application.

Commercial Applications and Other Benefits as described by the awardee: In addition to enabling electron accelerators to be more productive, powerful lasers with similar characteristics are useful for semiconductor processing, where they can improve the performance and reduce the costs of flat-panel display screens, and improve the yield of semiconductor chips. The lasers can also be used for critical marking, cutting, and micromachining applications. Defense applications can include high data-rate communication with submerged submarines, and non-lethal weapons to incapacitate enemies while avoiding injury to noncombatant bystanders.

80235S06-II

Integrated Modeling of ECR Charge Breeder Ion Sources--FAR-TECH, Inc., 3550 General Atomics Court, MS 15-155, San Diego, CA 92121; 858-455-6655; www.far-tech.com
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DOE Grant No. DE-FG02-06ER84498
Amount: $750,000

The production of high-quality, high-charge-state ion beams is an area of intensive research and development worldwide for particle accelerators, atomic physics studies, and industrial applications. In nuclear physics research, using radioactive ions with extreme proton-to-neutron ratios provides insight into the synthesis of new elements and the discovery of rare nuclei. The use of electron cyclotron resonance ion sources to generate multiply charged ions reduces the cost to produce radioactive ion beams by decreasing the accelerating voltage needed to achieve the desired beam energy. However, there is currently no numerical tool that can simulate all stages of the production a highly charged ion beam with one of these sources. A simulation tool is being developed that integrates numerical models for each of the three interlinked steps in the production of highly charged ion beams: the capture of singly charged radioactive ions, the breeding of highly charged ions, and the extraction of the beam from the source. Linking the three models ensures self-consistency of the overall numerical simulation. An innovative particle-in-cloud-of-points code was developed to simulate extraction of the ion beam from the source. Models of singly charged ion capture and charge breeding were developed and linked under a separate Phase II SBIR grant. The particle-in-cloud-of-points code will be enhanced to simulate three-dimensional (3D) particle distributions. The code will also be linked to the existing ion capture and charge breeding codes to create an integrated, 3D, self-consistent numerical tool for simulating the production of highly charged ion beams.

Commercial Applications and Other Benefits as described by the awardee: An integrated, self-consistent numerical tool for simulating the production of highly charged ion beams will reduce the cost of building sources of highly charged ions and improve the efficiency of both radioactive ion beam facilities and industrial applications that use highly charged ions.

80240S06-II

High-Fidelity Simulations of Fixed-Field Alternating Gradient Accelerators--Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
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DOE Grant No. DE-FG02-06ER84508
Amount: $749,602

The next-generation particle accelerator for nuclear physics research, necessary for making fundamental advances in this important field, will likely involve high-energy electron-ion collisions. A promising candidate for the cost-efficient acceleration of high-charge electron bunches is the non-scaling fixed-field alternating gradient (FFAG) synchrotron. Existing codes include only some of the key effects required for the accurate design and evaluation of non-scaling FFAG accelerators. We will augment an existing code for tracking the acceleration of charged particles, which already includes special features required to handle large rectangular dipole magnets without a well-defined synchronous trajectory. In particular, we will add generalized magnetic fringe-field models and the ability to include the self-fields of the electrons. The enhanced code will be capable of parallel processing on clusters and supercomputers. We developed a simple three-dimensional fringe-field model for rectangular magnets that have a horizontal gradient in the dipole field. We identified an optimal approach for adding space-charge effects and implemented a simple two-dimensional model. These algorithms were implemented in a tracking code widely used for such systems. The enhanced code was used to simulate an existing accelerator design. We identified an optimal approach for parallelizing the code.We will extend the simple 3D magnet model to more general magnets, including curved magnets. We will implement a fully parallel 3D space-charge model and parallelize the tracking operations. The resulting code will be used for detailed parameter scans of possible designs for non-scaling FFAGs, including the misalignment effects, magnet mispowerings, multipole errors, fringe fields, and space-charge. We will also update the documentation.

Commercial Applications and Other Benefits as described by the awardee: The proposed software development will directly benefit scientists working to design highcurrent electron accelerators required for fundamental advances in experimental nuclear physics. The computational scientists working on this project will develop expertise in this area, creating opportunities for contract work in the future.

