U.S. Department of Energy

Small Business Innovation Research

And

Small Business Technology Transfer Programs

Phase II Grant Abstracts

FY 2005

75004B04-II

Hydrogen Recovery and Carbon Dioxide Separation In Steam Methane Reformers—Membrane Technology and Research, Inc. (MTR), 1360 Willow Road, Suite 103, Menlo Park, CA 94025-1516; 650-328-2228, http://www.mtrinc.com
Dr. Ingo Pinnau, Principal Investigator, ipin@mtrinc.com
Ms. Elizabeth Weiss, Business Official, egweiss@mtrinc.com
DOE Grant No. DE-FG02-04ER83999
Amount: $749,982

If hydrogen is to be used as an environmentally-friendly fuel, hydrogen production costs must be lowered and carbon dioxide, a by-product of hydrogen production, must be separated for sequestration. This project will develop a membrane process to recover hydrogen and separate carbon dioxide from steam-methane-reformer pressure-swing-absorption plants. The process should increase hydrogen production by 15% while simultaneously producing a liquid carbon dioxide stream for sequestration. The value of the recovered hydrogen will offset the cost of the process. In Phase I, two novel membranes were produced: one to separate carbon dioxide, the other to separate hydrogen. Composite membranes with a carbon dioxide/hydrogen selectivity of 10 were prepared and tested as bench-scale membrane modules. A process simulation model, based on the performance of these membranes combined with hydrogen-permeable membranes, was used to design an efficient pressure-swing-absorption tail-gas treatment process. In Phase II, the membranes that were prepared in Phase I will be scaled up to industrial scale and evaluated in a complete pilot-scale system, in order to demonstrate the technical and economic feasibility of the process.

Commercial Applications and Other Benefits as described by the awardee: The new carbon dioxide/hydrogen membranes will increase hydrogen production and sequester carbon dioxide in steam reformer plants. The cost of the process will be covered by the value of the hydrogen produced.

75016S04-II

Development of a High Gain, High Power Traveling Wave Relativistic Klystron--Haimson Research Corporation, 3350 Scott Boulevard, Building 60, Santa Clara, CA 95054-3104; 408-988-6007
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DOE Grant No. DE-FG02-04ER83973
Amount: $725,000

Relativistic klystrons, presently under development for linear collider applications, and existing high-power pulsed klystrons, used to energize research linear accelerators, typically have amplification factors (gain) between 45 and 55 dB. These klystrons generally require pulsed vacuum tube drivers to supply input power levels up to several hundred watts. However, for applications in which a 20 dB klystron gain would be sufficient, these relatively complex vacuum-tube driver systems could be replaced by small, low power, solid state sources, resulting in considerable simplification and cost savings. This project will develop technology leading to stable, high gain (>70 dB), high efficiency (>50 percent) klystron performance. During Phase I, phase orbit characteristics were analyzed and microwave parameters were established for an asynchronously operated, tapered phase velocity, traveling wave output structure designed for a 17 gigahertz relativistic klystron. To prevent parasitic oscillations, special suppression circuits were designed and configured for contiguous assembly with the high-gain-klystron, dual-feed-racetrack, output coupler. Phase II will be directed at engineering and fabricating the traveling wave tapered phase velocity, high gain dual feed output structure, parasitic oscillation suppression circuits, and the associated evacuated rectangular waveguide components. In addition, the new high-gain-klystron and waveguide components will be assembled; and the system will be tested to evaluate the stability, efficiency and gain of the high power 17 gigahertz klystron.

Commercial Applications and Other Benefits as described by the awardee: The availability of stable, high gain klystron amplifiers should enable existing complex driver systems and associated pulsed helix and filament power supplies to be replaced by low power, simple solid state amplifiers.

75026S04-II

Stable Membranes for Separating Hydrogen Containing Petrochemical and Refinery Streams—
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DOE Grant No. DE-FG02-04ER84000
Amount: $749,969

As the Nation moves toward a hydrogen economy, new sources of hydrogen will be required. Many low-pressure, hydrogen-containing refinery and petrochemical streams would appear to be good candidates for hydrogen separation by membranes. However, membranes have not been used for these applications because hydrocarbons in the gas stream plasticize the membranes, resulting in collapse and failure. This project will develop new perfluoro membrane structures that are completely inert to hydrocarbon liquids. The membranes will not fail after exposure to vapors or condensed liquids, and will be 10 to 20 times more permeable to hydrogen than current membranes. In Phase I, the new membrane materials were made into composite membranes. The membranes were tested in laboratory modules with gas mixtures that were known to cause the failure of current membranes. In addition, a membrane module test system was installed at a refinery. The results of these tests showed that the membranes are technically and economically viable. In Phase II, the membranes will be optimized and scaled up. A pilot system will be built and operated in the laboratory and at a refinery field site to demonstrate the membrane module's reliability in industrial use.

Commercial Applications and Other Benefits as described by the awardee: Membranes have not been widely used to separate hydrogen from refinery and petrochemical streams because of poor membrane reliability. The hydrogen-permeable, hydrocarbon-resistant membranes should allow for the economical separation of hydrogen from these streams.

75027S04-II

Bioethanol Production with Membranes—Membrane Technology and Research, Inc. (MTR), 1360 Willow Road, Suite 103, Menlo Park, CA 94025-1516; 650-328-2228, http://www.mtrinc.com
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DOE Grant No. DE-FG02-04ER84001
Amount: $749,952

The development of bio-based fuels can help reduce our nation's dependence on imported oil. This project will develop an integrated membrane pervaporation-dephlegmation-dehydration process to separate water from ethanol and produce 99.5% fuel-grade ethanol. In particular, high-flux, moderately-selective membranes will be developed for the dehydration step of the integrated process. The new membranes would lower capital and operating costs, increasing the competitiveness of biomass-to-ethanol process, compared to distillation and molecular sieve technologies. In Phase I, composite membranes were made, and their performance was evaluated in laboratory stamps and in bench-scale. Membrane permeances exceeded those for existing commercial pervaporation membranes by a factor of 4 to 5. An economic analysis of the total process showed that if the new membranes were formed into commercial-scale spiral-wound modules, the costs would be significantly less than current technology. In Phase II, a pilot unit, which uses a membrane-based pervaporation-dephlegmation-dehydration process, will be constructed, field tested, and evaluated. The field test will be used treat a slipstream at a corn-to-ethanol plant or a whey-lactose stream from cheese production.

Commercial Applications and Other Benefits as described by the awardee: The pervaporation-dephlegmation-dehydration process being developed should allow a large number of small (50 ton-per-day) fermentable waste biomass streams to be economically converted to ethanol. Such streams are produced in cheese, wine, beer and sugar production. Distillation is too expensive to use for ethanol recovery at this small a scale. Nationwide, more than 200 new process plants could be installed. The process also could replace molecular sieve dehydration in large corn-to-ethanol plants.

75057S04-II

Novel, Low-Cost Solid Membrane Water Electrolyzer—GINER, INC., 89 Rumford Avenue, Newton, MA 02466-1311; 781-529-0501, http://www.ginerinc.com
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DOE Grant No. DE-FG02-04ER83968
Amount: $749,998

Transforming the United States from a fossil-fuel base economy to a "hydrogen economy" will require cost-effective methods for manufacturing and delivering hydrogen. The electrochemical dissociation of water into elemental hydrogen and oxygen is a well known and widely practiced means of generating hydrogen. However, commercially available water electrolysis technologies are capital-cost intensive, leading to a high hydrogen costs. This project will develop a Solid Membrane Alkaline Electrolyzer system, based on a unique solid alkaline membrane, which is expected to provide high-current-density, high-differential-pressure electrolyzer operation. Phase I demonstrated the concept of the solid alkaline membrane electrolyzer. Cells were operated at high current density and differential pressure, producing hydrogen at greater than 85% voltage efficiency. A preliminary system design was generated. Phase II will identify corrosion resistant components, scale-up both the active area and the number of cells, and fabricate a full-size stack. A complete system design will be prepared, and an economic analysis will be conducted. The program will culminate in the operation of the full-size stack from a solar power source.

Commercial Applications and Other Benefits as described by the awardee: The hydrogen generation system should find use in hydrogen-fueled vehicles (both fuel cell and internal combustion-hydrogen), as part of a home-based hydrogen generator, in a bulk hydrogen generator for electric utility applications, and for on-board transportation power applications. Small hydrogen generators also could replace cylinders for the supply hydrogen gas for analytical instrumentation.

75077S04-II

Improved Fin Designs to Reduce Defective in Internal-Tin Nb_3Sn—SupergenicsI, LLC, 1233 Tree Bay Lane, Sarasota, FL 34242; 508-829-9041
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DOE Grant No. DE-FG02-04ER84085
Amount: $650,000

An economical process will be needed to produce super conducting material for the high field magnets that will be used in future accelerators for High Energy Physics (HEP) research. To achieve this economy, it will be necessary to reduce the hysteresis losses that occur in the new high-current-density conductors. One way of doing this is to reduce the size of the super conducting units into which these conductors are divided. This project will accomplish this goal by dividing the super conducting units (the subelements) with radial fins of non-superconductors. In Phase I, three different designs of small diameter billets with fins were assembled, extruded, and processed to wire. Reductions in the hysteresis losses were shown in most of the individual subelements and in several of the 18-subelement restacks. In Phase II, the most promising designs will be selected, the process will be scaled up to full sized billets, and material will be supplied to the National Laboratories for coil winding experiments.

Commercial Applications and Other Benefits as described by the awardee: In addition to its use in HEP accelerator applications, the material should be useful in magnets for 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). Fusion and levitated transportation projects represent other possible applications.

75080S04-II

Functionally Graded Aluminum Nitride - Oxide Coatings for Hot Pipe Protection—Eltron Research, Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263, http://www.eltronresearch.com
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DOE Grant No. DE-FG02-04ER83939
Amount: $749,996

Corrosion is a significant problem in pipelines exposed to corrosive and oxidizing conditions at high temperatures. Mild steel is the desired material for constructing these pipelines; however, mild steel corrodes very quickly compared to more expensive alloys. A new low-cost coating method is needed to deposit a corrosion resistant coating on the interior surface of mild steel pipes. This project will develop a low cost chemical vapor deposition method to deposit functionally graded aluminum-nitride/aluminum-oxide coatings onto the surface of mild steel. Aluminum nitride provides a strong chemical bond to the steel surface and aluminum oxide provides a high-temperature corrosion and oxidation-resistant surface. In Phase I, aluminum chloride molten salt and ammonia complexes were prepared. The aluminum chloride ammonia complex was then used to deposit aluminum nitride on the surface of mild steel using chemical vapor deposition techniques. By controlling deposition conditions, a functionally-graded aluminum- nitride/aluminum-oxide layer was shown to adhere well to mild steel substrates. In Phase II, deposition conditions will be optimized for controlling the density, composition, and thickness of functionally graded corrosion resistant coatings. Coated steel samples will be tested for corrosion/oxidation resistance and mechanical strength. Finally, the low-cost deposition process will be scaled-up to demonstrate commercial potential.

Commercial Applications and Other Benefits as described by the awardee: The new coating technology should be applicable to the prevention of corrosion in high temperature pipelines, which are utilized in such key industries as power plants, petrochemical plants, and paper mills. A related application would involve the prevention of steam-promoted, heavy-metal-cation migration in stainless steel steam pipes, found in coal gasification power plants.

75096S04-II

Fast Microcolumnar Scintillator for Radionuclide Imaging—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800, http://www.RMDInc.com
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Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-04ER84054
Amount: $749,999

Although CsI(T_l) has become the scintillator of choice for a wide variety of applications, it is not been widely used in radionuclide imaging or computed tomography (CT). The primary reason is the presence of an afterglow component in its scintillation decay, which reduces the energy resolution in emission tomography and results in image blur in CT. In addition, thick, pixelated scintillator structures, needed to overcome the traditional tradeoff between detection efficiency and spatial resolution, do not currently exist. This project addresses the first issue by co-doping the scintillator with ions capable of suppressing the afterglow. The issue of tradeoff between detection efficiency and spatial resolution will be addressed by developing thick, microcolumnar, films of co-doped CsI(T_l). In Phase I: (1) single crystals of co-doped CsI(T_l) material were grown and characterized; (2) a synthesis effort demonstrated the feasibility of depositing the material as a microcolumnar film by vapor deposition techniques; and (3) the resulting films were evaluated to confirm the appropriate scintillation properties. The codoped CsI(T_l) scintillator exhibited a reduction in afterglow of almost two orders of magnitude, compared to current commercial CsI(T_l). Phase II will (1) study the physics of afterglow to gain a better understanding of underlying mechanisms, (2) incorporate selected co-dopants into the CsI(T_l) lattice, (3) characterize the decay time, afterglow, light yield, and time-dependent spectral distribution of the crystals and the microcolumnar films under x-ray excitation, and (4) develop thick, fast films for x-ray and nuclear imaging.

Commercial Applications and Other Benefits as described by the awardee: Due to its low cost and excellent properties, the proposed scintillator should find widespread use in small animal/human SPECT/CT imaging systems in particular, and nuclear medicine systems in general. Additional applications include high-speed and ultrahigh-speed x-ray imaging, nondestructive testing, and homeland security.

75119T04-II

***STTR Project: Surface Films to Suppress Field Emission in High-Power Microwave Components**—
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DOE Grant No. DE-FG02-04ER86223
Amount: $650,000

Research Institution
University of California-San Diego
La Jolla, CA

The use of high microwave fields in next-generation high-energy room-temperature particle accelerators requires, among other things, that field emission and breakdown be held to within strict upper limits. One means to achieve this goal is to devise rugged thin-film coatings for vulnerable copper surfaces that have higher work function than copper alone. This project will evaluate a variety of candidate thin-film coating materials for inhibiting field emission in high-power microwave components and develop recipes for applying these coatings to copper test blanks. In Phase I, measurements of the work function for copper-platinum alloys were conducted. The results showed that, depending upon the percentage of each element, an increase in work function of up to 1.2 eV could be achieved, compared with pure copper. In addition, a coldtest version of a breakdown test cavity cell was built and successfully tested. Phase II will refine techniques for applying 50-100 micron thick coatings of graded platinum-cooper alloys to copper test samples, in order to achieve good adherence of the coatings to the substrate. Test samples will be subjected to repeated X-band RF pulses, with pulse widths up to one microsecond and surface field strengths up to 600MV/m, to measure the incidence rate of breakdown events. Comparisons to the case of pure copper will be made. *Commercial Applications and Other Benefits* as described by the awardee: RF breakdown is a major factor that limits the high-field operation of accelerator structures and microwave components. A process that can increase the reliability of these structures and components and to allow operation at higher fields could have wide-ranging commercial applications, representing a business opportunity of millions of dollars in annual sales. Applications to high-power radar systems are also possible.

75125S04-II

Use of Reactive Distillation in Chain Propogation Reactions—MC International Research, Inc., P.O. Box 1053, Kemah, TX 77565; 281-824-9819, http://www.mcirinc.com
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DOE Grant No. DE-FG02-04ER83998
Amount: $692,933

The use of reactive distillation for the Fischer-Tropsch process would have significant technical and economic benefits. Technically, the process would be far simpler than a conventional reactor followed by a hydrocracking unit. Economically, products produced by a Fischer-Tropsch reactive distillation column could be sent directly to a fuels blending unit, bypassing all intermediate refinery processes and significantly reducing processing costs. This project will demonstrate the use of Fischer-Tropsch reactive distillation to control the product molecular weight, and in turn, reduce the energy requirements of chain growth reactions. In Phase I, two reaction systems, isobutylene oligomerization and Fischer-Tropsch, were selected to determine the applicability of reactive distillation for chain growth reactions. Reactive distillation was found to be effective for both, but its use for the Fischer-Tropsch reaction was found to be of greater significance. Phase II will collect the engineering data necessary to scale-up and commercialize the concept. The effort will be divided into five steps: (1) system design, (2) construction and operation, (3) configuration testing, (4) economic evaluation, and (5) progress reporting.

Commercial Applications and Other Benefits as described by the awardee: The Fischer-Tropsch reactive distillation system should benefit refiners, oil and gas producers, engine manufacturers, and government agencies. Refiners would have ultra-clean, low sulphur fuels added to their blending stocks to aid in meeting new low sulphur fuel requirements. Oil and gas producers would be able to "monetize" wells that were previously considered to be too marginal to be profitable, either due to substandard gas or environmental requirements. Engine manufacturers would benefit from the compositional consistency of the fuel produced, and Federal and State agencies would benefit from the ability to develop oil and gas wells on government property.

75153S04-II

Electron Cloud Diagnostic for Quadrupole Magnets—TechSource, Inc., P.O. Box 31057, Santa Fe, NM 87594-1057; 505-988-1726, http://www.techsource-inc.com
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DOE Grant No. DE-FG02-04ER84105
Amount: $650,000

Electron cloud effects, including electron cloud induced instabilities, are a critical technical risk for the next generation of high intensity, accelerator-based research facilities. In particular, new diagnostics are required to observe electron cloud formation and trapping in quadrupole magnets, in order to test theories and simulations of cloud buildup and beam dynamics effects induced by electron clouds. To date, no diagnostics have been developed that can measure the electrons trapped in accelerator quadrupole magnets. This project will develop a diagnostic instrument that can measure electron cloud formation and trapping in quadrupole magnets used in high intensity rings or beam transport. In Phase I, extensive simulations of electron cloud formation and trapping in were made to determine the expected characteristics (including trapping) of the electron cloud in quadrupole magnets. The simulations revealed the unexpected result that numerous electrons were ejected from the quadrupole when the long bunch beam pulse was present. Based on these simulations, an optimized physics design for a diagnostic was developed. Phase II will involve the design, fabrication, and installation of a prototype diagnostic assembly. Tests of the prototype will evaluate the effectiveness of the diagnostic, and data on the electron cloud formation and trapping in quadrupoles will be collected.

Commercial Applications and Other Benefits as described by the awardee: The results of this project should benefit the high intensity proton and positron rings now being upgraded, under construction, or under active consideration at such facilities as the Spallation Neutron Source, the International Linear Collider, the Relativistic Heavy Ion Collider, Proton Drivers for Neutrino Factories, the Japanese Proton Accelerator Complex, and the Large Hadron Collider. The primary commercial application would involve the adaptation of the diagnostic to accelerator rings or beam transport.

75173B04-II

An Efficient and Practical Method for New Bright Scintillator Searching—Boston Applied Technologies, Inc., 6F Gill Street, Woburn, MA 01801-1721; 781-935-2800, http://bostonati.com
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DOE Grant No. DE-FG02-04ER83913
Amount: $749,823

Current scintillator materials do not fully satisfy the requirements for high and intermediate energy particle/photon detection, needed to support the monitoring and verification of the Nonproliferation of Nuclear Weapons Treaty and other international arms control agreements. Due to intrinsic deficiencies in scintillation properties or difficulties in materials fabrication, next generation scintillators must have brighter scintillation, higher resolution, faster response, larger detection area, and lower cost. This project will utilize a low cost, comprehensive searching/screening method to develop a bright scintillator/bulk material system with optimized doping concentration, low scattering induced loss, and improved optical and scintillation characteristics. In Phase I, nanopowders of various scintillator material systems were synthesized using sol-gel and co-precipitation processes. Combinatorial studies of perovskite, garnet, and other ceramic scintillator systems demonstrated satisfactory light emitting and transmitting characteristics. Phase II will optimize the excitation and emission characteristics of the scintillator in order to maximize the performance at the lowest possible cost.

Commercial Applications and Other Benefits as described by the awardee: A new generation of bright scintillation materials should greatly benefit DOE's high energy missions, such as high energy particle detection (heavy ions, electrons, and nuclei) and intermediate energy phonon imaging (UV-radiation, X- and Gamma-rays, and Beta-particles). The technology also should find use in homeland security, nondestructive testing, and medical radiography applications.

75185S04-II

High-Power Ferroelectric Switch for an X-Band RF Pulse Compressor—Omega-P, Inc., 199 Whitney Avenue, Suite 200, New Haven, CT 06511-3773; 203-458-1144, www.omega-p.com
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DOE Grant No. DE-FG02-04ER84030
Amount: $700,000

High energy electron linear accelerators use microwave pulse compression to produce the high peak power levels needed to obtain high acceleration gradients. Present passive pulse compressors produce a power gain of about 3:1, in return for a 4:1 compression in pulse width. Active pulse compressors are predicted to have a capability for much larger compression ratios, with high efficiencies as well. Therefore, this project aims to develop a fast, ferroelectric X-band switch for activating a pulse compressor with the ability to switch several times during the input pulse, thereby allowing efficiency values >90%. In Phase I, computational techniques were used to refine the design of the ferroelectric switch, in order to minimize losses and thereby increase device efficiency. Fabrication techniques for large (10-cm diameter) ferroelectric rings were demonstrated, and a plan was formulated for testing high-power versions of the switch in the Naval Research Laboratory (NRL) magnicon facility. In Phase II, fabrication, sintering, and finishing techniques will be used to produce a quantity of ferroelectric rings needed for the switches. An engineering design for manufacturing the switches will be developed, and at least two switches will be built. The switches will be tested at NRL up to an input power level of 50 MW.

Commercial Applications and Other Benefits as described by the awardee: Hundreds of active microwave switches could be used in a future multi-TeV linear collider, or other high-gradient room-temperature linear accelerator, representing a market of millions of dollars. Other commercial and military applications of rapid, efficient active switches using ferroelectrics at other frequencies and powers also exist, representing additional market potential.

75201S04-II

Optimization of Metal Alloys for High Pressure Hydrogen Separation Membranes—Eltron Research, Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263, http://www.eltronresearch.com
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DOE Grant No. DE-FG02-04ER83935
Amount: $749,997

One of the technological barriers to developing an efficient and low-cost hydrogen-separation membrane technology is hydrogen-induced embrittlement associated with the hydrogen-permeable metals at high hydrogen pressure and low temperature. This project will develop ruggedized and efficient alloy membranes that can resist fracture under a broad range of temperature and pressure conditions. New membrane materials will be developed by systematically alloying various elements in order to improve the membrane resistance to fracture. Substituents will be introduced into the membrane lattice to manipulate hydrogen solubility, scavenge interstitial impurities, and control alloy grain size. In Phase I, ten different binary and ternary Group VB-based alloys were prepared and fabricated into dense hydrogen transport membranes. The hydrogen permeation through such membranes was systematically studied at high hydrogen pressure differential (up to 12 bar) in a temperature range of 200-440°C. Important material characteristics that affected membrane performance were identified. Phase II will focus on identifying the optimum membrane composition (which is not only highly hydrogen-permeable but also maintains high mechanical integrity under a broad range of process conditions). A cost effective protocol for fabricating large planar alloy membranes will be developed, and a scaled-up membrane unit will be designed, constructed, and tested.

Commercial Applications and Other Benefits as described by the awardee: High-performance, low-cost hydrogen transport membranes should significantly contribute to the commercial implementation of IGCC and FutureGen power plants. Hydrogen separation membranes also should be key components for the low cost supply of hydrogen for Fischer-Tropsch liquid fuels synthesis, fuels hydrodesulfurization, and as a fuel feedstock for fuel cells.

75219S04-II

Lithium Ion-Channel Polymer Electrolyte for Lithium Metal Anode Rechargeable Batteries—TDA Research, Inc., 12345 West 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300, http://www.tda.com
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DOE Grant No. DE-FG02-04ER84093
Amount: $750,000

Electric vehicles of the future require improved rechargeable batteries with higher performance. Although it is widely accepted that lithium-ion batteries can achieve the performance metrics required for these applications, some technical limitations still must be overcome. Specifically, improvements in the electrolyte are needed so that lithium metal can be used as the anode. To achieve this goal, this project will develop a novel, solvent-free polymer that will be chemically stable to metallic lithium. Also, its lithium ion-channels will make it highly Li+ conductive. In Phase I, polymer electrolyte materials were produced that had room-temperature conductives as high as 1.6×10^{-3} S/cm (with conductives at 40ºC above 10^{-4} S/cm), were stable in contact with lithium metal during reversible cycling tests in Li/electrolyte/Li coin cells, and were mechanically stable over the electric vehicle battery's operating temperature range of -40 to 90ºC. In Phase II polyelectrolyte membranes will be produced, and the ionic conductivity and stability against lithium metal will be evaluated. A viable process for making the electrolyte material on the size scale needed for commercialization will be developed. Prototype lithium/electrolyte/$LiCoO_2$ rechargeable batteries will be produced, cycled, and evaluated for electric vehicle applications.

Commercial Applications and Other Benefits as described by the awardee: The improved rechargeable batteries should have application to electric and hybrid electric vehicles or fuel cell vehicles, as well as other products that use rechargeable lithium batteries, such as portable electronics and electrical appliances.

75225S04-II

High Resolution Seismometer Insensitive to Magnetic Fields for the Linear Collider Program (Currently ILC)—PMD Scientific, Inc., 625 N. Euclid Ave., Suite 404, St. Louis, MO 63108; 314-454-9977, http://www.eentec.com
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DOE Grant No. DE-FG02-04ER84046
Amount: $700,000

The elevated level of vibrations complicates the achievement of sub-nanometer stability for the final focusing lenses in supercolliders. This project will develop a radiation-hardened seismic (vibration) sensor, with sub-nanometer precision and fully immune to strong magnetic fields, for monitoring the stability of the final focusing lenses. In Phase I, two electrochemical prototype sensors were built and successfully tested at the Standford Linear Accelerator Center in strong magnetic fields. Phase II will modify the electrochemical prototypes, refine the major sensor components, design and implement a built-in magnetohydrodynamic (MHD) calibrator, and optimize the sensor configuration based on the parameters required for the International Linear Collider.

Commercial Applications and Other Benefits as described by the awardee: A high performance vibration sensor should have application to the beam focusing systems of super colliders and other accelerators. In addition, very compact, economical, rugged seismometers should find application in structural monitoring, general and special seismic applications, and nuclear test monitoring.

