
# U.S. Department of Energy

# Small Business Innovation Research

# And

# Small Business Technology Transfer Programs

## Phase II Abstracts

## FY 2006

78004S05-II

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**Fast, Dense, Low Cost Scintillator for Nuclear Physics—**Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
Dr. Gerald Entine, Principal Investigator, GEntine@RMDInc.com
Dr. Gerald Entine, Business Official, GEntine@RMDInc.com
DOE Grant No. DE-FG02-05ER84160
Amount: $749,999

Although inorganic scintillators are one of the most common detectors used in nuclear and particle physics experiments, the properties of currently available scintillator materials limit the performance and increase the cost of these systems. This project will develop a new class of scintillation materials that can be produced using a low-cost fabrication approach. Phase I demonstrated the feasibility of producing high performance scintillators with the low-cost fabrication approach. Samples of the scintillators were produced, and their performance was evaluated. Phase II will be aimed at advancing the new scintillation technology for positron emission technology (PET). Large samples of the new scintillators will be produced and their performance will be evaluated. Then, PET modules based on the new scintillators will be built and characterized.

*Commercial Applications and other Benefits* as described by the awardee: Over and above the use in nuclear physics, the new scintillators should be commercially applicable to medical imaging, non destructive evaluation, bore hole logging, homeland security, X-ray instrumentation, and materials analysis. They also should be useful in particle and space physics experiments.

78008S05-II

**112**

**A Reliable, Compact, and Inexpensive Klystron for the International Linear Collider—**
FAR-TECH, Inc., 10350 Science Center Drive, Building 14, Suite 150, San Diego, CA 92121; 858-455-6655
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DOE Grant No. DE-FG02-05ER84357
Amount: $650,000

The proposed International Linear Collider (ILC), a tool for future high energy physics research, places unprecedented demands on the high-power radio frequency (RF) system used to drive the accelerator structures. Even small improvements in system cost, power efficiency, or reliability could lead to dramatic cost savings over the life of such a collider facility. This project will design an inexpensive, compact, low-voltage, RF klystron tube, with adequate power for driving a single, ILC one-meter-long structure. The device should provide an operating voltage of 36 kV, an output power of 800 kW, and efficiencies greater than 65 percent. Such a tube would simplify the ILC's modulator design as well as its high-power RF distribution network. In Phase I, the tube design was optimized using electrostatic simulations for the gun region and a one-dimensional model for the cavity section. Then, design geometry was fully simulated with a 2½-dimension, electromagnetic particle-in-cell code; analyzed for stability; and optimized for low production cost, small physical size, and easy maintenance/interchange. The simulations predicted an energy conversion efficiency greater than 65%. In Phase II, engineering drawings will be made, and critical components (such as the cathodes, output window, permanent magnets, and ceramics) will be acquired. The klystron will be conditioned and tested with the help of Fermilab personnel and then made available for use within that program.

*Commercial Applications and other Benefits* as described by the awardee: The proposed tube should be useful in a wide variety of particle accelerator applications. In particular, there is a need for such a klystron for the ILC testing program at Fermilab. Its small size and cost also could enable some new uses of RF and accelerator technology in defense, medicine, and industry.

78011S05-II

**83**

**Nanoengineered Encapsulation of Enzyme Chiral Catalysts and Other Proteins in Their Native State—**LNKChemsolutions, 2411 Winchester South, Lincoln, NE 68512; 402-416-1811
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DOE Grant No. DE-FG02-05ER84326
Amount: $750,000

The commercial opportunities for products based on delicate biomolecules, such as enzymes and therapeutic proteins, are growing at a strong pace. However, many proteins of great commercial value, including enzymes, undergo loss of function on encapsulation, when approaches based on high-shear liquid-phase processes, or on immobilization inside a porous matrix, are used. This project will develop a gentle method, based on a nano-engineering approach, for encapsulating proteins and protein complexes. The resulting product would allow, for example, enzyme catalysis to be carried out at room temperature, providing significant energy savings over competing products. Phase I demonstrated that protein solutions could be encapsulated into true core-shell structures and that the technology would facilitate: (1) the reuse of enzyme catalysts for energy-efficient processes, and (2) the design of efficient protein drug delivery systems. In Phase II, pilot-scale quantities of encapsulated enzyme catalysts and one protein-based drug – namely, Tumor Necrosis Factor alpha (TNF-α) – will be produced, and further testing will be conducted.

*Commercial Applications and other Benefits* as described by the awardee: There are two primary applications for the technology. The first involves enzyme catalyst recovery, which is essential for the commercialization of certain chemical reaction processes. Some enzymes cannot be immobilized onto the surface of a carrier particle without loss of catalytic function. The encapsulation of enzymes within a porous shell would overcomes this obstacle. The second application involves the use of proteins for the treatment of certain types of cancer. Some of these proteins are toxic when administered systemically in therapeutic amounts. However, by encapsulating the proteins in submicron vesicles, the toxicity problem can be avoided and the proteins can remain undetected by the immune system.

78028S05-II

**132**

**High Resolution Gamma Ray Spectrometer for Nuclear Physics—**Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
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DOE Grant No. DE-FG02-05ER84161
Amount: $750,000

Scintillation spectrometers, which consist of inorganic scintillation crystals coupled to photomultiplier tubes, are an important element of nuclear and elementary particle physics experiments. However, the performance of the detection systems used in these experiments is often limited by the properties of presently available scintillators. This project will investigate the use of a new scintillator material, which appears to be very promising due to its high light output, fast response, and excellent energy and timing resolution. Phase I 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. During Phase II, larger crystals will be grown and evaluated for gamma-ray spectroscopy and nuclear physics experimentation. The physical and optical properties of the crystals will be measured, followed by detailed evaluation of scintillation properties, and of energy and timing resolution. Also, prototype crystals will be characterized in a nuclear physics experimental setting.

*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 should be commercially applicable to medical imaging, non-destructive testing, geological exploration, X-ray instrumentation, and materials analysis.

78035S05-II

**10**

**A New Scintillator for Time-of-Flight PET—**Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
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DOE Grant No. DE-FG02-05ER84299
Amount: $750,000

Scintillation detectors, consisting of inorganic scintillation crystals coupled to photomultiplier tubes, are an important element of medical imaging applications such as positron emission tomography (PET). Yet, the performance of these systems is limited by the properties of the currently available scintillation detectors. If faster scintillators were available, significant advancement in image quality could be achieved by reducing randoms and instituting time-of-flight. This project will investigate a new scintillator that is both fast and bright, and, as a result, promises excellent energy and timing resolution. Reduction in scatter and randoms should lead to significant improvement in image quality for time-of-flight PET. During Phase I, high quality crystals of the new scintillator were produced and their performance was evaluated, specifically for PET. The results confirmed that the new crystals are indeed bright and fast, and provide excellent energy and timing resolution. In Phase II, the crystal growth will be optimized and large crystals will be produced. Scintillation performance of the large crystals will be evaluated in detail. Finally, PET modules based on arrays of the new scintillator will be assembled and evaluated.

*Commercial Applications and other Benefits* as described by the awardee: Over and above the use in medical imaging, the new scintillators should be commercially applicable to NDE, geological exploration, homeland security and materials analysis. They also should be useful in nuclear, particle, and space physics experiments.

**50**

**Novel Nanoporous Polymer Membranes for Gas and Vapor Separations—**Membrane Technology and Research, Inc. (MTR), 1360 Willow Road, Suite 103, Menlo Park, CA 94025-1516; 650-328-2228
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DOE Grant No. DE-FG02-05ER84243
Amount: $749,945

The separation of value-added products from hydrocarbons is a widespread, process in energy industry processes. This project will develop a new class of nanoporous polymer membranes that have exceptional permeation characteristics for hydrocarbon/hydrogen and hydrocarbon/methane separation in refinery and natural gas applications. In Phase I, a nanoporous, polydioxane-based polymer was synthesized, and its gas sorption, diffusion, and permeability properties were evaluated using thick dense films. Defect-free, thin-film composite membranes were made, and their pure- and mixed-gas permeation properties were determined. The permeation data obtained showed that these membranes would allow membrane technology to be competitive with other more-conventional technologies in a number of important separations. In Phase II, the membranes produced in Phase I will be scaled up and packaged into bench- and pilot-scale membrane modules. These modules will be used to demonstrate membrane performance for hydrocarbon/hydrogen and hydrocarbon/methane natural gas separations. The modules will be tested in the laboratory and at field sites.

*Commercial Applications and other Benefits* as described by the awardee: Currently, membrane separation holds only a small share of the total hydrocarbon/hydrogen and hydrocarbon/methane separation market in refinery and natural gas applications. Membranes with improved permeability and selectivity should lower the cost of membrane processes and substantially increase the market share held by membranes.

78044S05-II

**16**

***In Situ* Optical Monitor for Waste Tank Gases—**Vista Photonics, Inc., 67 Condesa Road, Santa Fe, NM 87508-8136; 505-466-3953
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DOE Grant No. DE-FG02-05ER84307
Amount: $750,000

Department of Energy waste storage tanks require continuous monitoring of species in solid, liquid and gaseous phases. Gas phase species of interest include ammonia, methane, carbon dioxide and hydrogen. This project will develop *in situ* optical sensors that selectively and sensitively detect ammonia, methane, carbon dioxide, hydrogen and oxygen in the waste tank headspace. The sensors will take advantage of a rugged, compact, optical absorption method and inexpensive near-infrared lasers. In Phase I, an optical spectrometer for the detection of ammonia, methane, carbon dioxide, hydrogen, and oxygen was constructed, based on a single common sample cell. The sensitivity of the spectrometer for each species was quantified. In Phase II, fully-integrated sensor prototypes, based on laser-diode photoacoustic spectroscopy, will be constructed for waste tank headspace analysis, and standard operating protocols for the sensors will be established. The prototypes will be refined through beta-testing in several field applications, which are also Phase III commercialization opportunities.

*Commercial Applications and other Benefits* as described by the awardee: The new spectrometer, which would offer high-performance in a rugged compact package, could be manufactured inexpensively relative to existing devices of comparable performance. The instrument would offer a compelling blend of price, performance, and physical advantages in a variety of gas detection applications. Applications include atmospheric monitoring, environmental regulatory compliance, process gas analysis, and biomedical breath diagnostics.

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**External Cavity Stabilized LWIR QCL—**Physical Sciences Inc., 20 New England Business Center, Andover, MA 10810-1077; 978-689-0003
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DOE Grant No. DE-FG02-05ER84158
Amount: $749,911

Lasers based on quantum cascade (QC) gain media represent a powerful new tool for optical detection in the infrared spectral region, needed to help detect the proliferation of weapons of mass destruction. They have been demonstrated to be reliable, compact, efficient, bright sources of spectrally narrow radiation in midwave-, longwave-, and far-infrared. The ultimate utility of QC lasers, however, will be greatly enhanced if their tuning range can be increased. In this project, the quantum cascade gain medium will be incorporated into an external optical cavity, in order to increase the tuning range by over an order of magnitude. In addition to designing the external optical cavity, the quantum cascade medium will be modified to suppress the intrinsic optical cavity formed by its front and back facets. Phase I demonstrated that continuous-mode/hop-free tuning, with both cryogenic and room temperature quantum cascade lasers operating near 8 microns, could be achieved when the lasers were built into an external optical cavity. In order to reduce the facet reflectance, a number of approaches – including horizontal angling, vertical angling, and anti-reflection (AR) coating – were evaluated. The room temperature, anti-reflection coated laser performed best, tuning stably and consistently in a single external cavity longitudinal mode for more than 78 nanometers. In Phase II, a commercial, prototype, external-cavity quantum cascade laser system, emitting in the 8 to 14 micron spectral region, will be developed. This external cavity system will have a tuning range over 350 nm, which would be more that an order of magnitude greater than its inherent tuning range.

*Commercial Applications and other Benefits* as described by the awardee: The broadly-tunable, longwave-infrared, external-cavity quantum cascade laser should meet an unfilled need for narrow linewidth spectroscopic systems in the 8 to 14 micron spectral region. Such systems should find use in the high-precision spectroscopy of gas molecules related to national defense, homeland security, treaty verification, and industrial safety. Customers would include researchers – in DOE laboratories, university-based research teams, and industrial companies – developing advanced sensors for hazardous gas leak detection and process monitoring.

**51**

**Membrane Process for Bioethanol Production—**PoroGen Corporation, 200 Boston Avenue, Suite 4750, Medford, MA 02155-4257; 781-391-7073
Dr. Yong Ding, Principal Investigator, yding@porogen.com
Dr. Benjamin Bikson, Business Official, bbikson@porogen.com
DOE Grant No. DE-FG02-05ER84250
Amount: $750,000

Bioethanol is an established domestic chemical/fuel product that is environmentally friendly and offers the possibility of strengthening the American farm economy, while simultaneously lowering dependence on foreign oil. However, the broad-based introduction of bioethanol is limited by the high cost of separating and recovering fuel-grade ethanol from the fermentation solution, particularly when bioethanol is produced from distributed biomass. This project will develop a more efficient ethanol production process, in which fermentation is combined with a membrane separation process, so that ethanol can be continuously extracted from the fermentor. In Phase I, a nanoporous membrane, capable of selectively removing ethanol from the fermentation solution, was developed, and the production of concentrated ethanol was demonstrated in bench-scale tests, using a single step process. The novel membrane exhibited an order-of-magnitude increase in ethanol/water separatation, compared to prior-art membranes. An initial economic analysis showed that the membrane separation process would significantly reduce ethanol production costs and process energy consumption, compared to traditional distillation. In Phase II, membrane performance will be optimized, a pilot scale membrane module will be constructed and tested, and a commercial-scale hollow-fiber membrane module will be developed.

*Commercial Applications and other Benefits* as described by the awardee: The new membrane technology should reduce the cost of producing bioethanol, a renewable energy source and fossil fuel substitute, and provide an energy efficient process that integrates fermentation with ethanol separation. Increased bioethanol production would reduce U.S. dependence on foreign oil, enhance national security, and reduce atmospheric emissions.

**117**

**Dielectric-Lined High-Gradient Accelerator Structure—**Omega-P, Inc., 199 Whitney Avenue, Suite 200, New Haven, CT 06511; 203 789 1165
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DOE Grant No. DE-FG02-05ER84368
Amount: $650,000

A future multi-TeV collider requires the development of new technology to achieve its high acceleration gradient. An accelerator structure that embodies a dielectric-lined waveguide, which offers the promise of sustaining a high acceleration gradient, is currently under development. However, the all-metal structures used to achieve the high acceleration gradient have encountered limits from microwave breakdown. Recent evidence has suggested that selected dielectrics, such as diamond, have higher breakdown thresholds than metals. Therefore, this project will design and test dielectric-lined structures and determine their breakdown thresholds under conditions similar to those in an accelerator. In Phase I, both theoretical and computational design studies were carried out for dielectric-lined rectangular waveguides that could be suitable for a future high-gradient linear accelerator. A test cell was designed to determine breakdown thresholds for hydrogenated and dehydrogenated artificial diamond coatings (produced by chemical vapor deposition (CVD)) at 34 GHz, using about 10 MW of available magnicon power. Cold tests, using a mock-up of the high-power test cell, were carried out to confirm the design criteria. In Phase II, engineering designs for the high-power high-gradient test cell will be completed, and the cell will be fabricated and tested using a 34-GHz magnicon test facility. Tests will be conducted on diamond samples that are hydrogenated (as is usual) as well as dehydrogenated, the latter so as to greatly reduce the secondary electron emission coefficient and to raise the breakdown threshold. The results of these tests will be used to extend our understanding of microwave breakdown, thereby enabling the design of high-gradient accelerators for a future multi-TeV collider.

*Commercial Applications and other Benefits* as described by the awardee: High-gradient structures for a future multi-TeV collider, based on use of dielectric-lined waveguides, could create demand for thousands of accelerator structures, as well as for the artificial CVD diamond liners. This is a potential market of hundreds of millions of dollars.

**59**

**A Novel Growth Technique for Large Diameter AlN Single Crystal—**Fairfield Crystal Technology, LLC, 8 South End Plaza, New Milford, CT 06776-4200; 860-354-2111
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DOE Grant No. DE-FG02-05ER84232
Amount: $750,000

Nitride-based, high-brightness, ultraviolet, visible, and white light emitting diodes are candidate devices for replacing incandescent light bulbs and fluorescent light fixtures in general illumination applications, due to their tremendous energy saving potential, long lifetime, and high efficiency. However, the poor crystalline quality of the nitride epilayers, resulting from severely lattice-mismatched and crystal-structure-differed substrates, prevents higher-light-output efficiency from being achieved. Native aluminum-nitride single crystal has been shown to have the same crystal structure and a close lattice match to group III-nitride epilayers, and it can be grown in bulk single crystal form. Therefore, this project will develop aluminum nitride substrates suitable for the growth of high quality nitride epitaxial layers, leading to the fabrication of high brightness light emitting diodes for general lighting applications. In Phase I, aluminum nitride crystal boules larger than 20mm in diameter were demonstrated by using a novel, sublimation, physical-vapor-transport growth technique, and aluminum nitride crystal wafers of about 20mm in diameter were fabricated. Phase II will continue to develop and improve the sublimation physical-vapor-transport technique so that single crystal aluminum nitride boules of 2-inch in diameter can be produced. Aluminum nitride wafers and epi-ready aluminum nitride substrates will be fabricated from the aluminum nitride crystal boules. To demonstrate the suitability of the aluminum nitride substrates for high quality nitride epitaxy, III-nitride epi-layers will be grown on aluminum nitride substrates, using a metal-organic chemical vapor deposition technique.

*Commercial Applications and other Benefits* as described by the awardee: The aluminum nitride substrates should be suitable for volume production of high brightness light emitting diodes, with high-light-output efficacies adequate for general illumination applications. In addition, the high-quality aluminum-nitride substrates should find use in the fabrication of other types of nitride-based devices, such as blue laser diodes for optical recording, high frequency devices for telecommunications, and UV detectors for analytical applications (e.g., for the detection of chemical and biological agents for homeland security).

78092S05-II

**96**

**New Highly Radiation-Resistant Insulation Process for High Field Accelerator Magnets—**
Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026; 303-664-0394
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Mr. Fred L. Beavers, Business Official, fred@ctd-materials.com
DOE Grant No. DE-FG02-05ER84351
Amount: $600,000

High-field accelerator magnets based on niobium-tin superconductor technology are planned for use in several U.S. high energy physics programs. The use of these materials requires a high-temperature process to complete the production of the coil. As part of the process, a ceramic insulating layer is added to the superconductor. However, the currently available ceramic insulation is produced in tape form, which causes an increased-thickness buildup within the insulation layer. Braided ceramic insulation, which is stable at the superconductor processing temperatures, could provide a thin radiation-resistant insulation if it could be co-processed with the superconductor at elevated temperatures. This project will develop a method for braiding ceramic fibers directly onto superconducting cables to produce a thin ceramic-based insulation that is both radiation resistant and stable at the superconducting processing temperatures of 600 to 700°C. In Phase I, a process for braiding ceramic fibers directly onto continuous lengths of conductor cables was demonstrated. Insulation thicknesses on the order of 0.2 mm were measured via optical microscopy, and insulation performance was assessed through mechanical and thermal testing. Phase II will continue the development and optimization of the high-strength, braided ceramic insulation. The process will be scaled-up to levels suitable for industrial magnet fabrication. Insulated superconductor cables will be delivered to the Department of Energy at the conclusion of Phase II.

*Commercial Applications and other Benefits* as described by the awardee: The thin ceramic-based insulation would provide magnet developers with a means of producing densely packed superconductor coils, using a high-temperature wind-and-react process. This processing technology should simplify magnet production, lower fabrication costs, and allow for higher operating fields. Applications such as high field magnets, fusion magnets, and medical MRI instruments would become more viable, with improved magnet processing, higher strength, and improved reliability. Higher efficiency transformers that are resistant to heat damage also would become viable.

78093S05-II

**22**

**Optical Carbon Dioxide Field Isotope Ratiometer—**Vista Photonics, Inc., 67 Condesa Road, Santa Fe, NM 87508-8136; 505-466-3953
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Dr. Jeffrey S. Pilgrim, Business Official, jpilgrim@vistaphotonics.com
DOE Grant No. DE-FG02-05ER84306
Amount: $750,000

Anthropogenic greenhouse gas emissions are best quantified by determining their carbon dioxide isotope ratios. However, the required precision represents a challenge to optical measurement techniques under field deployment conditions. This project will develop a compact, rugged, mid-infrared spectrometer capable of determining isotopic carbon dioxide ratios at atmospherically relevant levels. In Phase I, a mid-infrared spectrometer for the detection of carbon dioxide at 4.3 microns was constructed, based on a pulsed quantum cascade laser (QCL). The sensitivity, selectivity, and precision of the instrument for isotopic carbon dioxide analysis were determined by using a high-performance optical cell specifically suited for QCLs. An isotopic abundance measurement precision below 0.2 'per mil' was predicted. In Phase II, a fully-integrated QCL sensor prototype, based on photoacoustic spectroscopy, will be constructed for field determination of atmospheric $CO_2$ isotope ratios. Standard operating protocols for the sensors will be established. The prototypes will be refined through field-testing in several applications, which also will be Phase III commercialization opportunities.

*Commercial Applications and other Benefits* as described by the awardee: The instrument should provide a compelling blend of price, performance and physical advantages in a variety of gas detection applications. Examples include atmospheric monitoring, environmental regulatory compliance, process gas analysis, and biomedical breath diagnostics. The targeted application for measuring greenhouse gas emissions is of high intrinsic value for the assessment of global warming.

**52**

**Membrane Mediated Extraction Process for Olefin/Paraffin Separation—**Trans Ionics Corporation, 2408 Timberloch Place, Suite D-5, P.O. Box 130511, The Woodlands, TX 77382; 281-296-5585
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DOE Grant No. DE-FG02-05ER84262
Amount: $750,000

Ethylene and propylene, two of the most important building blocks of the U.S. petrochemical industry, are produced by steam cracking of ethane, propane, or heavier hydrocarbons and are also a by-product of fluid catalytic cracking. Unfortunately, as produced, these species are always in admixture with other species from which they must be separated. The conventional method of separation is cryogenic distillation, which is extremely energy intensive. In this project, the best features of liquid-liquid extraction and membranes will be combined into a novel membrane-mediated extraction (MME) process. The process will use complexing agents, which are commercially viable and for which their ability to extract olefins has been quantified; their use in a high-surface-area membrane module will enhance their extraction efficiency due to the increased transport area. During Phase I, selected solvents and complexing agents were synthesized and used in batch laboratory extractions. The effect of solvent type, complexing agent composition, feed molecular type, and other parameters were evaluated for the extraction of olefins of commercial interest. During Phase II, the nature of the molecular interactions between olefins of different size and specific complexing agents will be quantified. The optimum complexing-agent/solvent combination will be scaled up and used in a pilot plant, which will be constructed in Phase II.

*Commercial Applications and other Benefits* as described by the awardee: The MME process could be used to effectively recover olefins from waste streams. Correspondingly, the first application for this process will be the recovery of valuable olefin from a waste stream produced by a major chemical company in Texas. The waste stream contains approximately 13 wt % of this olefin in an isoparaffininc solvent and is currently incinerated for lack of a cost-effective method of recovering the olefins. The process also provides environmental credits for eliminating incineration. Once demonstrated on a small scale for this application, the process would be expected to work well for ethane/ethylene or propane/propylene separation in steam cracking operations.

78128S05-II

**62**

**An Ultrahigh Resolution Specimen Holder with Large Tilt Range for the Transmission Electron Microscope—**Hummingbird Scientific, LLC, 5286 Lakehills Street SE, Lacey, WA 98513; 360-252-2737
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Mr. Norman J. Salmon, Business Official, Norman@hummingbirdscientific.com
DOE Grant No. DE-FG02-05ER84235
Amount: $750,000

Transmission electron microscopy (TEM) is the primary methodology for characterizing the internal structure of materials at the nanometer to sub-Angstrom scale. In the TEM, image formation results from the scattering of an incident electron wave by the atoms inside the crystal, and results in the formation of an image via either amplitude or phase contrast. In each case, the details of the scattering processes are highly dependent on the precise angle between the incident beam and the sample. However, the currently available mechanisms for *in situ* sample tilting is limited in resolution and accuracy by the frictional interfaces in the mechanism and the presence of large amounts of backlash. These mechanisms also have limited goniometer tilt range because of the width and thickness of the mechanism. This project will develop a specimen holder that will provide microscopists with unprecedented access to the crystallographic planes of their specimen, making it easy to achieve precise orientations. In Phase I, we developed and tested new hardware that provided both high resolution and high range in pole pieces suitable for materials science work. In Phase II, we will refine and extensively test this design, as well as improve the interface to the microscope.

*Commercial Applications and other Benefits* as described by the awardee: By providing high resolution, range, and stability, the new specimen holder should allow researchers in nanotechnology and materials science to fully exploit recent gains in resolution in advanced electron microscopes. The images produced by these microscopes are used routinely to guide discoveries in nanoscience and materials development, and form a critical component in the semiconductor failure analysis market.

78140S05-II

**105**

**A 3D Finite-Element Modeling Tool for Multipacting Analysis—**Simulation Technology and Applied Research, 11520 North Port Washington Road, Suite 201, Mequon, WI 53092-3432; 262-240-0291
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DOE Grant No. DE-FG02-05ER84373
Amount: $550,000

Strong radio-frequency electromagnetic fields in the high-power components used in colliders can induce a resonant cascade of particles near internal surfaces (called multipacting) – which can lead to poor performance and device failure, in some cases limiting the power than can be handled to a fraction of the design requirement. Existing tools for analyzing this phenomenon have limited accuracy, and are inefficient and difficult to use, particularly on complex three-dimensional structures. This project will create a new capability that performs both the field solution and particle tracking on the same boundary-conforming finite-element mesh, thereby avoiding errors from inaccurate surface modeling and field interpolation, which plague existing tools. The result will be a production-level capabilility for multipacting analysis in complex two- and three-dimensional structures. In Phase I, a prototype capability was created that manages the calculations necessary for multipacting analysis, including the generation of radio-frequency electromagnetic field solutions, an automated search for resonant particle orbits using a new adaptive particle tracker, and the accumulation and presentation of multipacting statistics. This capability was encapsulated within a new specialized environment hosted by a commercial analysis package and was benchmarked against established solutions for coaxial feed lines, a superconducting radio-frequency cavity, and a bunching cavity. Phase II will improve particle tracking by adding support for higher-order curvilinear elements, interactive visualization of particle orbits, adaptive mesh refinement, and a calculation for verifying multi-particle multipacting.

*Commercial Applications and other Benefits* as described by the awardee: The new multipacting analysis tool should enable more rapid development, lower costs, and more robust device designs for a broad class of high-power radio-frequency systems used in commercial and government applications. These systems include microwave tubes, radio-frequency “plumbing” for high power applications such as radar and microwave telecommunications links, commercial accelerators, and others. In particular, DOE projects such as the International Linear Collider require high-power, radio-frequency accelerator components that are at risk of failure due to electron multipacting, yet existing analysis software has only limited utility in the quest for hardware designs that avoid this problem.

78165S05-II

**63**

**A Full Rotation Specimen Holder for State-of-the-art Tomography in a Transmission Electron Microscope—**Hummingbird Scientific, LLC, 5286 Lakehills Street SE, Lacey, WA 98513-; 360-252-2737
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Mr. Norman J. Salmon, Business Official, Norman@hummingbirdscientific.com
DOE Grant No. DE-FG02-05ER84236
Amount: $750,000

Three-dimensional electron tomography can render images of the internal structure of solid-state and biological materials at the nanometer scale, and is finding increased application in nanotechnology, semiconductor industries, and the life sciences. However, current systems cannot acquire all the information necessary to construct an optimal tomogram. A major limitation is that these systems do not allow the specimen to be imaged over a full ±90º tilt of the sample. This project will develop a new sample manipulation methodology that will allow the sample to be fully rotated. In Phase I, new hardware and software developed to perform a full rotation of a sample. Testing in a TEM with a simple sample produced promising results. Phase II will involve improving the hardware, developing software, and testing the technique with a variety of samples.

*Commercial Applications and other Benefits* as described by the awardee: The new specimen holder should offer crucial advantages over existing market solutions – including full rotation of the sample (thereby increasing the inherent resolution in the three-dimensional tomograms), positioning of the sample with high precision and accuracy, and direct compatibility with common sample preparation methodologies – allowing scientists to produce the highest resolution tomograms yet seen.

78168S05-II

**49**

**Hydrogen Recovery Via Nanoporous Carbon Membrane for Large Scale Refinery Application—**Media and Process Technology, Inc., 1155 William Pitt Way, Pittsburgh, PA 15238-1368; 412-826-3711
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Dr. Paul K.T. Liu, Business Official, pliu@mediaandprocess.com
DOE Grant No. DE-FG02-05ER84241
Amount: $749,597

Hydrogen recovery from refinery off-gas offers a cost-effective and environmentally friendly alternative to meet the projected growth in hydrogen demand in refineries. Although a unique membrane-based process was demonstrated to be technically feasible in the past, several product- and process-related barriers have prevented its field implementation. This project will develop a nanoporous carbon molecular sieve membrane that can overcome the product-related barriers. An in-line regeneration technique will be employed to solve the process-related barriers. Hydrogen recovery efficiency will be improved through a membrane structure tailored for these applications. Phase I demonstrated significant hydrogen recovery from binary streams – containing hydrogen/hydrocarbons or CO – selected to simulate refinery waste streams and pressure swing adsorption (PSA) purge streams. After aging/fouling, the membranes were restored via *in situ* regeneration. An economic analysis demonstrated the feasibility of a payback period less than one year. Phase II will focus on product optimization and process development, in order to demonstrate the proposed hydrogen enrichment process. Then, the optimized process will be demonstrated in a bench-top experiment and verified with a mathematical simulation. Long term performance stability will be confirmed by testing the prototype in a slip stream in the field. Finally, a full-scale module will be fabricated for field testing in Phase III.

*Commercial Applications and other Benefits* as described by the awardee: The hydrogen recovery technology should achive significant energy savings and $CO_2$ reduction in refinery applications. Other applications include the recovery of residual chemicals from waste streams, following bulk separations in chemical production processes.

78200S05-II

**133**

**Commercial and Cost Effective Production of Gas Electron Multiplier (GEM) Foils—**Tech-Etch, Inc., 45 Aldrin Road, Plymouth, MA 02360-4803; 508-747-0300
Mr. David Crary, Principal Investigator, dcrary@tech-etch.com
Mr. George E. Keeler, Business Official, gkeeler@tech-etch.com
DOE Grant No. DE-FG02-05ER84169
Amount: $670,252

Particle tracking detectors are used extensively in nuclear and high energy experiments supported by the DOE. New advances in the technology of micropattern detectors, and in particular Gas Electron Multipliers (GEMs), offer significant improvements in performance over traditional tracking detectors. This project will develop a commercial source of GEM foils for use in the nuclear and high energy research community. Phase I involved a systematic investigation of various aspects of the production of GEM foils. Detailed measurements were made on the physical properties of the foils, such as hole size, hole spacing, and hole geometry. The principle cause of a gain instability was identified and solved by the use of a cleaning agent in the last stage of production. Overall, the study has lead to a much better understanding of the manufacturing process and to improved performance of the foils. Phase II will concentrate on improving the quality, reliability, uniformity and gain stability of the GEMs. Specific studies will involve measurements of gain stability over time, spatial gain uniformity, and rate dependent effects. The primary objectives of Phase II will be to identify the critical manufacturing parameters involved in producing reliable high-quality foils and to develop a capability for producing larger foils, while maintaining good quality control.