80241S06-II

Simulation Package for Parallel 3D Modeling of an Electron Gun with a Diamond Amplifier--

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DOE Grant No. DE-FG02-06ER84509
Amount: $749,871

The Relativistic Heavy Ion Collider (RHIC) contributes fundamental advances to nuclear physics by colliding a wide range of ions. A novel electron cooling section, which is a key component of the proposed luminosity upgrade for RHIC, requires the acceleration of high-charge electron bunches with low emittance and energy spread. A promising candidate for the electron source is the recently developed concept of a high quantum efficiency photoinjector with a diamond amplifier. However, there is no available code to use for investigating such a photoinjector via computer simulations. General statement of how this problem is being addressed: Numerical algorithms will be developed for the generation and transport of secondary electrons through diamond amplifiers in strong electric fields. These algorithms will be implemented in an existing parallel 3D particle-in-cell (PIC) code and then tested against experimental data. The resulting simulation package will be specialized for the purpose of evaluating and designing high current electron sources with diamond amplifiers. We implemented Monte Carlo models, extending the VORPAL PIC 3D electromagnetic code, for the generation and transport of secondary electrons in diamond (elastic and inelastic scattering) that take band structure into account. Proof-of-principle simulation results are in agreement with published data on the generated number of secondary electrons over time. We also demonstrated that the code can be effectively used to simulate an electron gun of interest to RHIC and is particularly valuable to study wakefield effects. We will implement code to model inelastic scattering from phonons and impurities, add models for electron emission from diamond surfaces with negative affinity layers, electron-hole recombination, and for more accurate calculation of elastic scattering. Simulation results from all implemented models will be extensively verified with published theoretical/computational results and validated with available experimental data. We will write regression tests and documentation for the developed code.

Commercial Applications and Other Benefits as described by the awardee: By providing code for simulating diamond amplifiers in electron photo injectors, the proposed software development will directly benefit scientists working to design high-current electron accelerators required for cooling high-energy ion beams at RHIC. These capabilities will also benefit an existing PIC code that is already commercially distributed, thus increasing its potential for generating further commercial revenue concept for such sources.

81192S06-II

Improving the Radiation Damage Resistance of Germanium Detectors--PHDs, 777 Emory Valley Road, Suite B, Oak Ridge, TN 37830-7071; 865-481-3725; www.phdsco.com
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DOE Grant No. DE-FG02-06ER84501
Amount: $750,000

Ever larger gamma ray detector arrays made from germanium crystals are being used, and will continue to be used, in nuclear physics research (Gammasphere, Rare Isotope Accelerator); however, these detectors are vulnerable to radiation damage. An average Gammasphere detector may function in the array for several months before the effects of the radiation damage become intolerable. Radiation damage ultimately limits the useful time a germanium detector can be used. Mitigating the effects of radiation damage could greatly reduce or possibly even eliminate the need for annealing detectors in radiation damage environments. Such an improvement would significantly improve operation of germanium detector arrays. Detector operating temperature has by far the most important effect on the degradation caused by radiation damage. This study proposes to analyze the effect of temperature reduction well below the ~95K range where liquid-nitrogen cooled detectors operate, and design viable options to cool complex arrays to much colder temperatures. Our Phase I successfully addressed the preliminary complexities of designing and fabricating a mechanically cooled prototype detector system having the size and cryostat geometry of a Gammasphere detector and this system was shown to achieve reliable operating temperatures of around 50K. The Phase II project proposes to develop, fabricate, and test a mechanically-cooled germanium detector system that will be fit into Gammasphere. The engineering complexities of multiple system arrays will have to be addressed. If this work is successful it will have a major impact on the operation of germanium detectors at nuclear physics user facilities like Gammasphere, many of which are DOE supported. Successful design and implementation will immensely extend the life of the instrumentation and decrease the cost of maintenance and repair required by the annealing cycles, which often necessitate the removal of the detector system from the array.

Commercial Applications and Other Benefits as described by the awardee: A successful design for integrating mechanically cooled multiple detector systems into complex arrays will reduce the physical size of the array, improve efficiency and longevity, and greatly diminish costs and maintenance of large-array diagnostic detector systems.

81197S06-II

Large Area, Robust GaN-Based Photocathodes for High-Efficiency UV and Cherenkov Light Detection--SVT Associates, Inc., 7620 Executive Drive, Eden Prairie, MN 55344; 952-934-2100; http://www.svta.com
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DOE Grant No. DE-FG02-06ER84506
Amount: $748,796

The requirements for ultraviolet (UV) light detection for most commercial applications such as flame and arc sensing, air and water purification, and combustion monitoring are adequately provided by commercially available GaN-based photodiodes. However, many UV photoncounting and imaging applications, including Cherenkov light detection, space-borne astronomy, and UV spectroscopy, demand much higher performance in detector sensitivity, speed, resolution, and noise level than what is currently possible using the available UV photodetectors. In this work, we propose to develop wide bandgap GaN-based photocathodes for high-sensitivity visible-blind UV photodetectors and imagers. In the phase I program, we demonstrated the remarkable efficiency and stability of GaN-based photocathodes for UV detector and electron emitter applications. We also performed device simulations to determine potential new photocathode structures for the Phase II research and development program. We will continue the development of GaN-based photocathodes in the Phase II program. To further improve reliability and reduced fabrication costs for the production of both high performance UV detectors and electron emitters, we will also study novel cesium-free GaNbased photocathode structures in this program.