75232S04-II

A New Low-Power MEMS Sensor for Atmospheric CO2 Measurements—Seacoast Science, Inc., P.O. Box 130485, 2151 Las Palmas Drive, Suite C, Carlsbad, CA 92009; 858-449-2151, http://www.deacoastscience.com
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DOE Grant No. DE-FG02-04ER84068
Amount: $743,202

Low power, low cost carbon dioxide (CO_2) sensors are needed to monitor the global carbon cycle, in particular for the exchange of carbon from man-made and natural sources. The sensors must be small and lightweight in order to be compatible with flight in balloonsondes. This project will develop prototype sensor systems with MEMS (microelectromechanical systems) microcapacitor sensor arrays that can monitor atmospheric CO_2 concentrations with 1 ppm sensitivity. The measurement will be accomplished by filling the sensors with chemoselective sol-gels whose electric permittivity changes when exposed to CO_2. The sensor systems will be battery operated, portable, and remotely operated, and will be able to compensate for changes in humidity, temperature, and pressure. In Phase I, MEMS capacitor sensors were demonstrated to have the necessary sensitivity (1ppm) to CO_2 in a background of high humidity. Detection of CO_2 – from 0 to 500 ppm, in ambient temperatures ranging from +40 C to -10 C, and in humidity ranges from 0to 80% – was demonstrated. In Phase II, a manufacturable process will be developed for the sol-gel technology. Software algorithms will be developed to mitigate interference form other gases and from humidity effects. Prototype systems will be built and tested.

Commercial Applications and Other Benefits as described by the awardee: In addition to their application for atmospheric monitoring, these lightweight, low cost, low power CO_2 monitors should find applications in HVAC monitoring, industrial process control, and industrial health and safety.

75239S04-II

Elimination of Methane from Landfill Gas—Alchem Field Services, Inc., 5909 Northwest Expressway, Suite 530, Oklahoma City, OK 73132; 405-603-5288, http://www.alchemltd.com
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Mr. Daniel J. Jacobson, Business Official, jakejacobson@alchemltd.com
DOE Grant No. DE-FG02-04ER83897
Amount: $750,000

Municipal solid waste landfills are the single largest source of anthropogenic methane emissions in the United States, producing 7 million tons, or 34% of the nation's total methane pollution. According to the Intergovernmental Panel on Climate Control's third assessment report, methane has a global warming potential 21 times that of carbon dioxide and is a key contributor to global climate change. This project will develop technology for capturing methane emissions from landfills and converting nearly 100% of these emissions into a high quality synthetic diesel fuel, using a commercially viable gas-to-liquids (GTL) process. This proprietary GTL technology, now being used in oil and natural gas fields, will be adapted for use with municipal solid waste landfills. During Phase I, a GTL processing unit with a 25,000 scf/day capacity was built; a catalyst manufacturing process was designed; a proprietary catalyst was produced for the project; and a field test was performed at a rural stranded gas well. The test demonstratead that a synthetic diesel fuel could be made directly from wellgas methane. During Phase II, additional gas stream clean-up technology will be developed and incorporated to remove corosives and catalyst poisons, in order to make a relatively pure methane/carbon dioxide gas stream for the GTL unit. Finally, the system will be evaluated to determine if the technology can be commercially applied to landfill gas, and if so, at what range of processing volumes.

Commercial Applications and Other Benefits as described by the awardee: The technology should be applicable to the servicing of a considerable portion of the 2,000 active landfills in the US, as well as a significant number of the 4,000 closed sites. The initial target market will be landfills with much smaller gas streams than can sustain electrical generation, liquified natural gas, or other technologies. The landfills would benefit from a new revenue source (sales of the waste gas stream and use of a non-sulfur synthetic diesel). Methane emissions would be significantly reduced, and the resulting synthetic diesel would provide a high-centane, sulfur-free, fuel that would burn with lower NOx and particulate emissions, compared to conventional diesel fuels.

75245S04-II

"Metal Rubber" Nanostructured Materials—NanoSonic, Inc., P.O. Box 618, Christiansburg, VA 24068; 540-953-1785, http://nanosonic.com
Dr. Jennifer H. Lalli, Principal Investigator, jlalli@nanosonic.com
Mrs. Linda Duncan, Business Official, lmduncan@nanosonic.com
DOE Grant No. DE-FG02-04ER84019
Amount: $750,000

This project will develop a “metal rubber” product – a highly electrically-conductive, elastomeric, and transparent nanocomposite – that maintains electrical conductivity or provides EMI shielding while under mechanical, thermal, and environmental stress. The materieal can be used as lightning strike and EMI shielding protective coatings for commercial and advanced aircraft, and in state-of-the-art flexible microelectronics and sensors. During Phase I, several nanocomposites were modeled and prepared layer-by-layer by the self-assembly of metal nanoparticles and elastomeric polymers. The relationship between sheet resistance, transmission, and mechanical properties were investigated. A bulk resistivity of 10-5 Ω·cm was demonstrated (recall that the resistivity of bulk gold is 10-6 Ω·cm), which is important because a smaller amount of metal would be needed for manufacturing, thereby reducing costs. The tradeoff in material properties was controlled through chemical processing based on (1) the choice and volume fraction of metal nanoparticles and (2) the choice and crosslink density of the organic polymer component. In Phase II, the properties of the material will be optimized for commerical applications, especially as high performance coatings for aircraft and microelectronics packaging.

Commercial Applications and Other Benefits as described by the awardee: The new “metal-rubber” material should find application as: (1) advanced window coating materials for next-generation commercial airplanes, (2) similar coatings for military aircraft transparencies, and (3) flexible conducting electrodes and mechanical sensors in the electronics market. In addition, the technology should expand the use of nanotechnology as a practical manufacturing technique.

75253S04-II

Investigation of (CaO)x(Al2O3)x for Thermal Insulation and Molten Aluminum Contact—Westmoreland Advanced Materials, Building 210C, Schreiber Industrial Park, Arnold, PA 15068-4531; 724-339-2041, http://www.westadmat.biz
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DOE Grant No. DE-FG02-04ER84118
Amount: $748,899

The beneficiation of bauxite ore, used to produce aluminum and the subsequent refining of the aluminum to specific alloys and/or shapes, is an energy intensive process. Large amounts of heat energy (generated via electrical discharge in the primary process and from the burning of fossil fuel in the secondary process) are lost as a result of the insufficient thermal insulating properties of current refractory linings. As a consequence, the increased BTU value per unit of aluminum is accompanied by a greater use of energy generating resources, increased emissions, and an elevated cost of the final metal product. This project will develop an insulating refractory lining, suitable for use in hot processes for aluminum manufacture. The lining will allow for limited metal and flux penetration, while offering an estimated 10 to 35 percent reduction in heat loss compared to conventional refractory linings. Phase I investigated compounds and mixtures of compounds of the general formula $(CaO)_x(Al_2O_3)_x$, in combination with aluminum penetration inhibitors, as candidate aggregates for forming a refractory monolith. Energy savings greater than 35% was demonstrated theoretically. Phase II will optimize the physical traits of successful compounds and provide sufficient material for experimental trials in customer process vessels via the creation of a pilot production facility. Data collected from the pilot production facility will be used to design, engineer, and build a full scale production facility.

Commercial Applications and Other Benefits as described by the awardee: The material should find use in the aluminum industry in the working lining of holders, hearths, upper and lower sidewalls, belly band areas, roofs, chip melters, troughing, transfer ladles, and over-the-road crucibles. In addition, the material should find use in float glass lines (molten tin contact), other non-ferrous metal applications, and the rotary kilns used to produce cement and lime (another area of intense energy use).

75258S04-II

Improved Magnetron Injection Guns for Gyrotrons—Calabazas Creek Research, Inc., 20937 Comer Drive, Saratoga, CA 95070-3753; 650-595-2168, http://www.CalCreek.com
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DOE Grant No. DE-FG02-04ER83918
Amount: $652,500

Gyrotrons and gyroklystrons, used for high power RF applications in the DOE Fusion Program, are being adversely impacted by poorly performing cathodes for which the current emission is not uniform over the entire surface. Poorly performing cathodes adversely impact all RF vacuum electron devices, including those used for accelerators, radar, communications, medical applications, and industrial heating. This project will determe the specific causes of poor cathode performance and developing cost effective solutions. In particular, controlled porosity cathodes will be developed to address problems with uniform work function of the emitter surface. Improved mechanical and thermal designs will provide uniform emitter temperatures and lower the cost of cathode assemblies. Phase I identified specific causes of temperature variation in magnetron injection guns and established a preliminary thermal model to analyze the problems and develop practical solutions. A concept for manufacturing controlled-porosity cathodes was developed and experimentally verified. Phase II will complete the development of controlled-porosity cathodes by defining specific processes for determining pore size and density. The results will be correlated with the barium diffusion rate to allow an optimal design, based on current density and lifetime requirements. Techniques for improved thermal performance will be developed and experimentally tested. The mechanical design of cathode heater assemblies will be improved to simplify the construction process.

Commercial Applications and Other Benefits as described by the applicant: The results of this project should reduce the cost and risk in the manufacture of cathodes for all vacuum electron devices. The concepts will be applied to magnetron injection guns for gyrotrons, which represents the greatest challenge. Successful completion should reduce the risk and improve the performance of gyrotrons for fusion, accelerators, defense, and industrial applications, with subsequent reductions in cost.

75272B04-II

Precision Holder Technology for In-Situ TEM Experimentation—E A Fischione Instruments, Inc., 9003 Corporate Circle, Export, PA 15632-8971; 724-325-5444, http://www.fischione.com
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Mr. David W. Casuccio, Business Official, dw_casuccio@fishione.com
DOE Grant No. DE-FG02-04ER83932
Amount: $749,980

Transmission Electron Microscopy is a technique that allows materials to be analyzed to the nanometer and sub-nanometer scales. The next level of materials analysis will require the ability to perform dynamic experimentation within the microscope, which would require specialized specimen holding technology to perform the desired experiments. This project addresses the treatment of a specimen with reactive gases at known pressures, gas flows, and temperatures (up to 2,000°K). In Phase I, a series of technical approaches to support the desired experiments were generated and evaluated by means of solid modeling, finite element analysis. In Phase II, prototype equipment will be constructed to verify the results of the analysis. Significant experimentation will be performed *in situ*. The experiments will include specimen heating, mechanical stability, and gas treatment.

Commercial Applications and Other Benefits as described by the awardee: The development of *in situ* specimen holder technology should greatly enhance the quantity and quality of information generated by Transmission Electron Microscopy. Substantial benefits would be provided to both life and physical science research by allowing structures to be characterized while undergoing various changes.

75295T04-II

***STTR Project: Chromium RenderServer: Remote Rendering and Visualization Servers Using Distributed Memory Parallel Clusters**—Tungsten Graphics, 416 Good Hill Road, Woodbury, CT 06798; 970-780-4272, www.tungstengraphics.com
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Mr. Jens Owen, Business Official, jens@tungstengraphics.com
DOE Grant No. DE-FG02-04ER86198
Amount: $750,000

Research Institution
Lawrence Livermore National Laboratory
Livermore, CA

While computational capacity at DOE's flagship computer centers continues to increase, there is a corresponding increase in need for interactive data analysis. Although researchers are capable of generating unprecedented amounts of data, they also need access to facilities and software that allow them to gain insight into the scientific phenomena hidden in their simulation or experimental data. However, most such researchers only have network-based access to the centrally located computer centers, yet the amount of data to be analyzed is so large as to preclude transfer over the network to a local computer system. This project will define and implement a platform-neutral software infrastructure that provides the ability to perform remote scientific visualization on high performance, interactive, parallel platforms, and transmit the resulting imagery to a remote user or to a remote team of geographically distributed users. Phase I developed a prototype architecture that allows a remote user to view results generated by a remotely-located graphics or visualization application running on a shared- or distributed-memory computer system. Phase II will develop a robust, full-featured Chromium Renderserver that delivers high-resolution visualization imagery to one or more remote users from distributed- or shared-memory parallel computer systems. *Commercial Applications And Other Benefits* as described by the awardee: The remote delivery of visualization results from scalable rendering platforms would meet a critical need that spans all computational science projects that generate data at centrally located facilities, but need to perform visual data analysis from remote locations. Commercialization opportunitis include the provision of long term consulting, development, porting and maintenance agreements.

75308S04-II

Sensitive SQUID-Based Detectors of the Magnetization of Polarized Nuclei—STAR Cryoelectronics, 25 Bisbee Court, Suite A, Santa Fe, NM 87508; 505-424-6454, http://www.starcryo.com
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DOE Grant No. DE-FG02-04ER84079
Amount: $250,264

Fundamental research in nuclear physics, such as the search for the neutron electric dipole moment (EDM), requires advances in detector systems and instrumentation. In particular, advanced detector systems are needed to enable precision measurements of the magnetization of polarized nuclei in noisy environments. This project will develop a novel magnetic detector system, based on ultra-sensitive superconducting quantum interference device (SQUID) sensors, that is sensitive to magnetic field gradients and discriminates against uniform magnetic fields and ambient noise sources. During Phase I, three prototype detector designs were developed, fabricated, and tested. The third design met the key technical goals and was shown to be operable in a typical laboratory environment with very low-noise performance. In addition, the design of suitable packaging for the detectors was completed and the first package assemblies were built. In Phase II, STAR further design improvements will enhance detector performance by a factor of two, and an existing detector fabrication process will be transitioned from 100-mm wafers to 150-mm wafers, significantly reducing detector costs.

Commercial Applications and Other Benefits as described by the awardee: The advanced superconducting quantum interference device magnetic detectors, with high ambient noise rejection and low cost, will be attractive for commercial biomedical imaging applications such as magnetocardiography. The integrated thin-film detector design should provide a more cost effective solution with greater manufacturability, compared to conventional designs that require a substantial amount of hand assembly and adjustment.

75320B04-II

Neutron Detector System Using Cross Fiber Scintillator Readout—PartTec, Ltd, P.O. Box 7317, 320 W. 8th Street, Suite 217, Bloomington, IN 47407-7317; 812-856-6756, http://www.parttec.com
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Mr. Herschel Workman, Business Official, heworkma@indiana.edu
DOE Grant No. DE-FG02-04ER84038
Amount: $749,931

New types of neutron detector technologies are required for the next generation of neutron sources in the United States, embodied at two extremes in size by the SNS national laboratory and the regional university-based LENS facility. For many neutron scattering instruments, detector specifications call for high rate capability, large area coverage, high spatial resolution, and low gamma sensitivity. Currently, no detector satisfies this demanding set of requirements. To meet this set of requirements, this project will develop a detector consisting of a scintillator with two perpendicular arrays of wavelength-shifting optical fibers. In this configuration, neutrons are incident on the front face of the scintillator, and scintillation light is collected in two perpendicular arrays of wavelength-shifting (WLS) fibers optically coupled to the scintillator. The fibers conduct the scintillation light to multi-anode photomultiplier tubes (MAPMTs), which produces analog pulse information that is decoded by electronics to determine the coordinates of the neutron capture event. Phase I studied the light balance of the scintillator/fiber arrangement and implemented prototype data acquisition electronics and software appropriate for a crossed-fiber readout system. A prototype scintillator/WLS-fiber detector was built, which demonstrated the feasibility of these technologies. Phase II will design, optimize, and construct a full-scale prototype of a neutron imaging detector with improved position resolution, efficiency, and maximum counting rate capability. A state-of-art electronics readout system will be developed, and the detector will be thoroughly tested in a thermal neutron beam.

Commercial Applications and Other Benefits as described by the awardee: Improved neutron detection devices should expand the scope of scientific research and development possible at neutron science instruments at both National and University facilities. Extensions of the technology may find use as large area neutron detectors for homelend security applications.

75323B04-II

Increasing Ethylene/Propylene Plant Product Yield via Three Phase Metathesis—MPM Technology, LLC, 2525 Battleground Road, Deer Park, TX 77536-1914; 281-930-2519, http://www.mtmetathesis.com
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Mr. Chris Lobue, Business Official, clobue@texasmolecular.com
DOE Grant No. DE-FG02-04ER84010
Amount: $746,400

Ethylene is the largest volume petrochemical in the world – some 40 large scale plants operate in the United States alone. Ethylene production is energy-intensive and non-selective, with a number of heavier, lower value products being made. As the price of energy in North America increases, the U.S. ethylene industry becomes less competitive compared to foreign producers. This project will develop multiple-phase metathesis technology, a reactive distillation application that will increase the yield of ethylene and propylene from ethylene plants. The process works by converting a large portion of the heavier, low value by-products to ethylene, propylene, and downstream derivatives of ethylene in a single step, thereby reducing both raw material and energy consumption per unit of product made. Phase I investigated catalyst life and defined design parameters. The catalyst life cycle was determined in a 30-day test run. The design parameters included the maximum throughput rate and the optimal feed location, both of which were identified during another 30-day test. A reactive-distillation simulation was developed and confirmed by comparison with pilot plant results. In Phase II, a semi-commercial pilot plant will be built and operated to confirm the design parameters. Pail, drum, and truck-load quantities of ethylene samples will be made, and the feasibility of making high value, heavier specialty products will be investigated.

Commercial Applications and Other Benefits as described by the awardee: Nearly every ethylene plant in the United States should be able to utilize the multiple-phase metathesis process to reduce raw material consumption, reduce energy consumption, increase capacity, and enhance profitability. In addition, the technology could be used to make higher olefins, which are currently made via separate step from ethylene or propylene. The derivatives could be used to make surfactants for laundry and industrial detergents, plasticizers for the processing of plastics, and lubricants or lubricant additives for the motor oil and drilling industries.

75333S04-II

Quantitative In-Situ TEM Nanoindentation Instrument—Hysitron Incorporated, 10025 Valley View Road, Minneapolis, MN 55344; 952-835-6366, http://www.hysitron.com
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DOE Grant No. DE-FG02-04ER83979
Amount: $750,000

Nanoindentation is the primary technique for assessing the nanomechanical behavior of small volumes of materials. With this technique, the force required to produce a given displacement into a sample by a sharp diamond tip is measured, and the hardness of the material being tested is determined analyzing the force-displacement curve. However, the microstructural origins of the measured mechanical response often are not readily understood. This project will develop a quantitative nanoidentation instrument capable of operating inside a transmission electron microscope. This capability would enable the real-time correlation between the evolving force-displacement curve and images of the evolving microstructure. Insights gained from such experiments would substantially improve the ability to engineer the mechanical behavior of materials. In Phase I, the following three components were developed and assembled into a working quantitative nanoindetation system: a miniature transducer capable of electrostatic actuation and capacitive displacement sensing, an *in situ* transmission-electron-microscopy holder equipped with a three-axis piezoelectric positioner and a three-axis course positioner, and a force-feedback controller. Tests in a transmission electron microscope showed the feasibility of the concept. Phase II will: (1) develop a prototype, ready-to-commercialize, quantitative nanoindentation instrument that is compatible with the transmission electron microscope; and (2) conduct applications research having industrial relevance using the quantitative nanoindentation system.

Commercial Applications and Other Benefits as described by the awardee: The ability to apply quantitative nanoindentation in transmission electron microscopes should provide a crucial understanding of structure-mechanical property correlations at nanoscale, leading to improvements in surface engineering and thin-film technology, and facilitating the design of useful shape-memory alloys and other smart materials.

75336S04-II

Advanced Fluoropolymer Vessels for Ultra-Clean Ionization and Scintillation Detectors—Applied Plastics Technology, Inc., 45 Broad Common Road, P.O. Box 45, Bristol, RI 02809; 401-253-0200, http://www.ptfeparts.com
Mr. David L. Woisard, Principal Investigator, david.woisard@ptfeparts.com
Mr. Andrew K. MacIntyre, Business Official, andy.machintyre@ptfeparts.com
DOE Grant No. DE-FG02-04ER83903
Amount: $650,000

A broad category of experiments in astro-particle and high energy physics requires the construction of ultra-high-purity and ultra-low-radioactive-background, cubic-meter-scale vessels to be used as containers for ionization and scintillation media. Double-beta decay experiments, solar neutrino experiments, and dark matter searches would all benefit from this technology. Plastics are among the materials with lowest radioactive contaminations, but they are usually not considered suitable because of their modest range of operating temperatures and their outgassing properties. This project will develop vessels made from high purity fluoropolymers, addressing the common problems of thermal expansion and stability at extreme temperatures, and vacuum/pressure sealing and plumbing, while maintaining ultra-low radioactivity properties. In particular, modified polytetrafluoroethylene (PTFE) sintering and sealing process methods will be developed, leading to the production a 67 liter chamber for the Enriched Xenon Observatory (EXO). In Phase I, PTFE welding techniques were developed both for sealing the chamber and for attaching plumbing and adapter fittings; a technique was developed that successfully fused the chamber material while maintaining an interior temperature low enough to avoid damaging the drift cell components installed inside; and the chamber was installed at the EXO laboratory at Stanford University. Phase II will fabricate a larger prototype chamber for the EXO Project, and also develop PTFE welding techniques for thicker container wall sections.

Commercial Applications and Other Benefits as described by the awardee: The processing methods developed to fabricate the modified PTFE chamber should have application to semiconductor processing and chemical handling components, bio-reactors and other high purity bio-pharmaceutical labware, and medical devices. The ultra-low radioactive background properties may have use national security applications. The molding, sintering, and welding techniques should have uses in high purity applications that now utilize conventional compression molding processes.

75338S04-II

Open Architecture Software Integration System for Particle Beam Optics—G. H. Gillespie Associates, Inc., P.O. Box 2961, Del Mar, CA 92014-5961; 858-677-0076, http://www.ghga.com
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Dr. G. H. Gillespie, Business Official, ghga@ghga.com
DOE Grant No. DE-FG02-04ER83961
Amount: $700,000

Because particle optics is at the heart of accelerator operation, particle optics computer programs play a critical role throughout the life cycle of every accelerator. Although new and innovative optics programs have been developed for a spectrum of existing and proposed accelerators, the ability to effectively use many of these programs is often limited to specialists. Non-specialists need improved software tools in order to apply these advanced optics computer programs to a growing range of accelerator applications. This project addresses the challenge by creating an Open Architecture Software Integration System that will allow both specialists and non-specialists to create easy-to-use graphic interfaces for any optics program. The system will provide an intuitive human-computer interface that can be customized to each user's requirements and provide full integration with other advanced software tools. In Phase I, a demonstration software package was developed, and a software user manual was written for the package. The package was then applied to selected optics programs to demonstrate feasibility. In Phase II, the Open Architecture Software Integration System will be further developed to support a wide variety of accelerator and particle beam optics design and simulation programs. The software tool will then be applied to four diverse particle optics codes to create innovative graphic user interfaces, which will be integrated with other advanced tools to enhance the utility of those codes.

Commercial Applications and Other Benefits as described by the awardee: The new software tool should find use in many new and emerging applications of particle accelerators. In addition, it should provide a valuable commercial tool for optimizing the performance of medical accelerators and improving manufacturing processes that use accelerators.

75351S04-II

Novel Silica Aerogel Panels as Radiators for Cherenkov Detectors—Aspen Aerogels, Inc., 30 Forbes Road, Northborough, MA 01532; 508-691-1150, http://www.aerogel.com
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Mr. Patrick J. Piper, Business Official, contracts@aerogel.com
DOE Grant No. DE-FG02-04ER83904
Amount: $700,000

Aerogels, with their low refractive index and reasonably high light transmission, would be highly desirable Cherenkov detectors in high-energy particle detection. Unfortunately, when aerogels are used as Cherenkov radiators, there are some disadvantages: medium to low light transmission in the UV-visible region, low moisture resistance, difficulty in fabricating large size panels, and extreme fragility. This project will establish the chemistry of transparent aerogels and develop process parameters for producing thick aerogel panels. This would eliminate the need for stacking tiles within the array of Cherenkov detectors, significantly decreasing the number of tiles and interfaces and thereby improving the accuracy of particle separation and detection. Phase I identified the sol-gel parameters that control the transparency and monolithicity of thick aerogel panels. The thick aerogel monoliths produced by the new drying process exhibited high light transmittance at 400nm, durable hydrophobicity, and a high degree of flexibility and resiliency. Phase II will involve the further development and optimization of 6” x 6” x 2” aerogels and the fabrication of panels. Monolith panels of that size will be tested as radiators in Cherenkov detectors.

Commercial Applications And Other Benefits as described by the awardee: The aerogels should be very useful not only for Cherenkov detection but also for applications that would significantly save energy and protect the environment: extra-high-R-value window glazing, insulated translucent building panels, and skylights.

75353B04-II

***STTR Project: Low-Cost Vibration Power Harvesting for Industrial Wireless Sensor**—KCF Technologies, Inc., 119 S. Burrowes Street, State College, PA 16801; 814-867-4097, www.kcftech.com
Dr. Jeremy E. Frank, Principal Investigator, jfrank@kcftech.com
Dr. Jeremy E. Frank, Business Official, jfrank@kcftech.com
DOE Grant No. DE-FG02-04ER86189
Amount: $743,627

Research Institution
Pennsylvania State University
University Park, PA

Wireless sensing is an emerging technology with a wide range of potential uses in industrial power generation and transmission systems, chemical processing plants, production assembly lines, and monitoring the environments of buildings and transportation systems. However, today's sensor nodes require frequent battery maintenance (3 to 18 months), which contributes to a total lifecycle cost that is at least three times higher than the installed sensor cost. To enable the expected revolution in wireless sensing, self-charging power supplies for the wireless sensor nodes will be needed. This project will develop piezoelectric, vibration-power-harvesting devices with optimal harvesting circuitry. The piezoelectric device converts mechanical vibration energy to electrical energy, and the circuit harvests and stores the electrical energy. Phase I developed, prototyped, and tested piezoelectric vibration-power-harvesting devices. Vibration power harvesting up to 124 mW was achieved for moderate vibration levels, and sufficient power was harvested even from extremely low vibration levels. Phase II will refine the prototype designs and prepare for high-volume production. Batch quantities of the prototypes will be produced, and demonstrations will be performed in industrial settings. Phase II will culminate in a family of low-cost ($0.50 to $50) power harvesting devices, which can be integrated with existing wireless sensor networks. *Commercial Applications and Other Benefits* as described by the awardee: Low cost, self-powered wireless sensors that never require battery replacement should greatly expand measurement capabilities for U.S. industries, leading to improvements in industrial efficiency, safety, and reduced lifecycle costs.

