90002S09-II

Bright Quantum Dot Scintillator for High Frame Rate Imaging—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
Dr. Vivek Nagarkar, Principal Investigator; VNagarkar@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85395
Amount: $999,974

Recent significant improvements in synchrotron radiation sources have enabled the growth of powerful techniques such as time-resolved X-ray diffraction studies for use in understanding dynamic phenomena in materials, including those in biological systems. To make the most effective use of synchrotron sources for protein and other such studies, however, new, efficient, high-throughput detectors are needed that will enhance the quality of the molecular model that is the end product of the macromolecular crystallography process. Novel detectors based on new designs of charge coupled devices (CCDs) have been developed, but the performance of these powerful devices is significantly limited by all current X-ray-to-light converters that provide low light, low X-ray absorption, and a tradeoff between spatial resolution and efficiency. To address these issues, we are developing a novel semiconductor quantum dot scintillator that promises to provide bright emissions, high X-ray absorption, and fast decay with no afterglow, emission in the wavelength range most suitable for CCD-type devices, and orders-of-magnitude higher radiation resistance compared to current scintillators. This scintillator will be fabricated in a thin film form, which, in addition to its excellent scintillation properties, will provide very high spatial resolution. When combined with a suitable readout, this scintillator will enable realization of a cost-effective high frame rate, large area, high resolution detector needed for many important time-resolved X-ray diffraction and other studies. The Phase I research accomplished, and in many respects exceeded, all stated goals, and as such successfully demonstrated the feasibility of developing novel scintillators based on quantum dot nanoparticles. Through our inventions of new technologies to synthesize quantum dots and incorporate them in suitable polymer matrices, our Phase I research succeeded in demonstrating the first ever X-ray imaging by means of quantum dot scintillators using both X-ray generators at RMD synchrotron sources. Highly encouraging Phase I results led us and our collaborators, to develop a comprehensive research plan for the Phase II and subsequent commercialization of the technology. Our Phase II research will focus on modifying quantum dot structural and morphological properties to further enhance X-ray absorption efficiency, decay times, and emission efficiency, and amplify Stokes shift to minimize re-absorption. Complementary developments in the medium in which quantum dots will be suspended will also be undertaken, with a goal of creating meta-particle structures for improved charge transport, and hence emission efficiency, and enhanced X-ray absorption. These parallel approaches will lead to the desired scintillator film fabrication and to experimental evaluations at Argonne National Laboratory and to substantial efforts toward commercialization of this technology.

Commercial Applications and Other Benefits: The technology proposed here is of critical importance in many important synchrotron-based applications, including time-resolved macromolecular crystallography and polymer research and other applications ranging from medical imaging to nondestructive testing. Due to its potential applications in homeland security and advanced biotechnology, National Security Technologies, LLC has become highly enthusiastic of the proposed research.

90005S09-II

A High-Resolution Transverse Diagnostic Based on Fiber Optics—RadiaBeam Technologies LLC, 1717 Stewart Street, Santa Monica, CA 90404-4021; 310-822-5845
Dr. Ronald Agustsson, Principal Investigator; agustsson@radiabeam.com
Dr. Salime Boucher, Business Official; boucher@radiabeam.com
DOE Grant No. DE-FG02-09ER85373
Amount: $896,618

Next generation light sources and advanced accelerator facilities create ultrashort electron bunches with complex transverse distributions. They demand high-resolution beam profile information that is currently limited to approximately 50microns. Structures on the microscale are not resolvable, thus limiting the efficacy of diagnostics. A novel transverse diagnostic based on fiber optics will be developed to address the demands of advanced accelerator facilities. An array of fibers is drawn to intercept the beam and generate Cernekov radiation. The radiation is collected on a linear array detector and post-processed to yield transverse profile information with a resolution on the order of 10 microns. In Phase I numerical studies were performed on the physical concept of the device, including Monte Carlo simulations to determine cross talk effects. Most significantly, test fibers were irradiated to simulate real-life beam doses to determine the effective lifetime of the diagnostic. In Phase II, we will complete the engineering of the diagnostic. We will perform a proof of concept test to determine the effective lifetime, as well as full characterization and commissioning at an advanced accelerator.

Commercial Applications and Other Benefits: Accelerators around the world use beam profile diagnostics that can be replaced by the proposed fiber mesh diagnostic. In addition, the remote tip/tilt bellows system for angular alignment may be an offshoot commercial product.

90012S09-II

Recovery Act - Development of a Pulsed, 10% Duty 140 kW, 402.5 MHz Elliptic-Beam Inductive Output Tube—Beam Power Technology, Inc., 5 Rolling Green Lane, Chelmsford, MA 01824-4469; 978-376-0143
Mr. Thomas M. Bemis, Principal Investigator; tbemis@beampower.com
Mr. Michael H. Lawrence, Business Official; mlawrence@beampower.com
DOE Grant No. DE-FG02-09ER85290
Amount: $999,999

There is a need to develop high-efficiency, high-power rf sources for current and future synchrotron radiation light sources free electron lasers, and spallation neutron source user facilities. At present, conventional circular-beam klystrons and IOTs are the technologies of choice for accelerators in physics research applications. While a conventional circular-beam inductive output tube (IOT) provides lower operating voltage, smaller size, and higher efficiency than a klystron, its output power is limited to less than 100 kilowatts. Beam Power Technology (BPT), Inc. proposes to develop an innovative elliptic-beam IOT using its proprietary elliptic electron beam technology to meet the advertised requirement for a 140 kW peak power, 10% duty 402.5 MHz IOT. It is anticipated that the BPT elliptic-beam IOT will overcome the current IOT power limitation, and that the elliptic-beam interaction will be as efficient as the conventional circular-beam IOT. In Phase I, BPT successfully demonstrated the feasibility of the proposed elliptic-beam IOT with theoretical analyses, 3D simulations, and concept design, including theoretical modeling and concept design of a gridded elliptic diode, concept design of the elliptic-beam system, 3D particle-in-cell (PIC) simulations of the elliptic-beam IOT interaction, and concept design of the rf output cavity and collector. In Phase II, BPT proposes to experimentally demonstrate a 140 kW peak power, 10% duty, 402.5 MHz elliptic-beam IOT. The Phase II technical objectives are: 1) Integrated modeling and design studies of the proposed elliptic-beam IOT; 2) Refined concept design; 3) Development of concept design drawings; 4) Development of production drawings; 5) Fabrication of the proposed elliptic-beam IOT; 6) Experimental test and data analyses; and 7) Report of Phase II findings. The Phase II efforts will be carried out under close consultation with National Laboratories and the support of a consortium of vendors and suppliers specializing in the manufacturing of microwave devices.

Commercial Applications and Other Benefits: If successful, the research and development in this SBIR project will lead to a new class of higher power IOTs, capable of extending the reach of IOTs into higher power territory. The elliptic-beam IOT will attract users of conventional round beam IOTs and klystrons for high power rf sources below 1.3 GHz. Targeted users of elliptic-beam IOTs will not only be the physics accelerator community but also the high power digital television broadcast community where IOTs have been widely used.

90013S09-II

Recovery Act - Design Studies of Megawatt-Class Continuous-Wave Elliptic-Beam Inductive Output Tubes—Beam Power Technology, Inc., 5 Rolling Green Lane, Chelmsford, MA 01824-4469; 978-376-0143

Mr. Thomas M. Bemis, Principal Investigator; tbemis@beampower.com
Mr. Michael H. Lawrence, Business Official; mlawrence@beampower.com

DOE Grant No. DE-FG02-09ER85291
Amount: $999,999

There is a need to develop high-efficiency, high-power rf sources for current and future synchrotron radiation light sources, free electron lasers, and spallation neutron source user facilities. At present, conventional circular-beam klystrons and IOTs are the technologies of choice for accelerators for physics research and applications. While a commercially-available, conventional, circular-beam inductive output tube (IOT) provides lower operating voltage, smaller size, and higher efficiency than a klystron, its output power is less than 100 kilowalts. Beam Power Technology's innovative elliptic-beam IOT will overcome the power limitation. Additionally, the efficiency of the elliptic-beam IOT interaction operating at a low voltage will be comparable to that of the conventional circular-beam IOT operating at a high voltage, which is 60% to 70%. Beam Power Technology (BPT), Inc. proposes to carry out design studies of megawatt-class continuous-wave (cw) elliptic-beam inductive output tubes (EBIOTs). The proposed design studies will be aimed at delivering 200 kW cw and 1 MW cw at 352 MHz, and 1 MW cw at 704 MHz. The proposed design studies will also include an experimental demonstration of a 200 kW cw 352 MHz EBIOT needed to build the megawatt-class cw elliptic-beam IOTs. In Phase I, BPT successfully demonstrated the feasibility of megawatt-class cw elliptic-beam inductive output tubes via theoretical analyses, simulations and concept designs, including thermal and mechanical analysis of the grids of the proposed EBIOTs, theoretical modeling and concept design of gridded elliptic diodes with high compressions, concept design of highly-compressed elliptic-beam systems, concept design of the proposed megawatt-class EBIOTs, and 3D particle-in-cell simulations of megawatt-class EBIOT interactions. In Phase II, BPT proposes to carry out engineering design studies of megawatt-class continuous-wave (cw) elliptic-beam inductive output tubes. The Phase II technical objectives are: 1) Modeling of converging elliptic diodes; 2) Development of engineering designs; 3) Development of concept design drawings; 4) Development of production drawings for a 200 kW cw 352 MHz EBIOT; 5) Fabrication of a 200 kW cw 352 MHz EBIOT; 6) Experimental test of the 200 kW 352 MHz EBIOT; and 7) Report of Phase II findings. The Phase II efforts will be carried out in collaboration with Argonne National Laboratory under the support of a consortium of vendors and suppliers specializing in the manufacturing of microwave devices.

Commercial Applications and Other Benefits: The proposed design studies and experimental demonstration of a 200 kW cw 352 MHz elliptic beam IOT will help establish a figure of merit for megawatt-class continuous-wave elliptic-beam IOTs. Future demonstrations of elliptic-beam IOTs at higher power and higher efficiency/lower voltage will produce a new class of high-power, high-efficiency RF sources for the physics accelerator community. As a highly efficient device, elliptic-beam IOTs have the potential to replace conventional circular-beam klystrons, circular-beam IOTs and possibly multi-beam high-order-mode (HOM) IOTs for accelerator applications requiring highly efficient high power RF sources at or below 1.3 GHz. Furthermore, elliptic-beam IOTs have the potential to replace conventional circular-beam IOTs which are widely used for television broadcasting.

90027B09-II

Recovery Act - Development of a CW NCRF Photoinjector Using Solid Freeform Fabrication (SFF)—RadiaBeam Technologies LLC, 1717 Stewart Street, Santa Monica, CA 90404-4021; 310-822-5845
Dr. Pedro Frigola, Principal Investigator; frigola@radiabeam.com
Dr. Salime Boucher, Business Official; boucher@radiabeam.com
DOE Grant No. DE-FG02-09ER85370
Amount: $865,143

Development of very high duty cycle, high gradient photoinjectors is critical for the next generation of accelerator systems, such as X-ray free-electron lasers (FELs), inverse Compton scattering (ICS) sources, energy recovery linear accelerators (ERLs), injectors for linear colliders, as well as variety of industrial systems for homeland security applications. A key issue for high average power, normal conducting, photoinjectors is efficient structure cooling. The fabrication of current state of the art high average power photoinjectors relies on conventional design and fabrication techniques, requiring a multitude of braze joints, and limited cooling channel geometries. This project will investigate a novel fabrication technique which will allow complex, conformal cooling channels to be integrated into a re-entrant gun design. Optimization of solid freeform fabrication (SFF) for copper RF components will be followed by the construction and testing of a prototype photoinjector with enhanced thermal handling features possible only through the use of SFF. In the SBIR Phase I we have demonstrated the feasibility of manufacturing pure copper parts using solid freeform fabrication. As well investigating the resultant material properties, and develop a conceptual design of a gun with optimized shaped conformal cooling channels based on thermal simulations. These steps position us to fabricate and test a high rep. rate prototype gun in Phase II, and eventually offer a high-power high-brightness photoinjector as a product in Phase III. In Phase II of the project, we will complete the engineering of the SFF CW gun, and build and test the prototype at JLab.

Commercial Applications and Other Benefits: The applications of very high duty cycle, high gradient photoinjectors include x-ray free-electron lasers (FELs), energy recovery linear accelerators (ERLs), and inverse Compton scattering (ICS) sources for medicine, as well associated imaging/analysis applications of interest to homeland security. The technical approach developed in this project may also be applied to a wide variety of rf structures, such as linacs and klystrons.

90030B09-II

STTR Project - H-Ion Sources for High Intensity Proton Drivers—Muons, Inc., 552 N. Batavia Ave, Batavia, IL 60510; 630-840-2424
Dr. Vadim Dudnikov, Principal Investigator; rol@muonsinc.com
Dr. Thomas J. Roberts, Business Official; tjrob@muonsinc.com
DOE Grant No. DE-FG02-09ER86395
Amount: $750,000

Research Institution
Oak Ridge National Laboratory

Spallation neutron source user facilities require reliable, intense beams of protons. The technique of H- charge exchange injection into a storage ring or synchrotron has the potential to provide the needed beam currents. However, the facility operation is limited by the performance of H- ion sources with currents, brightness, reliability and availability that could still be improved. In this project we will develop an H- source design which will synthesize the most important developments in the field of negative ion sources to provide high current, small emittance, good lifetime, and high reliability, by improving power efficiency. Several versions of new plasma generators with different antennas and magnetic field configurations were designed, built and tested on a test stand, where a factor of 5 improvement in useful plasma flux generation was demonstrated. These plasma generators are compatible with the SNS RF H- Source and were tested on the SNS Test Stand. Stable H- beam production up to 56 kW RF power was demonstrated with a beam current up to 67 mA using a prototype saddle antenna. An H- ion generation efficiency of 1.6 mA/kW was also demonstrated. An advanced version of an RF H- source with an improved plasma generator (developed in Phase I) will be developed in full scale with the goal of having a long operational lifetime with improved beam parameters (pulsed H- beam current up to 70 mA, average H- beam current up to 5 mA with pulsed power <40 kW and beam normalized rms emittance <0.25 ! mm mrad).

Commercial Applications and Other Benefits: The primary application of the new source to be developed in this project is the next upgrade of the Oak Ridge Spallation Neutron Source to higher reliability at higher beam power levels. The source would also be an essential component of a proton driver that might be used for muon colliders. However, the source would be an upgrade path for all other existing and planned applications such as medical treatments (including cyclotrons with external ion injection for cancer therapy, and high current tandem accelerators for Boron Neutron Capture Therapy), homeland defense (e.g. production of muons for cargo scanning or resonant gamma ray techniques to detect explosives), and ion implantation for semiconductor development and material modification.

90038S09-II

Extrudable NbTi Superconductor with Ferromagnetic Pins for Undulator Magnets—SupraMagnetics, Inc., 214 Canal Street, Plantsville, CT 06479-1742; 860-426-1961
Dr. Leszek Richard Motowidlo, Principal Investigator; LMOTO@cox.net
Dr. Leszek Richard Motowidlo, Business Official; LMOTO@cox.net
DOE Grant No. DE-FG02-09ER85463
Amount: $903,966

The development of an extrudable APC NbTi superconductor with Ni artificial pinning centers by the proposed approach in the Phase I and Phase II program is anticipated to have a significant impact on cost and performance in applications for undulator magnets. The overall technical approach for the Phase I/Phase II project will be to develop and demonstrate an extrudable NbTi superconductor with ferromagnetic pins as undulators. The critical aspects of the conductor design will include optimizing pin size and distribution in order to maximize the bulk pinning force of the conductor. Utilizing a hot extrusion process will help indicate commercial scale up issues and market potential for artificial pinning center (APC) technology. In the Phase I work, we successfully fabricated APC wire with nickel pins approaching 10 nanometers. Moreover, the (J_c) performance of the APC wire was 10,822 Amp/mm^2 at 2 Tesla. In the Phase II research and development program, the primary technical objective will be two fold, first to continue to improve the APC flux pinning and J_c performance at the applied field of 1 to 3 Tesla regime by incorporating nickel flux pinning centers. The second primary objective will be to demonstrate a scale-up process that includes two hot extrusions of 152 mm od billets.

Commercial Applications and Other Benefits: While undulator magnets are important for future photon sources, nuclear magnetic resonance (NMR) magnets have the nearest term commercial potential. The current NMR market includes spectrometers up to operating frequencies of 800 MHz. Any additional improvements in NbTi superconductors which are included in the outer sections of the NMR magnets could impact the cost of these high end spectrometers. The total NMR market is on the order of a quarter to a half billion dollars and growing. Such systems require magnets generating fields up to 18T range. NMR spectroscopy is a non-destructive technique for mapping molecular structures and learning how molecules function and relate to each other. This is important for many applications that have benefits to the public including discovering new drugs, evaluating new synthetic materials, and exploring the realm of the proteomics.

90042S09-II

High Fidelity Simulation of Low-Energy Ion Beam Chopping for the Spallation Neutron Source—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856
Dr. David L Bruhwiler, Principal Investigator; bruhwile@txcorp.com
Mr. Laurence D. Nelson, Business Official; lnelson@txcorp.com
DOE Grant No. DE-FG02-09ER85517
Amount: $999,588

The Oak Ridge National Laboratory ion source group will construct and operate a two-solenoid low-energy beam transport (LEBT) system for 60 mA H- beams, including rf chopping. This could increase the beam current in the Spallation Neutron Source (SNS), while eliminating the sparking problems of the existing electrostatic LEBT. Previous solenoid-based LEBT designs with beam chopping showed problems, due to background ion plasma around the chopper. The parallel simulation framework VORPAL will be used to simulate H- ion beam transport experiments being planned as part of the long-term SNS power upgrade project at Oak Ridge National Lab (ORNL). Tech-X personnel have established a collaboration with the ion source group at ORNL during the Phase I effort and this collaboration will be continued and strengthened during Phase II, enabling us to provide key computational support during design and commissioning of the LEBT and to benefit from the insight and guidance of ORNL physicists. It was demonstrated that the parallel VORPAL framework can model all key aspects of chopping in the ORNL LEBT design: 3D electrostatic particle-in-cell (PIC), complex 4-quadrant chopper geometry and radio frequency quadrupole (RFQ) entrance, gradual build-up of background ion plasma, converging ion beam with initial phase space taken from ORNL specifications, and external solenoidal magnetic field. The design potentials were applied to the chopper quadrants with specified rise and fall times and the beam steering angle was verified, while strong plasma dynamics was observed. All possible avenues for beam-plasma instabilities will be explored over multiple time scales: electron plasma frequency (very fast), ion plasma frequency (fast) and rf chopper frequency (slow). Previous experiments and present intuition suggest that problems are occurring on the slow time scale, for which a fast Boltzmann electron model will be used. Code validation and experimental support during LEBT design and commissioning are planned. VORPAL training will be offered to the ion source community and ease of use will be improved, especially through improvements to the graphical user interface (GUI), known as VORPAL Composer.

Commercial Applications and Other Benefits: The commercial VORPAL application will be further developed, making it more directly relevant to important commercial applications like compact deuterium on tritium neutron sources for homeland security and oil exploration, as well as ion implantation for the semiconductor industry. The work will also help to reduce risk and potentially lower costs for the planned SNS power upgrade.

90047S09-II

Beam Pipe HOM Absorber for 750 MHz RF Cavity Systems—Muons, Inc., 552 N. Batavia Ave, Batavia, IL 60510; 630-840-2424
Mr. Michael Neubauer, Principal Investigator; mike@muonsinc.com
Dr. Thomas J. Roberts, Business Official; tjrob@muonsinc.com
DOE Grant No. DE-FG02-09ER85248
Amount: $749,999

Superconducting RF (SRF) systems for accelerators typically contain unwanted frequencies or higher order modes (HOMs) that must be absorbed. Currently, ferrite or other lossy ceramic HOM absorbers and their attachments to drift tubes adjacent to SRF cavities are not robust enough, and tend to crack under tensile and thermal stresses. New processes, techniques, design and construction of improved HOM loads will be developed. A scaled-down version that can be assembled in the beam pipe of a 1.3 GHz Cornell cryomodule will be built, and the assembly processes can then be applied to larger diameters such as for high-gradient 750 MHz superconducting cavity systems. A process for applying a charge dissipative coating on the ferrite will be developed. The objective is a low cost, reliable, thermally efficient, broadband beam pipe HOM absorber that is scalable to reasonable diameters. Compression ring models were constructed and post brazing techniques were developed to evaluate the compression limits of the ferrite and the tensile limits of copper during the assembly processes. The compression ring sub-assembly allows for various ferrite materials to be used in a complete cost-reduced broadband beam pipe HOM assembly. Processes were experimented with to reduce charge buildup, and rugged stress tests showed the way to improvements in the design. Since the 750 MHz cavity is still being developed, a scaled down version for 1.3 GHz will be produced. In Phase II this complete HOM load will be constructed for assembly with an existing ERL injector 2-cell cavity at Cornell. The assembly can then be tested in Cornell's vertical test stand. The construction processes will also include a means for reducing charge buildup on the ferrite absorbers.

Commercial Applications and Other Benefits: The new assembly processes can be used for other ferrite toroid applications where the weak tensile limits of the ferrite material had previously precluded its use. The charge dissipative coating has wide application for vacuum applications of ceramics and ferrites in the presence of charged particles.

90048B09-II

STTR Project- High Power Co-Axial SRF Coupler—Muons, Inc., 552 N. Batavia Ave, Batavia, IL 60510; 630-840-2424

Dr. Michael Neubauer, Principal Investigator; mike@muonsinc.com
Dr. Thomas J. Roberts, Business Official; tjrob@muonsinc.com

DOE Grant No. DE-FG02-09ER86396
Amount: $750,000

Research Institution
Thomas Jefferson National Accelerator Facility

A superconducting RF (SRF) power coupler capable of handling 500 kW CW RF power at 750 MHz is required for present and future storage rings and linacs. There are over 35 coupler designs for SRF cavities ranging in frequency from 325 to 1500 MHz. Coupler windows vary from cylinders to cones to disks and RF power couplers will always be limited by the ability of ceramic windows and their matching systems to withstand the stresses due to non-uniform heating from dielectric and wall losses, multipactor, and mechanical flexure.We propose a novel robust co-axial SRF coupler design which uses two windows manufactured with compression ring technology and no matching elements in the coax line. This technology will allow the use of high thermally conductive materials for cryogenic windows because the braze joint will be in compression. In Phase II a scaled down version of the 500kW CW double window assembly will be built and tested at high power in order to finalize the design for the full size version. A compressed co-axial window was designed and fabricated using standard ceramics. The mechanical design incorporated several critical process elements that made sure other materials could be used without concern for metalizing issues. Low power tests confirmed the broadband match characteristics of a double window design. Window materials will be used in the assembly processes ranging from soft boron nitride to lossy aluminum nitride and sapphire. A scaled down version of the ultimate double window design for 500kW CW at 750 MHz will be built and stress tested at cryogenic temperatures as well as room temperature with varying pressures and gases. As a result of these comprehensive tests, a design scaled up to full power CW can be reliably produced.

Commercial Applications and Other Benefits: Double-window, coaxial input couplers or coaxial pressure barriers have high power CW applications ranging from RF guns for injectors to high power magnetron sputtering systems. Single half-wavelength coaxial windows built with our compression technology will handle significantly more power than standard windows.

90050S09-II

A Laser Power-Build-Up System for H Atom Ionization—Boulder Precision Electro-Optics, 5733 Central Ave, Boulder, CO 80301-2848; 303-570-1806
Dr. Mark Notcutt, Principal Investigator; mnotcutt@gmail.com
Dr. Mark Notcutt, Business Official; mnotcutt@gmail.com
DOE Grant No. DE-FG02-09ER85296
Amount: $756,850

1 Boulder Precision Electro-Optics 2 Power Buildup Cavity at 355 nm for MegaWatt pulse powers 3 Mark Notcutt 4 Topic 4d (7) 5 Prior to injection into a proton accelerator, GeV energy Hydrogen negative ions must be ionized with good efficiency. Presently used carbon foil strippers become radioactive and produce uncontrolled beam loss which limits the performance of high intensity proton sources. Laser assisted stripping of the electrons is an alternative method which has been demonstrated in proof-of-principle experiments. Laser excitation of the neutral atoms prepares the atoms for subsequent ionization in a magnetic field, and for this megaWatt peak powers are required. 6 This proposal describes a Fabry-Perot cavity which is capable of storing energy (stacking laser pulses) when resonant with the incident laser light. This power recycling multiplies the incident laser power to create fields that are sufficiently intense (MW peak powers) to excite the hydrogen atoms with high probability. The research in Phases 1 and 2 examines the mirror requirements for the extremely high circulating power, the cavity configuration to create a sufficiently large diameter beam, and ultra-high vacuum-compatible design. 7 In phase 1, we made sure that the mirrors would be able to operate with the kW of average circulating light power in the cavity without deformation from absorbed power that would reduce the circulating power. This was done by measuring the fractional power absorption of mirror coatings near 355 nm, and finite element models of the mirror thermal expansion. The large mode size required was modeled and designed, and the cavity design tested and shown to perform well. Mirror damage thresholds were measured. 8 In phase 2 we will build a prototype cavity, and lock a high-power pulsed laser to the cavity to attain MW peak pulse powers. We will quantify the mode distortion from absorbed power, and examine the performance of different mirror coatings. Attention to the materials used and the design will allow ultra-high vacuum cleaning techniques to be used to avoid mirror contamination issues. 9 Power buildup cavities for short-pulse lasers is a rapidly developing field, with applications in commercial spectroscopy systems for gas and molecule detection and recognition in industrial and medical systems, scientific spectroscopy, compact particle accelerators, cavity-dumped systems for short-pulse power increase in scientific uses, as well as part of the process of the stripping of electrons from Hydrogen atoms in particle accelerators. 10 power buildup, Fabry-Perot, 355 nm, mirror absorption 11 Very High power laser beams for multiphoton processes and saturation of weak resonances in atoms and molecules may be attained by stacking pulses in a power buildup resonant Fabry-Perot cavity, taking into consideration the problems posed by very high powers such as mirror damage and distortion, and vacuum contamination by attraction of contaminants into the beam. Use of low absorption mirror coatings on selected substrate materials, along with ultra-high vacuum cleaning processes, allow the pulse stacking to multiply the laser power to megaWatt levels for use in Hydrogen ionization.

90051S09-II

Development of High Efficiency High Average Power Picosecond (10-50ps) Laser for High Repetition Frequency Electron Guns—Kapteyn-Murnane Laboratories, Inc., 1855 South 57th Court, Boulder, CO 80301; 303-544-9068
Dr. Sterling Backus, Principal Investigator; sbackus@kmlabs.com
Dr. Sterling Backus, Business Official; sbackus@kmlabs.com
DOE Grant No. DE-FG02-09ER85584
Amount: $946,116

Next generation free electron lasers (FEL) will enable the exploration of physics at high powers and long and short wavelengths. The electron "gun" is a laser-driven photocathode, and the primary unproven part of this technology is the development of a laser with the required pulse characteristics, average power and pulse duration. In this project we will develop a laser system capable of generating pulses in a beam of coherent laser light at 1030nm, 515nm, and 257nm, with 300µJ, 120µJ, and 45µJ of energy in each pulse respectively, emitted at a 2 MHz repetition-rate. It will also be able to run at 1-20MHz, and the system will be capable of running in a burst mode at any repetition frequency up to 10-20MHz when the system is running at high repetition frequencies. The technical approach pursued is to develop an oscillator-amplifier laser system based on cryogenically cooled Yb:YAG in the required wavelength range. The photocathode laser power requirements also dictate that we generate 100-600W of "pump" light to power the photocathode. These capabilities have recently been developed at KMLabs, but a laser with the required characteristics has not yet been demonstrated. To test the feasibility of a high repetition rate, diode pumped, cryo cooled Yb:YAG oscillator at 60MHz. We constructed an oscillator and demonstrated a new technique to suppress self q-switching is modelocked high gain cryo cooled oscillators. We used this oscillator to measure power, temporal profile and energy, and to test the architecture that would be used in phase II of this project. We plan to design, construct, test, and install a fully functional prototype cryo cooled Yb:YAG oscillator-amplifier laser system. We will work to meet the specifications of the FEL photocathode requirements as much as possible. We expect to obtain 10-50ps pulses (which are adjustable) at a nominal 2MHz repetition rate, 300µJ energy in each pulse, and convert the pulses to the UV.

Commercial Applications and Other Benefits: This pulsed laser system developed for FEL photocathodes will also represent powerful system with unprecedented repetition-rate and average-power characteristics. In addition to its use at for a photocathode laser, this laser will find use in both basic science, for ultrafast laser systems, which can be used to study molecular dynamics, and industrial and medical applications such as precision laser machining.

