U.S. Department of Energy

Small Business Innovation Research

And

Small Business Technology Transfer Programs

Phase II Grant Abstracts

FY 2008

Improved, High-Moisture Ensiled Crop Feedstocks for Cellulosic Ethanol--
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DOE Grant No. DE-FG02-07ER84770
Amount: $750,000

As grain ethanol production capacity becomes constrained by the available supply of corn grain, production of ethanol from lignocellulosic biomass is widely seen as necessary to meet the surging demand for fuel ethanol. However, the high cost of biomass pretreatment and enzymatic hydrolysis make cellulosic ethanol too expensive. This project will develop technology to improve the quality of ensiled biomass, thus reducing both downstream pretreatment and hydrolysis costs. The approach builds on past research in which ensiled biomass was inoculated with cellulases and other enzymes to increase saccharification (sugar content) and digestibility, thereby improving feed quality for livestock. Analogously, energy crops will be engineered to express such enzymes in plant tissues, with the enzymes activated during ensilement. In Phase I, two crops, switchgrass and corn stover, were bioengineered to produce a cellulase in their leaves and stems. Ensilement increased the level of fermentable sugars in each crop relative to unensiled control crops. In Phase II, three crops – corn, switchgrass, and sorghum – will be bioengineered to produce cellulases in leaves and stems, then grown, harvested, and ensiled. The ensiled crops then will be tested for saccharification levels, improvements in ethanol yield, and reductions in processing cost relative to the control crops. Following Phase II, the technology will be applied to a DOE-supported, pilot-scale cellulosic-ethanol biorefinery in St. Joseph, MO.

Commercial Applications and other Benefits by the awardee: By ensiling crops that produce enzymes, the downstream processing costs of cellulosic ethanol can be reduced. Pricing models have indicated that even slight increases in the levels of fermentable sugars can substantially reduce overall production costs. The new technology will create value-added revenue opportunities for agricultural producers and ethanol cooperatives, and reduce fuel costs for consumers.

Bioprocess for Xylitol from Hemicellulose--ZuChem, Inc., 2225 W Harrison St, Suite F, Chicago, IL 60612-4671; 312-997-2150, www.zuchem.com
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Amount: $748,800

When ethanol is produced from corn, only the starch is transformed, and a significant amount of byproducts is produced. If these byproducts, which are rich in sugars, could be made into a valuable product, the cost-effectiveness of ethanol production will be enhanced. One such potential product is xylitol, a five-carbon polyalcohol that has gained acceptance as a natural food sweetener that can replace sucrose on a weight-for-weight basis. Although xylitol is in high demand by the food ingredient and confectionary industries, its use currently is constrained by the limited supply of raw materials. This project will develop a bioprocess to transform waste sugars into xylitol, thereby improving the economics of ethanol production. In Phase I, bacterial host strains were developed for the transformation of these waste sugars. In addition, the various feedstocks that would feed the bioprocess were evaluated, several prototype bioconversion systems were assembled and tested, and some preliminary metabolic engineering was performed to demonstrate feasibility. Phase II will involve further metabolic engineering, fine-tuning of the fermentation process, and scaling-up the process to commercial levels.

Commercial Applications and other Benefits as described by the awardee: The new bioprocess should significantly reduce the cost of commercial xylitol production, free xylitol production from the current raw-material-availability constraints, and have a positive impact on the economics of fuel ethanol production. Moreover, domestic firms would be able to produce xylitol more cheaply, thereby avoiding the need to relocate manufacturing facilities to Southeast Asia. Finally, the new bioprocess should be inherently cleaner and safer than the existing hydrogenation process for xylitol.

Flexible Spectrum Splitting Holographic Concentrator--Luminit, LLC, 20600 Gramercy Place, Suite 203, Torrance, CA 90501; 310-320-1066; www.luminitco.com
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DOE Grant No. DE-FG02-07ER84775
Amount: $750,000

The DOE has undertaken a new Solar America Initiative (SAI) to accelerate the development of photovoltaic systems, with the goal of making solar energy cost-competitive with other forms of renewable electricity by the year 2015. In support of this goal, this project will demonstrate a low-cost flexible Spectrum Splitting Holographic Concentrator (SSHOC) that focuses light onto solar cells with high efficiency, thereby increasing the output of existing photovoltaic (PV) systems. The SSHOC, which is based on four thin film holographic optical elements that are dispersion- and aberration-corrected, is easily manufactured, has 99% diffraction efficiency, is lightweight, and has low-cost. Phase I demonstrated feasibility by theoretical analysis and computer modeling, and by fabricating a compact experimental prototype. Spectral characteristics of the prototype were investigated through a series of laboratory experiments, performance tests, and the analysis of the results. A number of advantages over existing techniques and approaches were demonstrated: (1) highly stable spectral characteristics of volume holographic multilayers, (2) compact packaging into a single module for all wavelengths, and (3) tunable bandwidths over a spectral range from visible to near IR. Phase II will complete the SSHOC development and optimize the holographic optical elements so that they will be mass producible and superior to state-of-the-art technologies in terms of both performance and cost.

Commercial Applications and Other Benefits as described by the awardee: The flexible SSHOC technology should primarily benefit concentrator PV systems for use with multi-junction solar cells, providing mass reduction, simplified deployment, and increased efficiency and power output. Because it is scalable, the system can be adapted to a variety of applications, from large solar collectors in space to solar tiles for residential homes. The technology also find should find use in a wide range of other applications such as optical imaging systems, optical displays, virtual image displays, and optical instrumentation.

High-Throughput In-Line PV Manufacturing Diagnostic System--Luna Innovations Incorporated, 1 Riverside Circle, Suite 400, Roanoke, VA 24016; 540-769-8430; www.lunainnovations.com
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DOE Grant No. DE-FG02-07ER84776
Amount: $749,993

Photovoltaic (PV) technology is predicted to have a very substantial impact on the nation's wealth and economy in the 21st century. For very-large-scale PV cells, the high standards for production demand a reduction in labor costs and in-line automated methods to monitor and diagnose the production process. This project will develop a high-throughput, in-line, automated diagnostic system that will provide the needed speed and functionality to permit fast, accurate, and automated mapping of the uniformity, composition, and stress of the coating on a PV cell. In Phase I, a hyperspectral imaging setup was designed, assembled, and tested. Necessary software and data processing algorithms were selected and implemented. The feasibility of the approach was demonstrated by testing the assembled system with an organic solar cell. Phase II will involve the development of a mid-IR spectropolarimetric imaging system, capable of fast and accurate characterization of solar cells with structured surfaces. By the end of Phase II, a new high-throughput, in-line PV manufacturing diagnostic system will be completed.

Commercial Applications and Other Benefits as described by the awardee: The technology should yield a number of products, ranging from completely automated systems for in-line diagnostics on large PV manufacturing lines to relatively simple and inexpensive tabletop systems for thin film R&D. The installation of such systems should lead to significant yield improvement and cost reduction of solar cells, resulting in reduced cost for solar energy with an attendant reduction in the use of fossil fuels.

High Performance PV Concentrator--SVV Technology Innovations, Inc., 5022 Bailey Loop, S-te 120, McClellan, CA 95652; 916-714-4917; www.svvti.com
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DOE Grant No. DE-FG02-07ER84784
Amount: $749,882

Although new, high efficiency, III-V solar cells have conversion efficiencies approaching 40%, they are cost prohibitive without increased sunlight concentration. Conventional concentrator designs are capped at 500X magnification. This project will develop a reflective lens optical concept that removes this limit and offers a much greater choice of fabrication techniques and industrial materials for making concentrator modules. The reflective lenses uniquely combine the high concentration ability of parabolic mirrors and the design versatility of Fresnel lenses. The approach also avoids the need for secondary optical stages and aims at achieving manufacturing simplicity, low weight, and improved conversion efficiency. Phase I involved a design study, optical modeling, raytracing experiments, and the fabrication and test of a pilot-prototype concentrator. The resulting optical concentration not only exceeds the minimum benchmark of 500 suns but was close to the ultimate target of 1,000 suns. Phase II will build and evaluate a prototype integrated terrestrial concentrator PV module with high efficiency and a compact form factor. Phase II also will address issues associated with mass production, outdoor stability, and useful lifespan.

Commercial Applications and Other Benefits as described by the awardee: The technology should enable the replacement of conventional PV modules with inexpensive, flat-plate III-V concentrator panels that utilize up to 1,000 times less PV materials. Commercialization of the concentrator PV panels will help meet the national goals of securing energy independence and reducing carbon emissions.

In-line Crack Detection in Silicon Solar Cell Production Using Resonance Ultrasonic Vibrations--Ultrasonic Technologies, Inc., 27247 Breakers Drive, Wesley Chapel, FL 33544-; 813-974-2031; www.ultrasonictech.com
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DOE Grant No. DE-FG02-07ER84790
Amount: $737,279

Wafer breakage in automated solar cell production lines is a major technical problem and a barrier to further cost reductions in silicon solar module manufacturing. The fragility of silicon wafers is attributed to peripheral and bulk millimeter-length cracks. However, no commercial systems address the critical need for in-line inspection of these cracks. This project will validate the applicability of the Resonance Ultrasonic Vibrations system as a real-time, in-line, manufacturing quality control tool for the fast detection of mechanically unstable silicon solar cells caused by cracks. Phase I confirmed that the Resonance Ultrasonic Vibrations method produced a high 91% crack rejection rate and that the system was capable of matching the 2.0 seconds-per-wafer throughput rate of state-of-the-art solar cell production lines. Phase II is designed to move the technology from the laboratory level to commercial demonstration by developing a system prototype. Specifically, Phase II will (1) specify optimal configurations of the in-line system's component hardware and software; (2) develop and justify a system prototype that meets the major specifications for high throughput, high level of stability, reproducibility of data acquisition and analysis, and high sensitivity with respect to crack length and crack location; (3) design a system platform that allows easy integration within and adaptation to various solar cell production lines; and (4) develop a testing protocol.

Commercial Applications and Other Benefits as described by the awardee: The silicon-based solar industry, with crystalline silicon as a dominant segment, shows outstanding performance, with approximately 25% yearly growth during recent years. The Resonance Ultrasonic Vibration system should provide a critical quality control tool for this industry, thereby improving productivity, increasing the reliability of products, and reducing manufacturing costs.

Development of Highly Efficient Solid State Electrochemical Hydrogen Compressor--FuelCell Energy, Inc., 3 Great Pasture Rd., Danbury, CT 06813-; 203 825-6057; www.fuelcellenergy.com
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DOE Grant No. DE-FG02-07ER84772
Amount: $749,979

With the depletion of fossil fuel reserves, hydrogen-based energy is becoming increasingly important. However, the production, purification, and compression of hydrogen represent key technical challenges to the implementation of a hydrogen economy, especially in the transportation sector where on-board storage of pure hydrogen may require compression at pressures up to 12,000 psi. Existing compressors are inefficient and have many moving parts, resulting in significant component wear and, therefore, excessive maintenance. This project will develop an efficient, low-cost, solid-state electrochemical hydrogen compressor (EHC) based on advanced Polymer Electrolyte Membrane (PEM) technology. Phase I demonstrated a baseline, low cost, solid-state hydrogen compressor cell capable of compressing hydrogen from 50 psi to 2,000 psi, a 40-to-1 compression ratio. Phase II will involve a scale-up of the advanced cell architecture to 6,000 psi capability, development and demonstration of critical sealing technology, and the evaluation of candidate membranes that show low power consumption while minimizing parasitic gas crossover. Ultimately, the 6,000 psi design will be used to develop electrochemical cell architectures capable of compressing hydrogen up to 12,000 psi.

Commercial Applications and Other Benefits as described by the awardee; The EHC should find use in the conversion of low-pressure hydrogen derived from on-site sources to high purity, high-pressure hydrogen for vehicular refueling. In addition, this technology should be scalable, leading to compressors that can move large volumes of hydrogen through pipelines to meet infrastructure demands. In this manner, bulk hydrogen can be effectively delivered to the point-of-use. The technology also should find use in industrial applications, such as in refineries and ammonia plants.

Advanced Sealing Technology for Hydrogen Compressors--Mohawk Innovative Technology, Inc., 1037 Watervliet-Shaker Rd, Albany, NY 12205-2033; 518-862-4290; www.miti.cc
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DOE Grant No. DE-FG02-07ER84779
Amount: $742,891

In support of the hydrogen economy, the DOE seeks to develop delivery technologies for hydrogen as an energy carrier for transportation and stationary power. However, the 2003 DOE Strategic Initiatives for Hydrogen Delivery Workshop determined that existing hydrogen compressor designs cannot meet the need for a reliable, efficient, and cost-competitive transportation infrastructure. This project will develop non-contacting, low-leakage sealing technology for oil-free centrifugal hydrogen compressors capable of transporting up to 1,000,000 kg of hydrogen per day and compressing it from 300 psi to 1,000-2,000 psi. In Phase I, an existing foil seal design was enhanced for use with hydrogen, a subscale version of the enhanced design was fabricated, and preliminary static testing was conducted with air and helium to differential pressures of 100 and 250 psig respectively. The helium was used to simulate hydrogen. Leakage flow coefficients were determined to be substantially less than any other dynamic shaft seal. In Phase II, a full-scale seal will be fabricated, and low leakage will be demonstrated over a wide range of operating conditions.

Commercial Applications and Other Benefits as described by the awardee: The seal technology should allow higher efficiency natural gas pipeline compressors to be built and operated, thereby enabling large-scale hydrogen gas delivery. Based upon the almost 50 million horsepower of natural gas pipeline compressors in service today, it is estimated that the use of oil-free, non-contacting bearings and seals – in both hydrogen and natural gas pipeline compressors – could yield a savings of 33,000 MW-hours of energy per year. Significant potential also exists for application of the sealing technology to more efficient gas turbine engines for aircraft.

Photoelectrochemical System for Hydrogen Generation--Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501; 310-320-3088; www.poc.com
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DOE Grant No. DE-FG02-07ER84869
Amount: $749,999

One of the barriers to a hydrogen economy is the absence of a cost effective method of producing clean hydrogen. The direct electrolysis of water using solar energy (e.g., a photoelectrochemical process) would be ideal. However, this solution requires new semiconductor photoelectric materials with high energy conversion efficiency and high durability, along with the ability to cost-effectively synthesize these materials. This project will develop a new method of inexpensively synthesizing, processing, and stabilizing semiconductor photoelectric materials that can satisfy the performance criteria for photoelectrochemical cells. The approach is based on the electrochemical deposition of A2B6-based semiconductor heterojunctions, both n-type anode and p-type binary cathode. In Phase I, the system was designed and its feasibility demonstrated through simulation and a series of proof-of-concept experiments, including the validation of fabrication steps. The results suggested a hydrogen-production efficiency greater than 12% with a durability longer than 5000 hours. Phase II will involve optimization of the design, exploration of more A2B6 semiconductor films, maturation of the electrodeposition process, and development of a fully functional prototype. The prototype will be tested at a national laboratory to demonstrate its conversion efficiency, durability, and economic viability.

Commercial Applications and Other Benefits as described by the awardee: The semiconductor-based photo electrochemical system for generating hydrogen by solar energy conversion should significantly increase the efficiency of hydrogen production in industrial processes, in particular for hydrogen-hungry industries such as transportation. Other applications include autonomous, highly reliable, no-power sources for hydrogen fuel; augmentation of solar power generation; production of hydrogen for fuel cells; and the spin-off application for fabricating solar photovoltaic cells.

Nanotube Array Photoelectrochemical Hydrogen Production--Synkera Technologies Inc., 2021 Miller Drive, Suite B, Longmont, CO 80501; 720-494-8401; www.synkera.com
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DOE Grant No. DE-FG02-07ER84871
Amount: $750,000

The absence of a practical method for the production of pure hydrogen fuel keeps the potential of a hydrogen economy from being attained. What is perhaps the most-promising future source of hydrogen fuel – water-splitting via sunlight, or photoelectrochemical (PEC) hydrogen production – is currently rendered impractical by a number of technical and economic drawbacks related to materials properties. This project will develop novel nano-materials that will address the materials problems associated with photoelectrochemical hydrogen production. In particular, the approach will be based on a unique, three-dimensional, nanostructured architecture that will enable the attainment of the DOE targets for band gap, lifetime, and chemical conversion. In Phase I, nanotube arrays of PEC materials were fabricated and tested for photoelectrochemical hydrogen production. The feasibility of the nanostructured architecture was demonstrated. In Phase II, the nanostructured architecture will be optimized using the materials developed in Phase I. Once the structure is optimized, new materials will be explored in order to produce highly efficient PEC prototypes. Finally, a stand alone system for distributed hydrogen production will be designed.

Commercial Applications and Other Benefits as described by the awardee: The technology should eliminate one of the major hurdles that keeps the U.S. from capitalizing upon the potential offered by hydrogen, which offers highly efficient and environmentally friendly “limitless” energy and would allow the U.S. to substantially reduce its dependence on foreign oil.

Development of Nacelle Assembly Lifting System (LIFTCAP)--Native American Technologies Company (N. A. Tech. Inc.), P.O. Box 39, Golden, CO 80402-0039; 720-273-3404; www.natech-inc.com
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DOE Grant No. DE-FG02-07ER84868
Amount: $374,999

Utility-scale wind turbines are getting so large that transportation limitations are driving final, onsite assembly costs. To address this problem, this project will design an apparatus for placing wind turbine components – the nacelle, generator, gear box, rotor, and blades – on top of an *in-situ*-fabricated, self-erecting tower, without using an external crane. The approach builds on UltraTall, the result of a National Renewable Energy Laboratory funded project, in which a self-erecting tower (4 sections, 1:15 reduced scale, 5.3 meter tall) was fabricated and tested. However, it was beyond the scope of that project to develop a nacelle placement apparatus. In Phase I of this project, four different design concepts for the nacelle placement apparatus were prioritized and a detailed design of the leading concept was completed. Phase II will conduct a detailed Finite Element Analysis (FEA) of the nacelle placement system (tower plus nacelle placement apparatus), develop a full scale prototype, and then test the apparatus. The plan is to erect three sections of a full-scale UltraTall tower and use the prototype nacelle placement system to lift an equivalent weight. (The construction of a full-scale wind generating system for testing the nacelle placement system is beyond the scope of Phase II.) The nacelle placement apparatus and tower sections will have a complete set of sensors, and a structural health monitoring system will be used to collect data on the structural behavior. That data will be used to validate the FEA.

Commercial Applications and Other Benefits as described by the awardee: The plan for Phase III is to erect and demonstrate a full-scale wind energy system that utilizes the UltraTall tower. The site, which is on a farm in eastern Oklahoma, already has two transmission lines from utilities that have on-going wind-energy programs.

Wind Energy Reliability and Cost Reduction - Wind Turbine Condition Monitoring--Sentient Corporation, 850 Energy Drive, Suite 307, Idaho Falls, ID 83401; 802-876-3100; www.sentientscience.com
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DOE Grant No. DE-FG02-07ER84938
Amount: $747,017

Wind energy has numerous benefits as a power source, including price stability, lack of greenhouse gas emissions, and lack of dependence on imported fuels. As wind increases its penetration into the U.S. power market, it is imperative to minimize costs and maximize reliability, so that it can fully compete with traditional power sources. The primary recurring cost of energy in wind turbines is maintenance. Studies have shown that a few subsystems tend to account for most unscheduled maintenance costs, and for in-service failures and downtime. These subsystems include the gearboxes and the generator. Although technologies to monitor both of these systems already exist in a rudimentary form, these technologies require a large array of costly sensors and data acquisition hardware. This project will develop a low-cost, robust health monitoring system applicable to a wide range of commercial wind turbines. The approach involves the utilization of industry-standard vibration signal processing and condition indicators, which have been developed for aerospace applications. Phase I focused on demonstrating the underlying diagnostic algorithms. Phase II will develop several complete prototypes and demonstrate them on operating wind turbines.

Commercial Applications and Other Benefits as described by the awardee: A low-cost, high-payback health monitoring system would have a significant positive impact on wind turbine operations and maintenance costs. In turn, the net cost of energy for wind power would decrease, providing a good ROI for wind farm operators. Moreover, the reduced cost of energy and increased reliability would accelerate the adoption of this clean energy source. Today's 16,818 MW of wind power are keeping 28 million tons of carbon dioxide, the leading greenhouse gas associated with global warming, out of the air every year. Wind energy also helps revitalize rural and agricultural-based communities, and decreases our dependence on imported fuels.

Reducing Cost and Weight of Wind Turbine Blades Using Engineered Core--
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DOE Grant No. DE-FG02-07ER84792
Amount: $750,000

Wind energy has the potential of producing over 20% of the U.S. near-term electricity needs. However, reaching this potential will require an expansion of wind-turbine sites from the currently-exploited high-wind sites to lower–wind-speed sites. In turn, this expansion will require the development of technologies and manufacturing methods that are effective for both types of sites. A larger wind turbine rotor would provide a candidate solution, if reductions in weight and cost could be achieved. This project will develop a composite engineered core that has the potential to dramatically reduce the weight and cost of large wind turbine blades, while improving key material properties such as shear and fatigue strength. Phase I quantified and demonstrated the benefits of an engineered fiber-reinforced core for general application to large wind turbine blade construction. The benefits compared favorably to currently popular core materials for large blade construction, namely, end-grain balsa and low-density PVC foam. In Phase II, the advanced materials technologies will be applied to the design of new blades and to the replacement of materials in existing blade designs.

Commercial Applications and Other Benefits as described by the awardee: The improvements in core design should directly impact construction and maintenance costs associated with wind power generation. Reductions in initial production cost would lower the overall cost of turbine installation and make adaptation to wind power generation more appealing. Increased blade life due to improved mechanical and fatigue properties would lower downtime and maintenance costs for wind power generation facilities. Increased use of wind energy also would lower the nation's dependence on fossil fuels and foreign energy sources.

***STTR Project: High Performance Permanent Magnets for Advanced Motors--**
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DOE Grant No. DE-FG02-07ER86308
Amount: $750,000

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Better permanent magnets are needed to improve the performance of advanced motors for hybrid electric vehicles. In response to this need, this project will develop high performance permanent magnets with improved magnetic properties at temperatures up to 240^{o}C, high electrical resistivity to reduce eddy current losses in advanced motor applications, and low cost. In Phase I, feasibility was established through compositional and process optimization, including atomic substitutions and additions to enhance magnetic properties, and the use of dielectric constituents to increase electrical resistivity. The research was extended to both Sm-Co and Nd-Fe-B rare earth permanent magnets. Phase II will be dedicated to further optimization, including the development of composite/hybrid magnets with both high magnetic performance and an electrical resistivity that is 5 to 10 times higher than that of commercial magnets. Cost reduction will be addressed by shortening the thermal cycle length, through carefully tuning magnet stoichiometry and the use of less expensive raw materials.

Commercial Applications and Other Benefits as described by the awardee: The new composite/hybrid magnets, along with the simple fabrication process, should contribute to achieving the goal of more affordable high-performance magnets. In addition to the DOE application to advanced motors, the technology should find use in the aerospace and military markets, especially for engine and generator applications.

Low Cost, High Temperature, High Ripple Current DC Bus Capacitors For Hybrid Vehicles--SBE Inc, 131 S Main St, Barre, VT 05641; 802-476-4146;
www.wbelectronics.com
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DOE Grant No. DE-FG02-07ER84870
Amount: $747,477

Currently, no low-cost capacitors provide an elevated temperature, high reliability solution to the DC Bus Inverter need in hybrid electric vehicles. In previous work, an annular film capacitor design, which showed potential for use in the DC Bus application, was developed. The unique shape of the capacitor enables the potential use of polypropylene film at 105°C, a requirement for this application. However, the characteristics of the device in this application over transportation lifetimes need to be understood, and the overall design must be optimized. In Phase I, the characteristics of all of the materials that make up the capacitor were profiled as a function of temperature and fed into a sophisticated modeling program. The results, which were compared with actual tests of an annular film capacitor, confirmed the reliable 105°C operation of the device as a DC Bus Capacitor. In Phase II, the final material selections will be optimized for reliability, a low cost but reliable interconnect scheme will be developed, and a test package (which will allow power-train transportation designers to confidently specify the device) will be produced. In addition, modeling simulations to predict failure modes and lifetimes will be compared with actual test results of manufactured capacitors.

Commercial Applications and Other Benefits as described by the awardee: A low-cost, polypropylene film used as a DC Bus Capacitor, which requires nothing more than available 105°C engine coolant, would enable the potential elimination of a separate coolant loop and reduce the cost and weight of hybrid electric vehicles.

Aromatics from Alternative Sources by Catalysis with Sulfated Zirconia and Related Systems--Eltron Research & Development Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263; www.eltronresearch.com
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DOE Grant No. DE-FG02-07ER84771
Amount: $750,000

The production of high-volume chemicals from non-petroleum sources such as coal is of great importance for a post-oil economy based on alternative and renewable sources. In particular, there is the need to produce high-volume chemicals as feedstocks for various heavy industries. In turn, the solution will require better catalytic industrial processes, especially those based on solid acid catalysts. These processes includes the production of coal-derived Fischer-Tropsch naphtha, a potential large-scale source for naphtha paraffins from which the whole array of industrially-important high-volume aromatics could be produced. This project will design and prepare improved solid acid metal oxides with advanced properties, and test them as selective catalysts in paraffin-to-aromatics and aromatic transformation reactions that are capable of integration into future, coal-derived Fischer-Tropsch plants. Phase I designed, prepared, and characterized a variety of strong acid and superacid solid catalysts, and tested them in various catalytic reactions on a dedicated, fixed-bed microreactor designed and constructed for this project. The ability of some catalysts to effectively and selectively convert C6+ linear paraffins to aromatics and to transform basic aromatics to more valuable aromatics was demonstrated. Phase II will further improve the catalysts, optimize reaction conditions, and design continuous bench-scale processes for aromatics production. Engineering modeling will be used to find the best mode of operation and reactor type.

Commercial Applications and Other Benefits as described by the awardee: The development of more efficient and environmentally-friendly catalytic processes should speed the widespread use of Fischer-Tropsch coal-to-liquid plants for the supply of naphtha feedstock for aromatic hydrocarbons. In addition, the penetration of this technology would help grow the nation’s economy and create more jobs, especially in rural America.

RFCC Catalysts for Chemical Feedstocks--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300, www.tda.com
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DOE Grant No. DE-FG02-07ER84785
Amount: $750,000

When heavy oil and tar sands are accounted for, the petroleum reserves of the Western Hemisphere rival those of the Middle East. Unfortunately, many Western Hemisphere crudes are highly aromatic and contain more metals and sulfur than the light crudes that are currently processed in refineries. One of the most important processes in the refinery is the fluid catalytic cracking (FCC) unit which produces the majority of the gasoline and propylene produced by the refinery. This project will develop a new catalytic additive that can be used during normal FCC operations to (1) increase the conversion of the high-molecular-weight hydrocarbons (bottoms) found in heavy FCC feedstocks into valuable products; and (2) simultaneously lower the vapor pressure of the FCC gasoline stream, so that, when blended with ethanol, the FCC gasoline can meet the vapor pressure specifications for reformulated gasoline. In Phase I, several promising catalyst compositions were identified and tested using the ASTM microactivity test method. In Phase II, the catalysts will be optimized and long-term catalytic cracking tests will be performed in a fluidized bed reactor.

Commercial Applications and Other Benefits as described by the awardee: By increasing the conversion of bottoms in FCC units, refiners should be able to use feedstocks derived from heavy crude oils and still meet the vapor pressure specifications for reformulated gasoline without the loss of product from the FCC unit. The use of this technology not only would increase revenues for the refinery but also would reduce the amount of imported oil that must be processed for making gasoline and petrochemical feedstocks.

Improved Conversion of Cellulose Waste to Ethanol Using a Dual Bioreactor System--Technova Corporation, 3927 Dobie Road, Okemos, MI 48864-3480; 517-485-1402; www.technovacorp.com
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DOE Grant No. DE-FG02-07ER84872
Amount: $749,951

Inedible plant materials such as grass and corn stover represent abundant renewable natural resources that can be transformed into biofuel. Although the enzymatic conversion of biomass to sugars represents an attractive means for this conversion, a number of problems have inhibited its use: the use of incomplete synergistic enzymes, end-product inhibition, and adsorption and loss of enzymes necessitating their use in large quantities. This project will develop a defined consortium of natural microorganisms that will efficiently breakdown biomass to energy-rich soluble sugars, and convert them to cleaner-burning ethanol fuel. In addition, a novel biocatalytic hybrid reactor system, dedicated to this bioprocess, will be developed. Phase I successfully identified and enriched a synergistic bacterial consortium capable of effectively degrading inedible plant fibers. A streamlined bioreactor system utilizing a newly developed nano-biocarrier with enhanced catalyst site density also was developed, and lignocellulose saccharification was accomplished with continuous removal of sugar. Phase II will involve the further optimization of cell growth conditions and a validation of the effectiveness of the nano-biocarriers in enzyme immobilization. Also in Phase II, the design of the bioreactor system will be modified to maximize sugar yield, a continuous fermentation process will be integrated into the system to convert sugars to ethanol, and a prototype reactor system will be developed.

Commercial Applications and Other Benefits as described by the awardee: The technology should enable the development of alternative feedstock pathways for the production of biofuels and large-scale commodity chemicals. The global biofuel market was estimated at $15.7 billion in 2005, and is projected to grow by a factor of three by 2015.

Industrial Production and Applications of Hemicellulose:Lignin Etherase: Prototype Development--Tethys Research, LLC, 53 Downing Rd, Bangor, ME 04401; 207-942-9044; www.tethyresearch.com
Dr. Nancy Gail Kravit, Principal Investigator, ngkravit@tethysresearch.com
Dr. Nancy Gail Kravit, Business Official, ngkravit@tethysresearch.com
DOE Grant No. DE-FG02-07ER84788
Amount: $749,728

American forests have the potential to provide environmentally sustainable, carbon-neutral raw material for much of the nation's energy and chemical synthesis needs. However, wood has not been used to produce chemicals and biofuels because current technology cannot efficiently separate cellulose, hemicellulose, and lignin (the major components of wood) for downstream processing. The major difficulty in fractionating wood is breaking the ether bonds between the lignin and hemicellulose components. Currently, pulp and paper mills rely primarily on chemical means to break these bonds, but chemical methods have many disadvantages: damage to cellulose fibers; inability to cleanly separate the constituents; and serious environmental challenges. In this project, a fluorogenic model compound based on hemicellulose will be used to bioprospect for enzymes that cleave the ether bonds between lignin and hemicellulose. In Phase I, a microorganism designated B603 that secretes an enzyme capable of breaking ether bonds has been discovered. The enzyme was isolated, and its activity on native lignin-hemicellulose complexes was verified. In Phase II, processes will be developed to (1) apply the enzyme to the pre-treatment of wood chips in pulp mills; and (2) more efficiently convert wood into chemicals, for use in integrated forest biorefineries. Finally, molecular biology techniques will be used to facilitate the large scale production of the enzyme.

Commercial Applications and Other Benefits as described by the awardee: As a pre-treatment for wood chips in a pulp mill, the new enzyme should allow previously wasted hemicellulose to be recovered and added back to the pulp, thereby increasing yield. Alternatively, the hemicellulose could be converted via fermentation into an array of fine chemicals and energy products, including ethanol. Broadly speaking, the technology would allow wood, a renewable resource, to be used to meet a significant portion of America's energy and chemical needs. As a consequence, the corn currently slated for ethanol production could again be directed to food products, and America's pulp and paper industry (and the rural towns where mills are located) would receive a much needed economic boost.

Alternative Reaction/Extraction Media to Reduce Energy and Cost of Biodiesel Production--Aerophase, Inc., 401 Mountain View Ave., Longmont, CO 80501; 303-651-1791; www.aerophase.com
Dr. Brooks Hybertson, Principal Investigator, aerophase@hotmail.com
Dr. Brian N. Hansen, Business Official, aerophase@hotmail.com
DOE Grant No. DE-FG02-07ER84836
Amount: $749,859

Worldwide fossil-fuel consumption is skyrocketing – creating major social, political, economic, and environmental problems for the U.S. – and once again revealing the urgent need to boost renewable energy sources, including biodiesel. However, key technical and economic challenges continue to make biodiesel fuel production too costly to compete with other liquid fuels, largely based on the cost of commonly-used feedstock materials and currently-used biodieselproduction processes. This project will develop, validate, and commercialize a biodiesel production method that works when using "cheap" feedstocks. The new method will utilize supercritical carbon dioxide as an alternative medium in which the vegetable oil extraction step is linked with the transesterification reaction to achieve biodiesel production in a continuous, economical process. (In previous work, the benefit of using supercritical fluids was demonstrated separately for the two processes.) Phase I involved collecting experimental data and industrial systems modeling to demonstrate the advantages and of combining the two steps to save the energy costs associated with heating and pressurizing the supercritical fluid medium. Phase II will increase the scale of the process and establish the parameters necessary for successful Phase III commercialization.

Commercial Applications and Other Benefits as described by the awardee: The combination of the extraction and reaction processes into a single, continuous flowing system for the production of biodiesel should provide significant savings in both energy inputs and production costs, and contribute to the DOE goal of reducing U.S. dependence on foreign oil supplies.

Nano-scale High-Surface-Area Thermal Conductive Ceramic Composites as Effective Support for Metal Oxide Catalysts in Alkane Selective Oxidation--EverNu Technology LLC, 1616 Holly Hill Lane, Suite 108, Maple Glen, PA 19002; 610-519-7531; www.evernutech.com
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Dr. Manhua Mandy Lin, Business Official, mandylin@evermutech.com
DOE Grant No. DE-FG02-07ER84794
Amount: $749,989

Compared with conventional processes used to produce many oxygenated chemicals, processes based on the selective catalytic oxidation of alkanes to produce oxygenates could yield enormous economic, energy, and environmental benefits. However, commercial development of such processes has been hindered, in part, because the excessive heat released by alkane oxidation causes over-oxidation (burning) of a significant amount of the oxide catalysts. These catalysts have inherently small surface areas and poor thermal conductivity, and are not able to dissipate the heat. In order to reduce regional over-heating and enhance selectivity to the oxygenate products, this project will design and develop a high-surface-area thermally-conductive material for use as a support for metal oxide catalysts. In Phase I, a nano-scale, high-surface-area, thermally stable and conductive material was designed, prepared, and characterized. This material was used as a support for a model metal oxide catalyst and tested in a model alkane oxidation. Significant enhancement in oxygenate selectivity was observed, as compared with conventional support materials or unsupported catalyst. Phase II will optimize the preparation of the novel support material and demonstrate its application in the selective oxidation of several alkanes. Catalytic testing will be conducted to measure the enhancement in oxygenate selectivity as compared with conventional support materials and the unsupported metal oxide catalysts.