75376B04-II

Engineered Surfaces for the Lithium Tokamak Experiment—Plasma Processes, Inc., 4914 Moores Mill Road, Huntsville, AL 35811-1558; 256-851-7653, http://www.plasmapros.com
Mr. Scott O'Dell, Principal Investigator, scottodell@plasmapros.com
Mr. Timothy N. McKechnie, Business Official, timmck@plasmapros.com
DOE Grant No. DE-FG02-04ER84045
Amount: $650,000

Reactor studies have identified liquid lithium walls as a promising solution to magnetic fusion energy first wall problems. For near-term applications, such as the Lithium Tokamak eXperiment (LTX), a thin-film approach has been pursued; however, thin lithium films can become saturated with hydrogen and form LiH, which is not attractive as a plasma facing component. A "thick" lithium film approach would enable hundreds of discharges without the formation of LiH. This project will develop engineered surfaces to enable the evaluation of a thick lithium film approach for plasma facing components. Phase I demonstrated the feasibility of plasma-spray-formed engineered surfaces for use with liquid lithium plasma facing components. Testing was performed to demonstrate the excellent wetting characteristics of the plasma-spray-formed porous deposits with liquid lithium – plasma-sprayed porous Mo surfaces were wet at temperatures less than 300ºC. During Phase II, the engineered surface fabrication techniques will be optimized for full scale testing of a thick lithium plasma facing concept within LTX. Comparisons to thin films of liquid lithium adhered to a nonporous stainless steel surface by surface tension will be made.

Commercial Applications and Other Benefits as described by the awardee: The thick film technology should have commercial application to heat pipes; thermal and electrical insulating coatings for the electronics industries; improved chemical compatibility for molten metal processing; and improved thermal protection systems for furnaces, turbines, incinerators, plasma torches, rocket engines, fuel injectors, hard coatings, plasma treating of materials, and thick film heaters.

75396B04-II

Reactive Distillation for Vinyl Ether Synthesis—KSE, Inc., P.O. Box 368, Amherst, MA 01004-0368; 413-549-5506, http://kse-online.com
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Dr. James R. Kittrell, Business Official, kseinc@aol.com
DOE Grant No. DE-FG02-04ER83989
Amount: $750,000

Reactive distilation is a new technology for the chemical and petroleum industries, which can lower energy consumption, improve the yields of reactions, enhance production of desired products, and reduce manufacturing costs. This project will develop a novel reactive distillation technology, along with improved catalysts, for an important chemical intermediate, vinyl ether. In Phase I, new catalysts were developed specifically for reactive distillation, laboratory performance data were generated to demonstrate process feasibility, and process simulations and economic studies showed the competitive advantage of the new reactive distillation technology. The results showed that for the manufacture of polyvinyl alcohols, a multi-billion dollar market, energy consumption was cut in half compared to traditional technology. Phase II will complete the development of the new catalysts; evaluate the performance of these catalysts in bench scale laboratory systems; conduct reactive distillation simulations, design, and cost analyses; and will prove commercial operability in an integrated, large scale pilot plant. Production of polyvinyl alcohol that meets commercial specifications will be demonstrated.

Commercial Applications and Other Benefits as described by the awardee: The new reactive distillation technology should result in immediate benefits in the manufacture of an important set of chemical intermediate, vinyl ethers. The total manufacturing cost of this new technology is forecasted to be is as low as the raw materials cost alone for conventional manufacturing technology. Reactive distillation thus would be shown to be a viable technology for the production of other chemical products.

75399S04-II

Moldable Ceramic Composites for High Field Magnet Applications—MultiPhase Composites, 1130 Francis Street, #7012, Longmont, CO 80501-3704; 303-684-9396, http://www.MultiPhaseComposites.com
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Mr. John A. Rice, Business Official, multiphasecomposites@excite.com
DOE Grant No. DE-FG02-04ER84014
Amount: $349,826

High field magnets, such as those used in High Energy Physics facilities, require precision placement of the superconducting cables to achieve high performance. However, current coated metal insulators used for end shoes and spacers have sharp points that can easily damage the cable insulation during installation. When assembling the magnet, these spacers can be pushed through the fabric, damage it, and potentially flake off the coating. Electrical shorts can result that require rework. This project will develop novel moldable ceramic insulators for use in accelerator and fusion magnets, in order to minimize the potential for insulation damage and shorting. The material can be used in place of the sharp tips or wherever small gaps exist. The insulators will be capable of withstanding the high mechanical loads at cryogenic temperatures, surviving the high temperature heat treatments, and resisting radiation. Phase I demonstrated that moldable ceramic compounds can be easily formed to the desired shape or packed into small gaps within a magnet structure. Characterization included strength measurement, thermal expansion, and dimensional control. Phase II will focus on the optimization of the composition and processing to further increase strength and to control other properties such as thermal expansion. Evaluation of the mixing, drying, and firing processing stages will be performed. Compressive strength, thermal expansion, and electrical properties will be measured at room temperature and cryogenic temperatures.

Commercial Applications and Other Benefits as described by the awardee: The ceramic insulators should be more robust and reliable than existing materials used in high field accelerator and fusion magnet systems. More robust insulators would lower magnet production cost, which will help enable future devices to be constructed within budgetary restrictions. Commercial magnets could also benefit from molded insulator components, increasing their reliability at lower cost.

75416S04-II

Novel Scintillator for Nuclear Physics Studies—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800, http://www.rmdinc.com
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Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-04ER84052
Amount: $700,000

Inorganic scintillation crystals are a very important element of current and next generation experiments in. Scintillators are the most common detectors used In nuclear and particle physics experiments, the perfomance of the detection systems is often limited by the properties of the scintillators that are available for gamma-ray and neutron detection. This project will investigate a new scintillator that offers improved perfomance for the detection of gamma-rays and neutrons: good energy resolution and excellent timing resolution for gamma-rays, excellent light yield for neutrons. In addition, the new scintillator will allow discrimination between gamma and neutron events, on the basis of pulse shape and pulse height. In Phase, crystals of the new scintillator were grown, and its performance for gamma-ray and neutron detection was determined. In Phase II, large crystals of the scintillator will be grown, an extensive characterization of their properties for detecting neutrons (both thermal and fast) and gamma-rays will be conducted, and the new scintilltor will be optimized for gamma-ray and neutron detection.

Commercial Applications And Other Benefits as described by the awardee: The proposed detector technology should be very promising for nuclear and particle physics experiments. It should also be useful in nuclear waste characterization, astronomy, homeland security, and bore hole logging.

75422B04-II

Compact, Autonomous, Carbon Isotope Flux Monitor Using Difference Frequency Generation Infrared Absorption—Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500, http://www.aerodyne.com
Dr. Douglas R. Worsnop, Principal Investigator, worsnop@areodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-04ER83892
Amount: $750,000

The increase of atmospheric CO_2 from fossil fuel combustion is a major contributor to global warming and climate change. Improved measurement technology for directly determining the exchange fluxes of the stable isotopes of CO_2 is crucial to understanding the natural carbon cycle, which transforms atmospheric CO_2 into biological carbon, and to develop strategies to mitigate the problem. This project will develop a field-portable instrument to directly measure both $13CO_2$ and $C_{18}OO$ fluxes from terrestrial ecosystems – needed to differentiate the carbon exchange mechanisms of photosynthesis and respiration, and to assess the relative importance of different vegetation types for carbon sequestration. The instrument will have sufficient precision and time response, and will be capable of continuous, unattended operation at remote field sites, without the use of cryogenic lasers or detectors. In Phase I, a direct-frequency-generation (DFG) light source was designed, and the feasibility of obtaining sufficient power in an ultra-compact package was shown. A pulsed quantum cascade laser (QCL) was shown to provide measurement precision of 0.1 parts-per-thousand for the $13CO_2/12CO_2$ ratio with an averaging time of 200 s. Phase II will complete the designs of the DFG source module, the optical module, and the electronics data acquisition modules. A prototype instrument will be designed and constructed. The prototype instrument will be tested in the laboratory using flask samples of known isotopic abundance ratios, and by using roof top sampling of ambient tropospheric air mixed with local combustion CO_2 sources.

Commercial Applications and Other Benefits as described by the awardee: The instrument would provide a simpler and more compact alternative to presently available isotope ratio mass spectrometer systems. Potentially larger commercial markets exist in medical research, where stable isotope metabolic tracers can be used to monitor the isotopic ratio in exhaled breath, and in the oil and gas exploration industry, where stable isotopes can be indicative of oil-well productivity.

75438S04-II

High Performance Small Animal SPECT Imager—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800, http://ww.rmdinc.com
Mr. Kanai S. Shah, Principal Investigator, kshah@rmdinc.com
Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-04ER84055
Amount: $750,000

With the ever-increasing number of human diseases being modeled in small animals such as mice and rats, the high resolution radionuclide imaging (such as SPECT, single photon emission computed tomography) of these small animals is required. Clinical SPECT scanners used for human imaging are bulky, expensive, and do not have adequate spatial resolution for small animal studies. Dedicated, low-cost instruments are required for conducting small animal studies with higher resolution than currently achievable with clinical SPECT scanners. This project will develop a new approach to the design of a high resolution, low cost SPECT system for small animal imaging, using solid-state detectors. Phase I designed and built high resolution detectors for eventual use in small animal imaging. High spatial resolution and high sensitivity were achieved with these detectors using isotopes commonly used in small animal SPECT imaging. In Phase II, the detector design will be optimized, and a prototype small animal SPECT imaging system will be built and evaluated.

Commercial Applications and Other Benefits as described by the awardee: The detector technology should be very promising for SPECT and other medical imaging modalities such as positron emission tomography. It also should be useful in nuclear and particle physics research, astronomy, diffraction, non-destructive evaluation, and safeguards.

75442S04-II

High-Temperature Fiber Optic Sensors for Nuclear Power Applications II—Luna Innovations Incorporated, 2851 Commerce Street, Blacksburg, VA 24060-6657; 540-552-5128, http://www.lunainnovations.com
Mr. Robert Fielder, Principal Investigator, submissions@lunainnovations.com
Ms. Wendy Vogt, Business Official, submissions@lunainnovations.com
DOE Grant No. DE-FG02-04ER83991
Amount: $749,969

Emerging designs for nuclear energy reactors will require reliable, high-temperature physical sensors that are not currently available. These sensors will need to operate at temperatures of at least 800°C and pressures up to 1000 psi while undergoing heavy irradiation. This project will develop high-temperature, radiation-hardened fiber optic pressure and temperature sensors for existing and emerging nuclear reactor plants. During Phase I, a pressure sensor design, previously demonstrated at 800 °C, was optimized for reactor environments by adding same-point temperature measurement and by reducing thermal induced errors in the pressure measurement. Three prototypes were calibrated from 0-400 psi and from 0-172 °C, and then subjected to 16 hours of radiation testing. Less that 1% drift was demonstrated in the sensor during the radiation testing. A breadboard instrument was assembled, and software was developed, to measure both temperature and pressure in a single sensor at the same location on a single fiber. During Phase II, the sensor design will be optimized with respect to yield, cost, and ease of construction. Prototype sensor performance and endurance will be characterized at temperatures up to 1000°C. Long term endurance testing (400 hours) will be conducted in a high radiation environment with elevated temperature excursions.

Commercial Applications and Other Benefits as described by the awardee: The high-temperature, radiation-hardened sensors should allow for more accurate control, increased safety, and reduced overall costs for nuclear power plants – not only for Gen-IV fission reactors, but for commercial nuclear and conventional power plants as well.

75454S04-II

Novel Heat Exchangers with Enhanced Surface—MER Corporation (Materials and Electrochemical Research), 7960 South Kolb Road, Tucson, AZ 85706-9237; 520-574-1980, http://mercorp.com
Dr. Lev Tuchinskiy, Principal Investigator, mercorp@mercorp.com
Dr. James C. Withers, Business Official, jcwithers@mercorp.com
DOE Grant No. DE-FG02-04ER84004
Amount: $750,000

Current heat exchangers use a conventional fin-tube design, which requires a large volume, leading to low efficiencies in thermal management systems. This project will develop an innovative technology to enable the low-cost fabrication of compact microchannel heat exchanger modules with enhanced surface and thermal efficiency. Phase I demonstrated the critical processing steps for fabricating the microchannel heat exchangers with metal foams. In Phase II, the fabrication process will be further developed and optimized, and a modular design for the heat exchangers will be established. The potential for miniaturizing chemical engineering unit operations will be demonstrated.

Commercial Applications and Other Benefits as described by the awardee: The low-cost compact heat exchangers should result in dramatic reductions in the size and weight of fuel reformer used for hydrogen production. Other applications include heat recovery from microturbines and fuel cells, cooling electronic devices and vehicles, cabin heating, air conditioning, man-portable heaters for cold and hot climates, etc.

75471S04-II

Plant and Soil Sequestration of Carbon—Zimmerman Associates, Inc. (ZAI), 9302 Lee Highway, Suite 600, Fairfax, VA 22031; 703-883-0506, http://www.zai-inc.com
Dr. Patrick W. Johnson, Principal Investigator, pjohns@erols.com
Ms. Mary Blevins, Business Official, mblevins@zai-inc.com
DOE Grant No. DE-FG02-04ER84127
Amount: $749,701

Measurement techniques are needed to validate technologies developed to enhance the net long-term sequestration of carbon in man-made and natural environments. In particular, a capability is required to determine increases in carbon fixation or sequestration of 1 tonne per hectare per year. This project will develop modifications and improvements to an existing airborne remote sensing system, BioSAR 3, that will provide a much more exact survey of 3 square miles (777 ha) a day. The modifications will reduce the size of the radar footprint on the ground and allow for improved accuracy. Phase I defined the changes required for the hardware and software systems, developed requirements for the new laser radar, and developed specifications for the new linear array radar. The instrument was successfully used to survey 30 pine plantation sites in North Carolina. In Phase II, a new laser radar will be procured and integrated into the system, and a new wingtip-to-wingtip linear array antenna will be fabricated. The complete system will be installed and integrated into the aircraft, and two missions will be flown in North Carolina. The two missions will be flown one year apart, in order to measure the change in carbon of 1 ton per hectare per year.

Commercial Applications and Other Benefits as described by the awardee: The system should provide increased accuracy and precision for biomass and carbon surveys for the validation of technologies developed to enhance net long-term C sequestration. The measurements should have immediate applicability to the timber industry, for forest inventory and assessments.

75496B04-II

Ionization Cooling Using Parametric Resonances—MUONS, Inc., 552 N. Batavia Avenue, Batavia, IL 60510-1274; 757-870-6943, http://muonsinc.com
Dr. Rolland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Rolland P. Johnson, Business Official, rol@muonsinc.com
DOE Grant No. DE-FG02-04ER84016
Amount: $650,000

Muon collider luminosity depends on the number of muons in the storage ring and on the transverse size of the beams in collision. As presently envisioned, large muon intensities will be required, due to limitations with ionization cooling, the intended method for cooling the beam. However, the proton accelerators needed to produce the required muon intensity are expensive, and the decay of the large number of muons in the storage ring create troublesome boundary radiation and make the physics experiments difficult. This project will combine ionization cooling with parametric resonances to produce beams with much smaller tranverse sizes, allowing high muon collider luminosity to be achieved with fewer muons. In Phase I, the theory of transverse beam cooling, using half-integer parametric resonances and ionization cooling, was extended to include methods to compensate for chromatic and angular aberrations. Computer programs were developed which were used to confirm the general analytical predictions and to compare the relative effectiveness of a quadrupole channel to one based on solenoids with alternating polarity. Phase II will further develop the theory and simulations in order to demonstrate that transverse cooling using parameteric resonances can relax the requirements on the proton driver, reduce the boundary radiation, and provide a better environment for experiments at muon colliders. Complete simulations using realistic models of all components of the parametric resonance cooling channel will be conducted.

Commercial Applications and Other Benefits as described by the awardee: 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. This technology should relax the requirements for muon production rates leading to a muon collider with reduced costs and accelerated schedules.

75497

***STTR Project: Hydrogen Cryostat for Muon Beam Cooling**—MUONS, Inc., 552 N. Batavia Avenue, Batavia, IL 60510-1274; 757-870-6943, www.muonsinc.com
Dr. Roland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Roland P. Johnson, Business Official, rol@muonsinc.com
DOE Grant No. DE-FG02-04ER86191
Amount: $700,000

Research Institution
Fermi National Accelerator Laboratory
Batavia, IL

Ionization cooling, a method for shrinking the size of a muon beam, is needed for future muon colliders and neutrino factories. Hydrogen is needed in these applications, and a safe and efficient containment cryostat is a prerequisite for its use. This project will develop a single hydrogen system that provides ionization energy loss for muon beam cooling, breakdown suppression for pressurized high-gradient RF cavities, and refrigeration for superconducting magnets and cold RF cavities. In Phase I, a computer analysis program was developed, and experiments were begun, to study components that would impact the design of a HCC Helical Cooling Channel (HCC) cryostat. The components that were studied include magnet conductors (with new HTS data), RF cavities (with new techniques for resistivity and breakdown measurements), absorber containment windows, and the energy absorber. In Phase II, experiments will be conducted to investigate the temperature dependent qualities of the construction materials and designs of the superconducting cable and coils, the RF cavities, and other cooling channel components. Then, a cryostat will be designed for a six-dimensional muon beam cooling demonstration experiment, based on the HCC. *Commercial Applications and Other Benefits* as described by the awardee: Muon beam cooling is the key to achieving the very intense muon beams needed for the next generation of experiments that use muons for basic research.. The use of a single hydrogen system to refrigerate superconducting magnets, pressurized high-gradient RF cavities, and the energy absorber would help make neutrino factories affordable and muon colliders a compelling option for the energy frontier.

75500S04-II

Automatic Compilation of Firewall and Intrusion Detection Rules for High-Speed Network Processing Engines—Reservoir Labs, Inc., 632 Broadway, Suite 803, New York, NY 10012-2614; 212-780-0527, http://www.reservoir.com
Dr. Kenneth Mackenzie, Principal Investigator, kenmac@reservoir.com
Dr. Richard Lethin, Business Official, lethin@reservior.com
DOE Grant No. DE-FG02-04ER84062
Amount: $750,000

As networks move to 10 Gbps and beyond (including scientific networks within the Department of Energy) the need arises for high-speed security solutions capable of defending these networks from cyberattacks. The current market supplies no solutions that operate at these speeds. To address this problem, this project will develop a toolchain for automatically rendering signatures from an intrusion detection system (IDS) into high-speed signature detection engines that run on network processors. Phase I demonstrated the feasbility of applying mapping technology to the problem of rendering intrusion detection rulesets onto network processors. A technique was identified for selecting the signature from the space of possible problem framings at compilation-time. Phase II will develop a prototype toolchain for rendering IDS signatures into high-speed signature detection engines that run on network processors. The toolchain, which will target 10 Gbps on next-generation network processors and will be fully automatic, will be validated and verified.

Commercial Applications And Other Benefits as described by the awardee: The high-speed signature-detection technology should find use in multiple network applications, especially intrusion detection, spam detection, and deep-inspection firewalls. Because the system will run on network processors rather than fixed-function hardware, the product will have advantages in time-to-market, time-in-market, and price-performance.

75521S04-II

Coaxial Energetic Ion Deposition of Superconducting Coatings on Copper RF Cavities for Particle Accelerators—Alameda Applied Sciences Corporation (AASC), 626 Whitney Street, San Leandro, CA 94577-1116; 510-483-4156, http://www.aasc.net
Mr. Andrew Gerhan, Principal Investigator, gerhan@aasc.net
Dr. Mahadevan Krishnan, Business Official, Krishnan@aasc.net
DOE Grant No. DE-FG02-04ER83896
Amount: $700,000

Radio frequency (RF) cavities are a key component in particle accelerators for fundamental high-energy physics research and medical applications. To enhance their capabilities, niobium-coated superconducting copper cavities have shown promise for supporting higher electric field gradients when compared to non-superconducting designs. However, a satisfactory coating method has not been developed that can deposit high-quality superconducting films on the insides of these cavities. To date the maximum field gradient that can be supported in niobium coated copper cavities is about 15 MV/m, which is not adequate for future accelerator designs. Also, sheet niobium in use is expensive. This project will develop a deposition process for coating the inside of copper RF accelerator cavities with high-quality, superconducting films that will allow particle accelerators to achieve field gradients greater than 15 MV/m. In Phase I, copper test samples, along with several sapphire and copper witness plates, were coated with niobium films using the Coaxial Energetic Deposition process. The superconducting transition temperature, Tc, and Residual Resistivity Ratio (RRR) for the films was measured to determine the superconducting properties, and film properties were assessed. Finally, a segment of an actual RF accelerator cavity was coated with niobium. Phase II will develop a Coaxial Energetic Deposition system that is capable of accommodating and coating 1.3 and 1.5 GHz RF accelerator cavities. In addition, a production system for transition to Phase III will be developed.

Commercial Applications And Other Benefits as described by the awardee: The superconducting thin film coatings for accelerator cavities should reduce the development and operating costs of particle accelerators, and allow them to achieve higher particle energies. Other applications include enhanced protective coatings for coal gasification, olefin manufacturing, and gun barrels for the military.

75527S04-II

Development and Testing of a Demountable Sheet Electron Beam Analyzer with Fluorescent Screen—
Elcon Inc. (formerly MacroMetalics), 1009 Timothy Drive, San Jose, CA 95133-1043; 408-292-7800, http://www.elcon-inc.com
Mr. Robert W. LeClair, Principal Investigator, bobl@elcon-inc.com
Mr. Jesus E. Dayo, Business Official, jdayo@elcon-inc.com
DOE Grant No. DE-FG02-04ER83992
Amount: $700,000

The sheet-beam klystron holds great promise for providing high RF power for modern linear colliders. However, sheet beam generation is not readily amenable to computer simulation; therefore, experimental validation of the design is sorely needed. This project will develop a demountable sheet beam analyzer with a fluorescent screen for direct observation of the electron beam cross section. In Phase I, an analyzer with a fluorescent screen was designed, fabricated, and tested with a new kind of sheet-beam gun, which morphs a round beam into an elliptical beam. Two versions of the analyzer were fabricated and succussfully tested: one version was used to test the fluorescent screen, the second to provide direct viewing of the elliptical beam cross section. In Phase II, two 500-kV beam analyzers will be designed, fabricated, and tested at high voltage at the Standford Linear Accelerator Center.

Commercial Applications and Other Benefits as described by the awardee: The demountable beam analyzer should provide significant value for the design of future sheet-beam klystrons. The technology also offers the potential for providing RF power from light-weight, affordable generators for use with portable X-ray scanners of thousands of shipping containers.

75530S04-II

Novel Scintillator for PET Imaging—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800, http://www.rmdinc.com
Dr. Michael R. Squillante, Principal Investigator, mswillante@rmdinc.com
Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-04ER84057
Amount: $750,000

Positron emission tomography (PET) is a powerful imaging tool that can provide diagnosis for symptoms of diseases such as cancer, Alzheimer's disease, head trauma and stroke. However, the performance of current clinical PET systems is limited by available detector technology, and there is an urgent need for improvement in PET instrumentation, in order to exploit the full potential of this promising technique. This project will develop a new detector material for PET that shows high light output, fast response and high sensitivity, leading to a detector with high energy and timing resolution. Other benefits include significantly reduced scatter and randoms, the main limitations in three-dimensional PET, and the possibility of time-of-flight PET imaging. During Phase I, crystals of the new scintillation material were grown and their scintillation properties were measured. These crystals showed exceptionally high light output, fast response, and excellent energy and timing resolution. During Phase II , larger crystals of the proposed scintillation material will be grown. The light output, decay time, and energy and timing resolution of these large crystals will be determined as a function of the doping level. Arrays will be built using the new scintillation crystals and PET modules will be assembled and tested using these arrays.

Commercial Applications and Other Benefits as described by the awardee: The detector technology should be very promising for PET and other medical imaging modalities such as X-ray computed tomography. It also should be useful in nuclear and particle physics research, astronomy, nuclear waste characterization, homeland security, and geophysical exploration.

75546S04-II

Optimization of Electron-Cyclotron-Resonance Charge-Breeder Ions—FAR-TECH, Inc., 10350 Science Center Drive, Building 14, Suite 150, San Diego, CA 92121-1129; 858-455-6655, http://www.far-tech.com
Dr. Jin-Soo Kim, Principal Investigator, kimjs@far-tech.com
Dr. Jin-Soo Kim, Business Official, kimjs@far-tech.com
DOE Grant No. DE-FG02-04ER83954
Amount: $700,000

Many Radioactive Ion Beam (RIB) laboratories around the world are using or planning to use Electron Cyclotron Resonance (ECR) Charge Breeders because they provide an economical way of producing RIBs. Currently, charge breeders, which produce multi-charged radioactive ions for nuclear physics research, produce the RIBs by a trial and error method. This project will investigate the beam capture processes in charge breeders and produce a comprehensive suite of numerical simulation tools for the analysis, design, and optimization of ECR ion sources of rare ion beams produced by charge breeders. A significant upgrade to the GEM (Generalized ECR-ion-source Modeling) code will be made, fully utilizing it, for radioactive ion beam source optimization. Phase I established a groundwork for understanding beam capture processes for the singly-charged-ions injected to charge breeders. A Monte Carlo module was developed for estimating the beam capture and charge breeding efficiency within the GEM framework. Phase II will upgrade the Monte Carlo code and the GEM code, validate the codes with experiments, and perform simulations to guide current and future experiments. A suite of numerical modules for the rare ion ECR charge breeder will be developed, which will include the capture of injected ions, charge buildup in the plasma, and the extraction of highly-charged rare ions.

Commercial Applications And Other Benefits as described by the awardee: The numerical optimization of multiply charged (radioactive) ion sources should be directly applicable to the Rare Isotope Accelerator facility that is strongly supported by the DOE. A comprehensive suite of numerical tools also should have industrial applications, including advanced plasma processing.