*Commercial Applications and other Benefits* as described by the awardee: GEM detectors have potential use in many types of research, such as nuclear physics, high energy physics and astrophysics, as well as in medical imaging, nuclear non-proliferation, and homeland security applications.

78204S05-II

**47**

**Hybrid Membrane Distillation Process for Enhanced Integrated Ethanol Production—**
Compact Membrane Systems, Inc., 325 Water Street, Wilmington, DE 19804-2410;
302-999-7996
Dr. Sudipto Majumdar, Principal Investigator, smajumdar@compactmembrane.com
Ms. Nadine Cragg-Lester, Business Official, nlester@compactmembrane.com
DOE Grant No. DE-FG02-05ER84224
Amount: $750,000

The conversion of corn and other biomass to fuel grade ethanol not only would reduce U.S. dependence on foreign energy sources but also would be a major industrial application for agricultural products. However, the process of drying the ethanol to fuel grade consumes significant amounts of energy, incurring costs that continue to increase as cost of natural gas increases. This project will develop technology for introducing a hybrid membrane distillation process that will significantly reduce both the energy and capital requirements for drying. Phase I demonstrated that the membrane technology could preferentially remove water from water-ethanol azeotrope and produce fuel grade ethanol (FGE). The membranes were shown to operate at high temperature (130$^{o}$C) and high pressure (200 psia) while providing high flux, high separation, excellent chemical resistance, and long term stability. An engineering and economic model demonstrated that the membrane modules could provide major savings in both capital costs ($0.7 versus $4.2 million) and energy consumption (33 – 239 billion BTU/yr) for a typical 70 million gallon/yr ethanol plant, compared to conventional molecular-sieve driers. In Phase II, both prototype laboratory systems and field test systems will be built and evaluated. Participation by ethanol design firms will facilitate field testing and subsequent engineering and economic analysis.

*Commercial Applications and other Benefits* as described by the awardee: The intial target market for this technology is the growing 13 billion gallon/year ethanol business. The technology also should be applicable to many other energy intensive separation processes.

78208S05-II

**40**

**An Economic Process for Coal Liquefaction to Liquid Fuels—**Specialties Group, Inc., 1128 University Drive, Morrisville, PA 19067; 732-274-0050
Dr. Partha Sarathi Ganguli, Principal Investigator, p.ganguli@att.net
Dr. Partha Sarathi Ganguli, Business Official, p.ganguli@att.net
DOE Grant No. DE-FG02-05ER84256
Amount: $750,000

Currently, direct-coal liquefaction processes produce limited yields of moderate-quality liquid products, which are not cost-effective compared to petroleum-based liquid fuels. This project will develop a novel catalytic process for the liquefaction of coal into liquid fuels. Phase I provided a proof-of-concept regarding the ability of the catalyst and the processing technology to produce high quality liquid fuels with high yields. Phase II will: (1) improve and optimize the catalyst system; (2) improve and optimize the reactor system developed in Phase I; and (3) study the coal liquefaction process in a mini-pilot-plant-scale processing unit, in order to demonstrate technical feasibility, collect data for a commercial design and economic feasibility study, and optimize the process to obtain high yield of high quality liquid product.

*Commercial Applications and other Benefits* as described by the awardee: The coal liquefaction process should enable a coal-based refinery to produce transportation fuels for less than $25 per barrel. The low cost of the reactor system and high yield of liquid fuels would make the process cost effective. If successfully implemented, the technology should have a profound impact on the energy industry, creating energy-production jobs in the United States and dramatically decreasing reliance on imported petroleum.

78223S05-II

**109**

**200 MW L-Band Annular Beam Klystron for Accelerators—**Calabazas Creek Research, Inc., P.O. Box 330, Palo Alto, CA 94302; 650-595-2168
Dr. Michael E. Read, Principal Investigator, Mike@calcreek.com
Dr. Purobi Phillips, Business Official, Purobi@calcreek.com
DOE Grant No. DE-FG02-05ER84350
Amount: $700,000

Efficient, cost effective high power high frequency drivers are required for advanced accelerators. To address this need, this project will develop a 200 MW, 1.3 GHz Annular Beam Klystron (ABK) that will operate at a lower voltage than conventional klystrons. In Phase I, a preliminary design was developed, with detailed simulations of all critical components. All design goals were shown to be feasible: efficiency over 40%, power exceeding 200 MW, and a perveance of 3 microperv. In Phase II, the design will be refined, detailed mechanical drawings will be prepared, and the annular beam klystron will be fabricated and tested.

*Commercial Applications and other Benefits* as described by the awardee: The ABK would allow significantly lower voltages to be used, compared to conventional klystrons, reducing the cost of the system. Also, compared to other advanced source concepts, the ABK would be mechanically much simpler than a multiple beam klystron, and would have a lower risk than a sheet beam klystron

**Hybrid Anti-Fouling Membrane System for Natural Gas Separation—**Compact Membrane Systems, Inc., 325 Water Street, Wilmington, DE 19804-2410; 302-999-7996
Dr. Donald J. Stookey, Principal Investigator, dstookey@compactmembrane.com
Ms. Nadine Cragg-Lester, Business Official, nlester@compactmembrane.com
DOE Grant No. DE-FG02-05ER84225
Amount: $750,000

The need for natural gas continues to grow, and recent increases in petroleum prices have been paralleled by large increases in the price of natural gas. However, natural gas at the source often has high concentrations of carbon dioxide and hydrogen sulfide, which must be removed. Although existing commercial polymeric membranes (e.g. cellulose acetate and polysulfone) do a good job of sweetening the natural gas by removing both carbon dioxide and hydrogen sulfide to meet feed line requirements, these membranes are subject to foulant disruptions, which can lead to system outage and loss of productivity. This project will develop natural-gas-sweetening membranes that offer dramatically-improved fouling resistance while maintaining commercial flux and separation targets. The fouling resistance will be broad based and will have application to many membrane foulants and many membrane systems. Phase I demonstrated that the enhanced fouling resistance for natural gas sweetening membranes would significantly reduce the fouling outages. An engineering and economic analysis suggested a 1% increase in natural gas capacity (based on reduced outages) and significant energy savings associated with less loss of natural gas, due to high membrane effective selectivity. Phase II will: (1) optimize system performance related to fouling resistance, separation, flux, and projected cost; (2) fabricate full-scale membrane modules for laboratory and field testing; (3) perform extensive and long term (e.g., 1000 hours) laboratory testing with multiple foulants; (4) perform field testing at an actual site; and (5) upgrade the economic evaluation.

*Commercial Applications and other Benefits* as described by the awardee: The high-selectivity and robust membranes should economically enhance the 30% of natural gas wells in the United States that are in need of upgrading to remove impurities. This represents 62 quads of energy. Additionally, this technology should have application to enhanced carbon monoxide and methane separation in oil recovery operations.

78248S05-II

**130**

**Segmentation of the Outer Contact on P-Type Coaxial Germanium Detectors—**PHDs, 777 Emory Valley Road, Suite B, Oak Ridge, TN 37830-7071; 865-481-3725
Dr. Ethan L. Hull, Principal Investigator, ethanhull@phdsco.com
Dr. Ethan L. Hull, Business Official, ethanhull@phdsco.com
DOE Grant No. DE-FG02-05ER84157
Amount: $749,000

Segmented germanium detector arrays are needed by the DOE for the characterization of low-level radioactive samples. In addition, the same detector arrays could perform important fundamental physics measurements, including the search for rare-events like neutrinoless double-beta decay. However, because of their complexity, these segmented coaxial detectors are expensive and available only after relatively long lead times. Improved fabrication techniques would greatly reduce costs and improve the availability of these segmented detectors for the low-level counting community. Therefore, this project will experimentally investigate alternative techniques for making segmented contacts on p-type coaxial germanium detectors, which would be a much cheaper alternative to the segmented n-type coaxial detectors currently proposed. However, the difficulties associated with the segmentation of conventional thick lithium-diffused contacts must be addressed. Phase I experimentally evaluated detector fabrication techniques appropriate for segmented p-type coaxial detectors, and a fabrication recipe was established. In Phase II, the viability of alternative segmented detector contacts, as a competitive solution to the contacts established during Phase I, will be established. The best overall technique will be used to fabricate a large segmented p-type coaxial detector as a demonstration.

*Commercial Applications and other Benefits* as described by the awardee: The new germanium detector technology should provide better detector performance at lower cost for the measurement of low-activity radioactive sources. Applications of interest include national security (nuclear nonproliferation, nuclear explosion monitoring), areas of scientific importance (e.g., new levels of sensitivity in the Majorana search for neutrinoless doublebeta decay), medical imaging, and x-ray detection.

78276S05-II

**118**

**Ferroelectric Switch for a High-Power Ka-Band Active Pulse Compressor—**Omega-P, Inc., 199 Whitney Avenue, Suite 200, New Haven, CT 06511; 203-789-1165
Dr. Jay L. Hirshfield, Principal Investigator, jay@omega-p.com
Dr. George P. Trahan, Business Official, trahan@omega-p.com
DOE Grant No. DE-FG02-05ER84367
Amount: $650,000

A future multi-TeV collider requires the development of new technology to achieve a much higher acceleration gradient. An active pulse compressor would enable this development by multiplying the power of Ka-band microwave pulses to obtain peak power levels that are unattainable from a single source. This active pulse compression can be achieved by rapidly switching the coupling between delay lines and a load, so as to discharge energy stored in the lines into the load. This project will develop an active switch based on the use of ferroelectric elements, for which the dielectric constant changes rapidly upon application of a voltage pulse. The switch will be used with the 34-GHz magnicon to constitute a test facility for high-gradient accelerator R&D. In Phase I, design studies, involving detailed simulations on realistic structures, were carried out for an active Ka-band switch to be used with delay lines. In these studies, the switch produced compressed pulses with peak powers in the range of 200 MW, as required for the development of high-gradient accelerator structures for a future multi-TeV collider. In Phase II, engineering designs for a high-power prototype of the ferroelectric switch will be fabricated and tested using a 34-GHz magnicon test facility. A pair of low-loss delay lines and a quasi-optical hybrid coupler will be assembled to test the overall concept. The prototype will be used to generate 200 MW pulses that will be used to extend the understanding of microwave breakdown, thereby enabling the design of high-gradient accelerators for a future multi-TeV collider.

*Commercial Applications and other Benefits* as described by the awardee: A high-power, rapid-acting Ka-band switch could be marketed for high-power testing of a variety of millimeter-wave components and could find applications in high-power advanced radars.

78277S05-II

**42**

**Electroactive Polymer Separator to Protect from Overcharging in Lithium Ion Batteries—**
Physical Sciences Inc., 20 New England Business Center, Andover, MA 10810-1077;
978-689-0003
Dr. Aron Newman, Principal Investigator, newman@psicorp.com
Dr. B. David Green, Business Official, green@psicorp.com
DOE Grant No. DE-FG02-05ER84249
Amount: $749,882

Battery packs for hybrid electric vehicles need to be low cost and have a 15-year lifetime. However, the cycle life of lithium-ions cells, which are configured in series, is reduced by the overcharging of individual cells. The current method of overcharge control, which uses external control circuitry, has a gravimetric and cost burden, and is ineffective at eliminating all of the cell damage during overcharge. This project addresses the overcharging issue by developing an alternative separator that becomes temporarily conductive when a cell reaches an over-voltage condition, shunting electrons between the electrodes. This separator/shunt will keep the cell voltage below the value at which deleterious reactions occur. When the charging current is no longer applied to the cell at higher voltages, the separator will switch to an insulator and allows normal battery operation. The process will be fully reversible and will not limit the number of charging cycles that can be applied to the cell. In Phase I, the fabricated separator demonstrated the technical feasibility for controlling overcharge. At over-voltage conditions (> 3.9V), the electroactive polymer separator functioned as a current shunt at current densities up to 10 $mA/cm^2$. At cell operating voltages, the separator performed as an ion shuttle as the cell charged and discharged, maintaining cell capacity at typical C-rates. In Phase II, the polymer blend components that make up the separator will be modified to enable 10 $mA/cm^2$ current on overcharge and to allow performance as a typical separator with a fully charged open circuit voltage of 4.2 volts. The selected polymer blend will be scaled-up via film production on continuous process, solvent casting equipment. Experimental and control separators will be tested in 240 mAh pouch cells for overcharge and cycle life.

*Commercial Applications and other Benefits* as described by the awardee: The new separator technology should be appropriate for lithium ion battery stacks that require greater cycle life than what is available currently. The electroactive separator is a cost-effective and gravimetrically-effective means of protecting the electrodes locally for improved cycle life. In addition to the HEV and electric vehicle markets for this separator, other potential consumer applications include laptop computer batteries.

78301S05-II

**15**

**An Ultra-Precise System for Electrical Resistivity Tomography Measurements—**Multi-Phase Technologies, LLC, 310 Rebecca Drive, Sparks, NV 89436; 775-425-9606
Dr. Douglas J. LaBrecque, Principal Investigator, dlabrecque@mpt3d.com
Ms. Marjorie O. LaBrecque, Business Official, mlabrec913@yahoo.com
DOE Grant No. DE-FG02-05ER84289
Amount: $493,755

One of the most widely used geophysical methods for monitoring flow within the shallow subsurface is Electrical Resistivity Tomography (ERT). The latest generation of ERT systems can monitor data to a precision of around 1%, allowing *in situ* changes to be interpreted within a few percent. In turn, subsurface temperature changes can be monitored to within a few degrees Centigrade, low levels of tracers – only slightly higher than background variations – can be tracked, and fracture propagation on a site of several thousand square meters can be watched. This project will make improvements to hardware and data collection procedures that will raise ERT precision by an order of magnitude. In Phase I, modifications were made to a number of interdependent hardware and software systems, resulting in reductions in both random and systematic noise sources. Random noise was reduced by implementing longer data averaging periods and by improving stacking algorithms. Systematic noise was reduced by improving hardware design, including the isolation of transmitter and receiver paths in the multiplexer and the use of temperature-stabilized higher-precision components to improve calibration. Electrode and cable effects also were found to be larger sources of noise than anticipated. Phase II will investigate the use of alternative materials for the electrode and cable, in order to mitigate the noise from these sources. Alternative data collection strategies will be investigated. Improvements to hardware and software will focus on calibration. Field trials will be held in difficult environments, such as the Idaho National Laboratory, Box Canyon fractured rock study area, and Vadose Zone Research Park.

*Commercial Applications and other Benefits* as described by the awardee: An improved ERT technology should increase measurement precision, increase resolution, and enhance effectiveness in existing monitoring applications without significantly increasing costs. These improvements should broaden the range of applications for the method, particularly in monitoring flow in the shallow subsurface. The DOE complex alone has been estimated to contain 200 million cubic meters of contaminated soils, including those at the Hanford Reservation, the Savannah River Site, the Idaho National Laboratory, and the Nevada Test site.

78310S05-II

**61**

**Multi-Function Inspection Scope: Enabling New Surface Science at High-Energy Beamline Facilities—**Creative Light Source, Inc., 4845 Pearl East Circle, Suite 101, Boulder, CO 80301-6113; 303-417-6360
Mr. Joseph A. DiMasi, Principal Investigator, joseph@creativelightsource.com
Mr. Joseph A. DiMasi, Business Official, joseph@creativelightsource.com
DOE Grant No. DE-FG02-05ER84226
Amount: $749,726

Neutron scattering facilities provide a cutting-edge tool for researching the structure and phase behavior of surfactant films and organic interfaces, which are important in science, medicine, energy, and nanotechnology. However, a significant problem for the interpretation of scattering data is that these films are generally inhomogeneous. Therefore, microscopy must be performed separately to obtain the needed complementary information about molecular domain size. This project will develop a high-resolution Brewster Angle Microscope (BAM) to enable simultaneous scattering, diffraction, and processing experiments. Phase I implemented the tilted-plane imaging design; specified the laser source, custom optical elements, and charged-coupled-device (CCD) chip to optimize the image; and built a working prototype capable of diffraction-limited Brewster Angle imaging from a tilted surface, as needed for monomolecular films on water substrates. The prototype system was designed to fit the NG7 horizontally scattering cold neutron reflectometer at the NIST Center for Neutron Research. Following characterization in the optics laboratory, the prototype instrument was brought to the National Synchrotron Light Source (NSLS) for commissioning, for the very first *in-situ* BAM measurements of its kind. In Phase II, a world-class imaging instrument, which goes far beyond Brewster Angle Microscopy, will be manufactured. The new instrument will combine BAM, Imaging Polarimetry, Imaging Ellipsometry, and 3-D Reconstructive Imaging Microscopy in a single, compact instrument.

*Commercial Applications and other Benefits* as described by the awardee: The proposed optical design should revolutionize sample characterization for industries that process films, semiconductors, and microdevices. With a high-resolution microscope positioned away from the surface-normal axis, these industries will be able to image surfaces simultaneously with a vast array of characterization and quality-control techniques. Commercial applications include flat-panel display inspection, semiconductor inspection, nanotechnology, and MEMS.

**High Efficiency, Low-Cost Reforming to Produce Hydrogen—**TDA Research, Inc., 12345 W. 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300
Dr. Jeannine E. Elliott, Principal Investigator, jelliott@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-05ER84215
Amount: $750,000

Current natural gas reforming plants that produce hydrogen are expensive because of the large capital cost associated with the reformers. The heat required to drive the reforming reaction is transferred in a fired-furnace through heat exchanger tubes. These tubes are extraordinarily expensive because they are high nickel alloys, which cost ten times as much as carbon steel, and have thick walls to run at high temperatures (up to 900 °C) and high pressures (400-500 psi). In addition, the efficiency of current reformers is limited by the temperature at which they operate, which is in turn limits the operating temperature of the reformer tubes. This project will develop a steam reforming system for the production of hydrogen, which uses direct combustion to generate heat reforming, instead of using combustion in a fired-furnace reformer. In Phase I, experimental research, system design, and cost analysis studies were used to show that the new hydrogen-generation approach can reduce capital cost, increase methane conversion efficiency, and reduce the cost of hydrogen. In Phase II, a new test apparatus will be built to demonstrate the performance of the entire system. Also, a full system design and an economic analysis for a large-scale plant operation will be conducted.

*Commercial Applications and other Benefits* as described by the awardee: The new process should reduce the cost of hydrogen from natural gas, while increasing efficiency and emitting far less carbon dioxide to the atmosphere. U.S. demand for hydrogen is now about nine million tons per year, and growing rapidly.

78339S05-II

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**Technology to Improve the Performance of Lithium-Ion Cells at Low Temperatures—**
TIAX, LLC, 15 Acorn Park, Cambridge, MA 02140-2390; 617-498-5655
Dr. Karen Thomas-Alyea, Principal Investigator, Thomas-Alyea.Karen@tiaxllc.com
Ms. Renee Wong, Business Official , wong.renee@tiaxllc.com
DOE Grant No. DE-FG02-05ER84260
Amount: $732,443

Hybrid electric vehicles (HEVs), plug-in hybrid-electric vehicles (PHEVs), and electric vehicles (EVs) are key technologies for reducing the nation's dependence on imported petroleum, reducing greenhouse-gas emissions and air pollution, and conserving petrochemical feedstocks. Because lithium-ion batteries have a higher energy density relative to the presently-used nickel-metal hydride batteries, lithium-ion batteries have the potential to extend the range of these vehicles, while also reducing battery mass and size. In particular, lithium iron phosphate – which offers much higher safety, higher abuse tolerance, longer cycle life, and lower cost – presents an opportunity to accelerate the introduction of lithium-ion batteries for automotive applications. However, the low-temperature performance of present lithium iron phosphate materials does not meet the targets of the U.S. Advanced Battery Consortium. This project will conduct a study to improve the low-temperature performance of lithium iron phosphate. Phase I targeted the activation energy for transport processes, as a potential pathway for improving the low-temperature performance of lithium iron phosphate. Phase II will continue the strategies identified in Phase I and develop a material that meets the requirements for automotive batteries at low temperature.

*Commercial Applications and other Benefits* as described by the awardee: Because of its great advantages in cost and safety relative to presently-used, metal-oxide cathode materials, an improved lithium-iron-phosphate cathode would accelerate the introduction of lithium-ion batteries for hybrid electric vehicle applications. In a field currently dominated by a few Asia-based companies, this technology may allow the U.S. to reclaim large parts of the lithium-ion battery market.

78341S05-II

**111**

**New Concepts for Pulse Power Modulators—**Diversified Technologies, Inc., 35 Wiggins Avenue, Bedford, MA 01730-2345; 781-275-9444
Dr. Jeffrey A. Casey, Principal Investigator, casey@divtecs.com
Mr. Michael A. Kempkes, Business Official, kempkes@divtecs.com
DOE Grant No. DE-FG02-05ER84352
Amount: $700,000

The international science community recently selected a superconducting approach for the next generation electron-positron collider. This machine will require nearly 600 high voltage modulators and power supplies, capable of driving the accelerator's L-band klystrons. The cost of these modulators and power supplies will represent a significant portion of the overall budget of the International Linear Collider (ILC). This project will apply the inherently modular capability of solid-state Marx banks – a relatively recent combination of a traditional pulsed power design and modern solid-state switches – to reduce the overall cost of the modulator and power supplies. In Phase I, a solid-state Marx bank modulator and power supply was designed, based on the design requirements for potential ILC klystrons, with the primary objective of minimizing both acquisition cost and total operating costs. A major element in the design was the optimization of energy storage and control in the modulator, in order to meet the klystron pulse fidelity requirements without very large and expensive capacitor banks. The cost-saving potential of a solid state Marx modulator for the ILC was estimated to 25-50%, compared to alternative architectures. Phase II will focus on the construction of a full scale, full power ILC Marx bank modulator, which will be delivered to a DOE laboratory for assessment and test with potential ILC klystrons.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the ILC application, the Marx bank modulator should provide a highly-cost-effective means of applying solid-state, pulsed power technology to commercial and industrial high voltage systems. Military radar, medical accelerators, high-energy X-ray systems for container inspection, and irradiation systems should directly benefit from the development of solid-state Marx bank modulators, which are reliable, inexpensive, and efficient.

78343S05-II

**65**

**Silicon Microchannel Neutron Lens—**Physical Optics Corporation, Photonic Systems Division, 20600 Gramercy Place, Building 100, Torrance, CA 90501-1821; 310-320-3088
Mr. Paul Shnitser, Principal Investigator, sutama@poc.com
Mr. Gordon E. Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-05ER84248
Amount: $749,979

The Department of Energy supports large-scale, national user facilities that generate intense neutron beams for the characterization of materials. Increasingly used in research, neutrons are making invaluable contributions to the physical, chemical, and biological sciences. Despite advances in neutron sources and instrumentation, many neutron scattering experiments remain flux limited. Improved focusing optics would enhance neutron flux density in samples, significantly reducing data collection time. This project will develop a compound silicon microchannel neutron lens with a geometrically ideal microchannel structure. The proposed microchannel "lobster eye" lens will focus neutrons into an approximately 0.1 millimeter spot, with much greater efficiency than conventional neutron lenses. In Phase I, the lens design was optimized, based on a lobster eye assembly of flat metal-plated silicon wafers; a functional lens prototype was fabricated; and proof-of-concept was demonstrated by focusing hard x-rays (30 kiloelectronvolt peak) to a less than 1 millimeter focal spot. In Phase II, a fully operational, large-scale, silicon microchannel, neutron focusing and radial collimation device will be developed, initiating a new class of neutron optics for stress, texture, and other analysis of advanced materials in small volumes by neutron diffraction. The device will be based on silicon elements coated with nickel/titanium supermirrors and assembled into microchannel structures with high-aspect-ratio channels (1:1250). The device will be specifically designed for government diffractometers, where it will be rigorously tested as part of the Phase II project.

*Commercial Applications and other Benefits* as described by the awardee: Besides the applications for unique instrumentation in national laboratories, the proposed lens should find use in the next generation of neutron microscopes now under development. Such microscopes, with spatial resolution far beyond the limits of visible light microscopy, are urgently needed for submicron photolithography and for biomedical research on cell structures. Other applications include homeland security screening systems and industrial nondestructive evaluation.

78363S05-II

**99**

**A New PIT $Nb_3Sn$ Process, Toward Improved Cost-Performance for HEP High Field Magnets—**SupraMagnetics, Inc., 125 South End Road, Southington, CT 06489-3959; 860-977-7416
Dr. Leszek Richard Motowidlo, Principal Investigator, LMOTO@cox.net
Dr. Leszek Richard Motowidlo, Business Official, LMOTO@cox.net
DOE Grant No. DE-FG02-05ER84381
Amount: $600,000

The development of improved, cost-effective $Nb_3Sn$ superconductors would have an immediate benefit for high field magnets in High Energy Physics (HEP) applications. This project will develop and demonstrate an economical powder-in-tube (PIT) $Nb_3Sn$ process for use in magnets for future HEP accelerator research. In Phase I, a low-cost, intermetallic, phase-pure $Cu_5Sn_4$ powder was developed, a PIT $Nb_3Sn$ process was designed, and prototype $Nb_3Sn$ conductors were fabricated. A cost-performance analysis was conducted, which suggested that the approach will meet DOE goals. In Phase II, powder manufacturing will be optimized, and advanced PIT designs will be fabricated on intermediate size billets. The data will be used to assemble and manufacture a scaled-up prototype conductor. Material will be produced and made available for building and testing prototype cables and test magnets at DOE national laboratories.

*Commercial Applications and other Benefits* as described by the awardee: In addition to HEP applications, an economical $Nb_3Sn$ superconductor would have application in high field magnets used in fusion machines and Nuclear Magnetic Resonance (NMR). For fusion machines, a successful demonstration would have enormous economic and social benefits. For NMR, we are on the verge of a technological explosion, with requirements in chemical research, biochemistry, pharmaceutical chemistry, polymer science, petroleum research, agricultural chemistry, and medicine.

78376B05-II

**12**

**Time-Lapse 3D GPR Characterization and Monitoring of Near-Surface Groundwater and Contaminant Flows—**4th Wave Imaging Corporation, 16A Journey, Suite 200, Aliso Viejo, CA 92656-9786; 949-916-9787
Dr. David E. Lumley, Principal Investigator, david.lumley@4thwaveimaging.com
Dr. Richard Wright, Business Official, rich.wright@4thwaveimaging.com
DOE Grant No. DE-FG02-05ER84266
Amount: $750,000

According to the Environmental Protection Agency, federal, state, and local governments, as well as private industry, will spend billions of dollars annually over the next several decades to clean up groundwater sites contaminated with hazardous waste and petroleum products. As many as 350,000 contaminated sites, including many sites operated by DOE, could require cleanup over the next 30 years, at an expense that may exceed $250 billion. This project will develop technology that uses ground-penetrating radar to image groundwater contaminant plumes underground, and monitor them in time-lapse mode as they undergo natural biodegradation or are cleaned up by remediation processes. The technology would enable engineers to monitor the effectiveness of clean-up operations in real time, make adjustments to remediation processes if necessary, and locate any residual contaminants before leaving the site. In Phase I, prototype methods and software algorithms were developed for processing time-lapse radar data; images and quantitative estimations of underground contaminant-saturation distributions were produced; and the feasibility of imaging groundwater contaminants – in the presence of rocks, water, contaminants, and radar noise – was demonstrated. In Phase II, a field trial will be performed at a DOE/DOD contaminant site undergoing active biodegradation or remediative clean-up of groundwater contaminants.

*Commercial Applications and other Benefits* as described by the awardee: In addition to monitoring groundwater contaminants at clean-up sites across the nation, the technology also should be useful for agricultural applications to monitor subsurface soil moisture over time for the enhancement of crop irrigation and production. The technology also may find use in monitoring groundwater depletion and recharge in subsurface aquifers, vital for securing the nation's supply of fresh water.

78405S05-II

**23**

**Advanced Coal Gasification System—**Eltron Research Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263
Dr. James H. White, Principal Investigator, eltron@eltronresearch.com
Mr. James Steven Beck, Business Official, contracts@eltronresearch.com
DOE Grant No. DE-FG02-05ER84200
Amount: $750,000

The efficient, clean, and cost effective conversion of coal is a principal goal of the U.S. energy industry and the DOE. Although still costly, coal gasification remains the most effective method for converting the raw feedstock into syngas for liquid fuel production, for hydrogen production (for fuel cell use), or for combustion in a gas turbine generator. In order to reduce capital costs, this project will develop technology for integrating fluidized bed gasification with chemical looping to allow gasification under less severe conditions. In particular, the technology eliminates cryogenic air separation and enables $CO_2$ sequestration. Phase I identified oxygen carrier materials and demonstrated the integration of air separation and coal gasification in chemical looping. Preferred catalyst materials not only were extremely inexpensive, but also exhibited an oxygen storage capacity as high as 30 wt% and proved to be rugged even with minimal processing. When incorporated into a fluidized bed reactor, the gasification system exhibited carbon conversion greater than 98% and cold gas efficiency greater than 70%, at a bed temperature less than 850°C. These results easily exceeded the performance of other fluidized bed gasification processes while enabling $CO_2$ sequestration. Phase II will consist of the final selection and development of catalyst materials; design, fabrication, and testing of a pilot scale chemical looping system; and employment of the system in chemical looping coal gasification and other potential applications.

*Commercial Applications and other Benefits* as described by the awardee: The technology should provide capital savings in coal gasification processes by eliminating the air separation unit, reducing plant cost by a significant amount (~20%). These savings should make the technology attractive in combined cycle, hydrogen production, coal-to-liquids, commodity chemical production, and other applications.

78469S05-II

**29**

**Downhole Heater Cables for Oil Shale Recovery—**Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026; 303-664-0394
Dr. Matthew W. Hooker, Principal Investigator, matt@ctd-materials.com
Mr. Fred L. Beavers, Business Official, fred@ctd-materials.com
DOE Grant No. DE-FG02-05ER84198
Amount: $749,897

Downhole heaters capable of long-term high-temperature operation are needed to assist in oil shale recovery. However, currently available, mineral insulated (MI) cables are not capable of surviving the temperature or other downhole environmental conditions encountered in this application. This project will develop high-performance downhole heater cables, based on high-performance composite insulation, to assist in oil shale recovery. In Phase I, prototype heater cables with composite insulation were produced using a readily-scalable manufacturing process and their performance was characterized. High-temperature high-voltage performance was demonstrated for long-term application in the downhole environment. Phase II will continue the development of materials and manufacturing processes for the heater cables. The initial focus will be on the further optimization of the composite insulation system. Then, the heater cable fabrication process will be scaled-up to levels suitable for the commercialization of the composite insulated heater cables.

*Commercial Applications and other Benefits* as described by the awardee: It is estimated that the United States possesses approximately two-thirds of the world's oil shale deposits. The new heater cables should allow this valuable resource to be exploited. These heater cables would be: (1) capable of extended operation at elevated temperatures, (2) able to withstand the downhole environmental conditions, and (3) produced using a process that is scalable to meet end-user production requirements.