Commercial Applications and Other Benefits as described by the awardee: The novel material should find application as a new product for catalyst support. Its application to various metal oxide catalysts in many alkane oxidations should help speed the commercialization of these alkane oxidation processes, thereby realizing the enormous economic, energy, and environmental benefits of these processes.

Step-Out Process to Upgrade Glycerol to Biodiesel--Exelus, Inc., 99 Dorsa Ave, Livingston, NJ 07039; 973-740-2350; www.exelusinc.com
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DOE Grant No. DE-FG02-07ER84795
Amount: $750,000

The production of biodiesel around the world is increasing at an astonishing pace. In the U.S., total annual production capacity is expected to be almost 2 billion gallons by the end of 2008. At this production rate, over 660,000 metric tons of glycerol will be produced as a by-product each year – over 2.5 times the current U.S. glycerol production capacity – creating a glycerol glut with few outlets. This project aims to develop technology for converting the excess glycerol byproduct from biodiesel production into glycerol tert-butyl ethers, an oxygenated additive for diesel fuel. Phase I demonstrated that this reaction can be conducted in a fixed-bed reactor using a highly active and selective heterogeneous catalyst. The catalyst was proven stable for 50 hours of continuous operation. Limitations on the reaction rate were identified, and methods to overcome these limitations were demonstrated. Phase II seeks to develop reactor configurations and process designs that can be integrated seamlessly into existing yet idle units for the production of methyl tertiary butyl ether (MTBE), taking full advantage of the similarity between glycerol etherification and MTBE process chemistry.

Commercial Applications and Other Benefits as described by the awardee: This technology eliminates the primary waste stream from the production of biodiesel and converts it into a valuable commodity, an additive for diesel fuel. It simultaneously improves the economics and profitability of conventional biodiesel by adding value to a waste stream, allows refiners to meet renewable fuel standards in diesel, and offers MTBE producers the opportunity to utilize existing plants with low capital investments.

Biobutanol Production with Hybrid Membrane-Distillation--Membrane Technology and Research, Inc., 1360 Willow Road, #103, Menlo Park, CA 94025; 650-543-3378; www.mtrinc.com
Dr. Yu (Ivy) Huang, PhD, Principal Investigator, ihuang@mtrinc.com
Ms. Elizabeth G. Weiss, Business Official, egweiss@mtrinc.com
DOE Grant No. DE-FG02-07ER84798
Amount: $749,856

Although biobutanol has a number of clear-cut advantages over bioethanol as a renewable alternative fuel, biobutanol is not currently produced as a biofuel for economic reasons. The current method of biobutanol production, by acetone-butanol-ethanol (ABE) fermentation and distillation, is too complex and energy-intensive. This project will develop a novel membrane-distillation hybrid process for biobutanol separation and recovery that uses membranes for both butanol removal and dehydration. Compared to conventional biobutanol distillation, the proposed technology could lower the energy consumption of the biobutanol separation steps by 87%. In Phase I, two types of membranes were successfully developed to recover and separate ABE from ABE fermentation solutions. The data obtained were used to conduct process simulations that confirmed the technical performance and economic feasibility of the process. In Phase II, the membranes and process design will be optimized, and a hybrid membrane-distillation separation process will be evaluated. A pilot system will be constructed to evaluate the performance of industrial scale membrane modules with both synthetic ABE solutions and real feedstocks. The pilot system will used in a small field test to demonstrate the technology.

Commercial Applications and Other Benefits as described by the awardee: The new membrane technology should enable economic production of butanol, a green fuel alcohol, from renewable resources. Existing and future corn-to-ethanol plants could be retrofitted for butanol production if the technology were proven to be economic. In addition, the technology could be adopted to replace petroleum-derived butanol and acetone.

Intensified Process for Biodiesel Production--United Environment & Energy, LLC, 111 Ridge Road, Horseheads, NY 14845; 607-796-0830; www.eco-web.com
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Dr. Ben Wen, Business Official, b-wen@unitedee.com
DOE Grant No. DE-FG02-07ER84797
Amount: $749,632

Although interest in biodiesel is rapidly increasing, the process by which biodiesel is synthesized has not changed much in the last two decades and is far from efficient. Currently, most biodiesel is made by a homogeneous-catalyst-based transesterification process, wherein soybean oil is reacted with methanol in the presence of sodium methoxide. After transesterification, the homogeneous alkaline catalyst is mixed-in with the biodiesel and the glycerol byproduct. Purification of both the biodiesel and the glycerol, by removing the homogeneous alkaline catalyst, is an energy and labor-intensive operation that produces a waste stream. In addition, the glycerol byproduct resulting from this process is of low quality. This project will develop a catalytic reactor that uses a heterogeneous catalyst for the highly efficient, high throughput, and low cost production of biodiesel. The reactor consists of thousands of microreactors coated with a highly-active, proprietary heterogeneous catalyst. Phase I demonstrated technical feasibility by determining the optimal reactor configuration (including reactor geometry and catalyst loading) and the optimal reactor operating conditions (including reaction temperature, molar ratio of soybean oil to methanol, and space velocity). Phase II will involve scaling the process from laboratory scale to pilot scale, producing a large-size honeycomb catalyst for pilot plant testing, and demonstrating commercial viability.

Commercial Applications and Other Benefits as described by the awardee: The application of the microreactor technology in biodiesel production should significantly increase biodiesel productivity, simplify product separation and purification, improve glycerin quality, eliminate the washing step and associated waste stream, and reduce plant size, and reduce capital and processing costs. In turn, these advantages should expedite the substitution of petroleum diesel with domestically produced alternative fuel, decrease energy consumption and its associated environmental impact, reduce U.S. dependence on foreign oil imports, and enable the U.S. transportation industry to sustain a strong, competitive position in domestic and world markets.

***STTR Project: High Temperature Membrane Reactors--**Compact Membrane Systems, Inc., 335 Water Street, Newport, DE 19804, 302-999-7996; www.compactmembrane.com
Dr. Sudipto Majumdar, PhD, Principal Investigator, smajumder@compactmembrane.com
Dr. Stuart Nemser PhD, Business Official, snemser@compactmembrane.com
DOE Grant No. DE-FG02-07ER86305
Amount: $750,000

Research Institution
Kansas State University
Manhattan, KS

Membrane reactors have the potential to improve reactivity and productivity of various chemical syntheses, including transesterification. However, to be of value, these systems must provide a higher use temperature, improved chemical resistance, and better mass transfer. This project will identify chemically- and thermally-resistant membrane components, fabricate a membrane reactor based on these components, demonstrate enhanced synthesis, and determine economic and energy savings. In Phase I, membrane reactors with far superior thermal resistance (e.g. 200ºC) and chemical resistance were fabricated. Consistent with their hollow fiber design, the membrane reactors exhibited superior mass transfer. Using the membrane reactor, a significant enhancement in the chemical reactions was demonstrated, especially with respect to transesterification and other equilibrium controlled reactions. Phase II will build larger-scale hollow fiber membrane modules (e.g., 1-10 ft^2), and use them to demonstrate enhanced transesterification reactions and the ability to maintain stability when exposed to high temperature and aggressive organics. Finally, the reactors will be field-tested, and the data collected will be used to conduct detailed engineering and economic evaluations, and for comparison to alternative non-membrane reactor processes.

Commercial Applications and Other Benefits as described by the awardee: A broad platform of equilibrium-controlled chemical reactions could be enhanced by membrane reactors. Direct applications for the technology could lead to the production well over 5 billion pounds of product per year, with an energy savings of over 600 trillion BTU/yr. Other applications could be related to the drying of organics, most specifically fuel grade ethanol and pipeline ethanol.

Nanofiber Paper for Fuel Cells and Catalyst Supports--Inorganic Specialists, Inc., 965 Capstone Dr, Suite 327, Miamisburg, OH 45343; 937-865-4491; www.inorganicspecialists.com
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Dr. David Firsich, Business Official, firsich@coax.net
DOE Grant No. DE-FG02-07ER84799
Amount: $721,075

The commercial viability of fuel cells is inhibited by the cost associated with the use of expensive catalysts such as platinum. Thus, a key DOE objective is to reduce the amount of catalysts while achieving improved performance. It has been found that when commercial fuel cell electrodes are modified with a very thin layer of cheap carbon nanofibers, the activity of catalysts on these electrodes goes up many times, allowing far less catalyst to be used. This project will apply this nanofiber modification technology to commercial fuel cell electrodes. In Phase I, a series of commercial fuel cell electrodes were nanofiber-modified in order to identify (1) the type of nanofiber that works best, (2) the optimum thickness for the nanofiber layer, and (3) the best way to apply the catalyst. Phase II will involve a thorough development program to use nanofiber modification to improve the existing products of a major manufacturer, which will be a collaborator on the project. An improved product, which uses less catalyst and is readily manufactured, will be demonstrated.

Commercial Applications and Other Benefits as described by the awardee: The nanofiber modification of commercial fuel cell electrodes should improve catalyst output by many times, reducing the required catalyst content. In turn, this improvement will drive down the cost for fuel cells in hybrid vehicles, backup power, portable power, etc. The manufacturing partner on the project is a worldwide supplier of fuel cell materials, which means that the technology should have a large impact.

Novel System for Solid Catalyzed Isobutane/Olefin Alkylation--Precision Combustion, Inc., 410 Sackett Point Road, North Haven, CT 06473; 203-287-3700; www.precision-combustion.com
Dr. William Pfefferle, Principal Investigator, bpffefferle@precision-combustion.com
Mr. John Scanlon, Business Official, jscanlon@precision-combustion.com
DOE Grant No. DE-FG02-07ER84846
Amount: $749,913

Isobutane/olefin alkylation is a major refinery process in which light hydrocarbons (isobutane and, mainly, C3 and C4 olefins) are converted to a high octane gasoline feedstock. Alkylate currently accounts for a key fraction of the total U.S. gasoline pool; in fact, concerns over emissions have led to an interest in increasing the amount of alkylate used in gasoline. However, environmental and safety concerns present a barrier to this increase, as current processes for alkylate production employ hazardous liquid acids. As yet, a practical process based on solid catalysts has not been identified – conventional fixed bed processes have faced rapid catalyst aging and downtime for regeneration. This project will develop a novel reactor approach to solid-catalyzed isobutane/olefin alkylation in which olefin polymerization at the catalytic surface is limited, thereby avoiding the primary issue with solid catalyzed alkylation. Moreover, the proposed approach offers the potential for higher quality alkylate. Phase I demonstrated the validity of the system to limit olefin polymerization, produced high quality alkylate via the reaction of isobutane with 2-butene, defined the basic parameters of the system (including coatings, reactor configuration and operating conditions), and documented stable operation over a 100-hour test run. In collaboration with a major petroleum refiner, Phase II will optimize the reactor configuration (geometry and catalyst selection) and operating conditions (feed rates/ratio, system temperature, and system pressure), and demonstrate long-term life (high productivity of high octane product for 1000+ hours of continuous operation).

Commercial Applications and Other Benefits as by the awardee: The replacement of liquid-acid-based HF and sulfuric acid processes with solid catalyst process should improve yield, eliminate environmental and safety complications, simplify plant design (e.g., by avoiding acids handling and refrigeration steps), reduce capital costs, and reduce energy consumption and operating costs.

Dewatering Membrane for Hazy Hydrodesulfurization of Unit Effluents--Compact Membrane Systems, Inc., 335 Water Street, Newport, DE 19804; 302-999-7996; www.compactmembrane.com
Dr. Stuart Nemser, PhD, Principal Investigator, snemser@compactembrane.com
Dr. Stuart Nemser PhD, Business Official, snemser@compactembrane.com
DOE Grant No. DE-FG02-07ER84838
Amount: $750,000

Many refinery product streams, particularly those from Ultra Low Hydrodesulfurisation units, are prone to haze due to water emulsions. Haze is also problematic for biodiesel production, as hazy fuel cannot be used until the haze settles or is removed, which creates costly scheduling and shipping delays. This project will develop a novel membrane process for the removal of dissolved and dispersed water from fuels in real time. In Phase I, the membrane was developed and feasibility was demonstrated on multiple fuels. An economic evaluation showed that the cost of dewatering with the membranes would be very attractive. Phase II will involve the fabrication of both a small scale (e.g., 1-5 ft^2) laboratory prototype and a large commercial size unit (e.g., 50 ft^2). Based on the Phase I study, the long term performance of the membrane modules (both the laboratory and field unit) will be enhanced, and performance over a four-year lifetime will be demonstrated. Dewatering tests will be conducted both at the laboratory and in conjunction with industry partners at an existing field site. With the data collected, detailed engineering and economic evaluations will be conducted, and a comparison will be made with alternative non-membrane dehydrating processes.

Commercial Applications and Other Benefits as described by the awardee: The membrane technology should have a large impact on a number of areas of interest to the Department of Energy. In addition to haze removal from fuel, applications include enhancing chemical reactors by removing by-product water, drying pipeline ethanol and other organics, and stabilizing hydraulic fluid by removing water.

Sorbents for Desulfurization of Refinery Off-Gases--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
Dr. Gokhan Alptekin, PhD, Principal Investigator, galptekin@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-07ER84802
Amount: $750,000

The off-gases from various refinery operations could be converted into valuable chemicals, such as hydrogen, instead of being sent to flare, where they contribute to energy loses and greenhouse gas emissions. However, refinery off-gases contain large concentrations of sulfur and other impurities. Before these gases can be converted to hydrogen, sulfur and other impurities must be removed to prevent poisoning of the reforming catalysts used in the conversion process. Traditionally, desulfurization has been achieved by a two-step process consisting of hydrodesulfurization (HDS) and subsequent removal of H_2S with an expendable chemical absorbent. Although this approach has long been used for the desulfurization of natural gas feed stocks (where the sulfur level does not exceed 5-10 ppmv), its utility for use with high sulfur off-gases is cost prohibitive. This project will develop a novel physical adsorbent to desulfurize refinery off-gases. The sorbent, which will be operated either in an expendable or regenerable manner, operates at near ambient temperatures (20-60^oC) and reduces the sulfur content of the gas stream to ppb levels, thereby protecting the catalyst used in the downstream conversion process. Unlike conventional sorbents, the material removes not only H_2S but also organic sulfur compounds (such as mercaptans, sulfides and thiophenes) with high capacity and higher removal efficiency. Phase I (1) developed low cost, regenerable sorbents that can remove sulfur compounds from refinery off-gases with very high capacity; (2) demonstrated that the regenerable sorbent maintains its capacity for over 20 absorption/regeneration cycles; and (3) established the potential for the cost-effective production of hydrogen from sulfur-contaminated refinery off-gas streams. Phase II will improve sorbent performance, scale-up its production using commercial manufacturing techniques, design and fabricate a prototype test unit, and carry out a detailed system analysis and engineering assessment.

Commercial Applications and Other Benefits as described by the awardee: The new sorbent technology should provide U.S. refiners with a cost-effective way to remove sulfur from refinery off-gases. The cost of the process should be low enough to allow the resulting gases to be profitably used as a low cost feedstock for hydrogen production. The sorbent also could be used to desulfurize any light hydrocarbon stream that is used as a feedstock for catalytic chemical conversion or as a feed for a fuel cell.

***STTR Project: Silicon Nanowire Solar Cell**—Illuminex Corporation, 1064 New Holland Avenue, Lancaster, PA 17601; 717-295-3746; www.illuminex.biz
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Dr. Youssef Habib, Business Official, joe.habib@illuminex.biz
DOE Grant No. DE-FG02-07ER86313
Amount: $750,000

Research Institution
Penn State University
University Park, PA

It is now an accepted fact that global warming due to greenhouse gases is occurring and could have a devastating effect for future life on earth. The need for the United States to plan, develop, and implement alternative, clean energy technologies is critical. In particular, the photovoltaic generation of electricity from the sun is a sustainable, elegant, clean, and practical source of usable energy. This project will develop silicon-nanowire-based photovoltaic technology as a highly efficient, low cost alternative energy source. Phase I established process technology for fabricating radial, p-n core-shell, silicon nanowire arrays on low cost, anodic, aluminum-oxide-coated glass substrates. This fabrication of large area photovoltaics represents an important first step towards the realization of commercial nanowire-based solar cell devices. Phase II will optimize the junction interface, electrical contacts, and nanowire growth process, in order to produce better devices.

Commercial Applications and Other Benefits as described by the awardee: A current impediment to the widespread utilization of photovoltaic technology is the cost, which is approximately four times that of the currently dominant means of generating electrical power. Nanotechnology-enabled solar cells could help bring the cost of solar power down to more competitive levels.

Carbon Nanosheets as Nanostructured Electrodes in Organic Photovoltaic Devices--
Luna Innovations Incorporated, 1 Riverside Circle, Suite 400, Roanoke, VA 24016; 540-552-5128; www.lunainnovations.com
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Ms. Angela Keen, Business Official, submissions307@lunainnovations.com
DOE Grant No. DE-FG02-07ER84806
Amount: $749,935

Photovoltaics, the direct conversion of sunlight into electric energy, is a promising clean-tech approach to energy production. Organic solar cells show particular promise because they have the potential for light-weight flexible devices with low material and production costs. Yet, despite significant improvements over the last couple of years, the maximum power conversion efficiency of organic photovoltaic devices is still about 5%, largely due to the low charge-carrier mobility in the organic materials. Low mobility increases resistance in the film, thereby reducing the photocurrent and the efficiency of the devices. This project aims to develop high efficiency, low-cost organic solar cells using novel nanostructured carbon electrodes consisting of free-standing carbon nanosheets. The volume between the sheets will be filled with photoactive material, thereby reducing the distance that charges have to travel to the collecting electrode. In Phase I, growth conditions for the carbon nanosheets were optimized for the organic photovoltaic application. An advanced spray coating technique was used to fill the nanosheets with photoactive material, and photovoltaic devices were built and tested. In addition, a technique was developed to transfer the nanosheets to a zero-thermal-budget substrate. Lastly, an atomic-layer-deposition process was developed to conformally coat the nanosheets with a dielectric interface layer. In Phase II, carbon nanosheet devices with superior photovoltaic performance will be demonstrated. A prototype device – which will be compatible with a large-scale, roll-to-roll manufacturing process – with commercially viable conversion efficiency will be built and characterized.

Commercial Applications and Other Benefits as described by the awardee: Applications for the technology should range from rooftop photovoltaic systems to light weight, flexible solar cells integrated into tents, textiles, and small electronic devices (i.e. cell phones, PDAs, etc.). A successful commercialization also would help the economically challenged region of Southern Virginia transform its economy by opening new high-technology jobs.

***STTR Project: A Nanofluid with Superior Thermal Properties--**Advanced Thermal and Environmental Concepts, Inc., 7100 Baltimore Avenue, Suite 300, College Park, MD 20740; 301-699-1024; www.atec.ahx.com
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Dr. John Lawler, Business Official, j. lawler@atec-ahx.com
DOE Grant No. DE-FG02-07ER86295
Amount: $749,800

Research Institution
University of Maryland,
College Park, MD

Many industrial processes in the chemical, petroleum, and pharmaceutical industries involve the transfer of heat from one medium to another. Usually, this transfer occurs within heat exchangers, which use thermal fluids to conduct the heat. However, most thermal fluids have thermal properties that require large heat exchangers or pumps. This project will develop a new class of fluids, PCM nanofluids (fluid with a nano-size phase change material (PCM) as the dispersed phase) with superior thermal properties, which will increase the rate of heat transfer in process equipment. During Phase I, two PCM nanofluids, containing nano-sized particles of low-melting metals, were synthesized and characterized. These fluids not only had increased thermal conductivity but also (and more importantly) had heat capacities that increased greatly near the phase change temperature of the metal nanoparticles. For heat transfer in a specific aircraft heat exchanger, calculations suggested that as much as 50% more heat could be transferred when the thermal fluid was replaced by one of the PCM nanofluids. During Phase II, a method will be developed to fabricate kilogram-size batches of the PCM nanofluids, and the thermal performance of these fluids will be tested in relevant heat transfer equipment.

Commercial Applications and Other Benefits as described by the awardee: PCM nanofluids should enable a reduction in the sizes of heat exchangers and pumps in industrial heat transfer applications. PCM nanofluids also should find use in the thermal management of power electronics and optoelectronics, which is becoming more challenging as the capability and speed of these electronic devices increase and their size decreases. The improved temperature control that is made possible by PCM nanofluids also would benefit the pharmaceutical industry, in which temperature uniformity would improve the quality of the resulting biological products.

***STTR Project: High-Efficiency, Cost-Effective Thermoelectric Materials/Devices for Industrial Process Refrigeration and Waste Heat Recovery—**Aegis Technology Inc., 3300 A. Westminster Avenue, Santa Ana, CA 92703; 714-265-1238; www.aegistg.com
Dr. Timothy Line, Principal Investigator, timlin@aegistech.net
Mr. Bob Liu, Business Officical, bobliu@aegistech.net
DOE Grant No. DE-FG02-07ER86296
Amount: $750,000

Research Institution
SUNY
Binghamton, NY

The development of high-efficiency thermoelectric (TE) devices represents an opportunity to cost-effectively exploit industrial waste heat and provide industrial process refrigeration. The key to developing these devices is to first develop a TE material with a high figure of merit, ZT. Therefore, this project will (1) develop a low-cost scalable approach for producing a novel class of high-ZT thermoelectric nanocomposites; and (2) build and characterize high-efficiency, cost-effective TE devices that can be applied to industrial process refrigeration and waste heat recovery. Phase I identified the underlying technical issues that govern the fabrication and performance of the TE nanocomposite, and demonstrated a cost-effective approach to produce the material in bulk. Phase II will design, build and test a TE generator utilizing the nanocomposite, in order to demonstrate the benefits at a system level.

Commercial Applications and Other Benefits as described by the awardee: Bulk TE nanocomposites should enable the production of high-efficiency, compact TE devices that can be used for space cooling and refrigeration for residential, commercial, and industrial applications. Another application area is in industrial waste heat recovery, in order to harvest the vast amount of waste heat embodied in manufacturing processes: the high-efficiency ZT devices could recycle the waste heat, thereby increasing energy efficiency and simultaneously reducing unfavorable pollutant and vapor emission.

Low Cost Microchannel Heat Exchangers--Altex Technologies Corporation, 244 Sobrante Way, Sunnyvale, CA 94086; 408-328-8302; www.altextech.com
Dr. John T. Kelly, PhD, Principal Investigator, john@altextech.com
Dr. John T. Kelly PhD, Business Official, john@altextech.com
DOE Grant No. DE-FG02-07ER84875
Amount: $749,969

Microchannel heat exchangers can greatly reduce heat exchanger size and weight, but are too expensive for most applications, because of high fabrication costs. This project will develop an innovative microchannel heat exchanger that uses low-cost materials, along with a low precision fabrication technique, to reduce heat exchanger cost by 58%. Moreover, the volume and weight of the heat exchanger will be reduced by 98% and 72%, respectively, relative to conventional plate and fin heat exchangers. In Phase I, the innovative microchannel heat exchanger was designed, and the fabrication approach was evaluated. A heat exchanger was built and tested to demonstrate manufacturability and performance. Lastly, the design and performance projections were updated, and costs were estimated, in order to demonstrate technical and economic feasibility. Phase II will involve the coordination of machining, manufacturing, and bonding processes to develop and demonstrate prototype microchannel heat exchangers for several applications of interest.

Commercial Applications and Other Benefits as described by the awardee: The microchannel heat exchangers should find use in energy, power, refining, chemical processing, hydrocarbon gas, and liquefied natural gas applications. If the concept was adapted to high volume applications, cost savings could be over $100 million/year.

Microchannel Magnetic Coolers with Negative Magnetocaloric Effect--MER Corporation (Materials and Electrochemical Research), 7960 South Kolb Road, Tucson, AZ 85706-9237; 520-574-1980; www.mercorp.com
Dr. Lev Tuchinskiy, Principal Investigator, jcwithers@mercorp.com
Dr. Raouf O. Loutfy, Business Official, rloutfy@mercorp.com
DOE Grant No. DE-FG02-07ER84943
Amount: $750,000

The recent discovery of a negative magnetocaloric effect in CoMnT1-xT'x alloys (where T, T' = Si, Ge, Sn) at room temperature opens new prospects for the development of high-efficiency solid micro-cooling devices. This project will combine these novel alloys with cutting edge technology for microchannel regenerators to develop lightweight, compact, low cost, and environmentally friendly cooling devices. Phase I explored the use of solid microchannel regenerator cartridges instead of traditional regenerator beds packed with spheres. Technologies were demonstrated for the fabrication of magnetocaloric CoMnT1-xT'x powders and for the fabrication of microchannel structures from these powders. The basic requirements (with respect to source materials, methods of deformation, and consolidation of the powders) needed to preserve the magnetocaloric effect in the microchannel structures produced from these powders were established. Phase II will optimize and scale up the fabrication technologies, both for the CoMnT1-xT'x powders and for the microchannel regenerators for magnetic coolers. The microchannel magnetocaloric regenerators will be manufactured and tested with respect to thermal efficiency and mechanical stability in active magnetic cooling systems.

Commercial Applications and Other Benefits as described by the awardee: Solid state cooling devices hold a promise to revolutionize the current market for refrigeration systems. Magnetocaloric materials would enable the creation of compact refrigeration units that run silently and vibration free, and most importantly, without the use of ozone-depleting gases. Magnetocaloric coolers should provide the cooling power required for markets such as home refrigerators, air conditioning, electronics cooling, and fluid chilling.

Utility and Industrial Heat Exchangers--Thermal Centric Corporation, 108 W. 13th Street, Wilmington, DE 19801; 787-528-2002
Dr. Brian Edward Thompson, Principal Investigator, bthompson@thermalcentric.com
Ms. Stephanie Jo Bariault, Business Official, sbariault@thermalcentric.com
DOE Grant No. DE-FG02-07ER84807
Amount: $750,000

The recovery of heat currently wasted in exhaust gases can reduce fuel consumption in almost every commercial and industrial sector. In the electricity generation sector alone, even modest improvements in energy recovery effectiveness would result in billions of dollars in savings annually. New materials made from conductive graphite have created a significant opportunity to produce heat exchangers for energy recovery from exhausts. This project seeks to advance this technology in preparation for the commercialization of energy recovery products, initially for microturbine generators and ultimately for thermal power generation by utilities. In Phase I, new elements made from conductive graphite materials performed beyond their thermal engineering and reliability expectations, demonstrating that they are ideal for exhaust heat recovery. Issues with bonding, sealing, pressure drop, thermal stresses, corrosion, and maintenance were overcome with solutions appropriate for commercial products. Phase II will extend these results and culminate in full-scale field studies. In particular, the conductive graphite materials will be optimized to maximize the recovery of energy from generator exhausts; robustness, reliability, and performance will be measured under practical operating conditions; and manufacturing tools will be advanced to optimize element fabrication.

Commercial Applications and Other Benefits as described by the awardee: The graphite heat exchangers should enable more energy to be removed from exhausts because graphite does not corrode in condensing combustion products. Costs should be reduced because the graphite would significantly extend the lifespan of energy-recovery heat exchangers. In addition to electricity generation, the technology should be applicable to energy recovery in residential, commercial, and industrial refrigeration and air conditioning; chemical, petroleum, and industrial plants; and automobiles, trucks, trains, and aircraft.

***STTR Project: Materials Degradation Analysis and Development to Enable Ultra Low Cost, Web-Processed White P-OLED for SSL--**Add-Vision, Inc., 1600 Green Hills Road, Suite 100, Scotts Valley, CA 95066; 831-438-8192; www.add-vision.com
Mr. Devin John MacKenzie, Principal Investigator, devinm@add-vision.com
Mr. Robert H. Roeloffs, Business Official, robertr@add-vision.com
DOE Grant No. DE-FG02-07ER86293
Amount: $748,258

Research Institution
Lawrence Berkeley National Laboratory
Berkeley, CA

In order to reduce the capital equipment and operating costs involved in the printing of specialty solid state lighting devices, a new LED (light-emitting diode) device structure, based on the use of a doped polymer, has been developed. This project will advance this concept through degradation analysis and material and process development, in order to achieve additional performance and process improvements that would enable commercialization of this technology into a broader range of applications. In Phase I, device and encapsulation materials trials, as well as chemical analysis techniques, were used to analyze the degradation mechanisms that limit performance in air-printed doped polymer organic light emitting devices. These studies showed that lifetimes could be improved by 300% by implementing residual moisture control. In Phase II, moisture control materials will be developed to enable higher performance devices consistent with a low-cost manufacturing approach. Further degradation analysis will be performed to uncover additional limiting factors.

Commercial Applications and Other Benefits as described by the awardee: Commercial applications for printed, flexible, polymer organic LED technology should reduce national energy consumption and improve overall product performance in future building applications, including digital electronic signage, architectural lighting, safety lighting, emergency and portable lighting, and other specialty lighting products.

Efficient Large Area WOLED Lighting--Universal Display Corporation, 375 Phillips Boulevard, Ewing, NJ 08618-1428; 609-671-0980; www.universaldisplay.com
Dr. Brian D'Andrade, Principal Investigator, bdandrade@universaldisplay.com
Mrs. Janice Mahon, Business Official, jkmahon@universaldisplay.com
DOE Grant No. DE-FG02-07ER84810
Amount: $750,000

In 2001, lighting was estimated to consume 8.2 quads (approximately 762 TWh), or about 22% of the total electricity generated in the U.S. New, high-efficiency, solid-state light sources, such as organic light emitting diodes (OLEDs), are needed to help reduce the ever increasing demand for energy. Potentially, an OLED is an inexpensive and energy saving diffuse source that may compete with conventional incandescent and fluorescent light sources. However, improvements in the overall efficiency and lifetime of these devices are required before they become commercially viable products. This project will enable the demonstration of an efficient, novel OLED illumination system with 150 lm/W power efficacy. Phase I demonstrated a non-stacked white phosphorescent OLED with 6 organic materials. The device exhibited extremely long lifetime (LT50 >200,000 hrs) at an initial luminance of 1,000 cd/m^2. Phase II will involve the design and fabrication of a prototype warm white OLED that achieves 75 lm/W with LT70 > 35,000 hours at an initial luminance of 1,000 cd/m^2.

Commercial Applications and Other Benefits as described by the awardee: Today, OLED technology is the leading emerging technology for flat panel displays (FPDs), with recent product introductions in cell phones and TV's. Many of the features that are desirable for FPDs are also making OLED technology of great interest to the solid-state lighting community. OLEDs are bright, thin, with desirable color rendering indices and excellent power efficiency at low voltages. Therefore, OLEDs are expected to provide significant energy savings for general illumination purposes.

High Efficacy Phosphorescent SOLED Lighting--Universal Display Corporation, 375 Phillips Boulevard, Ewing, NJ 08618-1428; 609-671-0980; www.universaldisplay.com
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Mrs. Janice Mahon, Business Official, jkmahon@universaldisplay.com
DOE Grant No. DE-FG02-07ER84809
Amount: $749,981

In 2001, lighting was estimated to consume 8.2 quads (approximately 762 TWh), or about 22% of the total electricity generated in the U.S. New, high-efficiency, solid-state light sources, such as organic light emitting diodes (OLEDs), are needed to help reduce the ever increasing demand for energy. Potentially, an OLED is an inexpensive and energy saving diffuse source that may compete with conventional incandescent and fluorescent light sources. However, improvements in the overall efficiency and lifetime of these devices are required before they become commercially viable products. This project will enable the demonstration of an efficient, novel OLED illumination system with 150 lm/W power efficacy. Phase I demonstrated a warm, white, stacked OLED (SOLED) with an efficacy of 50 lm/W at a forward luminance of 1,000 cd/m^2. The device had a Color Rendering Index (CRI) of 72 and a lifetime of over 80,000 hrs from an initial luminance of 1,000 cd/m^2. Phase II will involve the design and fabrication of warm white SOLED prototypes that have a light output similar to conventional fluorescent lighting fixtures

Commercial Applications and Other Benefits as described by the awardee: Today, OLED technology is the leading emerging technology for flat panel displays (FPDs), with recent product introductions in cell phones and TV's. Many of the features that are desirable for FPDs are also making OLED technology of great interest to the solid-state lighting community. OLEDs are bright and thin, with desirable CRIs and excellent power efficiency at low voltages. Therefore, OLEDs are expected to provide significant energy savings for general illumination purposes.

Neutron Compound Refractive Prisms--Adelphi Technology, Inc., 2003 East Bayshore Road, Redwood City, CA 94063; 650-474-2750; www.adelphitech.com
Dr. Jay Theodore Cremer, Principal Investigator, ted@adelphitech.com
Dr. Charles Kevin Gary, Business Official, cgary@adelphitech.com
DOE Grant No. DE-FG02-07ER84873
Amount: $750,000

The accurate detection of neutrons can make invaluable contributions to the physical, chemical, and biological sciences, and the DoE operates neutron user facilities to support these endeavors. The utility of prisms for neutron detection has long been established, but a single neutron prism has never been able to provide sufficient deflection for practical applications. This project will design and produce compound refractive prisms that more effectively deflect and spatially separate neutrons according to their wavelength. Unlike a single prism, a compound prism is a row of *N* prisms that combine to produce an *N*-fold increase in the refraction of neutrons. Phase I involved the design and construction of material and magnetic compound prisms, and demonstrated that they can be an optimum tool for neutron detection. Further, the magnetic prisms tested in Phase I polarized the neutron beams, thus creating an additional tool for analysis. Phase II will include the construction of material compound prisms from more complex yet higher performance materials such as MgF2 and Teflon. A number of systems will be designed and constructed based upon the prism technology; these systems include monochromators, spectrometers and stress analysis tools.