75553S04-II

Rigorous Screening Technology for Identifying Suitable CO_2 Storage Sites—Advanced Resources International, Inc., 4501 Fairfax Drive, Suite 910, Arlington, VA 22203; 703-528-8420, http://www.adv-res.com
Mr. Vello A. Kuuskraa, Principal Investigator, vkuuskraa@adv-res.com
Mr. Vello A. Kuuskraa, Business Official, vkuuskraa@adv-res.com
DOE Grant No. DE-FG02-04ER83889
Amount: $623,684

Currently, no rigorous set of easy to use methods and models exist, which would enable power plant operators or industrial firm managers to identify, screen, and select a suitable CO_2 storage site, or to evaluate its long-term integrity and storage capacity. Just as significant, government entities responsible for the permitting and oversight of CO_2 storage lack adequate data and protocols for assessing the risks and assuring the safety of CO_2 storage sites. This project will develop a rigorous, sophisticated set of screening and evaluation tools for selecting suitable CO_2 storage sites. During Phase I, a set of procedures and sophisticated screening tools were identified and tested for three types of storage sites: (1) a representative deep saline aquifer; (2) a depleted oil and gas field; and, (3) an unmineable coal seam. During Phase II, the procedures and screening tools will be incorporated in a stand-alone "tool kit" software program. This "tool kit" will be rigorously tested databases for CO_2 storage and CO_2 sequestration.

Commercial Applications and Other Benefits as described by the awardee: The CO_2 storage site selection "tool kit" should be of use to all power and industrial plant operators that need to consider the option of geological storage of CO_2. In addition to providing a rigorous methodology for selecting appropriate storage sites, a condition essential for gaining public trust and confidence, the economic optimization features of the "tool kit" would enable industry to save from $100 million to several billion dollars annually.

75554B04-II

Complex Coolant Fluid for PEM Cell Systems—Advanced Fluid Technologies, Inc. dba Dynalene Heat Transfer Fluids, 5250 West Coplay Road, Whitehall, PA 18052; 610-262-9686, http://www.dynalene.com
Dr. Satish C. Mohapatra, Principal Investigator, satifhm@dynalene.com
Mr. Daniel Loikits, Business Official, danl@dynalene.com
DOE Grant No. DE-FG02-04ER83884
Amount: $749,947

Fuel cells are an efficient, combustion-less, virtually pollution-free source of power. In particular, Proton Exchange Membrane (PEM) fuel cells are ideal for a number of applications, due to their "quick" warm-up characteristics. However, these fuel cells contain some inherent inefficiencies, which results in waste heat that must be removed rapidly via a coolant – currently, either Deionized (DI) water or glycol/water solutions with a DI canister. Although these coolants are non-flammable and thermally efficient, their electrical conductivity increases rapidly unless the DI canister is replaced frequently, which significantly increases capital and maintenance costs. This problem will be addressed by developing a novel Complex Coolant Fluid (CCF), comprised of a base composition and an additive package. The base composition addresses the non-flammability, thermal efficiency, freeze point, and materials compatibility issues, whereas the additive package maintains a low electrical conductivity in the CCF. In Phase I, key ingredients of the proposed additive package were prepared and incorporated into the coolant fluid. The resultant complex coolant fluid formulations were tested in two dynamic loops, and the additives were shown to maintain the electrical conductivity of the coolant below 2.0 microSiemens/cm for more than 325 hours. In Phase II, the additive package will be optimized and a more detailed study of the coolant performance and longevity will be carried out in a dynamic test loop that simulates fuel cell conditions. Optimized coolant samples will tested and validated in actual fuel cells under various operating conditions.

Commercial Applications and Other Benefits as described by the awardee: The new complex coolant fluid should significantly expand the versatility of the PEM fuel cells in both mobile and stationary applications by offering the advantages of freeze protection, corrosion inhibition, and low electrical conductivity in a single aqueous-based fluid, attributes that are not available in competitive alternates. The commercial applications include, but are not limited to, automotive fuel cell engines, power generation for residential and commercial buildings, back-up power for hospitals and other emergency establishments, fuel cells used in ships and space vehicles, and mobile machinery and equipment.

75565B04-II

Low Loss Ferroelectric Material Development for Accelerator Applications—Euclid TechLabs, LLC, 5900 Harper Road, #102, Solon, OH 44139-1866; 440-519-0410, http://www.euclidtechlabs.com
Dr. A. D. Kanareykin, Principal Investigator, alexkan@euclidconcepts.com
Dr. A. D. Kanareykin, Business Official, alexkan@euclidconcepts.com
DOE Grant No. DE-FG02-04ER83946
Amount: $650,000

Low loss ferroelectric materials based on BST (barium strontium titanate) could be used as the basis for new advanced technology microwave and particle accelerator devices. The electronic properties of this material would allow one the creation of an X-band, high-power RF switch with peak power sufficient for use in linear collider RF systems. This project will develop a new BST material with a permittivity of ~500 and a loss factor of 1×10^{-3} at 11.4 GHz. In addition, a process for sintering and forming large size objects (required for phase shifter components) made of BST ceramic will be demonstrated. In Phase I, a nonlinear ferroelectric material, intended for accelerator applications, was produced. The required tunability (De/e of 22- 29 % at 4-5 4.5 V/mm dc bias field, for thin substrates) and dielectric losses (5×10^{-3} at X-band) have been achieved. Forming and sintering technology was developed for large ferroelectric components. Phase II will improve the nonlinear ferroelectric BST-MgO (BSM) composition and demonstrate it's appropriateness for linear accelerator applications. The ferroelectric tunability of the new material will be increased (De/e up to 1.25-1.35 at 4.5-5.5 V/mm bias) and the loss factor will be reduced (to 3-4´10-3 at 10 GHz).

Commercial Applications and Other Benefits as described by the awardee: The ferroelectric-based tunable device technology should have application to a variety of high-frequency, large-signal devices in the military and wireless communication industries.

75571S04-II

Polythiophosphonate Electrolytes for Rechargeable Magnesium Batteries—Phoenix Innovation Inc., 20 Patterson Brook Road, Box 550, West Wareham, MA 02576; 508-291-4375, http://www.phoenixinnov.com
Dr. Brian G. Dixon, Principal Investigator, bdixon@phoenixinnov.com
Mr. R. Scott Morris, Business Official, rsmorris@phoenixinnov.com
DOE Grant No. DE-FG02-04ER84040
Amount: $749,669

Safety is a key concern in the development of higher energy density rechargeable battery systems, such as used in electric and hybrid electric vehicles. This project will identify a superior non-aqueous, aprotic electrolyte that can effectively support the development of practical, rechargeable magnesium batteries. In Phase I, carbon-magnesium composite anodes were fabricated and shown to be superior in performance to metallic magnesium anodes. The intercalation chemistry of advanced cathodes were adjusted to maximize the magnesium loading. The components were assembled into functional full cells, and the thermal and electrochemical properties evaluated. In Phase II, the anode-cathode-electrolyte combinations, identified during Phase I, will be optimized and scaled up to real world battery systems. The complete magneisum battery, either primary and secondary, will contain a nonflammable electrolyte, and be safe to handle under ambient conditions. Performance at cold and hot temperatures will be evaluated.

Commercial Applications and Other Benefits as described by the awardee: The technology should lead to the commercial development of new electrolytes and complete magnesium battery systems. Initial plans are to develop the materials for use in consumer batteries. Then, extensive testing would be conducted to develop prototype vehicular batteries.

75574T04-II

***STTR Project: Multiple-Input Data Acquisition System (MIDAS) for Measuring the Carbon Content in Soil Using Inelastic Neutron Scattering**—XIA, LLC, 8450 Central Avenue, Newark, CA 94560-3430; 510-494-9020, www.xia.com
Dr. William K. Warburton, Principal Investigator, bill@xia.com
Dr. William K. Warburton, Business Official, bill@xia.com
DOE Grant No. DE-FG02-04ER86200
Amount: $750,000

Research Institution
Brookhaven National Laboratory
Upton, NY

Soil management has been suggested as a method for sequestering massive amounts of carbon, in order to mitigate the buildup of CO_2 as an atmospheric greenhouse gas. In order to evaluate such schemes and document their performance, it will be necessary to quantifying changes in soil carbon stocks. However, current methods for quantifying carbon in soils (by core sampling, infra-red and LIBS spectroscopy) are invasive, slow, and relatively expensive. This project will develop a new non-invasive technology, Inelastic Neutron Scattering (INS), for static and dynamic *in situ* carbon monitoring in soil, which will speed up the rate of analysis at reduced cost and improve sampling statistics. The instrument will employ up to 16 gamma-ray detectors in a cost effective manner. Phase I upgraded an existing exploratory system at Brookhaven National Laboratory (BNL) with new multi-channel data acquisition electronics, leading to a small, low power device, which was shown to be compatible with field use. Performance evaluations at BNL lead to the design of a high performance prototype that will be produced in Phase II. Phase II will develop a commercializable four channel processing card designed to maximize output count rates from NaI(Tl) detectors while maintaining good energy resolution. Using these cards, a full prototype soil carbon measurement system with 16 gamma-ray detectors will be implemented. The goal is to demonstrate that the carbon content can be measured with an acccuracy of about 1.25% at the 100 mG/cm^3 level, with a measurement time of 4 seconds or less. *Commercial Applications and Other Benefits* as described by the awardee: The INS system should be a major advance over core sampling and laboratory analysis. Applications include: (1) monitoring soil for carbon sequestration, (2) improved soil management for agriculture (e.g., till versus no-till), and (3) advances in carbon cycle science (in agronomics, forest science, and ecology) by the rapid measurement of soil carbon on large scales.

75575B04-II

Thermal Recovery of North Slope (AK) Heavy-Oils from Ugnu and West Sak Sands is Feasible without Permafrost Melting around Multi-Branch Wells—S-Cal Research Corporation, 32 San Marino Drive, San Rafael, CA 94901-1536; 415-456-8237
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Mrs. Suzanne C. Gondouin, Business Official, gondouin@bigplanet.com
DOE Grant No. DE-FG02-04ER84063
Amount: $749,868

The existence, on the North Slope (AK) of two very large, shallow, heavy oil sands has been known since 1985. These are the Ugnu (8-12 API), at depths of 2,000 to 5,000 ft, and the West Sak (16-22 API), from 2,300 to 5,500 ft, both overlaying the Kuparuk field (which has been producing since 1981) and under-laying 1,800 ft of Permafrost. With combined oil-in-place over 40 MMBO, its recovery by a current “Cold Production” method is limited to 5%. By comparison, recoveries equal 70% in the Midway-Sunset (CA), using cyclic steam injection in multi-branch wells. If the steam could be injected through the Permafrost without any melting, domestic reserves would boosted by 28 MMBO and the life of the trans-Alaskan pipeline system would be extended by nearly 40 years, with little negative impact. This project will use engineering calculations, materials specifications, prototype fabrication and testing, and reliable cost estimates to demonstrate that this goal is now reachable. Phase I showed that steam injection could achieved by means of "super-insulated" well tubulars, which would prevent the Permafrost from melting. Heat transfer calculations showed that a cold, dry, gas-stream circulation would sub-cool the Permafrost. In Phase II, short-length prototypes of such tubular joints will be built and tested. Simultaneously, detailed specifications and welding protocols will be developed.

Commercial Applications and Other Benefits as described by the awardee: The new technology should permit a large increase in domestic oil production from the Alaskan North Slope with little environmental impact. The increased supply should slow U.S. dependence upon imported oil from un-stable sources.

75590S04-II

SAMTP (SONET Application Memory Transport)—Pentum Group, Inc., 111 W. El Camino Real, #109, Sunnyvale, CA 94087-1304; 408-718-4099, http://www.pentum.com
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Dr. John Brown, Business Official, johnbrown@pentum.com
DOE Grant No. DE-FG02-04ER84039
Amount: $749,984

The Grid, the network that links DOE and other research computing facilities, requires faster access to large amounts of data to feed faster computer systems, as well as the ability to reach data when required by applications (quality of service). Under current network technologies, data access is randomly affected by competing traffic, which slows response and makes interactivity next to impossible. Much of the commercially available, long distance, fiber optic links use SONET (Synchronous Optical NETwork), which lacks a transfer protocol that would allow its characteristics to be used to advantage. This project will develop a new data transfer protocol, based on SONET frames, to allow low cost, higher speed, and interactive networking between Grid computer systems that are connected through either carrier-provided or customer-provided fiber optic links. The protocol will be implemented in hardware and will be based on application-to-application communication rather than on computer-to-computer communication, which is used for current operating systems. Phase I developed a specification for a SONET Application Memory Transport (SAMTP) protocol, along with an appropriate hardware configuration for eventual manufacturing. In Phase II, protoype hardware boards implementing the SAMTP protocols will be developed suitable for use with an off-the-shelf microprocessor system. The resulting hardware will be evaluated for performance and application benefits at Oak Ridge National Laboratory and Sandia National Laboratory.

Commercial Applications And Other Benefits as described by the awardee: The new data transfer protocol should provide low cost, higher speed, and interactive networking between computers connected through existing long distance fiber optic links. Benefits are expected to include improved quality of video conferencing, technology collaborations, scientific and engineering simulations, computer gaming, and more efficient use of existing communications infrastructure.

75593B04-II

Single Crystal Molybdates for Neutrinoless Double Beta Decay Experiments—Integrated Photonics, Inc., 132 Stryker Lane, Hillsborough, NJ 08844; 908-281-0191, http://www.integratedphotonics.com
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Dr. Vincent J. Fratello, Business Official, vjfratello@integratedphotonics.com
DOE Grant No. DE-FG02-04ER83983
Amount: $700,000

The Neutrinoless Double Beta Decay Underground Detector has been identified by the DOE as a high scientific priority for Nuclear Physics research; however, the current generation of proposed experiments to determine neutrino mass would require 500 kg of germanium (Ge), which would cost more than $100 million. Therefore, several alternate parent isotopes for neutrinoless double beta decay have been suggested as candidates. The ^{100}Mo isotope of molybdenum is particularly promising because it has large decay energy, resulting in a signal above gamma ray backgrounds. The nuclear structure of this relatively light nuclide has been shown to be simple enough to allow reliable calculation of the parameters needed to extract the effective neutrino mass from the measured half-life. However, these advantages can only be exploited if a detector can be constructed with both high detection efficiency and excellent energy resolution. The only known method is to construct a bolometer of a single crystal from a compound that contains a significant fraction of molybdenum. Therefore, this project will develop technology for the bulk crystal growth of single crystal molybdate (a molybdenum oxide compound), so that large crystals can be routinely and cost-effectively grown. In Phase I, three molybdate compositions were investigated to determine: (1) their growability by the Czochralski method of bulk crystal growth; and (2) their potential use as cryogenic bolometer materials without any energy interferences, radiation effects, or other problems. One of the three materials was selected as a target composition, and independent bolometer tests indicated that the target composition would be an excellent host for ^{100}Mo in bolometer applications. In Phase II, the target molybdate compound will be optimized for crystal growth and fabrication of cubes for bolometer applications. A large crystal enriched with ^{100}Mo will be grown and fabricated for complete bolometer testing.

Commercial Applications And Other Benefits as described by the awardee: The dominant application of the single crystal molybdates would be for cryogenic bolometers for neutrinoless double beta decay. Because the target molybdate compound is a good low-temperature scintillator, with luminescence arising from the molybdenum oxide complexes, secondary commercial applications are anticipated.

75604S04-II

Robust Remote Seismic Station—Geotech Instruments, LLC, 10755 Sanden Drive, Dallas, TX 75238-1336; 214-221-0000, http://www.geoinstr.com
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Dr. Lani Oncesu, Business Official, lani.oncescu@geoinstr.com
DOE Grant No. DE-FG02-04ER83966
Amount: $746,043

The U.S. government sponsors and supports various programs to monitor nuclear explosions through seismic, hydroacoustic, and infrasound data collection stations. These stations are typically deployed in remote areas all over the world. However, current remote data acquisition station technology is limited by (1) poor data quality and reliability and (2) high installation, operation, and maintenance costs. This project will develop a compact, remote, seismic data acquisition platform using advanced low power electronics, packaging, and power source technologies. It will specifically address the problem of data quality and data communications reliability, and will reduce deployment, operational, and maintenance costs. Phase I identified: (1) low-power, high-resolution ADC devices and configurations; (2) low-power, highly-integrated miniaturized components for overall size and power reduction; (3) methods for integrating most of the major subsystems of the station into a single electronics package; (4) low power satellite and wireless communications options; and (5) advanced power supplies. Phase II will design, fabricate, and test a working prototype of robust remote seismic data acquisition platform that will integrate the technologies investigated in Phase I.

Commercial Applications and Other Benefits as described by the awardee: In addition to the national security application, the hardware and software developed in this project should be directly applicable to commercial earthquake monitoring, as well as other strong motion, infrasound, and hydroacoustic data acquisition and monitoring.

75616B04-II

Production of Seamless Superconducting Radio Frequency Cavities from Ultra-Fine-Grained Niobium—
Black Laboratories, LLC, 116 Villa Road, Newport News, VA 23601-3606; 757-596-5853, http://www.black-labs.org
Dr. Roy E. Crooks, Principal Investigator, roy.crooks@verizon.net
Ms. Tracy Flock Crooks, Business Official, gm@black-labs.org
DOE Grant No. DE-FG02-04ER83909
Amount: $700,000

Superconducting radio frequency cavities, used in high energy accelerators, are produced by the sheet metal forming of multiple sections, which are then joined by high-vacuum, electron-beam welding. The welding procedures are very expensive and produce flaws and contamination that limit cavity performance. Simpler approaches, based on the shaping of seamless tubes, have been hindered by limited formability and performance-limiting surface roughness. This project will develop a technique for manufacturing superconducting radio frequency cavities from highly formable, seamless niobium tubes. The seamless tubes will be produced from billets of ultra-fine grained niobium processed by equal channel angular extrusion. In Phase I a novel billet processing method, equal channel angular extrusion, was used to refine the grain structure of bulk niobium. Analytical results revealed a significant improvement in this bulk material over the currently used sheet metal. In Phase II, the process will be scaled-up to process full size billets, produce 150 mm diameter seamless tubes, and produce and test full-scale superconducting radio frequency (SRF) cavities for the International Linear Collider (ILC).

Commercial Applications and Other Benefits as described by the awardee: The demand for RRR niobium for SRF Cavities is expected to reach 1,000,000 pounds by 2012, at a cost approaching $250M for sheet metal, with another $150M or so for welding. The technology developed in this program should eliminate welding costs and offer a higher quality product at a substantial cost advantage. Sales could well approach a hundred million dollars for the International Linear Collider program alone. Lower cost, higher performance accelerators also would have applications in other fields: over 10,000 accelerators are now used worldwide for medical diagnostics, advanced materials characterization, communications, military devices, structural biology, pharmacology, and environmental studies.

75620S04-II

Nanocomposite Polymers for Smart Window Films—Wavefront Technology, Inc., 15149 Garfield Avenue, Paramount, CA 90723-4019; 562-634-0434, http://www.wft.bz
Dr. Jun Qi, Principal Investigator, jun@wft.bz
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DOE Grant No. DE-FG02-04ER84117
Amount: $750,060

The energy used to remove cooling loads from windows in both residential and commercial buildings totals about 1.4 Quads (quadrillion BTUs/yr), representing a cost to building owners of about $12 billion per year. Significant savings could accrue if a “smart” window film technology were available, which could reduce these cooling and heating loads. This project will develop a "smart" window film that allows more of the sunlight to penetrate a window when the sun is low in the sky (winter time), and reflects most of the sunlight when the sun is high in the sky (summer time). In Phase I, the feasibility of producing such an angularly selective smart window film was demonstrated by creating a prismatic micro-structured film and combining it with a nano-composite UV curable polymer. In Phase II, the properties of the smart window film will be further refined, optimized, and readied for mass production. Lawerence Berkeley National Laboratory (LBNL) will test the smart window film for its environmental robustness and ease of application to glazing products.

Commercial Applications and Other Benefits as described by the awardee: The smart window film should be immediately applicable to energy conserving window glazings for commercial, industrial, and residential buildings. End-user costs are projected to be $2-3 square foot, using UV cast/cure mass replication production processes. Other applications should include automobiles, military vehicles, aircraft, and the like, for the purpose of reducing their thermal equilibrium temperatures while sitting motionless in the sun, as well as for reduced cooling loads when these vehicles are in motion.

75621S04-II

An Inexpensive High-Current Betatron Using Fixed-Field Alternating Focusing and New Low-Loss Magnetic Materials—RadiaBeam Technologies LLC, 1600 Sawtelle Boulevard, Suite 205, Los Angeles, CA 90025; 310-444-1475, http://www.radiabeam.com
Mr. Salime Max Boucher, Principal Investigator, sboucher@radia-tech.com
Mr. Salime Max Boucher, Business Official, sboucher@radia-tech.com
DOE Grant No. DE-FG02-04ER84051
Amount: $700,000

Electron sources in the commercially important 5 to 20 MeV energy range are limited. These sources are used not only for the testing of advanced accelerator components but also for cancer treatment, medical device and mail sterilization, food irradiation, and plastics processing. Radio-frequency linear accelerators are the industry standard, but they are complicated and expensive. Betatrons hold the promise of being much simpler and less expensive, but previously they were limited to very low currents. This project will employ Fixed-Field-Alternating-Gradient focusing to increase the current capability of the betatron. Modern advances in low-loss magnetic materials also will be applied to increase the repetition rate. In Phase I, the focusing lattice was optimized, collective effects were examined to determine the stability limits, field magnets were designed, a betatron core power supply schematic was generated, and other hardware issues were addressed. The result of these activities is a robust, efficient, and extensive design for prototype fabrication. In Phase II, the field magnets, vacuum chamber, and diagnostics systems will be custom fabricated. Other major systems (the betatron core, power supplies, injector) will be purchased. Finally, the components will be integrated, and the accelerator will be commissioned to 6 MeV and more than 1 mA average current.

Commercial Applications and Other Benefits as described by the awardee: A 6 MeV, high power, inexpensive electron source should find application in a number of markets: the well-developed medical-products-sterilization industry would readily adopt a less expensive technology; cargo inspection is a rapidly growing application of high-power accelerators, and reduced costs would allow the equipment to be more widely used at port facilities; the use of this device for mail sterilization would fit within the budget of every large postal facility in the country; radiation cancer treatment would be made considerably less expensive, making this life-saving treatment more available in developing nations.

75647S04-II

SPECS: Small Particle Electron Cooling Simulations—Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856, http://www.txcorp.com
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Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-04ER84094
Amount: $700,000

The premier nuclear physics accelerator facility, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, is colliding heavy ions to create conditions like those a fraction of a second after the big bang. An electron cooling section is being planned as part of a luminosity upgrade. Because the parameters and conditions for this electron cooling section will be fundamentally different than those built at other accelerator facilities, the research and design process will require high-performance, high-fidelity numerical simulations. This project will develop a parallel three-dimensional particle code that incorporates novel features for the detailed simulation of the electron cooling section planned for the RHIC. In particular, a "smart" particle algorithm will be used to incorporate the physics of Coulomb collisions, enabling the simultaneous capture of space charge effects and thermal energy transfer. In Phase I, a proof-of-principle implementation of the smart particle algorithm was developed within a parallel particle-in-cell code. The importance of relativistic effects on thermal exchange via binary Coulomb collisions was found to be a modest concern for the case of large emittance electron beams. Relativistic treatment of space charge forces was shown to be important. In Phase II, a three-dimensional, semi-analytic algorithm for binary collisions will be implemented. The replacement of the expensive superconducting solenoid with a long “wiggler” magnet will be simulated in detail, and the “smart particle” implementation will be completed. The algorithm will be used to simulate the combined effects of space charge forces and thermal transfer, due to Coulomb collisions, during multiple passes through the cooling section.

Commercial Applications And Other Benefits as described by the awardee: The parallel 3-D code should benefit scientists working to design the electron cooling section for the luminosity upgrade to the Relativistic Heavy Ion Collider. This code also should provide an excellent starting point for modeling: (1) the Boersch effect in the transport of strongly-magnetized electron beams for coolers, (2) the intrabeam scattering effect in heavy ion accelerators, and (3) the formation of crystal beams.

75650S04-II

Inductive Plasma Accelerator—MSNW, 16436 SE 39th Place, Bellevue, WA 98008-5858; 425-319-5024
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Dr. John Slough, Business Official, sloughj@comcast.net
DOE Grant No. DE-FG02-04ER84011
Amount: $652,500

For the plasma jet liner approach to magnetized target fusion, a plasma accelerator is required that is capable of launching a plasma jet with a mass of 0.2 mg to 0.4 mg and a diameter no larger than about 20 cm. In addition, the accelerator must be capable of attaining plasma/plasmoid velocities in excess of 200 km/s, a timing precision better than a microsecond down to nanoseconds, and a controllable density profile of high uniformity and purity. This project will achieve the desired acceleration parameters by designing and constructing an inductive plasmoid accelerator (IPA). In addition, two IPAs will be merged to form a suitable target plasmoid that will be compressed to high density and temperature with a suitable plasma liner, providing the first experimental test of the plasma liner fusion concept. In Phase I, the inductive plasma accelerator was analyzed analytically and numerically to determine an optimal configuration for application to the plasma liner approach to target fusion. A complete design of the inductive plasma accelerator to be built was executed. Additional analysis and design was conducted on an experimental testbed for merging accelerated plasmoids and compressing with a plasma liner. Phase II will construct a plasmoid accelerator and produce a magnetized plasmoid that is suitable for the formation of the target plasmoid as well as for later compression by an array of similar plasmoids. An interaction chamber will be constucted that is capable of producing a plasma liner for compression experiments. Simulations will be performed for all three components of the experimental work: the acceleration of two plasmoids, their merging, and the formation of a plasma liner followed by the radial implosion of the plasma liner onto the colliding plasmoids.

Commercial Applications and Other Benefits as described by the awardee: The inductive plasma accelerator (IPA) should have a natural application to high power electric propulsion in space. The IPA also should be readily adapted as a fueler for future fusion reactors such as the international fusion reactor (ITER) now being planned. It also could find application in current tokamak experiments, in order to add rotational momentum and velocity shear for enhanced stability and transport control.