90052T09-II

STTR Project – Recovery Act - Development of a Fiber Based Source of High Average Power Ultrafast Pulses at 2.0 Microns—Kapteyn-Murnane Laboratories, Inc.**,** 1855 South 57th Court**,** Boulder, CO 80301; 303-544-9068
Dr. Daisy Raymondson, Principal Investigator; draymondson@kmlabs.com
Dr. Daisy Raymondson, Business Official; draymondson@kmlabs.com
DOE Grant No. DE-FG02-09ER86393
Amount: $750,000

Research Institution
Colorado School of Mines

Bright coherent light sources in the soft x-ray region of the spectrum are useful for a variety of applications of interest to DOE in the basic sciences, nanoscience and biology, and for technological applications. At Free-Electron Laser Facilities, peak power output of the x-ray pulses is enhanced by using a mid-infrared laser pulse instead of a near-infrared pulse. The current front end for mid-infrared pulse generation is a large research-grade titanium-sapphire laser amplifier. Fiber lasers constitute a promising technology for robust ultrafast systems in a compact footprint. In this project, we will make use of recent advances in ultrafast fiber laser design in combination with optical parametric amplification to convert the laser output to 2 micron wavelength for use in free-electron lasers or high harmonic generation. We will make use of the technique of crossed-polarized wave generation to remove the pedestals that tend to limit pulse duration in fiber lasers.We conducted simulations of the crossed-polarized wave pulse compression process to verify feasibility for 2 micron pulse compression. We also constructed a fiber oscillator operating in the all-normal dispersion regime, which allows high output power simultaneous with pulses that are compressible to sub-100 fs. This oscillator will form the front end of the amplifier to be built in Phase II. We plan to implement the fiber laser amplifier system we designed in the Phase I project. We expect to obtain 100fs, 250μJ output pulses at 100kHz (average power ~50W) from the amplifier system. The laser will consist of the oscillator built in Phase I, a stretcher and pulse picker, a fiber pre-amplifier and power amplifier, and a booster multipass amplifier. We will convert the fiber amplifier output to 2 microns through optical parametric amplification and clean and shorten the pulses through crossed-polarized wave generation.

Commercial Applications and Other Benefits: There is a current $7B global laser market for ultraviolet, visible, and infrared laser systems. But a new generation of extreme-ultraviolet and soft x-ray lasers will be needed to meet applications such as control, diagnostics, and metrology in the exploding nanoscience and nanoengineering fields. The subject proposal will build on our current ultrafast laser products to validate a new technique for compact extreme ultraviolet and soft x-ray generation at practically useful power levels and device footprint. Ultimate product requirements are informed by an active dialog with potential end-users such as Intel, Toshiba, IBM, and Cymer through an Industrial Advisory Board.

90058S09-II

Recovery Act - A High Applied Field Magnetizing Cryogenic In-Situ TEM Experimental Platform—Hummingbird Precision Machine Inc., 3340 Windolph Lane NW, Olympia, WA 98502-3837; 360-252-2737

Mr. Daan Hein Alsem, Principal Investigator; daan@hummingbirdscientific.com
Mr. Norman James Salmon, Business Official; norman@hummingbirdscientific.com

DOE Grant No. DE-FG02-09ER85415
Amount: $999,999

Interest in functional nanostructures is created by the strong nanoscale confinement and exchange phenomena shown by these systems, which are exciting from a fundamental scientific aspect and are important technologically. Some of the most exciting scientific developments are being made in the field of nanoscale magnetic materials, for example the discovery of the giant magnetoresistance (GMR) and tunnel magnetoresistance effects, which are still not fully understood. In Phase I, sample manipulation devices that allow researchers to expose magnetic and multiferroic samples to high magnetic fields, concomitant with imaging inside advanced high-resolution electron microscopes was developed and has successfully shown their capability to acquire meaningful data. These devices allow researchers to directly visualize the processes by which magnetic domains switch, and what processes impede their motion. In Phase II, a higher field magnetizing holder will be developed and additional capabilities will be added to the magnetizing holder. Specifically, a suite of commercially available magnetizing holders will be developed and manufactured: a magnetizing holder with rotating specimen cup, a magnetizing holder with sample cooling capabilities and a magnetizing sample holder with both a rotating specimen cup and cooling capabilities. Integrated controllers with computer user interfaces will be developed to allow easy control of these systems. These holders will allow unprecedented opportunities for researchers to study nano-scale magnetic phenomena, which in turn will lead to new developments in solid-state magnetic devices. The resulting scientific insights – while fundamental – has direct relevance to the creation of magnetic hard drive media, and can be expected to lead to new functional magnetic and multiferroic devices with wide ranging technological impact.

90067S09-II

Recovery Act - Fast-Scanning Nanoindenter—Hysitron, Inc., 10025 Valley View Road, Eden Prairie, MN 55344; 952-835-6366
Dr. Jason Y. Oh, Principal Investigator; joh@hysitron,com
Mr. Thomas J. Wyrobek, Business Official; thomas@hysitron.com
DOE Grant No. DE-FG02-09ER85582
Amount: $999,999

A nanoindenter can be a powerful tool used as a quality inspection instrument in a manufacturing process with its proven material characterization capability. However, its low bandwidth dynamic characteristics make it difficult to expand to manufacturing processes which demand fast operation and fast topography scanning. The overall objective of this project is to develop a fastscanning nanoindenter. Such a tool would have high bandwidth dynamic characteristics and enable fast nanomechanical testing and fast topography imaging. The completed Phase I effort demonstrated the feasibility of a fastscanning nanoindenter integrated with a high bandwidth transducer and electronics. In addition to designing and constructing the 2axis force transducer, finite element simulations, dual actuator control algorithm development and performance evaluation were conducted to ascertain its fastscanning capability. The Phase II effort intends to: 1) implement a faster control loop; 2) optimize the fastscanning control parameters; 3) develop fast scratch test and fast modulus mapping algorithms; 4) develop manual/automatic tip replacement mechanisms; and 5) develop a fast automated test procedure.

Commercial Applications and Other Benefits: The fast scanning nanoindenter will provide a novel tool for quality inspection in manufacturing processing. This instrument will be especially useful for industries which suffer from product quality change resulting from material property variations. The potential industrial applications of this fast scanning nanoindenter will be in semiconductor, data storage, polymer, pharmaceutical industries. In addition to the commercial benefits, the higher bandwidth of the instrument will enable researchers to investigate high-frequency behavior of various samples. Increasing the testing frequency for polymers and biomaterials characterization can provide for new insight into these materials behavior.

90069S09-II

Recovery Act - Magnetic Tunnel Junction Nanoprobe Compatible with an Atomic Force Microscope—Micro Magnetics, Inc., 617 Airport Road, Fall River, MA 02720-4722; 508-672-4489

Mr. Matthew J. Carter, Principal Investigator; carter@micromagnetics.com
Dr. Gang Xiao, Business Official; admin@micromagnetics.com

DOE Grant No. DE-FG02-09ER85500
Amount: $999,999

The burgeoning field of nanoscience and nanotechnology is limited by our ability to image and manipulate matter at extremely small length scales. As this field progresses, new tools and methods are needed to allow scientists and engineers to understand and control nanoscale systems. We will create a sensitive magnetic tunnel junction (MTJ) nanoprobe sensor which is capable of measuring weak magnetic fields at the nanoscale. To do this, we will combine our expertise in MTJ technology, with a micromachined nanoprobe which is compatible with the well-known technique of atomic force microscopy. This sensor will be able to measure electromagnetic properties up to gigahertz frequencies with nanometer-scale spatial resolution at ambient conditions. We successfully developed a fabrication process which resulted in the creation of micron-sized magnetic tunneling junction nanoprobe sensors. When integrating this nanoprobe into an existing atomic force microscopy system, we were able to simultaneously acquire the topographic and magnetic image of test samples. We will significantly increase the spatial resolution and sensitivity of our nanoprobe sensors and allow the measurement of weak magnetic field at nanoscale. We will also enhance the frequency response into the gigahertz regime, and create a user-friendly compatibility between our nanoprobes and commercial scanning probe microscopy systems.

Commercial Applications and Other Benefits: The new magnetic sensor nanoprobe will allow scientists and engineers to study physical properties of magnetic materials, and the flow of electrical current, at nanometer length scales. This will have applications for testing and diagnostics in the semiconductor and data storage industries, and will find utility in a wide variety of nanoscience and nanotechnology areas and projects.

90073S09-II

High Bandwidth Optical Detector for Scanning Probe Microscopy—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
Dr. Richard Myers, Principal Investigator; RMyers@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85396
Amount: $996,322

The rapid advancements in nanosciences are pushing the limits of surface probe microscopy (SPM) technology. Of particular interest is the ability to extend the SPM bandwidth of detection. This would provide more specific molecular recognition and allow studies of interaction chemistry that, to date, have been inaccessible. It would also allow higher scan rates without compromising imaging resolution. RMD, in collaboration with scientists at Oak Ridge National Laboratory, proposes to develop a new high bandwidth detector for the optical sensing of atomic force microscope (AFM) cantilever movement. By using an array of avalanche photodiodes along with custom electronics, we will offer a new detector format that is capable of detecting extremely small changes to the microcantilever's position, achieving a response bandwidth of greater than 100 MHz, and providing 2-dimensional response. During Phase I, RMD successfully completed or exceeded all of its program goals, including the assembly and testing of a novel APD detector array. We exceeded our goal of building a 10 MHz test unit by assembling a four-channel 50 MHz receiver. In addition, we conclusively demonstrated that developing a 100 MHz detector module can be achieved during Phase II. We will further refine the optical receiver that was developed during Phase I, design and assemble a stand-alone detector module that can monitor the deflection of microcantilevers in an atomic force microscope, and test the unit in a working AFM system. The proposed system will include digital data acquisition and user software to allow integration into custom as well as existing commercial technology. In addition, we will explore partnering with an established AFM manufacturer to accelerate the introduction of our technology into the research field.

Commercial Applications and Other Benefits: This work will further extend nanotechnology research and help the Department of Energy promote SPM use and development. The proposed SPM receiver unit would allow scientists the opportunity to achieve greater understanding and control of nanotechnology. The higher sensitivity offered would allow the use of cantilevers or other probe tips to achieve wider frequency response, producing richer spectral information about the nanomaterial under investigation. Scientists will be able to adapt the receiver technology to the development of new nanomaterials, and apply their results to better understand their interaction with the environment. The work will also be especially useful to help develop new biosensors and bio-identification techniques.

90080S09-II

Recovery Act - An Energy Tunable X-ray Delay Device—Square One Systems Design, Inc., PO Box 10520, Jackson, WY 83002-1050; 307-734-0211
Dr. Robert Viola, Principal Investigator; viola@sqr-1.com
Dr. Robert Viola, Business Official; viola@sqr-1.com
DOE Grant No. DE-FG02-09ER85605
Amount: $749,855

When completed, the Linac Coherent Light Source (LCLS) will produce the world's most concentrated beams of pulsed X-rays. The intense brightness and ultra-short duration of these pulses will provide materials researchers with a powerful experimental tool that promises to revolutionize our understanding of the dynamics of matter. However, to effectively probe ultra-fast dynamic phenomena, a method must be developed to temporally shape incoming X-ray pulses into two pulses with arbitrary relative intensity and time delay. For the LCLS to reach its full scientific potential, there exists an acute need for an apparatus that can manipulate the time structure of hard X-rays over a wide range of energies while preserving peak brightness. A novel, energy tunable X-ray delay device is proposed. This device employs a precisely-aligned train of crystalline beam splitters and reflectors to divide an incoming beam, direct the two resultant beams through paths of different lengths and then to recombine the beams such that their respective pulse trains are slightly out of phase. The device provides for user-selectable time delays from -1.0 to 4.0 nanoseconds. Its innovative design allows it to be automatically reconfigured for compatibility ith the LCLS's full spectrum of available X-ray energies. Under Phase I, the feasibility of the proposed delay strategy was conclusively established. High resolution crystal positioning mechanisms were designed and successfully tested, delay and energy tuning subsystems were validated, a top level controls strategy was developed and high stability synthetic structural materials identified. This work will be expanded under Phase II to create an intermediate version of the X-ray delay device. This intermediate device will support a range of important new science while serving as a critical evolutionary step toward a fully realized vacuum compatible system.

Commercial Applications and Other Benefits: A fully realized X-ray beam splitter will provide a key enabling technology to researchers at the LCLS. In addition, the proposed device's highly precise, in-vacuum opto-mechanical systems can be applied directly to all high resolution hard X-ray optical devices required on existing and upcoming 3rd generation storage rings. Examples include Very High Resolution Monochromators required for the study of inelastic scattering, Mossbauer spectroscopy and nuclear forward scattering.

90082S09-II

Recovery Act - Demonstration of a 5 Tesla Vector Magnetometer for Synchrotron Radiation Experiments—Wang NMR Inc., 550 North Canyons Parkway, Livermore, CA 94551-9472; 925-443-0212
Dr. Sou-Tien (Bert) Wang, Principal Investigator; bert@wangnmer.com
Dr. Sou-Tien (Bert) Wang, Business Official; bert@wangnmer.com
DOE Grant No. DE-FG02-09ER85611
Amount: $999,947

Magnetic field is a critical free parameter in a number of physical systems. For complex magnetic films control of both the field amplitude and its vector components is critical for a detailed understanding of the physical mechanisms at work, as exemplified by circular and linear dichroism experiments. Such experiments are critical to understand and improve materials for a variety of high-profile applications, such as magnetic memory. The proposed equipment development would provide unprecedented access to high magnetic field vector control for soft X-ray experiments at any advanced light source facility in the world. We propose to develop user-accessible fields in excess of 5T through the use of Nb3Sn superconductors and an appropriate mechanical and cryogenic structure. Wang NMR has previous successful experience with the development of series of ~3-3.5T NbTi-based vector magnetometers. In phase I, we have complete overall system design, compute field, force, and propose coil support. We have complete cryogenic design and heat leak analyses and we have done magnet protection with power supplies. In Phase II, we propose to use Phase I design to build 5 Tesla cryogen free vector magnetometer system with cryocoolers and complete instrumentation and control. It will be a turn-key system with complete UHV and power supplies.

Commercial Applications and Other Benefits: There is a large and growing, suite of synchrotron radiation facilities throughout the world, and most of these user facilities have, or are developing, programs to study magnetic materials. Vector magnetometers are highly-sought instruments, allowing detailed investigation of the behavior of magnetic materials, from rare-earth multi-layers to high temperature superconductors.

90085S09-II

Low Cost, High Speed, High Sensitivity Detector for Material Science Studies—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
Dr. Gerald Entine, Principal Investigator; GEntine@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85391
Amount: $977,448

Advanced photon sources, capable of providing extremely high X-ray intensities, have proven to be outstanding resources for X-ray scattering and time-resolved diffraction studies of materials such as organic semiconductors used in electronics, photodiode, and photovoltaic applications, and biological materials such as non-crystalline biological systems. The problem, however, is in finding a detector that can acquire multiple frames of detailed structural information on the required millisecond time scale with high spatial resolution and high sensitivity, over a large area. Recent detector designs address some of these requirements, but even though none satisfies all of them, they are still prohibitively expensive. Development of new and cost-effective detectors that can simultaneously address all of these demanding needs is the key to fully exploiting these outstanding new X-ray sources. To address these limitations we propose to develop a novel X-ray imaging detector that can simultaneously provide millisecond time resolution, high spatial resolution, large imaging area, sensitivity to detect individual low-energy X-rays above noise, and wide dynamic range, all at a very low cost compared to current detector systems. Our approach takes advantage of revolutionary new developments in low-cost readouts, and counterbalances their limitations using novel system components such as an advanced new scintillator from RMD. The Phase I research accomplished, and in many respects exceeded, all stated goals, and as such successfully demonstrated the feasibility of developing a low-cost, high-performance detector for materials studies and other synchrotron applications. We have developed technologies to fabricate the new scintillator with the desired properties, and have combined this sensor with a high-speed readout to form a prototype detector. The detector thus produced has been thoroughly evaluated in our laboratory as well as at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory and the Advanced Photon Source (APS) at Argonne National Laboratory to demonstrate its sensitivity, resolution, and speed of operation. The Phase II project will build on the Phase I research and will seek to develop and deliver a fully functional large-area detector for advanced materials studies to be performed at the NSLS and the APS synchrotron beamlines. Efforts for commercialization of the technology will also be undertaken during the proposed research.

Commercial Applications and Other Benefits: Beside its exceptional value in critical time-resolved X-ray diffraction and scattering studies of biological systems, this detector will find widespread use in many areas of medical imaging, high speed computed tomography, non-destructive testing, and basic physics research. Due to its high performance, compact nature and very low cost, the proposed detector will be ideally suited for homeland security applications ranging from baggage scanning to detection of biological agents without contaminating the detector system.

90086S09-II

Fast, Photon Counting Detector Arrays with Internal Gain—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6801
Mr. Richard Farrell, Principal Investigator; RFarrell@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85393
Amount: $999,998

Third generation x-ray synchrotron facilities such as Argonne National Laboratory's Advanced Photon Source (APS) create high brilliance x-ray beams which are focused to small spot sizes on a wide variety of materials and biological samples. For efficient use of these expensive facilities, it is of great importance for beamlines to have fast, sensitive, low noise x-ray detectors. None of the commercially available x-ray detectors satisfy all the requirements of this demanding application. The proposed project aims to investigate silicon based x-ray detector arrays with internal gain that have very fast response and potentially sub-nanosecond scale timing resolution for synchrotron beamline studies. These detectors will be arranged as an array and coupled to fast digitizing readout electronics. The Phase I project demonstrated the feasibility of producing very fast, compact X-ray detector arrays with excellent signal-to-noise ratio. These detectors showed a fast response time and good energy resolution to low energy X-ray rays, as well as very low noise levels. The X-ray detectors will be optimized further to increase their response time, while also reducing the electronic noise. Larger detectors arrays will be built. Fast integrated circuitry will be developed to readout the detector array. The final prototype will be a compact, fast, high performance X-ray detection unit.

Commercial Applications and Other Benefits: The proposed detectors will be very useful in X-ray detection studies conducted at synchrotron beamlines. Additional applications include nuclear and particle physics, astronomy, health physics, medical imaging, nuclear non-proliferation, and non-destructive studies.

90087S09-II

High-Dynamic-Range, Rad-Hard, Time-Resolved, Correlated X-Ray Photon Detector—Voxtel, Inc., 15985 NW Schendel Avenue, Suite 200, Beaverton, OR 97006-6703; 971-223-5646
Mr. George Williams, Principal Investigator; georgew@voxtel-inc.com
Mrs. Debra Ozuna, Business Official; debrao@voxtel-inc.com
DOE Grant No. DE-FG02-09ER85547
Amount: $999,998

Expanding user demand for X-ray beamline time for science experiments in diverse fields necessitates expensive new beamlines, or the more efficient use of existing resources. Detectors that collect more data, with efficient on-chip and off-chip processing of the resulting data streams, represent the most economical solution to this problem. The innovation is addressing the need for single-photon X-ray detection, combined with high-resolution time stamping, and a dual design for correlation functionality that allows immediate feedback on a region of interest, combined with full-scale data output to a PC for slower, full correlation in software. These functions will allow users to intervene in real time to adjust their experiments, and will increase the volume and precision of collected data, allowing studies over finer distance and time scales. A new time-resolved, correlating X-ray detection instrument was developed for high-throughput, high-sensitivity, time-resolved X-ray scattering and imaging experiments, especially X-ray photon correlation spectroscopy. The event-driven detector is capable of in-pixel single-photon detection and energy discrimination; with the capability to perform multi-channel real time autocorrelation in supporting camera electronics, this represents a major improvement over charge-coupled devices for experiments requiring sub-μs time resolution. The Phase I design demonstrated feasibility, with 32-bit time stamp capability in excess of 25×10^6 events per second across a full-format (22 mm × 22 mm) array, temporal recording span greater than 200 s, and supporting detector pulse pair resolutions of less than 40 ns. In Phase II, the full-reticle, 512 × 512-element detector will be fabricated and characterized, integrated with an FPGA-based real-time time stamping and correlation circuit board, assembled as a camera, and the instrument tested in a X-ray beam line. The Phase II program EDTS-XPCS system will contain the features designed in Phase I (e.g. 25-MHz X-ray photon count rates, sub-microsecond time resolution, 32-bit time stamps, and real-time auto-correlation), through integration of the EDTS-XPCS FPA and the TDC/correlator instrument. The Phase II design will be optimized for soft-X-ray XPCS.

Commercial Applications and Other Benefits: X-ray photon correlation spectroscopy relevant to many areas in statistical physics and many important phenomena in soft condensed matter physics. Coherent X-rays are also interesting for investigating “mesoscopic” dynamics, potentially achieving atomic resolution and learning about the internal modes of polymers, polyelectrolytes, block copolymers and micellar systems. The flexible, high-performance innovation will address a large part of this market, with cross application in time-resolved X-ray scattering experiments of all kinds.

90088S09-II

Electronics for Large Superconducting Tunnel Junction Detector Arrays for Synchrotron Soft X-Ray Research—XIA, LLC, 31057 Genstar Road, Hayward, CA 94544-7831; 510-401-5760
Dr. William K. Warburton, Principal Investigator; bill@xia.com
Dr. Peter M. Grudberg, Business Official; peter@xia.com
DOE Grant No. DE-FG02-09ER85550
Amount: $999,999

While the DOE has spent billions of dollars over the past two decades building, staffing and equipping four national synchrotron radiation facilities to support advanced research in all fields by supplying intense brilliant x-ray beams covering a wide range of energies, x-ray detector capabilities have not kept pace with developments in x-ray sources and beam line facilities. Thus, while x-ray fluorescence spectroscopy is one of the most successful research techniques in the energy range from 220 KeV, the solid state, energy dispersive detectors used for that research do not have adequate energy resolution to allow the same methods to be applied in the range 0.2 – 2.0 KeV. This is an issue because much important science could be done if adequate detectors were available. In the past 5-10 years, superconducting tunnel junction (STJ) detectors have been developed at Lawrence Livermore National Laboratory (LLNL) and elsewhere that are capable of delivering 10-20 eV energy resolution at high count rates in this soft x-ray regime, but, because these detectors are tiny (200 □m x 200 □m), they need to be arrayed in 100's or 1,000's to be used effectively. This proposal's objective is to develop low cost, easy to use electronics that support such large arrays cost effectively, delivering electronics at about $250/detector, so that a 1,000 element STJ detector array could be purchased for the same price as the large HPGe arrays now being used in the hard x-ray regime, while delivering 100's of times more counts with at least 5 times better energy resolution. In Phase I we developed an inexpensive, ultra-compact, low noise preamplifier, coupled it to an existing digital processor, and, in experiments with several STJ's, showed that we could meet our energy resolution target and also meet or exceed the performance of the current standard preamplifier. In Phase II we will focus on: a) optimizing our preamplifier design for a high density cards; developing control software for automatically setting up, calibrating, and collecting data with large STJ array detectors; and, d) carrying out periodic tests of our progress on an STJ detector array.

Commercial Applications and Other Benefits: If successful in Phase II, these detectors will provide two important benefits. First they will allow the nation's synchrotron facilities to significantly enhance the scientific return on their investment in x-ray sources by opening up the soft x-ray regime to highly productive fluorescence analysis techniques. Second, by providing detectors optimized for very low voltage scanning electron microscopy, they will benefit the semiconductor industry by providing a superior way to study manufacturing defects.

90104S09-II

NDE of Gas Turbine Thermal Barrier Coatings—Southwest Sciences, Inc., 1570 Pacheco Street, Suite E-11, Santa Fe, NM 87505-3993; 505-984-1322
Dr. Kristen A. Peterson, Principal Investigator; peterson@swsciences.com
Dr. Alan C. Stanton, Business Official; astanton@swsciences.com
DOE Grant No. DE-FG02-09ER85442
Amount: $999,999

Thermal barrier coatings are increasingly being used in advanced power plant and industrial gas turbines to protect metal components from the hot gas stream. Their use improves the durability of turbine parts and increases efficiency of operation. However, premature failure remains a critical concern. It is very important to have a *non-destructive* evaluation technique for quality control and to detect early damage of thermal barrier coatings during use. Current inspection methods are either destructive or do not provide sufficient evaluation of the coating. An optical, nondestructive inspection method for thermal barrier coatings based on a technology known as optical coherence tomography is being developed. This technology will provide unprecedented imaging of the thermal barrier coating layers and structure and will be capable of detecting damaged coatings and conditions indicative of degradation of the coating. In Phase I, a high-speed instrument capable of nondestructively imaging subsurface structures in thermal barrier coatings was constructed and tested. The dependence of imaging performance on various instrument components and parameters were investigated. The feasibility of this approach was confirmed and a design for a Phase II prototype was developed. In Phase II, an optimized instrument will be constructed and tested. Nondestructive inspection of thermal barrier coating samples subjected to different degrees of thermal aging will be performed. An algorithm for predicting the remaining service life of thermal barrier coatings based on optical coherence tomography data and other nondestructive testing will be developed and validated.

Commercial Applications and Other Benefits: Development of this technology will allow better quality control inspection of thermal barrier coating coated turbine parts at manufacturing and maintenance facilities, will allow identification of coatings that are close to failure. These capabilities will lead to cost savings for turbine parts manufacturers since destructive testing for quality control will be eliminated. Substantial operations savings can also be expected if this technology can help maximize the useful life of components or indicate when failure is about to occur. Unplanned shutdowns are extremely costly to the power industry and its customers.

91622S09-II

Ultra High Efficiency 100 lm/W Phosphorescent White OLED Lighting Panel—Universal Display Corporation, 375 Phillips Blvd., Ewing, NJ 08618-1428; 609-671-0980

Dr. Peter Levermore, Principal Investigator; plevermore@universaldisplay.com
Mrs. Janice K. Mahon, Business Official; jkmahon@universaldisplay.com

DOE Grant No. DE-FG02-09ER85543
Amount: $999,993

In 2009, lighting consumed 9.84 quads of primary energy in the U.S, or about 22% of the total electricity generated. New high-efficiency solid-state light sources are needed to reduce the ever increasing demand for energy. OLEDs are potentially inexpensive and highly efficient diffuse light sources that may compete directly with and offer a 'green' alternative to incandescent and fluorescent light sources. OLEDs also offer unique design possibilities that could potentially revolutionize the industry through entirely novel, non-hazardous, thin form factor lighting products. In order to realize this goal, highly efficient large area OLED lighting panels must be developed and demonstrated. For OLED lighting to become a commercial reality, we propose to scale phosphorescent OLED technology to demonstrate our high efficiency technology in large area lighting panels. During Phase I, we exceeded our goals and demonstrated a white PHOLED pixel with efficacy = 125 lm/W, CRI = 81, CIE 1931 (x, y) = (0.430, 0.428) and lifetime to 70% of initial luminance (LT70) ☐11,000 hrs at 1,000 cd/m^2. We also demonstrated a second pixel with slightly lower efficacy, but with chromaticity more closely matched to the Planckian curve: efficacy = 113 lm/W, CRI = 80, CIE 1931 (x, y) = (0.441, 0.414) and lifetime to LT70 ☐10,000 hrs at 1,000 cd/m2. This is the highest efficacy recorded to date for a WOLED pixel with emission color that meets stringent Energy Star chromaticity requirements for Solid State Lighting (SSL). In Phase II we propose to fabricate 15 cm x 15 cm OLED lighting panels using our phosphorescent emitters. We will target panel efficacy > 80 lm/W, which is 1.6x higher than our previous world record 15 cm x 15 cm OLED panel efficacy, and 3-4x more efficient that smaller area OLED panels that are comercially available today. Our panel will have lifetime to 70% of initial luminance > 20,000 hrs (at 1,000 cd/m^2) and deliver high quality white light with CRI > 80 and CCT and CIE meeting Energy Star criteria for Solid State Lighting. Crucially, our panel will also have minimal thickness. We seek to deliver energy savings with high quality light in a revolutionary thin form factor.

Commercial Applications and Other Benefits: OLED technology is the leading emerging technology for flat panel displays (FPDs), with recent product introductions in cell phones, smart phones and TVs. Many of the features desirable for FPDs are also making OLED technology of great interest to the solid-state lighting community. For example, OLEDs are bright and colorful lambertian emitters with excellent power efficiency at low voltages. In addition, OLEDs are thin-film devices that provide thin form factors especially when built on flexible substrates.

90219S09-II

High Efficiency R744 Centrifugal Chiller—R&D Dynamics Corporation, 49 West Dudley Town Road, Bloomfield, CT 06002-1421; 860-726-1204

Dr. Giri Agrawal, Principal Investigator; agragiri@rddynamics.com
Mr. Dennis Burr, Business Official; dennisb@rddynamics.com

DOE Grant No. DE-FG02-09ER85352
Amount: $999,758

Most medium and large commercial and industrial facilities use packaged water chillers ranging from 50 ton capacity and up for air conditioning and refrigeration. Their current refrigerants are chemicals which will soon be phased out and replaced by environmentally benign alternative refrigerants of zero ozone-depletion and negligible global warming. Among all candidate refrigerants, Carbon dioxide has been found to be the best considering all requisite conditions including non-flammability and non-toxicity. Because of its inherent inefficiency arising from a transcritical cycle with low critical temperature, a direct application to the conventional chiller cycle requires power consumption of 1.2 kW/ton at the rating condition. As an innovative breakthrough, a high efficiency carbon dioxide chiller will be developed. By reducing overall pressure ratio, the cycle efficiency is dramatically increased to provide the power consumption as low as 0.5 kW/ton at 150 tons of cooling capacity. The proposed innovative carbon dioxide cycle is easily scalable to chiller sizes other than 150 tons. In Phase I, the feasibility of the innovative carbon dioxide chiller concept was successfully confirmed through a thermodynamic analysis of the cycle. A preliminary analysis of all the components also showed the feasibility of anticipated performance. Mechanical integrity of all key components was verified through a preliminary mechanical design. An overall system size and volume was estimated, and any conflicts with commercial needs were checked. In Phase II, the novel design technology will be established through component tests. The demonstration of efficiency gain using the new technology installed in an existing commercial chiller will be made, which will create a near-term retrofit business of improving current chiller efficiency by simply adding the new technology, and which will minimize any potential trial-and-errors in the carbon dioxide chiller development. A complete design of the key components of the proposed carbon dioxide water chiller will be accomplished. A working relationship with a manufacturing company, specialized in packaged water chiller business, will be established. In Phase III, a prototype chiller of 150 ton capacity will be built and field tested. Marketing of the chiller will begin by targeting the replacement of existing reciprocating and screw chillers in commercial and industrial sectors rating from 50 to 400 tons of cooling capacity with cooperation in partnership with a water chiller manufacturer. The proposed project will provide a major breakthrough for improvement in energy savings using a natural refrigerant.