Commercial Applications and Other Benefits as described by the awardee: The prism-based tools should have application to materials research and development as well as to nondestructive testing. Specific applications include the measurement of magnetic films for information storage, crystallography and proteomics, stress analysis for metallurgy, and kinematic studies of boundary layers in materials.

***STTR Project: High Efficiency Electron Detector for Electron Microscopy--**
Cermet, Inc., 1019 Collier Road, Suite C1, Atlanta, GA 30318; 404-351-0005;
www.cermetinc.com
Mr. Jeff Nause, Principal Investigator, jnause@cermetinc.com
Mr. Jeff Nause, Business Official, jnause@cermetinc.com
DOE Grant No. DE-FG02-07ER86304
Amount: $749,128

Research Institution
Argonne National Laboratory
Argonne, IL

This project seeks to demonstrate an improved, ultra-fast and highly-efficient electron detector for electron microscopy. In Phase I, ultrafast (pico-second) ZnO based scintillators were developed and Schottky diodes with excellent performance were demonstrated. Phase II will (1) refine the development of the ZnO scintillator to maximize light output, while maintaining sub-nanosecond speed; and (2) build ZnO Schottky diode arrays in two geometries, enabling detection in backscatter and transmission modes. The ZnO scintillators and diodes will be fabricated and these devices will be provided to Argonne National Laboratory for testing in state-of-the-art electron and ion microscopes.

Commercial Applications and Other Benefits as described by the awardee: The extremely high speed of the proposed devices should enable a 10-to-50 times improvement in scanning times compared to current detector materials. The proposed technology should have applications in microscopy, geophysical studies, medical imaging, homeland security, and high energy physics.

Quantitative In-Situ TEM Nanotribology Tester--Hysitron, Inc., 10025 Valley View Road, Minneapolis, MN 55344; 952-835-6366; www.hysitron.com
Dr. Oden L. Warren, Principal Investigator, owarren@hysitron.com
Mr. Thomas J. Wyrobek, Business Official, Thomas@hysitron.com
DOE Grant No. DE-FG02-07ER84812
Amount: $750,000

Friction and wear are energy-robbing processes that represent a tremendous burden to the national economy, especially in this time of record oil/fuel prices. Unfortunately, the field of tribology (the science of friction, lubrication, and wear of interacting surfaces in relative motion) lags many other disciplines in terms of fundamental knowledge. What is needed is a new tool that enables tribological study at an unprecedented level of detail. The overall objective of this project is to develop a quantitative nanotribology tester for *in situ* experimentation in transmission electron microscopes. Such a tool would enable direct, real-time correlation of the friction coefficient and the wear rate to microstructure evolution and changes in sliding contact conditions. This project will develop a multidimensional force transducer that is miniature enough to be incorporated into the very cramped space of the holder of a transmission electron microscopy. Phase I demonstrated feasibility by designing and constructing the force transducer, conducting finite element simulations, and performing bench-top experiments. Phase II will (1) optimize the miniature multidimensional force transducer, along with the electronics and firmware/software associated with the force transducer; (2) incorporate the force transducer into a transmission electron microscopy holder capable of electrical contact resistance measurement; and (3) perform *in situ* tribological research in a transmission electron microscope, in order to identify suitable leading-edge applications.

Commercial Applications and Other Benefits as described by the awardee: The new tool would enable tribologists and microscopists to examine the exact nature of complex tribological processes in a quantitative, high-resolution, direct-observation fashion. The technology also could aid in producing breakthrough discoveries related to new nanotechnology-based solid lubricants – the question of how the few existing nanoscale solid lubricants impart their lubricity is currently a matter of debate.

Quantitative In-Situ TEM Tensile Testing Apparatus--Hysitron, Inc., 10025 Valley View Road, Minneapolis, MN 55344; 952-835-6366; www.hysitron.com
Dr. Zhiwei Shan, Principal Investigator, zshan@hysitron.com
Mr. Thomas J. Wyrobek, Business Official, Thomas@hysitron.com
DOE Grant No. DE-FG02-07ER84813
Amount: $750,000

In situ tensile testing in the transmission electron microscope (TEM) has been a powerful tool for revealing underlying physical mechanisms at the nano or even atomic scale when materials are subjected to an applied stress. However, all commercially available *in situ* TEM tensile holders suffer from the absence of quantitative ability and require complex sample preparation. This project will develop a tensile device for operation inside a TEM, not only yielding quantitative load-displacement data concomitant with real-time images of the microstructural behavior, but also simplifying the sample preparation procedure. In Phase I, a working quantitative tensile system was designed and built by integrating a newly-developed microelectromechanical systems-based push-to-pull device into an existing *in situ* TEM holder system. The feasibility of the concept was demonstrated by testing the system in the TEM. Phase II will (1) develop ready-to-commercialize, quantitative, *in situ* TEM tensile testing systems that will be compatible with the TEMs of all major manufacturers; (2) develop devices based on micro- or nano-electromechanical systems, in order to enable the quantitative investigation of the coupling effects between electro/mechanical and thermal/mechanical behavior of nanomaterials; and (3) conduct relevant experiments using the quantitative tensile system

Commercial Applications and Other Benefits as described by the awardee: The quantitative *in situ* TEM tensile technique should substantially improve our understanding of the relationship between and external applied stress and the materials' response at nano and even atomic scale, and thereby provide solid experimental parameters for optimizing the properties of components and products that result from nanoscience.

***STTR Project: Efficient Thermal Neutron Position Sensitive Detector**--NOVA Scientific, Inc., Sturbridge Technology Park, 10 Picker Road, Sturbridge, MA 01566-1251; 508-347-7679; www.novascientific.com
Mr. W. Bruce Feller, Principal Investigator, bfeller@novascientific.com
Mr. Paul L. White PhD, Business Official, pwhite@novascientific.com
DOE Grant No. DE-FG02-07ER86322
Amount: $750,000

Research Institution
University of California - Berkeley
Berkeley, CA

The new generation of neutron scattering and imaging facilities, such as the Spallation Neutron Source (SNS), will provide much higher fluences at sample positions than existing neutron sources, requiring detectors with better spatial resolution, sub-1 ms rate capability, and excellent gamma ray rejection. This project will develop a powerful new type of thermal neutron imaging and counting detector based on ^{10}B and Gd-doped, neutron-sensitive, microchannel plate (MCP) neutron converter/amplifiers, and integrated with novel solid-state Medipix-2 and Medipix-3 electronic readouts. Phase I demonstrated both cold and thermal neutron images of a Gd phantom with laser drilled 50 μm holes, where the limiting spatial resolution was dictated by the 55 μm Medipix 2 pixel size. Using beams with differing energies above and below the Bragg cutoff, dramatically enhanced contrast was demonstrated, indicating that energy-resolved imaging can be performed using this detector. Phase I also showed that pulse amplitude analysis can be implemented to differentiate between UV and alpha particle inputs, thereby enabling the enhancement of gamma rejection. Phase II will (1) further refine MCP neutron performance; (2) carry out design improvements to the electronics, data processing software, and detector assembly hardware; (3) fully investigate and test neutron energy-resolved imaging; and (4) add post-target collimators to optimize neutron efficiency, spatial resolution, and time-of-flight performance.

Commercial Applications and Other Benefits as described by the awardee: The MCP/Medipix detector should provide position resolution that is now available only with photographic film, but in real-time and with a neutron-beam-fluence-handling capability potentially superior to any neutron detection system currently available. The new type of thermal neutron imager should find use in biological imaging, nuclear fuel inspection, explosives detection, archaeological studies, and precise neutron beam monitoring.

Application of Pixel-Cell Detector Technology for Advanced Neutron Beam Monitors--ORDELA, Inc., 1009 Alvin Weinberg Drive, Oak Ridge, TN 37830;
865-483-8675; www.ordela.com
Mr. Daniel M. Kopp, Principal Investigator, dkopp@ordela.com
Mr. Daniel M. Kopp, Business Official, dkopp@ordela.com
DOE Grant No. DE-FG02-07ER84844
Amount: $750,000

Currently available neutron detectors are limited in their ability to be used with the intense neutron beams used for the advanced study of materials at large-scale national facilities. A large number of neutron-scattering experiments require beam monitors to operate in an intense neutron beam flux of more than10^7 neutrons per second per square centimeter. For instance, a 4 cm x 4 cm intense beam flux of 6.25×10^7 n/s/cm^2 at the Spallation Neutron Source will put a flux of 1.00×10^9 n/s at the beam monitor. Currently available beam monitors will need to be replaced in less than two years of operation due to wire and gas degradation issues. There is also a need for beam position information that is beyond the capabilities of currently available ^{3}He and BF_3 neutron beam monitors. This project will investigate the use of pixel-cell technology for developing a new generation of stable, high-count-rate neutron beam monitors and position-sensitive detectors. In Phase I, a prototypical 2 x 4 Pixel-Cell Neutron Beam monitor was conceptualized, designed, and constructed. The prototype unit was successfully tested and evaluated in a neutron beam at the High Flux Isotope Reactor in Oak Ridge. In Phase II, the pixel cell technology will be tested further with the prototype beam monitor, leading to refinement and optimization of the technology. Using these refinements, a two-dimensional pixel-cell area detector will be designed and built for testing at a neutron beam source.

Commercial Applications and Other Benefits as described by the awardee: The technology should lead to the development and commercialization of advanced neutron beam detectors that would directly benefit the Spallation Neutron Source and other intense neutron sources such as the High Flux Isotope Reactor. Advancing the detector capabilities is equivalent to increasing operational efficiency and reducing the experiment beam time at these facilities, which, in turn, results in important savings in operation cost and increased experimental output.

Development of a Bubble Generator Suitable for Spallation Neutron Source (SNS) Shock Mitigation Applications--Dynaflow, Inc., 10621-J Iron Bridge Rd, Jessup, MD 20794; 301-604-3688; www.dynaflow-inc.com
Dr. Georges L. Chahine, Principal Investigator, glchahine@dynaflow-inc.com
Dr. Georges L. Chahine, Business Official, glchahine@dynaflow-inc.com
DOE Grant No. DE-FG02-07ER84840
Amount: $749,995

The generation of a strong shock wave in the Spallation Neutron Source (SNS) can lead to cavitation and significant erosion on the vessel wall containing the liquid mercury target. Based on preliminary numerical and experimental work at various laboratories, it has been proposed that a cloud of small gas bubbles in the mercury target could absorb and deflect the shock waves and protect the walls from cavitation erosion. In order to maximize effectiveness, a bubble generator would have to produce a relatively large quantity (order of 1% void fraction) of micron sized bubbles. A method for generating a large quantity of tiny bubbles is to combine a classical bubble generation scheme, based on gas injection from nozzles, with a technique for screening unwanted large-size bubbles with a fine mesh. The liquid entrained by the gas injection contributes to a two-phase mixture impacting on the mesh. This two-phase bubble generator could be made more efficient by adding side liquid jets to apply a localized shearing force at the gas nozzle. In this project, this two-phase flow bubble generator will be further developed, adapted to large flow rate, characterized for the SNS mercury application, and scaled up for application in the SNS target. Phase I examined the physics of operation of simple, small-scale, two-phase-flow bubble generators. Techniques to test and analyze bubbles in mercury were developed, and the bubble generator was adapted to mercury applications and characterized. In Phase II, these concepts will be extended to a larger scale set-up that can be used in the mercury SNS application, and a prototype bubble generator will be developed and built for the mercury flow of the SNS facility. The prototype then will be tested at the facility, and the bubble sizes will be characterized using an acoustic bubble spectrometer and radiography.

Commercial Applications and Other Benefits as described by the awardee: Besides the SNS application, the bubble generation technology has many potential commercial applications: heat transfer in liquid metal assemblies for microelectronics using gallium, cooling of hard drives and other electronic components, removal impurities during refining, manufacturing of ultrasonic imaging contrast agents, production of chemicals in slurry bubble columns, separation of slurries using flotation, aeration in aquaculture and wastewater treatment, shellfish depuration, bubble curtains to acoustically shield a certain region under water, hydrodynamic studies of micro-bubble drag reduction, flow monitoring, mass transfer studies, and chemical synthesis reactions.

Development of a Numerical Design Tool for Spallation Neutron Source Cavitation Mitigation--Dynaflow, Inc., 10621-J Iron Bridge Rd, Jessup, MD 20794; 301-604-3688; www.dynaflow-inc.com
Dr. Georges L. Chahine, Principal Investigator, glchahine@dynaflow-inc.com
Dr. Georges L. Chahine, Business Official, glchahine@dynaflow-inc.com
DOE Grant No. DE-FG02-07ER84839
Amount: $749,958

The generation of a strong shock wave in the Spallation Neutron Source (SNS) can lead to cavitation and significant erosion on the vessel wall containing the liquid mercury target. Based on preliminary numerical and experimental work at various laboratories, it has been proposed that strategies such as inserting a cloud of small gas bubbles or a gas layer in the mercury target could absorb and deflect the shock waves and protect the walls from cavitation erosion. Another strategy involves the reduction of cavitation through new designs that take advantage of wall shaping and deformation, and energy absorption. In order to aid the design of such cavitation-mitigation schemes, this project will develop an advanced numerical software package, which couples multiscale, multiphase compressible fluid solvers with structure dynamics solvers. This code will be capable of simulating the relevant features of the flow, namely shock wave propagation through bubbly media, large liquid/gas interface deformations, shock wave induced cavitation, and deformation of structures due to shock wave and cavitation/structure interactions. In Phase I, multiphase codes adapted to study this problem were able to capture high pressure wave propagation in bubbly media, along with the interaction of the wave with the bubbles, free surface, and the wall structures. The potential success of different cavitation mitigation measures (including wall shape design, insertion of an air layer, and the generation of a bubbly medium) was demonstrated. Phase II will involve further improvements to the software package, including a generalization of interface capturing schemes for broader multiphase/material flows, a multiscale cavitation model for bubbly media, and a structure code for simulation of full fluid/structure interaction. The software package will then be validated by using existing and conducting benchmark experiments in SNS mercury test loops.

Commercial Applications and Other Benefits as described by the awardee: In addition to the SNS application, the software package should have application to multiple fields: (1) naval applications, where the mitigation of shock wave impact is of keen interest to vessel protection and to propeller blade design; (2) chemical processes, to improve performance of bubble column reactors and multiphase slurries; and (3) minimally invasive medical procedures that use acoustic cavitation-based treatments such as shock wave lithotripsy.

Development of New Mid-Infrared Ultrafast Laser Sources for Compact X-ray Sources--Kapteyn-Murnane Laboratories, Inc., 1855 S. 57th Court, Boulder, CO 80301; 303-544-9068; www.kmlabs.com
Dr. Hsiao-hua Liu, Principal Investigator, hliu@kmlabs.com
Dr. Sterling Backus, Business Official, sbackus@kmlabs.com
DOE Grant No. DE-FG02-07ER84841
Amount: $748,596

Bright coherent light sources in the soft x-ray region of the spectrum are useful for a variety of applications of interest to the DOE. However for many applications, such as nanometer-scale microscopy in the "water window" region of the soft x-ray spectrum (300-500 eV), only large-scale synchrotron facilities are currently capable of generating the required flux. Yet, the implementation of small-scale, tabletop sources of bright coherent soft x-rays would greatly expand the potential impact of the technologies developed at synchrotrons, allowing the source to be brought to applications in science and industry. One promising approach to addressing this need involves the coherent upconversion of laser light to short wavelengths through the process of high-order harmonic generation. The basic physics of the high-order harmonic generation process makes it easier to generate and phase-match shorter-wavelength harmonics when the process is driven by longer wavelength light. This project will develop an ultrafast laser amplifier that operates at wavelengths ~3x longer than current generation ultrafast lasers. This mid-infrared ultrafast laser will be integrated with a new set-up for high-order harmonic generation. In Phase I, the temperature dependence of the absorption and emission spectra was measured for two gain materials, which could serve as the driving source for generating soft x-ray light through the high-order harmonic generation process. The most promising gain material was selected, and a two-stage multipass amplifier system was designed. In Phase II, the design will be implemented in the construction of the mid-infrared laser amplifier system, and the amplified pulses will be used to generate efficient high-order harmonic light at 13nm and 4nm, with sufficient flux for applications.

Commercial Applications and Other Benefits as described by the awardee: The development of these lasers should directly translate into brighter tabletop soft x-ray sources for applications in control, diagnostics, and metrology. Currently, a $7B global laser market exists for ultraviolet, visible, and infrared laser systems.

Single Shot Bunch Length Monitoring, Based on Interferometer and Novel Terahertz Sensor--RadiaBeam Technologies, LLC, 13428 Beach Ave, Marina Del Rey, CA 90292; 310-822-5845; www.radiabeam.com
Dr. Gerard Andonian, Principal Investigator, andonian@radiabeam.com
Mr. Salime Boucher, Business Official, boucher@radiabeam.com
DOE Grant No. DE-FG02-07ER84814
Amount: $749,571

With the recent development of advanced photoinjector accelerators and next generation light sources, the progression towards high-current, ultra-short beams are very important. The knowledge of the longitudinal profile and bunch length of the short pulses is necessary for performance optimization and benchmarking to computational models. Thus, in order to achieve successful beam operation, it will be essential to measure these short pulses in a single-shot, in real time, and with sub-picosecond time resolution. This project will develop a real-time bunch-length interferometer utilizing a novel beam autocorrelation technique. In this approach, the interference of the beam with itself takes place on the plane of a terahertz detector array; the spatial interference is correlated to the horizontal position along the array. Phase I consisted of theoretical calculations and modeling of coherent radiation sources typical of accelerator facilities, and the design of an interferometer scheme efficient in the terahertz regime. Laboratory testing and a detector survey also were conducted.

Commercial Applications and Other Benefits as described by the awardee: The real-time interferometer would be of great use to the accelerator community. In addition, the real time interferometer could be incorporated into a feedback loop to lock the bunch length of the beam, thus guaranteeing consistent parameter sets for Free Electron Laser, Compton Scattering, and collider facilities. Finally, the technology should have numerous applications in the growing field of terahertz radiation creation and imaging.

High Performance X-ray Detector Arrays--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Dr. Gerald Entine, PhD, Principal Investigator, GEntine@rmdinc.com
Dr. Gerald Entine PhD, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84886
Amount: $750,000

X-ray detector arrays with high energy resolution, high sensitivity and high count-rate performance are required for synchrotron beamline studies. However, in many studies conducted with synchrotron beamlines, the characteristics of available X-ray detectors limit the overall system performance. This project will investigate a novel low-capacitance design for high purity silicon detector arrays that offers high energy resolution, high efficiency, and high count-rate operation, as well as relatively easy fabrication. Phase I demonstrated the feasibility of X-ray detection by producing a high-resolution, high-purity silicon detector array with low capacitance. Phase II will advance the technology by optimizing the detector design, constructing a larger format array, performing a detailed evaluation of the detector, and investigating the performance of a fully functional detector array system at a synchrotron beamline.

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

350 MHz 200 kW CW Multiple Beam Inductive Output Tube--Calabazas Creek Research, Inc., 690 Port Drive, San Mateo, CA 94404; 650-312-9575; www.calcreek.com
Dr. Robert Lawrence Ives, Principal Investigator, rli@calcreek.com
Dr. Robert Lawrence Ives, Business Official, rli@calcreek.com
DOE Grant No. DE-FG02-07ER84876
Amount: $749,937

RF sources are required for powering accelerators operating at approximately 350 MHz and for providing 200 kW CW for each accelerator cavity. This project will develop a fundamental-mode, multiple-beam Inductive Output Tube (IOT) for potential accelerator applications. The advantage of multiple beams is the reduction in operating voltage required to propagate several beams down individual beam tunnels. In turn, the lower beam voltage allows significant reduction in the power supply requirements and decreases the likelihood for electrical breakdown and x-ray generation. Combined with the IOT's inherent high efficiency, the multiple-beam IOT would be an extremely cost effective RF source for accelerator applications. Phase I developed preliminary designs for all major components and demonstrated feasibility. An analysis determined power supply, drive, mechanical, and performance specifications. Phase II will finalize the design, then fabricate and test a prototype multiple beam IOT at full power.

Commercial Applications and Other Benefits as described by the awardee: The multiple-beam IOT would operate at much higher efficiency and be considerably less expensive than the klystrons that are now used for numerous accelerator applications. The significantly lower operating voltage also would result in dramatic savings for the power supplies and ancillary equipment and facilities.

THz Source Based on Photoinjector--DULY Research Inc., 1912 MacArthur Street, Rancho Palos Verdes, CA 90275-1111; 310-548-7123; www.dulyresearch.com
Dr. Alexei Smirnov, Principal Investigator, davidyu@pacbell.net
Dr. David U.L. Yu, Business Official, davidyu@pacbell.net
DOE Grant No. DE-FG02-07ER84877
Amount: $750,000

Attaining high peak fields at terahertz (THz) frequencies is among the highest priorities among the common R&D goals of the DOE-NSF-NIH triad. However, THz science and technology have been underdeveloped because of the unavailability of effective and affordable THz sources. The few THz facilities currently available are based on free electron lasers (FELs), which are too bulky, expensive, and inefficient to serve as commercial sources. This project will design, build, and test a compact, pulsed THz source – a Cherenkov radiator comprising a capillary dielectric tube driven by an over-focused electron beam from a low-energy laser-driven photoinjector – that can deliver at least 100 kW peak power. The photoelectrons are produced from a metal cathode illuminated with a sub-picosecond laser. In Phase I, feasibility was demonstrated for the transport of an over-focused, low-loss, electron beam of 0.15 MA/cm^2 of peak current density and a few MeV of energy. Microjoule levels of radiated THz energy were produced using a pulsed DC or RF gun and a capillary tube. In Phase II, the development of the THz source will be completed. An in-vacuum THz radiator will be designed and fabricated as an inset for a conventional photoinjector, complemented by laser multiplexing and a THz radiation detector unit. Then, experiments will be conducted to demonstrate (1) beam alignment and transport of an over-focused, high-density electron beam; and (2) the measurement of THz radiation in single-bunch and multi-picosecond, microbunch modes.

Commercial Applications and Other Benefits as described by the awardee: The terahertz radiator unit should find application for various types of photoelectron guns, including DC, RF, and DC-RF photoinjectors. The compact THz source should be a powerful tool for myriad applications in physics, material science, chemistry, imaging, spectroscopy, biology, medicine, environmental monitoring, homeland security, defense, and communications.

Thin, Ceramic-Based Insulation for Nb_3Sn Wire--nGimat Co., 5315 Peachtree Industrial Boulevard, Atlanta, GA 30341; 678-287-2451; www.ngimat.com
Ms. Michelle Hendrick, Principal Investigator, mhendrick@ngimat.com
Mr. Dave Smith, Business Official, dsmith@ngimat.com
DOE Grant No. DE-FG02-07ER84926
Amount: $749,985

Nb_3Sn superconducting wire is a preferred superconducting medium for certain applications because of the high field it can produce. Nb_3Sn-based wire must be reacted at >600 ºC in an inert environment before use, and the wire's insulation also must be heated and remain intact throughout this reaction. Because the reacted wire is too brittle to wind, the wire, with its insulation, is first wound around a mandrel and then reacted. However, the existing fiberglass insulation sheaths are relatively thick, taking valuable space in the wound configuration – space that could be better occupied with superconductor. Moreover, the possible looseness of the insulator around the superconductor wire makes uniform, well-packed winding difficult. This project will develop a new insulation concept for Nb_3Sn superconductors: a thin (<30 micron) ceramic-based coating that not only can be wound but also can survive the wire's reaction cycle. The thin ceramic insulation will adhere to the wire and form a more stable and controllable base for precision winding compared to typical fiberglass insulation, which adds about 130 microns to the wire diameter. The improvement in packing factor could be as much as 35 to 45%. During Phase I, a flexible coating was applied from a prototype production coating unit capable of depositing the coating in a single pass. Segments of short Nb3Sn wire (<100 m) and long surrogate copper wire (>500 m) were coated to demonstrate coating capability and scalability. In Phase II, the insulation coating will be optimized, the coating unit will be improved, and the resulting wire/insulation product will be tested for superconductivity and other properties.

Commercial Applications and Other Benefits as described by the awardee: The initial market for the proposed insulated Nb_3Sn wire is for a superconducting undulator at a national laboratory, since a laboratory's verification will be necessary to generate further interest. This additional interest would come from other national laboratories and from related laboratories in Sweden, Germany, Italy, the UK, Canada, Taiwan, France, and Japan. Even if only a few of these opportunities came to fruition, demand for significant kilometers of insulated wire can be imagined. Commercial opportunities include the superconducting magnets that currently are used in medical instruments and industrial processing.

***STTR Project: Cryo-Cooled Yb:YAG Lasers for Advanced Photoinjectors--**
Q-Peak, Incorporated, 135 South Road, Bedford, MA 01730; 978-689-0003;
www.qpeak.com
Dr. Kevin F. Wall, Principal Investigator, kwall@qpeak.com
Dr. B. David Green, Business Official, green@psicorp.com
DOE Grant No. DE-FG02-07ER86323
Amount: $749,968

Research Institution
Lincoln Laboratory - MIT
Cambridge, MA

Advanced, high-brightness photoinjectors are required for the next generation of linear accelerators and free-electron lasers. Current photoinjector lasers are overly complex, due to the use of multiple amplifier stages to achieve the desired pulse energy, and have issues with power scaling. This project will develop a liquid-nitrogen-cooled, Yb:YAG, mode-locked-laser master-oscillator/power-amplifier for use as a high-average-power laser source for laser photoinjector applications. A liquid-nitrogen-cooled, Yb:YAG master-oscillator/power-amplifier can provide average powers in excess of 100 W with repetition rates from 100 kHz to 1 MHz. The addition of a second amplifier stage can be used to generate 1 kW of average power in the form of 1-mJ pulses at a 1-MHz rate. In Phase I, the development of the cryogenic-Yb:YAG laser was initiated by building a prototype mode-locked laser, examining amplification techniques, and studying ways of temporally and spatially shaping the laser pulses. The prototype produced 55 W, 214 ps pulses at a repetition rate of 80 MHz. Phase II will involve the construction of a master-oscillator/power-amplifier that produces 1 – 3 mJ at 100 kHz repetition rates or 100-300 μJ at a 1 MHz repetition rate. The wavelength will be ~1030 nm and the oscillator will be passively mode-locked to achieve pulse widths of ~10 ps.

Commercial Applications and Other Benefits as described by the awardee: A relatively simple method of generating high-energy, picosecond pulses would fulfill an important near-term need as a source used in photoinjector applications for linear accelerators and free-electron lasers. Other applications of the basic technology would be in the areas of time-resolved spectroscopy, terahertz generation, and materials processing.

Silicon Carbide Tritium Permeation Barriers for Steel Structural Components--
Ultramet, 12173 Montague Street, Pacoima, CA 91331; 818-899-0236;
www.ultramet.com
Mr. Matthew J. Wright, Principal Investigator, matt.wright@ultramet.com
Mr. Craig N. Ward, Business Official; craig.ward@ultramet.com
DOE Grant No. DE-FG02-07ER84941
Amount: $750,000

The reactor design proposed by the United States for the International Thermonuclear Experimental Reactor (ITER) requires development of advanced materials for breeder blankets. Aluminized coatings developed over the last several years for tritium permeation barriers work well in the laboratory but fail in radiation environments. Because silicon carbide (SiC) applied via chemical vapor deposition(CVD) does not lose tritium permeability resistance under radiation, this project will develop a material system that uses fully dense CVD SiC as a tritium barrier bonded to ferritic steel, with a SiC foam or a ductile metallic foam layer serving as a compliant interlayer between the steel and the CVD SiC tritium barrier. The composite structure offers significant advantages over current aluminized coatings, including high resistance to thermal- and radiation-induced stress, lower tritium diffusivity and solubility, and compatibility with the molten lead-lithium breeder/coolant. In Phase I, the initial bonding of SiC foam/SiC-tritium-barrier specimens to ferritic steel substrates was demonstrated. A matrix of dense SiC wafers was fabricated for deuterium permeation and tritium plasma testing. Resistance to high temperature thermal cycling and thermal shock was demonstrated through furnace testing, and barrier component bond strength was established through shear testing. The test results indicated that the concept has high potential for meeting the tritium barrier requirements of ITER test blanket modules. In Phase II, the material system will be used in the fabrication of a tritium-barrier tube liner, and performance will be demonstrated by subjecting the component to deuterium permeation and deuterium/tritium plasma experiments.

Commercial Applications and Other Benefits as described by the awardee: Nuclear fusion is an ideal alternative to increasingly scarce and expensive fossil fuels and can provide a much greater quantity of environmentally sound energy than wind, solar, and geothermal sources. Practical application of fusion for efficient electricity generation requires the development of materials and structures that can withstand the demanding reactor environment. The proposed barrier material would be a key safety component within reactors that ultimately would be scaled up for commercial use.

Membrane Systems for Coal Bed Carbon Dioxide Sequestration and Methane Production--Membrane Technology and Research, Inc., 1360 Willow Road, #103, Menlo Park, CA 94025; 650-543-3378; www.mtrinc.com
Dr. Haiqing Lin, Principal Investigator, hlin@mtrinc.com
Ms. Elizabeth G. Weiss, Business Official, egweiss@mtrinc.com
DOE Grant No. DE-FG02-07ER84819
Amount: $749,960

In order to reduce the accumulation of greenhouse gases, it has been proposed to sequester the carbon dioxide from the flue gas of coal power plants by injecting the CO_2 into unmineable coalbeds. The methane gas displaced by the carbon dioxide could be recovering and sold, thereby covering the cost of sequestration. However, nitrogen and oxygen typically is injected along with the carbon dioxide, which leads to a coalbed methane product contaminated with multiple impurities. Conventional gas processing technology applied to such contaminated gas is expensive and complex. This project will develop a membrane process that can remove all of the main impurities in a single operation. In Phase I, membranes with good properties for separating carbon dioxide, nitrogen, oxygen, and water from methane were produced and evaluated as bench-scale membrane modules. A preliminary technical and economic analysis showed that the process would be cost effective. In Phase II, the technology will be scaled up, and pilot-scale or small-industrial-scale membrane modules will be produced and installed in a field test system at a coalbed methane gas processing plant.

Commercial Applications and Other Benefits as described by the awardee: The membrane process should find wide applicability in the treatment of natural gas containing multiple contaminants. Coalbed methane produced by the injection of flue gas is one such gas stream.

HydroMax - Overcoming the Challenges of Industrial Coal Gasification--Diversified Energy Corporation, 2020 W Guadalupe Rd, Suite 5, Gilbert, AZ 85233; 480-507-0297; www.diversified-energy.com
Mr. Jerry Stephenson, Principal Investigator, Jerry.Stephenson@diversified-energy.com
Mr. Phillip Brown, Business Official, Phillip.Brown@diversified-energy.com
DOE Grant No. DE-FG02-07ER84665
Amount: $749,816

Volatile natural gas prices are negatively impacting the U.S. industrial sector, which consumes approximately 6.6 trillion cubic feet of natural gas annually. Over the last 24 months, natural gas prices have fluctuated between $5 and $12 per MMBtu, resulting in high and unpredictable fuel costs for the industrial sector. With abundant coal resources, an opportunity exists for the U.S. industrial sector to transition from high-cost natural gas to coal gasification as a source of fuel for process heating applications. However, practical issues such as scalability, economics, feedstock flexibility, and syngas quality must be addressed in order to make this transition feasible. This project will demonstrate the commercial viability of HydroMax technology, a breakthrough, high-temperature, feedstock-flexible, molten-metal gasification approach. In Phase I, two 6.125" internal-diameter HydroMax test reactors were designed, built, and successfully operated using Illinois #6 and Powder River Basin coal types to demonstrate feedstock flexibility. A detailed economic analysis conducted during Phase I revealed that HydroMax can produce syngas economically at a price of $6.65 per MMBtu, much less than the current natural gas price of ~$9 per MMBtu. Phase II will focus on the design, construction, operation, and test of a 0.5 meter, self-heated, HydroMax system that will gasify coal and coal/biomass blends.

Commercial Applications and Other Benefits as described by the awardee: An estimated 12,000 industrial operations in the U.S. could benefit from the HydroMax technology, including wallboard/glass manufacturers, pulp and paper mills, and other industrial companies that require process heat. As a result of reducing fuel gas costs, U.S. industry would become more competitive in the global marketplace, jobs would be created, and the American public would benefit from lower product prices.

Perovskite Adsorbents for Warm-Gas Removal of Sulfur--Eltron Research & Development Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263; www.eltronresearch.com
Dr. Michael V. Mundschau, Principal Investigator, eltron@eltronresearch.com
Mr. James Steven Beck, Business Official; contracts@eltronresearch.com
DOE Grant No. DE-FG02-07ER84666
Amount: $750,000

Technology is needed to remove impurities, especially sulfur, from the hydrogen produced from coal-derived synthesis gas. Although oxides of zinc now remove sulfur from industrial gas streams to the part-per-million level in the presence of steam, much greater removal effectiveness will be required for the hydrogen product. In fact, concentrations of sulfur in the part per *billion* level are required to prevent poisoning of fuel-cell catalysts, membranes, and catalysts used to produce synthetic fuels. Thermodynamic analysis indicates that sorbents incorporating cerium and lanthanum will reduce sulfur from the part-per-million to below the part-per-billion level, even in the presence of steam. In Phase I, measurements of the performance of sorbents incorporating both cerium and lanthanum showed excellent bulk uptake of sulfur, as predicted. In Phase II, the sorbents will be optimized for maximum sulfur uptake, for regeneration, and for attrition resistance. A techno-economic analysis will determine a cost-effective route for scale-up and integration with zinc-based sorbents and hydrogen purification membranes.

Commercial Applications and Other Benefits as described by the awardee: Removing sulfur and other impurities from coal-derived hydrogen should speed the commercialization of pollution-free coal-fired power plants. The technology also should benefit sequestration of carbon dioxide, operation of fuel cells, production of synthetic fuels, and long-term operation of hydrogen-powered turbines.