75655S04-II

An Innovative Technique of Preparing Solar Grade Silicon Wafers from Metallurgical Grade Silicon by In-Situ Purification—GT Equipment Technologies, Inc., 243 Daniel Webster Highway, Merrimack, NH 03054; 603-883-5200, http://www.gtequipment.com
Dr. Santhana Ragl Parthasarthy, Principal Investigator, raghavan@gtsolar.com
Mr. Jonathan A. Talbott, Business Official, talbott@gtequipment.com
DOE Grant No. DE-FG02-04ER83971
Amount: $600,000

The photovoltaics (PV) industry is having difficulty finding enough raw materials to match its rapid growth. In addition, traditional sources of secondary grade polysilicon are no longer readily available at inexpensive prices. Reducing the cost of solar silicon wafers is the key to lowering the price of crystalline silicon solar cells. This project will develop a single-step wafer fabrication process in which metallurgical grade silicon (MGSi) is purified by dissolving it in a tin (Sn) melt. The solar silicon wafers then can be drawn directly from the Sn-dissolved MGSi melt by edge-defined film growth (EFG) or ribbon growth methods. In Phase I, test runs were carried out with a broad range of tin concentrations. A significant amount of impurity reduction was observed when compared to the starting MGSi. It was also observed that the amount of tin incorporated into the growing wafer decreased along with the reduction in the solvent (tin) concentration, while the impurity reduction level remained more or less the same. Phase II will optimize the solution composition and processing conditions, construct a prototype system for solar wafer fabrication, characterize of the produced silicon materials, and evaluate of the photovoltaic properties of the fabricated wafers.

Commercial Applications and Other Benefits as described by the awardee: Most commercial production in the photovoltaic industry is based on crystalline silicon, which is likely to be the preferred material for the near term. The proposed technology should be a cost effective way to fabricate these solar cells. Instead of using more expensive solar grade silicon (at $20 per kg), it uses metallurgical grade silicon (at $2 per kg) as a direct feedstock. In addition, energy costs would be greatly reduced.

75661S04-II

High-Efficiency, Ultra-High Pressure Electrolysis with Direct Linkage to Photovoltaic Arrays—Avalence, LLC, 1240 Oronoque Road, Milford, CT 06460; 203-701-0052, http://avalence.com
Mr. Thomas Jackson, Principal Investigator, tj@avalence.com
Mr. Martin Shimko, Business Official, mas@avalence.com
DOE Grant No. DE-FG02-04ER83905
Amount: $749,465

The production of hydrogen fuel from renewable resources such as solar and wind in distributed-generation, small-scale applications would provide an environmentally-benign, truly sustainable transportation fuel supply. But before this can be achieved, the hydrogen generating systems must become as reliable as home appliances (e.g., central air conditioning or furnaces), which require only annual maintenance. The primary source of reliability problems is the separate mechanical compressor, which supplies high pressure hydrogen for portable applications, and its elimination is critical to achieving this goal. This project will develop a prototype of a renewably powered, hydrogen fuel producer that supplies high-pressure gas (5,000 to 10,000 psi) to a hydrogen fuel dispenser for the depot-style fueling of commercial or agricultural vehicles, without additional compression or power conditioning equipment. The approach will be based on an innovative ultra-high pressure electrolysis system that has the potential to deliver hydrogen fuel at pressures exceeding 10,000 psi, directly from the electrolysis cell. Phase I: (1) ran parametric tests on an ultra-high pressure electrolysis cell to determine the efficiency of producing fuel grade hydrogen; (2) linked an existing high-pressure electrolyzer to a PV array and ran additional tests to determine production at various light conditions and electrolyzer cell configurations; and (3) developed a conceptual design for a stand-alone, PV-powered, high-pressure electrolyzer system that includes a hydrogen fuel dispenser. Phase II will complete the detailed system design and demonstrate key systems related to the safety and manufacture of a hydrogen fueling station. Then, the hydrogen fueling station will be fabricated and tested.

Commercial Applications and Other Benefits as described by the awardee: The technology should contribute to the substantial market for distributed hydrogen fuel generation for vehicles (including internal combustion engines in the near term, and general fuel cell powered transportation in the long term). The technology should also support small-scale renewable energy storage for 24/7 availability, peak shaving, and load leveling.

75684S04-II

Remote In-Situ Monitoring of Metal Contaminants in Groundwater with a Compact Grazing-Incident Monochromatic Microbeam X-Ray Fluorescence Analyzer—X-Ray Optical Systems, Inc., 15 Tech Valley Drive, East Greenbush, NY 12061; 518-880-1500, http://www.xos.com
Mr. Brian Gallagher, Principal Investigator, bgallagher@xos.com
Mr. David M. Gibson, Business Official, bgibson@xos.com
DOE Grant No. DE-FG02-04ER84122
Amount: $749,315

The evaluation of radionuclide and metal contaminants, found in the groundwater during the monitoring of DOE sites, is typically done off-site, using plasma mass spectroscopy or optical emission spectrometry. These analysis techniques are not suitable for automated field use because they require control gas or vacuum to function. A simple, robust, non-destructive analysis technique is required for *in situ* remote monitoring applications. This project will develop a grazing-incident-monochromatic micro x-ray fluorescence (GI-MMXRF) analysis system, which, when combined with an innovative dried spot sample preparation system, will offer high sensitivity and automated sample preparation. The combination of low power GI-MMXRF and ink jet printing technology makes this an approach that can be readily adapted for remote monitoring or *in situ* applications. In Phase I, a doubly-curved crystal optic was designed for use with an existing x-ray fluorescence analysis setup. A lab setup of the sample deposition system demonstrated GI-MMXRF detection at parts-per-billion (ppb) levels. A detailed onceptual design of a field-deployable system was developed. In Phase II, the optics will be further developed to increase sensitivity and reliability, and system optimization will be performed to decrease system size, weight, power, and cost. Measurements with contaminated and base ground water samples will be used to demonstrate remote, unattended field operation. *Commercial Applications and Other Benefits* as described by the awardee: In addition to the remote monitoring of radio nuclides and metals in groundwater at hundreds of DOE sites, the technology also should draw interest from industries and government agencies concerned with the monitoring of groundwater and groundwater remediation.

75699S04-II

Real-Time Holographic Water-Drop-Size Measurement System—Physical Optics Corporation, Information Technologies Div., 20600 Gramercy Place, Building 100, Torrance, CA 90501-1821; 310-320-3088, http://www.poc.com
Dr. Fedor Dimov, Principal Investigator, sutama@poc.com
Mr. Gordon Drew, Business Official, gdrew@poc.com
DOE Grant No. DE-FG02-04ER84042
Amount: $749,899

To fully understand the global warming problem, the properties of the stratus clouds that cover much of the earth must be understood. In particular, new instrument technology is needed to make statistically significant measurements of the size distribution of water drops in these clouds. The regimes of interest include diameters from 3 to 200 microns, with total concentrations on the order of 10 to 100 drops per cubic centimeter. Existing *in situ* optical instruments, used on research aircraft and on the ground for measuring the drop size distribution of water clouds, are inherently limited in the volume — and thus drop size — they can measure. In the best technology, digital holography, resolution is limited by the large pixels of the imaging CCD cameras. This project will develop a new holographic water drop size measurement system with high-resolution (less than a micron), a highly sensitive (0.1 microjoule exposure level per square centimeter) photothermoplastic recording material for the hologram, and a high-speed and high-resolution CMOS camera for image recording and processing. It will record holograms in real time and increase system field-of-view, meaning that a larger number of droplets can be analyzed. In Phase I, an experimental optical setup was built, holograms of water droplets on photothermoplastic material were successfully recorded, and images from the holograms wre retrieved via a CCD camera. Droplet image sizes were measured directly and also estimated from interference patterns. In Phase II, a fully operational, compact, lightweight prototype system will be developed for real-time continuous hologram recording, development, and retrieval on research aircraft or tethered balloons.
Commercial Applications and Other Benefits as described by the awardee: The high-resolution, high-speed, holographic water droplet measuring system should find extensive commercial applications in atmospheric measurement; oil-fired direct-absorbing chillers and microturbines; and biological, medical, university, and research facilities. It also should improve the efficiency of fuel and commercial irrigation systems.

75703S04-II

SARD: A Novel Surveying Method to Develop Genomic Reagents—Taxon Biosciences, Inc., 3152 Paradise Dr., Tiburon, CA 94920; 415-254-3554, http://www.taxon.com
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Dr. Matthew N. Ashby, Business Official, ashbym@taxon.com
DOE Grant No. DE-FG02-04ER84089
Amount: $749,811

Microbes play a vital role in all aspects of our lives, yet our ability to understand these processes is limited by the availability of appropriate tools. Current microbial survey methods capture only the most abundant organisms in complex communities, organisms that may represent less than 1% of the species present. This project involves the development of a new genomics tool, known as SARD (Serial Analysis of Ribosomal DNA), which enables deep surveys of complex microbial communities by creating an inventory of short DNA sequence tages representing members of the community. A particular application of the technology is the identification of bacterial species that can be used to locate hydrocarbon plumes that originate from sub-surface petroleum reservoirs. Phase I isolated a greater number of unique sequence tages than currently reside in any public database, identified clusters of sequences that correlate with propane/butane abundance, developed quantitative assays, and conducted surveys to show the geographical distributions of these sequences. In Phase II, the technology will be further developed by profiling on-shore exploratory well sites and marine samples from known reservoirs. These profiles will be further analyzed to determine the ability of this technology to accurately predict a commercially viable well. *Commercial Applications and Other Benefits* as described by the awardee: By creating inventories of any microbial community, the SARD profiling technology should have commercial application to petroleum and mineral exploration, pollutant detection, and clinical diagnostics. In addition, the SARD DNA sequence tages themselves represent a genomic resource that should find use as: (1) a PCR (polymerase chain reaction) primer to recover the corresponding full-length 16S rRNA gene; (2) a primer in a quantitative PCR assay to query the presence of the tage sequence in a large sample collection; (3) a fluorescently-labeled probe in fluorscent *in situ* hybridization (FISH) experiments; and 4) a probe on a DNA microarray for hybridization-based surveys.

75716S04-II

Development of Soft-Ionization for Particulate Organic Detection with the Aerodyne Aerosol Mass Spectrometer--Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500
Dr. Douglas R. Worsnop, Principal Investigator
Mr. George N. Wittreich, Business Official
DOE Grant No. DE-FG02-04ER83890
Amount: $750,000

75716S04-II

Development of Soft-Ionization for Particulate Organic Detection with the Aerodyne Aerosol Mass Spectrometer--Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-663-9500, http://www.aerodyne.com
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DOE Grant No. DE-FG02-04ER83890
Amount: $750,000

Aerosol particles in the atmosphere have important effects on visibility, acid deposition, climate, and human health. A significant amount of anthropogenic aerosols is generated from energy-related activities, and organic compounds are known to constitute a significant fraction of ambient aerosol mass in many locations. However, there is a lack of are real-time, size-resolved, quantitative instruments for measuring the chemical composition of organic aerosols. This project will develop soft ionization technology for a recently-developed aerosol mass spectrometer that will enable better identification of organic species in ambient aerosol particles. (Soft ionization causes less fragmentation of molecular species than the currently used electron impact ionization.) During Phase I, two different soft ionization techniques were successfully demonstrated, Vacuum Ultra Violet (VUV) photoionization and Li+ ion attachment. A custom lamp to produce VUV photons was designed and coupled to the aerosol mass spectrometer. Selective detection of organic test aerosols was accomplished. A Li+ ion source was integrated into the aerosol mass spectrometer and successfully used to detect organic particles. Designs for prototype soft ionization modules that couple to the aerosol mass spectrometer were completed. Phase II will include further development of both the VUV photoionization and Li+ attachment modules. Improvements to the VUV photoionization module will include increasing the photon flux, designing a more suitable power supply, and using different gases for the lamp fill. For the Li+ attachment module, sources with more flux and fewer impurities will be investigated. The soft ionization modules will be deployed in the field on aerosol mass spectrometer instruments. Data analysis software to classify organic particles will also be developed. *Commercial Applications and Other Benefits as described by the applicant.* This instrument should have application in ambient pollution monitoring, chemical and biological warfare agent identification, and the characterization and control of aerosol emissions from a variety of industrial and energy production processes. These processes, which produce aerosol laden gaseous exhaust or waste

streams, include semiconductor manufacturing, gas turbines, and the diesel combustors and conventional furnaces used for electrical power.

75745S04-II

A New Ceramic Scintillator for Neutron Detection—ALEM-RMD Joint Venture, 44 Hunt Street, Watertown, MA 02472; 617-668-6800, http://www.rmdinc.com
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Dr. Gerald Entine, Business Official, gentine@rmdinc.com
DOE Grant No. DE-FG02-04ER83898
Amount: $750,000

The utilization of high neutron fluxes (such as at new DOE Spallation Neutron Source, SNS, which is used for materials science studies) is often limited by detection systems, particularly scintillators. For example, the widely-used ZnS:Ag/LiF phosphor, although very bright, is slow and opaque to its own light, forcing the use of thin layers and compromising detection efficiency. This project will develop a novel neutron scintillator based on a CaF2:Eu/LiF ceramic. This material, which is transparent to its own light, will allow the use of thicker layers, improving detection efficiency and pulse height discrimination. Since its emission it twice as fast as ZnS:Ag, with no long-term afterglow, it will also permit higher counting rates. Phase I that the material could be manufactured as a transparent ceramic and demonstrated that samples of this material can detect neutron particles. The basic properties of the material also were investigated. Phase II will optimize the fabrication of this material using hot press and pressureless sintering methods. Material properties as a function of its composition will be determined and the material will be optimized for different applications. Finally, the material will be evaluated for SNS instrumentation. *Commercial Applications and Other Benefits* as described by the awardee: The new material should find application in the Spallation Neutron Source – in the approximately 15 neutron scattering instruments that use scintillators for neutron detection. It also should expand the choices for neutron scintillators.

75747S04-II

Innovative, Low Cost, Radiation-Resistant Fusion Magnet Insulation—Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026-3359; 303-664-0394, http://www.ctd-materials.com
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DOE Grant No. DE-FG02-04ER83926
Amount: $652,500

Newly designed and proposed fusion magnet systems will require electrical insulation capable of withstanding high temperatures and high radiation doses. The lack of cost-effective, radiation-resistant insulation systems is compromising the design and operation of these devices. Therefore, this project will develop and formulate low-cost organic resins for use in the production of fusion magnet insulation by vacuum pressure impregnation (VPI). The new materials promise to be much less expensive than current insulation materials, while providing the necessary mechanical, electrical, and thermal performance. In Phase I, new low-cost organic resin formulations were developed and the materials were used to fabricate fiber-reinforced insulation materials. The materials displayed excellent high-temperature strength and withstood thermal cycling from 76 K to 373 K with minimal change in mechanical or electrical performance. Phase II will optimize the resin formulation, scale up the synthesis process, fabricate and characterize fiber-reinforced insulation materials, and determine the radiation resistance of these new resin materials. In addition, a subscale magnet assembly will be fabricated and tested to demonstrate the use of these new insulation materials in a representative, application-specific configuration. *Commercial Applications And Other Benefits* as described by the awardee: New, low cost, VPI-compatible insulation systems, capable of withstanding exposure to high temperatures and having improved radiation resistance and mechanical and electrical properties, should directly affect the viability and operation of new fusion magnet designs. Lower cost insulation systems, with equal to or greater properties than current systems, should significantly reduce the material and fabrication costs of magnet systems and extend the useful lifetime of these devices.

75772B04-II

Membrane-Based Hybrid Process to Capture CO_2 from Warm Flue Gas—Chembrane Research and Engineering, Inc., NJIT Enterprise Development Center III, 211 Warren Street, Newark, NJ 07103-3568; 973-379-4428
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DOE Grant No. DE-FG02-04ER83924
Amount: $749,246

Most coal-based power plants use pulverized coal boilers to generate superheated steam for turbine applications, accounting for over 50 percent of U.S. electricity generation. The flue gas stream from these plants contains CO_2, along with N_2 and other minor components such as SO_2 and NO_x. Although some commercial technologies are available to separate or capture the CO_2 from the flue gas, in order to reduce the buildup of greenhouse gases in the atmosphere, these processes are both capital intensive and high in operating costs. This project will develop a membrane-based hybrid process for capturing and enriching the CO_2 from the warm flue gas streams emitted from pulverized-coal-fired power plants. When retrofitted on conventional air-based, fossil-fuel-fired power plants or integrated into new power-generation facilities, the process will capture more than 90% of the CO_2, and compressed CO_2 with greater than 99 vol% purity will be obtained. In Phase I, the membrane-based hybrid system was developed and tested on a simulated flue gas containing 10 to 15% CO_2. A product stream containing 99.3-99.6 vol% CO_2 was produced with a recovery effeciency of >90%. Parametric optimization and techno-economic analysis were performed over a range of temperatures, CO_2 partial pressures, and SO_2 contents in the flue gas. In Phase II, the membrane hybrid sytem will be further optimized to provide higher CO_2 capture efficiency and higher CO_2 purity. Long-term experiments will be performed to test the operational stability of the membrane system when used to treat simulated flue gas containing both SO_x and NO_x. Finally, a prototype system will be tested in a pilot plant. *Commercial Applications And Other Benefits as described by the applicant.* The membrane-based hybrid process should provide superior performance compared to the conventional processes for CO_2 separation/capture (i.e., amine-based absorption/desorption, membrane gas absorption, and conventional membrane gas permeation processes). The cost of capturing (separating, compressing, and liquifying) 90% CO_2 from a flue gas stream containing 15% CO_2 would be 1.275 - 1.80 cent/kWh (or 13.5 – 20 dollars/ton CO_2 avoided).

75778B04-II

Microstructual Refinement of Ta for Superconductor Diffusion Barrier Applications—Shear Form, Inc., 2805 Brothers Boulevard, College Station, TX 77845-5712; 979-693-4102
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DOE Grant No. DE-FG02-04ER84073
Amount: $675,000

Previous research has shown that the Ta diffusion barrier in composite Nb_3Sn superconductors, such as those used in the superconducting magnets needed for fusion confinement systems, may develop a failure mode during wire drawing, due to the non-uniform deformation of the thin Ta layer. This non-uniform deformation can lead to breaches in the diffusion barrier and its premature fracture during wire drawing. In recent experiments, a process called Equal Channel Angular Extrusion (ECAE) was shown to be effective in refining the grain size in bulk material, homogenizing the microstructure, and substantially reducing the texture. This project will demonstrate that ECAE- processed Ta exhibits excellent mechanical characteristics for its use as a diffusion barrier in multi-filamentary composite Nb_3Sn superconductors. Phase I demonstrated: (1) the effectiveness of ECAE processing for grain refinement and microstructure homogenization of pure Ta and Cu, and, (2) the superior mechanical characteristics of ECAE processed Ta sheet, compared with commercially available Ta, for a diffusion barrier in Nb_3Sn multi-filamentary superconductors. Phase II will demonstrate that ECAE-processed Ta sheet is superior to commercially available Ta sheet for multifilamentary Nb_3Sn uperconductor diffusion barrier applications. Superiority will be demonstrated by forming a thinner and more regular Ta layer in experimental fusion magnet conductors. *Commercial Applications And Other Benefits* as described by the awardee: The technology should be applicable a to the production of Ta sheet for use as Nb_3Sn superconductor diffusion barrier material, with favorable economics.

75779S04-II

Linearized Wigglers for Damping Rings—STI Optronics, Inc., 2755 Northup Way, Bellevue, WA 98004-1403; 425-827-0460, www.stioptronics.com
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Dr. William J. Thayer, III, Business Official, bthayer@stioptronics.com
DOE Grant No. DE-FG02-04ER84081
Amount: $500,000

Both U.S. and European scientists are evaluating the use of permanent magnet wigglers to reduce emittance in the damping rings linear colliders. This project will address two problems related to this approach: (1) nonlinear magnetic fields and transverse roll-off can disrupt the beam quality and damage the wiggler, and (2) electron cloud build-up. During Phase I we will analyze two novel approaches. In Phase I, two novel approaches to reduce transverse roll-off and nonlinear field effects were analyzed using magnetic field analysis software. The analysis demonstrated performance could be improved by a factor of 40 with a 50 percent reduction in magnet costs. In Phase II, protypes will be built and verification tests will be performed to validate the Phase I analysis. *Commercial Applications And Other Benefits* as described by the awardee: Besides addressing the problem of transverse roll-off and nonlinear field effects in colliders, the linearized wiggler should also be less expensive to build. This reduced cost should directly benefit other applications of wigglers, such as in synchrotron storage rings, industrial processing, medicine, and academia.

75785S04-II

Ultra-Sensitive, Compact Mid-Infrared Spectrometer for Airborne and Ground-Based Atmospheric Monitoring—NovaWave Technologies, Inc., 230A Twin Dolphin Drive, Redwood Shores, CA 94065-1499; 650-610-0956, http://www.novawavetech.com
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DOE Grant No. DE-FG02-04ER84027
Amount: $749,991

Recent advances in both mid-infrared laser sources and ultra-sensitive optical detection technologies offer the promise of studying trace atmospheric species such as formaldehyde with unprecedented detail and accuracy. The development of corresponding instrumentation, suitable for both airborne and ground-based monitoring applications, would have a wide ranging impact on our understanding of atmospheric chemistry and dynamics. This project addresses this need by combining a novel tunable single-frequency, mid-infrared laser source with cavity ringdown spectroscopy. The combination will allow many important atmospheric constituents (including formaldehyde, CO, ethylene, acetylene, and N_2O) to be monitored with unprecedented sensitivity (less than 25 ppt_v mixing ratio) in real time (less than 30 seconds). In Phase I, a single-frequency infrared laser source, operating in the 2.65 micron spectral region, was constructed and fully characterized. The source produced up to 3 mW and 30 microwatts with and without a fiber amplifier, respectively. The source was combined with cavity enhanced spectroscopy to demonstrate the sensitive detection of water vapor isotopes. Phase II will significantly refine the infrared laser source as well as the overall apparatus. The apparatus will be integrated into an instrument capable of performing long-term, unattended field measurements of a variety of atmospheric trace species. *Commercial Applications and Other Benefits* as described by the awardee: The instrument should have a wide ranging impact on our understanding of atmospheric chemistry and dynamics. Commercial applications for the technology include trace gas monitoring, pollution monitoring, and industrial process monitoring.

75787S04-II

High-Pulse-Rate Sources for Active Imaging Systems—Q-Peak, Inc., 135 South Road, Bedford, MA 01730-2307; 781-275-9535, http://www.qpeak.com
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DOE Grant No. DE-FG02-04ER84049
Amount: $749,921

In support of systems to detect the proliferation of nuclear weapons, Los Alamos National Laboratory (LANL) has developed a photon-counting, Remote Ultra-Low Light Imaging sensor that has many advantages over conventional range-imaging devices. However, the photon-counting design requires a laser with unique characteristics: namely, a pulse rate in the 1 kHz-1 MHz range with a pulsewidth less than 1 ns. This project will develop compact seed lasers, to generate the needed pulse format, along with a compact power amplifier capable of power levels of 10 W or higher. The seed lasers will use 1064-nm, short-cavity, diode-pumped solid state lasers with either passive or active Q-switches. The amplifier will be an adaptation of a commercial product, configured for this particular application. Phase I designed the passively Q-switched seed laser; designed, constructed, and tested a short-cavity, actively Q-switched laser; tested an amplifier stage; and conducted an initial design of the packaging for the entire laser source. Both spreadsheet and rate-equation models for the passively and actively Q-switched lasers were developed and verified against experimental data. In Phase II, the semiconductor-based, passive Q-switches, will be fabricated; a breadboard facilty to test the lasers and the power amplifier will be built; system output will be converted into a green wavelength; and the entire system will be packaged into a ruggedized, modular configuration. At the end of Phase II, the system will be delivered to LANL for testing and system integration. *Commercial Applications and Other Benefits* as described by the awardee: Beyond the application to non-proliferation sensors, the Remote Ultra-Low Light Imaging sensor should be applicable to: NASA, for precision landing sensors; the DoD for intelligence on and tactical imaging of areas of interest; and various environmental agencies in need of accurate imaging data for, say, crop and vegetation analysis. The high-pulse rate laser source also should find use in Geiger-mode detectors, micromachining, and laser display systems.

75797S04-II

Adaptive On-Line Monitoring for Improved Equipment Reliability—Expert Microsystems, Inc., 7932 Country Trail Drive, Suite 1, Orangevale, CA 95662-2120; 916-989-2018, http://www.expmicrosys.com
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Mr. Randall Bickford, Business Official, rbickford@expmicrosys.com
DOE Grant No. DE-FG02-04ER83949
Amount: $600,000

In order to ensure the continued safe, reliable, and efficient operation of the Nation's nuclear power plants, improvements are needed in the accuracy and timeliness of information delivered to the operators about the condition of the plant equipment. The information is needed to determine the operability of safety and control systems, the health of active equipment, the necessity of preventative maintenance, and the status of sensory systems. This project will develop adaptive modeling and decision support software techniques to enable more effective life cycle management of aging nuclear plant equipment. The overall approach is to capture and preserve essential equipment diagnostic knowledge from veteran operators, so that the software can use this knowledge to assess equipment performance and integrity automatically and in real-time. In Phase I, adaptive on-line learning algorithms were demonstrated to enable the automated optimization of equipment-monitoring software for a wide variety of power plant systems. New decision support techniques were shown to be effective in capturing diagnostic knowledge in a portable and reusable format and to provide much earlier detection of equipment problems compared to current industry practice. Phase II will develop and implement adaptive modeling procedures to enable the production of more cost-effective equipment-monitoring software; develop and implement an effective on-line decision support capability; deploy and demonstrate the technology at two representative U.S. nuclear power plants; and produce a commercial-ready product for market development. *Commercial Applications and Other Benefits* as described by the awardee: In addition to the application for nuclear power plants, the on-line equipment-monitoring software should be applicable to any process control system where unexpected process interruptions could cause equipment failures, false alarms, or unsafe conditions. The new capability should substantially improve plant uptime, thereby increasing output and operating revenue in a wide range of industries.