78471S05-II

**91**

**Improved Internal-Tin $Nb_3Sn$ Conductors for ITER and Other Fusion Applications—**
Supergenics I, LLC, 336 Sterling Road, Jefferson, MA 01522-1333; 508-829-9041
Dr. Eric Gregory, Principal Investigator, ericgregory@charter.net
Dr. Eric Gregory, Business Official, ericgregory@charter.net
DOE Grant No. DE-FG02-05ER84191
Amount: $749,979

In the near future, there will be an urgent need for large quantities of $Nb_3Sn$ superconductor for the International Thermonuclear Experimental Reactor (ITER), an experimental fusion device. However, the DOE has only a few domestically-located companies that are capable of supplying this need, and two of these are subsidiaries of European companies that have orders and commitments to the EU fusion program. Thus, there is a serious need for a U.S. company that can supply some of this superconductor. This project will demonstrate that a United States company can supply superconductor strands that meet toroidal-field specifications from production-size billets. In Phase I, several lengths of strand were made from two small billets, without any fabrication problems. The aim was to meet the specification for the central solenoid conductor, which has lower electrical loss and slightly lower critical current density. The material produced had a lower critical current density than required, but the reasons for this result were identified and are not thought to be insurmountable. Phase II will focus on reducing the distortion of the filaments, enlarging the billets, controlling the spacing-to-diameter ratio of the superconductor rods, and improving the critical current density. First, small billets will be fabricated to enable the process to be refined and modified to meet the toroidal-field specification. Afterwards, large billets will be fabricated to demonstrate the viability of a domestic strand supplier.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the fusion application, $Nb_3Sn$ superconductors should find use in open-area Magnetic Resonance Imaging (MRI), where the patient is more accessible to the surgeon. (MRI is the largest commercial application of low temperature superconductors.) There is also a need for this type of product in High Energy Physics research and in Nuclear Magnetic Resonance.

78481S05-II

**81**

**High Efficiency Electro-Refining for Direct Capture of Saleable Metals—**Eltron Research Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263
Dr. Wayne E. Buschmann, Principal Investigator, eltron@eltronresearch.com
Mr. James Steven Beck, Business Official, contracts@eltronresearch.com
DOE Grant No. DE-FG02-05ER84320
Amount: $750,000

Electrowinning is a widely used process method for primary mineral extraction and refined metal production; however, conventional technologies have economic and efficiency limitations that leave significant resources either unutilized or lost to waste discharge. The major challenges for electrowinning technologies are increasing production efficiency; eliminating waste; and combining separation, refining, and production into a single process. This project will develop a unique, high-efficiency electrowinning technology that can capture metals from aqueous streams, especially at low concentrations (<500 mg/L), and simultaneously produce metals and reduced metal oxides. During Phase I, a number of process conditions and system configurations were evaluated for removing several different metals from acid solutions, without the use of additives. Unique capabilities in energy efficiency, waste treatment, and material production were demonstrated at low concentration (200 mg/L). In particular, it was demonstrated that copper or cuprous oxide could be produced for about $0.30 per pound, that iron ferrite could be produced directly from solution for less than $0.15 per pound, and that arsenic could be removed to achieve discharge levels. During Phase II, process conditions will be optimized for more selective production of specific products (metals and metal oxides) from feed streams relevant to solvent extraction and mine waste, using the pilot-scale reactor produced in Phase I. A pilot-scale system, incorporating several reactors, will be designed, fabricated, and demonstrated as the vehicle for transitioning the technology to one of several potential end-users.

*Commercial Applications and other Benefits* as described by the awardee: Commercial applications and market entry will initially focus on the metals recovery and reduced oxide products markets. These markets are very large (several $ billion each), the economic benefits are clear, and interested companies are numerous. For the production of cuprous oxide and iron ferrite alone (not including metals recovery), the internal rate of return for a licensing venture is estimated at 152%, with a net present value of about $145 million.

78556S05-II

**18**

**Vertically Integrated Measuring and Monitoring Instrumentation for Terrestrial Sinks and Sources of Carbon Dioxide—**Atmospheric Observing Systems, Inc., 1930 Central Avenue, Suite A, Boulder, CO 80301; 303-443-3389
Dr. James R. Smith, Principal Investigator, jim@aosinc.net
Dr. James R. Smith, Business Official, jim@aosinc.net
DOE Grant No. DE-FG02-05ER84273
Amount: $750,000

Tower-based observatories monitor terrestrial ecosystems from a single spot; however, it is not known if the observations are applicable to the entire ecosystem. A vertically-integrated suite of technologies could be used to evaluate ecosystem-atmospheric interactions and determine the actual utility of tower-based systems; however, for reasons of safety and expense, piloted aircraft cannot be used to provide the needed observations. This project will build and deploy such a vertically-integrated suite of technologies that will include: (1) probes for monitoring the transient flux of carbon dioxide ($CO_2$) associated with the dispersal of respiration at the onset of solar heating each morning; (2) tower- and mooring-based instrumentation for continuous observations of $CO_2$ concentration and steady-state, eddy covariance flux; and (3) a radio-controlled Unmanned Airborne Vehicle (UAV), fitted with a high precision analyzer system and capable of monitoring the time series of $CO_2$ for the entire range of ambient conditions. In Phase I, a commercial UAV was purchased and integrated with a high precision $CO_2$ analyzer. The UAV was deployed multiple times, and observations were verified by sampling from a short tower sited at the center of the flight pattern. Discrete probes were developed successfully to monitor $CO_2$ concentrations on or within the atmospheric interface. In Phase II, the UAV will be upgraded for increased flight time and the measurement of additional atmospheric variables. Inexpensive UAVs that carry the same payload will be developed to provide a platform that is suitable for high risk deployments.

*Commercial Applications and other Benefits* as described by the awardee: The integrated measurement suite could be used to provide observational services with respect to the monitoring of both terrestrial and marine ecosystems. The UAV platform could provide improved high precision payloads and products required for scientifically important missions.

78561S05-II

134

**Next Generation, Rugged, Low-Cost UV Femtosecond Laser Ablation System for Microanalysis**—New Wave Research, 48660 Kato Road, Fremont, CA 94538; 603-868-3990
Dr. Chung Po Huang, Principal Investigator, chuang@new-wave.com
Mr. Lawrence Neufeld, Business Official, lneufeld@new-wave.com
DOE Grant No. DE-FG02-05ER84331
Amount: $750,000

Laser ablation mass spectrometry, identified as a key technology for the DOE's Nuclear and Radiological National Security Program, has, since the mid-1980s, been gaining increased viability as a truly quantitative analytical technique. Over this same period of time, greater insights have been gained into the mechanisms associated with laser-material interations, particularly with respect to how these interactions affect the accuracy and precision of *in situ* elemental analysis. ~~Since the mid-1980s laser ablation mass spectrometry has been gaining increasing viability as a truly quantitative analytical technique. Over this same period of time greater insight into the mechanisms associated with laser-material interactions, particularly with respect to its effect on the accuracy and precision of in-situ elemental analysis, have been gained. Laser fluence (energy density), laser wavelength and laser pulse width are three of the dominant components effecting the stoichiometric relationship between the sample to be analyzed and the quantitative results obtained from the laser-generated aerosol transported to the analytical device.~~ The general concesus is that short pulse width (< 0.5ps), UV (<300nm) lasers have the physical charactistics necessary to achieve program goals. Unfortunately, current femtosecond laser systems (< 1ps pulse width) are expensive (>> $ 300k)), large, and require highly skilled operators. ~~The general consensus within the scientific community is that short pulse width (< 0.5ps), UV (<300nm) lasers have the physical characteristics necessary to accomplish these goals. Unfortunately, current femtosecond laser systems (< 1ps pulse width) are expensive (>> $ 300k)), large and require highly skilled operators.~~ This project will design and build a fit-for-purpose femtosecond laser for mass spectrometry, in which the performance specifications of three components (stretcher, amplifer, and compressor) can be relaxed, leading to a more cost effective and compact design. ~~Design and build a fit-for-purpose femtosecond laser for mass spectrometry whereby the performance specifications of the stretcher, amplifier and compressor in the ultra-short laser system can be relaxed, leading to a more cost effective and compact design.~~ Phase I ~~will be dedicated to~~ design~~ed~~, ~~and~~ build~~d~~t, and ~~then~~ demonstrate~~d~~ a femtosecond~~femto-second~~ laser that yielde~~d~~s 2 µ~~u~~J ~~of~~ at a UV wavelength ~~output~~ (<300nm), when operating at 1000Hz and ~~when~~ focused to a spot size of 5µ~~u~~M~~m~~. ~~using a non-conventional design that will ultimately lead to~~ In Phase II, the laser will be used to develop a more compact, rugged, and cost-effective ~~affordable~~ laser ablation system for mass spectrometry ~~.in Phase II. In Phase II the design will be further optimized then productized for integration with the Company's UP FEMTO LA-ICP-MS system (laser ablation for inductively coupled plasma mass spectrometry) and released to market.~~

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*Commercial Applications and other Benefits* as described by the awardee: ~~Due to the nature of the laser-material interaction induced by femtosecond laser ablation (1 x 10-15 sec. pulse width) this technique is gaining increasing acceptance within the analytical community. Nanosecond laser ablation (1 x 10-9 sec. pulse width) mass spectrometry has generated a wealth of data. However, its long pulse width is much more prone to thermal effects, diminishing the confidence of the data, for some materials.~~ Femtosecond laser ablation should satisfy ~~T~~the scientific community's need for ~~requires~~ a highly sensitive microprobe technique that will enable *in ~~-~~situ* solid sampling of all materials~~,~~ (metals, glasses, ceramics, polymers, biological, and ~~&~~ pharmaceutical)~~,~~ at the micron scale. ~~However, it must generate an aerosol that accurately matches the parent material. Femtosecond laser ablation shows immense promise in this area. The list of fields interested in LA-ICP-MS as a sampling technique continues to grow and includes:~~Areas of application include: ~~A~~analytical biochemistry, geochronology, ceramics, electronic materials, ~~environmental, industrial~~ and nuclear chemistry. ~~Currently approximately 600 units ($100M) ICP mass spectrometers are sold per year. Approximately 9% (54) of those systems use lasers as the sample introduction device. The proposed project design could double this value to 18% (> 100) per year.~~

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78574S05-II

**19**

**Ultralight, Low-Power Probes of Carbon Dioxide—**Atmospheric Observing Systems, Inc., 1930 Central Avenue, Suite A, Boulder, CO 80301; 303-443-3389
Dr. James R. Smith, Principal Investigator, jim@aosinc.net
Dr. James R. Smith, Business Official, jim@aosinc.net
DOE Grant No. DE-FG02-05ER84272
Amount: $750,000

A wide range of practical instruments is needed for monitoring carbon dioxide concentrations of the land, air, and sea. Moderate accuracy of order 1 ppm (dry mole fraction) and temporal response of a few seconds will suffice. Expense, weight, size, and electrical power must be kept low to make the instrumentation applicable to a large number (~10,000) of one-way deployments per year. Accessible platforms include weather balloons, floater buoys for probing the ocean's surface, sky hooks (tethered, small blimps) for vertical profiling of the atmospheric boundary layer, and towers for monitoring the accumulation of nighttime transpiration and its dispersal as a transient flux. This project will use a variation of a proven electro-optical design to build and deploy solid-state probe detection systems. Manufacturability, as expressed by a fully integrated electrical/mechanical/optical design, will be a key consideration to make the Probe detection system inexpensive and robust. Phase I built and tested two kinds of nondispersive infrared probe technologies: photo-electronic and photo-acoustic. The functionality of the photo-acoustic probe was proven for the stable isotopes of $CO_2$. Based on a wide range of laboratory tests, the photo-electronic probe proved advanced and robust enough to serve as the basis for Phase II. In Phase II, the photo-electronic probe will be upgraded and its observational capabilities will be demonstrated.

*Commercial Applications and other Benefits* as described by the awardee: The new probes should serve as the basis for: (1) observational services, consisting of deployments of the probes from sky hooks, towers, weather balloons, and floater buoys, and of management of the data streams; (2) sales of the probes for use on these same platforms and also for monitoring leaks from geosequestration of carbon dioxide; and (3) improved measurements of the amounts of sequestration of carbon dioxide by natural ecosystems.

78598S05-II

**43b**

**User Centric Monitoring—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
Dr. David A. Alexander, Principal Investigator, alexanda@txcorp.com
Mr. Laurence D Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-05ER84170
Amount: $749,771

Nuclear physicists routinely execute data processing and data analysis jobs on a Grid and need to be able to monitor job execution at an arbitrary site at any time. Existing Grid monitoring tools provide abundant information about the whole system, but are geared towards production jobs and are well suited for Grid administrators, while the information tailored towards an individual user is not readily available in a user-friendly and user-centric way. This project will develop a framework – composed of a library, database services, and a Web portal – that will collect and filter available job-monitoring information from various resources, and present it to users in a user-centric view. Virtual organizations can use the proposed framework to provide physicists with the ability to monitor such information as the status of submitted jobs, queue positions, time of start/finish, percentage of completion, error messages, standard output, and reasons for failure. In Phase I, a working prototype of the Grid service for user-centric job monitoring was created: the basic list of job properties that users want to monitor was identified, an interface for displaying the monitored information was developed, and a prototype service was built. Phase II will build a fully functional User-Centric Monitoring (UCM) framework that will allow scientists to track jobs in a workflow through a Web portal, with more information than currently available. The UCM Framework will provide a flexible library, services, and portlets to integrate within a virtual organization's existing Grid systems. Monitoring properties will be stored in a database for provenance and presented through the user's Web browser.

*Commercial Applications and other Benefits* as described by the awardee: The UCM framework should find use in Grid environments, where multiple users run multiple jobs and need to monitor their jobs on a per-user and per-job basis. High-energy and nuclear physics, space science, and climate modeling should greatly benefit from these tools. Also, business-to-business applications, where customers need specialized information about jobs, represents yet another market for the technology.

**36**

**Foil Gas Bearing Supported High Speed Centrifugal Blower—**R&D Dynamics Corporation, 15 Barber Pond Road, Bloomfield, CT 06095; 860-726-1204
Dr. Giri Agrawal, Principal Investigator, agragiri@rddynamics.com
Mr. Dennis Burr, Business Official, dennisb@rddynamics.com
DOE Grant No. DE-FG02-05ER84210
Amount: $749,818

The efficiency of solid oxide fuel cells can be increased with anode gas recycling, leading to a lower overall system cost. Therefore, in this project, a motor driven, high-speed, high-temperature Anode Gas Recycle Centrifugal Blower will be designed, manufactured and demonstrated. A high-speed direct drive motor, combined with foil gas bearing technology, will result in a low cost, efficient, small, oil-free, and reliable blower. In Phase I a prototype blower was designed and demonstrated in a test rig. The demonstration proved the feasibility of the high-speed centrifugal blower using foil gas bearings. In Phase II, a custom designed blower will be developed and demonstrated in an actual solid oxide fuel cell system.

*Commercial Applications and other Benefits* as described by the awardee: Fuel cell manufacturers and others should be able to use the high-speed centrifugal blower in both high and low temperature applications, where other types of blowers could not be used. It would provide high system efficiency, low operating cost, low life cycle cost, oil-free operation, high reliability, and maintenance free operation.

78618S05-II

**20**

**A Laser-based Instrument Platform for Measuring Methane and Other Trace Gases—**LI-COR Biosciences, 4421 Superior Street, Lincoln, NE 68504-1395; 402-467-3576
Dr. Liukang Xu, Principal Investigator, liukang.xu@licor.com
Dr. Dayle K. McDermitt, Business Official, dayle.mcdermitt@licor.com
DOE Grant No. DE-FG02-05ER84283
Amount: $750,000

Robust and reliable trace-gas analyzers (e.g., for isotopic carbon, methane, nitroxide, ammonia, etc.), suitable for long-term measurements, are not commercially available. Such analyzers are needed to achieve a better understanding of the global budget of these trace gases and to quantify their exchanges between the atmosphere and the terrestrial biosphere. This project will develop a tunable diode laser-based open-path methane analyzer using newly-developed laser technology. The new analyzer will be suitable for deployment over a wide range of ecosystems to understand methane exchange between the atmosphere and the surface. In Phase I, an open-path methane analyzer, with a newly available vertical cavity surface emitting laser (VCSEL) and wavelength modulation spectroscopy (WMS), was developed. The resolution of the analyzer was shown to be better than 10 ppb at a 10-Hz sampling rate, exceeding the required specifications for methane flux measurement; therefore, even low methane fluxes can be measured using eddy covariance with this instrument. Phase II will further develop the open-path methane analyzer by adding a multiple-pass Herriott optical cell to the VCSEL and WMS. Instrument-embedded software and application software also will be developed. The analyzer will be capable of field deployment for methane flux measurement over various ecosystems and other surface contexts (e.g. landfills and animal husbandry lots).

*Commercial Applications and other Benefits* as described by the awardee: The lack of robust and reliable methane analyzers has limited observations of methane exchange, between terrestrial ecosystems and the atmosphere, to short-time intervals only. The new analyzer should allow measurements of methane exchange to be made year-round, with a minor maintenance requirement. In addition, the hardware and signal processing software developed for the analyzer should provide the basis for developing other trace gas and isotopic element analyzers, including but not limited to analyzers for ammonia, nitroxide, carbon isotope, and oxygen isotope.

**Advanced Quasi Optical Launcher Systems—**Calabazas Creek Research, Inc., P.O. Box 330, Palo Alto, CA 94302; 650-595-2168
Dr. Jeffrey Neilson, Principal Investigator, jeff@calcreek.com
Dr. Purobi Phillips, Business Official, purobi@calcreek.com
DOE Grant No. DE-FG02-05ER84181
Amount: $750,000

Recently completed electromagnetic analysis and synthesis codes have been used to generate efficient designs for Vlasov-Denisov-type quasi-optical (QO) launchers in gyrotrons. However, significant improvements still can be achieved over existing QO launcher and mirror transmission approaches. Examples of advanced QO launcher concepts include compact QO launchers, coaxial mode QO launchers, step-tunable launchers, and systems for direct coupling of cavity mode power to corrugated waveguide. In this project, existing codes, developed for the analysis and design of Vlasov-Denisov type QO launchers, will be modified to increase capability and computational speed. These codes will then be used to design advanced QO launcher systems that are relevant for gyrotrons for the International Thermonuclear Experimental Reactor, the DIII-D tokamak at General Atomics, and the ASDEX tokamak in Germany. In Phase I, the QO launcher analysis and synthesis codes were extended to increase their speed and capability. Using the extended synthesis code, a large improvement was achieved in the design of a two-frequency launcher. The extended analysis code allowed a rapid calculation of scattering. Phase II will perform additional optimization and extensions of the QO launcher analysis and synthesis codes. The improved codes will be used to design a compact launcher and a multi-frequency coax launcher. The launchers then will be built and tested.

*Commercial Applications and other Benefits* as described by the awardee: The QO launcher systems should reduce electron-cyclotron heating-system costs by approximately 10%, allowing gyrotron systems to be more compact. The technology also should increase the efficiency of launcher systems and deliver more power to the tokamak plasma. Other applications include the stabilization of neoclassical tearing modes, plasma diagnostics, and spectroscopy (including electron paramagnetic resonance spectroscopy).

78651S05-II

**101**

**Automated Transfer Map Generator Utilizing Electromagnetic Field Solutions—**G. H. Gillespie Associates, Inc., 10855 Sorrento Valley Road, Suite 203, San Diego, CA 92121; 858-677-0076
Dr. George H. Gillespie, Principal Investigator, ghga@ghga.com
Dr. George H. Gillespie, Business Official, ghga@ghga.com
DOE Grant No. DE-FG02-05ER84360
Amount: $550,000

The design of advanced accelerator components increasingly relies upon sophisticated electromagnetic field software tools, and new tools have been developed that provide the designer with exceptional capabilities. However, utilizing the electromagnetic field information in particle optics codes remains a cumbersome task, and a reliable and accurate method of creating particle optics transfer maps from electromagnetic fields is needed. This project will create an Automated Transfer Map Generator that will allow both specialists and non-specialists to utilize detailed component electromagnetic field data in a variety of optics codes. A fast, reliable, and accurate software package will generate transfer maps for particle optics programs that play a critical role throughout the life cycle of every accelerator. In Phase I, a concept demonstration software package was developed to establish feasibility, and the package was applied to selected component designs to demonstrate utility. In Phase II, the Automated Transfer Map Generator software will be developed and tested. Verification and validation of the transfer maps generated will be performed for several accelerator devices. A documented library of validated applications of the software will be prepared for future users.

*Commercial Applications and other Benefits* as described by the awardee: Advanced software tools are at the forefront of many new and emerging applications of particle accelerators. The software for automated transfer map generation should provide a valuable commercial tool to aid in optimizing the performance of medical accelerators and improving manufacturing processes that use accelerators.

78652S05-II

**121**

**Scalable Intrusion Detection System for Rapid Global Detection of Network Attacks—**
Advanced Science and Novel Technology Company, 27 Via Porto Grande, Rancho Palos Verdes, CA 90275; 310-377-6029
Dr. Alexander G. Tartakovsky, Principal Investigator, tartakov@usc.edu
Dr. Vladimir Katzman, Business Official, traffic405@cox.net
DOE Grant No. DE-FG02-05ER84136
Amount: $750,000

Current ultra highspeed networks carry massive aggregate data flows that must be monitored and processed to detect and counteract intrusions. The problem is further compounded by the sheer number and complexity of attacks. As a result, the challenges of intrusion detection in ultra-high-speed networks are outstripping our ability to detect, track, fuse, and interpret them. This project will develop a distributed anomaly-based intrusion detection system, consisting of sensing nodes for local (e.g., host level) detection and fusion nodes to combine the output from the sensing nodes. Advanced statistical methods will be used to identify hidden patterns and to optimize the operating characteristics of the intrusion detection system. In Phase I, a novel detection system, which detects attacks with minimal delays for a given (low) false alarm rate at extremely high data rates, was developed. An adaptive parallel architecture allowed for an efficient auto-selection of the best possible configuration under existing conditions, thereby reducing susceptibility to a changing environment. The algorithms were evaluated using asymptotic analysis, Monte Carlo experiments, and deployment in a testbed. Phase II will: (1) develop statistical methods for an efficient, anomaly-based local detector with a low false alarm rate, as well as a hybrid anomaly-signature local detector with profiling capability; (2) develop an architecture for the distributed deployment of detectors, along with fusion algorithms to combine outputs for network-level detections; (3) design and implement sensor and fusion nodes using commercial-off-the-shelf technologies; and (4) develop a laboratory testbed to support implementation and testing.

*Commercial Applications and other Benefits* as described by the awardee: The new intrusion detection system should be of particular relevance to DOE networks that support large-scale science applications. Advantages over existing systems include an increased probability of detecting unknown attacks, and a lower false alarm rate and detection time.

78684S05-II

**120**

**Workstation Network Interfaces for 10 Gbps and Beyond—**Acadia Optronics, LLC, 13401 Valley Drive, Rockville, MD 20850-3630; 301-332-2900
Dr. Jesse Wen, Principal Investigator, jessewen@acadiaoptronics.com
Dr. Jesse Wen, Business Official, jessewen@acadiaoptronics.com
DOE Grant No. DE-FG02-05ER84134
Amount: $749,861

The increasing requirements of scientific visualization and collaboration software in the short term, and the demands of multimedia end-users in the near future, require dramatic advances in workstation throughput. In particular, desktop network-interface throughput must correspond to the bandwidth available on current high-performance networks. This project will develop and implement a high-speed data path suitable for workstation throughputs of 10 gigabits per second and beyond. Industry-standard high-speed interfaces will be incorporated into a modified workstation architecture to provide a rapid-execution protocol stack with a middleware solution. In Phase I, the feasibility of the modified network-centric workstation architecture was proven, the performance of a peripheral component interconnect was verified, and the validity of an approach based on a Field Programmable Gate Array (FPGA) was confirmed. It was shown that this approach had far-reaching potential for next-generation networking needs. In Phase II, a prototype network interface controller will be developed, and the workstation architecture will be substantially enhanced to provide previously unrealizable throughput to the end-user. The prototype will focus on reconfigurability, in order to provide a powerful and versatile solution for a variety of next-generation networking needs.

*Commercial Applications and other Benefits* as described by the awardee: The new network interface should greatly enhance tera-scale collaboration and applications that require real-time distributed processing. The approach should scale well from local to wide area networks, making it ideal for high-performance LANs and SANs, grid computing applications, and wide-area ultra high speed networks. The inherent reconfigurability should make the system suitable for the hybrid circuit/packet-switched networks envisioned for the next-generation DOE network infrastructure.

78702S05-II

**69**

**Properties and Design of a Nuclear Grade SiC/SiC Control Rod Sheath for Generation IV Nuclear Plants—**Hyper-Therm High-Temperature Composites, Inc., 18411 Gothard Street, Unit B, Huntington Beach, CA 92648-1235; 714-375-4085
Dr. Robert J. Shinavski, Principal Investigator, robert.shinavski@htcomposites.com
Mr. Wayne S. Steffier, Business Official, wayne.steffier@htcomposites.com
DOE Grant No. DE-FG02-05ER84237
Amount: $701,404

Some Generation IV nuclear reactor designs call for employing high reactor core temeratures 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 1000°C and also are stable in a high radiation environment. One such application is the outer containment of the control rod material, where the sheath material is subjected to large thermal gradients and thermal cycling in addition to the high-temperature high-radiative-flux environment. This project will develop a silicon-carbide-fiber/reinforced-silicon-carbide matrix composite that is stable under these high neutron fluxes and addresses the requirements for control rod sheaths. In Phase I, a nuclear grade SiC/SiC composite was made by using braided preform architectures, which are well suited for the fabrication of axisymmetric control rod sheath tubes. Preliminary mechanical and thermal testing was performed, and a preferred braid architecture was identified. In Phase II, material property data, including mechanical and thermal properties, will be acquired. The data will cover the range of use temperatures anticipated under normal and off-normal operating conditions of a high temperature gas reactor. The data will be used to develop a viable design concept for a nuclear grade SiC/SiC control rod sheath. The design approach will be validated through structural element testing and subcomponent testing. A prototype composite will be fabricated to demonstrate producibility.

*Commercial Applications and other Benefits* as described by the awardee: The nuclear grade SiC/SiC composite should benefit the Department of Energy efforts to develop Generation IV fission reactors, and also benefit the longer range development of fusion power. Both of these energy generation approaches could substantially reduce dependence on foreign sources of fossil fuels as well as reduce greenhouse gas emissions.

**Laser-based Sensor for Routine, High Precision, Field Measurements of Ambient $CO_2$—**
Physical Sciences Inc., 20 New England Business Center, Andover, MA 10810-1077;
978-689-0003
Dr. David M. Sonnenfroh, Principal Investigator, sonnenfroh@psicorp.com
Dr. B. David Green, Business Official, green@psicorp.com
DOE Grant No. DE-FG02-05ER84296
Amount: $749,902

Trace species such as carbon dioxide, carbon monoxide, and methane are important in the carbon cycle of the atmosphere and in global climate change. Highly precise measurements of these species are important to carbon cycle studies and global warming research. New, compact, low maintenance, and low cost instrumentation is required to make measurements of these trace gases with high specificity and sensitivity in national and international monitoring networks. This project will design and demonstrate a new sensor for high precision measurement of ambient $CO_2$. The sensor will combine advances in diode laser technology with cavity enhanced absorption methods, resulting in a measurement precision on the order of 1 in 3000. The cost will be low enough to allow wide deployment in atmospheric monitoring networks. During Phase I, a prototype laboratory sensor was created by coupling a tunable diode laser to a high finesse optical cavity, and the required measurement precision for ambient monitoring of $CO_2$ was demonstrated. A complete conceptual design for a compact lightweight sensor, which is particularly well suited for network monitoring, was developed. A production cost model indicated that the sensor design can meet the target acquisition price of $5000 per copy when produced in volume. In Phase II, an alpha prototype sensor will be fabricated. Extensive characterization of the sensor's performance, as well as in-house environmental testing, will be carried out. The sensor will be demonstrated in the field at several venues. By the end of the Phase II, a complete design for a beta-prototype will be developed.

*Commercial Applications and other Benefits* as described by the awardee: A new, high precision, economical sensor for ambient $CO_2$ measurements should fulfill a long-standing need for a precise instrument that is rugged enough for field use and economical enough for widespread application in monitoring networks. Applications include environmental and air quality monitoring, combustion emissions analysis, fugitive emissions control, industrial process control, and contraband detection.

**High Recombination Efficiency White OLEDs—**Universal Display Corporation, 375 Phillips Boulevard, Ewing, NJ 08618-1428; 609-671-0980
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Ms. Janice K. Mahon, Business Official, jkmahon@universaldisplay.com
DOE Grant No. DE-FG02-05ER84263
Amount: $750,000

Lighting is estimated to consume 8.2 quads (approximately 762 TWh), or about 22% of the total electricity generated in the U.S. New, high efficiency solid state light sources, such as light emitting diodes (LEDS) and organic LEDs (OLEDS), are needed to reduce the ever increasing demand for energy. An OLED is potentially a cost-effective diffuse light 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 and attain expected cost and performance goals (of $3 per 1000 lumens and 90 lumens per watt, respectively). This project will utilize novel OLED fabrication techniques to enable 40 lm/W, organic, solid-state lighting sources to replace 12 lm/W incandescent sources, and hence reduce overall energy consumption in the U.S. In Phase I, the stated efficiency goal was surpassed: OLED architectures were designed and materials were incorporated to enable the creation of a warm white phosphorescent OLED, which had an efficacy of 36 lm/W at a luminance of 1,000 cd/m$^2$, a correlated color temperature of 4,400 K, and a color rendering index of 71. In addition, it was shown that the device can be operated continuously at constant current for over 200 hrs before its initial luminance of 1,550 cd/m$^2$ decreases to 775 cd/m$^2$. In Phase II, the power efficiency and operational stability of the phosphorescent OLED will be enhanced via improvements in the recombination efficiency of electrons and holes in the OLED emissive layer. Because the recombination efficiency is directly affected by the doping of emissive molecules into a host material, precise control of the mixture of dopants and host molecules will be implemented by using an organic vapor phase deposition technology.

*Commercial Applications and other Benefits* as described by the awardee: Today, OLED technology is the leading emerging technology for flat panel displays (FPDs). Many features desired for FPDs also are making OLED technology of great interest for solid-state lighting: (1) OLEDs are bright and colorful lambertian emitters with excellent power efficiency at low voltages; (2) they are thin-film devices that provide thin form factors especially when built on flexible plastic substrates; and (3) they require less materials, have fewer processing steps, and may be less capital intensive than today's dominant liquid crystal displays. If high-recombination-efficiency materials were added to the mix, the technology should become cost-effective in general lighting applications.

**Development of Electrically Mediated Electrophoretic Deposition for Thermal Barrier Coating Systems—**Faraday Technology, Inc., 315 Huls Drive, Clayton, OH 45315-8983; 937-836-7749
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DOE Grant No. DE-FG02-05ER84202
Amount: $750,000

The gas turbine engine manufacturing industry is an important aspect of the U.S. commercial economy and critical to both the Departments of Energy and Defense. This project will develop an improved manufacturing process to deposit thermal barrier coating materials to enable operation at higher temperatures in natural gas and synthesis gas environments, while maintaining the necessary durability and reliability required to sustain the engine life expectancy. Specifically, an electrically-mediated electrophoretic process for the deposition of thermal barrier systems will be developed. The process will be easier to control and more cost efficient compared to the more conventional techniques of plasma spray and electron beam physical vapor deposition. In Phase I, an electrically mediated electrophoretic deposition (EPD) process was used to apply thermal barrier coating materials to Inconel 718 substrates. It was demonstrated that electrically mediated EPD could uniformly deposit thermal barrier material sets, including yttria stabilized zirconia and rare-earth-doped yttria stabilized zirconia, and could increase deposition rates compared to conventional industrial processes. Phase II will: (1) optimize and validate the process to permit the introduction of appropriate microstructures, in order to prevent coating failure during standard and accelerated turbine engine operation; (2) develop and validate a post-deposition thermal treatment for the EPD coatings, in order to preserve the microstructure needed to maintain coating durability and reliability during operation; and (3) conduct tests (thermal stability, thermal cycling, thermal conductivity) to determine coating durability and reliability.