Magnetic Catalysts for Fischer-Tropsch Synthesis--TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300; www.tda.com
Dr. Gokhan Alptekin, PhD, Principal Investigator, galptekin@tda.com
Mr. John D. Wright, Business Official, jdwright@tda.com
DOE Grant No. DE-FG02-07ER84679
Amount: $750,000

Among the candidate resources to produce liquid fuels – biomass, oil sands, oil shale, and coal – coal is the most promising, with over 250 billion tons of known domestic reserves. Fischer-Tropsch **(**FT) synthesis is the most economically promising method of converting coal into transportation fuels. Although the FT process is run on a commercial scale in both South Africa and Malaysia, three significant challenges remain: (1) the attrition resistance of the catalyst, (2) difficulties in separating the catalyst from the hydrocarbon wax products, and (3) an inability to carry out the water-gas-shift conversion and FT synthesis in the same unit. This project will develop a unique catalytic material that can address all three technical challenges. In Phase I, a highly active catalyst for the both the Fischer-Tropsch and water-gas-shift synthesis reactions were developed. By selecting the right promoters, a CO-rich coal-derived synthesis gas was converted into a desired molecular weight hydrocarbon wax product with great efficiency. Sorbent life was demonstrated in a long-term test under representative conditions, and a preliminary analysis demonstrated the economic viability of the process. In Phase II, catalyst performance will be improved, and production will be scaled-up using commercial manufacturing techniques. A prototype test unit will be designed and fabricated to demonstrate the concept at a larger scale. Finally, a detailed system analysis and engineering assessment will be conducted to fully quantify the benefits of the new technology.

Commercial Applications and Other Benefits as described by the awardee: A viable alternative to crude oil is needed to moderate the effect of oil price hikes and provide an interim bridge until some other fuel source can commercially supplant petroleum-based fuels. An effective FT synthesis plant could be coupled with a coal-based Integrated Gasification Combined Cycle (IGCC) to co-produce both electric power and fuels.

High Temperature Capability and Innovative Cooling with a Spar & Shell Turbine Blade--Florida Turbine Technologies, Inc., 1701 Military Trail, Suite 110, Jupiter, FL 33458-7887; 561-427-6337; www.fttinc.com
Mr. James Downs, Principal Investigator, JDowns@fttinc.com
Mr. Lloyd Mazer, Business Official, LMazer@fttinc.com
DOE Grant No. DE-FG02-07ER84668
Amount: $749,413

The efficiency of future power production facilities must be improved to address the well-known problems of increased global energy usage and increased emissions from the combustion of carbon-based fuels. These emissions, carbon dioxide in particular, are increasingly accepted by the scientific community as a leading cause and contributor to global warming. Technology advances within the turbine systems represent an excellent approach to improving overall power plant efficiency. In particular, technologies that permit turbines to operate at higher temperatures and pressures are desired. This project will develop the "spar-shell" system, which combines advances in both materials and cooling systems to provide highly durable turbine components that require the lowest cooling flow possible. Phase I involved a conceptual design of the spar-shell turbine blade, which included (1) a definition of the mechanical arrangement of an optimized turbine blade based on multi-piece construction, (2) identification of the materials best optimized to the spar-shell turbine blade for use in specific environments, (3) definition of cooling system features required to produce high thermal efficiency, (4) identification of manufacturing and fabrication requirements and (5) an evaluation of benefits and costs. In Phase II, a detailed design of the concept will be completed, which will focus on the development of a demonstration test article for future evaluation in a test engine. Phase II also will involve the creation of manufacturing drawings.

Commercial Applications and Other Benefits as described by the awardee: The spar-shell blade represents a promising leap in gas turbine technology and should be applicable to 14% of today's total world-wide power generation capacity. The spar-shell blade also should be an enabling technology for advanced zero-emission gas and steam turbines such as the High-Hydrogen and Oxy-Fuel turbines. Finally, the spar-shell technology could be leveraged to develop blade designs capable of enhancing existing gas turbine power plant performance and efficiency in Integrated Gasification Combined Cycle (IGCC) applications.

Novel Water Neutral Diesel Fuel Processor and Sulfur Trap--Precision Combustion, Inc., 410 Sackett Point Road, North Haven, CT 06473; 203-287-3700; www.precision-combustion.com
Mr. Subir Roychoudhury, Principal Investigator, sroychoudhury@precision-combustion.com
Mr. John Scanlon, Business Official, jscanlon@precision-combustion.com
DOE Grant No. DE-FG02-07ER84674
Amount: $749,891

To provide electricity for distributed and mobile applications, solid oxide fuel cells (SOFCs) have the potential to operate with much less fuel than that used by generators based on internal combustion engines. However, these systems also must have long life and sell for a price that is competitive with other technologies. Conventional SOFC systems either require makeup water, an expensive logistics burden, or suffer from low durability due to the formation of carbon deposits in the system generators. This project will develop an SOFC fuel reformer that operates at water neutral conditions and enhances the durability of the fuel cell system. The reformer is based on a technology that has been proven effective and durable in military applications, and is inherently cost-effective enough for use in commercial applications. In Phase I, a full-scale reformer was demonstrated, and preliminary durability tests were performed with a demonstrator solid oxide fuel cell system. The reformer met or exceeded all performance targets. A system containing all necessary components for stand alone operation was designed, and its subcomponents were tested at full scale conditions. In Phase II, a stand-alone prototype reactor will be designed, fabricated, and tested with a commercial fuel cell stack for long term durability confirmation. Component cost requirements and simplifications needed to meet commercial targets will be identified and detailed.

Commercial Applications and other Benefits as described by the awardee: The technology should help boost market opportunities for fuel cell systems, thereby greatly reducing dependence on oil resources for power generation and transportation, while substantially cutting emissions. Specific applications could include distributed home electric power generation and heavy truck auxiliary power units.

A High-Temperature Sealing Technology for Gas Separation Devices--Aegis Technology Inc., 3300 A Westminster Ave., Santa Ana, CA 92703; 714-265-1238; www.aegistg.com
Mr. Bob Liu, Principal Investigator, bobliu@aegistech.net
Mr. Bob Liu, Business Official, bobliu@aegistech.net
DOE Grant No. DE-FG02-07ER84934
Amount: $750,000

Gas separation devices are needed in a variety of advanced energy systems (e.g., high-temperature solid oxide fuel cells). For such devices, a reliable sealing technology is needed to enable the hermetical joining of the ceramic membranes used in high temperature gas separation to their underlying support structures (e.g., a metallic body). This project will develop and demonstrate a reliable, reactive air brazing (RAB) technology for these high-temperature sealing applications. Phase I demonstrated technical feasibility by: (1) developing a novel material composition design based on Ag-CuO, (2) preparing the filler material and brazing process, and (3) characterizing wetting behavior, mechanical strength, and microstructure. In Phase II, the material composition will be optimized, and the process will be scaled-up for potential commercialization. The high-temperature sealing technology will be incorporated in some typical components (e.g., solid oxide fuel cell stacks), in order to demonstrate the benefits of the sealing technology at the system level.

Commercial Applications and Other Benefits as described by the awardee: The sealing technology should be of particular importance for longer-term fossil energy applications, including gas separations and storage, which require operation under hostile conditions (e.g. high temperatures, elevated pressures, and corrosive environments). These applications include energy conversion devices (fuel cells), chemical reactors (e.g., for the economical upgrading of low-grade fuels), and other gas separation and purification processes.

Novel Instrumentation for Real-Time Combustion Monitoring and Control--Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041; 650-965-7772; www.lgrinc.com
Dr. Douglas Baer, Principal Investigator, d.baer@lgrinc.com
Dr. Anthony O'Keefe, Business Official, a.okeefe@lgrinc.com
DOE Grant No. DE-FG02-07ER84672
Amount: $673,049

The effective monitoring and control of high-temperature process streams that consist of reactive gases (including gases from syngas plants, chemical processes, power plants, industrial furnaces, boilers, and incinerators) is limited by the sensitivity, specificity, speed, and reliability of available sensors and control systems. As a result, many processes operate with sub-optimal efficiency and release excessive toxic emissions, pollutants, and greenhouse gases. This project will employ a patented Off-Axis Integrated Cavity Output Spectroscopy technology along with near-IR and mid-IR lasers to develop a field-portable gas analyzer for real-time quantification of several gases in high-temperature reactive flows. In Phase I, prototype bench-top instruments based on near-and mid-IR laser absorption were designed and developed. The instruments employed (1) single-pass laser diagnostics for fast, *in situ* measurements of H_2O and gas temperature; (2) cavity enhanced absorption (Off-Axis ICOS) for *in situ* measurements of several critical reactive species; and (3) fast extractive sampling into an Off-Axis ICOS measurement cell for rapid, sensitive (sub-ppm precision) measurements of selected trace gases. Phase II, will involve the construction, deployment, and testing of multi-species instruments in realistic industrial flows with high-temperature reactive gases.

Commercial Applications and Other Benefits as described by the awardee: The instrumentation should be applicable to the monitoring and control of combustion emissions (e.g., from power plants, furnaces, boilers, incinerators), industrial processes (coal gasification), and automobile engines, and the monitoring of atmospheric pollutants and greenhouse gases.

A New Cost Effective Sorbent for Mercury Removal From Flue Gas--NEI Corporation, 400 Apgar Drive, Suite E, Somerset, NJ 08873; 732-868-3141; www.neicorporation.com
Dr. Mohit Jain, Principal Investigator, mjain@neicorporation.com
Dr. Ganesh Skandan, Business Official; gskandan@neicorporation.com
DOE Grant No. DE-FG02-07ER84714
Amount: $749,322

The cost of reducing mercury emissions from coal-fired power plants is an impediment to the implementation of new mercury emission standards, particularly in older power plants. The use of a sorbent to capture mercury from the flue gas is considered to be the most effective approach, but issues pertaining to secondary emissions and the degradation of the fly-ash byproduct (which results from entrained sorbent) are yet to be resolved fully. This project aims to overcome these barriers by developing an environmentally benign sorbent powder that also renders the fly ash usable. Although the sorbent has a novel composite morphology, it is anticipated to be highly cost competitive. Sorbent powders were produced in Phase I and tested at a host utility in the western United States. In addition, to obtaining excellent mercury removal efficiency, it was demonstrated that the sorbent powders are more concrete-friendly than most state-of-the-art commercial sorbents. Phase II will involve the further development and optimization of the morphology of the sorbent particles. The production process will be scaled to a commercial level by working in partnership with a leading powder manufacturer based in the United States. Mercury removal efficiency initially will be tested in a slip stream at a utility, followed by full-scale tests in year two.

Commercial Applications and Other Benefits as described by the awardee: The federal government's Blue Skies Initiative targets a 70% reduction in mercury emissions by 2018. A new sorbent technology that could be readily used by coal-fired power plants with a minimal overall cost impact should help achieve this target. The market for sorbents to reduce mercury emissions is projected to be $1billion over the next ten years.

A Novel Wireless Sensor Network with Advanced Prognostic Algorithms for Condition Based Maintenance of Critical Power Plant Components--Signal Processing, Inc., 13619 Valley Oak Circle, Rockville, MD 20850-3563; 240-505-2641
Dr. Chiman Kwan, Principal Investigator, chiman.kwan@signalpro.net
Dr. Chiman Kwan, Business Official, chiman.kwan@signalpro.net
DOE Grant No. DE-FG02-07ER84676
Amount: $750,000

Improving efficiency, reducing emissions, and reducing costs are key objectives of power plants. The achievement of these objectives will require the development of two mutually dependent functions: distributed data acquisition and real-time data interpretation. This project will combine a wireless sensor network (WSN) with an advanced diagnostic and prognostic capability to monitor and assess critical power plant components. In Phase I, two testbeds were constructed: one for emulating electrical faults and one for emulating mechanical faults. Real-time experiments were performed, with wireless data collection used in all experiments. Real-time health monitoring algorithms were developed, and actual bearing data were used to validate the algorithms. Phase II will implement all of the diagnostic and prognostics tools in a real-time processing unit. Real-time field tests will be carried out with a WSN to collect various sensor data.

Commercial Applications and Other Benefits as described by the awardee: The technology should find use in any application (DOE, NASA, military, or commercial) involving electrical and mechanical components. Specific applications include turbine engines, bearings, pumps, gearboxes, motors, and generators.

Development of Technologies to Reduce Freshwater Use and Consumption in Coal-Fired Power Plants--TIAX, LLC, 15 Acorn Park, Cambridge, MA 02140; 617-498-5655; www.tiaxllc.com
Dr. David Kingston Owens, Principal Investigator, owens.kingston@tiaxllc.com
Dr. Renee Wong, Business Official, wong.renee@tiaxllc.com
DOE Grant No. DE-FG02-07ER84681
Amount: $746,741

The steam cycle process used in coal-fired plants requires about 38 gallons of water per kilo-watt hour of electricity produced. The water is used mostly for steam cooling with a lesser quantity used for pollution control devices. This project will develop a novel, low-cost, vapor distillation technology that will enable municipal wastewater and non-traditional waters to be used as process water for coal power plants. An important feature the approach is the use of stack gas waste heat – which otherwise would be discharged into the atmosphere – for cleaning the contaminated water through a humidification/dehumidification process carried out at atmospheric pressure. Access to this heat stream is relatively easy and would not require a major redesign of the plant or a major shutdown for installation, making this technology economically attractive. Technical feasibility was demonstrated in Phase I. Phase II will involve measuring the operating parameters of the vapor distillation concept in a 1000 gallon per day pilot plant, producing a preliminary design for a representative plant, and using the design to estimate construction and operating costs.

Commercial Applications and Other Benefits as described by the awardee: The technology should become suitable for retrofit to a large number of U.S. power plants. If 500 power plants (at an average size of 600 MW) used the technology, the volume of water recovered would be one billion gallons per day.

FGD Additives to Segregate and Sequester Mercury in Solid Byproducts--Trimeric Corporation, P.O. Box 826, Buda, TX 78610; 512-295-8118; www.trimeric.com
Ms. Katherine Searcy, Principal Investigator, Katherine.searcy@trimetric.com
Ms. Katherine Searcy, Business Official, Katherine.searcy@trimeric.com
DOE Grant No. DE-FG02-07ER84682
Amount: $738,682

Coal is used to generate more than half of the electricity in the United States. However, coal has a range of mercury-related environmental disadvantages: (1) emissions of mercury via the flue gas, and (2) environmental releases of mercury during subsequent processing and disposal of byproducts. This project will address both concerns through the use of chemical additives in the power plant's flue gas desulfurization (FGD) system. These additives will sequester mercury into the liquid phase, prevent mercury re-emissions into the flue gas, prevent precipitation and adsorption of mercury on primary FGD byproducts such as gypsum, and subsequently precipitate mercury from the FGD wastewater as a stable solid byproduct that is segregated from other FGD solid byproducts. In Phase I, laboratory testing using a bench-scale scrubber test apparatus demonstrated that the technology can control re-emissions of mercury, and that the mercury can be subsequently removed from the scrubber wastewater and concentrated into a stable solid waste product. An engineering cost analysis demonstrated that the technology would be economical and competitive with other control strategies. Phase II initially will involve additional laboratory testing to further refine the chemistry, and the selection of the additives and process conditions. Then, a larger pilot-scale demonstration will be conducted at two host utility sites, using actual flue gas and the FGD scrubbing slurry from the utility.

Commercial Applications and Other Benefits as described by the awardee: The proposed technology should have extensive commercial applications in the electric utility industry at both new and existing coal-fired power plants equipped with wet FGD scrubbing systems. The public would benefit through reduced exposure to mercury emitted from power plant stacks and through reduced exposure to the mercury-containing FGD byproducts during their disposal or re-use in gypsum wallboard products and agriculture applications.

Novel Low Cost Method to Install Geophones for CO2 Monitoring--Impact Technologies LLC, 5350 E. 46th Street, Suite 131, Tulsa, OK
4135-6611; 918-627-8035; www.impact-tek.com
Mr. Kenneth D. Oglesby, Principal Investigator, kdo@impact2u.com
Mr. Kenneth D. Oglesby, Business Official, kdo@impact2u.com
DOE Grant No. DE-FG02-07ER84670
Amount: $750,000

In order to monitor the location of sequested CO_2 that has been injected in reservoirs, the most promising technology involves the use of geophones within wellbores. These geophones perform Vertical Seismic Profiling (VSP) and passive seismic monitoring. However, this geophone technology is currently very expensive to apply – drilling a new well or taking a valuable well out of service is costly. Consequently, the technology is seldom employed; making it is very difficult to determine whether the CO_2 remains where it is intended. This project will utilize a patented High Pressure Slurry Pump, proven coiled tubing, and a patent-pending supercritical abrasive slurry system to drill low-cost microholes (two inches in diameter) for the permanent installation of small, inexpensive VSP receivers. Phase I demonstrated the drilling process and identified currently-available geophones that can fit inside the tubing at a depth of 2,000 feet. Moreover, the geophones were shown to be capable of monitoring fluids in rock at 4-to-5 times that depth. Phase II will assemble and field-test these combined components, drill up to three wells, equip them with geophones, and conduct a VSP quality-check survey within an existing CO_2 flood.

Commercial Applications and Other Benefits as described by the awardee: In addition to reducing the costj of CO_2 monitoring with VSP, the overall system should find use in conventional oil and gas drilling (vertical and directional), boring, and digging and trenching in hard rock areas; for utility installation of buried pipes and pipelines; and in mining, construction piering, geothermal sinks, and environmental well drilling.

A Novel Oxygen Separation Membrane for Oxygen Production--Enogetek, Inc., 46 Bari Manor, Croton-on-Hudson, NY 10520; 914-426-2577; www.enogetek.com
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Dr. Lin-Feng Li, Business Official, crotonlfli@netzero.com
DOE Grant No. DE-FG02-07ER84667
Amount: $749,716

The production of oxygen is ranked among the top five commodity chemicals in the U.S. However, low energy efficiencies and high costs are preventing the widespread implementation of traditional oxygen separation technologies. This project will develop and demonstrate a novel, low-cost, high-flux, high-selectivity, highly-efficient oxygen separation membrane. The Phase I effort demonstrated that the membrane (1) is simple to make in any shape or dimension; (2) can be easily scaled up; (3) would reduce the energy consumption of the overall oxygen separation system by 12% compared to cryogenic and ion transport membrane techniques; and (4) would provide oxygen permeability and O_2/N_2 selectivity that exceeds the performance of state-of-the-art polymer membranes. In Phase II, membrane performance will be further improved and prototype oxygen separation device will be designed, fabricated, and tested. The Phase II goals are to reduce energy consumption 25% and system cost by 80%.

Commercial Applications and Other Benefits as described by the awardee: The oxygen separation technology should be applicable to the production of pure oxygen needed in the steel making industry, in varieties of chemical processes, in the paper industry, and in waste water treatment plants. In addition, oxygen gas also is used extensively in medical procedures for patients suffering from impaired respiratory function.

Enhanced Monitoring of Geological Carbon Sequestration Using 3-D Passive Microsesimic Location Techniques--Weston Geophysical Corp., 181 Bedford St., Suite 1, Lexington, MA 02420; 781-860-0127; www.westongeophysical.com
Dr. Delaine Reiter, Principal Investigator, Delaine@westongeophysical.com
Mr. James Lewkowicz, Business Official, jiml@westongeophysical.com
DOE Grant No. DE-FG02-07ER84683
Amount: $749,686

The DOE's carbon sequestration program requires careful monitoring and verification to ensure high-confidence with respect to the accounting of stored carbon dioxide and other greenhouse gases. Passive seismic monitoring of microseismicity occurring at the reservoir scale can help to ensure the permanent sequestration of captured carbon dioxide. This project will adapt a state-of-the-art, three-dimensional location technique to passively monitor the microseismic movement of sequestered carbon dioxide in geological formations. In Phase I, the location algorithm was adapted to the microseimic scale of the carbon dioxide storage environment, and a wavelet-based phase detection algorithm was developed to process the microseismic waveform data. Phase II will involve the further development of the location methodology for use in the reservoir environment and its augmentation with data processing algorithms and field data demonstrations. One field demonstration will involve a microseismic study at a Department of Energy carbon storage pilot site performed in collaboration with researchers at Lawrence Berkeley National Laboratory.

Commercial Applications and Other Benefits as described by the awardee: In addition to the application to carbon sequestration, passive monitoring at the microseismic scale should have many potential commercial uses, including applications in enhanced oil recovery, geothermal field monitoring, and mining operations.

Wireless Sensors for Equipment Health and Condition Monitoring in Nuclear Power Plants--Analysis and Measurement Services Corporation, 9111 Cross Park Drive, Building A, Knoxville, TN 37923; 865-691-1756; www.ams-corp.com
Mr. Hashem M. Hashemian, Principal Investigator, hash@ams-corp.com
Mr. Darrell W. Mitchell, Business Official, Mitchell@ams-corp.com
DOE Grant No. DE-FG02-07ER84684
Amount: $749,899

Power generation utilities are striving to use wireless technologies in nuclear power plants, but a number of important challenges must be overcome. These challenges include infrastructure issues, security risks, reliability questions, and interference problems. This project will develop a prototype system to acquire data from wireless sensors for equipment and process diagnostics in nuclear power plants. In Phase I, the feasibility of using wireless sensors for equipment condition monitoring in nuclear power plants was demonstrated. Phase II will (1) design and develop a prototype system for acquisition, qualification, storage, and display of data from wireless sensors; (2) test the system using data from wireless sensors installed in a laboratory test loop; (3) assess technology security risks and develop recommendations and procedures for risk reduction; (4) investigate electromagnetic and radio frequency interference, including the effects of wireless transmissions on existing plant equipment; and (5) implement the prototype system for selected applications in a host utility plant.

Commercial Applications and Other Benefits as described by the awardee: In addition to the application for nuclear power plants, the technology should benefit almost any other industrial process for plant health assessment, residual life estimation, plant aging and obsolescence management, manpower savings, reduction of radiation dose to maintenance personnel, and asset management.

Spent Nuclear Fuel Separation with the Archimedes Plasma Mass Filter--
FAR-TECH, Inc., 3550 General Atomics Court, Building 15, Suite 155, San Diego, CA 92121; 858-455-6655; www.far-tech.com
Dr. Brian Cluggish, Principal Investigator, cluggish@far-tech.com
Dr. Jin-Soo Kim, Business Official, kim@far-tech.com
DOE Grant No. DE-FG02-07ER84685
Amount: $750,000

The Global Nuclear Energy Partnership (GNEP) and the Advanced Fuel Cycle Initiative (AFCI) programs are searching for (1) separations technologies for spent nuclear fuel (SNF) and (2) devices that allow for fission product separation of highly radioactive, low-atomic-mass isotopes from spent transuranic and minor actinide wastes, and that are compatible with the UREX+ process. The innovative, plasma-based, Archimedes Filter Technology (AFT) is an attractive option for SNF recycling because it can separate fission products from actinides by mass without explicit separation of plutonium. Recent research also has shown that the AFT could be of great benefit to the UREX+ process. However, implementation of the AFT requires development of a technique for vaporizing SNF for injection into the Filter device. This project will develop this vaporization source, which will be critical for a demonstration of the existing full scale prototype. Numerical simulations in Phase I demonstrated that the AFT has the potential to separate actinides from fission products with sufficient throughput and separation quality to be of benefit to the UREX+ process. The tasks defined the feed basis, used that feed to determine the relative decontamination factors for collisional versus collisionless operation of a commercial AFT, and determined the optimal operating parameters. In Phase II, a vaporization technique for feeding SNF to the main AFT plasma will be developed, and a more efficient neutral collector, which will improve the decontamination of the heavy actinide product, will be designed.

Commercial Applications and Other Benefits as described by the awardee: Separation by mass would produce a proliferation-resistant actinide product that can be burned in a reactor. Furthermore, by removing actinides from fission products, the long term capacity of a geologic repository for these products would be greatly expanded.

Low Drift Ultra High Temperature Thermal Sensors--Luna Innovations Incorporated, 1 Riverside Circle, Suite 400, Roanoke, VA 24016; 540-769-8430; www.lunainnovations.com
Mr. Matthew Palmer, Principal Investigator, submissions@lunainnovations.com
Mr. Michael Pruzan, Business Official, pruzanm@lunainnovations.com
DOE Grant No. DE-FG02-07ER84686
Amount: $749,990

In planned Gen-IV nuclear reactor designs, accurate temperature measurements are needed to identify hot spots (especially in the fuel cladding), control thermal cycles, and perform temperature compensation of other sensors. At temperatures beyond 1000°C, temperature spikes may occur, which could lead to premature failure of the reactor pressure vessel, fuel meltdown, containment breach, and possible fission product release. Although these measurements are critical to the safe operation of these reactors, no drift-free measurement of temperature exists for monitoring in-core reactor temperatures. This project will develop low-drift, ultra-high-temperature fiber-optic temperature sensors that are hardened for radiation environments, specifically for Gen-IV reactors. The proposed sensors will be designed for reliable, sustained operation at temperatures up to 1100 °C and for survival at temperatures up to 1400°C for short periods of time. The sensors will be constructed from specially selected materials to be chemically resistant, oxidation resistant, and diffusion resistant. In Phase I, feasibility was demonstrated by testing six different materials and seven kinds of optical fibers in a radiation environment. With respect to radiation drift, the optical sensor exhibited a variation of only 0.05°C over a total fluence of 4.7x1017 cm^{-2}. A specially-designed optical fiber, which is more radiation hard than conventional "rad hard" pure silicon core fiber, was identified. Phase II will focus on a high-temperature, high-fluence endurance test of the temperature sensors at an advanced test reactor.

Commercial Applications and Other Benefits as described by the awardee: The low-drift temperature measurement would be an enabling technology for the commercialization of Gen-IV reactors. Since the sensors will be radiation tolerant and high-temperature capable, they also should find application in space probes, rocket engine monitoring, rocket engine development, and gas turbine health monitoring. By reducing the use of fossil fuels for power generation, Gen-IV nuclear reactors will reduce both greenhouse gas emissions and U.S. dependency on foreign oil.

Development of AgeAlert: A Predictive Maintenance Sensor for Electrical Insulation Systems in Nuclear Power Applications--Polymer Aging Concepts, Inc., 372 River Drive, Dahlonega, GA 30533; 706-864-6304;
www.polymeragingconcepts.com
Mr. Kenneth S. Watkins, Jr., Principal Investigator,
kwatkins@PolymerAgingConcepts.com
Mr. Kenneth S. Watkins Jr., Business Official, kwatkins@PolymerAgingConcepts.com
DOE Grant No. DE-FG02-07ER84687
Amount: $750,000

Component failures resulting from degradation within insulation systems represents a significant contribution to reliability and cost issues facing the nuclear power industry. For example, the Electric Power Research Institute found that 37% of motor failures were due to winding failures, many of which involve failure of the insulation system. Although a number of visual, tactile, or electrical tests exist for detecting and locating insulation problems, current methods are complex and expensive, and require considerable expertise, or they are subjective and require shutdowns and/or disassembly. This project will develop a new sensing technology, called AgeAlert, which will provide the first direct measurement of insulation degradation, both *in situ* and in real time. In this approach, a tiny low-cost sensor – installed in the windings of a motor, generator, or transformer – responds to actual environmental conditions in the motor and accurately correlates to insulation degradation. Because AgeAlert sensors are conductive composites made with the same insulation resin of the insulation being monitored, the sensors respond in exactly the same manner, and under exactly the same conditions, as the insulation itself. Phase I developed prototype AgeAlert sensors and demonstrated feasibility by accurately tracking the insulation in a reactor coolant pump motor. In Phase II, expanded aging trials will be conducted on additional insulation systems in thermal, radiation, and humidity environments. The prototype sensor will be tested in a realistic nuclear component test bed, and an integrated system design will be completed for the incorporation of AgeAlert sensors in plant-wide condition-monitoring systems.

Commercial Applications and Other Benefits as described by the awardee: The AgeAlert technology should reduce the cost of screening individual electrical components for insulation deterioration and provide advance warning of insulation degradation. In addition to the application to the nuclear power industry, the sensors should be applicable to degradation monitoring of virtually any polymeric material, opening possibilities for use in wire and cable systems, seals and gaskets, hybrid automobile motor/generators, tires, belts, and aerospace composite structures.

Nuclear Physics Electronics Design and Fabrication - Advances in Digital Electronics--XIA LLC, 31057 Genstar Road, Hayward, CA 94544; 510-401-5760; www.xia.com
Dr. Hui Tan, Principal Investigator, htan@xia.com
Dr. William K. Warburton, Business Official, bill@xia.com
DOE Grant No. DE-FG02-07ER84760
Amount: $750,000

U.S. national laboratories are developing microcalorimeters as very precise detectors of electromagnetic radiation from near infrared to gamma ray frequencies, with much better energy resolution than existing detectors. Since microcalorimeters are small, they must be fabricated in large, 100-to-1000 channel arrays that, in turn, will require low-cost readout electronics with good energy resolution and high count rate capability. This project will extend the high precision digital readout electronics and digital filter algorithms, previously developed for germanium gamma-ray detectors, to very large microcalorimeter arrays. The objectives are to achieve (1) energy resolutions comparable to existing electronics, but with much higher count rates; (2) automated software for setup, calibration, and monitoring; and (3) a price of $100 per channel. In Phase I, microcalorimeter data was acquired from several research laboratories, and then processed offline and occasionally online. The resolution matched or exceeded the resolution from currently used "optimum" filters: ~0.07% resolution at low rates (versus 0.7-0.9% for optimum filters) and ~0.13% resolution at higher rates (versus 0.31%). The maximum theoretical count rate with good resolution was 155-1100 counts/s (versus ~ 8 counts/s). A preliminary design of a multi-channel prototype board was created that would meet the cost target. Phase II will complete the multi channel electronics design, build the hardware, and develop on-board firmware and software for multiplexed processing of slow microcalorimeter signals in high speed digital components.

Commercial Applications and Other Benefits as described by the awardee: The proposed instrument should have applications in various scientific experiments employing arrays of microcalorimeters for X-ray or gamma-ray spectroscopy. A notable practical application is very precise isotope analysis of nuclear materials, which would make the instrument a valuable tool for nuclear non-proliferation. Similar instruments also could be used for quality control in semiconductor processing.

***STTR Project: High-Energy Gamma-Ray Calibration Source**--Adelphi Technology, Inc., 2003 East Bayshore Road, Redwood City, CA 94063; 650-474-2750; www.adelphitech.com
Dr. Melvin Arthur Piestrup, Principal Investigator, melpie@adelphitech.com
Dr. Charles Kevin Gary, Business Official, cgary@adelphitech.com
DOE Grant No. DE-FG02-07ER86294
Amount: $750,000

Research Institution
Lawrence Berkeley National Laboratory
Berkeley, CA

No long-lived gamma-ray calibration sources exist with energies above 3.5 MeV, which is an impediment to the calibration of high-purity-germanium (HPGe) and scintillation detectors used in homeland security, nuclear physics and astrophysics. Recent advances in Prompt Gamma-ray Activation Analysis (PGAA) with guided neutron beams have led to the precise calibration of neutron-capture gamma-ray sources with energies up to 10.8 MeV. In this project, these neutron-capture gamma-ray sources will be produced in a moderator/transducer surrounding a compact, low-yield neutron generator that uses the safe D-D fusion reaction. In Phase I, a portable gamma-ray generator was designed using (1) an inexpensive ion source, (2) a self-replenishing target for generating neutrons, and (3) a compact moderator with a γ-ray transducer. The parameters for selecting the three major components were based on the required count rate for calibrating the frequency and efficiency of the detector, while still ensuring operator safety and minimizing possible damage to the detector. The high-energy gamma-ray spectrum was measured using the selected transducer material. In Phase II, the ion source will be fabricated and tested, and the fast neutron generator will be fabricated and integrated into the moderator and γ-ray emitter. Then, the source's gamma-ray yield will be measured, and the source's safety and benefits for detector calibration will be determined.

Commercial Applications and Other Benefits as described by the awardee: The DOE and the International Atomic Energy Agency (IAEA) must provide for the application of standards for the safety of nuclear installations and radioactive sources. The new device should enable the easy calibration of the energy and efficiency of HPGe detectors at high γ-ray energies, at in-house installations or in the field, for the identification of nuclear and radioactive materials. It also should reduce security concerns about the storage of radioactive sources currently in use.

***STTR Project: Si Nanowires for High Efficiency Gamma Ray Detectors--A**giltron, Inc. 15 Cabot Road, Woburn, MA 01801; 781-935-1200; www.agiltron.com
Dr. Larry Domash, Principal Investigator, ldomash@agiltron.com
Dr. Jing Zhao, Business Official, Jzhao@agiltron.com
DOE Grant No. DE-FG02-07ER86297
Amount: $749,913

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

The gamma ray spectrometers used for nuclear physics research at national laboratories are expensive, bulky, and limited in maximum count rate and other performance measures. Scintillators would be a viable alternative, provided that conventional glass photomultiplier tubes could be replaced with a high-quantum-efficiency, UV-sensitive solid state detector that operates at low voltage, has low noise, and provides active areas of at least 5 cm^2. To date, no silicon-based detector meets these needs. This project will develop a novel silicon-nanowire (Si-NW) photodetector that is ideally matched to the scintillator requirements, offering high quantum efficiency, low bias voltage, large sensitive areas, a large gain-bandwidth product, ruggedness, and low cost. In Phase I, the feasibility of the wafer-scale Si-NW fabrication process was demonstrated. This achievement – along with earlier data on the UV photo-response, gain, and excess noise of experimental Si-NW detectors – demonstrated the feasibility of the concept. Phase II will develop full-scale photodetectors with active areas of 1-5cm^2, integrate the photodetectors with state-of-the-art $LaBr_3$:Ce scintillator crystals to produce fully functional gamma instruments, and deliver the instruments to a cooperating national laboratory for testing.

Commercial Applications and Other Benefits as described by the awardee: In addition to the application for nuclear physics research, the new gamma ray detectors should become key tools for the nuclear power industry for use in monitoring reactors and the nuclear fuel cycle, for industrial non-destructive testing, and for the medical PET scan market. Compact, rugged, low-voltage gamma detectors also would be essential for homeland security and the global war on terror.