75803S04-II

A Method for Electroforming Copper with Ultra-Low Levels of Radioactivity—Reeves & Sons, LLC, 2000 Logston Boulevard, #133, Richland, WA 99354; 509-943-1653
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Mr. James H. Reeves, Business Official, ark.ie@verizon.net
DOE Grant No. DE-FG02-04ER84060
Amount: $700,000

The search for rare events, such as double beta decay and dark matter, requires large masses of detectors and support materials. These extremely rare events are difficult to distinguish from other interactions caused by the radioactive decay of radionuclides contained in these materials. Therefore, if these materials could be made virtually free of radioactive contamination, the probability of successful searches would be enhanced. In this project, the radiopurity of one such material, electroformed copper, will be enhanced by using an already pure form of copper, oxygen-free high conductivity (OFHC) copper, which is electroplated in baths assembled from ultra-pure chemicals and construction materials. By performing the electroplating deep underground, cosmic-ray-induced radioactivity, which would otherwise be present in the copper, can be radically reduced. Other metals could be produced in a similar manner. In Phase I, an underground copper electroplating laboratory was constructed and outfitted with plating baths made from very pure plastics and high purity chemicals. It was shown that ultra-pure copper, collected on the cathodes of one bath, could be used as anodes in a second bath, thus progressively increasing the purity of the final product. In Phase II, techniques will be developed for testing the plating bath and the quality of the copper produced. Methods will be developed to continually clean the bath of radioactive contaminants thus prolonging the useful life of the bath. Two tons of copper will produced for use as inner shielding for ultra-low background detectors. *Commercial Applications And Other Benefits* as described by the awardee: The high purity material would have applicability to research projects in nuclear physics and other sciences.

75812S04-II

Development of Polymer Processing Techniques for Dramatic Cost Reduction of Large Core Plastic Optical Fiber, for Use with Advanced, High Intensity Discharge (HID) Distributed Accent Lighting System—Fiberstars, Inc., 32000 Aurora Road, Solon, OH 44139-2814; 440-836-7421, http://www.fiberstars.com
Mr. Chris Jenson, Principal Investigator, cjenson@fiberstars.com
Mr. Roger Buelow, Business Official, rbuelow@fiberstars.com
DOE Grant No. DE-FG02-04ER83957
Amount: $749,749

Incandescent and halogen accent lights remain some of the last lighting applications without cost effective, energy efficient solutions. Potential energy efficient lighting systems exist; for example, one high efficiency metal halide lamp and ballast can run eight points of light. However, these systems have product limitations due to their high cost. This project will optimize the fabrication of the plastic optical fiber components of the system, reducing the cost per point below that of conventional halogen sources. In Phase I, eight alternatives were identified that would simplify the downstream polymer processing. Two of the processing alternatives were shown to offer dramatically reduced post-extrusion processing time and lower costs. In Phase II, the two polymer processing alternatives will be further developed. The best approach will be carried into a pilot scale demonstration of the technology. *Commercial Applications and Other Benefits* as described by the awardee: The lighting system should provide the energy efficiency of a metal halide lamp at the cost of a halogen lamp. Applications include: supermarkets, where the lack of infrared and ultraviolet radiation would permit food to stay fresh longer; clothing and jewelry stores at malls, where savings in energy usage and the costs of lamps will be significant; and office buildings where low fixture costs and an 80% savings in installation costs will be a factor. Altogether, approximately 0.19 quads of energy per year could be saved as this product is used in new installations and energy retrofits.

75823S04-II

A 200 km/s Plasma Accelerator for Magneto-Inertial Fusion and for Refueling Magnetic Fusion Energy Systems--HyperV Technologies Corp., 11316 Smoke Rise Court, Fairfax Station, VA 22039-1002;
703-250-3689, http://www.hyperv.com
Dr. F. Douglas Witherspoon, Principal Investigator, fdwitherspoon@compuserve.com
Dr. F. Douglas Witherspoon, Business Official, fdwitherspoon@compuserve.com
DOE Grant No. DE-FG02-04ER83978
Amount: $652,500

In magneto-inertial Fusion, which offers the promise of a faster, lower cost path to fusion energy, a material liner is imploded to compress a magnetized target plasma to fusion conditions. In one approach, plasma-jet-driven magneto-inertial fusion, an array of pulsed plasma guns is utilized to create a spherically imploding shell of very high velocity, high momentum flux plasma. This approach requires the development of plasma accelerators capable of achieving velocities of 200 km/s, with very precise timing and density profiles. This project will investigate a new coaxial plasma accelerator configuration, which will allow the acceleration of high density collisional plasmas to velocities of 200 km/s. To control and prevent the formation of deleterious instabilities, such as the blowby instability, a specialized plasma injection system will be developed. In Phase I, magnetohydrodynamic (MHD) modeling, using the AFRL Mach 2 code, was used to confirm the concept. An additional geometrical configuration of the coaxial electrode profiles, which can achieve the required mass and velocity parameters, was identified. Experimental hardware for a Phase II experiment was designed, and preliminary experimental tests demonstrated the successful operation of the plasma injector hardware design. In Phase II, the plasma injector and associated accelerator hardware will be built, followed by an experimental demonstration. MHD computational modeling and code benchmarking will be performed, using the experimental data, to establish a scientific database for high velocity, high momentum flux plasma jets. *Commercial Applications and Other Benefits* as described by the awardee: The plasma jets should be useful for developing commercial fusion power, refueling magnetically confined plasma, high specific impulse plasma thrusters for space, laboratory simulations of astrophysical jets, ultrafast high current switches for pulsed power applications, and materials processing.

75825S04-II

High Efficiency, White TOLED Devices for Lighting Applications—Universal Display Corporation, 375 Phillips Boulevard, Ewing, NJ 08618-1428; 609-671-0980, http://www.universaldisplay.com
Dr. Michael Lu, Principal Investigator, vadamovich@univeraldisplay.com
Ms. Janice K. Mahon, Business Official, jkmahom@universaldisplay.com
DOE Grant No. DE-FG02-04ER84113
Amount: $750,000

General lighting is responsible for more than 20% of the energy consumption in the U.S., New broadband white-lighting sources are sought that offer significant gains in power efficiency and color quality while having less environmental impact than traditional incandescent and fluorescent lights. Recent breakthroughs in highly-efficient phosphorescent organic light-emitting device (PHOLED) technology have created an enthusiasm that this technology may someday provide such a solution. However, significant engineering challenges remain. For example, OLED extraction efficiency needs improvement in order to meet the demanding power efficiency targets of general lighting. This project will develop a higher-optical-extraction-efficiency device using transparent-cathode OLED (TOLED) technology for white lighting sources and future smart windows. Phase I simulated and fabricated a white transparent phosphorescent OLED (T-PHOLED), with light output equivalent to a conventional bottom emission OLED, and demonstrated an approximately 1 cm^2 white T-PHOLED light source on a glass substrate. The resulting optical extraction was 20% greater than that for a similar conventional bottom emission device. Phase II will further improve the TOLED efficiency by optimizing the cathode transmission, replacing the conventional glass package with a monolithic mutilayer thin film encapsulation, and optimizing the design by taking advantage of microcavity effects and reduced optical losses at the air/OLED interface. Lastly, a phosphorescent TOLED lighting prototype will be fabricated to achieve greater than 25 lm/W at a luminance of 1,000 cd/m^2. *Commercial Applications and Other Benefits* as described by the awardee: The light source should find use in diffuse lighting applications in commercial, residential, and industrial sectors. Because the product can be thin, lightweight, and transparent, it also should find use in architectural, automotive, and wearable electronic applications.

75853B04-II

High Availability Unmanned Aerial Platform for Carbon Cycle Measurements—KalScott Engineering, Inc., 3226 SW Timberlake Lane, Topeka, KS 66614-4515; 785-979-1113, http://www.kalscott.com
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Mr. Tom Sherwood, Business Official, tom.sherwood@kalscott.com
DOE Grant No. DE-FG02-04ER83986
Amount: $749,959

Carbon cycle monitoring is a key component of the mission to understand global scale climate change. In particular, there is a need to accurately measure atmospheric carbon dioxide levels at regular intervals, and at various altitudes and locations, using low cost and simple aerial platforms. This project will create and demonstrate an unmanned aerial vehicle (UAV) that will lift carbon monitoring payloads from the ground to an altitude of 10,000 feet. The high-availability UAV will be able to perform long endurance missions at low cost. Phase I developed a concept for operations and defined the fuctional and technical requirements for the UVA and supporting systems. Phase II will integrate the carbon dioxide and other sensors into the selected air vehicle platform. The air vehicle will be tested under human pilot control, radio control, and finally, fully autonomous mode flight. The performance of the instruments will be evaluated, and the efficiency of the measurements system will be validated. *Commercial Applications and Other Benefits* as described by the awardee: The primary application of the UAV would be for stand-off monitoring of environmental parameters such as the atmospheric distribution of key gases, aerosols, radiation studies, global albedo, etc. In addition, the UAVs could be used for radiological, biological, and chemical threat monitoring for military and homeland security applications. Lastly, the UAVs could serve as communications nodes for emergency situations, and could be used to monitor wildfires, crops, weather, and traffic.

75857S04-II

Improving the Performance of High Gradient RF Structures by Surface Treatment with Gas Cluster Ion Beams—Epion Corporation, 37 Manning Road, Billerica, MA 01821; 978-215-6212, http://www.epion.com
Dr. David R. Swenson, Principal Investigator, dswenson@epion.com
Mr. Allen Kirkpatrick, Business Official, akirkpatrick@epion.com
DOE Grant No. DE-FG02-04ER83944
Amount: $600,000

Mitigation of high voltage breakdowns is a major concern in the development of higher-field radio frequency (RF) cavities for next generation accelerators. It is widely believed that the local surface condition of high-voltage electrodes, at atomic-scales, is the critical factor that determines the maximum electrical field strength that can be maintained without breakdown. However, all existing techniques for electrode surface preparation and conditioning fail to provide adequate correction and passivation of atomic scale defects and asperities. As a result, RF cavities invariably must be operated at much lower potentials than would otherwise be possible. This project will apply an established surface processing technique, Gas Cluster Ion Beam (GCIB) smoothing, to produce surface smoothing to atomic levels on RF cavity surfaces. It is anticipated that use of GCIB smoothing will dramatically increase breakdown strengths and result in a major improvement of operating stabilities. In Phase I, samples of electrode materials with typical surface finish were treated with various GCIB processes. It was found that large asperities could be removed, and that smoothing effects could be extended up to 2μm. A new theory of the role of nanoscale roughness in RF breakdown was developed, and a useful model of cluster smoothing of large asperities was demonstrated. In Phase II, the GCIB chemical removal of the grain structure from Nb electrode material will be further investigated. Studies of the RF breakdown of GCIB-treated electrodes will be conducted, and an apparatus for *in situ* GCIB treatment of RF cavities will be designed and built. *Commercial Applications and Other Benefits* as described by the awardee: Gas Cluster Ion Beam processing of RF cavities would significantly reduce the size and cost of high-energy particle accelerators by allowing reliable operation at higher acceleration gradients. The processing also should increase the service lifetime of RF components by reducing damage caused by RF breakdown, and it may decrease the time and expense of conditioning RF cavities by eliminating steps used to prepare them for high-vacuum, high-voltage operation. In addition, electrode smoothing could benefit any application where achieving the maximum surface field strength is critical.

75861S04-II

High Throughput Fermentation and Cell Culture Device--Gener8, Inc., 897 Independence Avenue, Building 4L, Mountain View, CA 94043; 510-798-5090, http://www.gener8.net
Dr. David L. Klein, Principal Investigator, dklein@gener8.net
Mr. Stephen Boyer, Business Official, sboyer@gener8.net
DOE Grant No. DE-FG02-04ER83963
Amount: $744,608

The Genomes-to-Life (GTL) program has plans to grow multiple microorganisms in high throughput under a variety of carefully controlled-state conditions. To accomplish this, technology will be required to: (1) grow specific biomass under well-characterized states for proteomics, (2) rapidly identify optimal culture conditions for expression of tagged proteins and complexes, (3) express intact protein complexes, and (4) grow microbial cells in nonstandard conditions. To accomplish these objectives, this project will develop 24-well, cassette-based microreactor system with integrated control of critical culture parameters (pH, dissolved oxygen, and temperature). Phase I designed and fabricated a prototype of a cassette-based bioreactor system that not only provided independent, closed-loop control of each well's pH, dissolved oxygen, and temperature, but also offered culture conditions similar to stirred-vessel bioreactors. The prototype was tested with a variety of microbial systems to demonstrate feasibility. During Phase II, the prototype instrument will be optimized, the consumables (cassettes and cassette closures) will be re-designed for mass production, and fluid handling capabilities and a new modular design will be added. *Commercial Applications and Other Benefits* as described by the awardee: A technology gap exists between systems that can be used for controlled cultivation (stirred vessel bioreactors) and systems that can be used in routine screening applications (microtiter plates, shake flasks, spinner bottles, roller bottles). The microreactor system should bridge this gap, creating a set of screening tools capable of controlled cultivation. Applications include public initiatives (the DOE Genomes-to-Life Program and the NIH Protein Structure Initiative), industrial biotechnology (food, animal feed, paper, cleaning products, cosmetics, textiles), and medicine (protein therapeutics are projected to exceed $50 Billion by 2018).

75866B04-II

***STTR Project: Development of PUNDA (Parametric Universal Nonlinear Dynamics Approximator) Models for Self-Validating Knowledge-Guided Modeling of Nonlinear Processes in Particle Accelerators and Industry**—Pavilion Technologies, Inc., 10415 Morado Circle, Building #3, Suite 100, Austin, TX 78759; 512-438-1560, www.pavtech.com
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Mr. Ralph T. Carter, Business Official, rcarter@pavtech.com
DOE Grant No. DE-FG02-04ER86225
Amount: $650,000

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SLAC, Stanford University
Menlo Park, CA

The difficult problems being tackled in the accelerator community are those that are nonlinear, substantially unmodeled, and vary over time. These problems would be ideal candidates for model-based optimization and control if representative models could be developed. Such models must be inexpensive to deploy and maintain, and must remain valid throughout the operating region of the system and through variations in system dynamics. This project will develop methodology and algorithms for building high-fidelity mathematical representations of complex nonlinear systems via a combination of first-principles and neural network models. In Phase I, empirical data and first-principles information were used to train a combined a neural network model and nonlinear parametric model through constrained nonlinear optimization. The combined model was applied to three challenging problems (local orbit correction in electron storage rings and colliders, beamline model verification in accelerators, and gas composition model in gas-phase polymerization reactors), demonstrating both accuracy and computational efficiency. In Phase II, the combined model will be further developed and deployed in three important applications in particle accelerators: (1) minimizing longitudinal emittance for RF photocathode guns, (2) modeling beam loss at storage rings, and (3) to optimizing local orbit correction at storage rings and colliders. Algorithms for self-validation of these models will be developed, and the diagnostic value of such algorithms will be assessed. *Commercial Applications and Other Benefits* as described by the awardee: The new software product should allow the modeler to easily use first-principles information, process data, and operator know-how to build high-fidelity models to address current and future needs in process industries and high-energy physics.

75874S04-II

CO2 Sequestration in Cell Biomass of Chlorobium Thiosulfatophilum—Bioengineering Resources, Inc., 1650 Emmaus Road, Fayetteville, AR 72701; 479-521-2745
Dr. Dinesh K. Arora, Principal Investigator, bresi@aol.com
Mr. Stephen S. Adams, Business Official, sadamsii@aol.com
DOE Grant No. DE-FG02-04ER83907
Amount: $749,940

Worldwide carbon dioxide emissions from the combustion of fossil fuels have increased at a rate of about 3 percent per year during the last 40 years to over 24 billion tons today. One candidate technology for dealing with the carbon dioxide problem involves the anaerobic bacterium Chlorobium thiosulfatophilum, which uses hydrogen sulfide and carbon dioxide to produce elemental sulfur and cell biomass. This project will develop a commercial process for the biological sequestration of carbon dioxide along with the simultaneous conversion of hydrogen sulfide to elemental sulfur. Phase I demonstrated technical and economic feasibility by utilizing the bacterium in continuous reactor studies. Economic projections showed that low quality natural gas (LQNG) can be desulfurized for about $0.23/MSCF, while subsequently converting stoichiometric quantities of carbon dioxide. Phase II will develop the engineering and scale-up parameters for commercialization of the technology. Tasks include culture isolation and optimization studies, further continuous reactor studies, light delivery studies, high-pressure studies, process scale-up, and economic projections. *Commercial Applications and Other Benefits* as described by the awardee: In addition to the sequestration of carbon dioxide in cell biomass, the technology should have immediate application in desulfurizing LQNG or other gas streams. This biological approach should be a viable economical alternative to existing hydrogen sulfide removal technology, because it would not be sensitive to the presence of hydrocarbons acting as catalyst poisons.

75884T04-II

***STTR Project: Cellulose Production and Increased Biomass in Multifunction Crop Plants**—Edenspace Systems Corporation, 15100 Enterprise Court, Suite 100, Chantilly, VA 20151-1217; 703-961-8700, www.edenspace.com
Dr. Michael J. Blaylock, Principal Investigator, blaylock@edenspace.com
Mr. Bruce W. Ferguson, Business Official, ferguson@edenspace.com
DOE Grant No. DE-FG02-04ER86183
Amount: $749,964

Research Institution
Michigan State University
East Lansing, MI

To increase the domestic supply of clean, renewable energy sources, the President's National Energy Policy and the U.S. Department of Energy's Strategic Plan contemplates the increased production of hydrogen as a fuel. The production of hydrogen from plant biomass is especially attractive because it is a renewable energy resource and because it recycles atmospheric carbon dioxide. However, new technologies and co-production opportunities are needed to reduce current costs. This project will create new transgenic crop plants characterized by: (1) greater biomass, (2) constitutive production of endoglucanase, hemicellulase, and ligninase (to aid the post-harvest hydrolysis of plant biomass to simple sugars), and (3) delayed flowering as a bioconfinement technique (to increase plant mass and prevent diffusion of transgenes). In Phase I, proof-of-concept was demonstrated in tobacco by combining the *Acidothermus cellulolyticus* E1 endoglucanase gene with *Arabidopsis* Flowering Locus C (FLC) gene. The transformed plants demonstrated 10% greater biomass, flowering delays averaging 15 days, excellent cellulose activity, and comparable phytoremediation performance, compared to control plants. In addition, an E1-FLC construct was used to transform maize, which will be grown and tested in Phase II for bioenergy and phytoremediation applications. Also in Phase II, enzyme genes will be added for hemicellulase and a ligninase, in order to increase the percentage of maize biomass that can be converted to biofuels. A pilot demonstration for producing ethanol from transgenic corn stover will be conducted at the National Renewable Energy Laboratory (NREL). *Commercial Applications and Other Benefits* as described by the awardee: The new plants should be useful for production of hydrogen and ethanol through hydrolysis of plant cellulose, particularly in co-production with an agriculture-based application such as phytoremediation. The plants also should be useful in the production of low-cost celluloses for other industrial markets.

75903T04-II

***STTR Project: High Brightness Neutron Source for Radiography**—Adelphi Technology, Inc., 981-B Industrial Road, San Carlos, CA 94070; 650-598-9800, www.adelphitech.com
Dr. Jay Theodore Cremer, Principal Investigator, ted@adelphitech.com
Dr. Charles K. Gary, Business Official, cgary@adelphitech.com
DOE Grant No. DE-FG02-04ER86177
Amount: $600,000

Research Institution
E. O. Lawrence Berkeley National Laboratory, Sponsored Projects Office/Contracts
Berkeley, CA 94720

Neutron radiography, which uses nuclear reactors and accelerators as sources of neutrons, has been demonstrated to be an excellent method for imaging high-density, thick objects for the detection of corrosion, voids, and cracks, particular in nuclear power plants. Unfortunately, no high brightness neutron sources exist that are portable, inexpensive and capable of neutron radiography in short imaging times. This project will develop a robust, portable, high-brightness neutron generator, which is capable of imaging with reasonable exposure times. The device will produce either fast or thermal neutrons, permitting the imaging of cracks and voids in a wide range of material thicknesses. Phase I simulated the required neutron yield that was needed for a variety of practical imaging situations. Imaging experiments, using both fast and thermal neutrons from prototype sources, were performed. Based on the results, fast and thermal neutron generators were designed. Phase II will fabricate two compact, high-brightness neutron generators that will produce either fast or thermal neutrons. The generators will be rugged and safely operated in a power plant environment. Unlike previous RF Induction, neutron generators, these generators will have their high-voltage components safely enclosed in the interior of the devices, and previously peripheral devices (e.g., RF power matching network) will be integrated into the generator heads. *Commercial Applications and Other Benefits* as described by the awardee: Neutron radiography would be the nondestructive evaluation technique of choice where the diameter and thickness of the piping are too large for x-ray radiography or where the presence of multiple layers of extruded insulation materials around metal piping or conduits renders other techniques (ultrasonic, eddy current, magnetic particle) ineffective. In particular, a compact fast neutron source, capable of penetrating steel, lead, or uranium, should greatly improve nondestructive evaluation in nuclear plants. The neutron radiography source also should be applicable to the nondestructive testing needs of commercial and military aircraft, public utilities, and petrochemical organizations.

75905S04-II

Enhancing Charge Injection and Device Integrity in Organic LEDs—Agiltron, Inc., 15 Cabot Road, Woburngton, MA 01801-1003; 978-694-1006, http://www.agiltron.com
Dr. King Wang, Principal Investigator, qwanq@agriltron.com
Dr. Lei Zhang, Business Official, lzhang@agiltron.com
DOE Grant No. DE-FG02-04ER83894
Amount: $749,942

Solid state lighting based on organic light emitting diodes (OLED) offers significant gains in power efficiency, color quality, and lifetime, with less cost and environmental impact than traditional incandescent and fluorescent lights. However, currently available OLED devices do not meet the power efficiency and lifetime requirements for general lighting. Among several limiting factors, two very important ones are: (1) non-efficient and non-balanced charge injection and (2) poor device structural stability. This project will develop innovative, low cost, OLED anode surface modification technology, which will increase device energy efficiency by 5 to 10 times, and simultaneously promote significant thermal stability and long life for the device. In Phase I, anode surface modification agents TPD-$(SiCl_3)^2$ and TPD-$[Si(OCH_3)^3]^2$ were successfully synthesized with high yield and purity. Improvements of approximately 200% in luminance and 50% in energy efficiency were achieved with these materials compared to industry standard, PEDOT-PSS. In Phase II, the TPD-$(SiCl_3)^2$ and TPD-$[Si(OCH_3)^3]^2$ synthesis processes will be optimized for OLED polymers and scaled up cost-effectively to 6 inch wafers. *Commercial Applications and Other Benefits* as described by the awardee: The novel substrates should improve OLED performance and help it realize its potential applications: solid state lighting, high brightness image displays, sign indicators, automobile displays, and wearable electronics.

75909S04-II

Physical Model Development and Benchmarking for MHD Flows in Blanket Design—HyPerComp, Inc., 31255 Cedar Valley Drive, Suite 327, Westlake Village, CA 91362-5607; 818-865-3713, http://www.hypercomp.net
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Dr. Vijaya Shankar, Business Official, vshankar@hypercomp.net
DOE Grant No. DE-FG02-04ER83977
Amount: $652,500

A simulation environment, named HIMAG, is under development for modeling incompressible magnetohydrodynamic (MHD) flows relevant to blanket conditions in fusion reactors. This project addresses two important components of this development: (1) incorporating such physical phenomena as turbulence and extending capabilities beyond fluid flow prediction to the modeling of heat transfer with natural convection and mass transfer, including tritium transport and permeation; and (2) designing a sequence of tests to establish code competence for several classes of physical phenomena. In Phase I, a sequence of benchmark problems were studied for single-phase MHD, and strategies were developed to overcome certain key limitations in HIMAG. A two-equation turbulence model was added to the code and preliminary tests were performed. Graphical interfaces were developed to assist a novice user in in learning the code. Phase II will: (1) incorporate recent advances in MHD fluid flow (eg. turbulence, heat transfer with natural convection, and mass transfer including tritium transport and permeation); (2) perform a set of validation exercises to enhance confidence in the accuracy of the code's predictive capability; and (3) transition HIMAG into a physical module, with this module serving the function of predicting MHD fluid flow and heat and mass transfer. *Commercial Applications And Other Benefits* as described by the awardee: While the breadth of issues dealing with liquid metal MHD has been rather vast, there is no accepted test cases to which the fusion community is uniformly receptive. In addition to providing these test cases, the new code should find use in metallurgical applications, and MHD-based flow control in aeronautics.

75935S04-II

Improved ECR Charge Breeder for Rare Ion Species—Scientific Solutions, P.O. Box 500207, San Diego, CA 92150; 858-485-6411
Dr. Wayne D. Cornelius, Principal Investigator, wcornelius@ssolutions.cc
Dr. Wayne D. Cornelius, Business Official, wcornelius@ssolutions.cc
DOE Grant No. DE-FG02-04ER84066
Amount: $700,000

Conventional electron-cyclotron resonance (ECR) charge breeders, used to create beams of rare ion species as part of the DOE Nuclear Physics program, have gravitated towards higher frequencies and smaller plasma chambers. However, the smaller plasma chambers exacerbate the problems of plasma interactions with the walls and complicate the injection of rare ion species. Increasing the physical dimensions of the plasma chamber should improve the performance. This project seeks to accomplish this goal by developing a charge breeder based on lower frequency operation. Lower frequencies require lower magnetic fields, provide additional volume for larger plasma chambers, and improve the acceptance phase space for injected rare ion species. Phase I created a solid model of a charge breeder using a modular design, which facilitates the easy replacement and/or substitution of major subsystems and components. The device also can be used as a test bed for further development. In Phase II, the cyberspace design of the charge breeder will be converted into hardware. *Commercial Applications And Other Benefits* as described by the awardee: Improvements in the efficiency of converting rare and short-lived radioactive ion species into ion beams for further acceleration is crucial to the future of the Nuclear Physics Research program.