*Commercial Applications and other Benefits* as described by the awardee: With the application of thermal barrier coatings composed of new materials, higher operating temperatures should be achieved, which would increase fuel efficiency and reduce waste energy and energy costs.

78756S05-II

**114**

**High Gradient Research on 17 Gigahertz Accelerating Structures—**Haimson Research Corporation, 3350 Scott Boulevard, Building 60, Santa Clara, CA 95054-3104; 408-988-6007
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DOE Grant No. DE-FG02-05ER84362
Amount: $700,000

High power experiments with full length linear accelerator structures, using radio-frequency pulse widths in the range of 150 to 400 nanoseconds at both 11.4 and 17.1 gigahertz, have indicated that the maximum practical accelerating gradient is essentially independent of the frequency. Moreover, an extensive 11.4 gigahertz test program, using copper structures, has established that, for reliable long term operation, the upper limit of the accelerating gradient is 70 to 75 megavolts/meter. Attempts to operate accelerator structures at higher gradients, in order to satisfy the 100 to 200 megavolt/meter requirement of future linear colliders, have resulted in microwave breakdown of the cavities and the coupling irises; in several instances, permanent phase changes have occurred due to erosion of the copper cavity surfaces. This project will design, fabricate, and test a gradient-hardened accelerating structure that features high-temperature brazed and machined stainless steel inserts in the high stress regions of the cavity and coupler irises. Phase I investigated the microwave characteristics of accelerator cavities and dual-feed racetrack-shaped couplers, modified with stainless steel (and molybdenum) inserts. Brazed cavity test data was obtained, the microwave design parameters of a gradient-hardened 17 gigahertz accelerator structure were established, and overall system and component layout drawings were developed. In Phase II, a prototype accelerating structure will be engineered, fabricated, and tested at high gradients.

*Commercial Applications and other Benefits* as described by the awardee: The new accelerating structures should avoid radio-frequency breakdown in traveling-wave-linear-accelerator mixed-metal structures, as well as the high-gradient structure, reducing the lifetime foreshortening caused by surface erosion detuning.

78764S05-II

**129**

**SuRF:Three-Dimensional Self-Consistant Simulations of Multipacting in Superconducting Radio Frequencies—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
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DOE Grant No. DE-FG02-05ER84172
Amount: $749,900

Superconducting radio frequency (SRF) accelerator cavities lose power to stray electrons, especially when the electron motion is in resonance with the fields and the electrons strike the cavity surface repeatedly (multipacting). One of the main tools for studying multipacting is numerical simulation, but none of the existing codes has sufficiently realistic models of all the physical processes. One main limitation of present modeling approaches is the lack of three-dimensionality. A related need is for parallel computing to handle the increased computational requirements of running in three dimensions. Typically, new designs for SRF cavities are tested by building physical prototypes and examining their performance. This practice renders the use of a large variety of different geometries (for different accelerating sections) problematic, due to the high cost of prototyping the different designs. This project will add needed models and features to the VORPAL plasma simulation code so it can function as a virtual prototyping tool for understanding multipacting in SRF cavities. Phase I demonstrated that VORPAL's higher-order conformal boundary algorithms and flexible interface could be used to accurately model the electromagenetic fields in typical SRF cavities. Phase II will fully integrate the field emission and secondary electron emission routines with the conformal boundaries in VORPAL. Diagnostics will be added, VORPAL's post-processing tools will be improved to measure common quantities used by SRF researchers, and VORPAL's interface will be simplified to make it easier to specify SRF cavity geometries.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the application for Nuclear Physics accelerators, SRF cavities are major component of free electron lasers. Consequently, the new design tool for SRF cavities should provide low cost prototyping for industries that use free electron lasers, such as defense and surface processing.

78769S05-II

**79**

**System Integrated, Multiport, Multimode Power Converters for On-Grid and Off-Grid Renewable Energy Applications—**Distributed Power, Inc., 3547 South Higuera Street, Suite C, San Luis Obispo, CA 93401-7361; 805-543-4520
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DOE Grant No. DE-FG02-05ER84319
Amount: $748,849

System-driven, high performance, cost effective solutions for residential renewable energy systems do not exist for on-grid systems where battery backup is desired or for off-grid systems having multiple energy sources. Current system solutions are compromised by low efficiency when converting from renewable power sources to AC loads, and by lack of coordination between system power components. This project will develop system-integrated electrical power converter products for renewable energy applications. In Phase I, a proof-of-concept power converter was designed, fabricated, and tested. Performance was proven, and cost targets were verified. A multiport converter topology was created, enabling the precise orchestration of any number of sources and loads. In Phase II, two system-integrated power conversion prototype products (one on-grid product and one off-grid product) will be designed, fabricated, optimized, stress tested, and made ready for high volume production. The on-grid product will have two photovoltaic ports, one storage battery port, and one AC load port. The off-grid product will have one photovoltaic port, an optional wind turbine port, a storage battery port and an AC load port with connections for an optional reciprocating generator. Both products will offer a highly-integrated system solution with capabilities that are not currently available.

*Commercial Applications and other Benefits* as described by the awardee: The two power conversion products should be ready for high volume production in 2008. Based on market forecasts for residential on-grid and off-grid renewable energy systems, 101 megawatts of new power conversion capacity will be needed in 2008. Based on a retail sales price of $.50/Watt, a potential domestic market of $50.5M would be forecasted, with growth of at least 15% per year in 2009 and 2010.

78794B05-II

**58**

**New Energy Efficient Route to Styrene—**Exelus, Inc., 99 Dorsa Avenue, Livingston, NJ 07039; 973-740-2350
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Mr. Mitrajit Mukherjee, Business Official, mmukherjee@exelusinc.com
DOE Grant No. DE-FG02-05ER84231
Amount: $750,000

Styrene is an important monomer used in a variety of plastic products. In terms of monomer production, styrene ranks fourth in the U.S. behind ethylene, vinyl chloride, and propylene. However, styrene plants use dramatically more energy compared to the production of other petrochemicals. This project will develop a styrene monomer technology that uses alternative feedstocks (toluene and methanol), thereby reducing raw material costs, improving energy efficiency, and lowering the cost of production. During Phase I, experimental samples of a novel catalyst were synthesized, characterized, and tested for activity and selectivity. Product yields of 80% were achieved at complete reactant conversion. A preliminary economic assessment indicated operating savings in excess of $300/ton of styrene produced, compared to conventional process. Phase II will optimize the catalyst design, choose a viable reactor configuration, develop the mathematical tools needed for commercial scale-up, identify a window of optimum operating conditions, and test the catalyst for an extended period to establish long-term stability.

*Commercial Applications and other Benefits* as described by the awardee: The new process should reduce the energy consumed by the manufacture of styrene by 70%. Capital costs also will be greatly reduced.

78807S05-II

**137**

**UV Solid-State Laser for Proliferation Detection—**Aculight Corporation, 11805 North Creek Parkway South, Suite 113, Bothell, WA 98011-8803; 425-482-1100
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DOE Grant No. DE-FG02-05ER84135
Amount: $750,000

Compact laser systems are needed to interrogate possible sites of nuclear proliferation that, for strategic or political reasons, cannot be sampled and inspected directly. This laser system would be used with a nonlinear optical wavelength converter for remote spectroscopic analysis of effluents from suspected sites. This project will develop an advanced laser system that will be compact, lightweight, efficient, and suitable for deployment on a UAV. The laser system will be based on Yb:S-FAP, a relatively novel laser material with an upper state lifetime more than five times longer than Nd:YAG. For this particular application, the increased lifetime translates into a fivefold reduction in the number of pump diodes, leading to a more cost-effective and compact laser system. In Phase I, a full-scale, diode-pumped, Yb:S-FAP gain module was designed, fabricated, and tested. The module provided an output over 400 mJ in long-pulse quasi-cw operation as an oscillator, and a single-pass small signal gain of $G_o = 7.6$ ($g_o l = 2$ nepers) in an amplifier configuration. A detailed analysis, along with the experimental results, showed that the approach was likely to meet the 200 mJ/pulse energy requirement. In Phase II, Yb:S-FAP slabs will be procured, and the system will be built and tested. Finally, the laser system will be configured into a rugged package suitable for airborne deployment.

*Commercial Applications and other Benefits* as described by the awardee: Diode pumped solid-state lasers are used extensively in materials processing and other high value commercial applications. However, to date, these lasers have not achieved significant market penetration in high pulse energy (> 100 mJ) laser markets currently dominated by excimer and lamp pumped solid-state lasers. Despite their significant advantages, the use of diode pumped solid state lasers has been limited by the high cost of the diode laser pump sources. By using Yb:S-FAP, the diode cost (the main cost driver in high pulse energy systems) should be reduced by a factor of 4 to 5, compared with an Nd:YAG laser, resulting in a cost-effective solution for a wide range of commercial applications.

78808S05-II

**56**

**Nanostructured Materials for Olefin Oligomerization—**TDA Research, Inc., 12345 W. 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300
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DOE Grant No. DE-FG02-05ER84258
Amount: $750,000

Advanced synthetic lubricants have the potential to reduce automotive gas consumption, improve startup in colder U.S. climates, and reduce the quantity of disposed oil. These lubricants could benefit from the development of nanostructured catalysts – a growing class of materials with designed surfaces, structures, and pores – whose features on the nanometer scale give rise to chemical and catalytic phenomena not seen with bulk materials. For synthetic lubricants, nanostructured catalysts offer the potential to control both the molecular weight and the extent of branching. Better control over these properties would allow formulators to mix and match lubricants to get an optimal lubricant blend. Phase I developed a mesoporous catalyst that showed high conversion and desired selectivity to oligomers. The catalyst was easy to prepare, thermally stable, and provided size-selective catalysis by virtue of its functionalized nanometer-sized pores. Phase II will optimize the catalyst properties and develop an oligomerization process, using the new material in collaboration with a commercialization partner.

*Commercial Applications and other Benefits* as described by the awardee: Better synthetic lubricants would lead to better gas mileage and longer service life of automotive engines, gas turbine engines, and other rotating equipment. If 10% of the U.S. transportation sector switched from petroleum derived lubricants to synthetic lubricants, a energy savings of 0.15 Quads/year would be possible. Also, an environmental benefit would accrue, because synthetic lubricants last much longer than mineral oil lubricants; therefore, disposal quantities would be reduced.

78810S05-II

**90**

**Framework for Modernization and Componentization of Fusion Modules—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
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DOE Grant No. DE-FG02-05ER84192
Amount: $749,658

Hundreds of person-years are invested in established fusion codes, providing scientists with invaluable physics insights. Many of these codes are being and will be used in integrated modeling efforts required for the successful operation of the International Thermonuclear Experimental Reactor (ITER). However, each such effort is concerned primarily with new physics and pays relatively low attention to interoperability of the developed components. Because fusion scientists need to ensure that these various codes can work interchangeably, this project will develop a componentization framework (as opposed to a coupling framework) that will contain a set of common interfaces for coupling commonly used types of fusion codes (including equilibrium, stability and transport). The interfaces will be developed in consensus with several teams involved in integrated modeling, and the components will work interchangeably in multiple coupling frameworks, such as SWIM and CPES. In Phase I, the compatibility of the standards of the National Transport Code Collaboration (NTCC) – which consists of modules extracted from established fusion codes – were analyzed, and an approach to the modernization and componentization of several NTCC transport modules and solvers was developed. Phase II will: (1) extend the effort to the modernization of fusion modules used in ongoing and emerging modeling projects, (2) define common interfaces and data structures for seamless data exchange between equilibrium codes, stability codes, transport models, and transport solvers; (3) implement a representative set of components created out of the modules; and (4) develop a comprehensive suite of tests for transport solvers.

*Commercial Applications and other Benefits* as described by the awardee: The componentization framework should facilitate the incorporation of well-established scientific codes into modern, high-performance computational environments. This system should find use in many areas of scientific research and in commercial sectors using multiple legacy codes.

78825S05-II

**71**

**Reduction of Parasitic Losses to Improve Quantum Well Efficiency—**Hi-Z Technology, Inc., 7606 Miramar Road, Suite 7400, San Diego, CA 92126-4210; 858-695-6660
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Mr. Norbert B. Elsner, Business Official, n.elsner@hi-z.com
DOE Grant No. DE-FG02-05ER84324
Amount: $550,000

Huge renewable heat sources are continuously being generated but are not being used. For cars and trucks, two thirds of the gasoline consumed is converted to waste heat and thrown away. Within the basic materials industries (aluminum plants, steel mills, oil refineries, etc.), about the same amount of waste heat also is being generated and lost. Combined, the amount of waste heat is equivalent to 300-1,000 million barrels of oil/year. This project will develop a waste heat recovery technique, based on new, more efficient thermoelectric materials, in which quantum well (QW) layers, 100 Å thick, are deposited on a substrate. The research will focus on overcoming a parasitic heat leak problem associated with the substrate. In Phase I, the heat leak problem was separated into temperatures above and below 300°C, the temperature at which organic materials (such as Kapton) can no longer be used. Below 300°C, N and P type Si/SiGe QW films were deposited on Kapton. The N and P films were joined with the metal molybdenum, producing very low resistance contacts, and the power produced was very close to the anticipated values. Above 300°C, the Si/SiGe QW films were successfully deposited on a 25 μm thick SiGe substrate. The α, ρ, and κ parameters for the film show that QW behavior was obtained in the films, and a figure of merit (ZT) of 3 to 5 was obtained at room temperature. The plans for Phase II also differ for the two temperature regimes. Below 300°C, the deposition of the Si buffer coat and the QW films on Kapton will be improved, so that it can be scaled up to yield 15 – 20% at ~ 300°C. Above 300°C, the promising SiGe buffer coat, deposited on mica or glass, will be evaluated with Si/SiGe, as well as with the high temperature QW films Si/SiC and B4C/B9C, for use up to 1000°C. At 800°C, an efficiency of ~ 40% is expected.

*Commercial Applications and other Benefits* as described by the awardee: Vehicles fitted with the new waste heat recovery device should expect an increase in mileage by ~10%. In addition, the high temperature, basic materials industries should be able to recover appreciable waste heat when their processes are fitted with the QW thermoelectric generators. Other applications include geothermal wells. The total market could be in the range of a billion dollars per year.

**Filtration of Fluid Media Containing very Fine Heavy Metals—**Wright Materials Research Company, 1187 Richfield Center, Beavercreek, OH 45430-1120; 937-431-8811
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Dr. Sean C. Tan, Business Official, sctan@sprintmail.com
DOE Grant No. DE-FG02-05ER84264
Amount: $750,000

The development of filter materials that can capture fine ferromagnetic and paramagnetic particles, as well as radioactive contaminants, with high efficiency is of great industrial significance in pollution control processes such as water purification and waste-water treatment. The main problem facing the development of an effective filter is the ability to efficiently filter fine particles below one micron. This project will address this problem by developing composite, nano-structured, lightweight filter materials that can effectively remove micron and sub-micron-sized particle contaminants, especially heavy metal species. The technique to grow the nano-structured filter media will have low energy consumption. In Phase I, composite nano-structured lightweight filters were developed from high performance polymers and other ingredients. Filters were designed, fabricated, and tested with a fluid media containing very fine silicon or iron oxide particles. The particle capture efficiency was far superior to the conventional filter media, with practically the same thickness, weight, and pressure drops. Phase II will optimize and scale-up the nano-structured composite filter media developed in Phase I. A continuous growing process and device will be designed and constructed as a first step toward mass production. A series of filtration tests and SEM analyses will be performed to assist the optimization.

*Commercial Applications and other Benefits* as described by the awardee: The lightweight composite filter media should have application in a variety of recovery and pollution-control processes: treatment of radioactive water, waste water and metalworking fluids; purification of drinking water; separation of metal contaminates from engine oil; and recovery of precious metals.

78844S05-II

**135**

**Algorithms for Multilook Effluent Detection and Identification—**Space Computer Corporation, 12121 Wilshire Boulevard, Suite 910, Los Angeles, CA 90025-1123; 310-481-6000
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DOE Grant No. DE-FG02-05ER84168
Amount: $749,955

Hyperspectral imaging systems are used for the remote detection and identification of gaseous chemical effluents, which is needed for monitoring suspected nuclear, biological, or chemical weapons manufacturing sites. This project will develop automated software, which uses a time series of remote target observations from infrared hyperspectral imaging sensors, to dramatically improve the detection and identification of chemicals in effluent plumes. In Phase I, optimal clutter suppression, based on co-registered multi-look images, yielded gains in plume detection sensitivity on the order of 100% for many industrial chemicals. Multi-look methods of chemical identification realized an initial 10% improvement in false alarm reduction, and the potential for much greater improvement was indicated. Phase II will: (1) refine and optimize the multi-look algorithms, (2) implement the software prototype, and (3) demonstrate prototype performance using airborne and ground-based sensor data from target sites with simulated proliferant activities.

*Commercial Applications and other Benefits* as described by the awardee: The software package for detecting and quantifying effluent chemicals from multi-temporal hyperspectral imagery should be of interest to: intelligence image analysts performing time-critical tasks such as WMD threat location or bomb damage assessment, military units concerned with tactical chemical threat warning, or civilian agencies requiring warning of the presence of dangerous chemicals.

**Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts—**Materials Innovation Technologies, 1529 Greenville Highway, Hendersonville, NC 28792; 828-698-1330
Mr. Neal Baitcher, Principal Investigator, nbaitcher@aptllc.com
Mr. James E. Stike, Business Official, jstike@mchsi.com
DOE Grant No. DE-FG02-05ER84327
Amount: $750,000

The U.S. could significantly reduce oil consumption by decreasing the weight of its automobile fleet, especially by using lightweight carbon composite materials. However, lightweight materials in automobile structures have been problematic for two reasons: (1) the high cost of carbon fiber materials themselves, and (2) the high processing costs of these materials. Although programs exist to reduce the cost of carbon fibers (from $12-$14/pound today to $5-$7/pound in the near future), current manufacturing processes are neither fast nor cost-effective enough to meet the demands of high volume production. This project will develop an innovative, high-volume molding process for complex-shaped carbon-fiber performs, which will allow cost effective carbon composite components to be incorporated into commercial passenger vehicles. In Phase I, a carbon fiber slurry was developed and molded into an automotive complex shape (B-pillar). It was indicated that controlled fiber orientation could be achieved in cycle times of seconds – not minutes or hours as with conventional preforming techniques. (Control of fiber orientation is critical because it provides an ability to customize the design of the preform to meet end use characteristics and specifications.) Phase II will fully develop the carbon slurry, along with innovative tooling gimbal molding equipment for a pilot plant. The pilot plant process will be optimized, and cost models will be validated for an actual automotive component.

*Commercial Applications and other Benefits* as described by the awardee: The new composite molding process should enable manufacturers in the automobile and aerospace industries to use lightweight, high performance carbon composite structures without the time and cost problems that plague other manufacturing technologies.

78897S05-II

**87**

**Non-Perturbing Multi-Axis Magnetic Field Sensor—**FieldMetrics Inc., 13352 82nd Avenue, Seminole, FL 33776-3126; 727-698-1742
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Ms. Pamela Jane Hamilton, Business Official, Hamilton@fieldmetricsinc.com
DOE Grant No. DE-FG02-05ER84188
Amount: $750,000

Plasma fusion research experiments require magnetic field measurements over a wide range of bandwidth and sensitivity. However, existing pickup coil sensors are limited in bandwidth, require time integration, and perturb the experiment when used as inserted diagnostics. Novel sensors that can be used for edge or insertion measurements of magnetic fields ranging from 0.01 to 100 Gauss over a bandwidth from DC to 100 MHz are needed. This project will develop a non-perturbing, high bandwidth, high sensitivity optical sensor as a next generation magnetic field diagnostic for plasma fusion experiments. The sensor's galvanically isolated output signal will not require time integration. The sensor package will be engineered to handle high bake-out and operating temperatures in excess of 250°C. Phase I optimized the design of a novel optical magnetic field sensor for plasma fusion applications. A complete system design was developed including the light source, receiver, optical sensor, and packaging. In Phase II, several sensor designs will be assembled and tested on the Spheromak at Lawrence Livermore National Laboratory. High frequency performance will be determined for other commercial applications.

*Commercial Applications and other Benefits* as described by the awardee: The proposed optical sensor design should allow various sensitivity and bandwidth configurations to support magnetic field measurements in plasma research, ranging from low temperature university experiments to larger scale spheromak and tokamak machines. The sensor also should find use in pulsed power and accelerator research; high power antenna mapping; radiographic machines; and non-invasive, non-loading, high-speed current probes for electronic test equipment.

78911S05-II

**103**

**Multi-processor Embedded Front-End Electronics Platform with Multi-Function Network for Pulsed Accelerator Control Systems—**NYCB Real-Time Computing, Inc., 18 Meudon Drive, Locust Valley, NY 11560-1025; 516-759-0707
Dr. Eric J. Siskind, Principal Investigator, nycbrealtime@verizon.net
Dr. Eric J. Siskind, Business Official, nycbrealtime@verizon.net
DOE Grant No. DE-FG02-05ER84366
Amount: $600,000

Electronics for pulsed front-end devices at pulsed particle accelerators are typically accessed through up to 4 networks, which carry timing information, pulse-to-pulse sequencing, real-time streaming data, and configuration information, respectively. Although modern commercial networks offer a rich variety of features, they are not well optimized to the needs of pulsed accelerators for clocking, pulse-by-pulse control, or reliable real-time data acquisition with sub-millisecond timeouts in an electrically noisy environment. In this project, circuit switching will be used to provide preferential delivery of real-time data streams, with error correction adding noise immunity. The accelerator clock frequency will be carried by synchronizing the data link byte clock to the accelerator clock. Clock phase and fiducial timing data will be sent by custom extensions to the circuit switching protocols. In Phase I, a previously-developed approach for circuit switching both real-time and non-real-time data onto a single network physical link, via additional hardware inserted between the media access and serializer-deserializer layers, was extended to carry accelerator clock and fiducial timing data. A method for coupling multiple power PC processors embedded within a single field programmable gate array via shared memory was developed. In Phase II, the hardware design will be completed and two prototype circuit boards will be constructed and debugged. A large volume of real-time operating system and application-level software will be developed. End-to-end testing will demonstrate simultaneous real-time data streaming and Internet-accessible, non-real-time, data acquisition control and data analysis.

*Commercial Applications and other Benefits* as described by the awardee: The technology should find application in embedded device controllers for accelerator devices that provide large volumes of data during each pulse – data that must be processed before the next pulse is generated. The technology should lead to more reliable accelerators and significant increases in average effective luminosity. Other applications include computer network interface cards and network fabric switching points.

78925B05-II

**75**

**Novel Low Cost Processes for Production of Crystalline Silicon Wafers for Photovoltaic Industry—**GT Equipment Technologies, Inc., 243 Daniel Webster Highway, Merrimack, NH 03054; 603-883-5200
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DOE Grant No. DE-FG02-05ER84323
Amount: $700,000

"Clean energy" is attracting more and more interest, which in turn exerts cost pressure on photovoltaic (PV) manufacturers for more efficient solar panel production. This project will develop a cost-effective technology to produce PV-grade silicon wafers. In Phase I, a non-oxide-based reuseable crucible was developed for the production of high purity, low oxygen content crystalline silicon ingots. The approach was based on a reusable thermal-expansion-coefficient-matched graphite crucible and a high purity, multilayered release coating. The crucible was used to develop a rapid, single-crystal growth technique for photovoltaic-grade silicon. Silicon ingots grown with this technique resulted in better yield and higher throughput. Phase II will: (1) scale-up the reusable crucible to grow 270 kg ingots, using a state-of-the-art directional solidification system; (2) optimize the rapid crystal growth process using the reusable crucible; and (3) develop a high-throughput, continuous, in-line, silicon brick casting system using the reusable crucible.

*Commercial Applications and other Benefits* as described by the awardee: The new silicon wafer production technique should reduce the cost of solar wafers, which is the bottleneck for the healthy growth of the photovoltaic industry. The new technology should have significant advantages over existing techniques – reduced energy costs, much lower cost of solar wafers, higher cell efficiency.

78930S05-II

**30**

**Advanced Sealed Bearing Assembly for Positive Displacement Motors used in Micro-borehole Drilling—**Kalsi Engineering, Inc., 745 Park Two Drive, Sugar Land, TX 77478-2843; 281-240-6500
Dr. Manmohan S. Kalsi, Principal Investigator, kalsi@kalsi.com
Dr. Manmohan S. Kalsi, Business Official, kalsi@kalsi.com
DOE Grant No. DE-FG02-05ER84206
Amount: $750,000

The DOE has identified a need for a sealed bearing assembly (SBA) so that positive displacement motors (PDMs) for microhole oil drilling can be used at high differential pressures. Current off-the-shelf small PDMs are not designed for open hole drilling; rather, they are used primarily for scale removal and drill-out of cement inside tubing – short run operations at standard differential pressures. This project will develop a highly durable, low cost, low maintenance, long life (in excess of 1000 hours), advanced Sealed Bearing Assembly (SBA) capable of operating under high differential pressures. In Phase I, a three-dimensional Finite Element Analysis and a large matrix of laboratory tests were used to evaluate several concepts for next generation, micro-hole size, hydrodynamic rotary seals. A hydrodynamic thrust-bearing concept was extended to bidirectional, low cost designs, which also were evaluated by laboratory testing. The results confirmed the feasibility of a long-life high-differential-pressure SBA for micro-hole PDMs. In Phase II, concepts for enhanced lubrication seals and "bi-directional floating" hydrodynamic thrust bearings will be further developed and implemented in different SBA for microhole PDMs.

*Commercial Applications and other Benefits* as described by the awardee: The advanced Sealed Bearing Assembly, which will be designed to mate with any of the new PDMs being developed to meet DOE goals, should significantly reduce the cost of drilling and exploration. The new hydrodynamic rotary seal and bearing designs also should find use in extending the life of high-speed drilling motors (turbodrill, electrodrill), rotary steerable/directional tools, and Integrated Rotary Percussion Motors, which are being developed by others for micro-hole applications.

**Oil-Free Hydrogen Compressor—**Mohawk Innovative Technology, Inc., 1037 Watervliet-Shaker Road, Albany, NY 12205-2033; 518-862-4290
Dr. Hooshang Heshmat, Principal Investigator, hheshmat@miti.cc.com
Mr. James F. Walton II, Business Official, jwalton@miti.cc.com
DOE Grant No. DE-FG02-05ER84245
Amount: $750,000

The DOE is developing delivery technologies that will enable the introduction and long-term viability of hydrogen as an energy carrier for transportation and stationary power. To be successful, approaches must address hydrogen's relatively low volumetric energy density and its difficulties with respect to transportation, storage, and final delivery to the point of use. In particular, existing hydrogen compressor designs can not meet the need for a reliable, efficient and cost competitive transportation infrastructure. Therefore, this project will develop an oil-free bearing technology that will enable oil-free centrifugal hydrogen gas compressors to boost in-line pressures by approximately 700 psig and deliver 300 kg/min of hydrogen gas. In Phase I, a number of oil-free centrifugal compressor configurations were identified that could meet the stated boost pressure and flow requirements. However, the high operating speeds and sealing requirements indicated that very low power loss bearings and low leakage seals would be needed to make the compressor system viable. Therefore, Phase II will involve the design and fabrication of full-scale, oil-free compliant foil bearings. The bearings will be tested at design speeds of 50,000 to 60,000 rpm, while realistic loads are to be applied to the bearings. (The development of very low leakage seals and has been proposed under a separate program.)

*Commercial Applications and other Benefits* as described by the awardee: The bearing technology developed for hydrogen compressors should allow higher efficiency natural gas pipeline compressors to be built and operated, making large-scale, hydrogen gas delivery viable. Today, almost 50 million horsepower is used to service natural gas pipeline compression needs; an estimated savings of 33,000 MW-hours of energy savings per year would be possible if advanced oil-free bearings and seals were employed.

78953S05-II

**95**

**Inert-Gas Buffering for Particle Size Separation of Superconductor Precursor Powders—**
Accelerator Technology Corporation, 9701 Valley View Drive, College Station, TX 77845; 979-255-5531
Mr. Satyananarayanan Seshadri, Principal Investigator, satya@neo.tamu.edu
Dr. Peter M. McIntyre, Business Official, acctec@cox.net
DOE Grant No. DE-FG02-05ER84344
Amount: $328,600

The removal of all particles over a desired micron-scale size threshold from a powder sample is critical to the development of fine-filament, powder-in-tube superconducting wires, for which the final filament size is limited by the largest particles in the precursor powder filling. This project will develop a particle-removal technology that disperses the powder in an aerosol suspension and then passes the dispersed powder through a Stokes-flow geometry, in which the powder particles are separated. The basic approach has been used for several decades for size classification, but never for separation of bulk quantities of powder. In previous work, a slot-geometry impactor was developed and evaluated for bulk separation applications. Phase I improved the earlier process in three respects: (1) dry nitrogen gas was used as the buffer gas rather than air, in order to eliminate contamination of the precursor powders; (2) a fluidized-bed dispersal system was developed to increase mass loading without aggregation; and (3) a boundary-sheet flow of powder-free gas was introduced along the walls of the impactor structure, in order to suppress particle wall interactions that limit large mass loadings. In Phase II, an electron-beam-assisted precipitator will be developed to remove the separated fines from the aerosol flow. The present pressurized inert-gas flow will be converted into a recirculating closed-circuit flow. The slot impactor vane structure will be rebuilt with 1-m-long vanes, and manifolds for supply, exhaust, and boundary flow along the vane structure will be pressure-equalized to assure a uniform Stokes threshold along the extended geometry.

*Commercial Applications and other Benefits* as described by the awardee: In addition to high-performance superconductors, the technology also should be applicable to the separation of particles used in specialty sintered metal and ceramic materials for aerospace and defense, and in consumer products. For ceramics, large particles cause stress concentrations, which cause brittle fracture. For sunscreen, powders utilize $Ti_2O_3$, the most effective UV absorber; however, $Ti_2O_3$ is also the pigment for white paint, and makes skin appear pasty. By reducing particle size, the powder becomes invisible, while retaining its UV protection capability.

78957S05-II

**139**

**ISENS: Information Processing System for Sensor Data—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
Dr. Dimitre A. Dimitrov, Principal Investigator, dad@txcorp.com
Mr. Laurence D Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-05ER84171
Amount: $749,856

The overload of sensor data and related analyses demand the development of a distributed system for managing associated semantic metadata, in order to enable efficient decision making. Although significant advancements have been made in emerging semantic technologies, a critical missing piece is the development of an integrated, secure, and distributed system for optimized processing of sensor related metadata. This project will develop a distributed-knowledge management system for heterogeneous sensor metadata. The system will support ontologies, dynamic and static knowledge bases, querying on a semantic level, and efficient data storage and retrieval to enable fundamentally improved decision making and reasoning capabilities. Phase I evaluated and selected specific semantic Web, database, and networking technologies for use in the ISENS system. A working distributed prototype was developed, which demonstrated the feasibility of building a production quality, information management system for sharing semi-structured sensor data. In Phase II, a fully functioning system, with an extended set of capabilities for testing and evaluation by clients, will be built. Algorithms will be implemented to enable the integration of independent and distributed data centers, support for metadata representation, querying on a semantic level and by key words, secure data transfer, access control, and a portable user-friendly interface.

*Commercial Applications and other Benefits* as described by the awardee: The semantic knowledge management and information integration system should be directly applicable to the sharing of distributed data sets from processed sensor data and imagery analyses, in order to enable situation assessment and decision making. Potential customers include commercial companies with information integration problems.