Novel, Low Cost, High Gain, Micropattern Detectors--Integrated Sensors, LLC, 2403 Evergreen Road, Toledo, OH 43606-2323; 419-536-3212; www.sensors.com
Dr. Peter S. Friedman, Principal Investigator, psfriedman3@yahoo.com
Dr. Peter S. Friedman, Business Official, psfriedman3@yahoo.com
DOE Grant No. DE-FG02-07ER84749
Amount: $749,985

Nuclear physics research has a need for new radiation detector structures having improved characteristics and lower cost. These detectors are needed to provide higher resolution capability for detecting, tracking, and analyzing gamma rays, high- and low-energy neutrons, low-energy ion beams, etc. This project will develop a novel, low cost, hybrid sensor with potential amplification gains on the order of 10^{11}, positional resolutions approaching 10 μm, good spectral resolution, and device risetimes in the range of 10 picoseconds. Phase I established technical feasibility via a combination of device design, materials and performance analysis, development of a viable electronics readout scheme, and computer modeling simulations. Five targeted applications areas in nuclear physics, which could significantly benefit from the new detector technology, were identified and analyzed. Phase II will involve the fabrication, experimental testing, optimization, and analysis of the proposed detector devices. A number of fully-integrated and hermetically-sealed detectors will be delivered to Oak Ridge National Laboratory, along with readout electronics, for analysis and performance testing with respect to the targeted applications. In-beam functional testing will be included, along with measurement of device efficiency, timing resolution, position resolution and energy resolution.

Commercial Applications and Other Benefits as described by the awardee: In addition to nuclear physics, the two most important commercial applications are medical imaging and homeland security. For medical imaging applications, lower-cost, higher-resolution detectors should be applicable to CT imagers, PET, SPECT, PET/MRI, SPECT/MRI, digital Xrays, CTA, myocardial imaging, scintillation mammography, etc. For homeland security, the detectors could be used for active and passive radiation detection systems, including vehicle and cargo monitors/radiography.

High Efficiency and Less Expensive Nanocrystal Based Scintillator--Mesolight, LLC, 401 S. Cedar Street, Little Rock, AR 72205; 479-799-3368; www.mesolight.com
Dr. Yunjun Wang, Principal Investigator, yjwang@mesolight.com
Dr. Yunjun Wang, Business Official, yjwang@mesolight.com
DOE Grant No. DE-FG02-07ER84750
Amount: $750,000

There is immediate need for a new generation of scintillation materials for nuclear physics research, high-energy radiation (x- and gamma-rays) screening/imaging, and passive detection of nuclear materials with improved quality and low production cost. Inorganic scintillators have high output efficiency, but relay on the growth of bulk crystal that is still a challenging task. Due to their relatively low cost and availability as large size sheets, organic scintillators are ideal for use in applications such as portal monitors and waste monitors. However, organic scintillators have low light output efficiency, and thus are not very suitable for detection of lower energy radiation. This project will develop nanocomposite-scintillating medium (scintillating nanocrystals embedded in transparent polymer) that would have the advantage of conventional inorganic materials (i.e. high light output) and that of organic materials (i.e. low cost and availability of large size/area sheet).

The Phase I project developed scintillating nanocrystals as well as their polymer composite, and tested their optical and scintillating properties. The Phase II project will develop nanocomposite scintillators with improved scintillating features and physical-mechanical properties.

Commercial Applications and other Benefits as described by the awardee: Highly sensitive and low cost nanocomposite scintillators could be commercially used for portable monitors for passive identification of nuclear materials, and large radiation detectors for active interrogation of large sea-land containers or cargos. They also can be used for medical imaging, X-ray instrumentation, and materials analysis.

New Detector for Gamma Ray and Neutron Studies--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472 4699; 617-668-6800; www.rmdinc.com
Mr. Kanai Shah, Principal Investigator; KShah@rmdinc.com
Dr. Gerald Entine, PhD, Business Official; GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84753
Amount: $750,000

Inorganic scintillation crystals are a very important element of the current and the next generation experiments in nuclear and particle physics. Performance of the nuclear physics detection systems is often limited by the properties of scintillators available for neutron and gamma ray detection.

This project will investigate new scintillator materials that provide excellent light yield for neutrons and also provide pulse shape discrimination between neutron and gamma events. The new scintillators will also provide very good performance for gamma ray detection, including high light output, excellent energy resolution, fast response and very high timing resolution.

The Phase I project was aimed at demonstrating the feasibility of producing the scintillators for neutron and gamma detection. Extensive characterization of the scintillators was conducted in the Phase I project. The Phase II project will be aimed at optimization of the proposed scintillators for eventual use in nuclear physics studies. Growth of large crystals, tuning of dopant concentration, and extensive characterization of scintillation properties is planned. Evaluation of these new scintillators in actual nuclear physics experiments is also planned.

Commercial Applications and other Benefits as described by the awardee: The proposed detector technology is very promising for nuclear and particle physics experiments. It will also be applicable in medical imaging systems, astronomy, diffraction, non-destructive studies, nuclear non-proliferation, and bore hole logging.

SSPM Detector for Polarized Target Scintillation Readout--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Dr. James Christian, PhD, Principal Investigator, JChristian@rmdinc.com
Dr. Gerald Entine, PhD, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84752
Amount: $749,996

Nuclear physics investigations require photodetectors that operate in harsh conditions (e.g., temperatures of 5 K and below, and magnetic fields greater than 1 T), yet existing methods of photodetection cannot provide the needed quality of data at a reasonable cost. This project will develop a photodetector that will tolerate these conditions and can be made in a commercially available, low-cost semiconductor fabrication process. Phase I demonstrated the operation of CMOS photodetectors at 5 K. The prototype photodiodes showed high gains at these low temperatures when operated below breakdown, or in proportional mode. The detailed radiometric performance indicated that a photodetector operated in proportional mode can meet the demands of experiments in these harsh environments. In Phase II, a prototype instrument will be developed to collect data in a nuclear physics experiment. The device will consist of solid-state photodiodes operated in proportional mode, and the instrument will be optimized in terms of gain, energy resolution, dark noise, and heat load. Once optimized, the photodetector will be packaged to allow for robust and sensitive operation for multiple applications.

Commercial Applications and Other Benefits as described by the awardee: A photodetector that can operate at low temperatures (< 5 K) and in large magnetic fields, has sufficiently high gain, and provides high detection efficiency (> 10%) would be a marketable device for novel scientific experiments that operate under these extreme conditions. The detector also should find use with positron emission topography at cryogenic temperature, or as LXe detectors for detecting Weakly Interacting Massive Particles.

Modeling of Signal Generation in Gamma Ray Detectors--Tech X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303 1379; 720-974-1856; www.txcorp.com
Dr. Paul J. Mullowney, Principal Investigator, paulm@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84758
Amount: $749,679

Gamma ray detectors are widely used devices in nuclear physics research. The GRETINA gamma ray detector significantly improves upon existing technologies like Gammasphere due to its novel segmentation design, however much work is needed in order to maximize its full capabilities. In particular, there are problematic regions on the detector that could strongly benefit from high fidelity computational modeling. This project will develop accurate bulk-and surface-transport models of charged carriers as well as codes for computing the electric fields in the GRETINA crystals. Moreover, we will focus our efforts on poorly understood regions of the devices such as the passivated surface where the measured signals are highly pathological. These developments will yield a more accurate set of basis signals from which to efficiently determine the location of gamma ray events. Ultimately, this will vastly improve the performance of these detectors.

Monte Carlo models of charged carrier bulk-transport were developed during Phase I. Refinements were also developed along with prototype codes for computing the electric field in the entire crystal. The codes reproduce results from commercially available software. The Phase II project will extend the code to more accurately model transport in the crystal bulk, implement methods for computing surface carrier transport on problematic passivated surfaces, and extend field calculation code to incorporate more realistic boundary conditions. The new computational infrastructure will then be used to understand the surface physics of the GRETINA detectors

Commercial Applications and other Benefits as described by the awardee: This project will enhance modeling both bulk-and surface-transport in semiconductors. Studies performed during Phase II will also be made available to the nuclear physics community via peer-reviewed journal articles and conference presentations in order to disseminate knowledge gained to the nuclear physics community.

***STTR Project: Refractory Coated Silica Aerogels-Catchrs fro the Fast Release of Unstable Light Nuclei--**InnoSense, LLC, 2531 West 237th Street, Suite 127, Torrance, CA 90505; 310-530-2011; www.innosense.us
Dr. Uma Sampathkumaran, Principal Investigator, uma.sampathkumaran-1@innosense.us
Dr. Kisholoy Goswami, Business Official; kishology.goswami@innosense.us
DOE Grant No. DE-FG02-07ER86315
Amount: $750,000

Research Institution
Argonne National Laboratory
Argonne, IL

Short-lived isotopes are expected to play a key role in unraveling the unanswered questions in nuclear physics, nuclear astrophysics and fundamental interactions at low energies. The Facility for Rare Isotope Beams (FRIB), under consideration for construction in the U.S., will have unique capabilities to develop exotic beams to facilitate these studies. The DOE-FRIB program is seeking advances in production techniques and improved yields of rare isotopes to overcome the limitations of existing Isotope Separation On-Line (ISOL) techniques. This project will develop and test ISOL catchers based on aerogel nanotechnology.

Silica aerogels with interconnected pores of different sizes have been developed and coated with refractory metal, tungsten, to achieve a density of 3.52 g/cc. The aerogels were structurally stable with open pores when heated to ~ 1300°C. Phase I studies indicated the potential for further optimization and testing in Phase II. The Phase II project will develop the catcher materials from silica and zirconia aerogels and other nanoporous refractory materials. Internal pores of the silica aerogels will be coated with tungsten by atomic layer deposition. The nanoporous refractory materials will be evaluated at high temperatures up to 2000°C. Promising catcher materials will be tested at a radioactive beam line facility for their ability to trap and release radioactive isotopes of alkalis and noble gases.

Commercial Applications and other Benefits as described by the awardee: In addition to nuclear physics research, metal and metal oxide coated aerogels will have applications in catalysis, nano-photovoltaics, and in environmental decontamination, insulation, fuel storage, and in capacitors for energy storage.

Development of a Low Frequency SRF Electron Gun--Niowave, Inc., 1012 N. Walnut Street, Lansing, MI 48906; 517-230-7417; www.niowaveinc.com
Dr. Terry L. Grimm, Principal Investigator, grimm@niowaveinc.com
Mr. Jerry L. Hollister, Business Official, hollister@niowaveinc.com
DOE Grant No. DE-FG02-07ER84861
Amount: $750,000

Radio frequency (RF) electron guns have the potential to generate short bunch length, high charge, high brightness bunches with better characteristics than other sources. Superconducting versions of these guns could operate continuously with high average current beams that would open a broad range of applications from x-rays for cancer therapy and sterilization, to tunable x-ray and gamma ray sources, to high energy electron coolers. This project will develop a low frequency superconducting RF electron gun. By using low frequency with a small gap, the electrons will transit the accelerating region in much less time than an RF period so the fields are nearly electrostatic. Also, the low frequency reduces heating and other difficulties of the cathode, thereby allowing removable room temperature and cryogenic cathodes.

Phase I demonstrated the technical feasibility of the project by completing the preliminary gun and cryomodule design, and a beam dynamics study. Phase II will finalize the design, and fabricate and test the superconducting RF gun.

Commercial Applications and other Benefits as described by the awardee: Cryogenic tests will be carried out at Brookhaven National Laboratory to make use of their test facilities, cryogenics and laser systems. Demonstration of this new type of superconducting RF electron gun will open many new applications as well as the development of different cryogenic and room temperature cathodes.

High Intensity Proton Accelerator--Omega P, Inc., 199 Whitney Ave., Suite 200, New Haven, CT 06511; 203-789-1165; www.omega-p.com
Dr. Jay L. Hirshfield, PhD, Principal Investigator, jay@omega-p.com
Dr. George P. Trahan, Business Official, trahan@omega-p.com
DOE Grant No. DE-FG02-07ER84862
Amount: $750,000

Conventional designs for the proton accelerator imply a several-hundred meter long superconducting linear accelerator for this purpose. This project will design, and demonstrate, using a small electron counterpart, a much shorter, room temperature, cyclotron accelerator to generate the proton beam.

The Phase I project designed an eight-cavity version for acceleration of protons to 1 GeV. The Phase II project will build and test a small four-cavity electron counterpart accelerator to prove the underlying principle of operation and to demonstrate that effects of high space charge can be controlled. The electron counterpart cavity cyclotron experiment will be built and carried out, to assess performance and compare with predictions, especially regarding maximizing acceleration gradient and minimizing emittance growth. Analysis of proton dynamics in the accelerator and in a beam transport line will continue.

Commercial Applications and other Benefits as described by the awardee: High-intensity GeV proton beams are required for neutron production, nuclear waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy, and radioisotope production.

High Performance Lossy Dielectric HOM Absorbers for SRF Cavities--Sienna Technologies, Inc., 19501 144th Ave NE, Suite F 500, Woodinville, WA 98072 4423; 425-485-7272; www.siennatech.com
Dr. Ender Savrun, Principal Investigator, ender.savrun@siennantech.com
Ms. Karen D. Valdastri, Business Official, Karen.valdastri@siennatech.com
DOE Grant No. DE-FG02-07ER84755
Amount: $750,000

Recently developed high thermal conductivity aluminum nitride (AlN) based lossy dielectrics can replace the toxic beryllia (BeO) based lossy dielectrics as high order mode (HOM) absorbers in superconductor radio frequency (SRF) cavities in linear accelerators and in microwave tubes. AlN-based lossy dielectrics must be joined metallic copper members in these applications. However, lack of suitable metallization and brazing technologies hampers the insertion of AlN-based lossy dielectrics into SRF cavities and other vacuum electron devices. This project will develop a family of vacuum compatible robust joining technologies to attach AlN-based lossy dielectrics to copper members for SRF cavities and power microwave tubes.

The Phase I project successfully demonstrated the target joining techniques. The Phase II project will expand the Phase I development by investigating the reliability and repeatability of the joining techniques developed in Phase I, fabricating prototype S-band test assemblies, and carrying out S-band cold and hot cavity tests to compare the performances of the prepared test assemblies.

Commercial Applications and other Benefits as described by the awardee: SRF cavities in linear accelerators and medium-to-high vacuum electron devices (microwave tubes) would benefit from the AlN-based lossy dielectric HOM absorbers that are robustly joined to Cu components. Commercial applications include linear particle accelerators for scientific research; x-ray sources for medical diagnostic and treatment devices; klystrons and gyrotrons to supply microwave energy to improve the performance of chemical processes and materials processing; klystrons for direct broadcast satellites; gyrotrons for magnetic fusion based on electron cyclotron heating; and microwave communications.

Customizable Web Service for Efficient Access to Distributed Nuclear Physics Relational Databases--Tech X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303 1379; 720-974-1856, www.txcorp.com
Dr. Mark L. Green, Principal Investigator, mlgreen@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84757
Amount: $749,740

An increasing fraction of the data generated in Nuclear and High-Energy Physics (HENP) is managed in distributed and relational databases. As the size of this data grows and the collaborative nature of HENP experiments increases, the ability to access differently organized relational databases remotely, efficiently, and yet in a user-friendly and interoperable manner, is becoming very important. The HENP community lacks tools addressing this need and accommodating related challenges. This project will develop a customizable Web Service for efficient access to distributed Nuclear Physics (NP) databases. The system will consist of a generic Web Service for accessing arbitrary distributed relational databases, a reference client implemented for the Solenoidal Tracker at the RHIC (STAR) experiment at Brookhaven National Laboratory (BNL), and a tool for creation of the high-level and domain-specific clients required by particular applications.

The Phase I project implemented a generic customizable Web Service for accessing distributed relational databases while supplying the capability of multiple language bindings without significant user modifications. The Phase II project will continue to build on the existing prototype and incorporate several additional modern computer science technologies. It will develop auto-caching mechanisms for increasing the effective system performance and provide on-demand resource allocation tools to meet growing data demands efficiently.

Commercial Applications and other Benefits as described by the awardee: Relational databases are widely used in commercial applications (pharmaceutical drug trials, transactions in banking and financial trading, credit history and fraud detection, consumer "churn" in subscriber businesses (cell phone, cable TV), among others). The tools developed in this project will also be made available to the High Energy and Nuclear Physics community, as well as other scientific domains.

High Resolution and Fast Scanning Speed SQUID Based Non destructive Inspection of Niobium Sheets for SRF Cavities--AMAC International Inc., 12050 Jefferson Avenue, Suite 348, Newport News, VA 23606; 757-249-3595; www.amacintl.com
Dr. Quansheng Shu, Principal Investigator, qsshu@amacintl.com
Dr. Quansheng Shu, Business Official, qsshu@amacintl.com
DOE Grant No. DE-FG02-07ER84852
Amount: $749,995

High energy physics accelerators and instruments in other fields require the use of thousands of superconducting radio frequency (SRF) cavities that are made of high purity niobium (Nb) material. The purity of Nb is critical for these cavities to reach the highest accelerating fields. Tantalum (Ta) is the most prolific of metal contaminants, can cause thermal breakdown, and can prevent the cavities from reaching their theoretical performance limits. Therefore, DOE Labs are searching for a technology that could detect small impurities in superconducting Nb. This project will develop an innovative superconducting quantum interference device (SQUID)-based nondestructive system that can scan Nb sheets used in the manufacturing of SRF cavities with both high speed and high resolution.

The Phase I project modified an existing SQUID-based eddy current system to detect 100-micron size Ta defects. The Phase II project will prototype a working system capable of scanning 30cm x 30cm Nb sheets and detecting Ta defects down to 25 microns in less than 15 minutes. It will deliver a modern prototype scanning system, with fully integrated hardware and software, as a complete instrument for DOE lab users and for commercialization.

Commercial Applications and other Benefits as described by the awardee: The SQUID-based scanner will help reach the highest accelerating field in SRF cavities and will provide a considerable cost reduction for new accelerators and for upgrades of existing accelerators. The SQUID-based scanner will also be useful for the detection of defects on the surface, inside the bulk, or at the back side of metallic sheets in other industries.

High Efficiency Fundamental Power Coupler for ILC SRF Cavities--AVAR Incorporated, P.O. Box 14341, Newport News, VA 23608; 757-595-4643; www.avarinc.com
Dr. Viet Nguyen Tuong, Principal Investigator, Nguyen@avarinc.com
Ms. Roisin Preble, Business Official, rpreble@avarinc.com
DOE Grant No. DE-FG02-07ER84909
Amount: $650,000

Superconducting radio frequency (SRF) power couplers are used to introduce RF power into evacuated accelerating cavities typically operating at a few degrees Kelvin. These couplers are historically a problematic component that adversely affects the cost and reliability of the entire accelerator system. This project will develop a coupler which is low in capital and operating cost, highly reliable, and efficient. The coupler design is intended to have application to a wide variety of Super Conducting Radio Frequency Accelerators, such as Free Electron Lasers, Energy Recovery Linear Accelerators, as well as the International Linear Collider. Cost drivers considered in the design include fabrication costs as well as handling and processing requirements during assembly of the couplers. All known coupler operational limitations have been addressed and eliminated in the design, including vacuum thermal radio frequency breakdown, and catastrophic failure.

During the Phase I project simulations were performed to optimize the radio frequency design for a highly efficient power coupler. Low power models were built and tested to verify the design simulations. Additionally, material properties and surface treatments for reducing radio frequency break down were characterized. During the Phase II project a final low power coupler will be built and tested before building two high power couplers. These high power couplers will be tested at cryogenic temperatures and characterized.

Commercial Applications and other Benefits as described by the awardee: Reduced cost fundamental power couplers are an enabling technology for broad use of particle accelerators in many fields. These fields includes medical, defense, material processing and fundamental research.

Magnesium Diboride Short Period Helical Undulator for the International Linear Collider Positron Source--Hyper Tech Research, Inc., 1275 Kinnear Road, Columbus, OH 43212; 614-481-8050; www.hypertechresearch.com
Mr. Matthew Rindfleisch, Principal Investigator, mrindfleisch@hypertechresearch.com
Mr. Lawrence Walley, Business Official, elwalley@hotmail.com
DOE Grant No. DE-FG02-07ER84913
Amount: $650,000

This project will design and construct a short-period helical undulator for the International Linear Collider (ILC). An extensive technological research and development program will be initiated to manufacture and test several undulator prototypes wound with advanced superconducting strand.

In the Phase I project, a model undulator was designed, fabricated with high-permeability steel poles, wound with insulated MgB_2 wire, and tested in LHe. The Phase II undulator development will be based on the specifications of the ILC Design Reference Report. The Phase II project will continue with the development of the MgB_2 helical undulator successfully demonstrated in Phase I, fabricating and testing several sub-size undulators wound with custom-optimized versions of the new Nb_3Sn strands. In Year-1, up to four 0.25 m modules wound with several versions of MgB_2 and Nb_3Sn strand will be constructed and tested. In Year-2, at least two 1.0 m undulators with selected strands will be wound and tested.

Commercial Applications and other Benefits as described by the awardee: Suitably modified versions of the helical undulator in association with electron synchrotrons and linacs (hence free-electron lasers) could provide high-energy photons for medical and materials science applications.

Activation Layer Stabilization of High Polarization Photocathodes in Sub Optimal RF Gun Environments--Saxet Surface Science, 3913 Todd Lane, Suite 303, Austin, TX 78744; 512-462-3444; www.saxetsurfacescience.com
Dr. Gregory Mulhollan, Principal Investigator, mulhollan@saxetsurfacescience.com
Dr. Gregory Mulhollan, Business Official, mulhollan@saxetsurfacescience.com
DOE Grant No. DE-FG02-07ER84832
Amount: $650,000

It is likely that next generation electron sources for future accelerators will initially utilize a direct current gun based injector with a semiconductor photocathode for electron production.

The goal of this project is to create a recipe or series of recipes that will immunize a photocathode against the background gasses likely to be found under operation in a generic RF gun, thus reducing or eliminating the need to restrict operation to vacuum environments. The protected/immunized photocathode will retain sufficient quantum yield to satisfy charge requirements and be capable of high polarization electron emission. The process by which such an emitter can be produced and introduced into an RF gun capable of hosting and maintaining these high polarization photocathodes, will be generated.

The Phase II work will include optimization of the current activation recipe for high polarization photo emitters, quantification of the reactivity of the stabilized surface to other gasses, determination of the effects of the stabilized surface on electron-spin polarization, characterization of the stabilized surface using synchrotron light-source photo emission ,and testing of a-Si emitter layers as a means to achieve even greater immunity.

Commercial Applications and other Benefits as described by the awardee: The improved environmental immunity as defined by this work will allow these more robust photocathodes to be used in appropriately designed accelerator injector RF guns. Better immunized photo emitters can also have applications in other low emittance sources. Longer lived photo emitters are desirable to manufacturers of imaging, e.g. night vision, and photomultiplier tubes.

***STTR Project: High Polarization of High Peak Current Compositionally Graded AlGaAs/GaAS Superlattice Photocathodes for RF Gun Application--**SVT Associates, Inc. 7620 Executive Drive, Eden Prairie, MN 55344; 952-934-2100; www.svta.com
Dr. Aaron Moy, Principal Investigator, moy@svta.com
Dr. Brian Hertog, Business Official, hertog@svta.com
DOE Grant No. DE-FG02-07ER86330
Amount: $749,532

Research Institution
Stanford Linear Accelerator Center
Menlo Park, CA

New experiments and technologies in the science of physics employ electrons with a certain and known polarization. Sources of these electrons typically have imperfect polarization (< 80%) and low quantum efficiencies (< 1%). Increasing either or both of these device properties greatly enhances the physics research being undertaken in facilities such as high energy colliders. To increase the amount of extractable, polarized electron current from photocathodes, a new device design has been developed utilizing aluminum gallium arsenide alloy with graded aluminum composition. In the Phase I, several devices with the new design were created and tested. A 25% increase in quantum efficiency was measured in the experimental photocathode, validating the theoretical approach. For the Phase II, the design of the structure will be further refined, along with the semiconductor growth technology utilized to create the device. The program will follow a systematic approach of photocathode design, growth, and testing, with collected data fed back into the design for subsequent rounds.

Commercial Applications and other Benefits as described by the awardee: This project will produce a highly efficient polarized electron source for use in experimental research at SLAC and other electron collider facilities. These devices have applications in other areas which include magnetic imaging research, surface analysis, Quantum computing and cryptography.

Development of a Non Axisymmetric Permanent Magnet Focusing System for Elliptic Charged Particle Beams--Beam Power Technology, Inc., 150 Lincoln Street Suite 3C, Boston, MA 02111 ; 978-376-0143; www.powertechnology.com
Mr. Thomas Bemis, Principal Investigator, tbemis@beampower.com
Mr. Michael Lawrence, Business Official, mlawrence@beampower.com
DOE Grant No. DE-FG02-07ER84910
Amount: $600,000

A high-brightness elliptic electron or positron beam is a novel device that has wide applications in high energy accelerators. In addition to the high-energy accelerator applications, high-brightness elliptic charged-particle (electron, muon, proton, antiproton, and ion) beams have wide applications in other accelerators for nuclear physics research and high-energy density physics research. The Phase I project successfully designed an elliptic electron beam system, fabricated a periodic permanent magnet stack prototype, and tested the prototype in agreement with three-dimensional design predictions. The Phase II project will: (1) Demonstrate focusing of a periodically twisting elliptic electron beam using a periodic non-axisymmetric permanent magnet stack consisting of an array of elliptic dipole magnets; (2) Design a periodic non-axisymmetric permanent magnet stack consisting of a quadrupole magnet and an array of elliptic dipole magnets for the focusing of a non-twisting elliptic electron beam; and (3) Demonstrate the focusing of a non-twisting elliptic electron beam using a periodic non-axisymmetric permanent magnet stack consisting of a quadrupole magnet and an array of elliptic dipole magnets.

Commercial Applications and other Benefits as described by the awardee:
Demonstrating non-axisymmetric permanent magnet systems for elliptic beam focusing will not only be a significant technical achievement, but will also support the development of elliptic-beam-based RF source and accelerator products in Phase III.

Reduced Parasitic Lasing in Ti:Sapphire Lasers: Removing a Bottleneck to New Ways of Acceleration--Crystal Systems, Inc., 27 Congress Street, Salem, MA 01970; 978-745-0088; www.crystalsystems.com
Dr. David B. Joyce, Principal Investigator, djoyce@crystalsystems.com
Ms. Leila Panzner, Business Official, leila@crystalsystems.com
DOE Grant No. DE-FG02-07ER84820
Amount: $749,923

New, ultra-fast, ultra-intense solid state lasers can be efficient sources of accelerated particle beams in applications ranging from high energy physics research to real world medical applications. Parasitic lasing represents a severe bottleneck to scaling up this new technology. Removing this bottleneck will open up a range of applications of these compact lasers, efficiently bringing accelerator technology to a real world problems. Parasitic lasing is being reduced by a series of growth and post-growth treatments, to ultimately allow production of large Ti:sapphire crystals without parasitic lasing for laser applications.

Commercial Applications and other Benefits as described by the awardee: During the Phase I, treatments of laser crystals were developed to form layers that would stop parasitic lasing. One of these treatments was applied to a large, high-power laser crystals and this crystal was successfully used in a real high power system at Lawrence Berkeley National Laboratory. Better ways to limit parasitic lasing were developed with smaller scale rods. The techniques evaluated in Phase I will be developed further and scaled up in Phase II. After the treatments are optimized, they will again be applied to a large-scale real laser rod, and tested in a high power system for reduced parasitic lasing, and thus higher output power.

Device Oriented Process Controller--EPIC Consulting, 101 Mountain Ridge Drive, Mount Sinai, NY 11766; 443-834-3775; www.epicconsulting.com
Dr. John Dalesio, Principal Investigator, jdalesio@comcast.net
Mr. Leo Dalesio, Business Official, bdalesio1@comcast.net
DOE Grant No. DE-FG02-07ER84853
Amount: $724,200

This project will develop a control system for very large High Energy Physics projects. A de-facto standard in accelerator control is the Experimental Physics and Industrial Control System (EPICS), which has been applied successfully to many physics projects. EPICS is a channel-based system that requires that each channel of each device be configured and controlled. In Phase I, the feasibility of a device oriented extension to the distributed channel database was demonstrated by prototyping a device aware version of an EPICS input/output (I/O) controller that functions with the current version of the channel access communication protocol. Extensions have been made to the grammar to define the database. Only a multi-stage position controller with limit switches was developed in the demonstration, but the grammar should support a full range of functional record types. In phase II, a full set of record types will be developed to support all existing record types, a set of process control functions for closed loop control, and support for experimental beam line control. A tool to configure these records will be developed. A communication protocol will be developed or extensions will be made to Channel Access to support introspection of components of a device. Performance benchmarks will be made on both communication protocol and the database. After these records and performance tests are under way, a second extension of the grammar will be undertaken.

Commercial Applications and other Benefits as described by the awardee: The proposed approach to configuring the I/O for a large physics project reduces the time to produce and maintain the massive amount of configuration data by providing the engineers and physicists with tools that configure the system at a high level. The creation, duplication, and management of devices, compresses the external view of the process by an order of magnitude. At the end of phase 2, the database engine, record types, configuration tool, and communication protocol will provide the fundamentals needed to make a beta release to potential users.

Beam Breakup Instability in Dielectric Structures--Euclid TechLabs, LLC, 5900 Harper Rd. #102, Solon, OH 44139; 440-519-0410, www.euclidtechlabs.com
Dr. Alex Kanareykin, Principal Investigator, alexkan@euclidtechlabs.com
Mr. David Dunay, Business Official; daved@euclidtechlabs.com
DOE Grant No. DE-FG02-07ER84823
Amount: $700,000

The single bunch beam breakup (BBU) instability is a potentially serious limitation on the performance of advanced accelerators, particularly those based on the wakefield principle. Development of mitigation techniques for BBU requires both experiment and high performance simulation tools. This project will study three representative high performance wakefield devices using new diagnostics. An advanced simulation code to model these experiments is being developed. The combined results from the experiments and simulations will enable the design of focusing systems to control BBU in wakefield devices.

The Phase I project developed new software for rapid, efficient simulation of beam breakup effects in advanced linear accelerators. Simulations of the beam breakup experiments planned for Phase II, a 26 GHz high power extractor, transformer ratio enhancement and high gradient device experiments were performed. Two different beam diagnostics were developed, a heterodyne differential probe and a beam spot moment diagnostic. During Phase II, the two new diagnostics for transverse deflection effects will be implemented at Argonne. These will be used to measure beam dynamics effects in advanced dielectric accelerating structures. Improvements to the code will be made and simulation results compared to experiments.

Commercial Applications and other Benefits as described by the awardee: The tools developed under this project will enable the design and operation of high performance wakefield accelerators, primarily for physics research but also for industry and medical applications.

Development of a Tunable Dielectric Loaded Accelerating Structure--Euclid TechLabs, LLC, 5900 Harper Rd. #102, Solon, OH 44139; 440-519-0410; www.euclidtechlabs.com
Dr. Alex Kanareykin, Principal Investigator, alexkan@euclidetechlabs.com
Mr. David Dunay, Business Official, daved@euclidtechlabs.com
DOE Grant No. DE-FG02-07ER84822
Amount: $600,000

Dielectric structures driven by wakefields or external radio frequency (RF) are presently being studied intensively as a promising technique for next generation linear colliders. This project will develop dielectric loaded accelerating structures that can be adjusted in frequency using a bias electric field. The method proposed here is inexpensive and easy to implement without affecting beam quality. A Tunable Dielectric Wakefield Accelerating Structure is to be designed, developed and demonstrated.

The Phase I project developed thin (400 μm) cylindrical ferroelectric layers for prototype tunable cylindrical DLA structures. The Phase II project will test the tunable DLA structure. A new type of the tunable dielectric based accelerating structure will be fabricated and tested in a high current beam experiment at the Argonne Wakefield Accelerator. Frequency tuning will be demonstrated at frequencies of 10, 15.6 and 33 GHz. The frequency adjustment will be studied both by varying the temperature and applied high voltage. Finally, a new power source – the tunable 26 GHz power extractor based on a dielectric loaded structure – will be designed and demonstrated.

Commercial Applications and other Benefits as described by the awardee: This technology can be applied directly to microwave power sources and switches, passive microwave resonators, filters and phase-shifters, thus finding immediate application in the communications industry. This work also represents a step towards use of dielectric structure technology for efficient cost effective future electron accelerators.

Magnets for Muon 6D Helical Cooling Channels--Muons, Inc., 552 N. Batavia Ave., Batavia, IL 60510; 630-840-2424; www.muonsinc.com
Dr. Rolland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Thomas J. Roberts, Business Official, tjrob@muonsinc.com
DOE Grant No. DE-FG02-07ER84825
Amount: $650,000

This project will develop the magnets needed to create bright muon beams for many applications ranging from scientific accelerators and storage rings, to beams to study material properties and new sources of energy. The Helical Cooling Channel (HCC), a new technique for six-dimensional (6D) cooling of muon beams using a continuous absorber inside superconducting magnets, has shown considerable promise based on analytic and simulation studies. The implementation of this method of muon cooling requires high field superconducting magnets that provide superimposed solenoid, helical dipole, and helical quadrupole fields.

This project will develop and design a magnet system for a 6D muon beam cooling channel. In Phase I, an engineering study showed the Helical Solenoid (HS) invention to be superior to the conventional approach to the HCC. The Phase II project will develop the concepts and engineering designs of HCC systems that use HS magnets to incorporate the most appropriate superconductor technologies, with special emphasis on the use of High Temperature Superconductor (HTS) for high fields at low temperature. The HS concepts will be developed to incorporate RF cavities for practical HCC designs. Numerical simulations will be used to optimize and verify the muon cooling behavior of the HCC designs.

Commercial Applications and other Benefits as described by the awardee: The new magnet system will support energy frontier muon colliders, Higgs and neutrino factories, muon stopping beams for studies of rare fundamental interactions and muon-catalyzed fusion, and muon sources for cargo screening for homeland security.

Stopping Muon Beams--Muons, Inc., 552 N. Batavia Ave., Batavia, IL 60510; 630-840-2424; www.muonsinc.com
Dr. Rolland P. Johnson, Principal Investigator, rol@muonsinc.com
Dr. Thomas J. Roberts, Business Official, tjrob@muonsinc.com
DOE Grant No. DE-FG02-07ER84824
Amount: $650,000

Physics experiments often use low-energy beams of unstable particles that stop in a target in order to provide high sensitivity to rare processes with reduced backgrounds. However, the stopping rate in the target is limited by the dynamics of the production process and by multiple scattering and energy straggling in the material used to slow the particles. As a result, the event rates and sensitivity to rare processes are limited.