90221S09-II

Nanofluids Enhanced Twisted Tape Heat Exchanger—Advanced Cooling Technologies, Inc., 1046 New Holland Ave., Lancaster, PA 17601-5606; 717-295-6058
Dr. Devdatta Prakash Kulkarni, Principal Investigator; Devdatta.Kulkarni@1-act.com
Dr. Jon Zuo, Business Official; Jon.Zuo@1-act.com
DOE Grant No. DE-FG02-09ER85253
Amount: $999,999

Heat exchangers are a used in a commercial, residential, and military cooling systems. Their thermal performance is measured by their ability to efficiently transfer heat. By increasing the heat exchanger efficiency, the size and weight of the system can be reduced. This work explores the use of twisted tape technologies and the use of advanced nanofluids for improving thermal performance. ACT has demonstrated excellent thermal performance with our concept in Phase I and plan to further develop the technology for large volume, commercial applications. The overall objective of the Phase I and Phase II programs is to demonstrate ACT's advanced heat exchanger design that incorporates twisted tape technology with advanced high conductivity nanofluids. In Phase I, the feasibility of the concept was successfully demonstrated and the increase in heat transfer coefficient was substantially greater than the increase in pressure drop for a range of test conditions. A prototype twisted tape enhanced heat transfer apparatus will be design, optimized, fabricated and tested in the Phase II study in preparation for commercialization. The increase in heat transfer coefficient using nanofluids in a twisted tape heat exchanger and straight channels was quantified and compared to results acquired with water. A model was developed to understand the mechanism(s) responsible for the substantial improvement in heat transfer. Work was also performed to determine the increase in effective heat transfer coefficient relative to the pressure drop to determine the optimal range of flow and geometric parameters to be used in the design of a prototype cold plate in Phase II. The technology developed in Phase I will be used to develop heat transfer correlations for nanofluids in twisted tape heat exchangers. These results will then be used to design an advanced cold plate based on this technology. Commercial partners will support the development and testing of the prototype.

Commercial Applications and Other Benefits: The proposed advanced heat exchanger technology will benefit residential,commercial and military cooling applications for which the thermal performance is limited by the working fluid selection and heat exchanger design. These applications include building HVAC, automobile radiators and high performance electronics cooling. The use of nanofluids with twisted tape inserts will allow for a higher performance heat exchanger with lower overall size and weight.

90222T09-II

STTR Project - Stabilization of Nanofluids Using Self Assembled Monolayers—Advanced Cooling Technologies, Inc.**,** 1046 New Holland Ave.**,** Lancaster, PA 17601-5606; 717-295-6058
Mr. Richard W. Bonner, III, Principal Investigator; Richard.bonner@1-act.com
Dr. Jon Zuo, Business Official; Jon.Zou-act.com
DOE Grant No. DE-FG02-09ER86378
Amount: $750,000

Research Institution
Pennsylvania State University

Heat exchangers are a used in a commercial, residential, and military cooling systems. Their thermal performance is measured by their ability to efficiently transfer heat. By increasing the heat exchanger efficiency, the size and weight of the system can be reduced. This work explores the use of twisted tape technologies and the use of advanced nanofluids for improving thermal performance. ACT has demonstrated excellent thermal performance with our concept in Phase I and plan to further develop the technology for large volume, commercial applications. The overall objective of the Phase I and Phase II programs is to demonstrate ACT's advanced heat exchanger design that incorporates twisted tape technology with advanced high conductivity nanofluids. In Phase I, the feasibility of the concept was successfully demonstrated and the increase in heat transfer coefficient was substantially greater than the increase in pressure drop for a range of test conditions. A prototype twisted tape enhanced heat transfer apparatus will be design, optimized, fabricated and tested in the Phase II study in preparation for commercialization. The increase in heat transfer coefficient using nanofluids in a twisted tape heat exchanger and straight channels was quantified and compared to results acquired with water. A model was developed to understand the mechanism(s) responsible for the substantial improvement in heat transfer. Work was also performed to determine the increase in effective heat transfer coefficient relative to the pressure drop to determine the optimal range of flow and geometric parameters to be used in the design of a prototype cold plate in Phase II.The technology developed in Phase I will be used to develop heat transfer correlations for nanofluids in twisted tape heat exchangers. These results will then be used to design an advanced cold plate based on this technology. Commercial partners will support the development and testing of the prototype.

Commercial Applications and Other Benefits: he proposed advanced heat exchanger technology will benefit residential,commercial and military cooling applications for which the thermal performance is limited by the working fluid selection and heat exchanger design. These applications include building HVAC, automobile radiators and high performance electronics cooling. The use of nanofluids with twisted tape inserts will allow for a higher performance heat exchanger with lower overall size and weight.

90254S09-II

NanoEngineered High ZT Solid State Nanocomposite Thermoelectric (ssnTE) Manufacturing for Multiple Energy Generation Applications—Structured Materials Industries, Inc., 201 Circle Drive North, Unit 102, Piscataway, NJ 08854-3723; 732-302-9274
Dr. Gary S. Tompa, Principal Investigator; GSTompa@aol.com
Dr. Gary S. Tompa, Business Official; GSTompa@aol.com
DOE Grant No. DE-FG02-09ER85614
Amount: $999,999

Thermoelectrics, a technology for the direct conversion of heat into electrical energy, is a mature technology that is; however, undergoing a revolution in capability and applicability with the introduction of nanotechnology. Recent results with nanocomposite films have shown that Figures of Merit (ZT) much greater than 1.0 are possible at laboratory-scale; however a technology road map with the view towards large-volume and low-cost manufacturing processes of such TE devices has not previously been envisioned. These demonstrated results must now be transitioned into commercial applications. SMI has teamed with a leading thermoelectric (TE) research group in order to optimize and convert high-performance solid state TE materials developed at laboratory-scale into economically producible products for DOE desired products, military needs, and commercial applications in general. We propose to develop a scalable manufacturing process of large-volume and cost-effective nanocomposite TE device films with ZT values exceeding 2.0. In Phase I, SMI and our partner have demonstrate proof-of-concept scalable manufacturing technology for nanocomposite films required for high-performance TE devices. In Phase II, we will continue materials development and device demonstration and optimization in a pilot scale tool. We will also develop scaling designs for production and establish cost of ownership projections. Importantly, we will market the technology with end product producers. The Phase III result will be the availability of high-performance TE devices that utilize nanocomposite films for a wide range of applications.

Commercial Applications and Other Benefits: Conversion of heat directly to electrical energy is needed for many DOE programs and, following solar energy, will be an important part of many energy generation needs. The realization of high volume production of rugged, high-efficiency, and low-cost thermoelectric devices will have substantial positive impacts on reducing instrument size, weight and cost – dramatically benefiting energy consumption ratios. Devices which recover waste heat from industrial or transportation usages or solar-thermal applications (among others) will soon come into great demand. SMI intends to meet this emerging need by providing one of the primary enabling tools to produce the materials and thus enable devices themselves (directly and through our customers).

90291S09-II

Novel Ethanol Dehydration Membranes—Compact Membrane Systems, Inc., 335 Water Street, Newport, DE 19804-2410; 302-999-7996
Dr. Dan Campos, Principal Investigator; dcampos@compactmembrane.com
Dr. Stuart Nemser, Business Official; snemser@compactmembrane.com
DOE Grant No. DE-FG02-09ER85314
Amount: $996,265

There continues to be a need for production of fuel-grade ethanol from renewable sources. Ethanol from agricultural sources has many advantages including development of fuel independence. While there continues to be a significant need for ethanol, the cost of agricultural based ethanol is quite severe although existing and new legislation provides significant incentives for its use. This program addresses novel routes to enhance the low-cost production by means of a novel water-ethanol separation membrane and process. The proposed membrane process for small plants should be of great value in increasing capacity and/or reducing energy consumption for ethanol plants. Membrane processes are ideal for small applications. Existing biomass-to-ethanol plants are at 40 million gallons per year or greater and very few are at 10 million gallons per year. A membrane process would be the most advantageous route for operation of small scale plants. Membrane processes are ideal at removing the minor component. A membrane that preferentially removes water would be ideal for final drying of highly concentrated streams such as 60-90% ethanol. The membrane and system ability to economically dry bioethanol in both existing and new bioethanol plants was demonstrated. Savings for existing plants was projected at $0.22/gal and $0.08/gal for a greenfield plant. This program demonstrates broad value for the membrane platform to be responsive to DOE's Chemical Industry Vision 2020 goal regarding chemically and thermally resistant membranes. A prototype membrane system for evaluation/demonstration in the laboratory and in the field for low cost drying of ethanol will be constructed. Key outside personnel and companies to participate in Phase II have been acquired. Phase II will focus on providing low cost drying of bioethanol at pilot and plant level with expectations that the unit operation of chemically and thermally resistant membranes will be of broad value to DOE.

Commercial Applications and Other Benefits: This program represents both a broad platform technology and a large market opportunity. The proposed membrane technology combines the high flux, chemical resistance and thermal stability to be useful in many applications. The government has targeted 10% of gasoline as replaceable by biomass feed stock sources to enhance energy independence. If cellulose to ethanol is viable, the DOE and USDA suggests that 30% to 50% of our fuel can come from biomass. The membrane technology will provide a core increase in manufacturing capability and energy savings. In addition, as Phase II commercial activity is introduced into bioethanol plants parallel DOE related markets are expected to develop, including the broad DOE goal as stated by DOE Chemical Industry Vision 2020 for chemically and thermally resistant membranes. In addition, biofuels will have higher levels of dissolved/dispersed water than petroleum that needs to be managed. The membranes are ideal at managing and removing this high level of water.

90292B09-II

Novel Membranes for Enhancing Value of Bio-Oil—Compact Membrane Systems, Inc., 335 Water Street, Newport, DE 19804-2410; 302-999-7996

Dr. Praveen Kosaraju, Principal Investigator; pkosaraju@compactmembrane.com
Dr. Stuart Nemser, Business Official; snemser@compactmembrane.com

DOE Grant No. DE-FG02-09ER85315
Amount: $989,128

Bio-oil is a liquid fuel made from biomass such as wood chips and low grade wood byproducts by fast pyrolysis process. Presence of carboxylic acids in raw-bio-oil makes the bio-oil very acidic and corrosive. Raw bio-oil has low heating value primarily because of its high water content (up to 35 %). Oligomerization aldehydes and other compounds with an unsaturated carbon bond in raw bio-oil results in increased viscosity with aging/storage. To summarize, quality and stability of raw bio-oil has to be improved in order to use bio-oil as a fuel in engines, gas turbines and boilers, and as a refinery feedstock to produce transport fuel. A membrane separation process will be developed to remove all the undesirable compounds, water, carboxylic acids and aldehydes from bio-oil to substantially improve its quality and stability. Economics of this novel membrane separation process will be superior to the alternative bio-oil treatment technologies. Novel membranes were developed to remove undesirable compounds from raw bio-oil. By removing undesirable compounds, water, carboxylic acids and aldehydes, from bi-oil, its stability and quality was improved substantially. The novel membrane separating process is highly economical and its payback time was estimated as less than a month. Membrane and membrane separation process will be first optimized to enhance its separation performance. Then, a prototype device will be built to perform the long-term stability studies and field evaluation. Based on these results, engineering and economic analysis of the membrane separation system will be carried out for bio-oil treatment.

Commercial Applications and Other Benefits: Bio-oil is renewable, sustainable, and environmentally benign. Bio-oil upgraded in quality and stability could ultimately reduce our dependence on fossil fuels. Bio-oil production plants could provide jobs along with a badly needed market for the timber industry's wood chips. Membrane separation technology developed for the bio-oil treatment is highly energy efficient and can be an alternative to the high energy consuming distillation processes (Examples: drying chemicals, solvent recovery in vegetable oil processing and petroleum processing).

90312S09-II

Acetic Acid Recovery Using Membranes—Membrane Technology and Research, Inc., 1360 Willow Road, #103, Menlo Park, CA 94025-1524; 650-543-3378
Dr. Yu (Ivy) Huang, Principal Investigator; ivy.huang@mtrinc.com
Ms. Elizabeth G. Weiss, Business Official; Elizabeth.weiss@mtrinc.com
DOE Grant No. DE-FG02-09ER85492
Amount: $999,671

Recovery and recycling of acetic acid from aqueous streams is an important industrial separation that is high cost and energy intensive when performed by conventional technology. This makes acetic acid recovery a tantalizing target for a more efficient, lower cost, simpler approach such as membrane technology. However, the required separation performance, combined with the need for robust chemical and thermal stability of the membrane materials, makes the use of membrane technology for acetic acid recovery very challenging. In this project, perfluorinated polymer membranes are used to dehydrate acetic acid using two new membrane processes. The membranes are stable in hot acetic acid/water mixtures and have good selectivities for separation of water from acetic acid. The proposed membrane processes will lower energy costs by more than 50% compared to conventional separations. *In Phase I*, we demonstrated the feasibility of the proposed technology. Stable membranes were made that met the permeation criteria required for an economical process. A few bench-scale modules were made and successfully tested with aqueous acetic acid solutions at 90-100°C. Industrial process designs based on the module performance showed the membrane processes could achieve significant cost and energy savings compared to the azeotropic distillation or liquid-liquid extraction technologies now used for this separation. *In the Phase II project*, the membranes developed in Phase I will be further optimized and pilot/small industrial-scale modules will be made to demonstrate long-term performance and stability. An existing pilot system will be modified and evaluated with both model acetic acid solutions and industrial solutions obtained from an industrial partner. The data obtained will lead to a second year field test using the pilot system at the partner's plant facility in Louisiana. The field test results will be used to design a full-scale system for use in a follow-on Phase III, and a commercialization plan will be developed.

Commercial Applications and Other Benefits: If successfully developed, the technology will allow acetic acid to be recovered far more economically than today's technologies allow. Over 200 large acetic acid/water separation plants are installed worldwide. Use of membrane systems in new and retrofitted plants represents a potential market of about $70-110 million/y. Longer term, a successful distillation-membrane technology could be applied to commercial separations of other similar dilute aqueous streams.

90331S09-II

Novel Catalytic Alkane Oxidation Process—TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300
Dr. Girish Srinivas, Principal Investigator; gsrinivas@tda.com
Mr. John Wright, Business Official; jdwright@tds.com
DOE Grant No. DE-FG02-09ER85491
Amount: $999,999

Ethanol is a versatile chemical that is used as a chemical solvent, sterilizer, antifreeze, chemical intermediate, but mostly an oxygenate in fuels. Ethanol is produced primarily by fermentation of grains, however, there are a few industrial processes that manufacture high purity ethanol, mostly from the hydration of ethylene. Due to its projected use as an oxygenate in gasoline, ethanol demand is projected to grow by as much as 10% per year. Currently, 83% of the ethanol in the U.S. is produced by fermentation processes from corn. As a result, food prices spiked in 2008, in part driven by the fact that farmers were growing corn for ethanol production instead of for food crops. If synthetic ethanol could instead be made directly by oxidizing the cheaper light alkanes that are found in abundance in the petroleum industry, these low value fuel gases could be converted into a high value alcohol. Conversion of low value ethane to high value ethanol would be an advantage for both the fuels and chemical industries. TDA Research, Inc. (TDA) has identified a novel catalyst to convert light alkanes to valuable oxygenates such as alcohols. Since the process directly oxidizes light alkanes instead of olefins, it could operate far more cheaply than current industrial synthetic alcohol manufacturing processes. In the Phase I project, TDA successfully demonstrated that it can convert light alkanes such as ethane directly to ethanol in higher yields than reported to date. In addition, we carried out an economic analysis for a 50 million liters/year ethanol plant based on our technology. In the Phase II project, with our partners, we will continue to refine our catalytic process with a combination of modeling, catalyst testing, and process and economic analysis. We are working with a major ethanol manufacturer who will consider adopting our technology should the results our process and economic analysis meet industry benchmarks.

Commercial Applications and Other Benefits: Since the alkane feedstocks proposed here used for oxidation to ethanol are far less expensive than traditional synthetic raw materials, synthetic ethanol may become cheaper to manufacture. As a result, developing an alternate route to ethanol from a cheap, abundant (domestic supply) fossil fuel feedstock such as ethane will help to alleviate some of the demand for corn-fermentation ethanol.

90336S09-II

Catalytic Processing of Biomass to Ethylene & Propylene—Exelus, Inc., 110 Dorsa Ave, Livingston, NJ 07039-1003; 973-740-2350
Mr. Mitrajit Mukherjee, Principal Investigator; mmukherjee@exelusinc.com
Mr. Mitrajit Mukherjee, Business Official; mmukherjee@exelusinc.com
DOE Grant No. DE-FG02-09ER85372
Amount: $999,999

The U.S. has abundant biomass resources and with the right technology, has the potential to convert these renewable resources into valuable industrial products and bio-fuels. However, current high temperature thermochemical processes to convert renewable feedstocks to fuels or chemicals such as pyrolysis and gasification or low temperature enzymatic processes are simply not cost-competitive with conventional fossil-fuel based processes. This SBIR project seeks to produce large volume monomers such as ethylene and propylene from bio-mass, thereby reducing the use of non-renewable raw materials in plastics manufacturing. This project applies novel reaction and reactor concepts with environmentally benign homogeneous and heterogeneous catalysts in a multi-step process that deconstructs and stabilizes biomass before conversion to light olefins – ethylene and propylene. Phase I R&D was used to determine both the technical feasibility and the commercial viability of using biomass as a feed-stock for producing large volume monomers such as ethylene and propylene. The Phase I work conclusively demonstrated the viability of the process and its ability to produce the desired products at high selectivity and commercially desirable reactor productivity. The process was shown to produce olefins from biomass at a cost that is highly competitive with conventional fossil-based feedstocks. Phase II research seeks to undertake the catalyst, reactor, and process development steps needed to commercialize this biomass-to-olefins (BTO) process. At the heart of the Phase II effort is the development of engineered catalysts, reactor configurations and process designs that will allow design of small scale BTO units while maintaining economic viability.

90340S09-II

Pre-Production Optimization of Cellulolytic Enzymes—Allopartis Biotechnologies, 1700 4th St, 219 Byers Hall, UCSF MC2522, San Francisco, CA 94158; 510-931-6080
Dr. Charles Emrich, Principal Investigator; charlie@allopartis.com
Dr. Charles Emrich, Business Official; charlie@allopartis.com
DOE Grant No. DE-FG02-09ER85569
Amount: $999,999

Abundant cellulosic biomass is an ideal starting material for biofuels, but unlocking the latent energy potential of cellulose is technically difficult because cellulose is one of nature's most resilient biological materials. Currently available enzymes are inefficient and the resulting high cost of this critical step in biofuel production is a major pain point in reducing next generation biofuels production costs and increasing gross margins. While there has been significant process development to increase cellulase production yield, it has proven extremely difficult to improve cellulase activity using conventional methods. The largest unmet need for making next-generation biofuels cost competitive is increasing the activity of cellulases against pretreated biomass. The goal of this project is to extend the success of our AlloScreen technology to quickly improve cellulase activity directly against biomass by transitioning it from simple bacterially based systems to filamentous fungi, which are currently the workhorse production microbe for cellulases. By evolving many cellulases against biomass in vitro and screening them for activity in from fungal hosts, we hope to double the activity of the cellulases secreted from a pre-production strain of the industrial fungus, *T. reesei*. In Phase I, we developed advanced methods for performing our core directed evolution technology, the AlloScreen against both solid, crystalline cellulose and the ultimate target, pretreated biomass (acid-pretreated switchgrass). While biomass presented many challenges we did evolve an enzyme with twice the activity on pre-treated switchgrass as the parent enzyme. The first phase of our three phase approach will be to generate new, optimized cellulases from bacteria and probe them for synergist action with the cellulolytic model fungus, *Neurospora* crassa. In the second phase, we will leverage the huge genetic toolkit of Neurospora to transition our testing and selection from a bacterial to fungal system and test AlloScreen-optimized enzymes directly in a native fungal system for enhanced, synergistic activity. In the final phase, we will transition those optimized enzyme from *Neurospora* to a hypersercreting strain of the industrial cellulaseproducing workhorse, *Trichoderma reesei*.

Commercial Applications and Other Benefits: The outputs of this project are directly oriented towards rapid commercialization through cellulose manufacturing for the growing cellulosic biofuels and industrial biotechnology industries. More efficient cellulases are a key need for the industry and will lower production costs of sustainable biofuels, eventually lessening our reliance on carbon-intensive petrofuels, which will benefit both the environment and the economy as imports are lowered while domestic agriculture and are technology strengthened.

90379B09-II

STTR Project - Direct Conversion of Carbon Dioxide to Methanol—InnoSense LLC, 2531 W. 237th Street, Suite 127, Torrance, CA 90505-5245; 310-530-2011
Dr. David Hess, Principal Investigator; david.hess-1@innosense.us
Dr. Kisholoy Goswami, Business Official; kisholy.goswami@innosense.us
DOE Grant No. DE-FG02-09ER86390
Amount: $750,000

Research Institution
Duquesne University

Although carbon capture and storage (CCS) technology has received the most attention for its potential to reduce emissions, processes that convert CO2 into a useful product can provide a positive return on investment and not just be an unrecoverable cost. Compared to CCS technology, the potential revenue generated by the use of CO2-based product is likely to grow popular with time while reducing or stabilizing greenhouse gas emissions. Due to its reactivity, CO2 can be used as a raw feedstock material for the production of chemicals such as methanol. Fabrication of cost effective photocatalytic electrodes for use in an efficient photoelectrochemical cell to reduce CO2 is the main technical objective for the Phase II project. Phase I demonstrated the feasibility of producing methanol using photoanodes in tandem with cathodes. The Work Plan consisted of three major experimental tasks to achieve the two stated objectives. They were successfully accomplished by demonstrating methanol conversion efficiency exceeding literature values with working model of the proposed electrodes.The photoelectrochemical cell will be fine-tuned by optimizing electrode physical properties such as material, geometry, size, and surface morphology. In addition, parameters of the cell including the reactant delivery rate, electrode orientation, and device size and shape will be optimized to increase carbon dioxide to methanol conversion efficiency.

Commercial Applications and Other Benefits: Worldwide energy demand is driving the need to explore new environmentally friendly and economically viable sources of energy. Technologies such as photo and electrolytic conversion of CO2 to methanol create no harmful byproducts and release no greenhouse gas emissions. These issues are very important in the light of growing awareness of the climate change.

90390S09-II

Fused Nanocomposite Claddings for Oil and Energy Applications—MesoCoat, Inc., 24112 Rockwell Dr., Euclid, OH 44117-1252; 216-404-0053
Mr. Greg Engleman, Principal Investigator; gengleman@mesocoat.com
Mr. Andrew Sherman, Business Official; asherman@mesocoat.com
DOE Grant No. DE-FG02-09ER85493
Amount: $999,998

This proposal directly addresses the significant problem of wear and corrosion resistant materials in natural gas and oil well drilling, pipelines, slurry pipe, drilling heads, and mining and has applications in automotive and aerospace applications. Current oil wells are being drilled deeper, with longer drill trails than ever before. This imparts conditions of pressure and temperature that can't be handled by current materials. This Phase II project is addressing these problems by developing new materials and processes for use in cladding high strength low alloy steels. These materials and processes maintain wear and corrosion resistance at higher temperatures while not sacrificing the strength of the base materials.
In the Phase I project, several coating formulations were manufactured and applied to plain steel coupons. The coating formulations were comprised of ceramic reinforcements in metal matrices. The ratio of the ceramic to metal was varied to determine the effects of ceramic volume on wear and corrosion resistance. Additionally, coating application and fusion parameters were varied in an effort to achieve a first order process optimization. During the Phase II project, the coating formulations will be optimized and additional wear and corrosion testing will be performed in order to down-select to the best coating. Working with an industrial partner, small components will be coated and tested in the field.
The product and technology will be matured to offer breakthrough potential, imparting high temperature wear and corrosion resistance to large structures such as oil pipe. Additional benefits include the replacement of electrolytic chrome, the ability to extract energy from ever harsher environments and coating and cladding materials that will be suitable for use in renewable energy applications where wear and corrosion are an issue, such as in wind farms and in fuel cells.

90429S09-II

Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells—Tiax, LLC, 35 Hartwell Avenue, Lexington, MA 02140--230; 617-498-5655
Dr. Suresh Sriramulu, Principal Investigator; sriramulu.suresh@tiaxllc.com
Dr. Renee Wong, Business Official; wonr.renee@tiaxllc.com
DOE Grant No. DE-FG02-09ER85528
Amount: $999,746

For lithium-ion battery-based HEVs and PHEVs to become commercially viable, occurrences of rare but violent spontaneous field failures of lithium-ion cells must be prevented. We are developing a methodology to reliably and reproducibly implant and activate internal short circuits of the type believed to be responsible for field failure incidents in lithium-ion cells. This methodology is being used to develop battery safety technologies for mitigating safety incidents of internal short circuits in lithium-ion cells.

Commercial Applications and Other Benefits: Safer lithium-ion batteries will be of benefit to existing portable power applications (e.g. laptops, cell phones, power tools), while at the same time enabling the implementation of Li-ion technology in the emerging HEV and PHEV applications. HEVs and PHEVs will have substantial positive impact on national energy efficiency and energy independence.

91364B09-II

STTR Project - 3-D Nanofilm Asymmetric Ultracapacitor—Ionova Technologies, Inc., 182 Thomas Johnson Drive, Suite 204L, Frederick, MD 21702; 301-560-4474
Mr. Fraser Seymour, Principal Investigator; fwseymour@ionova.com
Mr. Fraser Seymour, Business Official; fwseymour@ionova.com
DOE Grant No. DE-FG02-09ER86392
Amount: $750,000

Research Institution
Florida State University

Asymmetric ultracapacitors achieve greater energy density versus today's Electric Double Layer Capacitors (EDLC) by utilizing one activated carbon EDLC ion adsorption electrode and one ion insertion (battery-like) electrode. Asymmetric ultracapacitors based on non-aqueous electrolytes provide improvements in energy density but they typically do so at the expense of power density while providing no improvement in cost, safety or in environmental impact. Alternatively, aqueous asymmetric ultracapacitors can provide improvements not only in cost, safety and in some cases, environmental impact, but can also provide greater energy and power densities than the non-aqueous approach. This project will develop an asymmetric ultracapacitors with aqueous electrolytes, based on a 3-dimensional (3-D) mixed-oxide nanofilm cathode. The high surface area 3-D nanofilm approach will reduce resistances in solvated ion transport, in solid-state ion diffusion and in electron transport thereby maximizing power density and efficiency while reducing generated heat and rate-induced capacitance fade. This approach will also improve the utilization of the active material resulting in increases in energy density while improving cost, safety and environmental impact. Following Phase I, the system will be scaled up for HEV and PHEV applications. During Phase I, a number of candidate substrate materials for the 3-D nanofilm cathode were investigated, as were a number of nanofilm active layer material combinations and anode activated carbon materials. These were characterized at the materials level and electrochemically characterized in a set of electrolytes at the electrode and lab-cell levels. During the proposed Phase II project, the awardee will perform materials and synthesis process optimization. Also, a cell will be designed, fabricated and characterized against DOE stated hybrid electric vehicle objectives.

Commercial Applications and Other Benefits: The proposed approach should lead to safe, cost-effective and environmentally benign ultracapacitor systems with increased usable energy suitable for electric vehicle, hybrid electric vehicle and plug-in hybrid electric vehicle use. Due to the unique characteristics of this chemistry, resultant ultracapacitor devices can be constructed of multiple stacked cells in a single package allowing direct support of higher voltage applications including UPS, medical, consumer electronics, power tool, military and industrial applications.