Commercial Application and other Benefits as described by the awardee: The high-performance UV photocathodes proposed in this work can provide a springboard to commercialization of two main products - an efficient electron emitter and a sensitive photodetector. These products have a great commercialization potential for many applications, including UV imaging, spectroscopy, maskless electron lithography and thin film metrology.

80244B06-II

***STTR Project: Multi Chamber Gas Proportional Counter for Screening Ultra-Low Background Materials and Identifying Radioactive Contaminants—**Reeves & Sons, LLC
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DOE Grant No. DE-FG02-06ER86287
Amount: $749,448

Research Institution
Texas A&M Research Foundation
College Station, TX

The goal of this research is to develop a method to detect ultra-low levels of radioactive contaminants in materials. The next generation of experiments to search for dark matter in the form of weakly interacting massive particles, to search for neutrinoless double beta decay and to study neutrinos from the sun, earth and other sources will require the screening of materials to levels that are currently difficult or expensive to achieve. There will also be a need to screen larger and larger wafers for the electronics industry. The approach being addressed in this program is the development of a compact parallel plate structure that is constructed mainly out of the materials to be tested. The goal is to maximize the sample mass and surface area while maintaining sensitivity to alpha, beta and gamma radiation from radioisotope contaminants. In Phase I, several different structures were investigated that employed; 1) proportional charge gain; 2) proportional scintillation coupled to wavelength shifting fibers; and 3) proportional scintillation coupled to scintillation plates. Methods to discriminate between alphas, betas and gammas were also considered. In Phase II, the goal for the first year will be to investigate the most promising Phase I approaches in a shielded enclosure in the Soudan Mine. The work will involve a bootstrap approach to find the most radio-quiet components to minimize the radioactivity while maximizing detector sensitivity. The key material available that makes the goal feasible is underground electroformed copper produced by Reeves and Sons LLC. In the second year, a 6 inch cubical prototype using the optimum approach will be constructed and tested to determine the ultimate sensitivity.

Commercial Applications and Other Benefits as described by the awardee: If the goal of the research can be achieved, it will provide a more economic way to screen materials for radioactive contaminants at extremely low levels. Next and future generation physics experiments as well as the electronics industry have a need for such screening.

81000S06-II

Bright, Fast Scintillator for Nuclear Studies--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472; 617-668-6800; www.rmdinc.com
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DOE Grant No. DE-FG02-06ER84504
Amount: $750,000

Scintillation spectrometers, consisting of inorganic scintillation crystals coupled to photomultiplier tubes, are an important element of nuclear and elementary particle physics experiments. Performance of the detection systems used in these experiments is often limited by the properties of scintillators available at present. The goal of the proposed project is to investigate a new scintillator which appears to be very promising due to its high light output, fast response, high efficiency and excellent energy resolution. Large crystals of the new scintillation material will be grown and their properties will be extensively examined in our study. The Phase I project was aimed at demonstrating the feasibility of applying the new scintillation material towards gamma ray spectroscopy. Single crystals of the proposed scintillator were grown and their scintillation performance was evaluated. Energy and timing resolution measurements were conducted. During the Phase II project, larger crystals of the proposed scintillator will be grown and extensive evaluation of scintillation performance will be conducted. Characterization of the new scintillator in nuclear physics experimentation will also be conducted.

Commercial Applications and Other Benefits as described by the awardee: Over and above the scientific use in nuclear, high energy, and space physics experiments, the new scintillator will be commercially applicable to medical imaging, nuclear waste characterization, geological exploration, industrial imaging, X-ray instrumentation, and materials analysis.