75963S04-II

High Efficiency Nanocomposite White Light Phosphors—Nanosys, Inc., 2625 Hanover Street, Palo Alto, CA 94304-1118; 650-331-2162, http://www.nanosysinc.com
Dr. Jian Chen, Principal Investigator, wkwoo@nanosysinc.com
Mr. Calvin Y. Chow, Business Official, kvergura@nanosysinc.com
DOE Grant No. DE-FG02-04ER84020
Amount: $749,414

Today, 23% of electricity production in the United States is consumed by lighting; yet current technologies (i.e., incandescent and fluorescent sources) operate at a mere 15% or less efficiency. The need exists for a novel, solid-state lighting technology that provides high luminous efficiency and high color rendering at low cost. This project will develop an innovative down-converting system, based on engineered nanocomposite materials, which will dramatically improve the overall cost, performance, and efficiency of solid-state white light (SSWL). This is not merely a new phosphor, but rather a complete down-converting system with the potential to produce solid-state white light that exceeds the performance of the best traditional fluorescent and incandescent bulbs. Phase I proved the feasibility of the concept by: (1) fabricating optimum nanocomposite mixtures based on theoretical predictions; (2) demonstrating the effect of controlling the index of refraction and scattering in the phosphor layer; and (3) projecting eventual performance improvements, based upon the continued materials optimization and device design that will be performed in Phase II. Phase II will focus on the further development of material components and the optimization of white-light device performance. The output of Phase II will be a prototype white-light-emitting device that employs nanocomposite down-conversion technology and delivers a color rendering index greater than 80, a color temperature of 4,000K, a luminous efficiency greater than 200 lm/W, at a cost less than $5/klm.

Commercial Applications and Other Benefits as described by the awardee: High efficiency, high color rending, low power consumption, rugged, long lifetime solid state white lighting should have commercial applications in general illumination (residential, commercial, and industrial) and mobile platforms for signaling and lighting (automobile, aviation, marine, trains). Significant reductions in energy consumption, pollution, and cost should accrue to end users.

75969S04-II

Development of a Magnetically Coupled Borehole Source for Use in Dry Gas Environments—Z-Seis Corporation, 6209 Windfern Road, Houston, TX 77040-4913; 713-690-5880, http://www.z-seis.com
Mr. James Minto, Principal Investigator, jminto@z-seis.com
Mr. Bruce P. Marion, Business Official, bmarion@z-seis.com
DOE Grant No. DE-FG02-04ER84125
Amount: $749,768

Unconventional gas and oil reservoirs (including tight gas sands, coalbed methane, oil and tar sands and shales) are expected to play a vital role in providing secure sources of energy in North America. Subsurface seismic imaging will be required for the proper delineation, completion, and production of these unconventional reservoirs., and powerful borehole sources of seismic energy will be a critical element of the imaging process. This project will develop a magnetically-coupled source to cost effectively impart high levels of seismic energy into the wellbore. Phase I designed and built a small-scale prototype, which produced a definitive, measurable output. The prototype was then reduced in size and operated in cased wells in the oil sands of Canada. The perforance exceeded that of current industry-standard sources. In Phase II, the source will be scaled-up, implemented, and tested to achieve the most powerful prototype source that can be cost-effectively produced.

Commercial Applications and Other Benefits as described by the awardee: The new source is expected to be a critical-path element for the widespread use of subsurface borehole imaging. Specific applications should include: (a) crosswell seismic at 2 km between wells with receivers operated inside production tubing; (b) reverse 3-D VSP in environmentally sensitive areas and rough terrain; (c) high power, cost effective acoustic stimulation; and (d) moving surface seismic below the weathered layer into low-cost horizontal wells.

75974B04-II

Microalgae Biofixation of CO_2 and Fertilizer Production for Greenhouse Gas Abatement—SeaAg, Inc., 705 27th Avenue, SW, Suite 5, Vero Beach, FL 32968-1315; 772-538-1051
Dr. Joseph C. Weissman, Principal Investigator, weissm_j@bellsouth.net
Dr. Joseph C. Weissman, Business Official, weissm_j@bellsouth.net
DOE Grant No. DE-FG02-04ER84067
Amount: $749,135

Microalgae biofixation is a candidate technology for abating the emissions of greenhouse gases, particularly CO_2, while simultaneously producing fuels and chemicals. One approach is to use nitrogen-fixing microalgae (cyanobacteria) cultivated in large open ponds and harvested to produce both renewable fuels (e.g., methane, and possibly, in the future, ethanol or hydrogen) and organic nitrogen fertilizers (as substitutes for chemical fertilizers). However, a major issue is productivity, measured in tons of fertilizers and biofuels that can be produced per acre (hectare) of ponds per year. In this project, cultures of nitrogen-fixing cyanobacteria will be cultivated in open ponds, with the harvested algal biomass digested to generate methane gas and a liquid organic fertilizer suitable for crop production. Productivity will be maximized by selecting for high productivity strains and by developing mutants with reduced light harvesting pigments. During Phase I, wild-type strains of nitrogen-fixing cyanobacteria were isolated and cultivated indoors, and work on outdoor mass cultures was initiated. The anaerobic digestion of cyanobacterial biomass was determined, and selection low pigment- high productivity strains were selected for further study. Phase II will emphasize the outdoor mass culture of both wild-type and low-pigment mutant strains to determine maximum productivity, in terms of both of both carbon dioxide sequestration into biomass and nitrogen fixation. Genetic selection techniques will be used to develop algal strains with low phycobiliprotein content and higher productivities, due to reduced self-shading and photoinhibition.

Commercial Applications and Other Benefits as described by the awardee: The technology should contribute to the production of organic fertilizer in U.S. agriculture, of particular importance after the establishment of the USDA National Organic Plan. One immediate commercial application would be in the production of Spirulina, a commercial microalga used as a food and food supplement.

76008S04-II

Development of an Advanced Deterministic Reactor Physics Modeling Tool—Transpire, Inc., 6659 Kimball Drive, Suite D-404, Gig Harbor, WA 98335; 253-857-1058, http://www.radiative.com
Dr. Todd A. Wareing, Principal Investigator, todd@radiative.com
Mr. Gregory A. Failla, Business Official, greg@radiative.com
DOE Grant No. DE-FG02-04ER84059
Amount: $743,962

A compelling need exists for the development of accurate and efficient reactor physics simulation tools in the analysis of currently operational nuclear reactors, and in the design of next generation reactor concepts. More accurate simulation methods can improve safety and reliability, shorten the development cycle of next generation reactors, and lead to the design of reactors with improved efficiency, safety, and reliability. This project will develop an intuitive, fast, and accurate reactor physics simulation tool that is compatible with established computer aided design (CAD) and computer aided engineering (CAE) practices. It is based on the application of a novel deterministic solver, which has been shown to provide a favorable combination of accuracy and speed for a broad range of simulations. Phase I involved the development and verification of a proof-of-concept reactor modeling process. Both steady-state and time-dependent simulations were run, and the results were compared to experimental data. The accuracy and efficiency of the solutions verified the feasibility of the approach. Phase II will focus on the development and testing of enhancements that can improve efficiency, accuracy and ease-of-use for the analysis of both commercial and research/test reactors. In particular, solver and model generation enhancements will be incorporated, a graphical user interface will be developed, cross section and thermal-hydraulics integration will be provided, and source generation routines will be developed.

Commercial Applications and Other Benefits as described by the awardee: By reducing uncertainties associated with design and operation, the new simulation tool should help improve the safety and efficiency of a broad range of reactor types, including reactors for commercial power, research, isotope production, and naval and space propulsion.

76022S04-II

High Temperature Electronic Nose for In-Situ Exhaust Measurement—Makel Engineering, Inc., 1585 Marauder Street, Chico, CA 95973-9064; 530-895-2771, http://www.makelengineering.com
Dr. Darby B. Makel, Principal Investigator, dmakel@makelengineering.com
Dr. Darby B. Makel, Business Official, dmakel@makelengineering.com
DOE Grant No. DE-FG02-04ER84132
Amount: $694,243

In order to actively control both combustion efficiency and pollution suppression in industrial boilers, power generation turbines, and other engines, the real-time measurement of exhaust gas composition is required. Current detection techniques are large and expensive and, therefore, not suited for the *in situ* measurement of the exhaust streams of these engines. This project will develop a high-temperature, small-form-factor platform that will allow multiple gas microsensors to perform *in situ* measurements on exhaust stream emissions, allowing the control of combustion parameters for improved efficiency and reduced pollution. During Phase I, individual high temperature sensors were tested, both in the laboratory and in the field, to determine their suitability for detecting emission species. A high temperature packaging concept, suitable for the incorporation of multiple sensors in a compact probe, was developed. In Phase II, sensors will be fabricated for extensive testing and characterization, a prototype system will developed, and the system will be demonstrated at fossil-fueled utilities and/or other relevant facilities. Phase II will culminate in the development and demonstration of a High Temperature Electronic Nose, suitable for monitoring emissions and feedback for the control of boiler burners in utility and industrial applications.

Commercial Applications and Other Benefits as described by the awardee: In addition to industrial boilers and utility boilers, the high-temperature electronic nose should have application to almost any combustion engine, including gas turbine generators, aircraft, and automobile engines. These markets not only are very large, but also will require new technologies to meet the mandated pollution control requirements and to achieve improved engine efficiency.

76023B04-II

***STTR Project: A Compact, In-Situ Instrument for Organic Acid Aerosols**—Aerosol Dynamics, Inc., 935 Grayson Street, Berkeley, CA 94710-2401; 510-649-9360, www.aerosol.us
Dr. Susanne Hering, Principal Investigator, Susanne@aerosol.us
Dr. Susanne Hering, Business Official, Susanne@aerosol.us
DOE Grant No. DE-FG02-04ER86179
Amount: $593,943

Research Institution
Colorado State University
Fort Collins, CO

Among the contributors to atmospheric pollution, carboxylic acids (including mono- and dicarboxylic acids, aliphatic ketoacids, and aromatic acids) are an important class of oxygenated, organic compounds in atmospheric aerosols. To better understand their effect on global climate, and to identify their direct and precursor sources, time-resolved, quantitative measurements of their concentrations are needed. This project will develop an automated, *in situ* instrument for the quantitative measurement of the concentrations of organic acids in atmospheric aerosols. The instrument will utilize emerging lab-on-a-chip and capillary electrophoresis technology, along with a new water-based aerosol condensation methodology. Phase I: (1) adapted a new, laminar flow water condensation technology to the direct deposition of submicrometer and nanometer diameter particles; (2) achieved 98% or higher collection efficiency for particle sizes from 20 nm to 1000 nm; (3) interfaced the deposition technique onto a lab-on-a-chip device; (4) evaluated the use of capillary electrophoresis for the separation and quantification of organic acids important to atmospheric aerosols; and (5) achieved the analysis for a suite of 12 compounds ranging from formic to pinonic acid. Phase II will: (1) refine the aerosol-collector/lab-on-a-chip interface to provide for more concentrated collection and for electrophoresis analysis; (2) refine the analytical method to improve separations and extend sensitivities to lower concentrations; (3) integrate the collection and analytical capabilities into an automated system; and (4) test the system under laboratory and field conditions. *Commercial Applications and Other Benefits* as described by the awardee: The instrument should be applicable to the routine, hourly monitoring of carboxylic acids in atmospheric aerosols, providing improved time resolution and data immediacy at lower cost.

76055S04-II

FSML-Fusion Simulation Markup Language for Interoperability of Data and Analysis Tools—Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856, http://www.txcorp.com
Dr. Svetlana G. Shasharina, Principal Investigator, sveta@txcorp.com
Mr. Laruence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-04ER84101
Amount: $652,500

Visualization and analysis of data generated by simulations in the fusion and plasma physics communities are difficult because of the incompatibility among the multiple data formats and multiple data analysis tools. This incompatibility also makes comparison of the data difficult and the inter-working of codes problematic. Therefore, systems are needed to facilitate data interchange and the interoperability of analysis tools. This project will address these problems by developing the Fusion Simulation Markup Language (FSML), which is based on the extensible Markup Language (XML). The system will include: (1) metadata markups and schemas for describing magnetohydrodynamic (MHD) simulation data; (2) uniform C++ API for accessing MHD HDF_5 data on different meshes, and interpolating the data without converting it; and (3) comprehensive three-dimensional (3D) environments for visualization of MHD data. Phase I developed a prototype FSML schema for several fundamental variables of two MHD codes (NIMROD and M_3D), implemented a C++ library for parsing FSML and accessing the native HDF_5 data, and wrapped this library into AVS/Express modules for data visualization. Phase II will generalize the FSML schema to include all fundamental MHD variables and other simulation metadata, facilitating data analysis and visualization, and develop comprehensive modules for 3D visualization using AVS/Express and SciRun. Then, the FSML will be augmented with a set of tools for data interpolation and for accessing data on structured and unstructured meshes through a uniform API.

Commercial Applications and Other Benefits as described by the awardee: The set of tools should enhance data interchange and the interoperability of analysis tools for the fusion community. It should be of immediate use to the Fusion Simulation Prototype Centers. The interpolators should be of use to multiple scientific applications, such as computational plasma physics and astrophysics, and combustion modeling.

76059S04-II

Using Downhole Probes to Locate and Characterize Buried Transuranic and Mixed Low Level Waste—
Applied Physics and Measurements, Inc., 1810 Timber Creek Drive, Missouri City, TX 77459; 281-835-6364
Dr. Donald K. Steinman, Principal Investigator, dksteinman@aol.com
Dr. Donald K. Steinman, Business Official, dksteinmen@aol.com
DOE Grant No. DE-FG02-04ER83902
Amount: $749,907

In order to safely remove transuranic waste (TRU) and mixed low-level waste buried in the subsurface disposal areas (SDAs), it is important to anticipate exactly what materials are directly below the surface. This project will develop neutron-based, logging tools that can identify TRU and volatile organic compounds (VOCs) in the vicinity of probe holes, thereby permitting safer retrieval and removal of waste from the SDA. Phase I demonstrated that the tools can identify the material, quantify its concentration, and estimate the radial distance to objects. Phase II will: (1) modify to the tools to peform reliably, (2) characterize the response of the tools to TRU and VOC materials, (3) develop data interpretation methods based on the characterization data, and (4) demonstrate the value to personnel concerned with waste removal at the SDA.

Commercial Applications and Other Benefits as described by the awardee: The technology should lead to the development of a commercial logging service for SDAs that will be made available to the Department of Energy. In addition, these tools, in modified form, should be directly appicable to the metal mining industry as a complement to core drilling.

76060S04-II

High Performance Algorithm for Signal Decomposition in Gamma Ray Detectors—Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856, http://www.txcorp.com
Dr. Chet Nieter, Principal Investigator, nieter@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-04ER84096
Amount: $700,000

The GRETINA detector, used in nuclear physics research, consists of highly-segmented Ge crystal diodes that produce currents upon impact of gamma rays. The decomposition of these currents into combinations of known signals determines the number, location, and energies of the gamma ray interactions. This decomposition must be done in real time as the experiment runs, which requires fast and efficient algorithms. To address this need, this project will develop signal decomposition software that incorporates singular-value decomposition along with other signal decomposition techniques. In Phase I, the requirements for variable grids for the crystals were examined, Singular Value Decomposition (SVD) was evaluated as a possible algorithm for the signal decomposition, and candidate hybrid algorithms using SVD were identified. Phase II will implement an exact SVD matrix decomposition algorithm that can handle large matrices. Hybrid algorithms for the signal decomposition of highly-segmented gamma ray detectors will be developed, and the algorithms will be applied to the GRETINA experiment.

Commercial Applications and Other Benefits as described by the awardee: The software product should provide gamma ray detectors with greater spatial resolution and efficiency than currently available. Such improved detectors should have use not only in nuclear physics but also in astrophysics and nuclear medicine.

76062S04-II

Power Converters for Diverse Applications—UQM Technologies, Inc., 7501 Miller Drive, P.O. Box 439, Frederick, CO 80530; 303-278-2002, http://www.uqm.com
Mr. Gerald Eberhardt, Principal Investigator, geberhardt@uqm.com
Mr. Donald A. French, Business Official, dfrench@uqm.com
DOE Grant No. DE-FG02-04ER84114
Amount: $600,000

The development of cost effective distributed and renewable energy technologies can reduce the nation's dependence on fossil fuels. However, alternative power sources such wind turbines, fuel cells, and microturbines will require improvements in existing power inverter technologies, in order to make these systems feasible for widespread commercial or industrial use. Existing power inverters are large in size, expensive, limited in power capability, and prone to failure. This project will develop a family of DC/AC power converters that utilize a modular design based upon a current-sourced motor drive. The new design will deliver a smaller, reliable inverter that will operate more efficiently, deliver more power capability, and be more cost effective than what is presently available on the market. In Phase I, a compact DC-DC converter, which will serve as a prototype for a family of modular DC-AC converters, was designed, built, and tested. A packaging concept also was created for the modular inverter. Phase II efforts will entail the complete development of a modular family of DC-AC inverter products. A 5 kW base unit will be designed, built, and tested to demonstrate higher power levels through "stackability." Two 5 kW modular inverters will be used to demonstrate a paralleled power level of 10 kW.

Commercial Applications and Other Benefits as described by the awardee: The energy conversion market is enormous, and products currently on the market are not meeting needs. Applications include private use (farm, home, RV, electric and hybrid-electric vehicles), new energy source use (photovoltaic, wind turbine, fuel cell), commercial use (construction sites, oil wells, telecommunications infrastructure), public utilities support (through distributed generation systems), and federal agency use (military applications, remote site support).

76063S04-II

A Soil Probe for In-Situ Near Infrared Spectroscopic Measurement of Soil Carbon—Veris Technologies, Inc., 601 N. Broadway, Salina, KS 67401; 785-825-1980, http://www.veristech.com
Mr. Colin D. Christy, Principal Investigator, christyc@veristech.com
Mr. Larry Kejr, Business Official, kejrl@veristech.com
DOE Grant No. DE-FG02-04ER84115
Amount: $333,409

International initiatives are underway to reduce greenhouse gases in the air. The sequestration of carbon in agricultural soils is a candidate technology for achieving this reduction; however, more rapid and less expensive methods of measuring soil carbon are needed. This project will develop a soil probe for carbon measurement based on near infrared reflectance spectroscopy. The probe will measure carbon and bulk density in order to provide a rapid inventory of carbon on a field or project scale. In Phase I, a probe was designed that delivered low noise spectra during *in situ* field measurements in Kansas, Missouri, and Iowa. Calibrations using these spectra were used to measure soil carbon with a root-mean-square error of 0.5% or less. Phase II will automate the optical reference on the probe to make it practical for usage by a more general end-user. In addition, modifications will be made to the probe geometry to increase the accuracy of bulk density measurements. Finally, effective calibration methods will be identified, tested, and integrated into a user-friendly interface.

Commercial Applications and Other Benefits as described by the awardee: The soil carbon measurements made by this probe should find use in auditting sequestered soil carbon, the subject of carbon trading and carbon offsets. In addition, the probe and calibration methods would be applicable to the measurement of other soil attributes that are important for making good agronomic decisions.

76066S04-II

Composite, High-Temperature Seals for Gas Separation Membrane Devices—Ceramatec, Inc., 2425 South 900 West, Salt Lake City, UT 84119-1517; 801-978-2114, http://www.ceramatec.com
Dr. S. Elango Elangovan, Principal Investigator, elango@veramatec.com
Mr. Raymond K. Miller, Business Official, rkm@veramatec.com
DOE Grant No. DE-FG02-04ER83919
Amount: $749,856

Ceramic membranes with ion-specific conducting properties can provide gases with purity unmatched by other gas separation methods. However, in order to realize the full potential of these membrane devices, high temperature seal materials are required to isolate the ultrahigh purity product gas from the inlet gas mixture. This project will develop a composite seal material that combines the thermal and physical characteristics of a rigid crystalline phase with the wetting and process compatibility of a vitreous phase. In Phase I, the composite seal was used to demonstrate a leak-tight joint between metal and ceramic couples. Thermal cycle capability was also demonstrated. In Phase II, additional compositions will be evaluated to obtain seal materials with a range of physical and thermal properties. The sealing efficiency will be demonstrated in a short stack assembly of prototype membrane devices.

Commercial Applications and Other Benefits as described by the awardee: The new seal material should be applicable to various types of high temperature membrane devices for use in ultrahigh purity oxygen and hydrogen separations, steam electrolyzers, chemical synthesis reactors, and solid oxide fuel cells.

76075S04-II

Novel, High Energy Density Intermetallic Anode Material for Li-Ion Batteries—Farasis Energy, Inc., 23575 Cabot Boulevard, Suite 206, Hayward, CA 94545-; 510-732-6600, http://www.farasis.com
Dr. Keith D. Kepler, Principal Investigator, kkepler@farasis.com
Dr. Yu Wang, Business Official, ywang@farasis.com
DOE Grant No. DE-FG02-04ER83950
Amount: $750,000

The current classes of anode and cathode materials used for Li-ion batteries do not have sufficient energy density to meet many advanced application requirements. Intermetallic anodes have the potential to triple or quadruple the energy density over current carbon anodes, but have not been able to achieve the cycle life required in an economically viable manner. This project will develop an engineered intermetallic anode that will have a similar cycle life to that of current carbon materials, but with a much greater energy density. The final product will be in powdered form, and will be completely compatible with current Li-ion manufacturing processes. In Phase I, several approaches to make the novel materials were developed and evaluated in coin cells. Much greater cycling efficiency and cycle life was demonstrated with these materials. The best materials were scaled up to make 0.2 Ah cells with $LiCoO_2$ cathodes. Phase II will develop and evaluate a number of the Phase I approaches and process steps for making the high capacity anode. The best synthetic method will be scaled up and used to make large high-energy, high-power cells for evaluation and demonstration.

Commercial Applications and Other Benefits as described by the awardee: The anode material should allow the production of rechargeable Li-ion batteries with at least double the current energy density of commercially available cells, without an increase in cost. Applications should include electric and hybrid electric vehicles (including automobiles, scooters, and bikes), stationary backup power, and portable power applications (e.g., cell phones, computers, and PDAs) for both civilian and military use.

76088S04-II

Zinc Oxide Based Light Emitting Diodes—Materials Modification, Inc., 2721-D Merrilee Drive, Fairfax, VA 22031-4429; 703-560-1371, http://www.matmod.com
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Dr. T. S. Sudarshan, Business Official, sudarshan@matmod.com
DOE Grant No. DE-FG02-04ER83996
Amount: $750,000

The currently-used transparent conducting oxide electrode for OLED construction is very expensive. It is desired not only to lower the electrode material cost, but also to lower its electrical resistivity and increase its optical transmissiveness. In order to improve the cost and efficiency of OLEDs for solid-state lighting, this project will develop an alternate transparent conducting oxide electrode. In Phase I, selectively-doped conducting oxides were deposited on polished glass substrates. The substrates were converted into fully functional OLEDs. In Phase II, these conducting oxides will be deposited on flexible substrates for fabrication of green colored exit signs.

Commercial Applications and Other Benefits as described by the awardee: The alternative transparent conducting oxide electrode should provide for lower cost and higher performance exit signs that have high brightness. Other applications for the transparent conducting oxides are in flat panel displays, electrochromic mirrors and windows, and defrosting windows.

76092B04-II

Large-Scale Microalgae Cultivation in Agricultural Wastewaters for Biofixation of CO_2 and Greenhouse Gas Abatement—Kent Sea Tech Corp, 11125 Flintkote Avenue, San Diego, CA 92121-1213; 858-452-5765, http://www.kentseatech.com
Mr. Michael J. Massingill, Principal Investigator, mmassingill@kentseatech.com
Ms. Barbara D. Cota, Business Official, bcota@kentseatech.com
DOE Grant No. DE-FG02-04ER83988
Amount: $750,000

Novel, cost-effective technologies are needed to stabilize and reduce greenhouse gas emissions. Microalgae have been shown to be able to fix carbon dioxide (CO_2) at high rates, producing a biomass that can be converted to biofuels and chemicals to replace fossil fuels. However, additional research is needed to increase the efficiency of CO_2 fixation and develop the techniques for managing algal cultures in large-scale applications. This project will develop large-scale microalgae-based carbon sequestration technologies using power plant flue gases for CO_2 and agricultural wastewaters as nutrient sources. The algal biomass harvested from the mass culture ponds will be converted to methane fuel, a substitute for fossil fuels, with the residues used as fertilizers. Phase I cultured several strains of microalgae that showed high capacity for CO_2 fixation. Preliminary experiments were conducted to determine the optimal conditions for producing rapid and consistent blooms of microalgae using nutrient-rich agricultural wastewaters. Techniques were identified for concentrating the algal biomass harvested from the ponds and digesting it to produce methane gas. In Phase II, experiments will be conducted to determine the optimal temperature, light, nutrient, water depth, and water velocity conditions for stimulating microalgae growth in the high-rate pond systems. An innovative sedimentation belt concept will be evaluated as a cost-effective means for concentrating and harvesting the algal biomass. Optimal techniques for converting the harvested algal biomass to biofuels (methane gas) and biofertilizers will be developed.

Commercial Applications and Other Benefits as described by the awardee: A carbon sequestration process that results in the production of biofuels and fertilizers should provide sufficient revenues to allow the abatement of greenhouse gas emissions to be accomplished. A potential commercial application of this technology is the removal of nutrients from agricultural drainage waters to prevent pollution of the receiving waters.

76101B04-II

***STTR Project: Fully Integrated Optical Micro Gyroscope**—Elsicon, Inc., Delaware Technology Park, 5 Innovation Way, Suite 100, Newark, DE 19716; 302-266-7030, www.elsicon.com
Dr. Iulian Codreanu, Principal Investigator, icodreanu@elsicon.com
Dr. Wayne M. Gibbons, Business Official, wmgibbons@elsicon.com
DOE Grant No. DE-FG02-04ER86210
Amount: $750,000

Research Institution
University of Delaware
Newark, DE

Tactical grade, miniature gyroscopes are needed in real-time synthetic aperture radar systems that provide the advanced imaging capabilities needed for the detection of nuclear proliferation activities and the enforcement of nuclear nonproliferation agreements. This project will design, fabricate, and demonstrate a breadboard miniature gyroscope that is compact in size, is rugged and robust, has no moving parts, and is completely compatible with planar/wafer-scale fabrication processes – thus being very well suited for low cost, high volume manufacturing. Phase I developed an approach for removing gyro lock-in at low rotation rates, developed and refined fabrication processes, and identified geometric parameters needed to attain the desired performance. Phase II will demonstrate the performance and stable operation of the gyroscope components, integrate the components onto a breadboard, and build a prototype breadboard optical gyroscope. *Commercial Applications and Other Benefits* as described by the awardee: The mini-gyroscope should find use in both the military and commercial sectors. Military applications include platform stabilization, attitude and heading reference systems (AHRS), torpedoes, tactical missiles, smart munitions, and navigation for land military vehicles. Commercial applications include oil drilling and exploration, and tunnel boring equipment. Lower performance optical gyros could compete with the current micro-electro-mechanical systems gyros in such consumer applications as automobiles, robotics, and camera stabilization.