78966S05-II

**9**

**Rapid Microfluidic Production of PET Biomarkers—**NanoTek, LLC, 217 FenceRail Gap, Walland, TN 37886-2510; 865-806-2059
Mr. Joseph Carl Matteo, Principal Investigator, jmatteo@nanotek1.com
Mr. Joseph Carl Matteo, Business Official, jmatteo@nanotek1.com
DOE Grant No. DE-FG02-05ER84290
Amount: $749,250

Positron Emission Tomography (PET) is a valuable non-invasive imaging tool for the diagnosis and follow up of such diseases as cancer, heart disease, and Alzheimer's. The DOE has identified a need for novel probes and radiolabeled compounds for PET, along with advanced methods to deliver them. Short-lived radioactive tags such as [$^{18}$F] fluoride ion and [$^{11}$C] carbon can be attached to molecules or chemical biomarkers prior to injection into patients or small animals, and then imaged at various stages of biodistribution. For example, [$^{18}$F] fluorodeoxyglucose has been used to monitor glucose metabolism in the body. Other more specific biomarkers – e.g., [$^{18}$F] fluoromisonidazole, a marker for hypoxia, and [$^{18}$F] fluorothymidine, a marker of proliferation – have been developed, but have been extremely difficult to bring to market. Much of the problem is that these specialized biomarkers are difficult to synthesize, often have poor yields, and require expensive precursors. This project will develop a microfluidic platform to synthesize PET biomarkers. The technology will reduce processing times and reagent usage by a factor of 30 to 100. In Phase I, small, low cost, modular microreactor cartridges were developed and used routinely to synthesize a host of PET biomarkers, each with better yields than conventional chemistry and each within 1 to 2 minutes. Phase II will develop processes to enable complex multi-step microfluidic synthesis with intermediate purification, multiple organic solvents, and micro- purification of the final product.

*Commercial Applications and other Benefits* as described by the awardee: The rapid biomarker production technology should reduce production time, reagent consumption, and manpower requirements. Commercial applications exist in clinical, pre-clinical, and drug discovery markets.

78997S05-II

**125**

**Affordable Petabyte Storage for Scientific Data Distribution and Archiving—**
MicroContinuum, Inc., 57 Smith Place, Cambridge, MA 02139; 617-354-5684
Dr. W. Dennis Slafer, PhD, Principal Investigator, dennis.slafer@microcontinuum.com
Ms. B. Diane Martin, Business Official, diane.martin@microcontinuum.com
DOE Grant No. DE-FG02-05ER84151
Amount: $743,770

The data storage market constitutes a sizeable and rapidly growing facet of the world economy, and worldwide data storage needs are growing at an unprecedented rate. New technologies are needed to keep up with the demand for affordable, efficient, and permanent (archival) digital storage. This project will develop a new type of data storage system that uses very thin layers of material to permanently store digital information in a very small volume. The hardware to record and read back the data will be based on components already developed for DVD and CD products. During Phase I, all of the key elements of the novel data storage technology were demonstrated, including the most critical aspect, the production of nanometer-sized features over large areas on an ultra-thin support film. The ability to coat the material, in order to make it recordable, was demonstrated. The ability to permanently record data structures on the material also was demonstrated. Based on these results, the possibility of storing a petabyte of data in a relatively small volume was confirmed. During Phase II, a continuous roll-to-roll pilot fabrication process, capable of manufacturing consistent 6-in wide quantities of TLO media, will be demonstrated. In addition, a media formatter/reader/writer will be developed to address several specific sub-features of any ultimate system.

*Commercial Applications and other Benefits* as described by the awardee: The new data storage technology should address the explosive growth in digital data that is being driven by the internet and other factors. Areas of application include satellite weather imaging, digital and motion picture imaging, surveillance, and security, to name a few.

**Nanowire Optical Assay Probe—**Illuminex Corporation, 627 Conestoga Boulevard, Lancaster, PA 17602; 717-871-8971
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Dr. Youssef M. Habib, Business Official, joe.habib@illuminex.biz
DOE Grant No. DE-FG02-05ER84282
Amount: $750,000

More sensitive detection methods leading to early diagnosis could significantly impact the treatment of cancer and other diseases and dramatically increase survival rates. However, current methods used to detect disease indicators do not have the needed sensitivity and often are effective only once the indicator concentration has reached a critical level. Nanotechnology-enabled probes, which can interact with and sense biological compounds on the molecular level, hold great promise for point-of-care diagnosis of disease. This project will develop a nanowire optical probe that uses surface enhanced Raman scattering (SERS) as a method for molecular identification. The probe will be incorporated into a portable, rapid, and highly sensitive assay system that will detect multiple biomedical substances in patients. In Phase I, a nanowire optical probing platform was successfully engineered. Antibodies for the ovarian cancer marker CA 125 were used to characterize the sensor platform as to its optical, chemical, and biological properties. Phase II will expand the development of the nanowire optical assay probe, integrate the probe with diagnostic control systems, and perform clinical laboratory tests to compare the nanowire assay performance with standard clinical laboratory assays. Finally, a prototype diagnostic instrument will be produced.

*Commercial Applications and Other Benefits* as described by the awardee: The nanowire assay probe should be able to identify virtually any antibody, offering the potential to replace hundreds of assays in clinical and research laboratories with a portable instrument. In addition, the probe could have a significant impact on world health because the system could be used with very little infrastructure requirements. Lastly, these probes could be configured to detect chemical and biological compounds in the environment, lending them valuable in the detection of chemical and biological weapons for homeland security.

79015S05-II

**6**

**Innovative Aerosol Collector for On-Line Analysis of Individual Particulate Organics—**
Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500
Dr. John T. Jayne, Principal Investigator, jayne@aerodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-05ER84269
Amount: $749,074

Atmospheric aerosol particles play an important role in the earth's climate, visibility, acid deposition, and human health. Detailed chemical characterization of ambient aerosol particles is necessary in order to fully understand the physical and chemical processes underlying the formation and transformation of aerosol particles in the atmosphere. However, standard analytical methods for detailed aerosol chemical speciation require long sampling times, are subject to artifacts during aerosol collection and storage, and are labor intensive. This project will develop an Aerosol Collector Module and demonstrate its feasibility for routine measurements of ambient and laboratory-generated aerosols in near real time with high time resolution (< 1 hour averages), and without artifacts due to filter sampling and storage. Phase I designed and assembled the aerosol collection chamber, connected it to an existing vacuum chamber, and prepared an interface to analytical instruments. Control hardware and software were designed and implemented. Laboratory-generated organic particles were used to evaluate the concept. During Phase II, an integrated, stand-alone Aerosol Collector Module will be developed. Further improvements to the hardware will improve sensitivity and linearity. A scheme to obtain particle size measurements will be implemented. Finally, the performance of the Aerosol Collector Module will be demonstrated in field measurements of ambient aerosol particles.

*Commercial Applications and other Benefits* as described by the awardee: The Aerosol Collector Module should provide a universal interface for aerosol collection and concentration and should easily be adapted to existing analytical techniques and new spectrometric techniques. The instrument should be ideal for the on-line characterization of airborne particles emitted from anthropogenic and natural or photochemically-produced sources in the atmosphere. Due to its universal interface and its low cost both for acquisition and operation, the long term commercial potential is large.

**Low Cost Sensors for Real Time Monitoring of Overhead Transmission Lines—**
Underground Systems, Inc., 86 Business Park Drive, Suite 109, Armonk, NY 10504;
914-273-8727
Mr. Larry Fish, Principal Investigator, larryf@usi-power.com
Mr. Larry Fish, Business Official, larryf@usi-power.com
DOE Grant No. DE-FG02-05ER84176
Amount: $999,999

Historically, the cost of systems that operate in real time and extract performance data from overhead transmission and distribution lines has been too high to justify widespread adaption into transmission control systems. This project will develop a low cost, wireless sensor for the real time monitoring of overhead transmission lines. The sensor, developed and demonstrated in Phase I, provided real-time wireless data with more than 99% availability. Analytical results derived from the sensor measurements were verified using high-accuracy field-monitoring equipment. Phase II will involve: (1) adding signal processing/waveform analysis capabilities, including current, voltage, and voltage phasors; (2) engineering the product for manufacturing; (4) carrying out additional field tests; and (5) manufacturing a first lot of devices.

*Commercial Applications and other Benefits* as described by the awardee: The device should have multifunction capability with a very low cost per function. Commercial applications include dynamic line rating, clearance monitoring systems, load survey systems, fault and event recording systems, and grid monitoring for security and reliability.

79082S05-II

**106**

**An Advanced Simulation Toolkit for Photon Band Gap/Advanced Structure Development—**Simulation Technology and Applied Research, 11520 North Port Washington Road, Suite 201, Mequon, WI 53092-3432; 262-240-0291
Dr. John F. DeFord, Principal Investigator, john.deford@staarinc.com
Dr. John F. DeFord, Business Official, john.deford@staarinc.com
DOE Grant No. DE-FG02-05ER84374
Amount: $626,768

The development of high-gradient accelerating structures is critical to reducing the cost of next generation particle colliders. In order to develop any novel structure, such as a photo band gap structure, its responses to the drive pulse and to a beam bunch must be fully characterized. This characterization includes the determination of wake-potentials and transient peak surface fields, and an analysis of potential field-emission in high-field regions. Although modeling capabilities for these characterizations have recently been developed, they have yet to integrated and packaged for use by the accelerator community at large. This project will create a specialized modeling toolkit that will be customized for high-gradient structure development, providing access to custom analysis sequences, postprocessing, and design optimization that are specific to advanced structures. In Phase I, a prototype toolkit was created. It contained specialized model templates for creating the complex geometry of photon band gap structures, and it also supported specialized analysis sequences for analyzing photon band gap lattices, cavities, power input couplers, and slow-wave structures. Phase II will add time-domain modeling capabilities to the toolkit, which will greatly extend its utility for advanced structure development, enabling characterization of important effects that are very difficult to determine experimentally.

*Commercial Applications and other Benefits* as described by the awardee: Accurate and sophisticated computer modeling should play a pivotal role if the development of novel structures for efficiently accelerating a charged particle beam. The proposed modeling toolkit will increase the rate of innovation in novel structures, leading to improved, lower cost accelerators for high-energy physics, medical research and therapy, lithography, and other applications.

**32**

**High-Temperature Ceramic Capacitors for Applications in Deep Drilling and Completion Processes—**Synergistic Advanced Technologies, LLC, 8987 East Tanque Verde Road, Suite 292B, Tucson, AZ 85749-9610; 520-760-0291
Mr. Thomas L. Venable, Principal Investigator, tvenable@dakotacom.net
Mr. Thomas L. Venable, Business Official, tvenable@dakotacom.net
DOE Grant No. DE-FG02-05ER84214
Amount: $600,000

In deep drilling and completion processes, a central challenge to both the sensor system and the data transmission system is the lack of high-temperature electronic components. An important component common to all electronics is capacitors. For electronics used in deep drilling and completion, the capacitor must be able to work downhole, in high temperature environments. This project will develop high temperature capacitors by using a new type of temperature-compensating nanocomposite dielectrics. The approach will be based on the use of materials with a positive temperature coefficient of dielectric constant, and a particular design for the composite microstructure. Phase I demonstrated dielectrics with less than 14% reduction in dielectric constant over a range from room temperature to 300$^{o}$C, with relatively low dielectric loss and high resistivity. During Phase II, manufacturing formulations and processes for high-temperature capacitors will be developed and optimized, and the performance the capacitors will be assessed through actual application testing.

*Commercial Applications and other Benefits* as described by the awardee: The new capacitors should have application in consumer electronics, medical electronics including defibrillators, automotive electronics including electric vehicles, and electric utilities. High temperature applications include aircraft engine ignition systems and electrical actuation, NASA's deep space power systems, and under-the-hood automotive applications. Many military systems need high-temperature capacitors to perform properly, reliably, and safely.

**High Power Density (100 kW) Silicon Carbide (SiC) Three-Phase Inverters—**Arkansas Power Electronics International, Inc., 700 Research Center Boulevard, Fayetteville, AR 72701; 479-443-5759
Dr. Alexander B. Lostetter, Principal Investigator, alostet@apei.net
Mrs. Sharmila D. Mounce, Business Official, smounce@apei.net
DOE Grant No. DE-FG02-05ER84143
Amount: $750,000

With worldwide energy consumption becoming an epidemic and the future need for power conservation self evident, the improvement of power conversion systems and the reduction of energy waste has become a global priority. This project will develop very compact, light-weight, silicon carbide power converters, capable of operation at high efficiencies and high junction temperatures. Silicon carbide – which offers higher blocking voltages, higher operating temperatures, higher frequency, and lower switching losses compared to other more conventional devices – is a new semiconductor material with the promise of vastly exceeding the constraints of devices based on silicon. High temperature operation will result in highly miniaturized and power dense converters, with an order-of-magnitude smaller footprint and reduced volume over state-of-the-art silicon systems. In Phase I, a single-phase, silicon-carbide-based, three-kilowatt inverter module was built and tested, achieving significant volume reduction (85% smaller) over similar, state-of-the-art , single-phase inverter modules based on silicon. The feasibility of high temperature operation beyond 500°C at the junction was demonstrated. Phase II will design, build, and test a high-energy-efficiency, silicon-carbide, 100-kilowatt, three-phase inverter system with a size and volume reduction of 75%, compared to state-of-the-art silicon-based inverters, with nearly an order-of-magnitude increase in power density. The approach will utilize a multichip, power-module design strategy, which integrates control and power devices into a single module, and will allow for higher frequency operation.

*Commercial Applications and other Benefits* as described by the awardee: By improving electrical efficiencies through the use of silicon carbide electronics, and in implementing the technology in a wide range of power converter applications, the technology should have the potential to save billions of dollars annually in wasted energy. Commercial power-electronics systems that would significantly benefit from these high efficiency energy improvements include: high efficiency and low cost industrial motor drives, light-weight motor drives for electric and hybrid-electric vehicles, power inverters for renewable energy and power distribution/transmission, and backup power supplies for telecommunications systems.

79175S05-II

**93**

**Flow Channel Inserts for Dual-Coolant ITER Test Blanket Modules—**Ultramet 12173 Montague Street, Pacoima, CA 91331-2210; 818-899-0236
Mr. Brian E. Williams, Principal Investigator, brian.williams@ultramet.com
Mr. Craig N. Ward, Business Official, craig.ward@ultramet.com
DOE Grant No. DE-FG02-05ER84193
Amount: $749,997

The International Thermonuclear Experimental Reactor (ITER) is an international effort to build the first power-producing, magnetically-confined fusion reactor within the next decade. The reactor design requires the development of advanced materials for flow channel inserts that will accomodate a lead-lithium (Pb-Li) alloy, tritium-breeder exit temperature of ~700°C. The flow channel insert must have low thermal and electrical conductivity, resistance to thermally induced stress, impermeability, and non-reactivity with the Pb-Li alloy. This project will develop a sandwich structure for these inserts, using a previously-developed, high-specific-stiffness open-cell silicon carbide (SiC) foam with integrated, thin, dense SiC face sheets (80-90% porous). The structure not only will satisfy the above requirements, but also will be far more manufacturable, exhibit higher thermal stress resistance, and cost substantially less than SiC/SiC composites. In Phase I, a matrix of SiC-foam/SiC-facesheet, flow-channel insert specimens was fabricated, and thermomechanical modeling and liquid metal testing were performed. The modeling and test results indicated that the concept could meet the flow channel insert requirements. In Phase II, a 30-cm tall, flow-channel insert section (12×12 $cm^2$ cross-section) will be designed and fabricated for testing with high temperature Pb-Li. The properties of the SiC foam/SiC facesheet insert first will be optimized through thermal, mechanical, and chemical testing. Test results will be incorporated with thermomechanical modeling to determine the optimal SiC foam density and foam/facesheet thickness. Performance will be demonstrated by subjecting components to an environment that simulates that of an actual flow channel insert.

*Commercial Applications and other Benefits* as described by the awardee: Nuclear fusion is an ideal alternative to increasingly scarce and expensive fossil fuels, and can provide a much greater quantity of environmentally sound energy than wind, solar, and geothermal sources. The proposed flow channel insert should serve as a key component that would enable fusion reactors tol ultimately be used for large-scale commercial energy generation.

**Low Cost Hot Anode Recycle Blower—**Phoenix Analysis and Design Technologies, 7755 S. Research Drive, Suite 110, Tempe, AZ 85284-1803; 480-813-4884
Dr. Mark Christian Johnson, Principal Investigator, mark.johnson@padtinc.com
Dr. Mark Christian Johnson, Business Official, mark.johnson@padtinc.com
DOE Grant No. DE-FG02-05ER84209
Amount: $745,766

Concerns about the high cost of energy, dwindling natural resources, and environmental pollution are pressuring the country to explore energy production technologies that offer greater efficiency and cleanliness. Solid Oxide Fuel Cell (SOFC) systems are one such technology. In order to operate SOFC systems at their best efficiency, the anode fuel mixture require recirculation. In turn, a hot anode recycle blower will be needed. However, the extreme temperature of the anode gas (850C) necessitates a very unusual blower. Additionally, the cost of this blower must be low enough to not appreciably increase the cost of the overall system. This project will develop a low-cost, high-temperature recycle blower for SOFC systems. In Phase I, a pumping concept was designed, built, and demonstrated at nearly 600C.. Test station inadequacies prevented testing at full temperature, but the results indicated that the design should be adequate for the desired temperature. In Phase II, the pump's thermal management technology will be demonstrated at full temperature. For cost reduction, the design will be modified to include the use of a high-volume low-cost motor and controller, and a reduced-size pump head. For performance improvement, the regenerative pump head will be adjusted to use improved aerodynamics. Finally, the cost-reduced version of the pump will be demonstrated for 5000 hours.

*Commercial Applications and other Benefits* as described by the awardee: Implementation of this recycle blower in Solid Oxide Fuel Cell systems should provide an approximately 10% improvement in overall efficiency.

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**Ultrahigh Heat Flux Plasma-Facing Components for Magnetic Fusion Energy—**Ultramet, 12173 Montague Street, Pacoima, CA 91331-2210; 818-899-0236
Mr. Brian E. Williams, Principal Investigator, brian.williams@ultramet.com
Mr. Craig N. Ward, Business Official, craig.ward@ultramet.com
DOE Grant No. DE-FG02-05ER84194
Amount: $749,999

The potential economic, environmental, and strategic benefits associated with the development of magnetic fusion energy are enormous. However, fusion technology cannot be realized without the development of advanced materials that allow operation under the high heat flux and radiation conditions necessary for maintaining burning plasmas. This project will develop and demonstrate innovative materials and components to allow extended steady-state operation of fusion devices at heat flux levels greater than 15 MW/m, with brief, more intense pulses of energy deposition during plasma disruptions. Chemical vapor deposition/infiltration will be used to produce refractory materials and structures for this application that cannot be fabricated by conventional processing techniques. In Phase I, preliminary design work was performed on an innovative, ultrahigh-heat-flux plasma-facing component composed of a thin tungsten shell integrally bonded to an open-cell tungsten foam core. Tungsten-foam/tungsten-shell heat exchangers were fabricated using chemical vapor deposition. High-heat-flux testing demonstrated an outstanding heat flux capability of 22.4 MW/m at 4 MPa pressure and 27 g/s of helium flow, a world-class heat flux for a helium-cooled refractory device. In Phase II, ultrahigh-heat-flux capabilities (>20 MW/m ) will be achieved by further optimizing the plasma-facing component design; size scalability of a unique modular channel concept operating at very low pressure drop will be demonstrated; and high-heat-flux capability limits will be established through an expanded matrix of tests.

*Commercial Applications and other Benefits* as described by the awardee: Heat exchangers with high-heat-flux capability and low-coolant pressure drop are critical for efficient heat transfer in nuclear power generation plants (fission and fusion), which remain the only practical alternative to fossil fuel energy sources. Other areas of commercial application are high-Mach combined-cycle propulsion and airframe systems. In addition, the automotive industry is turning to the use of refractory materials for high-efficiency, low-heat-rejection engines and exhaust systems, which have the potential to significantly reduce fuel consumption and unwanted emissions.

79197S05-II

**113**

**A 200 MHz High Power RF Amplifier—**FM Technologies, Inc., 4431-H Brookfield Corporate Drive, Chantilly, VA 20151-1691; 703-818-9400
Dr. Frederick M. Mako, Principal Investigator, fmako@erols.com
Dr. Frederick M. Mako, Business Official, fmako@erols.com
DOE Grant No. DE-FG02-05ER84359
Amount: $650,000

When muon beams are produced for high energy physics research, they initially have transverse and longitudinal emittances that are too large. Low frequency amplifiers (200 MHz is desired) at high power (10 to 30 Megawatt), with a power gradient of 5 MW/m, are required to ameliorate this problem This program will develop a low frequency, high power amplifier that meets these requirements. By modulating the current of an electron gun, the extracted radio frequency (RF) power from the system will be capable of producing a large range of output frequencies suitable for muon accelerator applications. In Phase I, a theoretical/simulation study with electron gun modulation experiments was conducted to develop a prototype design. The results demonstrated feasibility for the frequency range of interest (88-300 Megahertz). Phase II will build, test and develop a nominal 200 Megahertz, 13 Megawatt, compact, RF amplifier suitable for muon accelerators.

*Commercial Applications and other Benefits* as described by the awardee: An RF amplifier that operates the 20-1000 MHz range should find use in high-energy physics and microwave applications. In addition to muon accelerators, potential applications include UHF and television broadcasting; low-resolution long-range radar, ground-penetrating radar, and land-mine detection. The compact packaging of high RF power would allow for the insertion of these amplifiers into portable systems (including ground based, shipboard, and airborne), leading to broad market penetration, as replacements for current lower power systems become necessary.

**Sorbents for Air Separation—**TDA Research, Inc., 12345 W. 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300
Dr. Gokhan O. Alptekin, Principal Investigator, galptekin@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-05ER84216
Amount: $750,000

Gasification-based power generation processes, such as Integrated Gasification Combined Cycle (IGCC) plants, offer the possibility of higher thermal efficiency and better environmental performance than competing technologies. Yet, additional improvements are needed to reduce their capital and operating costs. One such improvement would be the use of oxygen instead of air for gasification, which would increase efficiency, reduce NOx emissions, and improve gas purity. However, oxygen is expensive to produce. Therefore, this project will develop a high-temperature sorbent-based system for air separation, so that the gasification process can be supplied with low cost oxygen. Phase I developed a low-cost regenerable sorbent that can remove oxygen with very high capacity, demonstrated that the sorbent maintains its capacity for over 200 absorption/regeneration cycles under representative conditions, demonstrated economic viability, and reported the potential for dramatic reductions in the cost of oxygen. In Phase II, improvements in sorbent's performance will be continued, and the sorbent will be scaled-up for production using commercial manufacturing techniques. A prototype test unit will be designed and fabricated, in order to demonstrate the concept at a larger scale. Lastly, a detailed system analysis and engineering assessment will be performed to fully quantify the benefits of the new technology.

*Commercial Applications and other Benefits* as described by the awardee: Oxygen is a strategically important chemical, with a $2.0 billion market value. It supports the combustion of fuels that supply heat, light, and power, and enters into oxidative combination with many materials. A cost-effective air separation technology should find immediate use in the U.S. energy manufacturing and chemical industries.

79234S05-II

**26**

**High Volume Utilization of Fly Ash Containing Mercury-Impregnated Activated Carbon—**
Ceramatec, Inc., 2425 South 900 West, Salt Lake City, UT 84119-1517; 801-978-2114
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Mr. Raymond K. Miller, Business Official, rkm@ceramatec.com
DOE Grant No. DE-FG02-05ER84197
Amount: $745,910

In March of 2005, the EPA published final regulations to control mercury emissions from coal-fired electric utilities. The most mature retrofit technology available for mercury collection is the injection of a sorbent such as powdered activated carbon. Unfortunately, carbon injection technology is accompanied by high concentrations of mercury in the fly ash, (an important by-product that is used in concrete), which renders the fly ash unacceptable for concrete use. This project will develop reaction-bonded, castable ceramic materials, made with high carbon/mercury content fly ash, that can replace concrete in commercially viable applications. In Phase I, it was demonstrated that various types of fly ash, containing excess activated carbon and mercury could be made into strong reaction-bonded, castable ceramic materials through the selection of activators, water content, and curing temperature. The reaction not only generated strong bonding materials, but effectively encapsulated both the mercury and activated carbon, rendering the new cement composition environmentally benign and suitable for use in various concrete applications. Phase II will further characterize and optimize the engineering properties of the materials, including compressive strength, workability, freeze-thaw resistance, indirect tensile strength, elastic constants, etc. These properties will be compared against the standards developed for current fly ash concrete and Portland cement based concrete.

*Commercial Applications and other Benefits* as described by the awardee: The new materials would allow fly ash to remain useful and marketable, even after the adoption of mercury control technologies by coal-fired power plants. The use of this reaction-bonded material also would minimize emissions of greenhouse gases by minimizing the demand for Portland cement-based concrete.

79248S05-II

**44**

**Improved Electrolytes For Electrochemical Capacitors—**TOXCO Inc., 1830 Columbia Avenue, Folcroft, PA 19032-1905; 610-522-5960
Dr. Novis Smith, Principal Investigator, NOVIS@LITHCHEM.COM
Mr. James J. Gormley, Business Official, JIM2591@LITHCHEM.COM
DOE Grant No. DE-FG02-05ER84261
Amount: $749,721

Currently, the best performing ultra-capacitors, an important technology for hybrid electric vehicles, utilize a non-aqueous electrolyte based on acetonitrile, which is highly flammable and considered toxic. Alternative electrolytes that do not contain acetonitrile are based primarily on propylene carbonate and have about 35% of the conductivity of those with acetonitrile, which significantly degrades the performance of the capacitor. This project will develop and synthesize a number of new quaternary ammonium tetrafluoroborates and determine their solubility and maximum conductivity in non-acetonitrile electrolytes. Phase I successfully found and developed a group of non-acetonitrile electrolytes with conductivity as high as 60% of the acetonitrile-containing electrolytes. In addition, the flash point of these electrolytes was increased from 2$^{o}$C to 120$^{o}$C (increased safety), and the allowable capacitor voltage was increased from about 2.8 volts to over 4.2 volts (increased performance). The increased performance and safety were accomplished with relatively non-toxic, low-cost solvents and newer versions of quaternary ammonium tetrafluoroborate salts. Phase II will complete the optimization and final selection of the preferred electrolyte compositions. Processes for manufacturing and purifying the preferred electrolytes will be developed on a small pilot scale.

*Commercial Applications and other Benefits* as described by the awardee: The new ultra-capacitor electrolytes should overcome a major safety and hazard barrier in the wide acceptance of the use of ultra-capacitors in hybrid electric vehicles (HEV) and electric vehicles (EV). The replacement of the currently used acetonitrile-based electrolytes with these essentially non-flammable, non-toxic, higher-voltage electrolytes could eliminate the safety issues that have been raised for ultra capacitors. Further, the use of ultra-capacitors with these new safe, high performance electrolytes should aid the rapid commercialization of HEVs and EVs.

79270S05-II

**48**

**Dehydration of Acids and Harsh Chemicals Via Pervaporation/Vapor Permeation Using Inorganic Membranes—**Media and Process Technology, Inc., 1155 William Pitt Way, Pittsburgh, PA 15238-1368; 412-826-3711
Dr. Paul K.T. Liu, Principal Investigator, pliu@mediaandprocess.com
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DOE Grant No. DE-FG02-05ER84242
Amount: $749,600

Pervaporation (PV) and vapor permeation (VP) membranes have been touted as highly effective for a wide array of liquid and vapor separations, particularly for dehydration of aggressive chemicals; yet, they have been limited to a relatively small number of niche applications. The barriers to further penetration include cost, reliability, and performance stability. This project will develop molecular sieving nanoporous inorganic membranes to overcome the limitations of current PV/VP membrane technology. These low-cost high-performance membranes will deliver outstanding thermal, mechanical, and hydrothermal stability at temperatures in excess of 200ºC. Further, they offer the potential to deliver very high fluxes and selectivities in a range of PV/VP applications, reducing system costs and improving separation efficiency, in comparison to the current generation of polymeric and other inorganic based PV/VP membranes. An experimental study in Phase I demonstrated the technical viability of the membrane as a universal dehdyration membrane. An economic analysis confirmed the commercial viability. Phase II will involve membrane product optimization, process development, and an extended bench-scale stability test. Then, a pilot field test, using a slip stream, will be conducted to confirm the performance and material stability. Finally, a full-scale membrane module will be designed, constructed, and tested, and prepared for a full field demonstration in Phase III.

*Commercial Applications and other Benefits* as described by the awardee: The new composite membrane should permit widespread applications of this promising technology. Net energy savings on the order of 5 TBtu/year have been estimated.

79281S05-II

**82**

**Gas Phase Catalytic Oxidation of Cyclohexane to Cyclohexanone and Cyclohexanol—**
EverNu Technology, LLC, 1616 Holly Hill Lane, Suite 108, Maple Glen, PA 19002-3171; 610-519-7531
Dr. Manhua Mandy Lin, Principal Investigator, mandylin@evernutech.com
Dr. Manhua Mandy Lin, Business Official, mandylin@evernutech.com
DOE Grant No. DE-FG02-05ER84321
Amount: $749,984

In the U.S., the annual production of 4.6 billion pounds of nylon starts with the liquid-phase oxidation of 3.5 billion pounds of cyclohexane to KA-oil (a mixture of cyclohexanone and cyclohexanol) and the subsequent oxidation of the latter to adipic acid with $HNO_3$. The liquid-phase cyclohexane process, which operates at only 4-10% cyclohexane conversion, is the "least efficient" industrial process, and wastes trillions of Btu of energy in the repeated recycling of 90-96% of the 3.5 billion pounds of unreacted cyclohexane. This project will develop an effective metal-oxide-based catalyst for the efficient conversion of cyclohexane to KA-oil in a gas-phase process. A gas-phase catalytic process would greatly enhance KA-oil productivity while capturing ~7 trillion Btu/yr of energy released in the exothermic reaction. Phase I proved the feasibility of producing cyclohexanone via cyclohexane gas-phase oxidation with air as the oxidant. Several lead catalysts were discovered that met and exceeded the targets of 20% cyclohexane conversion and 20% cyclohexanone selectivity. Phase II will seek to achieve one-pass 30% cyclohexane conversion and 50-60 % KA-oil selectivity by: (1) conducting studies to understand and minimize the undesirable cyclohexane oxidation pathways, and to enhance KA-oil production; (2) enhancing the catalytic performance of the lead catalysts through the optimization of catalyst composition and preparation methods; and (3) conducting an economic analysis to compare the new process to existing commercial processes.

*Commercial Applications and other Benefits* as described by the awardee: The gas-phase cyclohexane catalytic oxidation process should replace current conventional cyclohexane liquid-phase processes for the production of KA-oil, the key intermediates for the production of 4.6 billion lb/yr of nylon in the U.S. The advantages of the gas-phase process include: (1) improved productivity, (2) significant reduction of energy consumption, (3) the capture for use of at least 7 trillion Btu/yr of energy from the exothermic high temperature gas-phase process; (4) the elimination of the need to use and recycle billions lb/yr of boric acid; and (5) the elimination of massive amounts of acidic aqueous waste streams.