80245S06-II

Double-Helix Coil Technology for Bent Accelerator Magnets--Advanced Magnet Lab, Inc., 328-A West Hibiscus Blvd., Melbourne, FL 32901-2715; 321-728-7543; http://magnetlab.com
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DOE Grant No. DE-FG02-06ER84492
Amount: $748,767

High field superconducting dipole magnets with a field strength of about 4.5 Tesla and a bend radius of about 0.7 m are required in the high radiation areas of beam transport in future rare isotope accelerators. The small bending radii of these magnets produce unwanted higher-order harmonics in the magnetic field that are detrimental to accelerator operation. The requirements for these magnets can be met by using a novel coil design called the double-helix dipole. The technology employs helical windings on composite or moldable ceramic coil forms that create very robust coil structures as needed for reliable superconducting magnets. The double-helix coil design also offers the inherent ability to cancel unwanted higher order harmonics by modifying the conductor path in the coil. This is accomplished with no additional cost or addition of separate correction coils. During Phase-1 of this project the design of a bent dipole magnet has been developed, which meets the specifications of the planned Rare Isotope Accelerator (AEBL or RIA). It was shown that the higher-order harmonics caused by the bending radius of the coil can be compensated by modifying the conductor path of the double-helix coils, thus allowing the magnet to meet field quality requirements. The manufacturing technology of double-helix coils on CNC machines has been developed, and two prototype coil windings have been manufactured. The produced coils have been shock tested with liquid nitrogen to qualify the constituent materials for cryogenic applications. During Phase-2 two superconducting magnets will be manufactured and cryogenically tested at a national laboratory. The first magnet will be a short straight coil without iron yoke to qualify the superconducting cable and the manufacturing technology. The second magnet will be a prototype bent magnet with iron yoke. Field measurements will be performed at operational temperature, which will verify the method of compensation of higher-order multipole components in the winding itself.

Commercial Applications and Other Benefits as described by the awardee: Magnets based on the proposed technology are splice-free. They benefit from highest field quality, increased robustness, reliability, radiation resistance, and substantially reduced manufacturing costs. The coil geometry is especially suitable to the fabrication of coils using brittle type superconducting materials such as HTS. The successful development of the bent double-helix magnets will be an important contribution to accelerator magnet design for planned rare isotope accelerators. The DOE provided “Trailblazer Report” to assess the opportunities, needs, preferences, barriers, and competition for the Bent Dipole technology stated that the technology has applications in a wide range of industries, but the high uniform field and the low cost manufacturing make it an ideal fit for use in the field of proton therapy. This coil technology is also especially suitable for use in rotors and stators of high power electrical machinery; related proposals have been submitted to various agencies and contacts with industry have been made.

80246B06-II

***STTR Project: Experimental Validation of Critical Radiation Exposed Materials for RIB-Fragmentation Room—**I.C. Gomes Consulting & Investment, Inc.1728 Killdeer Drive, Naperville, IL 60565; 630-416-7534; http://www.icgomes.com
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DOE Grant No. DE-FG02-06ER86277
Amount: $750,000

Research Institution
Argonne National Laboratory
Argonne, IL

The fragmentation target and separator of a next generation Radioactive Beam Facility will have several radiation sensitive components that will be in the high radiation area. The most sensitive are the pump for the liquid lithium target and the superconducting magnets. These elements utilize permanent magnet and superconducting cable materials that are not fully characterized in terms of their long-term performance in high radiation environments. Hence, it is important to set up a facility and carry out irradiations of various candidate materials to reduce uncertainties that will ultimately lead to a robust and cost-effective design for these components of this advanced Department of Energy user facility. The irradiation of high temperature superconductor and low temperature superconductor and of Samarium Cobalt permanent magnet material under strictly controlled conditions is presented as the solution for the lack of irradiation data for those materials. The irradiations will be performed under environment conditions that can be directly correlated with the conditions that the material will be used in the Radioactive Ion Beam facility. During Phase-I an initial simulation of the radiological environments on which to base the choice of irradiation facilities was carried out. Candidate materials for study were identified and selected based on their appropriateness for the application and their commercial availability. Potential irradiation facilities were contacted and discussions and initial agreements for irradiation were carried out. Also, the initial design of a cryostat that can deliver the required temperature for irradiation to the samples was performed. Finally, this proposal was developed based on these findings and the input of all participants in the project. During Phase-II it is planned to finish the design and procure the cryostat for the irradiation of high and low temperature superconductors, to actually perform irradiation of superconductors and permanent magnets, collect the data, and summarize the results for the community.

Commercial Application and Other Benefits as described by the awardee: This project will provide a systematic way of performing irradiation at cryogenic temperature and it will be a unique capability for the community to perform this kind of irradiation. After the collection of the data to fulfill the commitments of this project the cryostat will be available through the small business to perform irradiation of components that will operate at cryogenic temperature and under radiation. The scientific community will benefit by having the irradiation apparatus available for irradiation testing at a reasonable cost.