76104S04-II

Self-Cleaning Surfaces with Morphology Mimicking Superhydrophobic Biological Surfaces—nGimat Co., 5315 Peachtree Industrial Boulevard, Atlanta, GA 30338-; 678-287-2402, http://www.ngimat.com
Dr. Yongdong Jiang, Principal Investigator, yjiang@ngimat.com
Dr. Andrew T. Hunt, Business Official, ahunt@ngimat.com
DOE Grant No. DE-FG02-04ER84007
Amount: $749,969

The development of self-cleanings windows and other surfaces could lead to significant energy savings. Unfortunately, current state-of-the-art solutions have a number of shortcomings: low clarity, poor abrasion resistance, and insufficient weatherability. This project will develop low cost, high perfomance, self-cleaning coatings based on the superhydrophobic nature of the lotus leaf. Two proprietary processes, Combustion Chemical Vapor Deposition (CCVD) and NanoSpray technology, will be utilized to synthesize nanostructured surfaces, which will demonstrate improved performance at a much reduced manufacturing cost. Phase I investigated the critical process parameteres for the fabrication of the selected materials system. Excellent material and physical properties were achieved, including optical haze less than 0.5%, water contact angle higher than 165 degrees, and water rolling angle less than 5 degree. In Phase II, the process parameters will be fine-tuned to further improve the film's properties, with a shift in focus from laboratory measured properties (hydrophobicity) to field tested properties (abrasion resistance and weatherability). In addition, the fabrication process will be scaled to accomodate prototype samples (12 inch x 12 inch, or larger) for customer evaluation.

Commercial Applications and Other Benefits as described by the awardee: Self-cleaning surfaces have many applications and therefore several large market opportunities, such as architectural glass, automotive glass (where the self-cleaning feature can result in reduced vehicle weight by eliminating the need for cleaning fluids and improved driving safety), and cover glass of photovoltaic cells (increasing light transmission to the cells and thereby increasing the long-term efficiency of solar panels). It is estimated that self-cleaning surfaces could yield energy savings of over $100 million a year by removing the need for washing, scrubbing, and chemically polishing windows, ceramics, and other surfaces.

76105S04-II

Rapid 3-D Simulation of a Bunch-Length Diagnostic for Laser Wakefield Accelerators via Coherent Transition Radiation at THz Frequencies—Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1858, http://www.txcorp.com
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Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-04ER84097
Amount: $650,000

Laser wakefield accelerator (LWFA) concepts, characterized by ultra-high gradients and ultra-short bunch lengths, show great promise for reducing the cost and size of future high-energy electron linacs. A new non-invasive, bunch-length diagnostic is critical to continuing the rapid advances in LWFA technology. Coherent transition radiation (CTR), generated as the short bunches exit the plasma, could provide this diagnostic if the effects of various secondary complications were quantified. This project will develop particle-in-cell (PIC) simulations to characterize the CTR emitted from a LWFA and self-modulated (SM) LWFA configurations. Phase I demonstrated that explicit two-dimensional (2D) PIC simulations could correctly model a full SM-LWFA interaction, including CTR emission from the micron-scale electron bunches emerging from plasmas. Also, a 2D ponderomotive-guiding-center treatment of the laser pulse was implemented within the framework of the existing PIC code. In Phase II, the ponderomotive-guiding-center model for the laser envelope will be extended to three dimensions, with improved dispersive properties. The emission of THz-scale CTR, from accelerated electron bunches (at 10 μm scale) emerging from the plasma, will be simulated using a numerical technique, in order to obtain far-field radiation patterns from near-field plasma currents. The simulations will be compared with on-going experimental work will clarify the effect of plasma density gradients on THz emission.

Commercial Applications and Other Benefits as described by the awardee: The enhanced PIC simulation code, together with experimental measurements, should provide a uniquely powerful bunch-length diagnostic for plasma-based accelerators. Another potential benefit would be the development of a new and uniquely powerful source of THz radiation, with applications in medicine, science and national security.

76111S04-II

Development of a Distributed Advanced High Intensity Discharge (HID) Lighting System with Instant Light to Directly Replace Incandescent Accent Lighting—Fiberstars, Inc., 32000 Aurora Road, Solon, OH 44139-2814; 440-836-7421, http://www.fiberstars.com
Mr. Roger Buelow, Principal Investigator, rbuelow@fiberstars.com
Mr. Roger Buelow, Business Official, rbuelow@fiberstars.com
DOE Grant No. DE-FG02-04ER83956
Amount: $749,677

Efficient accent lighting systems using distributed lighting do not have instant light when turned on. Until this instant light function is added, incandescent and halogen accent lights, which use about 0.25 quads of energy, will remain as one of the last lighting applications without a cost effective, energy efficient solution. This project will develop a distributed lighting system that can run eight points of light from one high efficiency metal halide lamp and ballast. The improved system will use 80% less energy, have instant light capability, and be cost competitive with halogen systems by splitting the cost of lamp and ballast over eight points. In Phase I, a series of lamp and ballast design tests were conducted to determine the characteristics required for instant light starting, while preserving 80% of system efficiency. The lamp parameters tested included electrode design, fill-gas type, and fill-gas pressure. The ballast parameters included starting pulse voltage, pulse width, pulse repetition, and minimum warm up drive current. Feasibility was demonstrated in operable samples that warmed up to 20% of final light output in as little as one second. In Phase II, final lamp parameters will be determined through structured engineering tests on lamp body size, wall thickness, and inner wall shape. The gas and electrodes will be optimized for manufacturability, and the ballast concept will be developed into a manufacturable design.

Commercial Applications and Other Benefits as described by the awardee: The lighting system should provide the energy efficiency of a metal halide lamp at the cost and instant-on ability of a halogen lamp. Applications include: supermarkets, where the lack of infrared radiation would permit food to stay fresh longer; clothing and jewelry stores at malls, where savings in energy usage and the costs of lamps will be significant; and office buildings where low fixture costs, long lamp life, and an 80% savings in installation costs will be a factor. Altogether, about 0.09 quads of energy per year could be saved as this product is used in new installations and energy retrofits.

76142S04-II

Tm-Doped Ceramic Laser for Laser Accelerator Applications—Boston Applied Technologies, Inc., 6F Gill Street, Woburn, MA 01801-1721; 781-935-2800, http://bostonati.com
Mr. Run Zhang, Principal Investigator, rxhang@bostonati.com
Dr. Hua Jiang, Business Official, hjiang@bostonati.com
DOE Grant No. DE-FG02-04ER83911
Amount: $625,000

High power, high wall-plug efficiency, mass producible, reliable, and low-cost 2 µm lasers are needed for a laser accelerator with Si optics. The technology would benefit the DOE's High Energy Physics program. This project will develop a novel Tm doped ceramic laser material and diode pumped solid-state laser at 2 µm. In Phase I, strong photoluminescence in the 1..87 ~ 2.2 µm region was observed in Tm or Tm/Ho co-doped ceramics while maintaining electro-optical properties, thereby demonstrating the feasibility of the approach. In Phase II, the Tm and Tm/Ho doped ceramic laser materials will be optimized via pseudo-reaction-sintering; longitudinally pumped, solid state Tm- doped ceramic lasers will be designed and constructed; and Q-switching and wavelength tunability will be studied.

Commercial Applications and Other Benefits as described by the awardee: The Tm ceramic laser should find in both defense and civilian applications, including coherent laser radar, remote wind sensing, remote sensing of "smart dust", trans-canopy ranging, stand-off coherent laser inspection of laminated-composite aircraft components, materials processing, ultra fast laser machining, medical therapeutics, entertainment, image recording, and remote sensing.

76144B04-II

***STTR Project: Ion Beam Drift Compression Technology for NDCX**—First Point Scientific, Inc., 5330 Derry Avenue, Suite J, Agoura Hills, CA 91301-5053; 818-707-1131, www.firstpsi.com
Dr. Craig Burkhart, Principal Investigator, burkhart@firstpsi.com
Dr. John R. Bayless, Business Official, jb@firstpsi.com
DOE Grant No. DE-FG02-04ER86184
Amount: $750,000

Research Institution
Lawrence Berkeley National Laboratory
Berkeley, CA

The heavy ion beams produced by modest energy accelerators can be a useful tool for creating strongly coupled plasmas in the warm dense matter regime of high energy density physics. These beams must be compressed both longitudinally and radially to near their emittance limit, in order to achieve the energy density required to drive a sample to the desired plasma state. However, the voltage errors in the acceleration waveforms, which are typical for these types of accelerators, introduce large perturbations to the longitudinal ion energy distribution. This project will overcome this limitation by developing a novel induction accelerator-based energy corrector, which will apply a time-dependent correction to the beam to remove the errors in the longitudinal ion energy distribution. Phase I determined the energy corrector requirements (voltage, accuracy, and bandwidth); designed an induction acceleration module to apply the energy correction to the ion beam; and designed agile-waveform, high-voltage modulators to power the induction acceleration module. In Phase II, prototype versions of the induction acceleration module and modulator will be constructed and tested, and a complete energy correction system will be constructed and tested. The system will then be transported to the national laboratory and installed on the ion beam compression experiment, in order to demonstrate the energy regulation of the ion beam. *Commercial Applications and Other Benefits* as described by the awardee: In addition to the benefits to the heavy ion fusion program, the new class of agile-waveform, high-voltage modulators should find use in numerous applications including low and high energy particle accelerators, pulsed laser systems, RF and microwave generators, and lithographic sources.

76151B04-II

***STTR Project: Multi-Gigabit OS Bypass System for Grid Computing**—SeaFire Micros, Inc., 39 Dodge Street, #319, Beverly, MA 01915; 978-921-0000, www.seafire.com
Mr. James Michael Awrach, Principal Investigator, jma@seafire.com
Mr. James Michael Awrach, Business Official, jma@seafire.com
DOE Grant No. DE-FG02-04ER86204
Amount: $749,945

Research Institution
The Ohio State University
Columbus, OH

Upon transmitting or receiving messages, the classical network interface card (NIC) generates an interrupt to the operating system kernel and thus to the host processor, which must service the interrupt. However, as network speeds approach 10 - 20 Gigabits per second and beyond, the host can be tied down with interrupt latency. To solve this problem, this project will develop new Operating Systems (OS) Bypass hardware and software that implements a variation of Remote Direct Data Placement (RDDP). The architecture will be modular (allowing for multiple component sources) and scalable (to handle bandwidths from 10 through 40 Gigabits per second) while providing true OS Bypass performance. In Phase I, an architecture capable of sustaining scalable bandwidth was developed. New 10 Gbps NPU simulators, capable of supporting the new NPU subsystems, were constructed and tested. Feasibility was proven through network processor simulation using RDDP over dual 10 Gbps NPU's per NIC, for 20 Gbps full-duplex offload per NIC. In Phase II, the architecture will be used as a basis for developing a prototype, which will be tested and verified for packets and full-duplex data rates from OC-192 to 2 x OC-192. *Commercial Applications And Other Benefits* as described by the awardee: The RDDP OS Bypass protocol firmware should benefit the entire Grid Computing community, and sales of related offload engine products should allow scalable, complete offload engines to be introduced into the Grid market. Applications include ultra high-speed offload engine capabilities for Grid Computing and for cluster computing, GridFTP Lite compatibile offload engines, long-haul WAN NIC’s with FEC, TeraGrid Cluster WAN’s, and Blade Servers.

76166B04-II

Automated Impedance Tomography for Monitoring Permeable Reactive Barrier Health—Multi-Phase Technologies, LLC, 310 Rebecca Drive, Sparks, NV 89436; 775-425-9606, http://www.mpt3d.com
Dr. Douglas LaBrecque, Principal Investigator, dlabrecque@mpt3d.com
Mrs. Marjorie LaBrecque, Business Official, mlanrec913@yahoo.com
DOE Grant No. DE-FG02-04ER84013
Amount: $651,504

Although permeable reactive barriers (PRBs) are an important treatment option for groundwater remediation, no reliable methods are available to monitor or predict their long-term behavior. The large-scale implementation of reactive barriers will require a means of monitoring their long-term degradation. For example, gaps can occur in the placement of the reactive material, particularly when construction methods such as jetting or deep soil mixing are used. This project will develop a reliable method to verify placement and monitor the effectiveness of permeable reactive barriers. The approach will use arrays of inexpensive electrodes, coupled to autonomously operating hardware and software, to characterize the barrier and determine its effectiveness. In Phase I, column studies using ZVI and apatite PRB materials were performed. Numerical modeling showed that a monitoring configuration, consisting of boreholes spaced at 2 m intervals along the upstream face of the barrier, could be tuned to detect age-spots of 2x3 m in size. Existing instrumentation was modified to provide autonomous operation using solar power, and a reliable, low-overhead protocol for two-way communications was implemented. In Phase II, a full scale field validation for an existing, instrumented PRB will be performed. Web-based, automated geophysical monitoring systems will be enhanced, and software for imaging the temporal signature of an aging PRB will be developed.

Commercial Applications and Other Benefits as described by the awardee: The automated monitoring system should find use in more than 100 permeable reactive barriers that will have been installed in North America by the time this project is completed.

76181B04-II

***STTR Project: Fast Real-Time Decision Processor Using an FPGA Array**—Northern Microdesign, Inc., 533 193rd Street, Ames, IA 50010; 515-232-0990, www.nmicrodesign.com
Dr. Nader Badr, Principal Investigator, nbadr@microdesign.com
Dr. William Black, Business Official, wcblack@nmicrodesign.com
DOE Grant No. DE-FG02-04ER86192
Amount: $750,000

Research Institution
Iowa State University
Ames, IA

In nuclear and particle physics experiments, the beam intensities and rate of collisions are increasing at a dramatic rate; yet, the physics of interest is often contained in events that occur very rarely. This project will develop a trigger processor that can recognize these rare events in real-time, so as to greatly minimize required storage requirements and subsequent data processing. In particular, Field Programmable Gate Arrays (FPGAs) will be configured to efficiently identify the real-time vertex location in nuclear and high energy physics experiments. In Phase I, algorithms for line and vertex determination were developed and demonstrated for collisions expected at the Relativistic Heavy Ion Collider. A vertex finding algorithm was demonstrated on actual FPGA hardware, and architectural issues pertaining to the implementation of the trigger function were addressed. Phase II will build a prototype of an easily reconfigurable and scalable FPGA-based computing engine that will be suitable for the trigger processing function. The prototype will be used in demonstrations of computationally intensive commercial applications such as graphics processing, computer tomography, or real-time network traffic analysis. *Commercial Applications And Other Benefits* as described by the awardee: The processor should be capable of trillions of operations per second with production costs as low as ten thousand dollars in a space comparable to a shoebox. In addition to applications in nuclear and high energy physics, the technology should contribute to commercial and governmental image processing problems such as synthetic aperture radar, computer tomography, beam-forming, image reconstruction and texturing, and code-breaking.

76212S04-II

Multicontaminant Warm Gas Cleanup—TDA Research, Inc., 12345 West 52nd Avenue, Wheat Ridge, CO 80033-1916; 303-940-2300, http://www.tda.com
Dr. Girish Srinivas, Principal Investigator, gsrinivas@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-04ER84091
Amount: $750,000

Emission control technologies for IGCC (Integrated Gasification Combined Cycle) plants must address the removal of mercury, sulfur oxides, nitrogen oxides, and particulates. Two types of technologies are available for synthesis-gas clean-up from these plants: (1) hot gas cleanup (which operates at approximately 1,000ºF) and (2) cold gas cleanup (less than 100ºF). However, a warm gas cleanup technology that operates at 300 – 700ºF could more easily be used in association with downstream power generation (gas and steam turbines) as well as in fuel and chemical synthesis (e.g. methanol and Fisher-Tropsch synthesis). This project will develop technology for the simultaneous removal of sulfur and mercury compounds from syngas in this mid-temperature range (300 – 700ºF). Phase I identified a family of a catalysts that can be used to oxidize the hydrogen sulfide, found in synthesis gas produced by coal gasification, directly into elemental sulfur. These catalysts do not consume valuable hydrogen and can operate at warm gas temperatures of approximately 400 degrees Fahrenheit at gasifier pressures. In Phase II, the catalyst formulation will be further developed and optimized to improve its activity for hydrogen sulfide oxidation and reduce the amount of oxygen that must be added to the system. A bench scale demonstration of the process will be conducted, and an independent evaluation will be performed by an outside laboratory. This will be followed by a detailed economic analysis of the process.

Commercial Applications and Other Benefits as described by the awardee: This technology should significantly improve the energy efficiency and process economics for producing electric power from coal gasification. With this technology, the synthesis gas would not have to be cooled in order to remove the contaminants, thus improving the thermal efficiency of the process.

76223S04-II

A High Efficiency PV to Hydrogen Energy System—Amonix, Inc., 3425 Fujita Street, Torrance, CA 90505-4018; 310-325-8091, http://www.amonix.com
Mr. Kenneth W. Stone, Principal Investigator, info@amonix.com
Ms. Linda Koschier, Business Official, Linda@amonix.com
DOE Grant No. DE-FG02-04ER83900
Amount: $600,000

In order to facilitate energy independence, increased usage of alternative enery sources will be required. Unfortunately, of the renewable technologies now available, there are no viable alternatives that can produce power 24 hours a day. For example, wind energy requires a threshold wind speed and solar energy requires sunlight. However, if solar energy could be used to produce hydrogen, then the hydrogen could be used as a fuel source for fuel cells, which in turn could produce totally clean energy 24 hours a day, 7 days a week. The challenge is to incorporate both of these technologies in an efficient and cost effective system. This project will address this challenge by integrating a high-concentration photovoltaic system with a hydrogem electrolyzer. Phase I identified the system and subsystem requirements for both power input and output. A preliminary design was completed, and estimates of annual hydrogen production and system cost were calculated. Phase II will incorporate a feedback system into the design to ensure the most efficienct use of the solar energy. Efficiencies will be further improved, and costs reduced, by using a smaller silicon device in the solar sub-system.

Commercial Applications and Other Benefits as described by the awardee: The PV-Hydrogen system should contribute greatly to President Bush's 2003 Hydrogen Initiative by providing an alternative renewable energy source for the production of clean hydrogen.

76252S04-II

Low Level Radioactive Xenon Monitoring by Phoswich Detector System—XIA, LLC, 8450 Central Avenue, Newark, CA 94560-3430; 510-494-9020, http://www.xia.com
Dr. Wolfgang Hennig, Principal Investigator, whenning@xia.com
Dr. William K. Warburton, Business Official, bill@xia.com
DOE Grant No. DE-FG02-04ER84121
Amount: $750,000

The detection of dilute radioactive xenon isotopes in the atmosphere is an important component of both national and international efforts to detect clandestine underground nuclear weapons tests. Pacific Northwest National Laboratory has developed an Automated Radioxenon Sampler/Analyzer (ARSA) that concentrates Xe from the atmosphere and then counts it using a nuclear beta-gamma coincidence counter. Although extremely sensitive, this system employs 12 photomultiplier tubes to count 4 sample cells and requires far more complex calibration and gain stabilizations efforts than would be compatible with remote, unattended operations. Therefore, this project will construct a composite "Phoswich" scintillator by joining a fast plastic scintillator for beta detection to a slow CsI(Tl) scintillator for gamma-ray detection, and coupling this composite to a single photomultiplier tube. Phase I demonstrated that a phoswich detector and digital signal processing could be used to detect beta-gamma coincidences characteristic of Xe radioactive decay, achieved energy resolutions equivalent to typical CsI detectors, and found an upper limit for wrongly detecting coincidences of 0.1%. Monte Carlo simulations of the radiation transport and light collection in the detector were used to produce an optimized design. Phase II will build a replacement module for the current ARSA detector system, consisting of four phoswich detectors along with their readout and high voltage electronics, a pulse-shape analyzer integrated with the readout electronics, and a control computer with software for interfacing with the current ARSA system.

Commercial Applications and Other Benefits as described by the awardee: An upgraded ARSA system would be a key component of the U.S. monitoring network for detecting nuclear explosions. The phoswich technology also should find use in the detection of radioactive Xenon emitted by nuclear power plants, providing U.S. and international agencies with a sensitive tool to confirm compliance with environmental regulations. The technology also should have application to the environmental monitoring of key isotopes of nuclear processing activities, and to medical imaging.

76276B04-II

An Analysis Process Execution Language and Execution Engine for High Energy Physics—FiveSight Technologies, Inc., 213 North Morgan Street, Chicago, IL 60607; 312-432-0556, http://www.fivesight.com
Dr. Paul Brown, Principal Investigator, prb@fivesight.com
Mr. Justin Guinney, Business Official, jguinney@fivesight.com
DOE Grant No. DE-FG02-04ER83958
Amount: $450,000

Current data analysis methodologies in high-energy physics often fall short when managing large scale processing tasks over distributed datasets and used by distributed members within a collaboration or working group. There is no commnon semantic to describe analysis workflow and its attributes for the myriad of complex process types comprising a typical physics study. Without a formal syntax, clarity and composition of methodologies, reproducibility of results, and portability of execution are difficult to achieve over the lifetime of typical high energy physics experiment. This project will develop process oriented programming methods and environrments for the production and analysis of distributed datasets in high energy particle physics. This would result in an "Analysis Process Management" system comprised of a reduction engine for process execution, a toolkit for user composition of processes, and a robust set of client tools for analysis, monitoring, and debugging of running processes. The focus of Phase I was on modeling the workflow and replacing the execution module. A prototype system was developed, which provided scalability, recoverability, and process clarity to the Atlas experiment. Phase II will focus on software-controlled process orchestration, specifically the management and analysis of such processes. A foundation of generic tooling will be created, which could be used by operators in assessing and manipulating destributed datasets.

Commercial Applications and Other Benefits as described by the awardee: A system that improves clarity of expression in applications with large data sets should be of interest in both the physics and business communities. Specific opportunites for commercialization include supply chain management, epidemiology, and computational biology.

76293S04-II

Grid Network Session Processing and Forwarding Engine—Open Solutions GP, 43182 Christy Street, Suite 43030, Fremont, CA 94538-3165; 925-846-5331
Mr. Peter Reali, Principal Investigator, preali@sbcglobal.net
Mr. Kam K. Pang, Business Official, kam_k_pang@sbcglobal.net
DOE Grant No. DE-FG02-04ER84032
Amount: $750,000

With network bandwidth increasing more rapidly than processor speed for the past two decades, a serious performance problem exists for the transport, storage, and retrieval of large amounts of scientific data. This project will identify current performance bottlenecks, and develop a high-performance, processing and forwarding engine-hardware architecture that will handle data rates of 10 Gbps and beyond. Phase I developed a software profile and determinged system performance for a scaled-down version (1Gbps) of the Grid Network Session Processing and Forwarding Engine (GNSPFE). The results were used to extrapolate the design of the 10 Gbps Engine. Phase II will develop a prototype 10 Gbps GNSPFE and verify its peformance on a transoceanic network.

Commercial Applications And Other Benefits as described by the awardee: The Grid Network Session Processing and Forwarding Engine should become an enabling technology, providing economical 10 Gbps service to high-performance cluster file systems. In addition, the technology should find use as a Grid network solution for file servers, on-demand video servers, and game servers.

76307S04-II

Development of Solar Grade (SoG) Silicon—Crystal Systems, Inc., 27 Congress Street, Salem, MA 01970-5597; 978-745-0088, http://www.crystalsystems.com
Dr. David B. Joyce, Principal Investigator, djoyce@crystalsystems.com
Dr. Chandra P. Khattak, Business Official, chandra@crystalsystems.com
DOE Grant No. DE-FG02-04ER83928
Amount: $600,000

The continued rapid growth of the photovoltaic (PV) industry (over 60% growth in 2004) is limited by the availability of low-cost solar-grade (SoG) silicon feedstock in large quantities. The use of scraps and surplus silicon from the semiconductor industry is no longer adequate. While the timing is ripe to push photovoltaics as a reliable renewable energy source, further expansion must overcome this materials-availability issue. This project will develop low-cost technology for SoG silicon production by upgrading metallurgical-grade silicon, which is commercially produced in large quantities worldwide. In Phase I, a crucible was developed for the removal of impurities under vacuum processing. Starting with commercially available metallurgical-grade silicon, significant reductions in the difficult-to-remove impurities, B, P and Al, were demonstrated – impurities were reduced from 12, 15 and 370 ppmw to 5.8, 0.23 and 0.065 ppmw, respectively. Phase II will develop techniques to improve the vacuum processing. This step will be followed by directional solidification in order to provide even further reductions in these impurities.

Commercial Applications and Other Benefits as described by the awardee: There is currently no commercial source of solar-grade (SoG) silicon feedstock. By reducing the impurities in metallurgical-grade silicon, this technology should provide a low-cost solution to the materials shortage problem.

76334S04-II

Distributed CCA Components and Grid Services for Scientific Computing—Tech-X Corporation, 5621 Arapahoe Avenue, Suite A, Boulder, CO 80303-1379; 720-974-1856, http://www.txcorp.com
Dr. Johan A. Carlsson, Principal Investigator, johan@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-04ER84099
Amount: $749,799

There is an increasing need to design large-scale scientific computations by combining established codes that use multiple physics models. Currently, there is no systematic way to develop and maintain these applications, which require the simultaneous use of high-performance and distributed resources, such as distributed clusters and supercomputers. To address this problem, this project will extend an existing Common Component Architecture (CCA) framework to support the development of distributed and parallel high-performance computing applications. In Phase I, prototype Remoting Components for adding distributed capability were developed, preliminary performance comparisons were conducted, and procedures for passing arrays in the CCA framework were identified. Phase II will develop software tools for assisting both the creation of Remoting Components and the development of distributed and parallel high-performance computing applications. Support for a modern language feature, “struct", will be added to the scientific interface definition language (SIDL.) Finally, examples that demonstrate the usage and benefit of distributed and parallel high-performance computing will be developed. *Commercial Applications And Other Benefits* as described by the awardee: All software developed will be released as Open Source. Training and consulting services will be provided to customers in industry and government that utilize high-performance computation in such applications as weather and climate modeling, automobile development, and battlefield simulations.