**Dimensionally Stable High Performance Membrane—**Giner Electrochemical Systems, LLC, 89 Rumford Avenue, Newton, MA 02466-1311; 781-529-0504
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Dr. Anthony J Vaccaro PhD, Business Official, avaccaro@ginerinc.com
DOE Grant No. DE-FG02-05ER84322
Amount: $749,613

Devices that employ fuel cell technology (such as vehicles, portable devices, and remote installations) require frequent startup/shutdown cycles. Surviving these cycles, particularly at freezing temperatures, will require the development of cost-effective, high-performance, proton-exchange membrane (PEM) materials. This project will develop a high performance membrane with excellent dimensional stability over a wide range of temperature and relative humidity. The new membrane will alleviate the water/ice expansion problem during the freeze/thaw process while simultaneously facilitating operation at low humidity and high temperature. This improved operability under suboptimal conditions will retard shorting and enhance the durability of the membrane. Phase I developed a dimensionally stable membrane that showed stellar mechanical stability compared to Nafion®, with a creep rate at least one order-of-magnitude lower. The feasibility of the concept was demonstrated in membrane formation, membrane-electrode assembly fabrication, fuel cell performance, and freeze/thaw stability. Phase II will develop alternative membrane fabrication processes to lower cost and increase performance, and demonstrate freeze/thaw stability and scalability with both 50 $cm^2$ fuel cells and short stacks (3-5 cells, 100-200 $cm^2$, 250-500W).

*Commercial Applications and other Benefits* as described by the awardee: The new PEMs should be readily applicable to fuel cells employed in vehicles, portable devices, and remote installations. Compared to conventional ionomer membranes, the new membrane should provide higher reliability, longer life, and wider relative humidity and temperature operating ranges. Its low projected fabrication cost of ~ 2 ¢/$cm^2$ should enhance commercialization possibilities.

79298S05-II

**128**

**High Z Droplets-A Novel Source of Heavy Ions for Nuclear Physics—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
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DOE Grant No. DE-FG02-05ER84173
Amount: $749,434

Substantially higher beam currents and luminosities must be achieved to continue fundamental advances in experimental nuclear physics and astrophysics research. Present heavy ion beam injectors, based on electron cyclotron resonance (ECR) techniques, must be optimized to produce the necessary beam current with sufficient reliability and reasonable cost. This project will develop a novel, fully-kinetic simulation code to investigate the loading of heavy metals into ECR ion sources (ECRIS) via such alternate mechanisms as vapor loading, ion sputtering, and laser ablation. In Phase I, a massively-parallel 3D particle-in-cell (PIC) code was enhanced by adding impact ionization and recombination models. The simulation generated oxygen ionization state distributions consistent with published experimental data. The feasibility of using a particle-in-cell (PIC) code to model important kinetic effects in an ECRIS plasma was demonstrated. In Phase II, coordinated simulations and experiments will be used to optimize the location and orientation within the ECR magnetic bottle for both a metal vapor oven and a biased rod for ion sputtering. The merit criteria will be ion current at the extraction aperture, overall ionization efficiency, and the number of vapor particles lost to the wall. ECR loading via laser ablation will be simulated. The PIC simulation code will be further enhanced with ion/neutral charge exchange models, as well as with parametric models for the three types of neutral injection sources. The plasma shape and ion distribution functions at the extraction aperture will be modeled, providing improved initial conditions for extraction optics simulation codes.

*Commercial Applications and other Benefits* as described by the awardee: A high-quality, commercial modeling tool for ECR sources, which is benchmarked against experimental results, should provide a detailed understanding of the loading process of ECR sources, increasing the ion beam production efficiency of rare and expensive isotopes.

**Plasma Jet Injection of Angular Momentum in the Maryland Centrifugal Experiment—**
HyperV Technologies Corporation, 11316 Smoke Rise Court, Fairfax Station, VA 22039-1002; 703-378-4882
Dr. F. Douglas Witherspoon, Principal Investigator, witherspoon@HyperV.com
Dr. F. Douglas Witherspoon, Business Official, witherspoon@HyperV.com
DOE Grant No. DE-FG02-05ER84189
Amount: $749,848

The centrifugal confinement of plasma has great potential as a fusion device. In order to operate in the highest temperature and density regimes, angular momentum must be injected into the plasma without permitting the plasma to come into contact with a material surface. To accomplish this, the plasma must be injected at high velocity tangential to the direction of plasma rotation. In this project, angular momentum will be injected into a large centrifugally confined mirror plasma, using a two stage coaxial plasma accelerator with shaped electrodes. This process will allow the high velocity jets to efficiently couple to the target plasma. In Phase I, a prototype accelerator was designed and fabricated, and test-fired in the laboratory in preparation for injection experiments on a mirror machine plasma experiment. Simulations were performed that showed that high velocity, moderate mass slugs efficiently can indeed drive target plasma rotation. In Phase II, the plasma jet hardware will be installed on a large, centrifugally-confined, mirror plasma experiment, and extensive testing will be performed. The ideal set of parameters that will most effectively couple the jet momentum to the plasma rotation will be determined. The computational modeling will be benchmarked against these results.

*Commercial Applications and other Benefits* as described by the awardee: The plasma jet technology should be applicable to commercial fusion power, refueling of magnetically confined plasmas, high specific-impulse thrusters for space propulsion, laboratory simulation of astrophysical jets, fast-pulsed power switching, and materials processing.

**A High-Throughput Assay for Microbe-Based Hydrogen Production—**GVD Corporation, 19 Blackstone Street, Suite 1, Cambridge, MA 02139; 617-661-0060
Dr. Hilton Gavin Pryce Lewis, Principal Investigator, hilton@gvdcorp.com
Dr. Hilton Gavin Pryce Lewis, Business Official, hilton@gvdcorp.com
DOE Grant No. DE-FG02-05ER84281
Amount: $749,850

Microbe-based hydrogen production is a potentially cost-effective, non-polluting approach to the production of hydrogen, and research efforts are underway to identify, isolate, and enhance microbial strains which facilitate the process. However, these efforts are hampered by a lack of adequate instruments to detect and pinpoint hydrogen producers, and no assays currently provide the characteristics needed – in terms of sensitivity, short response times, scalability, and compatibility with high-throughput methodologies – for the rapid screening of colonies. This project will develop a commercial assay that provides high-throughput screening capabilities, safety in the presence of hydrogen, spatial determination, high sensitivity, reusability, and long lifetimes. The assay will consist of a flat, transparent array that, when placed in close proximity to the microbes under investigation, will identify the location and intensity of hydrogen producers. Phase I created successful prototypes of a high-throughput assay by combining a chemochromic sensor technology with a protective coating. The characteristics of the protective coating were optimized to achieve maximum sensitivity, short response times, and long lifetimes. The assay was field-tested by a photobiological hydrogen researcher, survived the warm wet conditions of testing, and pinpointed the hydrogen-producing organisms exactly as intended. In Phase II, the assay will be scaled-up to produce a greater volume of prototypes for testing by researchers, with whom collaborations will establish common formats and configurations. The manufacturability of the assay will be demonstrated by designing and building a prototype production tool.

*Commercial Applications and other Benefits* as described by the awardee: The new assay should accelerate the pace of discovery in microbe-based hydrogen production by allowing researchers to screen organisms and genetic libraries faster and more accurately. The assay could be made commercially available, at modest cost, in volumes sufficient to satisfy the demands of the research community. The improvements to the manufacturing process should encourage adaptation to other sensor markets, most notably safety sensors for fuel cell applications.

79369B05-II

**123**

**An Integrated Authorization and Intrusion Detection System for GMPLS Control Plane—**
Computer Networks & Software, Inc., 7405 Alban Station Court, Suite B-225, Springfield, VA 22150-2318; 703-644-2103
Dr. Chris Retna Dhas, Principal Investigator, chris.dhas@cnsw.com
Mr. James George Dramby, Business Official, jim.dramby@cnsw.com
DOE Grant No. DE-FG02-05ER84386
Amount: $749,242

Networking and security technology have become inextricably linked as enterprises rely on computer networks for everyday operations. It is imperative to integrate several types of security technologies into the network to foil various kinds of attacks before they can do any damage. Generalized Multiple Protocol Label Switching (GMPLS) has extended Multi-Protocol Label Switching to provide the control plane for devices that can switch packet, time, wavelength, and fiber domains. This common control plane simplifies network operation and management, but increases the risk of service disruption, because the control plane has not been secured. This project will develop an Intrusion Detection System (IDS) that discriminates between correct and incorrect signals on the basis of the context, content, and history of control messages. Phase I developed an intrusion detection and prevention technique that protects the GMPLS control plane from external as well as insider attacks. An analysis of signaling and management protocols was conducted, a security framework to protect the control plane was developed, and the integrated intrusion detection and protection techniques were validated by using a primitive test-bed architecture. Phase II will develop syntax and semantics verification modules for appropriate routing protocols (similar to those developed in Phase I for signaling and management protocols); add support for the state-dependent analysis of various control plane protocols; analyze the inter-protocol interactions among the link management, signaling, and routing protocols; and develop detailed security attack scenarios. A prototype IDS will be implemented and tested.

*Commercial Applications and other Benefits* as described by the awardee: The intrusion detection system would provide a unique security product that can be utilized to protect the control plane in the DOE's GMPLS-based high performance network. Other network applications include the Department of Defense's net centric network infrastructure. A modular and optimized system could be used by public carriers to protect their converged network infrastructure and provide end system security in the enterprise environment.

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**124**

**Interoperability between Ultra High-Speed Networks and Traditional IP Networks (SmartNIC)—**RNET Technologies, Inc., 555 Bryant Street, #578, Palo Alto, CA 94301-1740; 650-248-3371
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Mr. Ram Balasubramanian, Business Official, rbalasubramanian@Rnet-Tech.com
DOE Grant No. DE-FG02-05ER84163
Amount: $749,974

Emerging, large-scale distributed-science applications increasingly depend on ultra-high-speed lambda-based networks to securely deliver end-to-end throughputs of 10-100 gigabits per second. However, in order to achieve high levels of end-to-end performance, it will be necessary to match the performance of these ultra-high-speed networks to traditional "slow" Internet Protocol networks. This project will develop a solution to overcome this mismatch problem. Phase I proved feasibility by conducting a simulation that used a previously-developed middleware and networking software stack. It was determined that, in order to be effective in the real world, the middleware and the networking software stack must be off-loaded to a network interface card. Therefore, in Phase II, the required software infrastructure will be developed to off-load the networking software stack to a network interface card, which would serve as a bridge between the ultra-high speed lambda networks and traditional internet protocol networks.

*Commercial Applications and other Benefits* as described by the awardee: The bridging technology should benefit scientists in both national laboratories and universities who are working on large-scale simulation problems and have a need for on-time delivery of large amount of data. The simulations include computational climate modeling, nano-scale science (both experimental and computational), and high energy physics.

79392S05-II

**72**

**Abrasion-Resistant Membranes for Biomass Hydrolysate Clarification—**CeraMem Corporation, 12 Clematis Avenue, Waltham, MA 02453; 781-899-4495
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DOE Grant No. DE-FG02-05ER84315
Amount: $750,000

The development of processes to convert lignocellulosic biomass into ethanol and other chemicals is being enthusiastically pursued by the federal government as well as by private organizations. However, before these processes can be made cost effective, new materials are needed that are resistant to abrasion and corrosion in the aggressive streams associated with lignocellulosic processing – for example, in the removal of suspended solids from the hydrolysate produced in the pretreatment of biomass. This project will develop low-cost inorganic microfiltration membranes that have the requisite abrasion resistance and chemical durability for use in the clarification of hydrolysate generated during pretreatment. In Phase I, membrane fabrication and synthesis parameters were developed on laboratory-scale, ceramic membrane coupons. The performance of the new membrane was then demonstrated on a pretreated, corn stover hydrolysate sample. In Phase II, the membranes will be further optimized and scaled to produce pilot-scale elements. Field testing of the membrane elements will be conducted on hydrolysate streams.

*Commercial Applications and other Benefits* as described by the awardee: The new membranes should find use in the separation and isolation of the sugars produced during the hydrolysis of lignocellulosic biomass. If chemicals can be produced from biomass sugars, the process of converting biomass to ethanol would become more cost effective, providing Americans with an abundant supply of fuel and reducing the need to import petroleum. Other applications of the membrane technology include clarification processes in the production of sweeteners, sugars, and fruit juices.

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**Multi-Sampling System with Tree Architecture for Pulse Shape Analysis—**Advanced Science and Novel Technology Company, 27 Via Porto Grande, Rancho Palos Verdes, CA 90275; 310-528-2532
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Dr. Vladimir Katzman, Business Official, traffic405@cox.net
DOE Grant No. DE-FG02-05ER84137
Amount: $750,000

Shape analysis of pulses collected from arrays of fast particle detectors used in nuclear physics experiments requires data processing systems with fast (>500 Ms/s) sampling rates, in order to preserve the pulse shape information. Existing systems rely on multi-channel analog-to-digital converters with a single-in/single-out architecture, 8-12 bit accuracy, sampling rate below 250*MS/s*, low component density, and high power consumption. Improvements to the sampling rate and the input dynamic range is limited by the converter complexity, power consumption, and cost. This project will develop a novel multi-sampling system with a power-efficient, sub-Nyquist, shifted-phase, sampling tree architecture utilizing proprietary single-input/dual-output sample-and-hold amplifiers. The programmable system-on-chip also contains a signal preprocessor that performs a preliminary identification of the signal amplitude range, in order to detect the event occurrence and to extend the input dynamic range by means of the controlled signal attenuation. During Phase I, the preliminary system architecture was developed and the most critical blocks were designed and simulated. The feasibility of a novel, low-distortion sample-and-hold amplifier with a dual CMOS transmission gate was proven in computer simulations. Phase II will develop, fabricate, and test the programmable system-on-chip as an application-specific integrated circuit in SiGe BiCMOS technology.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the application for nuclear physics, the system-on-chip should find use in wireless ground stations, radar systems, software definable radio, medical diagnostic equipment, and measurement instrumentation.

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**Ultra High Speed Transport Protocol and Architecture—**Broadata Communications, Inc., 2545 W. 237th Street, Suite K, Torrance, CA 90505-5229; 310-530-1416
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Ms. Debby Roussell, Business Official, droussell@broadatacom.com
DOE Grant No. DE-FG02-05ER84144
Amount: $749,924

Emerging distributed science applications are expected to generate petabytes of data that must be transferred to geographically distributed tera-scale computing facilities. Ultra-high bandwidth will be needed to achieve this transfer. While the bandwidth is available in network link technology, transport architectural inefficiencies severely limit the throughput attainable over such links. This project will develop an innovative network transport mechanism, Transport Control Protocol-Fiber (TCPF) technology, that allows networking at full link speed over an ultra high-speed network. The approach deals with network data transport inefficiencies by providing intelligent, fast, and accurate network measurement, and employs a hardware-assisted approach for congestion control adjustment. Phase I demonstrated the feasibility and potential of the TCPF technology by using a real-world 10 Gigabit network testbed. For file transfers, network utilization improved by a factor of nine. Phase II will focus on optimization of the TCPF design, development/experimentation of the ultra high speed advanced network measurements, development of full-scale TCPF software, development of the TCPF Network Interface Card hardware, integration/testing/evaluation of the system prototype, and evaluation of commercial scenarios.

*Commercial Applications and other Benefits* as described by the awardee: The Transport Control Protocol-Fiber should enable large-scale distributed scientific applications such as environmental monitoring, energy physics, nuclear energy, computational genomics, climate modeling. It also should have significant commercial value in inter-networking applications such as private enterprise networks, distributed multimedia networks, and entertainment network applications. Due to its network independence, it also should be applicable as a transport directly over different link layers and heterogeneous networks, such as Internet II.

**Reformer for Conversion of Diesel Fuel into CO and Hydrogen—**Eltron Research Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263
Dr. Michael V. Mundschau, Principal Investigator, eltron@eltronresearch.com
Mr. James Steven Beck, Business Official, contracts@eltronresearch.com
DOE Grant No. DE-FG02-05ER84394
Amount: $750,000

A major impediment to the commercialization of solid oxide fuel cell systems for the very large automotive market is the lack of efficient, low-cost, compact reformers to convert diesel fuel into synthesis gas. The major issues involve carbon deposition in the cooler zones of the reformer and catalyst intolerance to sulfur. This project will develop a reformer that integrates a modified oxygen transport membrane material with sulfur-tolerant reforming catalysts. The system, which uses commercial grade diesel as a feedstock, prevents carbon build-up by transporting the oxygen through self-cleaning reformer walls. The system will be compact and inexpensive, and will operate stably. In Phase I, catalysts were designed for the partial oxidation of diesel fuel into synthesis gas, using oxides with high conductivity of both electrons and oxygen anions. Some 40 catalyst formulations were evaluated. The preferred self-cleaning catalysts showed stable reforming activity without carbon deposition for pump-grade diesel fuel. In Phase II, the catalysts will be incorporated into self-cleaning reformer walls, and the system will be optimized and tested. A design for a commercial prototype diesel fuel reformer will be completed and a techno-economic analysis, leading to commercialization in Phase III, will be performed.

*Commercial Applications and other Benefits* as described by the awardee: The sulfur-tolerant fuel reformer, which should cost less than $90 per kW and have an overall efficiency greater than 80%, would enable the wide-spread adoption of diesel-based solid oxide fuel cell systems. Such reformers also would allow conversion of very-high-sulfur military fuel and bottom-of-the-barrel petroleum reserves into synthesis gas. The synthesis gas from the latter could be used to run turbines or to produce alternative fuels, including low-sulfur diesel, methanol, and synthetic natural gas.

79454S05-II

**67**

**A Robust Microfabricated Specimen Support with Integrated Capabilities for In Situ Experimentation in the Transmission Electron Microscope—**Protochips, Inc., 419 North Boylan Avenue, Raleigh, NC 27603-1264; 919-341-2612
Mr. David Peter Nackashi, Principal Investigator, david@protochips.com
Mr. David Peter Nackashi, Business Official, david@protochips.com
DOE Grant No. DE-FG02-05ER84252
Amount: $719,619

As the nanotechnology revolution advances, existing and new applications are demanding improved capabilities from the transmission electron microscope – in particular, higher resolution and a greater ability to manipulate specimens *in situ*. No known commercial system provides both accurate control over specimen temperature and the simultaneous ability to create a stable gaseous environment. This project will develop advanced specimen-support technologies for observing and manipulating specimens at the nanoscale in an electron microscope. During Phase I, semiconductor microfabrication technology was used to create specimen supports with integrated heaters that could control specimen temperature up to 2000K within 15 milliseconds. The Phase II will focus on using these specimen supports as the core components of two prototype *in situ* systems for the transmission electron microscope – a Micro-Heating System and a Micro-Environmental Cell System – allowing control of temperatures and gases around the specimen. These prototype systems will be delivered to collaborators for evaluation.

*Commercial Applications and other Benefits* as described by the awardee: The specimen support technology should provide revolutionary capabilities to commercial, government, and academic markets by greatly enhancing *in situ* capabilities at an easily affordable price. Moreover, a microfabricated specimen support is a platform technology that offers opportunities for developing additional features and capabilities in future releases. Areas of application include hydrogen storage, air quality, high temperature and corrosion-resistant materials, and semiconductors.

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**Development of Magnesium Diboride for Near Term HEP Applications—**Hyper Tech Research, Inc., 1275 Kinner Road, Columbus, OH 43212; 614-481-8050
Mr. Matthew Rindfleisch, Principal Investigator, mrindfleisch@hypertechresearch.com
Mr. Lawrence Walley, Business Official, elwalley@hotmail.com
DOE Grant No. DE-FG02-05ER84363
Amount: $600,000

Magnesium diboride ($MgB_2$) is an emerging superconductor material, which offers the possibility of fabrication into multifilamentary strands from inexpensive starting materials using conventional metalworking processes. However, in order to be useful for high energy physics (HEP) applications, several improvements will be required. This project will develop technology to increase the in-field *Jc*, filling factor, filament count, and stability, the most relevant improvements for near term accelerator-related applications. Phase I successfully fabricated a 54 + 7 filament strand with good properties, extruded a 19 filament strand, fabricated multifilament strands with more conductive outer sheaths, improved fill factor by 50%, and increased mid-field performance of MgB2 strands using SiC additives. In order to develop MgB2 strands for HEP applications, Phase II will increase: (1) the filament count to 74, by investigating both CTFF-route and seamless tube niobium barriers; (2) the SC fill factor, with a goal of fabricating strands with a 30% fill factor; (3) strand stability, through the investigation of more conductive outer sheaths; and (4) *Jc* performance in the 3-5 T regime, through methods to improve connectivity and densification, and through the introduction of dopants.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the application to HEP, an improved $MgB_2$ superconductor material should accelerate the wire being developed for other commercial applications, such as MRI systems, power utility transformers, generators, motors and military applications.

79505S05-II

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**Modular Multipurpose RF Amplifier—**Diversified Technologies, Inc., 35 Wiggins Avenue, Bedford, MA 01730-2345; 781-275-9444
Dr. Ian S. Roth, Principal Investigator, roth@divtecs.com
Mr. Michael A. Kempkes, Business Official, kempkes@divtecs.com
DOE Grant No. DE-FG02-05ER84146
Amount: $749,747

Both existing and planned accelerators, synchrotrons, and light sources need radio frequency (RF) amplifiers at a range of frequencies. Typically, each amplifier is built to a unique design, potentially by multiple vendors, resulting in high acquisition costs, and complex operations and maintenance over the lifetime of the system. If a single modular design could satisfy a wide range of RF requirements, such an amplifier could be built in quantity, lowering its price to all users. This project will develop a modular RF amplifier, based on a vacuum electronic device (VED), suitable for use over a range of frequencies and applications. In Phase I, the RF amplifier was designed, the specific VEDs required for target commercial frequencies were selected, and the key RF drive elements of the amplifier itself were demonstrated. The design utilizes common power supplies, controls, and other components. Estimates of RF amplifier cost, reliability, and extensibility were made for a wide range of VED powers and frequencies. In Phase II, the modular RF amplifier will be designed for two widely applicable frequencies. The selected amplifier will be constructed and delivered to a national laboratory for assessment of its operability, controls and interfaces, and flexibility.

*Commercial Applications and other Benefits* as described by the awardee: The modular RF amplifier should find use in military systems, communication systems, and industrial applications such as plasma generation, RF heating, and drying/curing. Currently, none of these applications benefit from the efficiencies of scale that would be available if their requirements could be met with a single, modular design. A common, modular RF amplifier system would eliminate the extensive non-recurring engineering required for each individual amplifier, reduce the cost of acquiring and operating these systems, and simplify their integration into a wide range of systems and applications.

**Characterization of Carbonaceous Particles: Aerosol Mass Spectrometry and Light Scattering—**Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500
Dr. Timothy B. Onasch, Principal Investigator, onasch@aerodyne.com
Mr. George Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-05ER84268
Amount: $748,839

Aerosol particles have important effects on visibility, acid deposition, climate, and human health. A large fraction of the anthropogenic aerosol is generated from energy-related activities, and organic compounds are known to constitute a significant fraction of ambient aerosol mass in many locations. Yet, large uncertainties remain in quantifying the chemical composition and atmospheric transformations of these aerosols, especially with respect to organic particulate matter. Particularly lacking are real-time, size-resolved, quantitative instruments for the identification, speciation, and source apportionment of carbonaceous aerosols. An innovative thermal desorption, time-of-flight aerosol mass spectrometer recently has been developed with capabilities that can fill a critical need for size-resolved, quantitative chemical composition data on aerosol particles. This project will develop and demonstrate a light scattering module for this instrument, which will enable full characterization of carbonaceous components, including their state of mixing (and atmospheric aging), along with other chemical components such inorganics and dust. In Phase I, the light scattering system was optimized and installed in a quadruople aerosol mass spectrometer, ray tracing calculations were performed to optimize optical detection, software for analyzing data on individual particles in real-time was developed, and the system capabilities were quantified. Phase II will continue the development of the light scattering module and its incorporation into the new time-of-flight aerosol mass spectrometer. The combined instrument will be tested on multiple aerosol systems in the laboratory and during a future field study.

*Commercial Applications and other Benefits* as described by the awardee: Beyond the application for atmospheric research, the combined aerosol mass spectrometer and light scattering module could provide aerosol measurement capabilities for a variety of monitoring applications. A portable instrument could be employed in industrial process monitoring and chemical and biological warfare agent identification. In addition, the instrument is ideally suited for the characterization and control of aerosol emissions from production processes that produce aerosol laden exhaust, including semiconductor manufacturing, gas turbines, fluidized bed combustors, diesel combustors, and conventional furnaces.

79509B05-II

**100**

**Experimental and Numerical Studies of Particle Acceleration by an Active Microwave Medium—**Euclid TechLabs, LLC, 5900 Harper Road, #102, Solon, OH 44139-1866;
440-519-0410
Dr. A. D. Kanareykin, Principal Investigator, alexkan@euclidtechlabs.com
Mr. David Dunay, Business Official, daved@euclidtechlabs.com
DOE Grant No. DE-FG02-05ER84355
Amount: $450,000

The DOE is seeking new techniques for particle acceleration that are cost effective and efficient. This project will develop and verify one such concept, electron acceleration by a fullerene-based active medium. In particular, synthesis and manufacturing techniques will be developed for a fullerene-based active medium, its properties will be characterized, and numerical techniques will be developed to incorporate the measurement results into a structure design code. In Phase I, the chemistry of fullerenes was studied in liquid crystal matrices. The composition of the materials was optimized for maximum stored energy, using electron paramagnetic resonance spectroscopy. A design code, capable of designing an accelerating structure based on this technology, was developed, along with a design for a test system. Phase II will construct a device for measuring the electromagnetic characteristics of these materials and design an experiment to validate this acceleration technique.

*Commercial Applications and other Benefits* as described by the awardee: Beyond the application for low-cost, high-gradient electron accelerators, the technology could be extended to ion acceleration (with possible applications to ion implantation and ion microprobes). In addition, the active medium could have application as a low-noise, tunable microwave amplifier.

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**A Compact Crystal Positioning System for Neutron Diffraction—**Square One Systems Design, Inc., 3135 Mallard Road, P.O. Box 10520, Jackson, WY 83002; 307-739-0946
Mr. Robert J. Viola, Principal Investigator, viola@sqr-1.com
Mr. Robert J. Viola, Business Official, viola@sqr-1.com
DOE Grant No. DE-FG02-05ER84257
Amount: $749,382

When completed, the Spallation Neutron Source's (SNS) multiple beam lines will provide unprecedented opportunities to conduct studies in materials characterization, medical isotope production, and the transmutation of nuclear waste. However, to take full advantage of the greatly reduced data collection times made possible by the SNS's high neutron flux, new automated sample changers must be developed and deployed. The large goniometers, traditionally used to position samples relative to particle beams, will be incompatible with many of the new SNS instruments. This project will develop a very compact, high-precision manipulator, adjustable in six degrees-of-freedom, which is mounted *within* the bore of a temperature control cryostat. A kinematic "socket" will be incorporated into the manipulator, allowing samples to be efficiently loaded and unloaded using industrial robotics. Phase I established feasibility by creating a prototype positioning system, and demonstrating its ability to securely register an incoming sample and to accurately and rapidly adjust its position. The system's development was closely coordinated with an SNS instrument scientist and included designs for complementary temperature control and crystal alignment systems. During Phase II, the manipulator's design will be refined and fully characterized. A loading robot, tailored to the needs of the Single Crystal Diffractometer, will be developed. The manipulator will be mated with the handling robotics and a temperature control system, and installed in the beam line.

*Commercial Applications and other Benefits* as described by the awardee: The compact crystal positioning system should provide neutron scientists with a powerful enabling technology. Versions of this integrated system could be disseminated to other SNS beamlines and to other neutron science facilities. Applications in other branches of science include X-ray crystallography, fusion research, and electron beam lithography.

**66**

**Novel Large Area High Resolution Neutron Detector for the Spallation Neutron Source—**
Proportional Technologies, Inc., 8022 El Rio, Houston, TX 77054-4104; 713-747-7324
Mr. Jeffrey L. Lacy, Principal Investigator, jlacy@proportionaltech.com
Mr. Jeffrey L. Lacy, Business Official, jlacy@proportionaltech.com
DOE Grant No. DE-FG02-05ER84251
Amount: $749,620

The Spallation Neutron Source (SNS) facility, due for completion at Oak Ridge National Laboratory in 2006, will push available thermal neutron flux at least an order of magnitude above that achievable at any other neutron science facility. The markedly increased deliverable flux imposes extreme requirements on imaging detectors at many of the target stations. This project will develop a new detector technology, based on the 10-boron thin-film conversion of neutrons and the detection of reaction products in the gas of a thin straw detector. By using dense packed arrays of such straws, which can be as long as 1 meter, efficient high-resolution imaging can be achieved, with a quantum leap in integral and differential counting rate. Phase I developed a 150-element sub-array of detectors with the full 1 meter length and the required depth for the SNS. The sub-array was configured so that a 1 meter square detector can be constituted by replicating the single sub-array. The sub-array was thoroughly tested in a thermal neutron beam to determine all operating specifications, including spatial resolution, differential and integral counting rate, gamma rejection, and neutron sensitivity. Phase II will design and construct a complete, 1 square meter, neutron imaging detector, which will provide an integral rate capability approaching 2 x $10^7$ cps, a differential rate capability of at least 2000 cps per pixel, spatial resolution of 7 mm x 4 mm x 4 mm (depth encoded), sensitivity of 70% for thermal neutrons, and a capability of operating in gamma radiation fields approaching 1 R/hr. The device will be installed at an appropriate test site and thoroughly evaluated in an activity that simulates the demands of SNS operations.

*Commercial Applications and other Benefits* as described by the awardee: The large area neutron detector for the SNS should benefit many fields, including, for example, the development of improved drug therapies and materials that are stronger, longer-lasting, and more impact-resistant. In addition to the SNS, the detector should find application in nuclear terrorism detection and nuclear waste remediation.

79564S05-II

**80**

**Boron Nitride Capacitors for Advanced Power Electronic Devices—**Integrated Micro Sensors, Inc., 10814 Atwell Drive, Houston, TX 77096-4934; 713-748-7926
Dr. Nacer Badi, Principal Investigator, nacer@imsensors.com
Dr. Nacer Badi, Business Official, nacer@imsensors.com
DOE Grant No. DE-FG02-05ER84325
Amount: $749,805

Silicon carbide (SiC) and gallium nitride (GaN) are being used to break barriers with respect to the design and fabrication of high-temperature high-power transistors, but capacitors remain the weak link in achieving higher temperature electronics. In particular, the use of SiC should allow future power devices to operate safely at temperatures up to 400°C, but at these temperatures, the capacitors have been shown to severely degrade. Therefore, high-temperature-capable capacitors will be needed for SiC power components such as device gate drive circuits and RF power transistors. This project will fabricate long-life boron nitride (BN) capacitors for advanced SiC power electronics, using a physical vapor deposition (PVD) process. The BN capacitor will match the silicon carbide device operating at temperatures above 300°C. In Phase I, layers for the BN capacitors were first grown on a silicon substrate using an ion-source-assisted PVD technique. The use of vapor deposition provided for precise control and quality material formation. The capacitors were subjected to electrical and thermal characterization. The BN material exhibited high thermal stability, high thermal conductivity, and high breakdown voltage, and met the SiC power requirements. Phase II will further develop the advanced BN capacitors by fabricating and testing different capacitor structures, and by fabricating pre-commercial capacitor prototypes.

*Commercial Applications and other Benefits* as described by the awardee: High-energy density capacitors that can operate at hige temperatures should find use in ballistic missiles, electric guns, and high power microwave sources; microwave systems for communications such as cellular telephony and data transmission; satellite communications systems; high power pulsed amplifiers for ground, airborne and space-based radar; and high frequency switching power supplies.