90450S09-II

Novel High Performance Li-ion Cells—Farasis Energy, Inc., 23575 Cabot Blvd., Suite 206, Hayward, CA 94545-1657; 510-732-6600
Dr. Keith D. Kepler, Principal Investigator; kkepler@farasis.com
Dr. Keith D. Kepler, Business Official; kkepler@farasis.com
DOE Grant No. DE-FG02-09ER85385
Amount: $999,999

Current Li-ion technology offers the highest energy density of any rechargeable battery system. Unfortunately, Li-ion systems still do not meet the energy density and cost goals for emerging EV markets including PHEVs. A new strategy to meeting these goals includes selecting high capacity battery materials, curently incompatible with conventional assembly of Li-ion cells in the discharged state, and using them in novel Li-ion cell designs. To achieve such a goal, a method by which Lithium can be introduced into the cell must be developed. During the Phase I project the feasibility of using a unique source of lithium for Li-ion cells assembled in the charged state was demonstrated and used in the design and contruction of new high capacity, long life Li-ion cells. For Phase II the technology will be further optimized and scaled for the development of several new Li-ion battery systems. Each system has major advantages over comparable existing batteries and will have a major impact on the lithium ion industry.If successful, the technology developed under this SBIR project will lead to the production of a large product line of safe, low cost very high capacity Li-ion battery cells and systems. These cells will meet the needs of a wide range of advanced applications in the automotive, telecommunications and military supply industries. Some of these applications include electric and hybrid electric vehicles including automobiles, scooters and bikes, satellites, stationary backup power, and portable power applications like cell phones, computers and PDA’s for both civilian and military use

90462S09-II

SICS: A Sensor-Based In-Line Control System for the Surfaces of Continuously Cast Slabs—OG Technologies, Inc., 4300 Varsity Drive, Suite C, Ann Arbor, MI 48108; 734-973-7500
Dr. Tzyy-Shuh Chang, Principal Investigator; chang@ogtechnologies.com
Dr. Tzyy-Shuh Chang, Business Official; chang@ogtechnologies.com
DOE Grant No. DE-FG02-09ER85595
Amount: $999,999

The current practice in the continuous casters, the primary steel making process in the US, has room to improve for better efficiency and energy savings. Each year, millions of tons of metal are scrapped and energy in multiple trillion BTUs is wasted, due to process limits. New sensors and advanced process control are identified needs by the steel industry to further promote process and energy efficiency. The proposed project brings advanced imaging and process control technologies to the casting applications. The goal is to develop and demonstrate the SICS with the synergy of existing technological pool and other innovations, that work in the continuous casters, collecting data on surface features, verifying product quality, and providing process control to casting processes. During the Phase I project, the feasibility of the proposed SICS technologies was proven by way of installing a test unit in a slab caster. The critical performance indexes were verified. Market potential was also affirmed through close interaction with potential customers. The Phase II project is aiming at further development such that the innovations become a product with commercial value. That is, the technologies shall be made reliable, functional, applicable to a large scale, and easy to use. The work will be carried out for a period of two years by an academia-industrial team. The SICS will have a high impact. For the US steel industry, the SICS has the potential to improve the productivity by $1,000 million and save 30 trillion BTUs annually through improved yield and simplified processes in the continuous casters. This will also result in a reduction of 1.8 million tons in carbon-dioxide emissions. OGT expects to have a 10% market penetration by 2016 with a marketing strategy. It includes the pathway to build up the workforce in marketing, production and service, and the potential sources for required financing, space and equipment. Estimated annual sales for the SICS in the target applications to is more than $6 millions in the US by 2017. The potential abroad is $36 millions. Without SBIR funding, the SICS will be either delayed for a substantial time period or dropped and the benefits will be deferred or lost entirely.

90469S09-II

Real-Time Industrial Sensors for Process Control—Los Gatos Research, 67 East Evelyn Avenue, Suite 3, Mountain View, CA 94041-1529; 650-965-7772
Dr. Douglas Baer, Principal Investigator; d.baer@lgrinc.com
Dr. Anthony O'Keefe, Business Official; a.okeef@lgrinc.com
DOE Grant No. DE-FG02-09ER85468
Amount: $742,283

Effective monitoring and control of steel manufacturing plants, industrial furnaces, boilers, incinerators and other combustion systems is limited by the accuracy, sensitivity, specificity, speed (time response) and reliability of available sensors. As a result, industrial high-temperature processes release excessive toxic emissions, pollutants, and greenhouse gases and consume excessive energy during operation. The proposed project will yield a novel, robust instrument capable of accurately measuring several critical (off-gas) exhaust emissions (pollutants and greenhouse gases) in real time with unprecedented speed and reliability. The proposed instrument will be developed, tested and deployed in two steel manufacturing plants in Phase II to monitor several gases simultaneously to help increase process efficiency and significantly reduce hazardous and toxic gas emissions. An instrument based on tunable narrow-bandwidth mid-infrared lasers and open-path absorption spectroscopy will be developed and demonstrated to provide measurements with unprecedented speed, specificity and robustness for monitoring and control of industrial efficiency, unwanted pollutants and greenhouse gases. In Phase I, the instrument was demonstrated in a high enthalpy, high velocity flowfield generated by heterogeneous combustion processes. In Phase II, in collaboration with several industrial partners, the instrument will be deployed for long-term measurements of multiple pollutants and greenhouse gases and temperature in steel production plants and incorporated into a closed-loop system for real-time process control. LGR designed, developed and tested a novel breadboard instrument capable of monitoring several exhaust gas emissions from power plants, furnaces, boilers, incinerators and other combustion-based systems in real time with high speed and specificity. The instrument was deployed in a high enthalpy high velocity flow generated by heterogeneous combustion process for measurements of gas species and gas temperature in real time. In Phase II, the system will be incorporated into multiple industrial plants to validate performance and demonstrate ability for continuous measurements and control over extended periods, and incorporated into a closed loop system for real-time process control.

Commercial Applications and Other Benefits: Instrumentation for monitoring combustion emissions (e.g., from power plants, furnaces, boilers, incinerators), for monitoring and control of industrial processes, for monitoring atmospheric pollutants, pollutants and greenhouse gases, and for engine diagnostics and automobile monitoring.

90479S09-II

Structured Emission Thermometry Sensor for Burner Control—Spectral Sciences, Inc., 4 Fourth Avenue, Burlington, MA 01803-3304; 781-273-4770
Dr. Jason Cline, Principal Investigator; jcline@spectral.com
Ms. Leslie McCarthy, Business Official; lmccarthy@spectral.com
DOE Grant No. DE-FG02-09ER85444
Amount: $999,943

Industrial processes such as glass production burn huge quantities of natural gas. Burner settings are often set with large error margins to avoid producing pollution. They are also frequently set "by eye" and with feedback from one global stack-gas sensor, which tends to obfuscate which burner is improperly set. These margins and errors create inefficiencies and increase pollution. We are applying our patented passive optical thermometry technology into a new imaging sensor that will integrate into the burner control system. With this sensor, operating margins can be reduced, increasing fuel efficiency without increasing pollution. It will also provide a tight control feedback loop that would enable a burner controller to optimize the flame automatically and reproducibly. In Phase I we used spectrometers and a multispectral camera to take images and spectra of the flame from a 2 MMBtu/h high-luminosity oxy-fuel burner over a range of nominal and off-nominal operating conditions. The data show several metrics that correlate with flame condition. In Phase II, we will develop the instrument software to automatically perform the spectral and spatial processing that was performed manually in Phase I. The instrument will be fielded into an industrial setting and applied in a control loop.

Commercial Applications and Other Benefits: When the imaging sensor is integrated into the burner control, the producer of those burners that have the control system will have a product that delivers more heat to the load using the same amount of gas, increasing their competitive advantage. The industrial customers (e.g., glass manufacturers) will benefit by reducing fuel consumption and pollution per unit output, thus saving money and improving the environment. The US benefits from efficient use of fossil fuels and decreased pollution.

90495S09-II

Arc Tube Coating System for Metal Halide Color Consistency—Energy Focus, Inc., 32000 Aurora Road, Solon, OH 44139-2814; 440-715-1299
Dr. Roger Buelow, Principal Investigator; rbuelow@efoi.com
Dr. Karen Leak, Business Official; kleak@efoi.com
DOE Grant No. DE-FG02-09ER85360
Amount: $999,999

Color consistency of metal halide lamps must be improved in order to have this high efficiency technology maintain market share in the big-box retail / industrial market and to gain market share in the accent / commercial spot lighting market. Big-box retail stores and industrial space use high wattage metal halide lights today, but the lack of color consistency has been leveraged by Light Emitting Diode fixtures who offer to provide a very consistent color at a higher cost and lower efficiency. The accent and commercial spot lighting markets are dominated by inefficient Tungsten-Halogen lamps. Energy-efficient replacement technologies for incandescent spot lighting do exist but have been slow to gain acceptance because of large variability in lamp color and high initial cost. The proposed project will create an automated color modification system for metal halide lamps to reduce their color variations to equal that of incandescent lamps. Warm color metal halide sources can be made to fall within a single color oval (no perceived color differences). This color correction will enable market acceptance of the unique metal halide systems which outperform incandescent, ceramic metal halide and light emitting diode systems in cost-of-light. Software and programming which demonstrate the feasibility of the color correction algorithm. Real-life manufacturing process and variability were integrated into the simulation. The algorithm enables a metal halide lamp group to have a warm color and very tight color variation. The simulations and programming will be optimized and used to control hardware and coat substrate. The lamps will be manually handled in year one and robotically handled in year two. Cross cutting applications in light emitting diodes and photovoltaics will be explored.

Commercial Applications and Other Benefits: The technology allows high efficiency metal halide technology continue to serve its existing market and expand to new commercial applications. Commercial applications include both new construction projects and retrofits which could be driven by a simple desire for energy savings or customers who are pulled by regulations and incentives

90502T09-II

STTR Project - Lighting with No Watt Left Behind—NEMOmetrics Corp., 3 Tremont St, Suite 202, Charlestown, MA 02129-3108; 617-388-5550
Dr. Elmer C. Lupton, Principal Investigator; neil@nemometrics.com
Dr. Elmer C. Lupton, Business Official; neil@nemometrics.com
DOE Grant No. DE-FG02-09ER86399
Amount: $750,000

Research Institution
The Massachusetts Institute of Technology

Lighting a very large fraction of the electrical energy consumed in industrial and commercial facilities. Much of this energy is wasted because rooms and areas are unoccupied or underoccupied or are occupied for only a fraction of the day. Lighting management systems to date are expensive, complex, require multiple sensors, can involve elaborate networking and can rely on movement of occupants rather than simply presence.Technology will be developed and demonstrated to use the inherent properties of the lights themselves to detect occupancy and create a system to reduce greatly energy consumption in unoccupied areas. The system will be inexpensive, easy to install and flexible in design.Light fixtures were tested and the concept was demonstrated of using inherent properties of the lights to detect occupancy, control lighting and reduce energy consumption. Measurements were made of system detection range and capability.Fluorescent light ballasts will be designed, built and tested to refine the technology. Capability will be demonstrated in actual service. The capability will also be extended to control of solid state lighting systems (i.e. LEDs) and to building energy management systems controlling other energy consuming systems like HVAC.

Commercial Applications and Other Benefits: Commercial products will include light ballasts with inherent occupancy monitoring, self regulation and energy saving capability. Benefits can include substantial energy saving and easy to implement energy management systems.

90503S09-II

Networked Lighting Power and Control Platform for Solid State Lighting in Commercial Office Applications—Redwood Systems, Inc., 3839 Spinnaker Court, Fremont, CA 94538-6537; 510-270-5355

Mr. Mark Covaro, Principal Investigator; mark@redwoodsystems.com
Mr. Jeremy Stieglitz, Business Official; Jeremy@redwoodsystems.com

DOE Grant No. DE-FG02-09ER85408
Amount: $997,500

Lighting control systems are expensive, complex, and often piecemeal in their approach to how to manage light spaces. We aim to take advantage of the unique voltage and power properties of solid state lighting (SSL) to create a novel lighting power and control system that addresses cost, energy usage, complexity, and comprehensive coverage. For solid state lighting, Redwood Systems sees cost-savings opportunities by centralizing power conversion in an electronic appliance capable of powering or dimming up to 64 light fixtures over low-voltage wiring (e.g. Category 5 cable). Through this centralized power conversion, costs associated with electrical conduit, circuit relays, switches, and light ballasts/drivers will be reduced. With this new network infrastructure in place, we can also more easily install, commission and automate the discovery and configuration of per-light motion and ambient light sensors to reduce lighting energy consumption by 50-75% with comprehensive daylighting, occupancy sensing, scheduling, demand response, and user tasking features. In Phase I, basic validation of the power, control, and communications architecture was validated. Successful integration of software and hardware to permit powering and control of commercial office space was demonstrated. In addition, the ability of the system to gather data was shown. Redwood Systems will complete research, design, and development work for global export of the system, improve system electrical efficiency, add the capability to power the system directly from local renewable energy sources, and develop software enhancements to improve monitoring and control of energy usage.

Commercial Applications and Other Benefits: The Redwood architecture is designed for commercial offices, schools and universities, healthcare facilities, hotels and restaurants, and government facilities. By combining three typically discrete systems (power, communications, sensors) into one low-voltage networked system, Redwood's LED lighting platform will make smart buildings vastly simpler, easier, and lower cost to own and operate.

90521S09-II

High-Efficiency Microalgae Biofuel Harvest and Extraction Using Ionic Liquids—

Streamline Automation, LLC, 3100 Fresh Way SW, Huntsville, AL 35805; 256-713-1220
Dr. Rodrigo Teixeira, Principal Investigator; Rodrigo.Texeira@StreamlineAutomation.biz
Mr. Alton Reich, Business Official; Alton.Reich@StreamlineAutomation.biz
DOE Grant No. DE-FG02-09ER85607
Amount: $999,874

Producing renewable fuels from algae does not use agricultural lands and could make the US energy-independent while drastically reducing greenhouse gas emissions. However, biomass processing steps are currently. We are exploring new chemistry to obtain an energy- and cost-efficient way to dry algae biomass and extract energetic substrates for conversion into renewable fuels. We have discovered and demonstrated a chemical reaction that dries biomass, lyses (breaks up) algae cells, and extracts its lipids. The reaction is fast at atmospheric pressure and low temperatures, and produces greater lipid yields than conventional methods. Furthermore, the reaction is scalable, works with any algae species, does not use hazardous chemicals, and consumes less than10% of the net energy gain. We plan to develop a laboratory-scale Pilot Plant based on the reaction demonstrated in Phase I. The Pilot Plant will accept moist algae and output: *i*) lipid stream, *ii*) a carbohydrates and proteins stream, *iii*)water stream. The Pilot Plant will yield engineering data, Net Energy Gain analysis and Economic Feasibility studies to help attract the necessary investors and partnerships to reach commercialization of the industrial-scale process.

Commercial Applications and Other Benefits: Our algae drying and extraction technology, if coupled to breakthroughs of similar magnitude in algae cultivation, could make renewable fuels cost-competitive with fossil fuels in the near future, given that microalgae is the only crop that can grow in unproductive lands and with sufficient energy yields to completely displace all fossil transportation fuels consumed in the US, the end result is a real potential for making this country energy independent while curbing CO2 emissions worldwide.

90556S09-II

Optimization and Low Energy Production of Woody Biomass Particles—Forest Concepts, LLC, 3320 West Valley Highway N, Suite D110, Auburn, WA 98001; 253-333-9663
Dr. James Henry Dooley, Principal Investigator; jdooley@forestconcepts.com
Dr. James Henry Dooley, Business Official; jdooley@forestconcepts.com
DOE Grant No. DE-FG02-09ER85577
Amount: $999,999

Conventional biomass comminution machines like chippers, grinders, and hammer mills consume too much energy and produce feedstocks with wide size distributions and poor flow characteristics. Next generation biorefineries will require low-cost feedstocks with engineered properties optimized for particular conversion processes. We will optimize our new high quality, low cost, granulated densified biomass feedstock for candidate biochemical and thermochemical conversion systems. We will develop modular comminution units and subsystems — based on low-energy rotary bypass shear machinery — for next generation biorefinery applications. We developed a new class of low-cost, flowable, precision particles from woody and herbaceous biomass by working with the structural and mechanical properties of the plant materials. We identified specific particle properties that can be readily optimized to enhance the performance and efficiency of next generation conversion processes including pyrolysis, fermentation, and steam explosion. We will (1) develop particle size, shape, surface area, species, and uniformity specifications for candidate chemical and thermochemical conversion processes; (2) design and demonstrate low-energy manufacturing process and machinery to produce the optimized particles in bulk quantities; and (3) develop mathematical models that document the associated energy, capital and operating costs.

Commercial Applications and Benefits: The Phase II results will enable design, manufacture and implementation of a new class of low-energy comminution equipment for biorefineries and their feedstock suppliers. Our Phase I data indicates that comminution energy costs can be reduced by at least 50 percent, compared to grinders and hammer mills, while producing flowable precision feedstocks with enhanced conversion properties.

90568T09-II

STTR Project - Development of a Self-Adaptive Air Turbine for Wave Energy Conversion using an Oscillaating Water Column (OWC) Air System—Concepts NREC**,** 39 Olympia Avenue**,** Woburn, MA 01801-2073; 802-280-6170
Mr. Francis Anthony DiBella, Principal Investigator; fdibella@conceptsnrec.com
Mr. Robert Hewett, Business Official; rdh@conceptsnrec.com
DOE Grant No. DE-FG02-09ER85319
Amount: $749,966

Research Institution
Maine Maritime Academy

The oscillating water column (OWC) wave energy conversion system has the highest potential of providing efficient renewable energy in the form of electric power but its efficiency to recover a wider range of wave energy frequency and amplitudes must be improved to make the system economics viable. The efficiency can be improved if the OWC wave energy systems can be "tuned" to adjust for changes in wave energy climates but without increasing the complexity and hence overall cost to manufacturer of operate the system The Phase 1 STTR effort identified several simple and cost effective methods of improving the energy recovery of OWC systems by as much as 30% by using a Turbine Shutter Valve that can improve the overall turbine efficiency by eliminating low air flow rates through the turbine which reduces turbine efficiency. Also it has been shown that controlling the height of the OWC with respect to the mean water wave level can "tune" the OWC system to recovery more energy from a wider range of incident waves. The numerical models that determined the benefits of these innovations was validated by wave tank experiments by the Maine Maritime Academy project collaborators. The concepts NREC project team will continue to include faculty members from the Maine Maritime Academy but also the collaboration of the world's leading developer of water wave energy conversion systems: Oceanlinx Ltd. The phase 2 work will validate the Turbine Shutter Valve design concept with wave tank experiments using Maine Maritime Academy's wave tanks. MMA will also complete a feedback control algorithm based on the previous numerical modeling that can affect control of the Shutter Valve and the height of the OWC system. Oceanlinx will make available their prototype component test platform: an in-water OWC system that is designed to provide actual test experience for proposed OWC components.

Commercial Applications and Other Benefits: The purpose of the proposed research is to increase the energy recovery from a wider range of incident wave energies; estimated to be as high as 30%. This increase in energy recovery is in effect a reduction in the cost per kW for an OWC system. This cost reduction improves the economics of the OWC application and thus makes the system more attractive to entrepreneurial commercial developers and/or governmental or institutional funding agencies. The net benefit to the world is to make available a viable, renewable energy resource that can be used to recovery the projected 17.5 x 1012 kW-hr energy from the world's oceans. Assuming even a 0.1% utilization factor of the world's ocean energy, this is enough energy to power an additional 70 million households throughout the world.

90573S09-II

MECT, The Next Generation Hydrokinetic Turbine—FloDesign Inc., 380 Main Street, Wilbraham, MA 01095; 413-596-5900
Mr. Jeffery King, Principal Investigator; jking@lodesign.org
Mr. Arthur Martin, Business Official; amartin@flodesign.org
DOE Grant No. DE-FG02-09ER85576
Amount: $999,911

The problem addressed herein is that of increasing the USA's renewable energy portfolio further toward a state of energy independence and security. This will be addressed by demonstrating a new, novel, hydrokinetic water turbine, the Mixer-Ejector Hydrokinetic Turbine (MEHT), a new type of shrouded hydrokinetic turbine incorporating proven aerospace propulsion and power technologies into an integrated, tightly coupled system delivering extremely high hydrodynamic efficiency levels. Compared to its unshrouded counterpart, MEHT provides three or more times as much power while shifting the bulk of the axial loads off the rotating elements to the static structure—thus providing a significantly more robust structure and efficient system than exists in the marketplace today. MEHT, with it's very low cost-of-energy, will serve as a catalyst to excite and ignite the relatively nascent hydrokinetic water turbine market. The overall objective of this program is to demonstrate MEHTs high performance levels in a flume and tidal test facility. Phase I of the program utilized the demonstrated very high performance (nearly three times the Betz limit) of MEWT's wind turbine counterpart the Mixer-Ejector Wind Turbine (MEWT), combined with new analytical and computational fluid dynamic studies to verify the MEHT concept. Also, an in-depth study of MEHT's potential impact on fish was conducted indicated the potential for a very low degree of fish mortality. Additionally, Phase I provided design a prototype model and detailed test plan for Phase II performance testing. In the proposed Phase II, which will be significantly cost-shared, a prototype model will be tested in both Alden Labs flume and in the tidal test facility at the University of New Hampshire. MEHT's performance and structural breakthroughs will be used to assure the economic viability of water hydrokinetic turbines for application in rivers/streams, tidal currents and ocean currents, and thereby help transform and accelerate this energy sector to a significant contributor of electricity in the US renewable energy portfolio. An aggressive commercialization plan is provided for entry into the market within three years.

90589S09-II

High-Voltage, Highly-Efficient, Power-Dense Electronic Converter Using Silicon Carbide and AC-link—Princeton Power Systems, Inc., 201 Washington Road, Building #2, Princeton, NJ 08540-6642; 609-955-5390

Mr. Erik Limpaecher, Principal Investigator; elimpaecher@princetonpower.com
Mr. Darren Hammell, Business Official; dhammell@princetonpower.com

DOE Grant No. DE-FG02-09ER85332
Amount: $999,205

Ocean and hydropower generators face unique problems transmitting power to shore and integrating with the electric grid. As gridintegration standards evolve, power electronics are usually required, and they face unique formfactor and environmental challenges in marine applications. There is a need for advanced highpower electronic converters that are small, watercooled, and efficiently and cost-effectively connect to highvoltage transmission lines. A highpower converter that uses silicon carbide devices, enabled by the AClink circuit design, will have a much higher powerdensity and allow direct connection to 12 kV or higher power lines, without a transformer. This will drastically reduce the space and logistics requirements for ocean and hydropower systems, and increase the efficiency of transmitting power and interconnecting with the utility grid. In Phase I, Princeton Power Systems conducted a feasibility study for a highpower converter that uses silicon carbide devices enabled by the AClink circuit. The team generated a product specification and product design achieving 98.0% efficiency and 3.0 MW/m^3 power density, verifying that the Distributed Generation Transformer can meet its stated goals. For Phase II, our team will create a highpower prototype converter to demonstrate highvoltage interconnection and operation. The team will design, assemble, and perform functional testing, while establishing manufacturing capabilities for commercialization. Furthermore, the team will identify commercialization opportunities in the developing wave/tidal energy market for Phase III.

Commercial Applications and Other Benefits: 1) Wave Power 2) Tidal Power 3) OffShore Wind Power 4) Highvoltage transmission 5) Distributed Generation

90612S09-II

Tapered Composite Wind Turbine Tower Utilizing CNC-Machined Pultruded Lineals—Ebert Composites Corporation, 651 Anita St., STE B8, Chula Vista, CA 91911; 619-423-9360

Mr. David Johnson, Principal Investigator; davidj@ebertcomposites.com
Mr. Scott Garrett, Business Official; garrett@ebertcomposites.com

DOE Grant No. DE-FG02-09ER85574
Amount: $998,853

The wind turbine industry is in need of lighter weight and lower cost support towers. Composite materials can offer many advantages to small wind systems. But also, the technology developed in the Phase I can apply to very large wind turbines up to 5 MW, and in environments of the future, such as off-shore in the US in deep water. During Phase I, Ebert Composites has developed a hybrid composite pole support that can be adapted to very large wind turbine structures. Working with the University of Maine, Ebert has developed a low cost hybrid pole structure that has great potential for off-shore applications. Additionally, the technology can scale to any sized installation including small wind at 100 KW. In Phase I, Ebert's composite pole technology was modified with a hybrid design that allows low cost capability, derived from what was strictly an electric utility pole structure. Through testing Ebert verified the feasibility of its proposed concept. In Phase II Ebert Composites will design, fabricate and test a wind turbine support structure that will be capable of supporting the largest wind turbine system available today.

Commercial Applications and Other Benefits: Ebert's design will enable future systems, by economically providing a solution to difficult installations, with transportation and construction issues. This will particularly solve some key problems associated with current tower technologies in off-shore applications.

90616S09-II

Improved Wind Blade Joints Based on 3D Fiber Architecture—3TEX, Inc., 109 MacKenan Drive, Cary, NC 27511; 919-481-2500

Dr. Keith Sharp, Principal Investigator; cpgaylor4@gmail.com
Mr. Charles Gaylor IV, Business Official; pennellp@3tex.com

DOE Grant No. DE-FG02-09ER85567
Amount: $999,370

Wind blades are complex constructions of composite materials. As with all composite structures, forming joints between the various elements has long been problematic, since composites cannot easily be bolted, fastened, or welded together. Current manufacturing methods result in thick adhesive layers that have varying dimensions and which are the most common failure area in wind blades during operation in the field. Integral Pi shaped (shaped like the Greek letter π) and "Y" –shaped joints based on 3-D fiber architecture preforms will be used to form the joints at the shear web and trailing edges, respectively. Pi joints of similar construction have demonstrated about two fold increases in strength in carbon composite aircraft structures and in glass fiber composite naval structures. When infused at the same time as the wing structure, manufacturing labor will be reduced and manufacturing variability will be reduced. Novel joint sections with integral 3-D fiber architecture Pi joints up to 2 meters long were fabricated using the most common resin infusion technique in the wind blade industry, Vacuum Assisted Resin Transfer Molding. Computer modeling of preliminary joint architectures under loads representative of those experience by wind blades showed a 20% increase in joint strength, as well as a 10% increase in joint stiffness, compared to a traditional wind blade joint structure. Sections with various joint architectures will be modeled, fabricated, and tested to gain improved understanding of the internal stresses and thus to optimize their strength and stiffness. Full wind blades with the optimized novel 3D fiber architecture joint structures will then be manufactured at commercial wind blade manufacturer and will undergo static and limited fatigue testing at a certified test center. These efforts will verify the manufacturing labor savings and increased strength of the novel 3D fiber architecture joints, enabling engineers and designers to incorporate them into new wind blades.

Commercial Applications and Other Benefits: The target application is for wind blades. However, the results will be more broadly applicable to a wide range of composite structures.

90639S09-II

An Advanced Vibrothermography Approach for Wind Turbine Applications—Resodyn Corporation, 130 North Main, Suite 600, Butte, MT 59701-1394; 406-497-5252
Mr. Peter A. Lucon, Principal Investigator; Plucon@Resodyn.com
Mr. Lawrence C. Farrar, Business Official; LCFarrar@Resodyn.com
DOE Grant No. DE-FG02-09ER85414
Amount: $999,999

The reliability of a wind turbine system is greatly impacted by hidden defects. An improved method of inspection is sought for manufactured composite materials. Also, field inspection methods to assure quality during and after installation are required. The ultimate goal of this project is to provide a reliable, portable, instrumentation deployment system that can be utilized during wind turbine composite members manufacturing, at the time of installation, and throughout the lifetime of a wind turbine system. An advanced Vibrothermography technique developed by this work will be designed to detect and characterize the manufacturing flaws and the damage done to turbine blades and supporting structures thought their service life. Algorithms will be derived to distinguish and determine the types of manufacturing defects, shipping damage, and fatigue related failure flaw types. The feasibility to generate heat in embedded flaws, surface flaws, surface cracks, and subsurface cracks in glass/epoxy composite samples and to thermographically detect those flaws was demonstrated. The energy and transmissibility of the sound waves used to excite the flaws was demonstrated at a flaw to excitation transducer distance of 24 inches for samples up to 2 inches thick. The Phase II project goal is a prototype development platform capable of demonstrating the technology on actual wind turbine components. The information from the demonstration/qualification test will be compared to other test methods, which are being explored through the Sandia led wind blade reliability collaborative for the DOE EERE Wind and Water program.

Commercial Applications and Other Benefits: Yearly operation and maintenance costs are approximately 30% of the total cost of a wind turbine. The proposed improved inspection technology can reduce manufacturing flaws, improved detecting field flaws during operation, and generally improve system reliability and therefore reduce maintenance costs. The overall net benefit to the public will be lower operating cost resulting in lower customer rates. An additional benefit of the proposed technology is that a final commercial system will include software algorithms for “smart” detection and identification of flaws; therefore, interpretation of the results does not require a high level of skill.

90675S09-II

Seismic Sensor—MagiQ Technologies, 11 Ward Street, Somerville, MA 02143; 617-661-8300
Dr. Keun Lee, Principal Investigator; anton@magiqtech.com
Dr. Andrew Hammond, Business Official; andy@magiqtech.com
DOE Grant No. DE-FG02-09ER85558
Amount: $999,835

Enhanced geothermal system has emerged as one of the key technologies for largescale use of costcompetitive geothermal energy. Enhanced geothermal system needs seismic sensors at the downhole depths for accurate mapping of the rock fractures before and after stimulation. Unfortunately, currently available seismic sensors are electronicsbased and cannot operate in the downhole environment where the temperature may reach well over 250°C. MagiQ addresses this problem by eliminating all electronic components from the borehole sensor and use fiber optic telemetry and a stateoftheart pathmatched differential interferometer to precisely measure the displacement of the seismic inertial mass. All signal processing electronics including optical sources and detectors will be located in the much less hostile environment at the surface, and the resulting sensor can measure inertial mass motion with better than 1 nm resolution. We designed, fabricated and tested a prototype flexure based sensor. Phase I results validate the feasibility of our optical approach to hightemperature seismic sensing for geothermal applications. We plan to design, manufacture and fieldtest a fully functional system prototype. It will include a surface located control station, 12,000ft long suspension/datalink fiber cable and a complete 3C sensor. The hermetically sealed sensor will contain three separate sensing heads – one for each direction of motion.

Commercial Applications and Other Benefits: Hightemperature seismic sensors will be in a great demand as the national interest in geothermal energy grows. In addition, the proposed sensor can also be used in hazardous industrial environments where conventional seismic or vibration meters fail.