This project will apply new six-dimensional beam cooling inventions, improved capture techniques, and new simulation tools to develop designs for low-energy beam lines to stop many muons in small volumes. It will develop the helical cooling channel (HCC) and the newer pion momentum spread reduction schemes for experiments such as mu2e as well as for others that require polarization. We will use G4beamline to improve the mu2e experimental sensitivity and to develop methods to understand and suppress rare background events.

Commercial Applications and other Benefits as described by the awardee: The use of the HCC and other new ideas for stopping muon beams will provide a new level of sensitivity for experimental physics searches for rare processes such as the direct conversion of muons into electrons. Many applications of intense stopping muon beams, such as spin-resonance investigations and muon-catalyzed fusion, will also benefit greatly.

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Development of a 6 Dimensional Muon Cooling System using Achromat Bends and the Design, Fabrication, and Test of a High Temperature Superconducting Solenoid for the System--Particle Beam Lasers, Inc., 18925 Dearborn Street, Northridge, CA 91324 2807; 818-885-8956
Dr. Alper A. Garren, Principal Investigator, algarren@mindspring.com
Mr. James J. Kolonko, Business Official, kolonko@pacbell.net
DOE Grant No. DE-FG02-07ER84855
Amount: $650,000

Cooled beams of muon particles for use in elementary particle physics experiments are needed to advance mankind's understanding of the fundamental nature of energy, the elementary constituents of matter, and the forces that control them. A major obstacle for building a case for future muon colliders or neutrino factories has been the lack of an experimental demonstration of the principle of ionization cooling of muons and, in particular, six-dimensional (6-D) cooling and emittance exchange.

Past work has focused on lattice design, simulation studies and magnet design for a compact gas-filled storage ring for 6-D cooling of muon beams. The Phase I project extended those design results. The Phase I feasibility studies made advancements, as beam cooling was observed under two of the five cases studied. The Phase II project will continue the refinement and optimization of the preferred lattice of a 6-D muon cooling system using achromat bends. Work will continue to define and develop a credible beam injection/extraction scheme. A high temperature superconducting (HTS) solenoid, a crucial sub-system of the 6-D muon cooling machine, will be designed, built, and tested during this phase

Commercial Applications and other Benefits as described by the awardee: A robust, simple and economical cooling system to cool ion and particle beams has use in ion lasers, biotech, medical, and nanotechnology applications. Development of HTS magnet technology may revolutionize future medical and accelerator facilities. Various magnets in muon colliders, hadron colliders, and facilities for rare isotope beams benefit significantly from the ability of HTS to produce high fields and to handle and economically remove large energy depositions. The whole field of muon colliders and neutrino factories may benefit from HTS technology.

Development of a 26 GHz RF Power Extractor--Euclid TechLabs, LLC, 5900 Harper Rd. #102, Solon, OH 44139; 440-519-0410; www.euclidtechlabs.com
Dr. Chunguang Jing, Principal Investigator, jingchg@hep.anl.gov
Dr. David Dunay, Business Official, daved@euclidtechlabs.com
DOE Grant No. DE-FG02-07ER84821
Amount: $650,000

The design trend in normal-conducting high gradient accelerating structures is to move toward higher frequencies. The same is true for other microwave applications like radar or communications. This project will develop a new high power radio frequency (RF) source that covers the frequency spectrum from 20-30 GHz. It will evaluate a prototype power extraction structure incorporating advanced low loss dielectric materials to produce 26 GHz RF when energized by a high current electron bunch train. The device will be evaluated experimentally using the beam facilities at Argonne National Laboratory.

The Phase I project fabricated a prototype 26 GHz dielectric loaded structure that was cold tested to verify efficient power transfer from the structure. Numerical simulations of beam interaction with the structure were carried out. The Phase II project will test the structure in a series of experiments at the Argonne Wakefield Accelerator facility. Rf output power levels will be measured. Loss of efficiency caused by the beam breakup instability will be characterized and new techniques for its mitigation will be tested.

Commercial Applications and other Benefits as described by the awardee: The new RF power source will permit construction of advanced, efficient linear accelerators for high energy physics research. The availability of a high power 26 GHz source will be useful for radar systems, remote sensing, and communications.

***STTR Project: SiC Optically Gated High Power Solid State Switch--**GeneSiC Semiconductor Inc.,43670 Trade Center Place, Suite 155, Dulles, VA 20166
703-996-8200; www.genesicsemi.com
Dr. Ranbir Singh, Principal Investigator, ranbir.singh@genesicsemi.com
Dr. Ranbir Singh, Business Official, ranbir.singh@genesicsemi.com
DOE Grant No. DE-FG02-07ER86311
Amount: $750,000

Research Institution
University of Illinois
Chicago, IL

This Phase-II effort, will design, fabricate and characterize high-gain, SiC-based high-voltage, Optically-Gated High-power Solid-state Switch (SiC-OGHSS) for electromagnetic-interference (EMI) immune and optically-isolated compact, sub-microsecond pulsed-power applications. Such features are uniquely applicable towards Marx Bank Modulator power supplies used in High Energy Physics Applications.

Ever increasing demand of pulsed-power systems for higher-voltage and current-handling capabilities has been met, at a circuit and component level, by a stacking approach i.e. series-parallel integration of lower rated components. This concept can be extended down to device level also where decoupling of triggering and main power-handling structure addresses similar scalability issues. The advantage of employing a hybrid structure can be leveraged, as the optical- triggering structure does not need to be scaled up in voltage. Moreover, the active area of the optical window does not need scaling in proportion to the size of the main power device. This can potentially keep the optical-triggering power requirement low even for a switch with higher voltage and higher current ratings.

Commercial Applications and other Benefits as described by the awardee: To avail the advantages of the scalability offered by structural decoupling, this research and development effort focuses on a hybrid device configuration with an optical front-end stage coupled to a dual-gate thyristor structure, which acts as the main power device. The primary goal of this project is to design and fabricate 4H-SiC based dual-gate thyristor and optical-triggering structure with the rating of the thyristor $\geq$ 6 kV and peak current $\geq$ 2 kA. A further goal is to individually characterize the thyristor and optical-triggering prototypes for steady state and switching performance and to integrate the two devices onto a single packaging platform. The final goal is to test the integrated packaged device for steady-state and switching performance in a switching circuit.

Multi MW 22.8 GHz Harmonic Multiplier Rf Power Source for High Gradient Accelerator R&D--Omega P, Inc., 199 Whitney Ave., Suite 200, New Haven, CT 06511 ; 203-789-1165; www.omega-p.com
Dr. Jay L. Hirshfield, PhD, Principal Investigator, jay@omega-p.com
Dr. George P. Trahan JD, Business Official, trahan@omega-p.com
DOE Grant No. DE-FG02-07ER84854
Amount: $700,000

Efforts towards development of a high-gradient warm accelerator structure for a future electron-positron collider require basic experiments to discover the upper limits to radio frequency (RF) electric and magnetic field strengths that can be sustained at material surfaces. The experiments should be carried out at several RF frequencies to explore the wide parameter range to improve understanding of the underlying physical limits. Yet high-power stand-alone RF amplifiers at frequencies above X-band for these experiments only exist at 17.1 and 34.3 GHz, so sources at one or more intermediate frequencies need to be developed. This project addresses this deficiency by constructing a harmonic multiplier, in which multi-megawatt powers can be generated at the 7th, 8th, and 9th harmonics of 2.856 GHz output from a high-power klystron. The 7th harmonic frequency multiplier will be built, tested and evaluated using facilities at Yale Beam Physics Laboratory.

Simulations of Waveguide Breakdown--Tech X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
Dr. Seth A. Veitzer, Principal Investigator, veitzer@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84833
Amount: $749,515

Future neutrino experiments will require neutrino beam intensities beyond the capabilities of today's sources. These experiments will require high-energy neutrinos from muon decay. The muons need to be cooled, and, in order to reduce costs, the number of cooling elements should minimized. However, breakdown of the accelerating cavities is expected to limit the performance of any proposed beam system. This project will help researchers use simulation to understand the breakdown of metallic structures planned for muon beam systems, enabling them to reduce the length and thereby the cost of future accelerators. It will implement new physics algorithms relevant to breakdown and add them to an existing library of routines developed to model plasma/material interactions. The project will also make existing codes easier to use for non-experts.

The Phase I project successfully modeled breakdown with parameters relevant to present muon cooling systems using two well-known commercial particle-in-cell codes. It also improved the user interface to one of the codes by improving the parallel computing features, allowing users to get answers more quickly. The work demonstrated the utility of these code enhancements by successfully modeling breakdown near a micron-sized surface imperfection with applied magnetic field for conditions similar to copper cavities presently being tested by muon collider researchers. The Phase II project will extend the physics algorithms improvements and improvements to the code user interface.

Commercial Applications and other Benefits as described by the awardee: Routines implemented here, such as plasma radiation effects and models of multiple ionization processes, are important to the Air Force community and to researchers developing more energy-efficient commercial lighting.

High Field MgB_2 Strands for High Energy Particle Colliders--Hyper Tech Research, Inc., 1275 Kinnear Road, Columbus, OH 43212; 614-481-8050;
www.hypertechresearch.com
Mr. Matthew Rindfleisch, Principal Investigator, mrindleisch@hypertechresearch.com
Mr. Lawrence Walley, Business Official, elwalley@hotmail.com
DOE Grant No. DE-FG02-07ER84914
Amount: $600,000

Superconductor technologies in support of magnets are needed for use in accelerators, storage rings and charged particle beam transport systems. Magnesium diboride (MgB_2), as an emerging superconductor material, offers the possibility of fabrication into multifilament strand from inexpensive starting materials using conventional metalworking processes. This project will develop improved MgB_2 superconductors with high critical fields and high at-field critical current density. Significant progress has been recently made for advancing the properties of MgB_2, however current wires are characterized by upper critical and irreversibility fields that are too low, and most directly, critical currents that are too low in the 12 Tesla regime. This project will address these problems. The Phase I project fabricated wires with nano-powder additions for improving flux pinning and current density. Nano-ceramic, refractory metal, and metallic oxide powders were investigated. Strands doped with either Zr-based powders or SiC were fabricated for improving critical current and upper critical fields. A third class of strands was fabricated with custom nano-powders for improving current density. Powder processing techniques were varied to optimize strand performance.

The Phase II project will fabricate MgB_2 wires with improved in-field current densities, enhanced critical fields and increased connectivity. It will investigate making wires with specific classes of nano-powder additions to improve properties. Finally, a prototype solenoid coil wound with an optimized MgB_2 conductor developed in this program will be fabricated.

Commercial Applications and other Benefits as described by the awardee: The wire samples developed under this program will have wide ranging benefits for commercial applications such as MRI systems, power utility transformers, generators, motors and military applications.

Flux Pinning Additions to Increase Jc Performance in BSCCO-2212 Round Wire for Very High Field Magnets—SCI Engineered Materials, Inc., 2839 Charter Street, Columbus, OH 43228; 614-486-0261; http://www.superconductivecomp.com/
Dr. Scott Campbell, Principal Investigator, scott@sciengineeredmaterials.com
Dr. Scott Campbell**,** Business Official, scott@sciengineeredmaterials.com
DOE Grant No. DE-FG02-07ER84831
Amount: $749,898

With the drive towards higher-field dipole magnets, the material requirements for superconductors have exceeded the performance of existing metal-based super conductor materials. For this reason, the ceramic superconductor, bismuth strontium calcium copper oxide (BSCCO-2212), in the form of a multifilamentary Ag alloy composite, is beginning to attract interest for future extremely-high-field magnets or magnet-insert coils. The material must achieve a critical engineering current density (J_e) of at least 250 A/mm^2 in a magnetic field of 12 Tesla at a temperature of 4.2K. This project will produce a commercially viable BSCCO-2212/Ag composite multifilamentary round wire with a J_e value equal to or exceeding 600 A/mm^2 at 12T and 4.2K. Phase I demonstrated the flux pinning properties of dopant materials added to BSCCO-2212, which improved the J_e of superconducting BSCCO-2212/Ag composite tapes. Phase I also indicated that J_e values equal to or greater that 600 A/mm^2 could be achieved. The plan for Phase II is to scale-up the powder and wire production processes so that kilometer-length BSCCO-2212/Ag composite multifilamentary wires, with J_e values equal to or greater that 600 A/mm^2 at 4.2K and 12T, can be reliably produced.

Commercial Applications and other Benefits as described by the awardee: The initial commercial application for the BSCCO-2212/Ag composite wire should be in high field magnets for high energy physics experimentation. Other applications would involve medical MRI and other commercial applications where high field magnets are required.

High Performance, Ti Doped Nb_3Sn Fabricated by the Internal Tin Tube Method--
Supercon, Inc., 830 Boston Turnpike Road, Shrewsbury, MA 01545; 508-842-0174;
www.supercon-wire.com
Mr. Charles Renaud, Jr., Principal Investigator, crenaud@supercon-wire.com
Mr. Terence Wong, Business Official, twong@supercon-wire.com
DOE Grant No. DE-FG02-07ER84917
Amount: $700,000

The High Energy Physics (HEP) community requires the development of superconducting wires for use in magnets generating magnetic fields greater than 12 Tesla. Currently, Nb_3Sn is the only commercially available superconductor capable of operating at such high fields. However, the technical and cost performance to date does not meet the stated requirements of the HEP Conductor Advisory Group. This project will develop an economical process for the fabrication of Nb_3Sn conductors that will meet the demands for next generation magnet development.

The Phase II project will utilize the tubular niobium method developed in the previous Phase I. The Phase II work will consist of heat treatment optimization studies and experiments aimed at further increasing the critical current density. Titanium doped niobium tubes will be fabricated by fixed mandrel tube extrusion and conductor will be scaled up to commercial quantities.

Commercial Applications and other Benefits as described by the awardee: High performance multifilament Nb_3Sn will find applications in HEP particle accelerators, magnetic confinement fusion machines, and commercial nuclear magnetic resonance magnets.

***STTR Project: React-Wind-Sinter Technology for $Bi_2Sr_2CaCu_2Ox$--**Supercon, Inc., 830 Boston Turnpike Road, Shrewsbury, MA 01545; 508-842-0174; www.supercon.com
Prof. Justin Schwartz, Principal Investigator, schwartz@magmet.fsu.edu
Mr. Terence Wong, Business Official, twong@supercon-wire.com
DOE Grant No. DE-FG02-07ER86328
Amount: $750,000

Research Institution
The National High Magnetic Field Laboratory
Tallahassee, FL

The superconductor $Bi_2Sr_2CaCu_2Ox$ (Bi2212) is currently being considered for high field particle accelerator magnets. Bi2212 has the highest Jc of any practical superconductor at fields greater than 15 Tesla. Thus it will be needed for making high field magnets to improve the performance of machines such as the Large Hadron Collider and Muon Collider. However, the processing requirements for Bi2212 are extremely stringent. It is very difficult to produce a reliable magnet of the size needed for these applications. Making accelerator magnets using Bi2212 represents a difficult and high risk technology. Since these high field accelerator magnetics are very expensive, the loss of a magnet has a significant financial impact on the program. Therefore, this project will develop an alternate fabrication process involving react-wind-sinter (RWS) technology. RWS breaks the heat treatment cycle into two independent segments. Process control is not nearly as stringent for RWS as it is for the conventional approach and is well within commercial capabilities. Thus large magnets can be fabricated without the concern for temperature variations and gradients in the magnet windings that lead to poor properties and magnet performance. The Phase I project demonstrated the viability of the process. The Phase II project will develop a commercially practical magnet fabrication technology for Bi2212 magnets based on the RWS process.

Towards a Non Cu Jc(12T) of 4,000 A/mm2 with Novel Second Phase Flux Pinning in PIT Strand for HEP Applications--SupraMagnetics, Inc., 214 Canal Street, Plantsville, CT 06479; 860-426-1961; www.supramagnetics.com
Dr. Leszek Richard Motowidlo, PhD, Principal Investigator, LMOTO@cox.net
Dr. Leszek Richard Motowidlo, PhD, Business Official, LMOTO@cox.net
DOE Grant No. DE-FG02-07ER84920
Amount: $600,000

Doing High Energy Physics (HEP) at higher energy collisions requires higher energy and luminosity. More luminosity means larger apertures and, therefore, bigger magnets with magnetic fields beyond 12 Tesla. The HEP engineering goal for the near future of five to eight years is 15T to 20T. This means a requirement for advanced Nb_3Sn superconductors with improved performance and cost. This project will develop and demonstrate an economical high-performance powder-in-tube (PIT) Nb_3Sn process for use in magnets for future HEP accelerator research. This will be accomplished by the improvement of the critical current density in high magnetic fields above 15T. The project will develop novel second phase flux pinning that will enhance the performance at high magnetic fields in PIT Nb_3Sn superconductors.

The Phase I project developed and demonstrated the effectiveness of the second phase flux pinning and grain refinement. This in turn resulted in improved property performance at high magnetic fields. The Phase II project will optimize the heat treatment temperature and time and the alloy compositions. The data will be used to assemble and manufacture a scale-up prototype conductor in the Phase II project.

Commercial Applications and other Benefits as described by the awardee: The improved cost-performance for this new conductor will have an immediate benefit for high field magnets in DOE HEP applications. Other important applications for these superconductors include fusion reactors and uses in chemical research, biochemistry, pharmaceutical chemistry, polymer science, petroleum research, agricultural chemistry, and medicine.

High Resolution 15 Micron Thin, Pixellated, Back Illuminated SOI CMOS Vertex Sensor--Voxtel, Inc., 12725 SW Millikan Way, Suite 230, Beaverton, OR 97006; 971-223-5646; www.voxtel-inc.com
Mr. George M. Williams, Principal Investigator, georgew@voxtel-inc.com
Mr. George M. Williams, Business Official, georgew@voxtel-inc.com
DOE Grant No. DE-FG02-07ER84919
Amount: $650,000

Planned high energy physics (HEP) experiments require improvements in detector technology characterized by improved parameters for granularity, readout speed, radiation hardness and sensor thickness. Of the available detector technologies, Complementary Metal Oxide Semiconductor (CMOS) pixilated imagers offer several advantages, but CMOS detectors, due to readout and fixed pattern noise, have not been widely used for scientific instrumentation. They are also difficult to thin. The goal of this project is to overcome the limitations of contemporary SOI (silicon-on-insulator) CMOS active pixel sensor (APS) technology, in a 3-dimensional stacked imager configuration, by establishing a new class of back-thinned, radiation-hard, stacked Silicon on Insulator/ SOI CMOS HEP imagers.

The Phase I project successfully fabricated and thinned photodetectors to the required specifications and uniformity. This addresses one of the major technical hurdles being addressed by the HEP detector community. The Phase II project will further investigate the technologies necessary to develop these high-performance detectors.

Commercial Applications and other Benefits as described by the awardee: In the past, developments in HEP instrumentation have found widespread application in other fields. This project will open up a new approach to radiological imaging, protein crystallography, time resolved x-ray synchrotron science, electron microscopy, laser radar, and others.

Large Area, High Dynamic Range, Sold State Photomultiplier Array for Cherenkov Calorimetry--Voxtel, Inc., 12725 SW Millikan Way, Suite 230, Beaverton, OR 97006; 971-223-5646; www.voxtel-inc.com
Mr. George M. Williams, Principal Investigator, georgew@voxtel-inc.com
Mr. George M. Williams, Business Official, georgew@voxtel-inc.com
DOE Grant No. DE-FG02-07ER84918
Amount: $650,000

Existing solid state detectors, such as charge coupled device (CCD) and complimentary metal oxide silicon (CMOS) imagers do not have adequate ultraviolet (UV) sensitivity for Cherenkov radiation detection. Therefore, a new type of UV-optimized, high-gain, low-noise, solid state avalanche photodiode (APD) is needed for low-level light detection of Cherenkov radiation.

In recent years, silicon, CMOS-compatible solid state photomultipliers (SiPM) detectors have been shown to be capable of registering low scintillating light, and consequently intensive studies have been carried out to qualify SiPM-like APDs as possible photosensors for scintillation detectors. The results of these studies have revealed encouraging performance characteristics. However, due to the SiPM circuit's architecture, the detector's sensitivity peaks in the 'green' part of the optical spectrum and is not very sensitive to the UV.

This project will develop a large area, pixilated SiPM detector architecture that is optimized for illumination from the backside, where, unencumbered by the individual detector's circuitry, high responsivity can be achieved over the entire spectral range of Cherenkov radiation. In Phase I, single photon sensitive APDs and two SiPM detector designs where characterized over a wide range of operating conditions. Based on the identification and characterization of those device performance attributes critical for Cherenkov detection applications, the design of a large area, tiled, silicon-on-insulator (SOI) CMOS SiPM focal plane array (FPA) was developed and on-chip readout electronics circuits designed. During Phase II, the back-illuminated SOI CMOS SiPM arrays will be fabricated, optimized, integrated and their performance evaluated.

Commercial Applications and other Benefits as described by the awardee: Improved SiPM devices will support future experiments in nuclear physics, high-energy physics, and astroparticle physics, DNA-sequencing, fluorescence and luminescence detection, positron emission tomography and single photon emission computed tomography.

Library Based Tuning of Mathematical Kernals on Petascale Systems--Tech X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
Dr. Peter Messmer, Principal Investigator, messmer@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84731
Amount: $749,615

Petascale supercomputers offer the computational power to make significant progress in DoE's most complex electromagnetic problems. Existing simulation tools have to be carefully tuned to take advantage of the high degree of concurrency offered by these systems. This project will optimize a plasma physics modeling tool widely used within DoE's scientific community for leadership-class supercomputing systems. Good performance on largest scale systems is achieved by addressing algorithm scalability, single processor performance and code portability. By separating the physics algorithms form the numerical kernel routines this project will be able to take advantage of highly tuned numerical libraries, thus getting good performance while maintaining a high level of portability.

The Phase I project completed a detailed performance analysis for an electromagnetic field solver by using profiling tools and comparison with reference implementations. It determined the optimal memory layout for this algorithm and developed a performance model that can predict the performance on large processor counts. It also demonstrated that numerical libraries can lead to high-performance implementations at low code complexity. The Phase II project will first resolve the scalability bottlenecks discovered in the Phase I and then focus on the performance of the charged particle model. It will use and enhance a code transformation system to implement optimizations in a portable way. Finally, it will address scalability of particle problems by using a load balancing library.

Commercial Applications and other Benefits as described by the awardee: This project will lead to a highly optimized commercial plasma physics code that fully utilizes leadership-class supercomputing systems.

Open Source OpenGL Driver for the Cell BE Processor--Tungsten Graphics, Inc., 114 S Prize Oaks Drive, Cedar Park, TX 78613; 512-673-9812; www.tungstengraphics.com
Mr. Brian Paul, Principal Investigator, brian.paul@tungstengraphics.com
Ms. Arleen LaMonica, Business Official, arleen@tungstengraphics.com
DOE Grant No. DE-FG02-07ER84933
Amount: $750,000

The Cell BE processor represents a technology trend towards the convergence of the Central Processing Unit (CPU) and the Graphics Processing Unit (GPU). By creating an open source OpenGL driver for the Cell BE processor, this project will allow the Cell BE processor to be used for visualization and graphics rendering. This is a boon to the scientific and research community that is currently using cell-based machines for scientific calculations and would be able to leverage those machines for visualization also. Delivering this driver in open source has already fostered the growth of a community of users and researchers around it. The intellectual property generated from this project will continue to be important to the convergence of the GPU and CPU independent of the Cell BE processor itself. An OpenGL driver is required to enable the Cell BE processor to be a viable platform for high performance graphics rendering within the context of scientific visualization. This project creates that driver, first for individual Cell BE-based computers and then on compute clusters based on the Cell BE processor.

The Phase I project validated that the Cell BE can be a viable platform for high performance graphics rendering within the context of scientific visualization. The subset driver in Phase I provided the proof of concept for Phase II, which is to develop the full OpenGL driver and optimize the performance to GPU-like levels.

Commercial Applications and other Benefits as described by the awardee: The commercial market for the intellectual property developed by creating the OpenGL driver for the Cell BE processor includes Intel, AMD, NVIDIA and Microsoft.

End System Control Architectures in E Science Networks--Acadia Optronics, LLC, 1395 Piccard Drive, Suite 210, Rockville, MD 20850; 301-332-2900; www.acadiaoptronics.com
Dr. Jesse Wen, Principal Investigator, jessewen@acadiaoptronics.com
Dr. Jesse Wen, Business Official, jessewen@acadiaoptronics.com
DOE Grant No. DE-FG02-07ER84726
Amount: $749,988

This project will develop software particularly well suited for applications requiring large-scale file transfers, visualization/remote steering, grid computing, and other high-end functionalities on dedicated ultra-high-speed networks. Storage and computing systems are facing growing challenges when inter-connecting across large wide-area network infrastructures. In particular, current technologies do not provide the desired automation and flexibility for end-system bandwidth delivery. This project will address this problem by developing advanced end-system control solutions that combine off-the-shelf software with intelligent middleware to deliver much-improved bandwidth delivery at the application layer. These offerings will allow end-systems and users to achieve genuine multi-gigabit speeds across global distances in a seamless, cost-effective manner.

Commercial Applications and other Benefits as described by the awardee: The Phase I project conducted a thorough analysis to determine the feasibility of the planned approach. The Phase II project will transition the Phase I feasibility study and preliminary software prototype/demonstrations into a complete system ready for commercialization. The initial baseline middleware specification produced in Phase I will be significantly expanded with additional capabilities and external interfaces. Next, this framework will be integrated with hardware to demonstrate a comprehensive end-system prototype suitable for use within the high-end user application communities. Finally, it will develop and test various client applications to demonstrate the final product and quantify its improvements at the application layer.

LAPACKrc An FPGA Linear Algebra Library for Maximal Performance Petascale Supercomputing--Accelogic, LLC, 609 Spinnaker, Weston, FL 33326; 954-249-4761; www.accelogic.com
Dr. Juan Guillermo Gonzalez, Principal Investigator, juan.gonzalez@accelogic.com
Dr. Juan Guillermo Gonzalez, Business Official, juan.gonzalez@accelogic.com
DOE Grant No. DE-FG02-07ER84728
Amount: $749,999

Over 70% of supercomputing usage today is dedicated to solving large systems of linear equations. Linear equations are at the core of the most important DOE computational problems in energy fusion research, accelerator simulations, weather modeling, oil & gas exploration, chemistry, materials, and astrophysics, among others. This project will provide computational power to the solution of large dense and sparse linear equations through both direct and iterative algorithms especially tuned to achieve maximal performance in a supercomputer enhanced with FPGA (field-programmable gate array) accelerators. The result of this research will produce the core of LAPACKrc, a linear algebra library that, by the end of Phase II, will be 2 to 3 orders of magnitude faster than traditional CPU-based solvers. The library will be easy to integrate with the leadership facilities of DOE supercomputers. Its use within a supercomputing network will be 1 to 2 orders of magnitude less expensive than CPU-based technology with similar performance.

The Phase I project demonstrated the world's first FPGA-accelerated solver to achieve speed increases >90x for large-scale dense linear equations with 64-bit accuracy. Similar levels of performance were demonstrated for a complex sparse iterative solver. Phase I also established the technical foundation upon which the LAPACKrc library will now be built. The Phase II project will produce the LAPACKrc core. Special attention will be given to industrial-quality software features, including scalability, portability, ease-of-use, and numerical robustness.

Commercial Applications and other Benefits as described by the awardee: This technology should enable the highest performance for linear algebra problems in future supercomputers, improving the ability to solve large systems of linear equations in fusion energy, aerospace, automotive, bridge building, logistics, financial engineering, and linear programming.

SVOPME:A Scalable Virtual Organization Privilege Management Environment (SVOPME)--Tech-X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
Dr. Nanbor Wang, Principal Investigator, nanbor@txcorp.com
Mr. Laurence D. Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84733
Amount: $749,958

Although modern Grid middleware is beginning to support role-based authorization, there is an information disconnect in existing mechanisms between Virtual Organizations (VOs) and site authorization control. This disconnect prevents privilege policies defined by VOs from propagating to Grid sites automatically. As more VOs are joining the Grid, manually maintaining and administrating VOs and grid sites becomes very costly. This project will develop SVOPME for automating the propagation of VO privileges to Grid sites. It will utilize the extensible Access Control Markup Language (XACML) for specifying VO privilege policies and will develop tools and services to facilitate the functionality. The Phase I project successfully developed a set of prototype tools for SVOPME that support 3 VO privilege policies as examples. It demonstrated how SVOPME helps VO define and document VO privilege policies and how SVOPME propagates these policies from VOs to Grid site and supports automatic validation and modification of local configurations. The Phase II project will focus on enhancing the usability and commercialization of the tools.

Commercial Applications and other Benefits as described by the awardee: An integrated and robust privilege management environment, like SVOPME, is a key addition to operating a Grid computing environment. SVOPME will reduce the cost in managing both the VOs and shared resources, making the Grid easier to use and operate.

Discovery Tools for Science Education Content--David Wojick, 391 Flickertail Lane, Star Tannery, VA 22654-1908; 540-858-3136; www.bydesign.com
Dr. David Eugene Wojick, Principal Investigator, dwojick@hughes.net
Dr. David Eugene Wojick, Business Official, dwojick@hughes.net
DOE Grant No. DE-FG02-07ER84849
Amount: $376,750

There is no reasonable way for teachers, parents or students to search on the Web for science content, especially Department of Energy research that is suited for a specific grade level or degree of difficulty. There are thousands of small collections scattered through the Web. The only way to search them is one by one, which is too difficult. This project will develop a grade level stratification system for science content, based on assigning grade level or degree of difficulty to every science concept normally taught in science education.

Phase I demonstrated the feasibility of a systematic method for generating concept based grade level stratification of technical content. A stratification was produced for the topic of electricity and magnetism. Computer searches using this stratification were successful in sorting content by grade level. The Phase II project will produce a complete grade level stratification for science education. The method used for the topic of electricity will be extended to all the other topics normally taught, about 30 in all. The computer search algorithm will be refined.

Commercial Applications and other Benefits as described by the awardee: This project has the potential to dramatically improve Web-based science education. Applications include a new search engine and grade specific content development.

Multi Lingual Federated Search--Deep Web Technologies, LLC, 301 North Guadalupe, Suite 201, Santa Fe, NM 87501; 505-820-0301; www.deepwebtech.com
Mr. Alex Quezada, Principal Investigator, alex@deepwebtech.com
Abe Lederman, Business Official, abe@deepwebtech.com
DOE Grant No. DE-FG02-07ER84699
Amount: $399,344

DOE research is hindered by the fact that much quality scientific information is not published in English. No mechanism exists for researchers to search for foreign language documents in their native language, with automatic translation of results and documents. A multi-lingual federated search environment is proposed that allows for searching and viewing of result lists and documents in a number of major languages.

Phase I proved feasibility of automated translation of search terms and search results between English and French in a federated search environment. Phase II will extend the Phase I work to include more languages of interest to scientists, it will extend the sophistication of the prototype developed in Phase I, and it will improve its performance.

Commercial Applications and other Benefits as described by the awardee: Automated language translation is a technology of great interest to organizations creating search portals, especially if they access scientific information that may be published in a number of languages. No multi-lingual federated search applications exist so market interest should be great. Researchers and the public will also benefit from access to a much larger volume of quality content.

Source Selection Optimization--Deep Web Technologies, LLC, 301 North Guadalupe, Suite 201, Santa Fe, NM 87501; 505-820-0301; www.deepwebtech.com
Mr. Dan Heidebrecht, Principal Investigator, dan@deepwebtech.com
Dr. Abe Lederman, Business Official, abe@deepwebtech.com
DOE Grant No. DE-FG02-07ER84700
Amount: $399,560

It is difficult for DOE researchers to keep apprised of relevant scientific information given its rapid rate of growth. No mechanism exists to automatically discover, configure access to, or select sources for searching. This project will develop a suite of applications that discover new information sources, build federated search query interfaces to them, and automatically select relevant sources for researchers to search.

Phase I proved feasibility of automated discovery of information sources, of human-assisted configuration of these sources for federated search, and of automated source selection using a database of sample queries. Phase II will extend the algorithms and approaches of the Phase I work to develop a prototype federated search application that can search a large number of sources simultaneously. The sources for the prototype will be discovered and configured with the assistance of software prototyped in Phase I and extended in Phase II.

Commercial Applications and other Benefits as described by the awardee: There is much commercial interest in source discovery, configuration, and in source selection at search time. Source discovery and configuration, in particular, are very time consuming tasks, thus any automation that can be applied to them will have commercial value.

Multi-Faceted Clustering of Meta-Search Results--Edgewater Technology Associates, Inc., 3528 Worthington Blvd., Suite 301, Urbana, MD 21704; 301-275-5041; www.edgewater.com
Dr. Antonio Zamora, Principal Investigator, tony.zamora@edgewaterit.com
Dr. David Yockman, Business Official, david.yockman@edgewaterit.com
DOE Grant No. DE-FG02-07ER84705
Amount: $404,621

The proliferation of information sources, media, formats, tools and interfaces on the Web has made it more difficult to find all relevant information, thereby decreasing productivity and user satisfaction. This project will develop the next generation search technology that combines universal meta-search, intelligent search result clustering, and pragmatic information visualization to provide the best answers to users, even when they do not know where to look. Universal meta-search simultaneously searches heterogeneous information sources and blends and ranks different information media and formats in a coherent way. Intelligent faceted clustering organizes the search results in a clear and useful manner to promote knowledge extraction, query refinement, and personalization by users. Information visualization helps support user exploration, understanding, and discovery.

The Phase I project researched, designed, and developed a next generation clustering technology for organizing meta-search results along multiple information facets in multiple information dimensions of multiple search spaces. The research goals were achieved by developing proof-of-concept pilots in different disciplines and application domains, such as energy and consumer health. The Phase II project will address the challenges of converting the innovative Phase I ideas and prototypes into a robust commercial product.

Commercial Applications and other Benefits as described by the awardee: Potential markets for universal meta-search and intelligent clustering technology include government agencies, universities and schools, as well as the R&D departments of corporations, including biotech companies, energy companies, technology firms, and financial institutions.