79578S05-II

**13**

**A Fiber Optic Multipass Raman Probe and Instrumentation for Monitoring Flammable Gases in High Level Waste Tanks—**EIC Laboratories, Inc., 111 Downey Street, Norwood, MA 02062-2612; 781-769-9450
Dr. Job M. Bello, Principal Investigator, bello@eiclabs.com
Mr. Jeffrey L. Bursell, Business Official, jefbursell@eiclabs.com
DOE Grant No. DE-FG02-05ER84278
Amount: $749,931

The Department of Energy (DOE) has 280 underground tanks used to process and store over 90 million gallons of high-level radioactive chemical waste. The conditions in the tanks are conducive to the formation of flammable gases such as hydrogen, ammonia, and methane, as well as fire accelerants (oxidizers) such as nitrous oxide. An accumulation of these flammable gases above their lower flammability limit (LFL) increases the risk of fire and explosion. To mitigate these risks, this project will develop a Raman instrument that can be deployed inside the tanks for monitoring the concentration of these hazardous gases below their lower flammability limit. Phase I showed that flammable gases such as hydrogen and methane can be detected at concentrations below their lower flammability limit in near real time with a multipass retroreflector Raman cell. In its current configuration, the limit of detection of the multipass Raman probe is at 10% of the gases lower flammability limit. Phase II will involve refinements to the multipass Raman gas probe design and the associated Raman instrumentation, in order to permit gas detection at concentrations lower than 10% of the lower flammability limit. A deployable probe and instrument will be developed for field-testing in a high level waste tank at the Savannah River National Laboratory (SRNL).

*Commercial Applications and other Benefits* as described by the awardee: In addition to the application to tank monitoring, the probe could be used by the DOE as an in-line monitor for hydrogen isotopes and other gases in tritium facilities, such as the hydrogen-tritium thermal cycle absorption process. A sensitive Raman probe also could benefit the private sector in relation to: (1) pollutant monitoring, where the probe could be used to monitor the release of hazardous gases from industrial sites for regulatory purposes; and (2) process control, such as in furnace atmosphere control monitoring, where the control and monitoring of such gases as nitrogen, carbon monoxide, hydrogen, ammonia, carbon dioxide, oxygen and other hydrocarbon gases are required.

**Enhanced Catalysts from Nanostructured Materials—**Lynntech, Inc., 7607 Eastmark Drive, Suite 102, College Station, TX 77840-4027; 979-693-0017
Dr. Jeremy D. Steinshnider, Principal Investigator, Jeremy.steinshnider@lynntech.com
Dr. G. Duncan Hitchens, Business Official, duncan.hitchens@lynntech.com
DOE Grant No. DE-FG02-05ER84240
Amount: $750,000

One of the most significant impediments to making the hydrogen economy a reality is the prohibitively high cost of fuel cell catalysts. In order to reduce these costs, a catalyst must be developed with lower precious metal content, using a streamlined production method that does not sacrifice fuel cell performance. This project will develop a plasma-based synthesis method that produces a nano-scale fuel cell catalyst at lower precious metal loadings than currently available. In addition, the process will reduce manpower requirements and eliminate the chemical wastes associated with traditional fuel-cell-catalyst production. Phase I developed a plasma-based synthesis process for a catalyst composed of nano-structured carbon support material imbedded with evenly distributed nano-scale platinum. The performance of fuel cells utilizing the synthesized catalyst was equivalent or superior to that of commercially available catalysts containing 2.5 times greater platinum loadings. In Phase II, the plasma process will be optimized to obtain long range order in the nano-structured carbon support material. The element of the system that deposits the synthesized catalyst onto the fuel cell membrane *in situ* also will be developed. Finally, a pilot scale, reel-to-reel, catalyst synthesis and deposition process, based on this technology, will be designed.

*Commercial Applications and other Benefits* as described by the awardee: In addition to the fuel cell application, the low-cost catalyst production process should benefit other chemical processes that require this type of catalyst. The process not only would reduce the amount of expensive precious metal, but also would reduce labor requirements, speed production times, and eliminate the chemical waste generation inherent in current catalyst production processes.

**Extreme Environment Control Sensors—**Luna Innovations Incorporated, 2851 Commerce Street, Blacksburg, VA 24060-6657; 540-552-5128
Mr. Matthew Palmer, Principal Investigator, submissions301@lunainnovations.com
Mr. Michael Pruzan, Business Official, submissions301@lunainnovations.com
DOE Grant No. DE-FG02-05ER84389
Amount: $749,948

Generation-IV reactor plants have the potential to drastically reduce our dependence on foreign oil and to reduce emission of greenhouse gasses. These plants will require reliable, high-temperature physical sensors that can operate at temperatures of 800°C to 1000°C and pressures up to 1000psi, while undergoing heavy irradiation. Conventional temperature and pressure sensors in nuclear and non-nuclear power plants rely on semi-conductor technology that will not withstand the high temperatures and neutron flux levels – the highest-temperature pressure sensors, commercially available, fail below 500°C without liquid or other cooling. This project will develop a fiber optic, hybrid pressure-temperature sensor system that is capable of reliable operation in a high-temperature (to 1400°C) and high-radiation environment ($>1x10^{19}$ n/cm$^2$). During Phase I, a new sensor design, which eliminated those materials that limited the maximum operational temperature of previous designs to about 900°C, was developed. The new design was prototyped, and several component construction procedures were optimized. A pressure sensor prototype measured pressure at temperatures up to 800°C. In Phase II, the sensor and packaging design will be optimized for inclusion in DOE Gen-IV development experiments. Prototype sensors will be characterized in a laboratory environment at temperatures up to 1400°C. A new, lower-cost demodulation system will be developed and prototyped to complete the sensor system. Finally, automatic health monitoring algorithms will be developed for the demodulation system.

*Commercial Applications and other Benefits* as described by the awardee: The improved fiber optic sensor should increase the safety and security of Gen-IV reactors, providing plant staff the capability to contain minor incidents before they develop into more serious accidents. In addition, the sensor system should have applicability to: (1) instrumentation for existing power generation reactors and power generation gas turbines, improving power generation efficiency and life extension; (2) instrumentation and control of space-based nuclear power reactors; (3) DOD applications for military nuclear power systems; and (4) DOD gas turbines engines to improve performance.

79629B05-II

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**An X-band, Traveling Wave, Deflection Mode Cavity for Ultra-Fast Beam Manipulation and Diagnosis—**RadiaBeam Technologies, LLC, 1600 Sawtelle Boulevard, Suite 300, Los Angeles, CA 90025; 310-444-1475
Dr. Alex Murokh, Principal Investigator, murokh@radiabeam.com
Mr. Salime Max Boucher, Business Official, boucher@radiabeam.com
DOE Grant No. DE-FG02-05ER84370
Amount: $650,000

Cutting-edge applications in high energy electron-beam-based physics, such as linear colliders, x-ray free-electron lasers, inverse compton scattering sources, and plasma wakefield accelerators, require beams with sub-picosecond pulses. These beams must be precisely diagnosed to be used for such advanced applications. While methods for the production of such beams are well-developed, the necessary diagnostics for accurate characterization are yet to be developed. In this project, a traveling-wave, x-band deflecting cavity will be designed to solve the problem of complete longitudinal measurement of ultra-short electron bunches. The approach will take advantage of the greater efficiency and compactness of X-band radio frequency (RF) structures. In Phase I, the RF structure was designed and a cold test prototype was built and tested. The results demonstrated the accuracy of the design and fabrication procedures. A plan for building and testing a full-power prototype was developed, and simulations were conducted to model the performance of the deflector. In Phase II, the full-power prototype of the X-band traveling wave deflector will be designed, engineered, and fabricated. The device will be installed at the Accelerator Test Facility at Brookhaven National Laboratory and beam-tested to measure its performance.

*Commercial Applications and other Benefits* as described by the awardee: Investments from governments in North America, Europe and Asia, in linear colliders and X-ray Free Electron Lasers, may total in the billions of dollars over the next decade and beyond. The traveling wave X-band RF deflector would address a number of these systems' needs: ultra-short time scales, detailed information concerning beam phase spaces, and high energy operation. Further application of the device may be found in manipulating, through fast kicker "pulse-picking" techniques, high average power, multi-bunch train systems that are now being developed in high energy physics, light sources, and industrial and military applications of accelerators.

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**GSIMF: A Grid Software Installation Management Framework—**Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856
Dr. Nanbor Wang, Principal Investigator, nanbor@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-05ER84384
Amount: $650,000

To process the vast amount of data from high energy physics experiments, physicists rely on Computational and Data Grids; yet, the distribution, installation, and updating of a myriad of different versions of different programs over the Grid environment is complicated, time-consuming, and error-prone. This project will develop a Grid Software Installation Management Framework (GSIMF) for managing software applications over the Grid infrastructure. A set of Grid services and tools will automate the software installation management process by installing and removing software packages on behalf of users. Phase I developed key prototype Grid services for querying available software packages and installing software on distributed Grid computing elements, demonstrated the prototype services using an ALTAS analysis software package, and explored and investigated other software installation management strategies. Phase II will focus on hardening the implementations and enhancing the functionality of the prototype Grid services. Specifically, the flexibility and the reusability of the software packages will be enhanced, and comprehensive security and administrative policy management support will be provided. Because an automatic and flexible software management system adds a new dimension to job management on the Grid, Phase II will also investigate ways of utilizing the framework for job executions.

*Commercial Applications and other Benefits* as described by the awardee: The new Grid management framework should enable users to remotely install programs and tap into the computing power provided by Grids. The new management framework should find use in various data intensive and collaborative applications, such as nuclear physics experiments (e.g., RHIC), space science observations, and climate modeling.

**Sectional Permanent Magnet Generator and Power Electronics for Multi-Megawatt, Direct Drive Wind Turbines—**Distributed Energy Systems Corporation, 182 Mad River Park, Waitsfield, VT 05673; 802-496-2955
Mr. Garrett Bywaters, Principal Investigator, gbywaters@northernpower.com
Ms. Michele Grimm, Business Official, mgrimm@northernpower.com
DOE Grant No. DE-FG02-05ER84317
Amount: $737,136

Wind power has the potential of supplying a significant percentage of the United States electrical demand at low cost. However, costs of transportation, erection, and repair must be reduced before these systems are competitive with current technology. The large size of multi megawatt turbine components makes transportation from manufacturing facilities to wind sites problematic. Once on site, the installation of these machines requires very large and expensive cranes. If a turbine fails during operation, these same cranes must be re-deployed to the site for the repair. This project addresses theses issues through the design of a direct-drive generator/power converter system that uses a modular architecture. Such a design allows for the transport and erection of a multi-megawatt turbine in sub-system-level building blocks. Further, if a module fails during operation, the rest of the turbine can continue producing power while the module is repaired or replaced *in situ* using on-board service equipment. Phase I developed a conceptual design of a sectional generator and power converter for a 6 MW wind turbine. Assembly procedures and detailed cost estimates were completed. The results showed that an improved cost of energy can be realized with modular, permanent-magnet direct-drive turbines. Phase II will: (1) verify the manufacturing and assembly processes by fabricating a full scale segment of the generator; (2) validate full and partial power mode operation for a 100 kW generator/power converter; and (3) fabricate and test specialized service tools.

*Commercial Applications and other Benefits* as described by the awardee: The technology, which should be ready for commercial development at the multi-megawatt level in Phase III, would be directly applicable to large commercial wind turbines in the fastest growing sector of the energy industry. The result will be a more robust and reliable energy supply to the national grid and a lower cost of energy to the end user.

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**Internal-Tin Nb/Sn Strand with Enhanced Ti Additions Aimed at 17 T Optimization—**
Global Research and Development, Inc., 1275 Kinnear Road, Columbus, OH 43212;
614-481-8050
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Mr. Lawerance Walley, Business Official, elwalley@hotmail.com
DOE Grant No. DE-FG02-05ER84361
Amount: $600,000

The DOE needs improved superconductors to support the high-field-magnet requirements of high energy particle accelerators. The immediate focus is the Large Hadron Collider (LHC) luminosity upgrade in the form of interaction-region quadrupole magnets, which require an evolutionary increase in field-at-windings to more than 15 T. To address this need, this project will develop a high-performance $Nb_3Sn$ strand with improved stability. The strand will combine high critical current density (*Jc*) and high upper critical field (*Bc2*) with manageable levels of magnetization and stability. Ti and Ta additions to the binary $Nb_3Sn$ will serve to increase *Bc2* and hence the high-field *Jc*. The Ti addition will flatten the *Jc vs B* curve, leading to strands with reduced low-field *Jc* and hence improved stability during ramp-up to high field. In Phase I, two internal-Sn type billets were designed and processed: one with added Ti only and one with both Ti and Ta. *Jc* values of 1000 A/mm$^2$ were obtained at 15T, 4.2K. Phase II will optimize the production process, leading to one 7" OD billet of selected design. The development will be accompanied by detailed characterization studies, followed by the production of many kilometers of strand suitable for cabling and coil winding.

*Commercial Applications and other Benefits* as described by the awardee: The new superconducting strand should be applicable to the large market for accelerator and fusion magnets. The largest commercial market would be for clinical MRI systems above 7T. High field magnets (over 7 tesla) also should find use in NMR, high gradient magnetic separation, and superconducting magnetic energy storage (SMES) applications.

**Nano Graphene Plate-Reinforced Polymer Composites—**Nanotek Instruments, Inc., 1214 43rd Street NW, Fargo, ND 58102; (937)531-6682
Ms. Aruna Zhamu, Principal Investigator, manager@nanotekinstruments.com
Mr. Jiusheng Guo PhD, Business Official, James.Guo@nanotekinstruments.com
DOE Grant No. DE-FG02-05ER84246
Amount: $750,000

This project will develop a new class of nanocomposites containing isolated, individual, nano-scaled graphene plates (NGPs). Like carbon nano-tubes, NGP materials exhibit attractive properties like carbon nano-tubes, but can be readily mass-produced and are expected to become available at much lower costs and in larger quantities. When incorporated as a nano filler in a matrix, isolated NGPs are expected to impart exceptional mechanical (strength and stiffness), electrical (conductivity and dielectric), thermal (conductivity), and gas barrier properties to the matrix polymer. Phase I experimentally demonstrated the superior mechanical and electrical properties of the NGP nanocomposite. The feasibility of incorporating a high percentage of NGPs in a polymer matrix, to produce highly conductive bipolar plates on a continuous basis, has been demonstrated. Processes for preparing continuous filaments containing highly oriented NGPs, and for converting these filaments into a high-strength nanocomposite, also were developed. Phase II will develop the mass production capability of NGP nanocomposites for fuel cell bipolar plates, supercapacitor electrodes, and thin films or coatings for electromagnetic interference (EMI) shielding and electrostatic charge dissipation (ESD) applications. The resultant material will be characterized with respect to strength, stiffness, gas permeation resistance (barrier properties), electrical conductivity, and dielectric properties (permittivity and loss factor). Modeling and computational work will be undertaken to theorize the experimental data.

*Commercial Applications and other Benefits* as described by the awardee: NGP-based nanocomposites, with unique and tailorable electric conductivity and dielectric constants, could find use as functional coatings (EMI shields, electrostatic paintable plastics, ESD films or coatings, and corrosion-resistant coatings), lithium-ion battery negative electrodes, fuel cell bi-polar plates, supercapacitor electrodes, and dielectric elements in telecommunication devices. Future applications could include automotive friction plates, solid lubricants, and micron- or nano-scaled bearings, springs, sensors, and switch contacts. The market for conductive polymers alone (primarily filler-resin composites, but not including fuel cell bipolar plates) has been estimated at 128.5 million pounds at a value of $205.3 million in 2003. Projected growth forecasts show the market reaching 745 million pounds, valued at nearly $1.6 billion, in 2008.

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**Portable NMR spectrometer (with magnet)—**TECMAG, Inc., 10161 Harwin, #150, Houston, TX 77036; 713-667-8747
Dr. John L Delayre, Principal Investigator, jld@tecmag.com
Dr. John L. Delayre, Business Official, jld@tecmag.com
DOE Grant No. DE-FG02-05ER84174
Amount: $746,480

Nuclear Magnetic Resonance (NMR) is a powerful, non-destructive spectroscopy technique used to investigate chemical structure. For nuclear non-proliferation, NMR offers many opportunities for qualitative identification and quantitative analysis of both organic and inorganic components of suspect materials, such as solvents, raw materials, and waste materials. This project will develop a portable instrument for the identification and analysis of these suspect materials. Analyses can be done on unprocessed samples, or by addition of a solvent, metal-complexing agent, indicator, or other test reagent, as appropriate. In Phase I, a portable NMR spectrometer console (8.5” x 11.5”) was developed. During Phase II, a smaller size console will be developed, along with portable permanent magnets needed to complete the instrument.

*Commercial Applications and other Benefits* as described by the awardee: The portable NMR instrument should have widespread applications, not only for on-site nonproliferation inspections, but also for forensics, the pharmaceutical industry, and the detection of chemical and biological weapons.

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**Adaptable Sensor Packaging for High Temperature Fossil Fuel Energy Systems—**Sporian Microsystems, Inc., 515 Courtney Way, Suite B, Lafayette, CO 80026-8821; 303-516-9075
Mr. Wenge Zhang, Principal Investigator, wenge@sporian.com
Dr. Brian Schaible, Business Official, Brian@sporian.com
DOE Grant No. DE-FG02-05ER84213
Amount: $749,429

Avanced, integrated control systems will be essential to achieving the cost and performance targets of high-efficiency, low emissions fossil-fuel plants. Micro-electric-mechanical-systems (MEMS) and other types of micro-sensors will play an important role by providing critical real-time measurements that are needed to optimize these processes. Although micro-sensor technologies have been demonstrated, better packaging is needed that will protect the micro-sensors from harsh environments, allow the sensors to be exposed to the gas stream, and interface the sensors with high temperature electronics, housings, and hardware. This project will develop a standard, engineered testing package, with an integrated protective housing, for applying micro-sensors in high temperature harsh environments. The technical approach will leverage established ceramic microelectronics packaging and high temperature thermocouple concepts, by using proper design and material selection. Phase I developed a design framework for a general purpose high temperature sensor package and conducted experiments to evaluate feasibility. Phase II will develop a prototype, standard, engineered testing package. Specific tasks include: (1) the development of key structural components; (2) the development and testing of high temperature electrical interconnect and “die attach” technologies; (3) the finalization of a design for, and fabrication of, a prototype package; and (4) the experimental demonstration of the prototype in high-fidelity laboratory testing and external stimulant application test systems.

*Commercial Applications and other Benefits* as described by the awardee: The sensor packaging technology would allow end application integrators, such as gas turbine and fuel cell manufacturers, to realize the benefits associated with the advanced sensors. These sensors could be designed sensors into their equipment using a common, standardized packaging infrastructure. In addition to energy generation, a low-cost high reliability packaging for harsh environmentals would be useful in a wider range of other commercial applications such as propulsion, aerospace, automotive, and the military. The public as a whole would benefit from reduced emissions, enhanced efficiency, and overall lower operating costs.

**Novel, Low-Cost, Non-Contact, High Accuracy Sensor for the Simultaneous, Reliable, Real-time Determination and Monitoring of HV Transmission Line Sag, Temperature, Current, and Ampacity—**Promethean Devices, LLC, 9896 Old Charlotte Highway, Fort Mill, SC 29715-7133; 803-802-7012
Mr. Steven J. Syracuse, Principal Investigator, syracuse@prometheandevices.com
Mr. Steven J. Syracuse, Business Official, syracuse@prometheandevices.com
DOE Grant No. DE-FG02-05ER84159
Amount: $750,000

Demand for electriciy has grown significantly faster than the transmission system's capability to deliver it reliably. As a result, the system is being operated in a manner for which it was not designed; congestion, blackouts, equipment damage, and system disturbances are becoming widespread, and are occurring with ever increasing frequency, duration, and economic effect. The low-cost monitoring of congested circuits would improve reliability and economic efficiency, increase transmission capacity, relieve congestion, reduce costs to consumers, and decrease operational risks. However, existing real-time transmission line monitoring and dynamic rating systems have total installed costs significantly in excess of $45,000 and $120,000, respectively. This project will develop a non-contact sensor system that will monitor sag, temperature, ampacity, and current in real-time. The measurements will have high accuracy and be communicated wirelessly to end-users. The system will be capable of rapid installation and calibration, with no required outages. Phase I designed, developed, and field-tested prototype non-contact sensors that produced real-time conductor sag and phase current information. Preliminary operating specifications, performance, and total manufactured cost of the device were established. In Phase II, three complete system prototypes will be networked wirelessly at a utility test site, and extensive field tests will be conducted.

*Commercial Applications and other Benefits* as described by the awardee: The sensor system should enable low-cost, networked, real-time monitoring (and alleviation) of congested paths, thereby maintaining the reliability of electric power delivery. The sensor could help reduce the frequency, extent, and duration of system disturbances (including blackouts) that cause large annual productivity losses. By enhancing transmission capacity and reducing congestion, the public will realize reduced electricity prices. Utilities, transmission organizations, and system operators will benefit from improved grid monitoring and visualization.

**Universal Probe Reagents for Detection and Quantitation of RNA Splicing—**Callida Genomics Inc., 750 N. Pastoria Avenue, Sunnyvale, CA 94085; 408-739-2353
Dr. Snezana Drmanac, Principal Investigator, snezana@sbhgenomics.com
Dr. Radoje Drmanac, Business Official, rade@sbhgenomics.com
DOE Grant No. DE-FG02-05ER84275
Amount: $749,146

The number of genes in the genome of higher organisms is relatively small; however, the protein complexity arising from these genes has been shown to be much higher. In part, this is due to alternative splice variants that are created during the processing of gene transcripts. The formation of gene splice variants has implications for human disease (for example, in cancer susceptibility) and also for medical diagnostics, drug development, and bioengineering. However, there are hundreds of thousands of exons for each higher organism, which imposes a technical problem of generating millions of exon-specific detection reagents. This project will advance gene splice variant detection and quantitation by utilizing a small library of a few thousand universal-probe reagents and universal-probe microarrays, sufficient to analyze any gene from any organism. In Phase I, efficient assay designs and analysis software were developed, and accurate exon detection was demonstrated on 11 genes. Accurate exon detection was also demonstrated on pools of 10 cDNA clones representing 10 distinct genes. Over 300 cDNA clones (~1Mb of DNA) from 6 human tissues were efficiently analyzed using this new splice variant analysis method. Phase II will develop fully functional prototypes and user-friendly protocols, and perform end-user-directed testing of: (1) pre-made probe pools for human genes; (2) on-demand probe pools for gene mixes and genes from other organisms; and (3) a universal set of labeled probe pools for multiplex detection of DNA clones or amplicons longer than 100 bp. The technical goal is to provide novel or improved chips, probe reagents, assay kits, and software, underlying all three products.

*Commercial Applications and other Benefits* as described by the awardee: Pre-made or easy made-on-demand-labeled gene probe cocktails, combined with universal 6-mer microarrays, would have many research and diagnostic applications, including fundamental studies of gene expression control, organism development and evolution, understanding disease susceptibility and progression such as in cancer, drug development for gene expression control, and agricultural and industrial research. An additional benefit involves the isolation of rare and complex splice variants for protein expression, without an expensive long gene synthesis process.

**High Bulk-Density, Large Capacity Activated Carbons for Small-Scale Natural Gas Storage—**CM-TEC, Inc., 1 Innovation Way, Suite 100, Newark, DE 19711; 302-369-6166
Dr. X. Daniel Wu, Principal Investigator, daniel.wu@cmtec-inc.com
Dr. X. Daniel Wu, Business Official, daniel.wu@cmtec-inc.com
DOE Grant No. DE-FG02-05ER84211
Amount: $726,845

Natural gas provides a clean and environmentally friendly fuel for electric power generation; however, the distribution network, and especially the storage system, is ill-suited for the projected gowth of natural gas for use in electical energy generation. This project will develop a natural gas (methane) storage system based on an innovative, high-bulk-density activated carbon that is especially designed with high adsorption capacity for methane. This adsorptive storage system would be well suited for small-scale residential and commercial users who currently use diesel generators as their backup, and for small- to mid-size electrical power generators that require some natural gas storage to meet peak electrical demands. Phase I demonstrated the feasibility of using a high bulk density activated carbon, synthesized with an appropriate distribution of micropores, to adsorb natural gas (methane) at ambient temperature and relatively low pressures. It was shown that a system based on this technology can store methane at a weight and volume that is comparable to a high-pressure cylinder, but at a fraction of the pressure. Phase II will continue the development of methane storage materials, develop primary material packaging, fabricate a prototype adsorbed-natural-gas storage system, and perform a pilot test of the prototype device

*Commercial Applications and other Benefits* as described by the awardee: The carbon-based natural gas storage system should allow residential, commercial, or small-scale power generators to store natural gas easily, without resorting to high-pressure designs. The storage system could be filled (or refilled) from a pipeline supplied by a single-stage compressor. Unlike liquefied natural gas storage systems, there would be no evaporative losses, and unlike liquefied natural gas and methane hydrate storage systems, the adsorptive storage does not require refrigeration, so there is no energy cost for storing the fuel. A highly-distributed natural gas storage network would improve the security and reliability of the natural gas supply. Finally, the room temperature and low-pressure system would provide inherent safety advantages.

79766S05-II

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**Innovative Modular, Multiple Power Levels, 325 MHz Spokes Cavities Power Couplers—**
AMAC International, Inc., 12050 Jefferson Avenue, Suite 348, Newport News, VA 23606-4385; 757-249-3595
Dr. Quan-Sheng Shu, Principal Investigator, qsshu@amacintl.com
Mr. Ian Phipps, Business Official, ianp@amacintl.com
DOE Grant No. DE-FG02-05ER84346
Amount: $625,000

In order to increase proton energy up to 8 GeV in a driver linear accelerator, particles must be accelerated through various stages and three different power levels (25kW, 100 kW, and 210kw). Unfortunately, no power coupler element for these cavities has ever been produced using U.S. industrial capabilities. This project will develop innovative modular, multiple power level, 325 MHz spoke cavities power couplers. Phase I optimized and defined parameters for the 325 Mhz RF power couplers. Multipacting calculations were made to determine the RF parameters and to investigate the thermal characteristics of the coupler designs. Phase II will involve further optimization and finalization of the RF and thermal characteristics; detailed engineering drawings with emphasis on the use of cost saving features and approaches; fabrication of a prototype coupler for operation at 25-210 kW peak power, in order to meet all specifications of the proposed Proton Driver Linac at Fermi National Laboratory (FNL); and high power testing of the coupler(s) at FNL to verify performance.

*Commercial Applications and other Benefits* as described by the awardee: The modular component design should significantly reduce the fabrication costs for the 110 power couplers required for the Fermilab Proton Driver, by reducing the parts fabrication costs and the number of brazing fixtures needed. The modular universal design could be the model for any future cost saving applications, where several coupler power levels are required for many DOE accelerator projects and industrial applications.

79770S05-II

**115**

**Marx Based Modulator for ILC and Industry—**ISA Corporation, 6780 Sierra Court, Suite R, Dublin, CA 94568-2616; 925-833-3755
Mr. Dan Shimer, Principal Investigator, danshimer@yahoo.com
Mr. Anthony A. Zante, Business Official, tzante@isa-corporation.com
DOE Grant No. DE-FG02-05ER84364
Amount: $749,560

The International Linear Collider (ILC) will require hundreds of klystron pulsed-power modulators that must operate in the very long pulse-width range (1 to 2 millisecond). Long pulse width modulators typically require large capacitive energy storage banks to prevent voltage droop, and large, costly pulse transformers. Marx-generator-based modulators have the potential to be effective for this application; however, little work has been done to tailor this type of modulator for long pulse widths. This project will develop a Marx-based modulator that is tailored to meet the specific requirements of the ILC. The approach will focus on a novel combination of Marx cells with unique control technology, which will dramatically reduce the modulator's capacitive energy storage while still meeting the precision pulse regulation required. In Phase I, circuit simulations and analyses were performed to optimize the configuration of the Marx-based modulator. Key components were defined and evaluations of these components were made to determine their suitability for this application. A conceptual design and a cost model were developed for the Marx cells, regulation circuits, and the entire modulator. Emphasis was placed on compactness while maintaining serviceability. In Phase II, a full sized Marx-based modulator, which meets the requirements of the ILC program, will be designed and constructed. Subsystem tests will be conducted to verify key component performance prior to modulator system construction. The modulator will be delivered to the Stanford Linear Accelerator Center (SLAC) for evaluation, and comparison with other modulators.

*Commercial Applications and other Benefits* as described by the awardee: The new Marx-based modulator should provide a cost-effective solution for the International Linear Collider. In addition, the modulator should have important commercial applications, including its use in radiation processing equipment for materials processing, disinfestation, food irradiation, and other electron beam processing industries where long-pulse, high-average-power sources are required. The variable pulse width and high repetition rate also would make this modulator a valuable microwave source for cargo inspection systems.

79778S05-II

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**Fabrication of Complex Copper Cooling Devices Using Ultrasonic Metal Consolidation to Locally Cool and Monitor High Energy Electron Sources—**Solidica, Inc., 3941 Research Park Drive, Suite C, Ann Arbor, MI 48108-2219; 734-222-4680
Dr. Dawn R. White, Principal Investigator, dawn@solidica.com
Ms. Tina Raiford, Business Official, traiford@solidica.com
DOE Grant No. DE-FG02-05ER84375
Amount: $650,000

The performance requirements for next-generation linear colliders and linear-accelerator-based light sources, such as X-ray free electron lasers, place extreme demands upon the electron beam source. Higher field gradients in the electron gun are required to maintain beam quality and beam energy, in order to increase the peak power (and heat) load applied to the gun. As of now, there is no practical way to provide the required cooling to the interior structures of the gun, while concurrently providing a means of monitoring conditions inside the gun cavities. This project addresses this need by extending the advantages of ultrasonic consolidation to copper-based systems. Ultrasonic consolidation, a unique and proprietary adaptation of ultrasonic welding used previously for aluminum, allows for the production of parts with complex interior geometries that would be impossible to achieve otherwise. Phase I demonstrated the viability of ultrasonically consolidating laminate copper structures, which included embedded optical fibers, thermocouples, and internal cooling channels. Phase II will produce complex functioning prototype parts – a cathode plate for a high brightness gun with sensors embedded in the plate, and an x-ray photon mask with cooling channels and temperature sensors – that address the critical cooling requirements of high power, high brightness electron guns.

*Commercial Applications and other Benefits* as described by the awardee: A strong commercial market for instrumented complex copper structures would exist in high performance thermal management devices. Initial applications include high-brightness electron beam sources, high performance electronics, and active cooling of coal gasifiers.

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**Thermal (Solar) Photovoltaics Using Luminescence Upconversions—**MetroLaser, Inc., 2572 White Road, Irvine, CA 92614-6236; 949-553-0688
Dr. Bauke Heeg, Principal Investigator, bheeg@metrolaserinc.com
Dr. Cecil F. Hess, Business Official, cecilh@metrolaserinc.com
DOE Grant No. DE-FG02-05ER84329
Amount: $749,943

Next generation, high-efficiency photovoltaic systems are expected to play a significant role in addressing the global need for renewable energy sources. To be effective, these systems must maximize absorption across the solar spectrum, while minimizing fundamental heat losses. In order to achieve this goal, several new approaches are currently being explored, which predominantly focus on the use of multiple band-gaps. A more universal approach is provided by the conversion of heat into electricity, since this process is suitable to non-solar energy conversion as well. This project will use a luminescence upconversion process to efficiently convert heat into electricity. Phase I performed an experimental and theoretical analysis of the optical properties of several semiconductor materials under relevant operating conditions. The analysis showed that an efficiency in the range of 10-20% could be obtained at operating temperatures of several hundred degrees centigrade, indicating performances comparable or higher than other small-scale, direct heat-to-electricity conversion methods. Phase II will: (1) refine the system model to determine the optical bandgap energy, operating temperature, and bias voltage; design a multible emiter with enhanced extraction efficiency; design and construct a prototype system using a surrogate heat source; and determine the efficiency of the prototype system.