90682S09-II

Fiber Optic High Temperature Seismic Sensor—Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088
Mr. Alexander Parfenov, Ph.D., Principal Investigator; EOSProposals@poc.com
Mr. Gordon Drew, Business Official; gedrew@poc.com
DOE Grant No. DE-FG02-09ER85313
Amount: $999,996

The U.S. Department of Energy (DOE) is seeking development of seismic sensors, under its Geothermal Technologies Program, to support the subsurface monitoring of geothermal reservoirs during reservoir stimulation and operation. It is anticipated that these sensors will respond within the frequency range from sub-Hz to multi-kHz, be compatible with packaging for downhole deployment, including the capability to operate within the temperature range from -20□C to +250□C, and having an expected operating lifetime of 5000 hr. Physical Optics Corporation (POC) proposes an innovative Fiber Optic High Temperature Seismic Sensor (FOTSS) technology based on a microbending sensor design using multimode fibers, which is stable at elevated temperatures. Using optical time domain reflectrometry with a diode laser for interrogation, and digital signal processing, the sensor provides sensitivity over a wide frequency range (sub-Hz to multi-kHz). In Phase I POC successfully demonstrated the feasibility of the FOTSS approach through computer simulations, developing and demonstrating a working prototype based on a series of proof-of-concept experiments and tests. POC demonstrated that the FOTTS Phase I prototype has sensitivity down to sub-mg levels with a bandwidth of 1400 Hz and high temperature resistance up to +250□C. The results of the testing were in good agreement with the simulation and modeling results. In Phase II POC plans to further develop the FOTSS system. POC will bring to maturity the FOTSS technology proven feasible in Phase I, and build a full-scale prototype FOTSS system for geothermal energy source monitoring directly applicable to DOE tasks.

Commercial Applications and Other Benefits: The proposed sensor addresses the major DOE requirements for high-temperature endurance (250□C for 5000 hr), wide (several kHz) bandwidth, seismic sensor solution. High-temperature-resistant, permanent downhole sensor technologies support the expansion of geothermal energy by improving safety and enabling the development of new techniques to identify and monitor geothermal resources. In addition to geothermal well monitoring, commercial applications include deep oil and gas well seismic profiling for exploration and monitoring, environmental monitoring, and vibration measurements in high-temperature environments (e.g., engines, motors, rockets, and wind turbines). Additional markets exist for “spin-off” applications including acoustic security systems for industrial and household use.

90690S09-II

Process Intensification of Hydrogen Unit Operations Using an Electrochemical Device—H2 Pump, LLC, 11 Northway Lane North, Albany, NY 12110; 518-783-2241
Dr. Glenn Eisman, Principal Investigator; glenn.eisman@h2pumpllc.com
Dr. Glenn Eisman, Business Official; glenn.eisman@h2pumpllc.com
DOE Grant No. DE-FG02-09ER85580
Amount: $771,088

There is a need to develop simplified hydrogen production and delivery technology so as to make alternative power generation devices such as fuel cells more reliable and cost effective. Successful implementation of these devices for numerous applications, including transportation and stationary power, will have a positive impact on the energy security and of the United States and the environment. Current methods used to process hydrogen include mechanical compressors followed by passive membrane separation systems. Together these processes are costly and are not amenable to variable operating modes or low volume applications. The problem is being addressed by utilizing an electrochemical method which combines hydrogen recovery, purification, pumping, and pressurization into a single, cost effective, efficient, and non-mechanical process. In Phase I, H2Pump's proprietary industrial electrochemical process technology was modified and adapted to successfully demonstrate the multi-functionality of the device using reformed hydrogen. Pumping, purification, and pressurization functions were demonstrated in a single device after evaluating numerous engineering configurations and materials options. However, optimization of the technology is required to reliably service all aspects of the application. Phase II efforts will focus on 1) advanced engineering solutions of the core stack-membrane module, 2) demonstrate the technology at a larger scale, 3) and integrate it with a reformer. The processed gas using this approach will then be fed to a fuel cell.

Commercial Applications and Other Benefits: The commercial benefits of the H2Pump device, in addition to simplifying hydrogen processing costs for the emerging alternative power generation applications, are realized in the immediate application of hydrogen recovery and recycling in industrial processes. Most industrial hydrogen is vented or combusted after use and H2Pump's device can reclaim this "waste" hydrogen for reuse, this reducing operating costs and hydrogen consumption. Alternatively, this reclaimed hydrogen can be used for on-site power generation. Public benefits include reduced emissions as well as a reduced carbon footprint as less hydrogen would be generated from methane, i.e., lower carbon dioxide resulting from the production of hydrogen.

90702S09-II

Unitized Design for Home Refueling Appliance for Hydrogen Generation to 5000 psi—Giner Electrochemical Systems, LLC, 89 Rumford Avenue, Newton, MA 02466-1311; 781-529-0504
Mr. Timothy J. Norman, Principal Investigator; tnorman@ginerinc.com
Dr. Anthony J. Vaccaro, Business Official; avaccaro@ginerinc.com
DOE Grant No. DE-FG02-09ER85404
Amount: $999,053

U.S. automakers have invested significant resources in the research and development of hydrogen fuel-cell vehicles. However, to enable their widespread use, an additional major investment will be required to construct an infrastructure for hydrogen production and delivery to fueling stations. In order to facilitate this transition, the DOE has recommended that high-pressure hydrogen generation for home refueling of fuel-cell vehicles be implemented as an intermediary approach. The proposed design concept will demonstrate a stationary cost-effective method for the generation of high-pressure hydrogen by means of "unitizing" a PEM-based electrolyzer stack with most major system components inside a pressurized safety dome. The combination of components eliminates the need for bulky and costly stack parts and facilitates a method for producing an electrolyzer stack that can safely operate at a balanced hydrogen pressure of 5,000 psig. In addition, a reduction of major system components and system cost is realized. The central aim of the Phase I program was to develop a novel, low-cost design for a unitized Home Refueling Appliance for hydrogen fuel cell vehicles. Innovative features involved modifications to simplify the design, primarily by replacing electrically-activated subsystems (pumps, radiator fans, etc.) with passive subsystems (thermosiphon for water circulation, passive cooling systems, etc.) An economic analysis showed the commercial feasibility of the proposed unitized design: it will be able to provide on-site residential hydrogen refueling at a cost that is below the DOE goal of $3.00/kg in 2017. The primary technical objective of the proposed Phase II research and development program is to demonstrate a thermosiphon-based, cathode-feed proton exchange membrane (PEM) water electrolyzer. The technology utilizes a "unitized" design concept, passive cooling, a pressure-swing adsorption (PSA) hydrogen dryer, and an advanced dimensionally-stable membrane (DSM™) to reliably and economically provide 5,000 psig hydrogen for residential vehicle refueling.

Commercial Applications and Other Benefits: A low-cost process for producing high-pressure hydrogen from water by electrolysis will significantly advance the development of the hydrogen economy, providing hydrogen for fuel-cell vehicles at a price competitive with that of gasoline on a per-mile basis. The ability to produce hydrogen economically, the relatively low capital cost of the electrolyzer unit, and the low maintenance cost of the unit will allow widespread distribution of hydrogen home fueling appliances deemed necessary for the introduction of fuel cell vehicles. In addition, the use of renewable energy for hydrogen production will provide a domestic source of fuel, offsetting U.S. dependence on foreign oil, and will reduce pollutant emissions, particularly if wind or solar power is the renewable energy source.

90709S09-II

Hydrogen by Wire Home Fueling System—Proton Energy Systems, 10 Technology Drive, Wallingford, CT 06492-1955; 203-678-2338
Mr. Luke Dalton, Principal Investigator; ldalton@protonenergy.com
Dr. Stephen Szymanski, Business Official; sszymanski@protonenergy.com
DOE Grant No. DE-FG02-09ER85340
Amount: $999,999

One of the challenges associated with transitioning our nation's transportation economy to any alternative fuel is bringing fuel production, storage, transportation and end-customer delivery infrastructure online. In the case of hydrogen as a transportation fuel, the network of fueling stations may include a combination of centralized and de-centralized fuel production. The continuum of centralized to de-centralized production includes the highly centralized massive hydrocarbon fuel processing plants that may number in the tens to hundreds, to neighborhood fueling stations that may number in the tens to hundreds of thousands, to the ultimate decentralized solution of home fueling stations that may number in the millions. The home fueler is the least defined of these options but has applicability besides in home fueling. The goal of this Department of Energy sponsored project was to develop requirements for a 5000 psi home-based hydrogen fueler, design concepts trading various parameters, and evaluate the feasibility of those concepts in meeting the requirements of the home fueler application. One of the most attractive ways to implement a home hydrogen fueling station is the proton exchange membrane (PEM) water electrolysis hydrogen generator. Proton's technology is currently able to generate hydrogen at 2400 psi. Increasing this capability to 5000 psi would allow elimination of all mechanical compression, while enabling a completely carbon free cycle when the fueler is integrated with a renewable energy source. Phase 1 focused on three major areas: 1) technical requirements definition to determine driving distance, recharge time, and resultant component sizing, 2) cost analysis based on design trades for power supplies, cell stack sizes and compression and storage scenarios, and 3) installation analysis including codes, standards, and safety requirements. Based on these areas, a conceptual design was developed. In Phase 2, build of a prototype 5000 psi PEM system is planned. Specific tasks will focus on prototype system design, prototype stack design, component verification, and system testing. Meeting the objectives of these tasks will provide a solid foundation for proceeding with a commercial design of the Hydrogen by Wire Home Fueling System.

Commercial Applications and Other Benefits: The high pressure hydrogen system has several potential markets. Removing mechanical compression eliminates the component with the highest ambient noise pollution and the most frequent maintenance requirements, two important factors in residential operation. The high generation pressure also allows small storage footprint, which is important in military applications such as supplementary power for submarines or unmanned underwater vehicles, where space is at a premium. It is also an attractive option for backup power when integrated with a PEM fuel cell and has advantages over batteries in factors such as available life and safety.

90764S09-II

A New Three-Part Architecture for Efficient and Stable Bulk Heterojunction OPV Devices—TDA Research, Inc., 12345 W. 52nd Ave., Wheat Ridge, CO 80033-1916; 303-940-2300

Dr. Michael D. Diener, Principal Investigator; mikee@tda.com
Mr. John D. Wright, Business Official; jdwright@tda.com

DOE Grant No. DE-FG02-09ER85499
Amount: $999,999

Rapid and encouraging progress in bulk heterojunction organic photovoltaics (BHJ OPV) has made them one of the most promising new technologies for inexpensively generating electricity from sunshine. However, power conversion efficiencies remain about ~60% of what is thought to be required in order for them to be commercially viable. Moreover, the champion devices incorporate both vacuum-deposited materials, which mitigate their advantage of inexpensive production, and highly reactive materials, which lead to poor stability. Our approach is a new architecture for BHJ OPV, which simultaneously extends the range of operation further into the red (from ~630 nm to ~850 nm and beyond) while retaining the excellent properties of the poly(3-hexyl)thiophene:fullerene blend for energy conversion at lower wavelengths. Issues related to device stability will be addressed by eliminating chemically unstable materials, which will prove to be unnecessary in the new architecture. True low-cost fabrication will also be achieved by limiting the cost of the organic materials and depositing both transparent conducting oxides and metal back electrodes from nanoparticle solutions. The new architecture proposed will lead to increased efficiency and stability while minimizing materials and production costs. That combination will lead to BHJ OPV devices that are less expensive than existing devices on a $/kW*h basis, enabling commercial utilization of BHJ OPV for electrical power production. Initial markets for BJ OPV are believed to lie in flexible and portable electronics for remote power generation, trending towards on-site business and residential power generation as manufacturing techniques are up-scaled and refined. In Phase I, we developed stable three-part BHJ OPV architectures which efficiently utilized the incident solar spectrum from the ultraviolet out to ~850 nm without an expensive low-gap polymer. The power conversion efficiency of the unencapsulated three-part devices is stable in air for at least two months. Having exhausted commercially available materials for the three-part architecture, in Phase II we will use the structure-property relationships developed during Phase I to design and synthesize molecular organic and/or inorganic materials for use in the active layer of the OPV devices. The active layer formulations will then be testes in a variety of device configurations to ascertain power conversion efficiencies and stability during illumination. The overall (Phase I & II) technical goal of this project is to produce 4 cm^2 inverted BHJ OPV devices via solvent deposition techniques with overall power conversion efficiency (PCE) of 8+%, and less than 5% drop in power output over 1,000 hours of operation.

90802S09-II

Concentrator PV Receiver Based on Crystalline Si Cells—SVV Technology Innovations, Inc., 1832 Tribute R-d, S-te C, Sacramento, CA 95815-4309; 916-226-1763
Dr. Sergiy Vasylyev, Principal Investigator; svasylyev@svvti.com
Dr. Sergiy Vasylyev, Business Official; svasylyev@svvti.com
DOE Grant No. DE-FG02-09ER85473
Amount: $999,921

The emerging concentration photovoltaic (CPV) technology has a broadly recognized potential in reducing the cost of electric power generation from sunlight and is seen as a key component of the national Solar America Initiative (SAI). However, the low- and mid-concentration CPV has suffered from inherent limitations of traditional optics and a lack of suitable receiver technology since its inception. The proposed project identifies a perfect match between the variety of solar collectors and PV cells and develops a complete CPV solution. The project strives to fill the final gap in the CPV technology by harnessing the novel Slat-Array Concentrator that provides a highly uniform concentrated flux and developing a low-cost, linear PV receiver fully conforming to the concentrator design. The new receiver will be based on inexpensive, off-the-shelf crystalline silicon (Si) cells rather than on highly specialized and costly concentrator cells employed in conventional CPV designs. The resulting CPV technology will capitalize on the mature PV technology and uniquely combine the reliability and performance of Si cells with the most recent advancements in solar concentrator optics. Our approach allows for boosting the power output from conventional Si cells by a factor of 20 while avoiding cell overheating and performance degradation due to the so called “hot spots” inherent to competing designs. This should allow for a direct reduction of the costs associated with semiconductor materials and help achieve about twice lower cost of generated electricity compared to the flat plate PV panels. We will develop an integrated CPV module based on the Slat-Array Concentrator and a linear receiver employing non-concentrating crystalline Si cells in this Phase II project. With the subsequent product development and commercialization in Phase III, we will make viable the replacement of conventional PV modules with inexpensive concentrator modules requiring a dramatically smaller quantity of Si material.

Commercial Applications and Other Benefits: The commercialization of the new concentrator PV module will help meet the national goals of securing the energy independence, reducing carbon emissions and generating a clean renewable energy from the inexhaustible and abundant sunlight.

90823S09-II

Backside Contact Multijunction Solar Cells for High Concentration Applications—Devices, Inc., 6457 West Howard St, Niles, IL 60714-3301; 847-588-3001

Dr. Chris Youtsey, Principal Investigator; cyoutsey@mldevices.com
Dr. David McCallum, Business Official; dmccallum@mldevices.com

DOE Grant No. DE-FG02-09ER85503
Amount: $999,999

The cost of electricity generated by concentrator photovoltaic systems is strongly dependent on the efficiency of the solar cells in the solar concentrator system. The efficiency of these solar cells is limited by the fact that the electrical contacts used to collect current from the solar cell are on top of the cell and partially shadow it. The top-surface electrodes prevent as much as 10% of the collected sunlight from reaching the active area of the solar cell. The problem is further exacerbated as the concentration level is increased. This problem is being addressed by developing a novel method for producing solar cells in which all electrical contacts are made from the backside of the solar cell. The backside contact is combined with an epitaxial liftoff process to facilitate the formation of the contacts and to reduce the manufacturing cost. The cost advantage is realized by multiple reuses of the expensive GaAs substrates, which significantly decreases the raw material consumption. In Phase I, a complete fabrication process was developed for producing backside contact interconnects in epitaxial liftoff-based solar cells. Detailed device simulations of the backside contact solar cell device show excellent performance under high concentration and a relative performance improvement of more than 10% at 500 suns compared with a conventional topside contact solar cell. In the Phase II project, the backside contact fabrication process will be extended to fabricate high-efficiency, triple-junction, inverted-multijunction-metamorphic epitaxial liftoff devices that are optimized for operation at high concentration. A process will be developed for attaching backside contact solar cells to submounts and these submounts will be tested in a solar concentrator test bed. The goal is to achieve a peak efficiency of >44% at 500 suns. The backside contact solar cells will also be subjected to reliability testing.

Commercial Applications and Other Benefits: The high efficiency cells to be developed in this project will be used in concentrator photovoltaic systems for utility and commercial electricity generation. The cells should result in a decrease in the cost of solar-generated electricity. Concentrator photovoltaics are projected to account for several gigawatts of generating capacity by 2020. Increased availability of low-cost solar power generation should result in reduced emission of greenhouse gases, increased domestic energy production, and increased national energy security.

90869S09-II

High-temperature Packaging of Planar Power Modules by Low-Temperature Sintering of Nanoscale Silver Paste—NBE Technologies, LLC, 2200 Kraft Drive, Suite 1425, Blacksburg, VA 24060-; 540-443-9297

Dr. Susan S. Luo, Principal Investigator; sluo@nbetech.com
Dr. Guo-Quan Lu, Business Official; gqlu@nbetech.com

DOE Grant No. DE-FG02-09ER85591
Amount: $999,999

This proposal addresses the Department of Energy's need for high-temperature packaging technologies to help automotive manufacturers to reduce costs of hybrid electric vehicles and future plug-in hybrid electric vehicles. A specific technology barrier to be removed calls for the development of a new die-attach method for joining power semiconductor chips. This die-attach technology is necessary to make double-side cooled power modules working reliably at high temperatures to meet the challenge of 105ºC inlet coolant that is risen from the need to eliminate extra cooling loops in future electric vehicles. An emerging lead-free die-attach solution, termed low-temperature joining technology by silver sintering, will be introduced for making high-temperature power modules. And, the small business's nanoscale silver paste technology will be used to greatly simplify the joining technology's implementation for fabricating planar, double-side cooled power modules. The small business's nanomaterial was successfully demonstrated as an enabling technology for making planar, double-side cooled power modules. The module was shown to be operational at chip junction temperatures over 175ºC. Other testing results show that the nanosilver sintered joints are thermally better in heat dissipation and more reliable than their soldered counterparts. Research activities of the Phase-I program will be expanded to include design, selection, and testing of substrate and encapsulation materials for making high-temperature planar, double-side cooled power modules. Multiple power modules will be fabricated and integrated with gate-driver electronics to construct inverters rated for a typical electric vehicle. Demonstration and testing results of the inverters will be used to guide the Phase III effort for manufacturing high-temperature inverters or converters in future electric vehicles.

Commercial Applications and Other Benefits: The United States' automakers would directly benefit from the successful completions of this Phase II program on the high-temperature packaging technologies and the future Phase III program on high-temperature packaging of inverters or converters. The cutting-edge technologies would provide them competitive advantage to offer consumers cost-effective, fuel-efficient vehicles. This, in turn, will help reduce the nation's reliance on petroleum and petroleum imports and decrease carbon emissions. Furthermore, the successes would allow this small business to rapidly grow its business by marketing its nanomaterial products to the auto industry. In so doing, it would create significant number of high-tech jobs for the region of Southwest Virginia which has been suffering extreme economic hardship.

90888S09-II

Wireless Electrical Resistivity Tomography System for CO2 Sequestration Monitoring—Multi-Phase Technologies, LLC, 310 Rebecca Dr., Sparks, NV 89441-7923; 775-356-7844
Dr. Douglas J. LaBrecque, Principal Investigator; dlabrecque@mpt3d.com
Mrs. Marjorie O. LaBrecque, Business Official; mlabrec913@yahoo.com
DOE Grant No. DE-FG02-09ER85245
Amount: $381,928

An effort is underway by the U.S. DOE to develop cost-effective and environmentally sound technologies in order to help to stabilize atmospheric concentrations of CO2 and to reduce greenhouse gas emissions. There is a significant need for economical methods to characterize potential sequestration reservoirs as well as determine the extent, location and nature of leaks from reservoirs both to assure that CO2 is effectively sequestered for long periods of time, and to reduce the likelihood of local environmental impacts. Electrical Resistivity Tomography (ERT) is a geophysical tool that has been used successfully to image the electrical resistivity of the subsurface, and is especially sensitive to pore fluid content. ERT is capable of monitoring movement of sequestered CO2 by measuring the change in the electrical resistivity of the subsurface, both in the saturated and vadose zones. Our ERT system under development consists of many, inexpensive, self-contained units that communicate with each other through a distributed wireless network. The capital expense of such a system would be relatively small. The operating expenses, once the system is automated, would also be small. In the Phase I project, the prototype system design was completed, a preliminary version of a new survey design strategy was implemented and a strategy for employing multiple, simultaneous current sources was developed. The new strategy will increase signal to noise levels and enhance target resolution. In Phase II Year 1 we will complete fabrication of the prototype system and operation software and adapt imaging routines for the multi-source strategy. We will complete all design upgrades and perform unit as well as full scale field tests in Year 2.

90891B09-II

STTR Project - Networked Sensors for Sequestration MVA—Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077; 978-689-0003
Dr. Michael B. Frish, Principal Investigator; frish@psicorp.com
Dr. B. David Green, Business Official; green@psicorp.com
DOE Grant No. DE-FG02-09ER86404
Amount: $749,984

Research Institution
LBNL

Geologic carbon sequestration (GCS) is advancing as a preferred means of mitigating CO2 emissions from fossil-fueled plants. To verify that GCS performs its intended function of reducing greenhouse gases, monitoring sequestered CO2 is essential**.** Novel cost-effective tools are needed for reliable longterm measurement to detect, locate, and quantify sources of any escaping CO2 or of surrogate leak indicators including CO2 isotopologues and methane. This STTR project is developing, demonstrating, and installing at a GCS site a set of gas analysis tools, based on networked Tunable Diode Laser Absorption Spectroscopy (TDLAS), which will enable cost effective monitoring and surveying for GCS site leaks. TDLAS is a flexible and configurable sensing technology for measuring trace concentrations of selected target gases in complex gas mixtures. Phase I demonstrated the feasibility of implementing low-cost networked TDLAS for monitoring and mapping leaks from geosequestration reservoir sites, and provided additional insight to the practical implementation of sensors at sequestration sites. Specifically, Phase I showed the use of fiber-coupled TDLAS multiplexing to measure and coarsely map CO2 and CH4 concentrations using a single TDLAS Control Unit serving three Open-Path transceivers. Phase I also included a literature review and a sequestration site visit to understand and specify sensor needs, detection requirements, and installation configurations. Phase II will build, install, and operate a permanent suite of TDLAS sensors that will gather scientific data and demonstrate continuous monitoring for surface leaks at an operating CO2 sequestration reservoir. The sensors will include three distinct configurations: 1) an “Open-Path” that continuously monitors CO2 levels along a line of sight approximately 100m long, intended for personnel safety; 2) a set of networked CO2 point sensors for surface or downhole monitoring, intended to provide long-term continuous measurement and mapping of CO2 concentrations and changes over time; and 3) a hand-portable standoff sensor intended for CO2 pipeline leak surveying and detection. Phase II will include sensor testing and evaluation via well-controlled sequestration site leak simulations.

Commercial Applications and Other Benefits: The sensing tools will immediately support ongoing GCS research projects. They will ultimately provide commercial benefits to GCS site operators by reducing the cost of leak surveying and verification of site integrity. There will also be commercial benefits, in the form of sensor sales, to the sensor manufacturer. The future market potential for sensors exceeds $100M.

90913S09-II

Unconventional High Temperature Nanofiltration for Produced Water Treatment—Eltron Research & Development Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263
Dr. Joel S Thompson, Principal Investigator; eltron@eltronresearch.com
Mr. James Steven Beck, Business Official; contracts@eltronresearch.com
DOE Grant No. DE-FG02-09ER85357
Amount: $999,999

The recovery of oil and natural gas in the United States, especially from unconventional sources, is often limited by economic and environmental impacts of water co-produced during the extraction process. Innovative and cost-effective produced water treatment methods are needed to improve the economic viability of unconventional reserves, particularly for removing salts and organic contaminants so that it meets regulatory quality standards for surface discharge. This program is developing a durable high temperature nanofiltration membrane (Duraflux™) on a ceramic support for removing salinity and other dissolved solids from produced water. This technology will enable harsh-service membrane processing in field-distributed systems where system upsets and uncontrolled shutdowns are common. Duraflux™ is capable of operating at relatively high temperatures; has high stability to oxidizers, metals, and organics; is resistant to abrasive or suspended materials; and is expected to tolerate frequent cleaning cycles. During the Phase I research, the following goals were achieved: 1) Duraflux™ membrane was successfully bound to a tubular ceramic support to provide a robust single tube filter. 2) Duraflux™ membrane was operated in temperature and pressure regimes from 20°C to 70°C and 50 psi to 150 psi, respectively. Following are the objectives of the Phase II project: 1) Fabrication process with be scaled up to create full-length tubular membranes. 2) Long-term tests will be performed on processed water samples to demonstrate salt rejection, stability after multiple cleaning cycles, and stability under harsh temperature/dissolved solid exposure. 3) Develop membrane filter plant reference design model and cost structure.

Commercial Applications and Other Benefits: The largest growing source of produced water originates from capture of hydrocarbons from coal bed methane, and shale gas reserves. Economic and environmentally responsible treatment methods will increase gas yields and provide freshwater resources for beneficial uses in arid regions while reducing environmental impacts in others. Cost-effective recycling of boiler feed water used for steam injection will reduce freshwater consumption and disposal costs. Duraflux™ technology also provides the ability to treat the produced water at high temperature which will reduce the energy required to re-heat the water.

90927S09-II

Molecular Separations Using Micro-Defect Free Ultra Thin Films—Eltron Research & Development Inc., 4600 Nautilus Court South, Boulder, CO 80301-3241; 303-530-0263
Dr. Richard A Bley, Principal Investigator; Eltron@eltronresearch.com
Mr. James Steven Beck, Business Official; contracts@eltronresearch.com
DOE Grant No. DE-FG02-09ER85353
Amount: $999,999

Gasification can provide the best path for development of power based on clean coal, as well as conversion of coal to other fuels and specialty chemicals. However, development of clean coal technologies requires carbon capture. To accomplish this, more efficient methods of CO2 separation from other gases are required. Current methods for separating carbon dioxide are energy and cost intensive. Molecular sieve development has been pursued for several decades because of the great potential these membranes possess for high selectivity using less energy than cryogenic or distillation methods and greater permselectivity than is possible from polymeric membranes. The adoption of this technology has been hindered by the defect fissures that always accompany these membranes when fabricated using economically practical techniques. Eltron is developing a process for eliminating defects in thin molecular sieve films to provide an inexpensive means for separating methane from CO2. Eltron's method for sealing off the defect fissures in thin film molecular sieves provides a means for fabricating these membranes in an economical way. This will also provide a means to repair zeolite membranes that have cracked due to fouling or aging, greatly extending their usable lifetimes. In Phase I, we demonstrated we can achieve a seven-fold improvement in the separation of CO2 and CH4 through the application of our technique of blocking the non-zeolite fissures. Results indicate this can be improved even more. We know that the material we block the fissures with is stable on our membrane for long periods up to 185°C and decomposes very slowly at 450°C. This material should remain stable at temperatures as high as 300°C but this has not yet been verified over long periods. We have shown that if these membranes become fouled, they can be easily revitalized. They are extremely durable and can be handled many times over with no ill effects. Phase II, we will continue to develop our technique for the simple and inexpensive closure of non-zeolite fissures in thin film zeolite membranes. Doing so will allow the fabrication of these membranes to become economically viable by providing a means to produce high quality thin film zeolite membranes that consistently possess a high flux for CO2 with a low flux of CH4. This project will establish what the temperature and pressure boundaries are over which these materials can operate as well as the best production processes for bringing this technology to market.

Commercial Applications and Other Benefits: Recovery of methane from the shifted syngas stream and removal of H2 via a hydrogen transport membrane would be an economical way of supplementing our supply of natural gas. The increasing price along with a diminishing domestic supply of natural gas, creates an incentive for developing a low-cost replacement. Gasification-based production of methane via the utilization of abundant, low-cost, domestic coal offers one means to address these concerns. There will be other direct applications that will result from this technology. CO2 is a large contaminant in many sources of natural gas as well as landfill gas, a natural bio-fuel source of energy whose capture and utilization would reduce greenhouse emissions. These methane sources can provide a resource for reducing dependence on foreign energy supplies. The presence of CO2 in these fuel sources greatly diminishes the power that can be obtained from them, so low-cost CO2 removal would be of a great benefit to the U.S. economy. In addition to the separation of these two gases, this technology can be adapted for use in many other industrially important separations.

90960S09-II

Jet Fuels from Algae—Exelus, Inc., 110 Dorsa Ave, Livingston, NJ 07039-1003; 973-740-2350
Mr. Mitrajit Mukherjee, Principal Investigator; mmukherjee@exelusinc.com
Mr. Mitrajit Mukherjee, Business Official; mmukherjee@exelusinc.com
DOE Grant No. DE-FG02-09ER85371
Amount: $999,999

This SBIR Phase II project addresses the pressing need to develop technologies to produce all types of transportation fuels from renewable sources. Specifically, the goal of this project is to create a complete, sustainable, and cost-effective technology that converts algae into conventional jet fuel at a sufficiently low cost as to be competitive with fossil-derived fuels. The proposed technology converts raw, low-cost algae into aviation fuel that meets or exceeds all current performance specifications. This project applies completely new chemistry with environmentally benign engineered catalysts that allows conversion of both triglycerides and free fatty acids found in algal oil into long-chain branched paraffins that are ideal traditional jet fuel components. Phase I of this project successfully demonstrated some of the key chemical reactions involved in the transformation of triglyceride oil to jet fuel. Phase II will focus on developing and optimizing the remaining key steps in the process and preparing the process for large-scale piloting and commercialization.

Commercial Applications and Other Benefits: The proposed process is designed to be competitive with existing jet fuels made from petroleum both in terms of performance and price. No modifications to the turbine engines or the infrastructure are required to use this product. Airlines will benefit from low, stable fuel prices and society benefits from reduced pollution and greenhouse gas emissions. This technology allows a fundamental shift away from reliance on imported oil for vital civilian and military aviation needs.