***STTR Project: Automated Tool for Locating, Harvesting and Storage Experimental Scientific and Technical Data-Ontology and Automated Concepts for Creating a Linked Data Infrastructure--**Information International Associates, Inc., 1055 Commerce Park Drive, Suite 110, P.O. Box 4219, Oak Ridge, TN 37831; 865-298-1262; www.infointl.com
Ms. Franciel Azpurua Linares, Principal Investigator, Franciel@iiaweb.com
Ms. Stephanie J. Cusatis, Business Official, scusatis@iiaweb.com
DOE Grant No. DE-FG02-07ER86314
Amount: $439,606

Research Institution
University of Tennessee
Knoxville, TN

Many Scientific and technical data sets have been placed in a distributed set of data repositories, and more are added continuously. Internet search engines can provide some answers to user queries, but the quality and completeness of the results are uneven and unreliable.

This project will demonstrate how an integrated tool can locate, harvest, and deposit data into a user-specified repository. The Phase I project developed a prototype to record essential facts about scientific and technical data collections. This prototype was designed to assist users in quickly locating data collections of interest. The project (1) Created a generic ontology for describing data, (2) Used that ontology to enhance a prototype web-based program to accept factual information about data sets from different disciplines, and (3) Dry tested the ontology and the data input tool using information about a variety of data collections generated and maintained by Department of Energy Data Centers.

The Office of Scientific and Technical Information created and hosts interfaces that search data repositories from federal agencies and worldwide organizations accountable for the quality and accuracy of their information. This project will provide a state-of-the-art tool for a more automated, streamlined process to create and maintain data repositories. A federated search interface can be provided to the scientific community and to the general public that retrieves up-to-date, relevant, valid information for a broad range of applications (e.g., technical analyses, policy, and education).

Commercial Applications and other Benefits as described by the awardee: This technology can enable government and commercial organizations that manage scientific data to provide various approaches to use and re-use data sets and related information.

Developing CZT for Single Element Spectrometers--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Dr. Paul R. Bennett, Principal Investigator, PBennett@rmdinc.com
Dr. Gerald Entine PhD, Business Official, GEntire@rmdinc.com
DOE Grant No. DE-FG02-07ER84764
Amount: $750,000

Cadmium zinc telluride (CZT) detectors have the potential to be a powerful and versatile tool in the tracking and control of nuclear materials. However, despite well over a decade of development, yield of spectrometer grade material remains low.

This project will investigate the traveling heater method (THM) as an alternative method for growing CZT. The Phase I project was aimed at demonstrating the feasibility of producing detector grade CZT by THM. Detector grade CZT was grown by THM, and extensive characterization of the material was conducted. The Phase II project will optimize the THM method for growing CZT for eventual use in nuclear non-proliferation. Growth of large crystals, tuning of dopant concentration and annealing, and extensive characterization of material properties is planned. Evaluation of detectors as high resolution spectrometers with 3-D corrections is also planned.

Commercial Applications and other Benefits as described by the awardee: The proposed detector technology may be used for nuclear non-proliferation, nuclear and particle physics experiments, medical imaging systems, astronomy, diffraction, nondestructive studies and bore hole logging.

Miniature Spherical Retroreflectors Fabricated by Fluidized Bed CVD--Structured Materials Industries, Inc., 201 Circle Drive North, Unit # 102, Piscataway, NJ 08854; 732-302-9274; www.structuredmaterials.com
Dr. Nick M. Sbrockey, Principal Investigator, sbrockeky@structuredmaterials.com
Dr. Gary S. Tompa, Business Official, GSTompa@structuredmaterials.com
DOE Grant No. DE FG02 07ER84765
Amount: $750,000

Miniature spherical retroreflectors are an enabling technology for remote laser sensing of chemical, biological and radiological agents in the atmosphere. Prior to this SBIR project, no suitable fabrication technique existed to produce spherical retroreflectors with the required graded index of refraction structure. This project will produce spherical retroreflectors with compositional grading from center to surface. This approach combines the well-established technology for fluidized bed processing with existing technology in chemical vapor deposition (CVD) of optical materials. The Phase I project demonstrated technical feasibility of the approach. The Phase II project will further optimize properties, improve production, and extend the process to other coating materials for application at different optical wavelengths. Also during Phase II, sample quantities of miniature spherical retroreflectors will be produced and delivered for evaluation by DOE.

Commercial Applications and other Benefits as described by the awardee: In addition to remote laser sensing, the spherical retroreflectors will be useful for many other sensing, tracking, and free-space communications applications. The technology will also benefit other industrial, commercial, and scientific applications.

Prototyping an Intrinsically Digital Broadband Seismometer--Geotech Instruments, LLC, 10755 Sanden Drive, Dallas, TX 75238-1336; 214-221-0000; www.geoinstr.com
Mr. David McClung, Principal Investigator, david.mcclung@geoinstr.com
Dr. Lani Oncescu, Business Official, lani.oncescu@geoinstr.com
DOE Grant No. DE-FG02-07ER84935
Amount: $746,861

The objective of this project is to design and build a seismometer that combines the essential features of a traditional pure analog seismometer, which outputs a voltage signal, with a traditional digitizer, which samples that voltage signal and provides digital word output. The design does not just physically integrate a seismometer with a digitizer. Instead, the design employs a new approach altogether. Digital delta-sigma over-sampling of the seismometer's mass suspension voltage occurs within the control loop of the sensor, and digital electronics are used in the control feedback path to maintain the instruments dynamic range. In theory this may provide for a system design that is more compact, draws less power, and is easier to manufacture. Furthermore, the development of this class of instrument may ultimately allow for on-the-fly changes to seismometer configuration that redefine its transfer function characteristics such as gain (ground acceleration to digital count), and frequency roll-off, providing more flexibility for a single instrument.

Next Generation Robust Low Noise Seismometer for Nuclear Monitoring--PMD Scientific, Inc., 105 F. West Dudleytown Road, Bloomfield, CT 06002; 860-242-8177; www.pmdsci.com
Dr. Igor A. Abramovich, Principal Investigator, igor@pmdsci.com
Dr. Igor A. Abramovich, Business Official, igor@pmdsci.com
DOE Grant No. DE-FG02-07ER84738
Amount: $749,614

This project will develop the next generation, very low noise, broadband, wide dynamic range, extremely robust, force-balanced digital seismometer for seismic monitoring. The new seismometers will be very competitive in various niches of the worldwide seismic market due to their unique combination of high performance, especially the low noise over broad passband, and exceptional ruggedness. The new generation seismometer will use improved electrochemical transducers built into three similar orthogonally mounted sensors, the latter based on conceptually new design ideas that, when implemented, will result in a drastic increase in signal to noise ratio. The project will present the principles of operation and detailed noise analysis of electrochemical motion sensors along with the explanation of how such major noise reduction can and will be achieved. At each developmental milestone, prototype instruments will be vault-tested side-by-side with Strekeisen STS2 seismometers. The complete digital seismometer is expected to consume less than 750mW.

Development of Low Noise Smart Sensors for Small Explosion Monitoring--Rocky Mountain Geophysics, LLC, 167 Piedra Loop, Los Alamos, NM 87544; 505-412-2893; www.rockymountaingeophysics.com
Dr. Steven R. Taylor, Principal Investigator, srt-rmg@comcast.net
Dr. Pamela Naugle, Business Official, pln-rmg@comcast.net
DOE Grant No. DE-FG02-07ER84740
Amount: $749,726

The Phase I study demonstrated that it is feasible to detect and identify small explosions amidst a background of natural and anthropogenic noise sources. The Phase II project will develop a commercial Low-Noise Smart Sensor that would be part of a Deployable Small Explosion Monitoring System for remotely monitoring small explosions. The Phase II project will design and build a prototype Deployable Small Explosion Monitoring System. Phase II will involve packaging a commercially available or experimental low-noise accelerometer with a small processor in order to develop a prototype low-noise smart sensor system. These systems have potential commercial applications to early earthquake warning systems, facility monitoring, perimeter monitoring, and border security.

Nanocomposite Insulation for 2G Superconducting Wires--Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026; 303-664-0394; www.ctd-materials.com
Dr. Matthew Hooker, Principal Investigator, matt.hooker@ctd-materials.com
Ms. Lori Pike, Business Official, lori.pike@ctd-materials.com
DOE Grant No. DE-FG02-07ER84711
Amount: $749,990

The U.S. Department of Energy, in collaboration with several industry participants, is developing power-distribution systems based on second generation high-temperature superconducting (HTS) wires and cables. U.S. industry has made considerable improvements in the electrical performance and large-scale production of these wires, and several HTS components have already been integrated into the United States' power grid. As these rapid developments in superconducting cable technology continues, a critical need has emerged for reliable, high-voltage dielectrics for use in these systems. High-voltage dielectric materials for HTS power applications must be capable of long-term, high-voltage, cryogenic-temperature operation. This project will develop nanocomposite-based dielectric materials and validate their performance under simulated operating conditions. The Phase I work involved the development and testing of high-voltage dielectric materials based on nanocomposite technology. The Phase II project will continue the development of the high-voltage dielectric materials and evaluate their performance relative to the requirements of HTS power systems.

Commercial Applications and other Benefits as described by the awardee: Reliable, high-performance dielectric materials are needed for use in future HTS power distribution systems, in cable systems, fault current limiters, transformers, and in generators based on HTS technology. Advancements in cryogenic dielectrics would also benefit superconducting magnet systems under development by DOE, as well as space-based electronic systems that operate at low temperatures.

Ultra Fast MOCVD Growth of Highly Textured YBCO Films for Coated Conductors--Metal Oxide Technologies, Inc., 8807 Emmott Road, Suite 100, Houston, TX 77040 3532; 832-243-0917; www.metox.biz
Dr. Alexander Molodyk, Principal Investigator, Alexander.mologyk@metox.biz
Mr. Chris Shay, Business Official, chris.shay@metox.biz
DOE Grant No. DE-FG02-07ER84691
Amount: $742,378

One of the major factors that inhibits rapid throughput, and hence increases the cost, of coated conductors is the moderate deposition rate of high temperature superconducting films. Thus far, the approach has been to increase the deposition area using moderately rapid deposition techniques. By developing the industrial methods of ultra-fast deposition to produce coated conductors, the overall production time, and thus overall cost, of second generation coated conductors can be reduced. The Phase I project demonstrated the technical feasibility of the proposed approach. The Phase II effort will implement appropriate enhancement of ultra-fast growth rate continuous deposition, and enable further process scale-up.

Commercial Applications and other Benefits as described by the awardee: The ultra-fast deposition of high current carrying capacity superconducting wire will deliver low cost, high performance superconducting wire to commercial markets for integration into motors, transformers, transmission lines, and other devices.

Large Area SiC GTO Thyristor Development--GeneSiC Semiconductor Inc., 43670 Trade Center Place, Suite 155, Dulles, VA 20166; 703-996-8200;
www.genesicsemi.com
Dr. Ranbir Singh, Principal Investigator, ranbir.singh@genesicsemi.com
Dr. Ranbir Singh, Business Official, ranbir.singh@genesicsemi.com
DOE Grant No. DE-FG02-07ER84712
Amount: $750,000

The extremely challenging speed and voltage specifications of converter circuits used to attach renewable energy sources and energy storage elements to the power grid require the development of new semiconductor switch technology. In addition, the robustness and reliability of energy storage power processing circuits used in conventional power grid systems are enhanced significantly with the availability of sub-microsecond Thyristors. The voltage specification achieved is beyond the theoretical limit that can be achieved with contemporary Silicon technology, is within the room temperature corona limit, and is compatible with commercially available capacitors. These challenging specifications are enabled by fully exploiting the superior electrical and thermal properties of the emerging power semiconductor material of choice: Silicon Carbide (SiC).

In the Phase I, a nearly-ideal blocking voltage SiC Gate Turn Off (GTO) Thyristor was found to offer the best solution for the challenging requirements. Extensive simulations were conducted to model SiC GTO Thyristor devices and their performance was verified. Test structures were fabricated and power-packaging technology was explored. In the Phase II project, five batches of SiC GTO Thyristor devices will be designed and fabricated with successively increasing voltage and current capabilities to meet the program objectives.

Commercial Applications and other Benefits as described by the awardee: Government and commercial markets that have been identified include electric power utilities, medical imaging and cancer treatment, and industrial systems for food irradiation and hospital waste sterilization.

Nano Engineered Carbon Electrochemical Capacitors--Giner, Inc., 89 Rumford Avenue, Newton, MA 02466; 781-529-0501; www.ginerinc.com
Mr. Mourad Manoukian, Principal Investigator, mmanoukian@ginerinc.com
Dr. Anthony B. LaConti PhD, Business Official, alaconti@ginerinc.com
DOE Grant No. DE-FG02-07ER84936
Amount: $749,950

The Department of Energy has identified a need for improved energy storage devices utilizing carbon nano-tubes and other nano-engineered materials. This project will develop an innovative all-solid-polymer-electrolyte Electrochemical Double-Layer Capacitor, utilizing nano-porous carbon powders obtained by selective leaching of metals from metal carbides. The proposed capacitors will not contain any liquid electrolytes and will be free of corrosive and toxic chemicals. The Phase I project successfully demonstrated the feasibility of devising high energy and high power capacitors using synthesized nano-porous carbon powders. The Phase II project will continue, as well as refine, the developmental work started in Phase I and fabricate a 150-cell all-solid-polymer-electrolyte Electrochemical Double-Layer Capacitor device that could be charged up to 150 volts, operate in the temperature range of -30 degrees Centigrade to +80 degrees Centigrade and capable of charging/discharging for 500,000 cycles.

Commercial Applications and other Benefits as described by the awardee: High-energy and high-power Electrochemical Double-Layer Capacitors are prime candidates for use in industrial power management, and in automotive and consumer electronics.

One-Cycle Controlled Reactive Power Supply Inverter (OCC-RPSI) for Distributed Energy--One-Cycle Control, Inc., 12 Mauchly, Suite P, Irvine, CA 92618;
949-727-0107; www.onecyclecontrol.com
Dr. Gregory T. Smedley, PhD, Principal Investigator, gsmedley@onecyclecontrol.com
Dr. Gregory T. Smedley, PhD, Business Official, gsmedley@onecyclecontrol.com
DOE Grant No. DE-FG02-07ER84692
Amount: $750,000

Reactive power is both a problem and a necessity for the electric grid. Loads on the electric grid such as AC electric motors need reactive power to function and this requires the electric grid to deliver the reactive power. Reactive power occupies valuable capacity on the electric grid and can prevent loads from sourcing adequate real power, leading to brown-outs and black-outs such as the New York blackout on August 14, 2003. By enabling distributed energy resources (DER) like fuel cells, reciprocating engine generators, etc. to provide real and reactive power closer to the loads that require it, the operating margin of the electric grid and therefore its stability, reliability, and efficiency can be substantially improved. This project will develop a controller for commercial distributed energy (DE) inverters that enables DER to deliver both real and reactive power.

The controller is based on technology that delivers a new paradigm: active conversion of 3phase power without software. The technology enables a ten-fold reduction in circuit complexity and the elimination of control software to provide a substantial boost in system reliability and performance, necessary for large-scale deployment on DER.

The Phase I project demonstrated a prototype able to rapidly deliver real and reactive power to the grid for voltage support without software. The Phase II project will develop a prototype that leverages the controller from Phase I to commercial size. The resulting controller product will interface with existing commercial DE inverters to accelerate market adoption. A streamlined subset of tests will be developed that facilitates regulatory approval for manufacturers who adopt the controllers for their end-user products.

Commercial Applications and other Benefits as described by the awardee: The controller has commercial applications on fuel cells, micro-turbines, and reciprocating engine generators. The primary benefits are high-quality power, high reliability (due to low component count and no software), and reactive power injection/absorption when needed to support the grid.

Development of Aircraft Borne 13CH_4 Analyzer Using a Continuous Wave Quantum Cascade Infrared Laser Spectrometer--Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01772; 978-663-9500; www.aerodyne.com
Dr. Mark S. Zahniser, Principal Investigator, mz@aerodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-07ER84889
Amount: $750,000

Methane (CH_4) is the second most important atmospheric greenhouse gas after CO_2, yet its global sources and sinks are still inadequately characterized. Monitoring the isotopic composition of atmospheric methane is one of the most promising approaches to closing the methane budget. Recent claims that plants may account for a substantial fraction of atmospheric methane have lead to an increased emphasis on studies of ecosystem CH_4 fluxes, with particular interest in using isotopic composition to identify specific production pathways. Currently, field deployable instruments for direct measurements of methane isotopes having sufficient precision do not exist. Recent advances in quantum cascade laser technology have made available continuous wave operation near room temperature without cryogenic cooling. With such devices, it is now feasible to develop a compact portable instrument with sufficient sensitivity for direct measurements.

The Phase I project modified an existing optical system and demonstrated the ability to directly detect the ratio of methane isotopes with a precision of 0.2 parts per thousand (0.2 ‰) in an averaging time of 100 seconds in ambient air without pre-concentration, exceeding the Phase I goals. Extended measurements of the isotopic ratio of ambient methane outside the research facility and measurements of the isotopic content of human breath and natural gas were performed. Preliminary designs for the aircraft-borne instrument were developed, and measurement opportunities for Phase II instrument deployment were identified. The Phase II project will complete the design and construction of a prototype instrument, which will be compact, rugged and field-deployable.

Commercial Applications and other Benefits as described by the awardee: This instrument will provide scientifically meaningful isotopic ratio measurements in real time, without pre-concentration and without cryogenic cooling of either laser or detector. Other applications of this technology include air pollution monitoring, human breath analysis, geochemical prospecting, and industrial process monitoring.

A Cost Effective Analytical Technology for Identification and Measurement of Greenhouse Gases--Lenterra Inc., 7 Tenney Road, West Orange, NJ 07052; 973-731-6281; www.lenterra.com
Dr. Gotze H. Popov, Principal Investigator, popov@lenterra.com
Dr. Valery A. Sheverev, Business Official, sheverev@lenterra.com
DOE Grant No. DE-FG02-07ER84894
Amount: $749,742

This project will develop a cost-effective analytical technology platform for identifying and measuring concentrations of greenhouse gases such as carbon dioxide, methane, and nitrous oxide and trace greenhouse gas constituents such as carbon monoxide. The proposed analytical platform is based on Penning Ionization Electron Spectroscopy (PIES) in plasma. PIES technology relies on a simple analog measurement configuration capable of unique identification of chemical species. No optical or high-vacuum equipment is required, which opens up the opportunity to make the proposed analyzer a miniature, low weight, low energy and low material consumption device.

Phase I experiments demonstrated capabilities of PIES technology when PIES analytical spectra were obtained in a breadboard version of a PIES detector coupled with a gas chromatograph. In the Phase II project, each element of the Analytical Platform based on PIES technology (APP) will be miniaturized and combined in an integrated analyzer platform capable of in situ real-time identification and monitoring of greenhouse gases. A prototype of the APP analyzer will be developed and tested. In Phase III, the APP will be realized on a single chip.

Commercial Applications and other Benefits as described by the awardee: Instruments based on APP are intended to serve multiple needs for industries where size, weight, resource and energy consumption requirements are top priority. A portable and rugged APP analyzer will be particularly attractive in fields as: microelectronics (e.g. for monitoring the environment of pure industrial processes), home security, pharmaceutical, biochemical, petrochemical, forensics (e.g., drug screening and toxicology research), and hazardous waste treatment.

Isotope Analyzer for Real Time Measurements in the Field--Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041; 650-965-7772; www.lgrinc.com
Dr. Douglas Baer, Principal Investigator, d.baer@lgrinc.com
Dr. Anthony O'Keefe, Business Official, a.okeefe@lgrinc.com
DOE Grant No. DE-FG02-07ER84895
Amount: $686,487

This project will use spectroscopy technology to develop, deploy and test a field-portable methane isotope analyzer for measurements of carbon isotope ratios and methane concentrations in ambient air. This instrument will be capable of providing in-situ, accurate, quantification of both methane concentration and carbon isotope ratio for real-time monitoring of methane sources and sinks in the biosphere and atmosphere (e.g., in landfills, wetlands, rice growing facilities, urban environments, geological formations). It will distinguish between biogenic and injected carbon sources, and identify, and subsequently capture, fugitive methane emissions. This project will build, test, and deploy a novel prototype instrument capable of real-time measurements of methane isotopomers in ambient air.

The Phase I project successfully designed, developed, and demonstrated a prototype instrument that measured methane concentration and the carbon isotopic ratio in ambient methane with great precision. Several improvements to the Phase I instrumentation design were identified and will be included in the Phase II field instrument to enable isotope ratio measurements with substantially better precision.

The Phase II project will construct, deploy, and rigorously test, a novel, easy-to-use, methane isotope analyzer for real-time measurements of carbon isotope ratio in ambient methane. It will demonstrate the performance and ruggedness of the instrument at several locations including landfills (California, Florida), wetlands (Alabama), a rice research site (Louisiana), urban environments (Pennsylvania), and a coal mine (Virginia).

Commercial Applications and other Benefits as described by the awardee: The development of a robust field-portable methane isotope analyzer will find uses in landfills, wetlands, oil and gas exploration, and environmental research.

Real Time Multispecies Greenhouse Gas Sensor--NovaWave Technologies, Inc., 900 Island Drive, Suite 101, Redwood City, CA 94065; 650-610-0956; www.novawavetech.com
Dr. James J. Scherer, Principal Investigator, jjscherer@novawavetech.com
Dr. Hans Jurg Jost, PhD, Business Official, hjjost@novawavetech.com
DOE Grant No. DE-FG02-07ER84929
Amount: $749,932

Highly accurate, robust sensors capable of monitoring fluxes and concentrations of greenhouse gases such as methane are needed. In addition to meeting sensitivity and accuracy requirements, size, weight, and power consumption will likely be drivers in selecting sensor systems for remote monitoring. The proposed sensor is based on a novel mid-infrared laser source that reduces the complexity of the sensing approach and increases robustness. This laser will provide high reliability, excellent beam quality, compact size, low power consumption, and room-temperature single-frequency operation. It can be combined with a rugged, miniaturized gas sampling system, or be used in a unique, open-path configuration to enable long-term measurements of trace gas fluxes and concentrations in the field.

During Phase I, a novel mid-infrared laser source was constructed and characterized, and new approaches to fabricating the core subcomponents were researched. Preliminary designs for a multi-species Phase II sensor were produced, including designs for extending the laser technology to new wavelength regimes. The Phase II work will continue the core Phase I technology development and employ this new laser platform to produce a prototype system. The system will be rigorously tested to demonstrate system efficacy for autonomous greenhouse gas monitoring for extended periods of time. The Phase II work will also demonstrate the efficacy of the core sensor technology platform for other gas sensing applications.

Commercial Applications and other Benefits as described by the awardee: The commercial applications of the proposed sensor include greenhouse gas monitoring for geophysical research and emissions compliance, hydrocarbon leak detection, and a variety of industrial process control venues.

Methane and Carbon Dioxide Eddy Covariance Flux Monitor--Picarro, Inc., 480 Oakmead Parkway, Sunnyvale, CA 94085; 408-962-3937; www.picarro.com
Dr. Eric R. Crosson, Principal Investigator, ecrosson@picarro.com
Dr. Tania Pashkevich, Business Official, tpashkevich@picarro.com
DOE Grant No. DE-FG02-07ER84902
Amount: $749,845

Methane (CH_4), water vapor (H_2O), and carbon dioxide (CO_2) are collectively responsible for the majority of the Earth's greenhouse effect. Robust instrumentation that can measure these gases with both high accuracy and precision and with sufficient speed would reduce the uncertainty in the determination of terrestrial sources and sinks of these dominant greenhouse gases. Such knowledge is needed to improve predictive models that lead to a better understanding of the human contribution to global warming.

The Phase I project built one prototype system. The prototype monitor met or exceeded all CO_2 and CH_4 performance targets as defined in the Phase I proposal, except for rise and fall times. The Phase II project will design, build, and fully test five analyzers able to produce continuous, high accuracy field measurements of ambient levels of atmospheric gases, at very high data rates, over years of operation in remote locations. Three analyzers will be sent to independent researchers as part of three performance and validation studies. One analyzer will be retained for long term software testing and validation, and the last analyzer will ultimately be destroyed during shock and vibration testing.

Commercial Applications and other Benefits as described by the awardee: Government agencies around the world are already installing atmospheric monitoring stations. The Ameriflux network currently has 89 active stations in six countries. An improved CO_2 and CH_4 flux monitor deployed at these stations would provide high accuracy as well as high precision information at a data rate required for flux measurement. In addition, the analyzer requires far less calibration and sample preparation than currently available technology, leading to better reliability and reduced operating cost.

High Precision CO_2 Field Sensor--Southwest Sciences, Inc., 1570 Pacheco Street, Suite E-11, Santa Fe, NM 87505; 505-984-1322; www.swsciences.com
Dr. Joel A. Silver, Principal Investigator, jsilver@swsciences.com
Dr. Alan C. Stanton, Business Official, astanton@swsciences.com
DOE Grant No. DE-FG02-07ER84906
Amount: $750,000

The U.S. Global Climate Change Initiative (GCCI) has the goal of significantly reducing greenhouse gas emissions over the next 10 years. However, the sources and sinks of carbon dioxide and other greenhouse gases are not well understood. High precision instruments to quantify the concentrations and fluctuations of carbon dioxide are essential to improve this understanding, yet existing instruments can not meet the combined specifications for precision, long-term unattended field operation, and cost. This project will develop a new type of high precision optical sensor combining traditional optical spectroscopy with a new self-calibrating method that will improve detection sensitivity and precision.

The Phase I research successfully demonstrated the proposed approach for high precision measurements, without the need for external calibration gases or dependence on ambient conditions. The Phase II project will result in a prototype sensor capable of high precision field measurements. It will be compact, run unattended with low power, and use no consumables. Its performance will be validated by field measurement comparisons with the best currently available instruments.

Commercial Applications and other Benefits as described by the awardee: Federal benefits include low-cost, field-deployable, instruments for the rapid and precise measurements of important gases that will improve modeling of atmospheric dynamics and climate change. This methodology is also applicable to Homeland Security identification of chemical agents. Direct commercial applications include environmental sensing and regulatory compliance, atmospheric research and optical sensing, as well as gas leak sensing for pipelines, fire detectors for commercial and private aircraft, combustor feedback control sensors, and process control sensors for energy and chemical production industries.

Engineering Isobutanol Production for High Yield—Gevo, Inc., 345 Inverness Drive South, Building C, Suite 310, Englewood, CO 80112; 303-858-8358; www.gevo.com
Dr. Thomas Buelter, PhD, Principal Investigator, tbuelter@gevo.com
Dr. Peter Meinhold, Business Official, pmeinhold@gevo.com
DOE Grant No. DE-FG02-07ER84893
Amount: $742,662

Due to political instability in oil-producing nations, growing concern about global warming and a need for indigenous energy resources, the scientific community shoulders the responsibility to identify and develop an economically viable and environmentally friendly fuel alternative. Higher alcohols, such as butanol and isobutanol that can be produced from the same biomass as ethanol are attractive second-generation biofuels both due to their higher energy content as well as their low hygroscopicity. However, the production processes for higher alcohols are not efficient enough to compete economically as a transportation fuel. The overall objective for the Phase I and the phase II projects is the development of an isobutanol production strain with a production yield high enough to enable commercialization in phase III.

During the Phase I project, microorganisms were engineered that produced isobutanol at yield, titer, and productivity values that proved feasibility of the technology. The Phase II project will increase the yield of the isobutanol process to levels sufficient for commercialization.

Commercial Applications and other Benefits as described by the awardee: Isobutanol has applications both in the transportation market as well as in the chemicals market. One of the biggest drawbacks with ethanol as a fuel is its hygroscopicity and the resulting inability to transport ethanol using the existing infrastructure. Using isobutanol as a replacement for ethanol overcomes this limitation as well as increases the energy content per gallon, bringing it closer to gasoline. In the chemicals market, the demand for isobutanol is growing at an annual rate of 4.5%. The growing price of oil has resulted in a corresponding increase in the cost of isobutanol. This project will promote the establishment of a renewable process for isobutanol production that is economically competitive with the petro-chemical market. This not only delivers a better second generation biofuel but also reduces the dependence on imported oil, lowers green-house gas emissions, and expands the use of bio-based products in the chemicals market.

***STTR Project: Ethanologenic/Electricigenic Consolidated Bioprocessing of Cellulosic Biomass**--Microbial Fuel Cell Technologies, LLC, 729 Veron Place, Mount Pleasant, SC 29464; 843-792-7140; http://www.microbialfuelcell.org/
Dr. Michael J. K. Nelson, Principal Investigator, mnelson@mdctech.net
Dr. Harold May, Business Official, hmay@mdctech.net
DOE Grant No. DE-FG02-07ER86319
Amount: $749,802

Research Institution
Medical University of South Carolina
Mount Pleasant, SC

Developing alternatives to fossil fuels is a major issue for the United States, as well as for the entire global economy. One alternative being aggressively pursued is the use of ethanol produced from renewable plant fiber. Plant fiber (cellulose) – which is contained in abundant resources such as wood pulp, agricultural wastes, and non-food crops such as switch grass and corn stover – represents an attractive alternative to corn as a feedstock. Although this material can be biologically converted (fermented) to ethanol, problems with the process currently make it too costly to be commercially feasible. In part, the problem is due to the generation of inhibitory organic acids, which cause low ethanol yields. This project seeks to combine fermentation with microbial fuel cell technology to reduce the amount of inhibitory acids produced and thereby increase the overall yield of ethanol from plant fiber. In Phase I, feasibility was proven by demonstrating a 5-fold increase in ethanol production and a 3-fold decrease in the amount of inhibitory acids relative to the ethanol produced. The objectives for Phase II include optimizing the system, matching the best biocatalysts with the best hardware, and testing at a scale that prepares the process for pilot-scale work and for a practical demonstration in Phase III.

Commercial Applications and other Benefits as described by the awardee: The public is well aware of the increasing cost and competition for energy, and concern over the use of fossil fuels and climate change continues to increase. A cost-effective process that converts plant fiber to ethanol should lead to the delivery of alternative renewable fuels that are not based on fossil fuels

***STTR Project: NamesforLife Semantic Resolution Services for the Life Sciences (N4L-SRS)**--NamesforLife, LLC, 4233 Jacob Meadows Drive, Okemos, MI 48824 3181; 517-639-0409; www.names4life.com
Dr. George M. Garrity, Principal Investigator, garrity@names4life.com
Dr. George M. Garrity, Business Official, garrity@names4life.com
DOE Grant No. DE-FG02-07ER86321
Amount: $750,000

Research Institution
Michigan State University,
East Lansing, MI

Within the Genomes-to-Life Roadmap, the DOE recognizes that a significant barrier to effective communication in the life sciences is a lack of standardized semantics that accurately describe data objects and persistently express knowledge change over time. As research methods and biological concepts evolve, certainty about correct interpretation of prior data and published results decreases because both become overloaded with synonymous (multiple terms for a single concept) and polysemous terms (single terms with multiple meanings). Ambiguity in rapidly evolving terminology is a common and chronic problem in science and technology. NamesforLife (N4L) is a novel technology designed to solve this problem.

The Phase I project was based on a prototype that demonstrated that names, concepts, and the objects to which names apply must be treated independently. As proof of principle, a preliminary data model and XML schema were developed and a simple semantic resolver was deployed. In Phase I, that model was substantially refined to address limitations of the prototype. The Phase II project will extend the scope of data curation and build a framework for distributing information services to users. N4L consolidates references to different kinds of data about the same organism, tracking the state of knowledge about it over time. For selected organisms, this aspect of the technology will be applied to a range of genomic and phenotypic data deposits. N4L's information services are made available to the user directly via the text in which they are reading related content. Phase II will achieve widespread deployment of these services, which are specific to the material being viewed by the user.

Commercial Applications and other Benefits as described by the awardee: N4L's proposed data and convenient applications will bring semantic accuracy to bioinformatics practice while simultaneously enabling new business models.

Genome-Enabled Advancement of Biomass to Biofuel Technology—SunEthanol Inc., 100 Venture Way, Hadley, MA 01035; 413-237-7447; www.sunethanol.com
Dr. John Kilbane, Principal Investigator, johnk@sunethanol.com
Dr. Jeffrey Hausthor, Business Official; jeffh@sunethanol.com
DOE Grant No. DE-FG02-07ER84930
Amount: $749,950

Development of cellulosic ethanol biofuels technology has emerged as a national priority. Clostridium phytofermentans is a novel, naturally occurring microbe that directly converts a broad-range of complex lignocellulosic materials, with ethanol as its primary fermentation by-product. Because it can consolidate hydrolysis and fermentation steps, C. phytofermentans has the potential to significantly reduce the process cost of biomass-to-ethanol conversion. Its demonstrated ability to convert a variety of complex feedstocks enables wide application potential for cellulosic ethanol production. This project will: 1.) Determine the preferred pH, temperature, agitation speed, and media composition for the conversion of cellulose to ethanol by C. phytofermentans, 2.) Select a complex feedstock for subsequent investigations (Ammonia Fiber Expansion -treated corn stover), 3.) Demonstrate the conversion of corn stover to ethanol, and 4.) Perform bioreactor studies to maximize the conversion of corn stover to ethanol.

Additionally, microbiological, genetic, and biochemical engineering data will be obtained that will allow us to model cellulose-to-ethanol conversion with C. phytofermentans and to use the biochemical reactor model to develop improved process conditions and microbial strains relevant to a viable biomass-to-ethanol process.

Commercial Applications and other Benefits as described by the awardee: The development of a metabolic model that is systematically evaluated with metabolic flux analyses and incorporates data from microbiological, biochemical, microarray gene expression profiling, plus bioreactor experiments, could greatly accelerate the pace at which this promising technology can be developed to a commercial scale.