*Commercial Applications and other Benefits* as described by the awardee: The luminescence upconversion approach should provide an added value to existing and future photovoltaic systems, by converting the waste heat generated by those systems. In addition, the approach should provide a higher Carnot efficiency than other available thermal energy converters; as such, it could provide renewable energy in situations where other photovoltaic approaches cannot – e.g. in industrial plant heat exchangers, geothermal sources, and power plants.

**Water-Conserving Steam Ammonia Power Cycle—**Energy Concepts Company, 627 Ridgely Avenue, Annapolis, MD 21401-1062; 410-266-6521
Mr. Donald C. Erickson, Principal Investigator, enerconcep@aol.com
Mrs. Reta Ward, Business Official, enerconcep@aol.com
DOE Grant No. DE-FG02-05ER84201
Amount: $749,989

Fresh water is growing scarcer and costlier. Power production is the second largest user of fresh water, consuming about 25 gallons per kilowatt-hour in coal-fired plants. In particular, steam power plants, which use air-cooling to reduce water usage, suffer large economic and efficiency penalties, due to the deep vacuum at which steam condensers operate. This project will develop a new power cycle (Steam-Ammonia Power Cycle) that markedly reduces water usage without increasing fuel consumption or cost. The approach involves a hybrid cycle, in which the vacuum portion of a conventional steam cycle is replaced with a tandem ammonia Rankine cycle. The condensing pressure is thereby raised to 150 psig, which makes possible very compact and economical air-cooled condensers. High cycle efficiency is achieved by superheating the ammonia vapor. In Phase I, the new cycle was thermodynamically analyzed in three different important applications: state-of-art combined cycle plant (600 MW), mid-size gas turbine bottoming cycle (12 MW), and reciprocating engine bottoming cycle (2 MW). The results validated the high cycle efficiency at all size ranges for both the air-cooled and water-cooled variants of the cycle. In Phase II, the new cycle will be developed and field-demonstrated at the smallest scale. Waste heat from an 840 kW reciprocating engine will be used to generate 130 kW of additional power, with minimal water consumption. The cycle is expected to be at least 50% more efficient than any existing reciprocating engine bottoming cycle, due to the ability of the cycle to use the cylinder jacket heat as well as the exhaust heat.

*Commercial Applications and other Benefits* as described by the awardee: The improved power cycle should be applicable to virtually all types of existing thermoelectric power plants. Due to the temperature glide of the heat rejection, this new cycle requires 5% less cooling water than current cycles when it is water cooled, equating to a fresh water savings of 6.2 billion gallons per day nationwide. Power plants with this modification also would achieve a reduction in fuel consumption. The multi-turbine variant of this cycle would apply to steam-based power plants, including coal gasification combined cycle plants, while the single-turbine variant would apply to small-scale plants powered by waste heat.

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***STTR Project: Accelerated Biomethanation of Sequestered Carbon Dioxide and Paraffin in Coal Beds—**Altuda Energy Corporation, 401 Austin Highway, Suite 209, San Antonio, TX 78209-4670; 210-829-8080
Mr. Andrew R. Scott, Principal Investigator, Andrew@altuda.com
Mr. Andrew R. Scott, Business Official, Andrew@altuda.com
DOE Grant No. DE-FG02-05ER86236
Amount: $749,999

Research Institution
Virginia Polytechnic Institute and State University
Blacksburg, VA

The conversion of carbon dioxide, an undesirable greenhouse gas, into methane, an environmentally friendly energy source, would satisfy two important national objectives. This project will enhance and accelerate the *in situ* bioconversion of sequestered carbon dioxide into methane in the presence of hydrogen-rich coal macerals and paraffin. The abundance of hydrogen, coupled with sequestered carbon dioxide in the presence of the appropriate microbes, is expected to accelerate the *in situ* bioconversion process, while simultaneously removing pore-plugging paraffin, and increasing gas production rates and ultimate recovery. Phase I focused on developing cultures of paraffin-degrading anaerobic microorganisms. First, Inocula were isolated from paraffin samples gathered from production equipment and from water samples collected from coal beds that contained emulsified paraffin. The microbes were enriched to make them capable of degrading the paraffin samples in real time. An assessment of the degradation pathways was conducted, and a preliminary model for the accelerated *in situ* bioconversion of carbon dioxide into methane was developed. In Phase II, additional microbes and paraffin samples will be collected from coal seams. The microbes will be isolated and characterized, and an optimum mix culture will be developed. Continued laboratory experiments will be designed to evaluate factors affecting the biomethanation potential (from paraffin) and the economics of the process.

*Commercial Applications and other Benefits* as described by the awardee: Accelerating the *in situ* bioconversion of sequestered carbon dioxide would reduce the risk of global warming and provide a reliable source of environmentally clean energy, thereby reducing dependency on foreign energy supplies. Accelerated biomethanation should be applicable to coalbed methane, sandstone, and carbonate reservoirs, resulting in higher production rates that prolong the life of some gas fields and increase ultimate recovery.

***STTR Project: Fiber-Optic Sensor with Simultaneous Temperature, Pressure, and Chemical Sensing Capabilities—**MicroMaterials, Inc., 6604 Harney Road, Suite F, Tampa, FL 33610-9424; 813-627-0474
Mr. Jermaine L. Kennedy, Principal Investigator, micromaterials@yahoo.com
Mr. Rex A. Lee, Business Official, micromaterials@yahoo.com
DOE Grant No. DE-FG02-05ER86262
Amount: $750,000

Research Institution
University of South Florida
Tampa, FL

A key to improving energy efficiency in the chemical and petrochemical industries is the ability to monitor such *in situ* parameters as the temperature, pressure, and chemical composition of the process stream under harsh and extreme conditions. Instruments with the required capabilities and/or robustness currently either do not exist or are inadequate. This project will develop a fiber-optic sensor that combines temperature, pressure, and chemical sensing capabilities into a single strand of sapphire fiber, using a novel measurement strategy. The integration of the three measurement capabilities into a single probe minimizes both the cost and intrusiveness of the device. Phase I demonstrated the feasibility of the concept for measuring temperature, pressure and chemical composition. Crucial data were obtained that allowed the capabilities of each sensor to be projected. Additionally, quantitative models for the three sensors were developed. In Phase II, the temperature, pressure, and chemical sensors will be optimized individually. Then, an integrated probe incorporating all three sensors will be fabricated and tested. Finally, a 90-day life test of the integrated system, under conditions typically found in chemical reactors, will be conducted.

*Commercial Applications and other Benefits* as described by the awardee: The multifunctional fiber-optic sensor should be suitable for the on-line monitoring of process streams in the chemical and petrochemical industries. In certain situations, such as microwave and plasma processing, viable alternatives are nonexistent. Parts of the sensor package also should have commercial value in the aerospace industry, in the processing of electronic materials, and in environmental monitoring.

***STTR Project: Development of Low Cost Conducting Polymer for Electrostatic Precipitators—**Applied Sciences, Inc. (ASI), 141 West Xenia Avenue, P.O. Box 579, Cedarville, OH 45314-0579; 937-766-2020
Mr. David Burton, Principal Investigator, dburton@apsci.com
Mr. Max L. Lake, Business Official, mllake@apsci.com
DOE Grant No. DE-FG02-05ER86237
Amount: $749,747

Research Institution
Ohio University
Athens, OH

About half of the nation's 1,000 coal-burning power plants are more than 25 years old and need to be rebuilt. However, the cost of rebuilding an electrostatic precipitator, an important air pollution control system in these facilities, ranges between $2 million to $10 million. This project will demonstrate high-performance, electrically-conductive polymer materials that will lower the cost, increase the efficiency, and extend the service life of these expensive but important pollution control devices in our nation's coal-fired power plants. The approach uses carbon nanofibers and glass fibers to make an electrically conductive polymer material for electrostatic precipitator components. These high-efficiency materials are lightweight, have lower fabrication cost, have lower installation costs, and last longer. Phase I demonstrated that carbon nanofibers, glass fibers, and polymers could be combined to produce an electrically-conductive polymer composite. Material specimens were made and successfully tested for strength, conductivity, and heat deflection temperature in a laboratory-scale electrostatic precipitator. Phase II will focus on the use of a long-fiber thermoplastic manufacturing technique and a patented composite material to maximize efficiency and minimize the cost of the electrically-conductive polymer.

*Commercial Applications and other Benefits* as described by the awardee: Electrically conductive polymers can be used in a wide range of applications, such as electromagnetic interference (EMI) shielding in consumer electronics, static dissipation in polymer truck bed liners, and preparing automotive plastics for electrostatic spray-painting. The commercial value of just the latter application is conservatively estimated at $500 million over the next 15 years.

***STTR Project: Direct Drive Power Buoy—**Peregrine Power, LLC, 27350 SW 95th Avenue, Suite 3030, Wilsonville, OR 97070; 503-682-7001
Mr. Dallas Austin Marckx, Principal Investigator, dmarckx@peregrinepower.com
Mr. Dallas Austin Marckx, Business Official, dmarckx@peregrinepower.com
DOE Grant No. DE-FG02-05ER86257
Amount: $749,924

Research Institution
Oregon State University
Corvallis, OR

The extraction of electrical energy from ocean waves can make a major contribution to power generation with little impact on the environment. A key subsystem of this technology involves the conversion of the linear motion of waves into electricity. This project will develop direct drive power buoys for extracting wave energy, thereby compressing the time required to make wave energy competitive. Phase I investigated and evaluated a variety of promising alternative approaches through modeling, and through testing prototype hardware in the laboratory and in a wave tank. In Phase II, the approaches which survived the Phase I evaluation will be further evaluated through modeling and the testing of more advanced prototypes. The best approach will be selected, implemented in an even more advanced prototype, and then tested in a wave tank and finally in the ocean off the Oregon coast.

*Commercial Applications and other Benefits* as described by the awardee: The direct drive power buoy should dramatically improve wave energy systems, which would provide electrical energy with all of the benefits of a renewable source – no fuel, no effluent, no fuel-related cost instability, little environmental impact, and a reduction in dependence on foreign fuel sources. In addition to utility-scale electricity generation facilities, possible uses include certain military applications, such as the powering of unmanned water vehicles and coastal defense systems.

***STTR Project: Plasma Source for a Diagnostic Neutral Beam—**NOVA Photonics, Inc.,
One Oak Place, Princeton, NJ 08540-4701; 609-243-3463
Dr. Fred M. Levinton, Principal Investigator, flevinton@novaphotonics.com
Dr. Fred M. Levinton, Business Official, flevinton@novaphotonics.com
DOE Grant No. DE-FG02-05ER86256
Amount: $750,000

Research Institution
Lawrence Berkeley National Laboratory
Berkeley, CA

Large neutral beams for heating plasmas have played an important role in plasma diagnostics, advancing our understanding of plasma physics in the development of fusion energy. A compact diagnostic neutral beam source for small-to-medium-scale experiments is needed to provide the same advanced level of diagnostics and insight into the underlying physics. This project will design and test a modest size radio frequency (RF) plasma source for a diagnostic neutral beam. In Phase I, a proof-of-principle experiment was conducted to estimate the size and RF power requirements for the neutral beam source. A conceptual design of the source and accelerator column was made, based on the results from the initial tests and on simulations. Power supply and vacuum system specifications were identified. Based on the Phase I results, the RF source, accelerator, and vacuum system for the beam will be designed and fabricated during Phase II. After the RF source iscompleted and tested, it will be installed on an accelerator for an evaluation of the extracted beam.

*Commercial Applications and other Benefits* as described by the awardee: The technology should find a market among the many groups in the U.S. and other countries that use neutral beams for diagnostics. For commercial applications, an RF plasma source would have application to plasma processing.

***STTR Project: An Automated Sample Handling Workcell for the SNS Liquids Reflectometer—**Square One Systems Design, Inc., 3135 Mallard Road, P.O. Box 10520, Jackson, WY 83002; 307-739-0946
Mr. Robert J Viola, Principal Investigator, viola@sqr-1.com
Mr. Robert J Viola, Business Official, viola@sqr-1.com
DOE Grant No. DE-FG02-05ER86260
Amount: $749,698

Research Institution
Oak Ridge National Laboratory
Oak Ridge, TN

When completed, the Spallation Neutron Source (SNS) will provide unprecedented opportunities for performing groundbreaking neutron science. Two reflectometers are planned for the SNS, one optimized for the measurement of liquid surfaces and the other for the measurement of magnetic materials. The SNS's high neutron flux will allow these instruments to collect complete data sets in minutes rather than hours. However, this same high flux will preclude users from entering the experimental area while the beam is on. Thus, to take full advantage of the SNS's power, special remote handling technologies must be developed. This project will develop an automated sample-handling workcell, optimized for use with the liquid surface reflectometer. This novel robotic system will allow a sample to be introduced into the experimental area, check the sample's identity, mate it with a size-specific carrier, and transfer it into an environmentally controlled chamber. The system also will be capable of dispensing precisely metered volumes of water, deuterium, and other liquids. Phase I included mechanism design, creation of a system-level controls architecture, and identification of sensor technologies, culminating in a robotic prototype that successfully performed all of the basic tasks required of the automated sample handling system. In Phase II, advanced sample environment technologies will be developed, along with a multi-function liquids handling capability. A beta system will be tested within the liquids surface reflectometer.

*Commercial Applications and other Benefits* as described by the awardee: The Automated Sample Handling Workcell should significantly increase the efficiency of SNS reflectometer experiments. Variations of the work cell should find applications in other SNS experiments as well as at other high flux neutron sources. It is anticipated that the life sciences industry could be another large market: protein crystallography requires huge numbers of crystallization "cocktails" to be precisely dispensed and manipulated, and the work cell would will be well suited to these complex, high-volume operations. Finally, the system could be adapted for difficult handling tasks in radioactive or other harsh environments.

***STTR Project: Two Dimensional Chromatography of Atmospheric Aerosols: A New In-Situ Instrument—**Aerosol Dynamics, Inc., 935 Grayson Street, Berkeley, CA 94710-2401; 510-649-9360
Dr. Susanne V. Hering, Principal Investigator, Susanne@aerosol.us
Dr. Susanne V. Hering, Business Official, Susanne@aerosol.us
DOE Grant No. DE-FG02-05ER86235
Amount: $749,995

Research Institution
The Regents of the University of California
Berkeley, CA

Organic matter is a major constituent of airborne particles, comprising 20-50% of their mass. Identification of its components is critical for tracing sources, elucidating transformation and formation processes, assessing affects on human health, and assessing affects on global climate. Therefore, *in situ*, high-time-resolution comprehensive measurements of organic aerosol speciation are required. In previous work, a Thermal Desorption Aerosol Gas Chromatography (TAG) Mass Spectrometer (MS) was developed, which provides identification and quantification of organic constituents at the molecular level, with hourly *in situ* measurements. Although many compounds can be identified with TAG, a significant portion of the material eluting from the single dimension chromatography column is not separated. Therefore, this project will improve the chromatographic resolution of the TAG by using two-dimensional (2D) chromatography, thereby allowing a vastly increased number of individual organic species in ambient aerosols to be measured. Phase I successfully incorporated a 2D chromatography system onto the existing 1D-TAG system. A considerable improvement in the separation of organic compounds, in both complex standards and ambient aerosols, was demonstrated. The 2D-TAG was able to separate more than 6 times as many compounds as the 1D-TAG. In Phase II, a fast mass spectrometry capability will be added to the 2D-TAG, and the chromatography will be refined to enhance the separation of individual organic compounds. The complete 2D-TAG-MS system will be tested, along with traditional filter-based methods and a variety of complementary measurement system.

*Commercial Applications and other Benefits* as described by the awardee: Beyond the on-line chemical analysis of aerosols for atmospheric research, the technology should be applicable to drug manufacturing and to the detection of biological or chemical agents related to homeland defense.

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***STTR Project: Muon Capture, Phase Rotation, and Precooling in Pressurized RF Cavities—**Muons, Inc., 552 N. Batavia Avenue, Batavia, IL 60510-1274; 757-870-6943
Dr. Rolland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Rolland P. Johnson, Business Official, rol@muonsinc.com
DOE Grant No. DE-FG02-05ER86252
Amount: $750,000

Research Institution
Fermi National Accelerator Laboratory
Batavia, IL

Bright muon beams are required for muon colliders, neutrino factories, and intense muon sources. To create the beams, high energy protons hit a target to generate pions that decay into a diffuse cloud of muons. The muon cloud is then: (1) captured in strong magnetic fields, (2) bunched, (3) phase-energy rotated by strong radio frequency (RF) electric fields, and (4) pre-cooled by passing the beam through a low-Z energy absorber. Because these four processes are done sequentially, the process is inefficient, requires extra length and expense, and suffers large muon losses. Pressurized RF cavities will enable higher gradient magnetic fields than is possible with evacuated cavities, thus allowing more options for the initial stages of a muon cooling channel. This project will develop techniques for using pressurized RF cavities for the simultaneous capture, phase rotation, bunching, and precooling processes. In Phase I, an experimental study of the RF breakdown of metals in dense gas was conducted. An RF cavity, pressurized with dense hydrogen gas, was operated for the first time in a strong magnetic field, demonstrating the feasibility of pressurized cavities for muon cooling applications. Simulations were used to demonstrate the combined cooling and bunching provided by the pressurized cavities. In Phase II, experiments will be conducted to systematically study the breakdown properties of gases and metals in beams of ionizing radiation and in strong magnetic fields. Simulations will be used to design the capture, phase rotation, and precooling systems of muon beams in pressurized cavities. Techniques will be developed for the creation of bunch structures appropriate for coalescing at high energy for muon collider applications.

*Commercial Applications and other Benefits* as described by the awardee: The generation of intense muon beams with small emittances should benefit many branches of science, where such beams are needed for muon colliders, Higgs and neutrino factories, bright muon sources, and studies of muon-catalyzed fusion.

*79264B05-II*

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***STTR Project: Reverse Emittance Exchange for Muon Colliders—**Muons, Inc., 552 N. Batavia Avenue, Batavia, IL 60510-1274 ; 757-870-6943
Dr. Rolland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Rolland P. Johnson, Business Official, rol@munonsinc.com
DOE Grant No. DE-FG02-05ER86253
Amount: $750,000

Research Institution
Thomas Jefferson National Accelerator Facility
Newport News, VA

Muon collider luminosity depends on the number of muons in the storage ring and on the transverse size of the beams in collision. As currently envisioned, adequate luminosity cannot be provided without large muon intensities, due to insufficient ionization cooling of the beam. Unfortunately, the proton drivers needed to produce these large muon intensities are expensive, and the decay of the large number of muons in the storage ring present environmental radiation problem, making experiments difficult. To address these problems, six-dimensional cooling schemes are being developed that would allow smaller, high-frequency radio frequency (RF) cavities to be used for later cooling stages and for acceleration. However, the bunch length at collision energy becomes shorter than needed to match the interaction region beta function. This project will develop a new concept for shrinking transverse beam dimensions by lengthening each bunch (reverse emittance exchange) to achieve high luminosity in a muon collider with fewer muons. In Phase I, analytic expressions for the reverse-emittance exchange mechanism were derived, including a new resonant method of beam focusing. Correction schemes for the aberrations were explored, and a scheme was invented to coalesce smaller intensity bunches, after being cooled and accelerated, to high-energy intense bunches suitable for a muon collider. In Phase II, the two stages of reverse emittance exchange, along with the third coalescing stage, will be optimized. The optimization will involve determining the fraction of momentum space to be allocated to each stage, in order to maximize the peak and average luminosity.

*Commercial Applications and other Benefits* as described by the awardee: The technology should allow the requirements for muon production rates to be relaxed enough so that existing or near future facilities could be modified for use as a muon collider. If the case for a muon collider as the next energy frontier machine can be made compelling, it becomes a candidate to be added to the other options for the High Energy Physics community.

***STTR Project: An Advanced Power Converter System Using High Temperature, High Power Density SiC Devices—**Aegis Technology, 3300 Westminster Avenue, Santa Ana, CA 92703; 714-265-1238
Dr. Timothy Lin, Principal Investigator, aegiste1400@earthlink.net
Mr. Bob Liu, Business Official, aegiste1400@earthlink.net
DOE Grant No. DE-FG02-05ER86234
Amount: $750,000

Research Institution
University of Tennessee at Knoxville
Knoxville, TN

Electronic power conversion systems introduce major cost and reliability issues in most distributed energy resources and energy storage systems. This project will develop a power conversion system based on an emerging wide-bandgap, SiC-based semiconductor technology. This system will be capable of operating at high power densities, high temperatures, and high frequencies, and will provide advantages of high efficiency, small size, and light weight. In Phase I, the modeling of a SiC inverter design for energy storage applications showed a dramatic reduction in power loss and heat sink size, compared with a Si-based inverter. A SiC power module was demonstrated, characterized, and compared a commercial Si power module. The high temperature packaging and gate drive also were investigated. Phase II will demonstrate, model, and characterize an 1200 V, 120 A SiC inverter that integrates technologies in circuit design, packaging, gate drive, and passive components. The underlying technical issues that govern the fabrication and performance of this novel inverter will be addressed, and the technical/economical impacts of the SiC inverter will be analyzed.

*Commercial Applications and other Benefits* as described by the awardee: High efficiency and small size are rapidly becoming key issues for improving both military and commercial power systems. High-performance, lightweight, compact SiC-based inverters should find use in energy storage, hybrid-electric vehicles, electric drives for transportation, and distributed energy resources. A large military application would involve ship/vehicle inverters.

***STTR Project: Improved Performance of Lithium-ion Cells at Low Temperature—**
MER Corporation (Materials and Electrochemical Research), 7960 South Kolb Road, Tucson, AZ 85706-9237; 520-574-1980
Dr. Sohrab Hossain, Principal Investigator, shossain@mercorp.com
Dr. Raouf O Loutfy, Business Official, rloutfy@mercorp.com
DOE Grant No. DE-FG02-05ER86251
Amount: $750,000

Research Institution
Brookhaven National Laboratory
Upton, NY

The widespread uses of hybrid electric vehicles (HEVs) and electric vehicles (EVs), which use rechargeable batteries as the power source, could significantly reduce U.S. dependence on foreign oil. Lithium-ion batteries have great potential for such applications but need improvement in low temperature performance. Therefore, this project will develop technology to improve this low temperature performance by incorporating anion receptor additives in the battery electrolytes. These additives should be highly effective in dissociating ion-pairs and forming complexes with the electrolyte anions, thereby improving ionic conductivity and interfacial impedance. In Phase I, several different types of electrolytes were prepared and their ionic conductivity and electrode/electrolyte interfacial impedance were measured at different low temperatures. Prototype 200 mAh lithium-ion cells were developed with these electrolytes, and their performance was evaluated at both ambient temperatures and low temperatures. Phase II will: (1) prepare electrolytes with different combinations of salts, solvents, and anion-receptor additives, (2) optimize salts, solvents, and additive combinations, (3) characterize the developed electrolytes, (4) evaluate the electrolytes for lithium-ion battery applications, and (5) develop prototype lithium-ion cells and evaluate their performance.

*Commercial Applications and other Benefits* as described by the awardee: The technology should lead to the development of a highly effective, low-temperature-performance electrolyte for lithium-ion batteries.

***STTR Project: Utilize Cementitious High Carbon Fly Ash (CHCFA) to Stabilize Cold In-Place Recycled (CIR) Asphalt Pavement as Base Course—**Bloom Consultants, LLC, 10001 Innovation Drive, Suite 200, Milwaukee, WI 53226; 414-771-3390
Dr. Haifang Wen, Principal Investigator, hwen@bloomconsultants.com
Mr. Mathew P Tharaniyil, Business Official, mtharaniyil@bloomconsultants.com
DOE Grant No. DE-FG02-05ER86238
Amount: $749,567

Research Institution
Board of Regents of the University of Wisconsin
Madison, WI

Because of stringent environmental regulations, the power generation industry must take measures to reduce the emission of nitrogen oxides (NOx), sulfur oxides (Sox), and mercury (Hg). Low-NOx burners reduce emissions by changing the combustion characteristics of coal boilers, but they increase the amount of residual unburned carbon in the fly ash. Increased carbon levels in fly ash make air-entrained concrete production more difficult, because the activated carbon absorbs the desired air-entraining admixture in the concrete. As a result, most high-carbon-content fly ash has to be landfilled, resulting in significant land purchase costs and potential environmental issues. This project will develop technology for using this fly ash as a base course for asphalt pavements. Unlike concrete, which needs air voids, minimal air void content is preferred for the asphalt application. In Phase I, laboratory tests were conducted to evaluate the performance of recycled asphalt treated with cementitious high-carbon fly ash. The test results indicated that the high-carbon fly ash could be used as a quality base course material for asphalt pavement. In Phase II, three test cells, each 500 feet long, will be built and subjected to accelerated traffic loads to compare the performance of fly-ash-treated recycled asphalt to that of conventional crushed aggregate, and to untreated recycled asphalt pavement. An economic analysis will be conducted to evaluate the cost-effectiveness of the material.

*Commercial Applications and other Benefits* as described by the awardee: The technology offers the potential to use one hundred percent of the cementitous high carbon fly ash that otherwise would be landfilled, eliminating the costs of disposing and landfilling. Both the power industry and the highway industry should benefit from significant savings in cost and energy.

***STTR Project: Development of HydroImage: A User-Friendly Hydrogeophysical Characterization Software Package—**Geomatrix Consultants, Inc., 2101 Webster Street, 12th floor, Oakland, CA 94612-3027; 510-663-4100
Dr. Chin Man W. Mok, Principal Investigator, cmok@geomatrix.com
Mr. Marty Mullins, Business Official, mullins@geomatrix.com
DOE Grant No. DE-FG02-05ER86244
Amount: $750,000

Research Institution
Lawrence Berkeley National Laboratory
Berkeley, CA

79633 - At thousands of sites across the U.S., groundwater and soils are contaminated with hazardous chemicals, metals, and radioactive contaminants. At both private and government sites, including DOE, there is strong interest in reducing the costs of cleanup and long-term monitoring. Many advances have recently occurred in the field of hydrogeophysics, where geophysical data are used to estimate hydrogeological parameters and monitor processes that govern contaminant fate, transport, and remediation. However, broad application of these advances has not yet occurred, because of the lack of user-friendly tools. This project will develop a user-friendly software package, which integrates continuous geophysical data with limited borehole data to estimate hydrogeological parameters of interest in the subsurface. The software package can be used to significantly enhance site-conceptual models and improve the design and operation of remediation systems. Phase I developed the basic components for the software package: a graphical user interface, a radar and seismic tomography inversion tool, a geostatistical integration tool, a petrophysical model development tool, and a Bayesian integration tool. Phase II will augment, refine, and test the software package using hydrological and geophysical data collected at several sites. The refinements will include: (1) an expansion of all components described above; (2) an ability to input and utilize surface geophysical, cone penetrometer testing, and processed electrical resistivity data; (3) the development of workflow modules to guide users through the estimation procedure; (4) the development of a centralized database and enhanced visualization capabilities, and (5) the development of quality control and help modules.*Commercial Applications and other Benefits* as described by the awardee: It is anticipated that the software package would be licensed to companies interested in providing groundwater monitoring services to the environmental industry, site owner, and consultants. Benefits would include vastly improved conceptual models and more effective remediation of groundwater and soils, with the potential for saving millions of dollars. The current U.S. environmental remediation market is greater than $6.4 billion annually.

***STTR Project: Development of Spectral and Atomic Models for Diagnosing Energetic Particle Characteristics in Fast Ignition Experiments—**Prism Computational Sciences, Inc., 455 Science Drive, Suite 140, Madison, WI 53711-1067; 608-280-9179
Dr. Joseph J. MacFarlane, Principal Investigator, jjm@prism-cs.com
Dr. Joseph J. MacFarlane, Business Official, jjm@prism-cs.com
DOE Grant No. DE-FG02-05ER86258
Amount: $750,000

Research Institution
University of Nevada - Reno
Reno, NV

In the fast ignition concept for inertial fusion energy, high-intensity short-pulse lasers are used to create energetic particles (protons and relativistic electrons) that propagate to the fuel within a compressed capsule. The efficient transport of these energetic particles to the fuel is a key issue in fast ignition research. A combination of well-diagnosed experiments and well-tested simulation tools are needed in order to understand energetic particle transport through dense plasmas, a prerequisite for fast ignition to become a viable option for inertial fusion. This project will develop and apply spectral and atomic physics models, used in concert with a particle-in-cell (PIC) code, to simulate diagnostic signatures associated with energetic particle transport in short-pulse laser experiments. The developed models will be applied to fast-ignition-related short-pulse-laser experiments to characterize the properties of energetic electrons and protons. Phase I developed and benchmarked cross section models for energetic protons and relativistic electrons, and utilized them in a collisional-radiative code; developed an interface for post-processing simulation results; developed and initiated a plan to utilize more accurate ionization modeling in PIC code simulations; and performed proof-of-principal simulations relevant to short-pulse laser experiments. Phase II will: (1) develop diagnostics for characterizing energetic particle distributions based on polarization spectroscopy; (2) develop atomic physics modules for use within PIC codes; (3) implement high-fidelity, Stark-broadened line profiles in a multi-dimensional spectral analysis code, in order to provide accurate spectral diagnostics based on inner-shell transitions; and (4) benchmark the new models by comparison with well-diagnosed short-pulse laser experiments.

*Commercial Applications and other Benefits* as described by the awardee: Beyond the application to fast ignition concepts for inertial fusion energy, powerful, user-friendly computational tools, capable of simulating the spectroscopic and atomic properties of laser-produced plasmas, should be applicable to radiation sources for EUV and x-ray lithography, plasma radiation sources used in defense research, magnetic fusion energy plasma diagnostics, materials plasma processing, and radiation sources developed for medical physics research and instrumentation.

***STTR Project: Nanostructured Coatings by Pulsed Plasma Processing for Alloys Used in Coal-Fired Environments—**Karta Technologies, Inc., 5555 Northwest Parkway, San Antonio, TX 78249-3339; 210-582-3252
Dr. Rao Govindaraju, Principal Investigator, rao@karta.com
Ms. Susan Wright, Business Official, swright@karta.com
DOE Grant No. DE-FG02-05ER86249
Amount: $749,601

Research Institution
Southwest Research Institute
San Antonio, TX

The efficient and profitable operation of coal-fired power plants requires higher steam temperatures and pressures, necessitating the use of advanced alloys. A major concern in using these advanced materials is their poor corrosion and oxidation resistance in fossil energy environments. Therefore, protective coatings on the ferritic and austenitic steels used in these coal-fired environments are needed to assure the economic and safe operation of the power plants. This project will develop an innovative plasma coating technology to apply durable nanostructured coatings of iron and nickel aluminide on Fe- and Ni-based alloys. Phase I demonstrated the feasibility of depositing nanostructured coatings of $Ni_3Al$ and $Fe_3Al$ on substrates of 304L and P91 steels. Coated samples were characterized by chemical, physical, structural, and microscopical techniques. The performance of plasma-coated samples was compared with uncoated samples in a simulated furnace environment. Phase II will optimize the coating chemistry and demonstrate the scalability of the process to coat tubes upto 24" in length. The performance of coatings will be evaluated in simulated and real coal gasification environments.

*Commercial Applications and other Benefits* as described by the awardee: The coating technology should have a significant impact on the electrical utility industry by saving the materials costs involved in replacing corroded tubes, reducing downtime, increasing efficiency in power generation, and reducing the probability of a catastrophic failure. The technology is versatile and could be extended to materials or components used in other industrial applications. Because the technology is not a line-of sight process, it could be used to coat complex shaped components. Lastly, the process is highly energy efficient and could be automated.