90973S09-II

Manufacturing Analysis of SOFC Interconnect Coating Processes—NexTech Materials, Ltd., 404 Enterprise Drive, Lewis Center, OH 43035-9423; 614-842-6606
Dr. Matthew M. Seabaugh, Principal Investigator; m.seabaugh@nextechmaterials.com
Mr. Andrew R. Patton, Business Official; a.patton@nextechmaterials.com
DOE Grant No. DE-FG02-09ER85592
Amount: $999,999

Due to the threat of global warming, and the economic need for energy independence, the United States Department of Energy is developing alternative means of energy production. Solid Oxide Fuel Cells offer a route for more efficient use of fossil fuels, bio-fuels, and biomass, with less pollution compared to combustion approaches. However, widespread use of SOFCs is currently limited, partially by the high cost and corrosion associated with available interconnect technologies. Current corrosion issues degrade performance and limit the life of SOFC systems. These limitations compromise SOFC economic viability and hold back commercial adoption. In this Phase II SBIR Program, NexTech Materials will perform a build upon the success of its Phase I study. Phase I efforts concluded that manufacturing cost for Aerosol Spray Deposition (ASD) of ceramic oxide coatings present an economically viable approach to addressing interconnect corrosion. Comparisons of anticipated manufacturing costs showed that in terms of materials, capital, and operating costs required to manufacturing at scales up to 1.6M parts/year, ASD was a strong choice for SOFC interconnect protection. Critical cost-reducing materials and process refinements were identified in Phase I through modeling and experiment. In this Phase II effort, process demonstrations at the production scale will be performed using representative interconnect components. Components will be produced and tested singly and in SOFC stacks for several hundred hours. Parallel efforts to will customize the technology to suit a range of SOFC developers, thus maximizing the market for the technology and its reach.

Commercial Applications and Other Benefits: The program will result in the commercial availability of low-cost metallic interconnects for SOFCs that can meet the lifetime requirements established by the Department of Energy.

90997S09-II

Advanced Cooling for IGCC Turbine Blades—Mikro Systems, Inc., 1180 Seminole Trail, Suite 220, Charlottesville, VA 22901-5713; 434-244-6480
Mr. Michael Appleby, Principal Investigator; appleby@mikrosystems.com
Dr. James E. Atkinson, Business Official; Atkinson@mikrosystems.com
DOE Grant No. DE-FG02-09ER85588
Amount: $999,895

Integrated Gasification Combined Cycle (IGCC) power plants are an attractive alternative to current coal fired technologies. Industrial Gas Turbines (IGT) engine manufacturers seek to produce engines capable of operating at higher temperatures by using closed loop steam cooling in place of compressor discharge air to raise inlet firing temperatures from approximately 1260ºC to around 1427ºC. This will enable higher combustion efficiency, improved fuel efficiency, and lower emissions. Turbine blade and vane survivability at higher operating temperatures is the key to improving engine performance. Innovative cooling approaches are a critical enabling technology to meet this need. This proposal addresses two important aspects of the problem. First is the need to increase ceramic core manufacturing process capability (quality and reliability) to enable advanced cooling features to be incorporated in future turbines. Second is the need to rapidly and economically produce new turbine blades whereby advanced designs can be empirically tested and optimized. Mikro Systems proposes to apply its patented Tomo Lithographic Molding process (TOMO™) to the manufacture of advanced turbine blades for use in Integrated Gasification Combined Cycle power plants (IGCC). In order to improve heat transfer and lower cooling air requirements, the advanced blade designs will require more complex internal cooling passages than can be produced using current investment casting techniques. During Phase I, an advanced cooling concept was applied to the trailing edge portion of an existing IGT turbine blade. Based on that design concept, Mikro produced foundry ready ceramic cores (trailing edge only) and proved the advanced geometries could be produced. An initial DS casting trial was also conducted further verifying the producability of the cooling features through the casting process. During Phase II we will expand the scope of our investigation and produce full-scale turbine blades with internal cooling passages that are beyond the current state-of-the-art. In support of blade design and production, heat transfer experiments will be conducted and the advanced designs will be CFD modeled and tested.
Our primary Phase II objectives are:
Produce an advanced turbine blade design and two design variants.
Perform CFD testing and analysis of the turbine blades.
Perform bench level heat transfer testing.
Produce a minimum of three full-scale blades of each design
Test the blades using bench level protocols
Demonstrate a two-thirds reduction in the overall design-to-production cycle for an advanced turbine blade.

Commercial Applications and Other Benefits: The production of airfoils with advanced cooling passages will have direct and immediate benefit for power plant operations by enabling increased turbine heat rates thereby increasing capacity and saving energy. Technology advancement is possible for both new power plants and blade retrofits for the existing installed based.

91007S09-II

Development of Packaging and Integration of Sensors for On-Line Use in Harsh Environments—MesoScribe Technologies, Inc., 7 Flowerfield Suite 28, Saint James, NY 11780-1514; 631-444-6645

Mr. Rob Greenlaw, Principal Investigator; rgreenlaw@mesoscribe.com
Dr. Jeffrey Brogan, Business Official; jbrogan@mesoscribe.com

DOE Grant No. DE-FG02-09ER85495
Amount: $840,315

A number of sensors and control systems have been developed for use within power systems; however the effects of high temperature, corrosive/oxidizing atmospheres, and abrasive media have limited their use in gas turbine engines, boilers, solid oxide fuel cells and other harsh environments. Improved sensor packaging and encapsulation is needed to enable on-line sensing for component sensing & diagnostics and structural heath monitoring. The inability to monitor the actual component in real time leads to higher operating and maintenance costs and decreases equipment availability which directly affects the reliability of the US electric supply. Sensors will also provide enhanced control enhancements and enable more efficient turbine operation which will decrease emissions and reduce fuel costs. New sensor packaging concepts are proposed to (1) encapsulate low profile temperature and strain gages with moisture-corrosion barrier coatings and (2) to improve lead-wire connections to sensors using Direct Write processes to enable robust sensor routing and attachment, and (3) to attach fiber optic sensors to components using Direct Write processing for use in ultra supercritical boilers.

Commercial Applications and Other Benefits: High temperature sensors are in high demand, spanning a range of industries including power generation, commercial and military aviation, aerospace structures and transportation. Steam turbines, gas turbines, and boilers used in the power generation industry are examples of critical equipment that must operate at top performance to provide the low cost electricity that drives the U.S. economy. Sensors are critical for accurate life prediction models and to operate power systems efficiently with fewer emissions.

91051S09-II

QuAI - A Quality Assurance Infrastructure for Data-Centric Applications—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856
Dr. Svetlana Shasharina, Principal Investigator; sveta@txcorp.com
Mr. Laurence D Nelson, Business Official; lnelson@txcorp.com
DOE Grant No. DE-FG02-09ER85515
Amount: $999,724

Data processing is becoming an integral part of modern experiments and should operate with the timeliness and reliability appropriate to each project. There is a need for a customizable, resource-aware and dynamic mechanism allowing for automatic dissemination of the quality assurance data to the right parties at the right time. The Data Distribution Service (DDS) is a promising new technology that is expected to deliver these features but needs to be tested within and adapted for DOE applications. Tech-X therefore proposes to develop QuAI, a Quality Assurance Infrastructure for timely and reliable distribution of quality assurance data between concurrent data processing applications. Theinfrastructure will consist of reusable C++ library and Python objects facilitating use of DDS for the upcoming Joint Dark Energy Mission (JDEM) cosponsored by HEP/DOE and NASA. QuAI will allow data exchange over the wide area network with the security and Quality of Service adequate the for the JDEM data processing needs. The project will be carried out in collaboration with the Ground Data System JDEM team at Fermi National Accelerator Laboratory. Software developed in Phase I consists of prototypes for the simplifying C++ library and Python wrappers for DDS entities and examples demonstrating the use of the developed software for distribution of the JDEM-relevant data (images and tables from FITS files and simple status data) and providing elements of the Quality of Service satisfying some JDEM requirements (getting data reliably and getting pre-published data).

Commercial Applications and Other Benefits: Software developed in this project will allow for quality-assured distributed data processing for DOE experiments and NASA missions. This project will bring Tech-X consulting business for developing custom extensions of QuAI, including custom security, for new HEP, NP and NASA teams, industrial control systems, and mission critical military applications. Adding Python support to DDSimplementations will result in strategic partnerships with DDS vendors.

91053S09-II

EVO-HD: A Globally Scalable Standards-based Full-HD Environment for Immersive Collaboration—EVOGH, Inc., 1876 Braeburn RD, Altadena, CA 91001-; 626-429-8422
Mr. Philippe D Galvez, Principal Investigator; philippe.galvez@evogh.com
Mr. Philippe D Galvez, Business Official; philippe.galvez@evogh.com
DOE Grant No. DE-FG02-09ER85575
Amount: $996,680

EVOGH, Inc. proposes to develop an extensible, globally scalable High Definition (HD) standards-based platform for remote collaboration (EVO-HD) at low cost, packaged for widespread corporate, research and at-home use over existing and future-generation broadband networks. Based on the successful results with a recent prototype built during Phase I of the program, where we were able to send several HD video streams using a single mass-market low cost PC, we are confident that we can develop and deploy standards-based HD videoconferencing and remote collaboration end points, embedding many high frame rate HD streams and a wide variety of shared content in a real-time 3D immersive collaborative environment. We will also integrate these multi-HD sessions into a highly capable autonomous system infrastructure that scales from a few to hundreds of end points, at low cost. The EVO-HD system would be alone in its class in terms of scalability, minimal operational burden and cost due to: 1) its built-in field tested and proven end-to-end intelligence (based on autonomous agents), 2) its automatic real-time topology and data flow optimization, 3) its ability to integrate across a wide range of home and work environments (including low cost mass market desktops, laptops and room-based systems), and 4) its unique user interface in which many interactive video streams, documents, remote desktop areas, and other information are presented live on 3D surfaces using OpenGL technology. During Phase II, we will build a full EVO-HD collaboration system by enhancing our unique video codec architecture and leveraging recent mass market developments that have sharply lowered the cost of a) HD video cameras, b) large LCD and plasma screens, c) capture and graphics cards with powerful GPUs, d) libraries supporting HD resolution, e) multi-core CPUs in mass market PCs that, together with the GPUs and libraries, as well as software tools to optimize threaded applications, can easily support one or several HD streams. The creation of low-cost HD Television (HDTV) systems running EVO-HD for remote collaboration, would thus represent a breakthrough that meets the needs for widespread collaboration and remote high quality Telepresence of the worldwide research community (during Phase II), and subsequently all sectors of society including both the business and consumer markets during Phase III.

91060S09-II

Radiation Hard GaAs Photomultiplier Chip(TM)—LightSpin Technologies, Inc., 4407 Elm Street, Chevy Chase, MD 20815; 301-656-7600
Dr. Eric Spangler Harmon, Principal Investigator; harmon@lightspintech.com
Dr. Eric Spangler Harmon, Principal Investigator; harmon@lightspintech.com
DOE Grant No. DE-FG02-09ER85466
Amount: $999,998

Some of the specialized detectors used in high energy physics experiments are bombarded by the highest energy particles on earth (other than cosmic rays that occur singly rather than in a bunch) – particles 70 million times more energetic than those detected in medical X-rays – yet the detectors need to remain extremely sensitive for years despite this hellish dose of particles. Over time, these energetic particles damage the detectors themselves, for example substantial damage is done to semiconductor crystals used in these detectors, causing defects that ruin performance. Recent developments in silicon-based photodetectors have given them excellent sensitivity, making them candidates worth considering for next-generation colliders and their upgrades. However, silicon photodetectors using arrays of single-photon avalanche devices (SPADs) are extremely vulnerable to radiation damage, greatly limiting their general utility. An intrinsically radiation-hard Photomultiplier Chip™ will be optimized, torture-tested, and demonstrated in Phase II; the material's rad-hardness and the match of experimental data to theoretical predictions having already been established in Phase I using neutron irradiation from a Cf-252 source. We expect to show 400 times better radiation-hardness than the best silicon detector by building high-density arrays of rad-hard SPADs in gallium arsenide (rather than silicon) and optimizing surface passivation techniques to prevent surface damage from ruining device performance. The approach also exploits intrinsic properties of certain III-V compound semiconductors, such as the wider band gap that suppresses thermal generation (noise) by a factor of 1E4 – 1E7 compared to silicon, fast intrinsic response, and proprietary device structures. The Photomultiplier Chip™ should provide a high dynamic range, and high quantum efficiency with excellent sensitivity, particularly when reading scintillators emitting between 280 and 890 nm.In Phase I, LightSpin demonstrated good agreement between the projected radiation hardness of gallium arsenide away from surfaces, tying together experiment and theory, and calculated that a Phase II device should be capable of a radiation hardness 400 times better than silicon's. Gallium arsenide photodetectors not designed for radiation hardness were irradiated with a 1 MeV equivalent neutron dose of 2E12/cm^2 from a calibrated ^{94}Cf source at NIST, and their properties then remeasured. Phase II will demonstrate a 400-fold improvement in radiation tolerance by optimizing new Photomultiplier Chip™ designs for radiation hardness and longevity. This entails burying the absorption, collection and gain regions; tweaking certain epitaxial thicknesses & doping concentrations; and moving to a more manufacturable process for beveling the angles of mesa edges.

Commercial Applications and Other Benefits: Affordable, fast, solid-state photodetection with single-photon sensitivity and wide dynamic range over the wavelength range of important scintillators, high speed, and enough radiation hardness to withstand years of operation in even the most intense radiation environments of next generation particle accelerators promises significantly better reliability and price:performance for particle physics experiments, positron emission tomography (PET) and the detection of special nuclear materials.

91069S09-II

High Count Restacks Nb3Sn using Subelements with over 3000 A/mm2 non-Cu Jc at 12T and 4.2K—Global Research and Development, Inc, 539 Industrial Mile Road, Columbus, OH 43212-1155; 614-481-8050

Mr. David Doll, Principal Investigator; ddollw5@aol.com
Mr. Lawrence Walley, Business Official; elwalley@hotmail.com

DOE Grant No. DE-FG02-09ER85406
Amount: $999,999

This proposal is in answer to Topic 36, High-Field Superconductor and Superconducting Magnet Technologies for High Energy Particle Colliders, subtopic (a) High-Field Superconductor Technology. High Energy Physics, magnet builders desire to push up into the 15-18T range. Present High Energy Physics Nb3Sn superconducting strands with distributed barriers need to have smaller d*eff* to be stable at lower fields. This means producing strands with higher subelement restack count without wire breakage. This SBIR Phase II will demonstrate higher subelement restack counts strand with non-copper *Jc*'s above 3000 A/mm^2 range at 12 T, and greater than 1500 A/mm^2 at 15T, and RRR above 50 or more. We will fabricate strands that will have 217 and 271 subelements in the restack. The strands will be characterized for the current density, AC losses and RRR of the strands. In this Phase I program, we successfully fabricated 91-, and 127-subelement restack billet strands achieving non-Cu J*c* s of over 3000 A/mm^2 12T-4.2K. We also fabricated 217 subelement restacks for 0.7 mm strands with subelement sizes of 35 □m. This Phase II proposal aims to develop non-copper *Jc*s greater than 3000 A/mm^2 at 12T-4.2K and 1800 A/mm^2 at 15T-4.2K with RRRs higher than 50, with subelement sizes of 30 □m or less for 0.7mm strands.

Commercial Applications and Other Benefits: Commercial Applications -The largest market for Nb3Sn is currently for accelerator and fusion magnets. The other commercial applications besides fusion and accelerators are high field 7-11T MRI, NMR systems, superconducting accelerators - protron radiation for cancer treatment, SMES, and high field magnetic separation.

91073S09-II

A Modified Internal Tin Tube Nb3Sn Conductor for Higher Non-Copper Critical Current Density—Supercon, Inc., 830 Boston Turnpike, Shrewsbury, MA 01545-3301; 508-842-0174
Mr. Mark Karl Rudziak, Principal Investigator; mrudziak@supercon-wire.com
Mr. Terence Wong, Business Official; twong@supercon-wire.com
DOE Grant No. DE-FG02-09ER85446
Amount: $999,999

Future magnets for High Energy Physics (HEP) require superconductors with improved high critical current carrying capacity at high magnetic fields, decreased effective filament sizes and lower cost. An improved method of fabricating such superconductors is being investigated using the Internal Tin Tube (ITT) Process that will improve the critical current density achievable. In Phase I, Sn-Ta alloys were fabricated by melt diffusion of mixed powders. The alloys were rolled to foil and placed at the interface between the niobium and the high tin copper-clad tin cores of ITT monofilaments. Thick Nb3Sn layers were formed after heat treatment. Fine grained Nb3Sn was observed in composites containing the alloys, but not in a control composite that did not contain Sn-Ta alloy. In Phase II, the Sn-Ta alloy homogeneity will be improved. The alloy compostion and thickness will be optimized. The process will be scaled-up to a commercial level, with conductor lengths and filament sizes suitable for high energy physics applications.

Commercial Applications and Other Benefits: Future accelerator and related superconducting magnets for HEP applications will become more feasible if this project is successful. Additionally, the technology developed if this project is successful can find application in commercial high field magnets for NMR, FT-ICR, and other analytic magnet applications.

91076S09-II

A Novel Quaternary Low-Cost PIT Nb3Sn Conductor for HEP Magnet Applications above 12 Tesla—SupraMagnetics, Inc., 214 Canal Street, Plantsville, CT 06479-1742; 860-426-1961
Dr. Leszek Richard Motowidlo, Principal Investigator; LMOTO@cox.net
Dr. Leszek Richard Motowidlo, Business Official; LMOTO@cox.net
DOE Grant No. DE-FG02-09ER85460
Amount: $861,724

To do physics at higher energy collisions require energy and luminosity. More luminosity means larger apertures and bigger magnets. To develop high field magnets will require higher performance low-cost Nb_3Sn Superconductors. The cost-performance of state-of-the-art commercial Nb_3Sn strand is $3/kA-m to $5/kA-m. By development of lower cost processing and materials, powder-in-tube (PIT) Nb_3Sn wire will improve the cost-performance to less than $1.00/kA-m for use in high field magnets for future High Energy Physics (HEP) accelerator research. The overall technical approach for the Phase I/Phase II project will be to develop and demonstrate a substantially lower strand costs for the PIT process. A new low-cost intermetallic tin powder will be introduced within a low-cost novel PIT conductor design. In the Phase I work, We have successfully fabricated a multifilament PIT $(Nb,Ti,Zr)_3Sn$ quaternary conductor for high field 15-20 Tesla magnet applications. This was achieved via a low-cost titanium doped tin powder core in Nb-1%Zr tubes. In the proposed development program, the main goal in the Phase II work will be to continue development and optimization of the $(Nb,Ti,Zr)_3Sn$ A-15 layer and properties in PIT conductors demonstrated in the Phase I work. Another goal of the Phase II work will be to demonstrate scale-up and produce significant amount of advanced $(Nb,Ti,Zr)_3Sn$ material for the DOE national conductor programs.

Commercial Applications and Other Benefits: The improved cost-performance for this new PIT Nb_3Sn conductor will have an immediate benefit for high field magnets in HEP applications. Particularly, the second generation LHC interaction region magnets including both quadrapole and dipole magnets will require bigger apertures and higher peak fields. Another important application for Nb_3Sn superconductors are fusion reactors. The successful demonstration of a prototype fusion machine based on an advanced cost effective Nb_3Sn conductor will have enormous economic and social benefits to the public. The application of NMR is on the verge of technological explosion with requirements for uses in chemical research, biochemistry, pharmaceutical chemistry, polymer science, petroleum research, agricultural chemistry and medicine. Giant strides by researchers are being made in understanding of cells, proteins, DNA, and drug interactions to name a few. Any advances in the development of high performance-cost effective superconductors will help bring these powerful research tools into wider use for the general benefit of the public.

instruments for the general benefit of the public.

91079S09-II

Development of MgB2 Current Distribution Systems for High Energy Particle Colliders—Hyper Tech Research, Inc., 539 Industrial Mile Road, Columbus, OH 43228-2412; 614-481-8050
Mr. Matthew Rindfleisch, Principal Investigator; mrindfleisch@hypertechresearch.com
Mr. Lawrence Walley, Business Official; elwalley@hypertechresearch.com
DOE Grant No. DE-FG02-09ER85422
Amount: $999,999

The DOE Office of High Energy Physics (HEP) seeks superconductor development technologies in support of magnets for use in accelerators, storage rings and charged particle beam transport systems. HEP is interested in improved current lead and current distribution systems based on high-temperature superconductors, such as magnesium diboride (MgB2), for application to superconducting accelerator magnets. MgB2 offers the possibility of the fabrication of long-length strand and cables from inexpensive starting materials using conventional metalworking processes. An important advantage of MgB2, especially when high radiation exposure is included, is that its critical temperature (*Tc*) of 39 K provides a high thermal margin. The two main objectives of the Phase II program are (1) developing MgB2 conductors for meeting the superconducting and mechanical specifications for low field, high amperage, current distribution applications for HEP and (2) demonstrating short lengths of model current distribution sub-cables using the improved conductor design developed in this project. Wires were fabricated using hot isostatic pressing for improving connectivity and current density. Strands doped with TiC were fabricated for improving flux pinning and critical currents. Strands with modified strand geometries were demonstrated and one wire bend test was performed to understand and improve strain sensitivity of MgB2 conductors. One model MgB2 cable was fabricated. We have planned an integrated materials development program that invests significant effort in improving the critical currents of MgB2 superconductors through various methods that aim to improve connectivity. We will also investigate making wires with nano-powder additions to improve properties and with higher copper content to improve stability. Modifications to strand geometry and a series of bend tests will be performed to understand and improve the strain sensitivity of MgB2 conductors. Finally, we aim to demonstrate the actual fabrication of MgB2 sub-cables with reacted wire.

Commercial Applications and Other Benefits: The wire and cables developed under this program will have wide ranging benefits. Improving MgB2 will accelerate the wire being developed for commercial applications such as MRI systems, fault current limiters, transformers, generators, motors and military applications. Also, magnesium diboride strands with high *Tc* (thermal margin) and radiation tolerance may find other near-term accelerator applications in the winding of muon colliders, light-source wiggler and undulator magnets.

91100S09-II

Electron Gun and Beam Collector for a FOR A 10-MW, 1.3-GHz, Low-Voltage, Multi-Beam Klystron—Omega-P, Inc., 258 Bradley St., 2nd fl., New Haven, CT 06510-1106; 203-789-1165
Dr. Jay L. Hirshfield, Principal Investigator; jay@omega-p.com
Dr. George P. Trahan, Business Official; enid@omega-p.com
DOE Grant No. DE-FG02-09ER85306
Amount: $999,999

Design of a future electron-positron collider, the International Linear Collider ILC, relies upon the availability of a large number of efficient, reliable 10-MW, 1.3 GHz RF amplifiers. Existing prototype multi-beam klystrons (MBKs) for this application operate at relatively high voltage (117 KV), and are physically too large for vertical mounting in the collider tunnel. The complications attending high-voltage operation and horizontal mounting can increase the cost for ILC. The same complications can apply to the FNAL proton accelerator needed for Project X. A low-voltage MBK design has been created to meet the needs of ILC and Project X that operates at 60 kV, and that is about half the height of the existing prototypes. This is achieved by use of 24 separate beams arranged in four independent clusters, with immersion of the electron guns and RF circuit in a common magnetic field. This project is for the electron gun and beam collector for this MBK, while design of the RF cavity chain and magnetic circuit are supported under a parallel SBIR grant. Plans for engineering and fabrication of the complete MBK in Phase II are to be developed in collaboration with a high-power RF tube manufacturer. Conceptual design of the RF cavity chain and magnetic circuit for 10 MW and 2.5 MW low-voltage multi-beam klystrons were completed. A plan for engineering, fabrication, and testing of a prototype 2.5 MW tube was developed. Engineering and fabrication of a prototype 2.5 MW multi-beam klystron will be done, with testing up to an average power of 20 kW.

Commercial Applications and Other Benefits: Availability of a low-voltage, 2.5 MW and/or 10-MW, 1.3-GHz MBK for ILC and other accelerator applications can lower the overall cost of a future collider, and create a multi-million dollar market for a new class of high-power microwave amplifiers. Other applications of high-power MBKs can be found in industrial processing, adding to the commercial potential of this device.

91101S09-II

RF Cavity Chain and Magnetic Circuit for a 10-MW, 1.3-GHz, Low-Voltage, Multi-Beam Klystron—Omega-P, Inc., 258 Bradley St., 2nd fl., New Haven, CT 06510-1106; 203-789-1165
Dr. Jay L. Hirshfield, Principal Investigator; jay@omega-p.com
Dr. George P. Trahan JD, Business Official; enid@omega-p.com
DOE Grant No. DE-FG02-09ER85307
Amount: $999,999

Design of a future electron-positron collider, the International Linear Collider ILC, relies upon the availability of a large number of efficient, reliable 10-MW, 1.3 GHz RF amplifiers. Existing prototype multi-beam klystrons (MBKs) for this application operate at relatively high voltage (117 KV), and are physically too large for vertical mounting in the collider tunnel. The complications attending high-voltage operation and horizontal mounting can increase the cost for ILC. The same complications can apply to the FNAL proton accelerator needed for Project X. A low-voltage MBK design has been created to meet the needs of ILC and Project X that operates at 60 kV, and that is about half the height of the existing prototypes. This is achieved by use of 24 separate beams arranged in four independent clusters, with immersion of the electron guns and RF circuit in a common magnetic field. This project is for the RF cavity chain and magnetic circuit for this MBK, while design of the electron gun and beam collector are supported under a parallel SBIR grant. Plans for engineering and fabrication of the complete MBK in Phase II are to be developed in collaboration with a high-power RF tube manufacturer. Conceptual design of the RF cavity chain and magnetic circuit for 10 MW and 2.5 MW, low-voltage multi-beam klystrons were completed. A plan for engineering, fabrication, and testing of a prototype 2.5 MW tube was developed. Engineering and fabrication of a prototype 2.5 MW multi-beam klystron will be done, with testing up to an average power of 20 kW.

Commercial Applications and Other Benefits: Availability of a low-voltage, 2.5-MW and/or 10-MW, 1.3-GHz MBK for ILC and other accelerator applications can lower the overall cost of a future collider, and create a multi-million dollar market for a new class of high-power microwave amplifiers. Other applications of high-power MBKs can be found in industrial processing, adding to the commercial potential of this device.

91104S09-II

A New Quarter-Wave Coaxial Coupler For1.3 GHZ Superconducting Cavity—Euclid TechLabs, LLC, 5900 Harper Rd. #102, Solon, OH 44139-1866; 440-519-0410
Dr. Alex Kanareykin, Principal Investigator; alexkan@euclidtechlabs.com
Mr. David Dunay, Business Official; daved@euclidtechlabs.com
DOE Grant No. DE-FG02-09ER85369
Amount: $999,721

The current design for the rf couplers for the ILC cavity introduces unacceptable emittance growth in the beam. We have developed two new couplers designed to mitigate the emittance growth problem by preserving the axial symmetry of the cavity fields. Optimization of the design of the coaxial coupler units. Complete analysis of the ILC structure with the new coupler units was performed to confirm its electrodynamic properties. Conceptual mechanical design of the coupler units. Choice of optimal configuration of the accelerating cavity and couplers. Optimization of coaxial coupler units to achieve the required damping of parasitic modes. Complete electromagnetic analysis of the ILC cavity incorporating our coupler designs. Analysis of multipactor effects in the devices. Selection of optimal design.

Commercial Applications and Other Benefits: The ILC cavities require a coupler with no back kick from higher order modes in order to preserve the beam emittance and hence the luminosity of the collider. We have proposed here a coupler design that can successfully achieve the requirements of the ILC.

91111S09-II

Coaxial Two-Channel Dielectric Wake Field Accelerator—Omega-P, Inc., 258 Bradley St., 2nd fl. New Haven, CT 06510-1106; 203-789-1165
Dr. Jay L. Hirshfield, Principal Investigator; jay@omega-p.com
Dr. George P. Trahan, Business Official; enid@omega-p.com
DOE Grant No. DE-FG02-09ER85305
Amount: $999,999

Development of accelerator structures that can sustain acceleration gradients in the range of 150 MeV/m are required in order to build a future multi-TeV collider with an energy reach beyond present or planned electron-positron colliders. A two-channel dielectric wakefield accelerator is to be developed that could have the potential to satisfy that need. A coaxial structure consisting of two dielectric pipes surrounded by a conductor is being analyzed so as to design (Phase I) and test (Phase II) a wake field accelerator driven along its outer channel by an annular charge bunch whose wake fields accelerate a test charge bunch moving along its inner channel. This structure can have the advantages of a high transformer ratio, favorable stability, and accelerator gradients in a mm-scale version of several 100 MeV/m induced by a single few-nC drive bunch. Computations were carried out to predict performance of coaxial dielectric wake field accelerator modules that can be tested using facilities at Argonne National Laboratory. Stability of the high-current drive beam and the low-current test beam was analyzed and found to be adequate for the range of experiments that are planned for Phase II. Experiments will be carried out using facilities at Argonne National Laboratory to measure test beam acceleration, structure transformer ratio, and beam stability. Further computations will be made to refine designs for a future TeV-scale version of this two-beam accelerator.

Commercial Applications and Other Benefits: Development of structures that can sustain high accelerating gradient without an undue frequency of breakdown, and which can be the basis for a future multi-TeV electron-positron collider, can hasten the day when the multi-TeV collider will be built, and thus hasten the day when the many commercial companies will have an opportunity to obtain the multi-million dollar manufacturing contracts for the accelerator structures.