***STTR Project: In-Situ Monitoring of the Radioactive Contaminant 99TC in Ground Water Using a Reagentless Equilbrium-Based Sensor: Enabling the Mapping of 99TC Plum Migration at Contaminated DOE Sites--**Burge Environmental, Inc., 6100 South Maple Avenue, Suite 114, Tempe, AZ 85283-2872; 480-968-5141
Dr. Scott Russell Burge, Principal Investigator, burgenv@globalcrossing.net
Dr. Scott Russell Burge, Business Official, burgenv@globalcrossing.net
DOE Grant No. DE-FG02-07ER86303
Amount: $742,190

Research Institution
Pacific Northwest National Laboratory
Richland, WA

The long-term monitoring of groundwater contamination plumes to determine the fate of contaminants in the environment is expensive and labor intensive. Current baseline methods have resulted in monitoring programs that collect less data than is required to fully understand the fate and transport mechanisms of the contaminants. In this project, an automated field-deployable monitoring system, which uses a reversible mini-column sensor, will be used to monitor technetium-99 concentrations. The system will be capable of being deployed and operated in the field for several months while measuring technetium-99 concentrations below the regulatory limits. The system will provide more frequent data with less reporting delay at a lower cost than the baseline methods. In Phase I, a prototype analytical system was developed and tested. The system successfully detected technetium-99 below the regulatory limit and appeared to have the necessary attributes for deployment in the field. In Phase II, two systems will be field-deployed to allow for near real-time monitoring at the 200-UP-1 and 200-ZP-1 areas of Hanford Site, Washington.

Commercial Applications and other Benefits as described by the awardee: The monitoring system should have application at DOE sites with radiological contaminants. The system would decrease monitoring costs, enhance the understanding of the fate of the radiologicals in the environment, and ultimately decrease the cost of groundwater remediation activities.

A New High-Resolution Method for the Characterization of Heterogeneous Subsurface Environments: Providing Flow and Transport Parameters via the Integration of MultiScale HYdroGeophysical Data—New England Research, Inc., 331 OLcott Drive, Suite L1, White River Junction, VT 05001; 802-296-2401; www.ner.com
Dr. Gilles Y. Bussod, Principal Investigator, gbussod@ner.com
Dr. Gilles Y. Bussod, Business Official, gbussod@ner.com
DOE Grant No. DE-FG02-07ER84898
Amount: $739,299

The Department of Energy's (DOE) remediation efforts have relied on numerical models to integrate laboratory and field characterization data, predict the fate and transport behavior of contaminant plumes, design remediation protocols to mitigate contaminant migration, and analyze data from field remediation results. High performance computations using "leadership class computers" are now making it technically feasible to model the complex flow and transport processes occurring over a wider range of scales. However, these models are limited by the lack of fine-scale site characterization data. This project will generate critical hydro-geophysical parameters to develop physical models that enable DOE scientists to produce high-performance site-scale computations of subsurface contaminant transport, and reduce prediction uncertainties.

The Phase I project resulted in new model parameters and results including: (1) new up scaled flow parameters that incorporate fine-scale anisotropic heterogeneity, result in anisotropic properties not previously predicted by standard models, and (2) Preliminary predictions using these parameters consistent with field measurements of contaminant migration in the contaminated subsurface at LANL.
The Phase II project will involve the development of a fully integrated *Environmental Shared Earth Model* (ESEM) for chromium-and uranium-contaminated "legacy waste" sites at LANL and the Hanford 300 Area (PNNL).

Commercial Applications and other Benefits as described by the awardee: This project will result in a new, improved, and marketable site characterization method and new technology applications for subsurface characterization. Phase II will directly benefit DOE's investment in massively parallel flow and transport model development. Benefits to DOE and the public include cost savings on remediation and verification activities, and should result in large cost savings over the life of the remediation programs.

Low-Cost Small Diameter NMR Technologies for In-Situ Subsurface Characterization and Monitoring—Vista Clara Inc., 2615 W. Casino Road, Suite 4-JK, Everett, WA 98204; 425-290-3626; www.vista-clara.com
Dr. David Oliver Walsh, Principal Investigator, davewalsh@vista-clara.com
Dr. David Oliver Walsh, Business Official, davewalsh@vista-clara.com
DOE Grant No. DE-FG02-07ER84931
Amount: $750,000

This project will address the problem of characterizing and monitoring subsurface hydro-geological and groundwater transport processes within 200m of the earth's surface, including both the saturated and unsaturated (Vadose) zones. The project will develop low-cost, small-diameter NMR (nuclear magnetic resonance) instrumentation and software for direct subsurface measurement of groundwater and its hydraulic properties. This effort will leverage magnet/coil designs and NMR techniques pioneered for deep petroleum exploration, and implement them in miniaturized, low-cost form factors suitable for hydro-geological investigations in the top 200 meters of the subsurface. The Phase I project performed computer simulations and laboratory NMR experiments to establish the technical feasibility of using NMR sensors to derive hydro-geological properties in boreholes as small as 2 in. in diameter using structural design and analysis to establish the feasibility of NMR cone penetrometers. The Phase II project will design, assemble and field test a complete borehole NMR instrumentation and software system for characterizing hydro-geological processes in the top 200m of the subsurface. It will also design, assemble, and field-test a cone penetrometer NMR sonde, and integrate it with an existing DoE cone penetrometer system.

Commercial Applications and other Benefits as described by the awardee: The results of this effort will be commercialized in the form of small-diameter NMR instruments and field services. Small-diameter down-hole NMR technology will bring the unique advantages of in-situ NMR measurements to a broad variety of subsurface hydrological investigations, at a fraction of the cost of existing borehole NMR instruments and services.

Aerosol Mass Spectrometry via Laser-Induced Incandescence Particle Vaporization—Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01772; 978-932-0215; www.aerodyne.com
Dr. Timothy B. Onasch, Principal Investigator, onasch@aerodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-07ER84890
Amount: $750,000

Aerosol particles have important impacts on visibility, acid deposition, human health, and climate. A large fraction of the anthropogenic aerosol is generated from energy-related activities known to contribute a significant fraction of ambient aerosol mass in many locations. Black carbon, formed in combustion processes, is believed to have a particularly strong influence on the earth's climate owing to its strong light-absorbing character. This project will develop a thermal desorption, time-of-flight, aerosol mass spectrometer for size-resolved, quantitative chemical composition data on aerosol particles using a laser-based vaporization technique. This instrument will enable full characterization of black carbon components, including their state of internal and external mixing. The new instrument will be made commercially available as a stand-alone instrument and as a laser vaporization module that can be installed and operated on existing time-of-flight aerosol mass spectrometers.

The Phase I project successfully demonstrated the concept of using laser-based vaporization to quantitatively measure the black carbon component of aerosol particles. During Phase II, the laser-based vaporization module will be re-engineered to provide a more robust package. The module will be fully integrated into the existing aerosol mass spectrometer hardware and software.

Commercial Applications and other Benefits as described by the awardee: The combined aerosol mass spectrometer and laser vaporization module will provide extended aerosol measurement capabilities to the atmospheric research community. In addition, the instrument is ideally suited for the characterization and control of aerosol emissions from a variety of industrial and energy production processes.

Ultrasensitive Airborne Instrumentation for the Quantification of Aerosol Precursors—Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041; 650-965-7772; www.lgrinc.com
Dr. Manish Gupta, Principal Investigator, m.gupta@lgrinc.com
Dr. Douglas Baer, Business Official, d.baer@lgrinc.com
DOE Grant No. DE-FG02-07ER84896
Amount: $736,885

Carbonaceous aerosols warm the atmosphere while sulfate aerosols reflect sunlight, moderating climate warming. In laboratory experiments, sulfate aerosol formation depends, in a strong, non-linear manner, on ammonia concentrations. There are limited field-studies, and uncertainties are partially responsible for limitations in predicting aerosol nucleation globally. Improving scientific understanding of aerosol formation is crucial and timely because of the need to better characterize climate sensitivities and assess warming mitigation options that involve the use of aerosol injections into the stratosphere. Current ammonia analysis instrumentation is expensive, heavy, and requires cryogens. This project will address these problems by developing ultrasensitive airborne and terrestrial instrumentation capable of rapidly quantifying trace levels of ammonia, and other critical aerosol precursors.

The Phase I project demonstrated technical feasibility by fabricating an Off-Axis ICOS analyzer that accurately measured ammonia in trace concentrations. The Phase I results were used to design a Phase II prototype.

Commercial Applications and other Benefits as described by the awardee: The Phase II project will develop and deliver two analyzer systems capable of making field measurements of ammonia and other aerosol precursors at ambient levels. The first instrument will be optimized for ammonia flux measurements and delivered to Lawrence Berkeley National Laboratories for field studies. The second instrument will be customized for airborne deployment aboard a DOE research aircraft and delivered to Pacific Northwest National Laboratory. Final Phase II work will include measuring and analyzing preliminary data for both terrestrial and aerial deployments in conjunction with DOE researchers.

During Phase III, the analyzer will be offered in a variety of markets, including environmental research, industrial process control, and medical diagnostics.

A Dual-Wavelength In Situ Cloud Lidar with Very Large Sample Volume—SPEC Incorporated, 3022 Sterling Circle, Suite 200, Boulder, CO 80301-2377; 303-449-1105; www.specinc.com
Dr. Paul Lawson, Principal Investigator, plawson@specinc.com
Dr. R. Paul Lawson, Business Official, plawson@specinc.com
DOE Grant No. DE-FG02-07ER84939
Amount: $699,706

Large-volume measurements of cloud microphysical properties are crucial for validating remote measurements from the earth's surface and satellites, which are necessary to improve predictions from global climate models. Current airborne in situ instruments are limited to microphysical measurements on scales of cubic centimeters up to a cubic meter. This project will develop a dual-wavelength in situ cloud light detection and ranging ("lidar": the optical analog of radar) system capable of measuring volumetric cloud properties over scales of millions of cubic meters.
The Phase I project included simulations and laboratory evaluations of components critical for development of the lidar system. SPEC previously developed a signal-wavelength system from which several components will be incorporated into the dual-wavelength (near infrared) system, thereby providing a significant cost savings to the DOE. The development of a near infrared high-power laser system with custom avalanche photodiode detector was a major challenge that was overcome in the Phase I research.

In Phase II, SPEC will build the dual-wavelength in situ cloud lidar, and in cooperation with the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS), install it in a research aircraft which will be used in the DOE Atmospheric Radiation Measurement (ARM) field campaign in 2009. Calibration flights will be performed and SPEC staff will deploy to the field program to train CIRPAS personnel on the operation of the equipment. Quick-look data will be placed on the program web site and final data will be placed in the ARM archives after the close of the experiment.

Commercial Applications and other Benefits as described by the awardee: The dual-wavelength in situ cloud lidar system will be useful as a tool to quantify the effects of stratus clouds on global climate change and has potential applications on several research aircraft. Military applications include providing information to landing aircraft, such as quantification of cloud properties and boundaries around aircraft carriers. The lidar system installed at uncontrolled airports could warn incoming aircraft of low clouds and fog, which are visually undetectable at night. It would also provide information on cloud boundaries and liquid water content that is critical for in-flight icing precautions. The system, installed in small unmanned aerial vehicles flying off costal areas, could provide critical information on the breakup of marine stratocumulus, resulting in cost savings to airlines by reducing flight delays and cancellations.

A Novel Microfluidic Detector with Position Sensitivity—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Mr. Kanai S. Shah, Principal Investigator, KShah@rmdinc.com
Dr. Gerald Entine PhD, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84904
Amount: $750,000

Microfluidic chips, fabricated from low cost polymers, are a promising, emerging technology for synthesis and study of new molecular imaging probes. These chips can contain a variety of microcircuitry and microwells, and are capable of manipulating nanoliter samples of reagents and solvents. The microfluidic chips have been designed for a multitude of applications, such as cell incubation and radiopharmaceutical synthesis. Adding the ability to quantify and image low amounts of radioactivity on a microfluidic chip can provide researchers with a platform to investigate new imaging probes, as well as molecular processes, with radiolabeled probes in a controlled, *in-vitro* environment. This project will design, build, and implement a high performance, position sensitive detector that can be integrated with microfluidic chips for detection and imaging of charged particles, emitted by the radiolabeled probes present in the fluids circulating in these chips. High sensitivity detection of these charged particles is desired with high spatial resolution, along with low minimum detectable activity.

The Phase I project designed and built novel position sensitive detectors for charged particle imaging that can function under conditions appropriate for *in-vitro* studies. The detectors were integrated with prototype microfluidic chips and their performance was evaluated. The Phase II project will optimize the proposed technology and implement it for studying biological processes at the molecular and cellular levels.

Commercial Applications and other Benefits as described by the awardee: Over and above the use in nuclear medicine, the proposed detection technology will be useful in nuclear and particle physics, space research, homeland security, environmental monitoring and synchrotron studies.

Novel Ceramic Scintillators for PET—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Dr. Charles Brecher, Principal Investigator, CBrecher@rmdinc.com
Dr. Gerald Entine, Business Official, GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84892
Amount: $750,000

Scintillation detectors, consisting of inorganic scintillation crystals coupled to photomultipliers, are an important element of medical imaging applications such as positron emission tomography (PET). Performance as well as cost of these systems is limited by the properties of the scintillation detectors available at present. The goal of this project is to investigate a new class of scintillation materials that can be fabricated using a low cost approach. The advantages expected from the proposed effort are higher performance and lower cost compared to existing scintillators used in PET. The Phase I project was aimed at demonstrating the feasibility of producing high performance scintillators using a low cost fabrication approach. Samples of these scintillators were produced and their performance was evaluated. The Phase II project will optimize performance as well as increase the size of the proposed scintillators. Extensive evaluation of these new scintillators will be conducted. PET modules will be constructed using these new scintillators and their performance will be characterized in detail.

Commercial Applications and other Benefits as described by the awardee: Over and above use in medical imaging, the new scintillators will be commercially applicable to nondestructive evaluation, bore hole logging, industrial computed tomography imaging, X-ray instrumentation, and materials analysis. They will also be useful in particle and space physics experiments.

Novel Parallax Free Sensor for Molecular Imaging—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800; www.rmdinc.com
Dr. Vivek Nagarkar, PhD, Principal Investigator, VNagarkar@rmdinc.com
Dr. Gerald Entine PhD, Business Official; GEntine@rmdinc.com
DOE Grant No. DE-FG02-07ER84903
Amount: $749,999

With the ever-increasing number of human disease models, particularly models in smaller animals, high-resolution emission/transmission tomography techniques have become extremely important. The barriers to using existing modalities in studies of laboratory animals have traditionally been poor spatial resolution, low sensitivity, and high cost. Although detector technologies have improved significantly in recent years, the current state-of-the-art scintillator technology remains the primary performance-limiting factor. To address these issues, this project will design and develop a novel scintillator coupled to a very high spatial resolution photodetector.

Phase I research demonstrated the feasibility of developing a novel scintillator array capable of providing parallax-free, high resolution imaging of high-energy radioisotopes. The Phase II research is a logical extension of the Phase I work, with the focus on improving the throughput of the materials processing technique, fabricating a larger-area focused scintillator array, fabricating a prototype detector, and thoroughly evaluating these devices at our collaborators' facilities. Substantial efforts toward commercialization of this technology will also be made.

Commercial Applications and other Benefits as described by the awardee: Molecular imaging techniques are well suited for imaging radiolabeled antibodies and other substances used to localize and characterize tumors in small animals, and for developing new radiolabeled agents for diagnosing and treating diseases in humans. This detector will significantly improve the resolution and sensitivity with which measurements can be made, allowing the development of superior drugs and technologies to diagnose and stage certain cancers, diseases of the heart and disorders of the circulatory system, and treatments to curtail the progression and even to cure these conditions. Beyond medical imaging, the detector will have broad application in industrial radiography, nondestructive evaluations, homeland security, and other advanced imaging applications.

***STTR Project: High-Performance Magnet Technology for Fusion Applications—**
Composite Technology Development, Inc., 2600 Campus Drive, Suite D, Lafayette, CO 80026; 303-664-0394; www.ctd-materials.com
Dr. Matthew Hooker, Principal Investigator, matt@ctd-materials.com
Ms. Lori Pike, Business Official, lori.pike@ctd-materials.com
DOE Grant No. DE-FG02-07ER86306
Amount: $749,965

Research Institution
University of Tennessee
Knoxville, TN

The U.S. Department of Energy is currently developing a series of fusion devices that will further advance the nation's fusion energy program. Magnet designers are presented with the challenge of ensuring the long-term reliability of these new systems. One challenge in particular is in developing an electrical insulation that can withstand the combined loads of extreme temperatures (both cryogenic and elevated), large shear and compressive stresses, high operating voltages, and high levels of incident irradiation. This project seeks to extend the performance capabilities of future fusion magnets by improving insulation to enable operation at either cryogenic or elevated temperatures, and in high-radiation environments. In previous work, CTD demonstrated the mechanical performance and radiation resistance of a new family of cyanate ester-based insulations, but to date no large devices have been produced using these materials. Therefore, the project includes developing and demonstrating large-scale processing techniques for use with these insulations, fabricating and testing of conductor assemblies, and modeling of insulation performance in fusion-specific configurations.

The Phase I work included the fabrication and testing of composite insulation specimens based on cyanate ester resin chemistries. The mechanical, electrical, and thermal properties, as well as the moisture resistance of these systems were evaluated. The requirements of the Quasi-Poloidal Stellarator (QPS) at Oak Ridge National Lab were used as the basis of this testing, although the results are directly applicable to several other fusion programs currently under development. In Phase II, CTD and the University of Tennessee will continue to collaborate on the development of magnets using cyanate ester insulations. The work will optimize materials and process for use in large-scale applications, test the electromechanical performance of cyanate ester-insulated cable assemblies, and develop models that predict insulation performance based on various parameters and magnet configurations.

Commercial Applications and other Benefits as described by the awardee: The insulation materials developed in this program will be directly applicable to the high-field magnets being produced in support of the nation's High-Energy Physics programs, as well as commercial magnet systems under development for medical applications. These magnets will require insulation materials that can withstand high levels of radiation during their

operation, while maintaining their mechanical, electrical, and thermal properties.

Rapid Turnaround MHD Modeling Ability for Liquid Breeder Blankets—
HyPerComp Inc., 2629 Townsgate Rd., Suite 105, Westlake Village, CA 91361;
805-371-7556; www.hypercomp.net
Dr. Ramakanth Munipalli, Principal Investigator, mrk@hypercomp.net
Dr. Vijaya Shankar, Business Official, vshankar@hypercomp.net
DOE Grant No. DE-FG02-07ER84716
Amount: $750,000

The ability to simulate magneto-hydrodynamic (MHD) flow of liquid metals in fusion relevant conditions is vital to US interests in liquid breeder reactors. This project will use a software environment that has demonstrated unique capabilities in modeling such flows accurately in complex and realistic geometries. These calculations tend to be enormously time consuming due to the extreme sensitivity of flow variables to small changes, the range of length scales that are to be resolved at high field values, and the stiffness caused by the multi-physical nature of the problem. This project will pursue a systematic sequence of advancements to overcome these constraints.

The Phase-I project showed promise in achieving an order of magnitude (or more) of speedup in the software. Hybrid grid and multi-grid features have been enabled in the code. A variety of implicit schemes and wall functions were studied, and run-time parameters were optimized. The Phase-II project will generalize these developments to complex flow situations. A friendly graphical interface will be developed such that the total time from geometry to solution is minimized. A series of wall functions will be added to the code, based on the customizations made in phase-I.

Commercial Applications and other Benefits as described by the awardee: There is a lack of numerical modeling software (commercial or research) that can model complex geometry flows relevant to fusion blankets that involve MHD and strong interactions of the flow with electromagnetic fields. The acceleration techniques developed here will address that lack and also render the software attractive for uses in a much broader marketplace of commercial computational fluid dynamics software.

Low Conductivity SiC-Based Ceramic Composites for Fusion Blanket Flow Channel Inserts—Hyper-Therm High-Temperature Composites, Inc., 18411 Gothard Street, Unit B, Huntington Beach, CA 92648; 714-375-4085; www.htcomposites.com
Dr. Robert Shinavski, Principal Investigator, Robert.shinavski@htcomposites.com
Dr. Wayne Steffier, Business Official, wayne.steffier@htcomposites.com
DOE Grant No. DE-FG02-07ER84717
Amount: $746,808

Dual-coolant blanket designs for fusion reactors currently under development benefit from flow channel inserts that possess low electrical conductivity and low thermal conductivity. Such flow channel inserts will advance the state of fusion technology closer to producing continuous low cost, non-polluting power. In addition to low electrical and thermal conductivity, the desired properties of the flow channel insert are compatibility with lead-lithium breeder/coolant, stability under a high neutron flux, and mechanical robustness. Silicon carbide fiber-reinforced silicon carbide matrix composites have been shown to meet all of these requirements with the exception of the thermal conductivity requirement.

The Phase I results indicated that an engineered approach is more viable at achieving all of the requirements for the flow channel insert compared to a chemical modification of the material, which resulted in a reduced thermal conductivity, but not of the required magnitude. The Phase II project will optimize an architecturally engineered SiC/SiC design for thermal, electrical and mechanical performance. This optimization will include modeling and experimental measurements of the targeted properties as well as an additional emphasis on maintaining impermeability to the lead-lithium coolant over time and varied operating conditions. The Phase II effort will also produce flow channel insert sub-elements for exposure to through-thickness temperature gradients including molten lead-lithium.

Commercial Applications and other Benefits as described by the awardee: The proposed technology is an enabling materials technology on the long- term path to deploying fusion energy systems. However the development of a high temperature, radiation compatible material can also be utilized near term in fission reactors currently under development. Such advancements also have implications for numerous applications in the aerospace industry for structural thermal protection systems.

Nano Tungsten for Diverter Plates—Materials Modification, Inc., 2721-D Merrilee Drive, Fairfax, VA 22031; 703-560-1371; www.matmod.com
Mr. James B. Intrater, Principal Investigator, jim@matmod.com
Dr. Tirumalai S. Sudarshan, Business Official, sudarshan@matmod.com
DOE Grant No. DE-FG02-07ER84719
Amount: $750,000

Tungsten is a primary candidate material for the plasma facing materials for plasma diverting. This research will lead to the development of tungsten plate with extremely fine grain size so as to produce a divertor structure with improved mechanical durability (e. g., crack resistance). Nano-tungsten powder will be processed through microwave synthesis. This powder will be rapidly sintered into testable, bulk material. This material will be evaluated for long-term use in high-energy nuclear plasma through such tests as plasma erosion and heat flux measurement. In Phase I, nanopowders of tungsten were synthesized and then specially consolidated. The resultant material was evaluated for microstructure, which was found to be very fine. Helium irradiation tests were performed which indicated that further study is warranted to address helium bubble formation. Hardness test on the fine microstructure tungsten yielded impressive initial results. The Phase II project will optimize powder synthesis and consolidation. Finer microstructure and 100% density of samples will be targeted along with scale-up of powder synthesis. Purdue University will run evaluation studies on the developed material.

Commercial Applications and other Benefits as described by the awardee: All reactors using a tungsten divertor or other plasma-facing component can benefit from the development of this material. In addition, armor-piercing bullets for police use can be made from nano-tungsten material. This work will help to scale up the production of tungsten and its compounds with highly developed nano-microstructure. Nano tungsten carbide can be used, for example, for cutting tools and wear surfaces.

Linear Analysis and Verification Suite for Edge Turbulence—Lodestar Research Corporation, 2400 Central Ave., P-5, Boulder, CO 80301; 303-449-9691; www.lodestar.com
Dr. James R. Myra, Principal Investigator, jrmyra@lodestar.com
Ms. Sonya Aamodt, Business Official, sonya@lodestar.com
DOE Grant No. DE-FG02-07ER84718
Amount: $750,000

Research in fusion energy is becoming increasing reliant on large-scale plasma simulation for both scientific understanding and hardware design. The accuracy and reliability of software codes must be insured through rigorous verification and validation. The edge physics simulation projects currently being undertaken in the US and international communities could benefit greatly from standardized benchmarks. Measurement of the linear growth rate of unstable modes emerging from a known, established equilibrium configuration provides one of the few quantitative ways of rigorously benchmarking turbulence codes with each other and with a universal standard. This project will develop a suit of such standards. The proposed suite, will be a community wide benchmarking/verification tool for nonlinear edge plasma simulation codes, and will have stand-alone uses for the analysis of experiments and for the theoretical study of edge plasmas.

The phase I project: (i) developed a new prototype code, (ii) carried out extensive benchmarking tests of the code, and (iii) demonstrated methods for the incorporation of kinetic physics extensions to the fluid model. The Phase II project will complete the development of the code, document standardized test suites, and perform physics applications and dedicated benchmarking with the two community nonlinear kinetic edge codes.

Commercial Applications and other Benefits as described by the awardee: Limited funding available to the development teams for the edge turbulence simulation projects in the US has resulted in even less resources being available for verification and benchmarking studies. The proposed linear code suite is applicable to verification work as well as to experimental modeling and theoretical studies.

Improved Controls for Fusion RF Systems—Rockfield Research Inc., 2 Olde Lyme Road, Winchester, MA 01890; 781-756-3460; www.rockfieldscience.com
Dr. Jeffrey A. Casey, Principal Investigator, casey@rockfieldresearch.com
Dr. Jeffrey A. Casey, Business Official, casey@rockfieldresearch.com
DOE Grant No. DE-FG02-07ER84762
Amount: $299,519

Radio frequency (RF) heating systems are vital components of plasma fusion facilities. The increasing scale of present and planned fusion experiments requires a similar increase of scale of RF systems, usually involving multiple RF sources. The complex controls for these systems must manage numerous fault scenarios, monitor key signals, and interconnect key power systems to provide the required performance. At the same time, pressures of cost, space, reliability, and safety are crucial to the operation of the facility. Modernization of RF subsystems is a necessary step in advancing towards a fusion demonstration plant. This effort will target the transmitter protection circuits for a tokamak Lower Hybrid Current Drive (LHCD) RF system. The specific application of the Alcator C-Mod tokamak LHCD experiment at MIT provides a convenient target of opportunity. This modernization will coincide with the upcoming expansion of their tokamak's LHCD system.

Under Phase I, advances in analog and programmable digital circuit design were used to greatly enhance the reliability, compactness, and safety of the transmitter protection controls. The Phase II project will fabricate and assess a suite of first article control systems, and deliver them to the C-Mod LHCD team for installation. This design will then be generalized for future availability for fusion, high energy, phased array radar, and other customers.

Commercial Applications and other Benefits as described by the awardee: The result of this effort will be a template for a modernized transmitter protection system, applicable to any multi-VED (Vacuum Electron Device) RF system for a fusion or similar facility. The immediate beneficiary will be the Alcator C-Mod facility, which will use the upgraded transmitter protection system with the expanded LHCD system beginning in 2009. Non-fusion applications that use multiple VED arrays (such as phased array radars) may also benefit from these results.

Analysis of RF Heating of Fusion Plasmas Using the Delta-f Particle-in-Cell (DFPIC) Method—Tech-X Corporation, 5621 Arapahoe Ave, Suite A, Boulder, CO 80303-1379; 720-974-1856; www.txcorp.com
Dr. Travis Austin, Principal Investigator, Austin@txcorp.com
Mr. Laurence D Nelson, Business Official, lnelson@txcorp.com
DOE Grant No. DE-FG02-07ER84722
Amount: $749,483

The ability to assess the efficacy of radiofrequency heating and current drive in fusion plasmas is critical to the US fusion program. At present, the primary means of assessment is through use of full wave codes that assume linearity and quasi-local plasma response. Needed are computational methods for addressing the effects caused by the curvature of particle orbits. The proposed project will include the development and application of new computational methods to toroidal plasmas, with the goal of analyzing low-frequency (ion time scale) phenomena. These new capabilities will be used to create a clearer understanding of plasma heating in a tokamak core. Studies of multiple pass resonance of particles and banana orbits, which contribute to the effectiveness of radiofrequency heating, will be performed and made available to the fusion research community.

Commercial Applications and other Benefits as described by the awardee: New capabilities of the particle-in-cell code will raise the profile of the code and contribute to increased sales. For example, commercial plasma applications in the semiconductor industry and applications of plasma-based satellite thrusters may benefit from the proposed work. Also, improvements in plasma heating made possible by simulations with the new code have the potential to yield enormous dollar savings for ITER experiments by supporting more efficient planning of experiments.

Holographic Density Measurements for the Disruption Mitigation Test Stand and the LTX Device—Third Dimension Technologies, 3601 Bluff Point Drive, Knoxville, TN 37920-2805; 865-579-0113; www.a3dt.com
Dr. C. E. (Tommy) Thomas, Jr., Principal Investigator, thomasce2@att.net
Dr. C. E. (Tommy) Thomas Jr., Business Official, thomasce2@att.net
DOE Grant No. DE-FG02-07ER84724
Amount: $749,954

Magnetic Fusion Energy holds out the hope of supplying clean energy to the world and eliminating the causes of global warming. While research to date has shown with high probability that an ignited magnetic fusion device can be built (e.g., the ITER Project), present research is focused on making fusion reactors more practical devices. Improving confinement and fueling in magnetic fusion devices can significantly improve the practicality of reactors by making them smaller, and easier to ignite and maintain. A digital holographic imaging device to provide 3D density, particle transport, and fueling data at high speed and high spatial resolution would make it possible to study and understand both transport and fueling with greatly increased resolution over current methods.

The Phase I project demonstrated the feasibility of this diagnostic tool. Additionally, a complete first-order design for the full diagnostic proposed for Phase II (exactly similar to the Phase I design) was completed in Phase I. The Phase II project will develop a full infrared (CO2) laser digital holography system for installation on the LTX compact Tokamak fusion physics research device at Princeton Plasma Physics Lab.

Commercial Applications and other Benefits as described by the awardee: Successful development of this infrared digital holography system for fusion energy plasma diagnostics can lead to improved commercial magnetic fusion energy generation. Additionally, the development could result in the commercialization of unique measurement systems in a number of electronics and manufacturing industries.

Compression of Compact Tori—Woodruff Scientific, LLC, 4501 Shilshole Ave NW, Suite 130, Seattle, WA 98107; 206-697-9401; www.woodruffscientific.com
Dr. Simon Woodruff, Principal Investigator, simon@woodruffscientific.com
Dr. Simon Woodruff, Business Official, simon@woodruffscientific.com
DOE Grant No. DE-FG02-07ER84924
Amount: $618,601

Several critical issues stand in the development path of a magnetized target fusion scheme to a working reactor. Important ones are the limit imposed by liner dwell time, and the requirement for symmetry in high convergences. The usual compression schemes tend to require a lot of energy and large chambers.

During Phase I we completed computational and analytic studies of the compression and acceleration of compact tori. We used advanced computations benchmarked against analytic theory to determine the best means for the acceleration and compression of a compact torus plasma. Our study included analysis of the stability of a compact torus under compression.

Commercial Applications and other Benefits as described by the awardee: The Phase II project will use a new means for compressing and trapping a compact torus to maximize the burn time. The new experiment will be supported by computational efforts and analytic modeling, and will be carried out in house by use of largely existing facilities. In Phase II we will build a plasma piston to impact and compress a small compact torus generated in a flux-conserver shaped to preserve stability. In Phase III, we would seek industrial partners to build a high field, high temperature, compact torus compressor, with the ability to repeat. The aim would be to skip the proof-of-principal stage and go straight to performance extension, based on existing results, and on our ability to accurately simulate plasma behavior with existing computational models.

Plasma Liner Compression of Compact Toroids to Fusion Conditions—MSNW, LLC, 8551 154th Avenue NE, Redmond, WA 98052; 425-867-8900; www.msnwll.com
Dr. John Slough, Principal Investigator, sloughj@msnwllc.com
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DOE Grant No. DE-FG02-07ER84922
Amount: $750,000

Nuclear fusion has the potential to satisfy the prodigious power demands of the future. It has yet to be harnessed as a practical energy source because of the challenge of finding an economical way to confine and heat the plasma fuel. The main reason for this is the complexity and size of the confinement systems. Essentially, the more massive the system required to confine and heat the fusion plasma, the higher the cost to develop and operate. A simpler path to fusion can be achieved by creating fusion conditions in a different regime at small scale (~ a few centimeters). This project uses developments in the very compact, high energy density regime of fusion commonly referred to as a Field Reversed Configuration (FRC). To make fusion practical at this smaller scale, an efficient method for compressing the FRC to fusion conditions is required. This project will use a plasma shell to compress and heat the FRC plasmoid. The closed magnetic field in the target plasmoid suppresses the thermal transport to the confining shell, lowering the imploding power needed to compress the target. With this configuration, many of the difficulties encountered with the implosion power technology are eliminated or minimized. This project will evaluate the feasibility of achieving fusion conditions from this comparatively simple and relatively low cost approach to fusion.

Commercial Applications and other Benefits as described by the awardee: In Phase I, the FRC plasmoid accelerator demonstrated the dynamic formation of a FRC suitable for the plasma liner compression experiment. In phase II a high density FRC plasmoid will be formed and accelerated into a compression chamber. The FRC will then be rapidly compressed by a deuterium plasma liner to fusion temperatures and densities. Experimental success would establish the concept at the “proof of principle” level and the follow-on phase III effort would focus on the development of the concept into a fusion gain device.

Enhanced Model for Fast Ignition—Research Applications Corporation, 148 Piedra Loop, Los Alamos, NM 87544-3837; 505-672-1938; www.oarcorp.com
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DOE Grant No. DE-FG02-07ER84723
Amount: $750,000

Target interactions in Fast Ignition, a significant Department of Energy initiative, have proven too difficult to model with standard plasma simulation codes, due to the high densities of the compressed cores and the complexities of the collisional, relativisitic electron transport initiated by laser absorption. New Implicit/hybrid codes can properly treat these conditions, but their optimal form is still undergoing intense research, their application has been limited, and their development and distribution has seriously lagged the more standard but less capable techniques. The overall objective of Phase I and II of this project is to further develop, refine, and extend a particularly successful implicit/hybrid code, ePLAS, distributing it throughout the Department of Energy community, academia, and industry, to hasten success in achieving fusion energy via Fast Ignition. Early versions of the new computer simulation model were distributed to users throughout the fusion energy community for testing and near term applications.

The Phase II project will complete further improvements in light coupling, atomic physics, multiple ion capabilities, and fast ion modeling. Thermonuclear burn diagnostics will be added, and personal computer parallelism will be explored. The user interface will be improved to facilitate simplified physics studies and experimental analysis, and wide use of the code.

Commercial Applications and other Benefits as described by the awardee: Commercial benefits from this project include the development of new modeling capabilities embodied in a commercial code that can be broadly distributed at minimal cost to aid academia, the National Labs, and industry.