91115T09-II

STTR Project – Recovery Act – Development of Photonic Band Gap Structure for Particle Acceleration—Incom Inc., P.O. Box G, Southbridge, MA 01550-0528; 508-765-9151
Dr. Michael Jay Minot, Principal Investigator; mjm@incomusa.com
Mr. Anthony M Detardo, Business Official; AMD@incomusa.com
DOE Grant No.DE-FG02-09ER86418
Amount: $749,478

Research Institution
SLAC Research Institution

As the dimensions of fundamental scientific and technological structures and processes become smaller, research in these areas is often limited to a few very large and costly particle accelerator facilities. A revolutionary approach utilizing photonic band-gap (PBG) microstructures offers the opportunity to develop compact high-gradient inexpensive accelerators. A unique opportunity of this proposal is that this new generation of linear particle accelerator (linac) with a 20-100-fold increase in accelerating gradients relative to OFHC copper also provides potential revolutions in other fields that rely on the use of free electron bunches or beams. Among many examples are instruments needed for both the fabrication and characterization of nanostructures because these are typically based on high-energy electron and ion beams i.e. e-beam lithography, scanning and transmission electron microscopy, focused ion beams, X-ray sources, Auger spectroscopy and the like. In Phase I Incom Incorporated (Charlton, MA) and Stanford Linear Accelerator Center (SLAC) collaborated to fabricate PBG structures from borosilicate glass that serve as TM01 cavities and couplers when properly driven by lasers and will allow tests of basic concepts for PBG accelerators. Prototype PBG wafer structures fabricated by Incom in Phase I and based on SLAC calculations that predicted accelerating modes were fabricated and then analyzed by using CUDOS software. The results were extremely encouraging since the presence of modes, and their general behavior in the presence of fabrication errors agreed with the overall design calculations. SLAC concluded that the existence of an accelerating mode (determined by the photonic software calculations) for the as-built geometry provides a technical basis to proceed to Phase II and provides key guidance for adjusting the defect size slightly to tune the mode's position in the band gap. In Phase II, PBG structure development, with both borosilicate and fused silica glass, will be further optimized with the goal of determining / testing the uniformity of modes and achievable accelerating gradients for each material.

Commercial Applications and Other Benefits: Successful development of photonic bandgap accelerators will provide an accessible low cost source of high energy electrons or ion beams and will result in a new class of small powerful low-cost accelerators that will replace current source technology in applications such as e-beam lithography, scanning and transmission electron microscopy, and Auger spectroscopy. The technology has the potential to transform applications that rely on focused ion beams, and X-ray sources including the methods used for fabrication and characterization of nanostructures. These small accelerators will have applications throughout industrial fabrication, structural analysis, diagnostics, and instrumentation. Potential medical benefits are profound e.g. by supplying systems with transmission through tissue but that do no damage such as THz versus x rays.

91123B09-II

Quasi-Isochronous Muon Collection Channels—Muons, Inc., 552 N. Batavia Ave, Batavia, IL 60510; 630-840-2424

Dr. Charles Ankenbrandt, Principal Investigator; chuck@muonsinc.com
Dr. Thomas J. Roberts, Business Official; tjrob@muonsinc.com

DOE Grant No. DE-FG02-09ER85246
Amount: $750,000

Intense muon beams have many potential commercial and scientific applications, ranging from low-energy investigations of the basic properties of matter using spin resonance to large energy-frontier muon colliders. However, muons originate from a tertiary process that produces a diffuse swarm. To make useful beams, the swarm must be rapidly captured and cooled before the muons decay. This is the overall objective of the combined Phase I and Phase II projects A promising new concept for the collection and cooling of muon beams to increase their intensity and reduce their emittances is being investigated, namely, the use of a nearly isochronous helical cooling channel (HCC) to facilitate capture of the muons into RF bunches. The muon beam could then be cooled quickly and coalesced efficiently to optimize the luminosity of a muon collider, or could provide compressed muon beams for other applications. Optimal ways to integrate such a subsystem into the rest of a muon collection and cooling system, for collider and other applications, will be developed by analysis and simulation. The application of quasi-isochronous helical cooling channels (QIHCC) for RF capture of muon beams was developed. Innovative design concepts for a channel incorporating straight solenoids, a matching section, and an HCC, including RF and absorber, were developed, and its subsystems were simulated. Additionally, a procedure that uses an HCC to combine bunches for a muon collider was invented and simulated. The Phase II research will refine the QIHCC by continuing to develop the design concepts. Difficult design aspects such as matching sections between subsystems and intensity-dependent effects will be addressed. The bunch recombination procedure will be developed into a complete design with 3-D simulations.

Commercial Applications and Other Benefits: Bright muon beams are needed for many commercial and scientific reasons. Potential commercial applications include the use of muon beams to screen cargo containers for homeland security, low-dose radiography, and muon catalyzed fusion. Scientific uses include low energy beams for rare process searches, muon spin resonance applications, muon beams for neutrino factories, and muon colliders as Higgs factories or energy-frontier discovery machines.

91135S09-II

An Inexpensive High Brightness Photoinjector using Solid Free Form Fabrication (SFF)—RadiaBeam Technologies LLC, 1717 Stewart Street, Santa Monica, CA 90404-4021; 310-822-5845
Dr. Pedro Frigola, Principal Investigator; frigola@radiabeam.com
Dr. Salime Boucher, Business Official; boucher@radiabeam.com
DOE Grant No. DE-FG02-09ER85367
Amount: $999,885

Development of very high duty cycle, high gradient photoinjectors is critical for the next generation of accelerator systems, such as X-ray free-electron lasers (FELs), inverse Compton scattering (ICS) sources, energy recovery linear accelerators (ERLs), injectors for linear colliders, as well as variety of industrial systems for homeland security applications. A key issue for high average power, normal conducting, photoinjectors is efficient structure cooling. The fabrication of current state of the art high average power photoinjectors relies on conventional design and fabrication techniques, requiring a multitude of braze joints, and limited cooling channel geometries. An, inexpensive, high brightness photoinjector will be developed utilizing a novel fabrication technique allowing for enhanced thermal handling capability. Optimization of solid freeform fabrication (SFF) for copper RF components will be followed by the the construction and testing of a prototype photoinjector with enhanced thermal handling features possible only through the use of SFF. In the SBIR Phase I we have demonstrated the feasibility of manufacturing pure copper parts using solid freeform fabrication. As well investigating the resultant material properties, and develop a conceptual design of a gun with optimized shaped conformal cooling channels based on thermal simulations. These steps position us to fabricate and test a high rep. rate prototype gun in Phase II, and eventually offer a high-power high-brightness photoinjector as a product in Phase III. In Phase II of the project, we will complete the engineering of the SFF high rep. rate gun, and build and test the prototype at LLNL.

Commercial Applications and Other Benefits: The applications of very high duty cycle, high gradient photoinjectors include x-ray free-electron lasers (FELs), energy recovery linear accelerators (ERLs), and inverse Compton scattering (ICS) sources for medicine, as well associated imaging/analysis applications of interest to homeland security. The technical approach developed in this project may also be applied to a wide variety of rf structures, such as linacs and klystrons.

91136S09-II

Robust GaN-Based Photocathodes for High-Current RF Electron Injectors—SVT Associates, Inc., 7620 Executive Drive, Eden Prairie, MN 55344-3677; 952-934-2100
Dr. Amir M. Dabiran, Principal Investigator; dabiran@svta.com
Dr. Amir M Dabiran, Business Official; dabiran@svta.com
DOE Grant No. DE-FG02-09ER85470
Amount: $999,398

Advanced electron injectors are based on photocathode electron guns. These guns can produces electron beams with short pulses and high brightness. High efficiency photo-injectors are the electron source of choice for future linear accelerators (linacs) and colliders, energy recovery linear accelerators (ERLs), fourth generation light sources, injectors for laser-driven plasma wake field accelerators, low-energy electron linacs for applied research, and high-power free electron lasers (FELs). Negative electron affinity semiconductor photocathodes, such as cesium-activated GaAs, can show relatively high quantum efficiency. However, these cathodes require very high vacuum environment for operation with reasonable lifetime which is generally incompatible with high intensity electron gun environment. Hence, there is an immediate need for the development of high QE photocathodes capable of robust operation at high emission currents. This program is directed toward the development of robust GaN-based photocathodes for operation in high-current electron injectors. The main goal is to optimize the electron source characteristics and lifetime for practical application in current and future DOE projects. In the phase I program, GaN-based photocathodes with novel structures were fabricated to demonstrate the remarkable efficiency and stability of these cathodes for electron emitter and UV imaging applications. Device modeling was also done to determine new cathode structures for the Phase II effort. Novel GaN-based photocathodes studied in Phase I will be further optimized by investigating parameters that can affect the reliability and lifetime of these cathodes for operation in high voltage electron guns. To speed up the development phase a new cathode activation and testing chamber will be added to the thin-film deposition system. However, the performance of the optimized cathodes will be evaluated in realistic gun environment by collaborators at Argonne National Lab and Cornell University facilities.

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

91148T09-II

STTR Project - Anti-Breakdown Coatings for High-Gradient Accelerator Structures—Omega-P, Inc., 258 Bradley St., 2nd fl., New Haven, CT 06510-1106; 203-789-1165
Dr. Jay L. Hirshfield, Principal Investigator; jay@omega-p.com
Dr. George P. Trahan, Business Officialenid@omega-p.com
DOE Grant No. DE-FG02-09ER86402
Amount: $750,000

Research Institution
University of California

Development of accelerator structures that can sustain acceleration gradients up to 150 MeV/m are required in order to build a future multi-TeV collider with an energy reach beyond present or planned electron-positron colliders. Limitations for operation with high acceleration gradient arise from RF breakdown. High-melting-point insulated coatings are to be applied first to test samples and to parts from an experimental SLAC accelerator cavity. Strong adherence of the coating to the underlying copper is to be achieved by use of a graded coating, in which the composition varies smoothly from the copper outwards to the pure insulator. Test elements will also be built for evaluation at 34 GHz, and for coatings on accelerator cavity parts for extensive tests during Phase II. Coatings of ZrO2 on copper were successfully applied, were subjected to adherence tests, and were subjected to thermal cycles to 500 ☐C. No evidence of cracking or delamination was observed. Coatings were also applied to test cavity parts supplied by SLAC. Coating development will continue. Tests at X-band will be carried out at SLAC, and at Ka-band at Yale, using samples and test cavity parts with a variety of coatings to judge the efficacy of this approach for elevating RF breakdown thresholds, and if successful, to optimize the coating technique.

Commercial Applications and Other Benefits: Development of structures that can sustain high accelerating gradient without an undue frequency of breakdown, and which can be the basis for a future multi-TeV electron-positron collider, can hasten the day when the multi-TeV collider will be built, and thus hasten the day when the many commercial companies will have an opportunity to obtain the multi-million dollar manufacturing contracts for the accelerator structures.

91157S09-II

Recovery Act - Ultra-High Gradient, Compact S-Band Accelerating Structure for Laboratory and Industrial Applications—RadiaBeam Technologies LLC, 1717 Stewart Street, Santa Monica, CA 90404-4021; 310-822-5845

Dr. Alex Murokh, Principal Investigator; faillace@radiabeam.com
Mr. Salime Boucher, Business Official; boucher@radiabeam.com

DOE Grant No. DE-FG02-09ER85363
Amount: $980,933

There is growing demand from the industrial and research communities for high gradient, compact RF accelerating structures. The commonly used S-band SLAC-type structure has an operating gradient of only about 20 MV/m; while much higher operating gradients (up to 70 MV/m) have been recently achieved in X-band, as a consequence of the substantial efforts by the Next Linear Collider (NLC) collaboration to push the performance envelope of RF structures towards higher accelerating gradients. Currently however, high power X-band RF sources are not readily available for industrial applications. RadiaBeam Technologies is developing a short, standing wave S-band structure which uses frequency scaled NLC design concepts to achieve up to a 50 MV/m operating gradient at 2856MHz. In Phase I of this project, the RF design along with thermal-stress analysis of the DECA accelerator was performed. A plan for prototype fabrication and testing was developed, including future installation and conditioning at BNL ATF for initial high power tests. In Phase II of the project, we will complete the engineering of the DECA accelerator, and build and test the prototype, after installation at BNL ATF.

Commercial Applications and Other Benefits: Upon development the DECA structure will offer an ultra-compact drop-in replacement for a conventional S-band Linac in research and industrial applications such as drivers for compact light sources, medical and security systems. From an R&D point of view, the DECA accelerator will be a valuable research project of its own – to investigate the frequency scaling of RF breakdown mechanisms and corresponding design limitations of high gradient structures.

91160S09-II

Recovery Act - Robust and Efficient Dark Current Modeling on Finite-Element Meshes—Simulation Technology and Applied Research/AWR Corporation, 11520 North Port Washington Road, Suite 201, Mequon, WI 53092-3432; 262-240-0291
Dr. John F. DeFord, Principal Investigator; john.deford@awrcorp.com
Dr. John F. DeFord, Business Official; john.deford@awrcorp.com
DOE Grant No. DE-FG02-09ER85439
Amount: $687,251

Understanding and suppressing dark current generation is an important part of designing a variety of high field-gradient structures, including radio-frequency electron guns, slow-wave structures, and power feed systems. There are present needs for dark current and multipacting modeling in design of the Machine Protection System for International Linear Collider Main Linac. To address this need we propose to create a first-of-its-kind design capability for use in dark current/multipacting amelioration for accelerator, microwave tube, and other particle beam applications. The capability will leverage existing support implemented for multipacting analysis in a commercial finite-element analysis package. In Phase I major improvements to the particle tracker were implemented including an improved accuracy tracker, support for more advanced emission models, 2D structures, and dark current statistics. The Phase II project proposes extending the existing software to support 2nd order shape function elements, improved parallel support, higher accuracy magnetic field support, and improved post processing and data-mining.

Commercial Applications and Other Benefits: New high-energy physics accelerators are very expensive to design and build, so predicting and correcting potential failure mechanisms early in the design process can have a substantial impact on overall machine development costs. Anticipated public benefits include lower development costs for new high-energy particle colliders and improved first-pass design success for high-power microwave tubes, helping the U. S. microwave tube industry compete in a worldwide marketplace.

91171S09-II

Recovery Act - Nanocomposite Film Capacitors for High Energy Accelerators—TPL, Incorporated, 3921 Academy Parkway North NE, Albuquerque, NM 87109; 505-342-4439
Mr. Kirk Slenes, Principal Investigator; kslenes@tplinc.com
Ms. Trista Mosman, Business Official; tmosman@tplinc.com
DOE Grant No. DE-FG02-09ER85533
Amount: $999,987

Capacitors represent a key component in many pulsed power systems, in particular power modulators for high energy accelerators. As switching technology improves, a need for improved capacitor performance has become more pronounced, as required for next generation solid-state pulsed power systems. The desirable parameters for such capacitors include: high energy density, high reliability, high peak current delivery, low loss, long life, and fast rise-time capability.

Specific to this need, a major milestone in TPL's materials technology and manufacturing capability was established in Phase I of the DOE SBIR program. The Phase I program was successfully completed and technical feasibility for producing a low loss, high energy density nanocomposite film was established. The dielectric film demonstrated the electrical, thermal, and mechanical properties to support capacitor capabilities needed to meet critical capacitor performance demands in government and commercial applications.

The proposed Phase II represents a logical continuation of the Phase I and is directed at realizing the performance capabilities of the nanocomposite film in high energy capacitors. To achieve this result, TPL will pursue a wound metallized film capacitor design using conventional manufacturing processes. Expectations are for capacitors capable of high peak current delivery, fast rise-time, long life, and high reliability in a packaged configuration with three times greater energy density than current technology.

Commercial Applications and Other Benefits: TPL considers this a breakthrough in capacitor technology that will provide significant advantages in applications related to accelerators, pulse power, cancer treatment, and electric vehicles. The increase in energy density will improve efficiency, reduce overall system cost, enable significant reductions in mass and volume, and enable mobile power systems. Further, the nanocomposite possesses high temperature capabilities (>200°C) that will allow TPL capacitors to operate in environments without active cooling, e.g., in vehicle engine compartments. Finally, the low dielectric loss will add to capacitor efficiency and enable its application in alternating current as well as pulse power applications.

91173S09-II

Recovery Act - Composite Energy Storage Capacitor—Physical Optics Corporation, 20600 Gramercy Place, Bldg. 100, Torrance, CA 90501-1821; 310-320-3088
Mr. Michael Reznikov, Principal Investigator; psproposals@poc.com
Mr. Gordon Drew, Business Official; gedrew@poc.com
DOE Grant No. DE-FG02-09ER85312
Amount: $999,991

High-energy-density storage capacitors for solid-state pulsed power systems need improved reliability while producing fast and high peak current pulse discharge. Ceramic dielectric materials provide the large dielectric permittivity but small breakdown strength at the voids and cracks, while polymers offer significant dielectric strength but low dielectric constant. To improve the dielectric constant (to greater than 10) and electric strength (to greater than 3 Megavolts/centimeter) of dielectric material while enabling fast discharge of the capacitor, a three-component nanocomposite with improved linkage of inclusions to the polymer host is used as a dielectric material. In Phase I, theoretical analysis, and fully working prototype demonstration of the proposed composite material were accomplished. The laboratory technology of fabrication of thin films of material with titanium dioxide nanoparticles impregnated into thermoplastic polymer was developed and fabricated Samples of composite material were fabricated and investigated in a wide frequency range (from 100 Hz to 10 MHz) utilizing a specially modified time-domain dielectric spectrometer. The prepared materials demonstrated significant improvement of dielectric constant (6 instead of 2.2 for pure polymer), very fast relaxation time (<40 ns), and low dielectric losses (<0.0005). These parameters of the composite material allow for the development of high-energy-density capacitors capable of providing the discharge parameters required by the DOE. POC's Phase II development of a capacitor prototype, in collaboration with Bollore Inc. and Organic Materials Department Sandia National Laboratories, will include: optimization of the composite material and electrode system, taking into account all DOE requirements. Several capacitors will be fabricated and tested onsite, and then in a laboratory at Bollore Inc.

Commercial Applications and Other Benefits: The developed composite material will significantly improve accumulated energy density in capacitive structures that can be implemented as energy storage for a variety of applications, from high-energy physics to medical defibrillators..

91179T09-II

STTR Project - Development of a 400 MHz Superconducting RF Crabbing Cavity—Niowave, Inc., 1012 North Walnut Street, Lansing, MI 48906-5061; 517-230-7417
Dr. Jean R. Delayen, Principal Investigator; jdelayen@odu.edu
Dr. Jerry Hollister, Business Official; hollister@niowavinc.com
DOE Grant No. DE-FG02-09ER86400
Amount: $750,000

Research Institution
Thomas Jefferson National Accelerator Facility

Superconducting radio frequency (SRF) cavities are being successfully used for acceleration of charged particle beams worldwide. The application of the SRF cavities for manipulation of the beam properties in the transverse direction is both immanent and appropriate. The use of superconducting (SC) structures helps maximize the accelerating gradient, which is a highly desirable trait for applications involving manipulations of the charged particle beams at the point of delivery, such as Final Focus point or the experimental areas. Application of the parallel bar SC structure in future SRF accelerators will allow a further increase of the existing machines performance. Compact equipment utilizing SRF cavities can be successfully used in the broad range of applications from increasing of the beam luminosity in colliders, manipulation of the correlation between the longitudinal and transverse phase space projections of the beam particle distribution, to assistance in generation of the sub-picosecond x-ray pulses. This STTR proposal will develop a 400 MHz superconducting parallel-bar crabbing cavity capable of tilting the proton beam with energy of up to 7 TeV at the Final Focus point with help of a single unit. The transverse size of the cavity is significantly reduced using the parallel-bar geometry compared to the traditional elliptical accelerating structures. In collaboration with Niowave, Phase I demonstrated the technical feasibility of the project by completing the preliminary cavity and cryomodule designs. Phase II will finalize the design, and then fabricate and test the SRF parallel-bar crabbing cavity. The cavity is designed to operate at 400 MHz and is capable of generating transverse electric voltage of up to 5 MV in a single unit with electric and magnetic surface peak fields of no more than 50 MV/m and 150 mT respectively. Cryogenic tests will be carried out by Old Dominion University (ODU) in collaboration with the Thomas Jefferson National Laboratory (JLAB). Demonstration of this new type of SRF crabbing cavity creates many new possibilities for scientific and industrial applications.

91187S09-II

Dual Modality Small Animal Imaging—Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800
Dr. Purushottam Dokhale, Principal Investigator; PDokhale@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85381
Amount: $749,998

The ideal biological imaging system would provide non-invasive, high-resolution, high-sensitivity, three-dimensional (3D) images of living systems. Positron Emission Tomography (PET) offers high sensitivity to a range of biological processes through the use of targeted radiolabeled probes. Unfortunately, precise signal localization can be extremely difficult due to low spatial resolution and the lack of anatomical information. Magnetic Resonance Imaging (MRI) can provide high spatial resolution and excellent soft tissue contrast, but suffers from poor signal strength leading to low sensitivity. Thus, these single modalities do not satisfy all requirements of imaging studies. The overall goal of the proposed effort is to combine the best features of PET and MR modalities for small animal studies into a single imaging instrument that will record data in both imaging modalities near simultaneously. The most immediate benefit of the melded system will be to provide high-resolution anatomical context for microPET studies. The Phase I project was aimed at demonstrating the feasibility of the proposed imaging system. Specifically, we designed and build PET detector modules that can be operated inside a small animal MR scanner. Effect of both PET and MR detectors on each other were analyzed and based on the results, the feasibility of Phase I was adequately demonstrated The Phase II project will be aimed at design, construction and evaluation of a high performance PET insert for conducting simultaneous PET-MR imaging of small animals. Optimization of the photodetection technology; construction of high performance PET modules and eventually, a single ring scanner; and detailed characterization of performance will be carried out in Phase II.

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

91189S09-II

Next Generation SPECT Detectors--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800
Dr. Michael Squillante, Principal Investigator; MSquillante@RMDInc.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85386
Amount: $749,998

Single photon emission computed tomography (SPECT) is a powerful, noninvasive medical imaging modality that mathematically reconstructs the three dimensional distribution of a radionuclide throughout the body of a human patient or research animal. At present, the performance of the available SPECT systems is limited by the available detector technology. The goal of the proposed effort is to investigate new gamma-ray detectors that have the potential to provide excellent energy resolution, a very important requirement in SPECT. High quality crystals of the new detector material will be produced, their properties will be evaluated and a prototype system will be implemented for conducting SPECT studies. The Phase I project aimed to demonstrate the feasibility of producing new scintillation detectors with high energy resolution. The Phase I effort was very successful and new scintillation crystals with very high energy resolution and light output were produced. Based on the results, the feasibility of the proposed effort was adequately demonstrated. Optimization of detector, including scale-up and implementation is planned for Phase II effort. To achieve this goal, large scintillation crystals will be produced, their scintillation properties will be measured and then a high performance SPECT detection system will be assembled and tested in the Phase II project.

Commercial Applications and Other Benefits: The proposed detector technology will be very promising for clinical SPECT applications. It will also be applicable to many other gamma-ray imaging systems for astronomy, nondestructive studies and nuclear non-proliferation.

91190S09-II

New Detectors for Small Animal SPECT--Radiation Monitoring Devices, Inc., 44 Hunt Street, Watertown, MA 02472-4699; 617-668-6800
Mr. Leonard Cirignano, Principal Investigator; LCirignano@RMDI.com
Dr. Gerald Entine, Business Official; GEntine@RMDInc.com
DOE Grant No. DE-FG02-09ER85378
Amount: $749,998

Single Photon Emission Computed Tomography has become a powerful new tool in imaging biological processes in small laboratory animals. Performance of this modality is limited by the properties of the detectors available at present. The goal of the proposed project is to investigate a new solid state detector which appears to be very promising due to its high efficiency, high signal to noise ratio and possibility of excellent energy resolution. Large crystals of the new material will be grown, detectors will be fabricated and their properties will be extensively examined in our study for eventual use in small animal SPECT imaging. The Phase I project was aimed at demonstrating the feasibility of applying the new solid state detectors towards small animal SPECT imaging. Single crystals of the proposed material were grown and the detector performance was evaluated. Energy resolution studies were conducted. The Phase II research will be targetted towards optimization of the proposed detection technology and institution of imaging detectors based on the proposed technology for small animal SPECT imaging. Appropriate multichannel readout electronics and collimators will be integrated to the proposed detectors.

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

91201S09-II

Recovery Act - Development of Homologous Recombination and Recombineering Technologies for Clostridial-Biotechnologies—ELCRITON, 15 Innovation Way, #288, Newark, DE 19711; 846-921-5146
Mr. Bryan Patrick Tracy, Principal Investigator; bryantracy@elcriton.com
Mr. Bryan Patrick Tracy, Business Official; bryantracy@elcriton.com
DOE Grant No. DE-FG02-09ER85341
Amount: $766,484

The bacteria genus, *Clostridium*, includes many species naturally capable of degrading cellulose and producing valuable chemicals and fuel alcohols. Unfortunately the genetic engineering tools for developing improved strains are limiting for all clostridia. In this project we will develop superior Homologous Recombination (HR) based genetic engineering and recombineering tools that are applicable to all clostridia species. Such developments would greatly aid our nation's goals of developing sustainable and green technologies for the production of chemicals and transportation fuels. We are addressing this problem by developing efficient HR based genetic engineering technologies that utilize native HR pathways, and others that utilize phage related pathways, often times called recombineering. In Phase I, we improved plasmid based HR efficiency by over-expressing proteins involved in HR, and by varying lengths of homology for the targeted region of integration. We also demonstrated the feasibility for single-stranded DNA recombineering in clostridia, and determined the necessary accessory proteins for pursuing double-stranded DNA recombineering. In Phase II we are advancing our plasmid based HR system to demonstrate the utility of simultaneous gene disruption and integration of large lengths of recombinant DNA into the chromosome. Specifically, we demonstrate this utility by engineering ideal strains for continuous biobutanol production. Additionally, we are finalizing development of an efficient single-stranded DNA recombineering technology, and demonstrating the feasibility for double-stranded DNA recombineering in clostridia.

Commercial Applications and Other Benefits: As we will demonstration, applications of our technology will significantly accelerate strain development of solventogenic and other clostridia species. Improved HR and recombineering technologies for clostridia will accelerate the necessary strain development tasks to bring clostridial-technologies to commercial-scale production of commodity chemicals and transportation fuels.

91232B09-II

High Precision C0S Monitor to Constrain the Partitioning of C02 Fluxes—Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-932-0215
Dr. Mark S. Zahniser, Principal Investigator; mz@aerodyne.com
Mr. George N. Wittreich, Business Official; gnw@aerodyne.com
DOE Grant No. DE-FG02-09ER85265
Amount: $990,610

Assessment of CO2 exchange between the atmosphere and the biosphere remains one of the largest uncertainties in predicting carbon sequestration by vegetative uptake on a global basis. Distinguishing between photosynthetic uptake and respiratory emission of CO2 is difficult, due to the small differences between two large parameters, but crucial for determining net ecosystem exchange for CO2 between the atmosphere and the biosphere. Carbonyl sulfide (COS) is a surrogate for CO2 uptake by plants during photosynthesis, but COS is not emitted from plants during respiration. COS measurements may be used to provide unique constraints on carbon assimilation by the biosphere that are independent of the influence of respiration. This proposal would develop a highly precise and portable instrument for absolute COS measurements based on newly available continuous wave mid-infrared quantum cascade lasers (QCL). The instrument, with a precision for COS of 1 part-per-trillion (ppt) with 100 s averaging time, would provide continuous measurements of COS both at ground level monitoring sites and from aircraft platforms in order to address the global distribution of COS sources and sinks. A newly acquired QCL was used in a pre-exisitng laboratory spectrometer to demonstrate detection sensitivity for COS of 5 ppt with 1 s averaging time and 1 ppt in 100 s. The system operated continuously for a period of 5 months sampling roof top ambient air from December to May. Gradual variations in COS due with wind trajectories in the winter contrasted to sharp daily variaitions due to uptake by soil vegetation with the onset of spring. This data set uniquely demonstrates the power of continuous monitoring for assessing carbon uptake cycles in the biosphere. We will develop detailed optical, thermal, electronic and spectroscopic designs for a Phase II prototype instrument. We will build two versions of the resulting instrument to demonstrate the capabilities both for long term unattended deployments at a local forest research site, and the potential for global COS measurements from aircraft platforms. The instrument will be rigorously tested against existing measurement techniques.

Commercial Applications and Other Benefits: The proposed instrument will provide the capability to measure atmospheric abundances of COS in real time in order to better asses CO2 uptake by vegetation. Improved understanding of CO2 uptake will improve our understanding of global warming and help mitigate global climate change. There is a worldwide market for such measurement systems in the environmental and ecological research communities. Potentially larger markets exist in the medical research community where COS measurements in exhaled breath can be used to diagnose cystic fibrosis, liver disease, and lung transplant rejection.

91234T09-II

STTR Project - Development of a Fieldable Soil Carbon Monitor—Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077; 978-689-0003
Dr. David M. Sonnenfroh, Principal Investigator; sonnenfroh@psicorp.com
Dr. B. David Green, Business Official; green @psicorp.com
DOE Grant No. DE-FG02-09ER86405
Amount: $749,966

Research Institution
University of Denver

Proper management of soils and vegetation can increase their uptake of CO2 and therefore allow them to become more effective "land-sinks" for the mitigation of global climate change. Verification of the relative permanence of these sinks is critical in the evaluation of management strategies. Physical Sciences Inc. (PSI), the University of Denver (DU) and Applied Research Associates (ARA) offer to perform a proof-of-principle project to measure carbon in soil using spark-induced breakdown spectroscopy (SIBS), a technique that has been used to perform elemental composition measurements in both aerosol and soil matrices, Physical Sciences Inc. (PSI) with the University of Denver (DU) and Applied Research Associates (ARA) propose to develop and field test a prototype instrument based on spark-induced breakdown spectroscopy (SIBS), to measure carbon in soil. Phase I of the program provided proof of the basic concept of applying SIBS to this measurement and identifying optimal data handling approaches. Phase II of the program will be devoted to the development of a fully miniaturized prototype by PSI personnel and testing of this hardware and the associated data processing strategies by DU researchers, including both graduate and undergraduate students. In Phase I, SIBS signals on a well-characterized, carefully presented series of local Denver soils were used as basis sets in various chemometrics approaches. We developed hardware and software approaches that yielded a detection limit of between 0.2 and 0.3 % carbon by weight. This detection limit is similar to that available with a traditional laboratory combustion analyzer, but can be packaged in a fieldable and robust package**.** In Phase II, a miniaturized prototype will be constructed by PSI and tested by DU, with the consulting help of the Phase I DU project leader, now employed at Applied Research Associates. In this program, the prototype will be used to finalize development of the data analysis approach, and will measure total carbon in 100 characterized soil samples from the National Resource Ecology Laboratory (NREL); these will be provided to us by recognized carbon sequestration expert Dr. Keith Paustian of Colorado State University.

Commercial Applications and Other Benefits: Successful development of this instrument through the second STTR phase will result in a fieldable, robust and inexpensive instrument to measure carbon in soils. The main benefit of this device to the Nation will be the ability to quickly and accurately determine the amount of carbon in various types of soil. This will in turn enable development of strategies to optimize the soil and its treatment with respect to carbon uptake. Globally, there is the potential to offset ~30% of annual CO_2 emissions with careful soil management. In the U.S., this corresponds to ~15 % of annual CO2 emissions.[5] Such a potential underscores the importance of the development of new instrumentation to monitor carbon content of soils.

91238B09-II

STTR Project - An Absolute C02 Monitor with Extremely High Accuracy - Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-932-0215
Dr. David D. Nelson, Principal Investigator, ddn@aerodyne.com
Mr. George N. Wittreich, Business Official, gnw@aerodyne.com
DOE Grant No. DE-FG02-09ER86380
Amount: $749,787

Research Institution
Harvard University

Carbon dioxide is monitored with high precision at hundreds of monitoring stations, world-wide. Those measurements rely upon frequent calibration using high pressure gas cylinders, which must be certified and then shipped to remote locations. Current calibration procedures are both labor intensive and expensive. Continuous monitoring of CO_2 at remote locations presents particularly difficult calibration problems. Thus, there is a pressing need for an affordable, highly accurate (at least 1 part in 3000) carbon dioxide monitor for the ambient atmosphere as called out in the DOE SBIR solicitation Topic 43b, Item 2. In addition to being extremely accurate, this instrument must operate unattended for several months or more. We propose an absolute CO_2 monitor which is based on spectroscopic measurements and sealed reference volumes of CO_2. The instrument will compare laser spectroscopic measurement of a flowing sample cell to a permanently sealed quartz reference cell. The spectroscopic measurement is based on the integrated absorbance of an isolated, temperature independent rovibrational line of CO_2 near 2.7 μm. The permanently sealed reference cell provides an absolute column density standard that will allow the instrument to measure mole fraction of $CO_2$with an accuracy of 0.1 ppm (one part in 4000) during long term, unattended operation without the use of any consumables (i.e. calibration tanks). A pre-existing laboratory apparatus was modified to test the proposed concept with a new 2.7 micron laser. We demonstrated outstanding precision (15 ppb in one second) and excellent stability (40 ppb over days), exceeding our Phase 1 accuracy goal. We will create detailed optical, thermal, electronic and spectroscopic designs for a Phase II deployable, prototype instrument. We will build the instrument and demonstrate its capabilities by deploying it at laboratory and field sites where it will be rigorously tested against existing measurement techniques.

Commercial Applications and Other Benefits: The proposed instrument will be an attractive addition to the hundreds of CO_2monitoring stations throughout the world since it will run unattended and will not require frequent calibration. It will have an accuracy that meets or exceeds that achievable with routine gas calibrations. Adoption of this technology will provide a significant societal benefit if the deployment of this instrument leads to better and more cost effective measurements of ambient CO_2. Improved measurements of CO_2 will help us to better understand and mitigate global warming and global climate change.

91253S09-II

Highly Compact CO2 Sensor for Balloon Deployment—Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077; 978-689-0003
Dr. David M. Sonnenfroh, Principal Investigator; sonnenfroh@psicorp.com
Dr. B. David Green, Business Official; green@psicorp.com
DOE Grant No. DE-FG02-09ER85318
Amount: $999,911

Trace gas species, such as carbon dioxide, are important in the carbon cycle of the atmosphere and in global climate change. Precise measurements of these species are important to carbon cycle studies and global warming research, especially in characterizing sources and sinks. New, miniaturized and low cost instrumentation is required to make measurements of the vertical concentration profiles of CO2 from balloons and small unmanned aircraft in order to develop the required database. A new sensor for high precision measurement of ambient CO2 from balloons and small aircraft is being designed and demonstrated. The spectrometer combines advances in light emitting diode technology with miniaturized electronics to enable a sensor with a measurement precision on the order of 1 part in 400. A breadboard version of the sensor was used to demonstrate a measurement precision of 1 ppmv out of 380 ppmv for a 10 sec measurement period. A conceptual design for a field prototype was also developed. In Phase II, a complete engineering design for a field prototype will be developed and fabricated. Separate configurations for small UAVs and balloons will be developed. The field prototypes will be characterized and tested at conditions representative of the atmosphere using available environmental chambers.

Commercial Applications and Other Benefits: This program will demonstrate a new, moderate precision, economical sensor for ambient CO2. This sensor will fill a need for a compact, low weight instrument that is rugged enough and economical enough for deployment on small aircraft and balloons. The technique is adaptable to the measurement of other trace gas species. Other applications include combustion emissions analysis, fugitive emissions control, industrial process control, and contraband detection.

91266S09-II

Oxygen A-Band Spectrometer—Yankee Environmental Systems, Inc. successor to Jerry Berndt, 101 Industrial Boulevard, Turners Falls, MA 01376-1611; 413-863-0200
Mr. Jerry Lee Berndt, Principal Investigator; mcb@yesinc.com
Mr. Mark Charles Beaubien, Business Official; nlt@yesinc.com
DOE Grant No. DE-FG02-09ER85458
Amount: $999,999

An important scientific challenge in understanding long-term climate change is being able to precisely measure the scattering properties of clouds and aerosols in our atmosphere. The High Resolution Oxygen A-Band Spectrometer will provide measurements that both validate atmospheric models and calibrate orbiting remote sensors for cloud and aerosol effects.

91269S09-II

Development and Characterization of a Compact Aerosol Chemical Speciation Monitor (ACSM)—Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-932-0215
Dr. John T. Jayne, Principal Investigator; jayne@aerodyne.com
Mr. George N. Wittreich, Business Official; gnw@aerodyne.com
DOE Grant No. DE-FG02-09ER85262
Amount: $851,389

Aerosol particles have important impacts on visibility, acid deposition, climate, and human health, although large uncertainties remain in quantifying their chemical composition and atmospheric transformations. A large fraction of the anthropogenic aerosol is generated from energy-related activities, and organic compounds are known to constitute a significant fraction of ambient aerosol mass. Organic aerosol can be directly emitted from combustion sources or formed through gas-phase reactions of volatile organic compounds. This Small Business Innovation Research Phase I project addresses the need for improved monitoring technologies for continuous particulate mass and chemical speciation of ambient aerosols. A prototype Aerosol Chemical Speciation Monitor will be developed that measures ambient aerosol mass and chemical composition of non-refractory PM2.5 aerosol particles in real-time, providing quantitative measurements of particulate ammonium, nitrate, sulfate, chloride, and organics. The instrument will be designed to run autonomously for extended periods of time and will need no expensive post-processing analysis. The Aerosol Chemical Speciation Monitor will be a simple, robust, modestly-priced, aerosol chemical speciation instrument ideal for routine monitoring of local and regional air quality, for continuous emissions monitoring, and for process control monitoring.The Phase I project succesfully demonstrated the feasibility of the Aerosol Chemical Speciation Monitor. A prototype was constructed and deployed in a field campaign for intercomparison with routine environmental monitoring instruments. Progress was made addressing quantification issues. During Phase II, a commercial version of the instrument will be developed. Specific tasks include designing and constructing new hardware, optimizing the design of the inlet and detector, and developing new data anlysis tools for fast and broad dissemination of particulate mass loadings and chemical composition.

Commercial Applications and Other Benefits: The Aerosol Chemical Speciation Monitor will provide cost-effective, quantitative particulate matter mass loading and chemical composition data for determining compliance with air quality standards, and for inclusion in atmospheric climate models. The primary market for this instrument will be government agencies that conduct routine environmental monitoring programs. In addition, atmospheric research groups at universities and national laboratories will provide a substantial market. We expect that the system developed in this program will yield a significant level of direct commercial sales in the atmospheric science and environmental pollution research and development communities.

91276B09-II

Volatility Resolved Measurements of Total Gas-Phase Organic (TGO) Compounds by High Resolution Electron Impact Mass Spectrometry—Aerodyne Research, Inc., 45 Manning Road, Billerica, MA 01821-3976; 978-932-0215
Dr. Scott Herndon, Principal Investigator; herndon@aerodyne.com
Mr. George N. Wittreich, Business Official; gnw@aerodyne.com
DOE Grant No. DE-FG02-09ER85264
Amount: $950,229

Aerosol particles have important impacts on visibility, acid deposition, climate, and human health, although large uncertainties remain in quantifying their chemical composition and atmospheric transformations. A large fraction of the anthropogenic aerosol is generated from energy-related activities, and organic compounds are known to constitute a significant fraction of ambient aerosol mass. Recently discovered discrepancies between measurements of organic aerosol mass and predictions from large scale atmospheric models suggest that our understanding of the sources of secondary organic aerosol is incomplete. This SBIR project addresses the critical need for improved chemical characterization of the gas-phase organic compounds that serve as precursors for organic aerosol in the atmosphere. We will develop and test a novel instrument for the measurement and characterization of atmospheric Total Gas-Phase Organics. Gas-phase organic compounds will be collected cryogenically, desorbed, and measured with high-resolution electron impact mass spectrometry, a general technique allowing for the measurement of the total mass of all organic species, as well as key chemical characteristics, such as the oxygen-to-carbon ratio. Temperature control of the sample desorption process will give information on the volatility of the organic compounds, a crucial element in understanding gas to particle conversion. The Phase I project succesfully demonstrated the feasibility of the Total Gas-Phase Organics instrument. A prototype was constructed and characterized in the laboratory. The prototype was deployed in a field campaign for intercomparison with other measurements of gas-phase organics. During Phase II, a commercial version of the instrument will be developed. Specific tasks include optimizing the design of the inlet and detector, developing techniques for separating gas- and condensed-phase organics, and developing new data anlysis tools for analyzing the complex chemically and volatility resolved datasets that will be acquired.

Commercial Applications and Other Benefits: The TGO instrument will be available as a stand-alone instrument or as a module for use with all existing and future aerosol mass spectrometer systems. The primary market for this instrument will be atmospheric research groups at universities and national laboratories. In addition, the instrument will be well-suited for environmental monitoring, as well as for the characterization of emissions from a variety of industrial and energy production processes, including aircraft combustors, gas turbines, fluidized bed combustors, diesel combustors, and conventional furnaces. We expect that the system developed in this program will yield a significant level of direct commercial sales and contract field measurements from the atmospheric science and environmental pollution research and development communities.

91291S09-II

Chemical Free Surface Processing for High Gradient Superconducting RF Cavities—FM Technologies, Inc., 4431-H Brookfield Corporate Dr, Chantilly, VA 20151-1691; 703-818-9400
Dr. Frederick Mako, Principal Investigator; fmako@erols.com
Dr. Frederick Mako, Business Official; fmako@erols.com
DOE Grant No. DE-FG02-09ER85394
Amount: $999,990

Chemical treatment such as buffered chemical polishing (BCP) or electropolishing (EP) followed by high pressure rinsing (HPR) of niobium (Nb) superconducting RF (SRF) cavities is expensive and complex multistep process. Furthermore, the cavity RF surfaces after the treatment still have numerous bubbles and pits that result from welding. These quench-producing weld defects together with the particulate contamination, result in significant scatter of the multi-cell Nb SRF cavities performance characteristics. This scatter is the major problem in the current manufacturing of the Nb SRF cavities. FM Technologies proposes a new chemical-free processing for multi-cell Nb SRF cavities using an internal electron beam (IEB). Specifically, FMT proposes to develop a new electron gun system that will perform electron beam melting over the entire interior surface of Nb SRF cavities to produce a smooth surface, free from voids, bubbles, and other imperfections. This will allow manufacturing of the Nb SRF cavities without the above chemical treatment procedures and increase the cavities high gradient performance. In Phase I, 30 Nb samples were surface melted by an electron beam, beam parameters were determined to achieve a quality Nb surface (qualified by HIROX, AFM, SEM and EBSD). A complete Nb SRF cavity ,without chemical etching, was electron beam melted at the interior surface and RF tested in the superconducting range. Several electron gun designs were evaluated. Phase II is aimed at building and testing a complete prototype computer controlled electron beam interior cavity surface melting system. Many Nb samples will be surface melted and beam parameters established to achieve a high quality surface (qualified by HIROX, AFM, SEM and EBSD). Single and multi-cell Nb SRF cavities will have the interior surface melted by this system at FMT, without chemical etching, Jefferson Lab (J-lab) will perform RF testing on these cavities.

Commercial Applications and Other Benefits: When developed the chemical free surafce processing using IEB will benefit first J-lab's CEBAF and Fermilab's Project X. Also, light sources, require 1.3 - 1.5 GHz SRF structures. Furthermore, IEB will produce much broader impact because it can be implemented into manufacturing of many other types of RF devices including both superconducting as well as normal conducting RF cavities.

91299B09-II

STTR Project - Phase and Frequency Locked Magnetrons for SRF Sources—Muons, Inc., 552 N. Batavia Ave, Batavia, IL 60510; 630-840-2424
Mr. Michael Neubauer, Principal Investigator; mike@muonsinc.com
Dr. Thomas J. Roberts, Business Official; tjrob@muonsinc.com
DOE Grant No. DE-FG02-09ER86398
Amount: $749,999

Research Institution
Fermi National Accelerator Laboratory

Typically, high power sources for accelerator applications are many megawatt microwave tubes that may be combined together to form ultra high-power localized power stations. The RF power is then distributed to multiple strings of cavities through high power waveguide systems, which are expensive to produce and to operate, because of reduced efficiency and lower reliability. Magnetrons are the lowest cost microwave source in $/kW with the highest efficiency, typically greater than 85%, but the frequency and phase stability of magnetrons has been a problem when used as power sources for accelerators.Novel variable frequency cavity techniques have been developed which will be utilized to phase and frequency lock magnetrons, allowing their use for either individual cavities, or cavity strings. Economies of scale will further reduce magnetron costs, in addition to removing the capital, efficiency, and reliability costs of combining and/or distributing power.Ferrite and YIG (Yttrium Iron Garnet) rods were inserted into the individual cells of a cold test fixture built to model an S-band California Tube Lab magnetron strapped π−mode structure. An external magnetic field, orthogonal to the magnetic RF field of the magnetron varied the permeability of the ferrite and YIG materials, and the results recorded. A feed-back loop was designed to control the magnetic field which will control the phase and frequency difference between a reference signal, and the output of the magnetron.A complete magnetron will be built and tested in Phase II with appropriately located ferrites or garnets. The magnetron will have a permanent magnet focusing system and individual solenoids designed to control the magnetron modes of operation. Suppressing the competing modes will increase the phase purity of the π−mode.

Commercial Applications and Other Benefits: Phase and Frequency locked magnetrons have wide uses in the commercial, military, and scientific markets, because they represent the most cost effective source of microwave energy.

91305S09-II

An Energy-Efficient RF Power Source for the Jefferson Laboratory CEBAF Linac—FAR-TECH, Inc., 3550 General Atomics Ct, Building 15 Suite 155, San Diego, CA 92121-1122; 858-455-6655
Dr. Nikolai Barov, Principal Investigator; barov@far-tech.com
Dr. Jin-Soo Kim, Business Official; kim@far-tech.com
DOE Grant No. DE-FG02-09ER85376
Amount: $999,999

The klystrons in use at CEBAF are operated at low efficiency, and the prices for servicing of existing tubes and for purchasing spare tubes have been increasing. FAR-TECH, Inc. studied a number of options in regards to improving the efficiency of the klystron systems, as well as replacement technologies such as solid state amplifiers. In Phase I, the solid state amplifier option was identified as the best alternative, and is being adopted as the Phase II plan. In Phase II, two complete prototype systems will be developed, tested, and integrated with the CEBAF accelerator system. The system will address the unique requirements of the present klystron installation, including tight space requirements, a high-efficiency design, reliability, and serviceability.

Commercial Applications and Other Benefits: FAR-TECH sees many benefits to this new technology to accelerator projects, both at national labs and universities, and in the private sector. Non-accelerator applications also exist, as the amplifier can meet general-purpose needs.

91315S09-II

Development of a Tunable 28 MHz Superconducting RF Cavity for RHIC—Niowave, Inc., 1012 North Walnut Street, Lansing, MI 48906-5061; 517-230-7417

Dr. Terry L. Grimm, Principal Investigator; grimm@niowaveinc.com
Dr. Jerry L. Hollister, Business Official; hollister@niowaveinc.com

DOE Grant No. DE-FG02-09ER85276
Amount: $999,999

The accelerating structures in the Relativistic Heavy Ion Collider (RHIC) ring are normalconducting copper structures used to capture the injected beam and accelerate across transition to the final energy, shortening the bunches before they are rebucketed into the storage RF system. This proposal seeks to replace these four accelerating structures with two superconducting RF (SRF) cavities, reducing the RF power requirements and the impact of unwanted higherorder modes, among other advantages. The SRF cavity design with tuning capacitor presented here is unique research and represents a significant contribution to RHIC. The “folded” quarterwave resonator geometry has not been previously built, the tuning range (~1 % of the operating frequency) is unprecedented for a superconducting cavity, and at 28.1 MHz, this will be the lowest frequency superconducting cavity in operation. This novel structure is a product of the successful Phase I design effort, in which a number of cavity geometries were explored. Superfish simulations were used to evaluate the potential of the various structures to fit the needs of the RHIC main ring. The novel folded quarter wave with tuning structure can provide the needed acceleration and tuning over the relevant range. The peak electric and magnetic fields required are a fraction of what is possible with superconducting niobium cavities, simplifying the required surface preparation procedures. A preliminary mechanical design has been created, using a niobium bellows to achieve the unprecedented tuning range. The technical objectives of this Phase II SBIR are to finalize the mechanical design of the tunable 28 MHz niobium cavity based on the electromagnetic design elaborated in Phase I, to construct the main cavity and tuning section, to test the frequency and tuning range of the cavity at room temperature, and to construct the liquid helium vessel that surrounds the cavity. Further, the mechanical design for the cavity cryomodule will be prepared so that Niowave and Brookhaven National Lab are fully prepared to complete the cavity system for use in the RHIC ring under a funded Phase III program.

91324S09-II

Recovery Act - Device for In-Situ Multiple Coatings of Long, Small Diameter Tubes—Poole Ventura, Inc., P.O. Box 5023, Oxnard, CA 93031-5023; 805-981-1784
Mr. Henry Joe Poole, Jr., Principal Investigator; joe@pooleventura.com
Mr. Henry Joe Poole Jr., Business Official; joe@pooleventura.com
DOE Grant No. DE-FG02-09ER85596
Amount: $750,000

Electron clouds and wall resistivity in accelerators limit their performance through dynamical instabilities, heating, and/or associated vacuum pressure increases. Coating of stainless steel vacuum tubes with Cu and a-C will mitigate these problems and result in luminosity increase. A robotic coating device comprised of staggered magnetrons mounted on a “mole” is to be developed for *in-situ* coating of long, small diameter tubes with copper and amorphous graphite. A cylindrical sputtering magnetron, was designed, fabricated, and successfully operated to coat RHIC tube pieces. Copper deposition rate was determined to be 30 Angstrom per second. Preliminary design of phase II full-scale device, including cabling & bellow transition was made. Design, fabricate and operated a full-scale robotic plasma deposition device, capable of coating a complete RHIC cold section, with cable driving mechanism to coat 3 RHIC vacuum tube sections separated by 2 bellows (the two RHIC bellow types) with Cu and a-C.

Commercial Applications and Other Benefits: In-situ coating of existing accelerator vacuum tubes with Cu and a-C is a very cost effective way to mitigate significant problems in accelerators trying to increase luminosity. The ability to in-situ coat small diameter tubes & pipes can provide the capability for existing chemical, pharmaceutical & other high purity material processing operations, to improve product quality and extend operational life of the process equipment.

91327S09-II

Improved Ion Resistance for III-V Photocathodes in High Current Guns—Saxet Surface Science, 3913 Todd Lane, Suite 303, Austin, TX 78744-1057; 512-462-3444
Dr. Gregory Mulhollan, Principal Investigator; mulhollan@saxetsurfacescience.com
Dr. Gregory Mulhollan, Business Official; mulhollan@saxetsurfacescience.com
DOE Grant No. DE-FG02-09ER85432
Amount: $850,000

A fundamental issue with high average current photoelectron guns is the generation of stray electrons and ions which can damage the photoemitter. Free electrons can potentially directly impact the photocathode, desorb molecules from the gun structure and act as ionization agents for background–gas atoms. Ion back-bombardment of the photoemitter can alter or damage both the photoemitter and the activation layer, resulting in diminished lifetime and poor photoyield, hampering efficient operation. The goal of this program is to enhance the activation layer stability against the ion and, to a lesser extent, electron flux likely to be found in a high average current gun in which III-V photocathodes are employed. The influence of charged particles, ions and electrons, will be investigated on mono- and bi-alkali activated photoemitters. The latter has been shown to possess chemical resiliency. The high secondary electron yield of the photoemitters can be used to provide the current densities required to reverse oxidizer-induced photoyield decay, an effect that was discovered during the course of the Phase I work. Cs+Li+NF3 activated photoemitters were shown to retain enhanced immunity to chemical reaction over Cs+NF3 activated photoemitters after having been exposed to low levels of hydrogen ions. A method was discovered for photoyield recovery by which the action of low energy electrons can be used to reverse the effects of both elevated oxidizer gas induced decay and ‘natural’ decay caused by background gas.

The effects of ion species mass and energy on the enhanced protection Cs+Li+NF3 activated photoemitters’ photoyield and resistance to oxide bearing gas will be measured. The energy and flux requirements for the electron stimulated recovery of NF3 activated GaAs will be quantified. This will include flux and energy as well as determination of surface chemistry and any desorption products.

Commercial Applications and Other Benefits: Improved ion resistance and exposure limit thresholds will allow III-V photocathodes to be used in properly designed, but less environmentally benign accelerator injector guns. The electron stimulated recovery technique can eliminate the need for dosing cesium, a field emission enhancer, in high field guns. The proposed research can also generate the foundation for a cold cathode, photon based electron source with small energy spread and source size limited only by the size of the exciting light spot.

91329S09-II

High-Fidelity Modulator Simulations of Coherent Electron Cooling Systems—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856
Dr. David L. Bruhwiler, Principal Investigator; bruhwile@txcorp.com
Mr. Laurence D. Nelson, Business Official; lnelson@txcorp.com
DOE Grant No. DE-FG02-09ER85508
Amount: $999,943

Coherent electron cooling (CeC) is an innovative concept for orders-of-magnitude increase in the luminosity of high-intensity relativistic hadron beams, which could dramatically increase the scientific productivity of the Relativistic Heavy Ion Collider (RHIC) and may be the only viable approach to enable future electron-ion collider (EIC) concepts. Construction of a proof-of-concept CeC experiment at RHIC will be proposed in early June, 2010. Detailed simulations are needed to reduce technical risk. The parallel VORPAL framework is being used to simulate the electron density/velocity wakes generated by co-propagating ions in a CeC modulator section. In lower dimensionality, Vlasov and of PIC (particle-in-cell) algorithms are both used for benchmarking, where no theory is available. In full 3D, of PIC is used. The parameters of the proposed CeC proof-of-principle experiment at Brookhaven National Lab are considered, including realistic non-ideal effects. Integrated simulations, using the GENESIS 3.1 code to model the free electron laser (FEL) amplifier will assess any reduction in the effective ion velocity drag. Prototype 1D1V and 2D2V Vlasov-Poisson models were implemented in VORPAL. Vlasov and of-PIC simulations of Debye shielding were shown to agree with each other and, for Lorentzian electron velocity distributions, with theory. A low-order Vlasov update enables future hybrid use with other algorithms and efficient parallelization. Vlasov is needed for code benchmarking, but full 3D3V Vlasov (i.e. a 6D mesh) will not be practical in the near term, even for leadership class facility (LCF) supercomputers. A general multidimensional (1D1V, 1D2V, 1D3V, 2D2V, 2D3V) Vlasov algorithm will be implemented in the parallel VORPAL framework, designed to work in hybrid mode with other VORPAL algorithms, such as PIC and fluid. The □f PIC algorithm and Poisson solver will be further improved. The integrated GUI that is being developed for ease of use and state-of-the-art 3D visualization, known as VORPAL Composer, will be generalized to work with the higher-dimensional Vlasov grids. VORPAL Composer will also be generalized to work with GENESIS 3.1 and to manage code coupling and processing that is required for the very specialized modeling of coherent electron cooling systems. Parametric models for the effective velocity drag will be developed or generalized to account for various real-world effects. We will provide computational support for design and commissioning of the CeC experiment at BNL.

Commercial Applications and Other Benefits: VORPAL is commercially-available software for simulating a wide range of electromagnetic and electrostatic phenomena, including the nonlinear kinetic behavior of beams and plasmas. Implementation of a general purpose Vlasov algorithm with up to 5D meshes (2D3V) will create additional opportunities for VORPAL sales to (and associated contract revenue from) a wide variety of commercial and scientific customers. Phase III revenue for electron cooling simulations is on-going and expected to grow.

91346S09-II

Electronics for Fast Vertex Position Measurement—Blue Sky Electronics, LLC, 401 Studewood, Ste 203, Houston, TX 77007-2733; 713-880-1108
Mr. Lloyd W. Bridges, Principal Investigator; lloyd@blueskyelectronics.com
Mr. Lloyd W. Bridges, Business Official; lloyd@blueskyelectronics.com
DOE Grant No. DE-FG02-09ER85557
Amount: $557,270

Particle colliders such as the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory have circular, counter-rotating particle beams which are focused such that they cross and collide at a few places around the collider ring. Large, complex particle detectors are located at these positions to record and measure the new particles resulting from the particle beam collisions. The location of each collision is called the "primary vertex position" and ideally is centered exactly within the particle detector, but in fact varies over some distance along the beam path. If more precise measurement of this primary vertex position is available, then that information can be used as part of the detector trigger to record data from only those collisions which are ideally located, and so can significantly increase the efficiency and sensitivity of the Solenoidal Tracker at RHIC (STAR) and similar existing detectors. For new, smaller detectors such as the proposed Heavy Flavor Tracker (HFT), which have physical dimensions smaller than the distribution of the primary vertex position, the efficiency gains are magnified. We propose to design and build new electronics to provide a high-resolution, real-time vertex position measurement for collider experiments and other applications. The proposed electronics will provide increased efficiency and sensitivity to the STAR and other detectors in a very cost effective manner, compared to the large capital and operational costs of the detectors and their collider environments. Specifically, a fast vertex position measurement can be used as part of the experimental trigger to provide improved operational efficiency (more useful data for a given experimental run time) by including more "good" hits for the calorimeters, more accurate track reconstruction seeds for both offline and high-level online triggers (resulting in faster data processing), real-time triggering for events within the very small vertex extent of proposed new detectors, and fast detector-only data streams. The proposed system is based on our existing experience and products for precise timing measurement, developed by Blue Sky Electronics as part of the successful STAR Time-of-Flight (STAR TOF) project. That project involved a close collaboration between Blue Sky and researchers at Rice University and the University of Texas, and we have maintained that strong team for this proposed project. Our team's extensive experience in integrating electronics within the STAR environment will significantly reduce project risk.

Commercial Applications and Other Benefits: Although fast vertex position measurement is a specialized application, the system we will create to make that measurement is a very high speed pulse processing instrument combining timing, magnitude and real time processing in programmable logic. The resulting capability is flexible and general, and creates significant commercial opportunities as a key component in diverse systems for 1) time-of-flight mass spectrometry, 2) time-of-flight positron emission tomography, 3) time-resolved confocal microscopy, 4) laser distance measurement for three dimensional imaging and ultra precision machining and 5) remote atmospheric sensing via laser induced, time resolved florescence, and 6) neutron/gamma detection for homeland security. These larger systems are addressing cutting

edge problems in life sciences, medical imaging, advanced manufacturing, environmental monitoring and homeland security.

91383S09-II

Segmented Rectifying and Blocking Contacts on Germanium Planar Detectors—PHDs Co.,
777 Emory Valley Road, Suite B, Oak Ridge, TN 37830-7048; 865-481-3725
Dr. Ethan Hull, Principal Investigator; ethanhull@phdsco.com
Dr. Ethan Hull, Business Official; ethanhull@phdsco.com
DOE Grant No. DE-FG02-09ER85310
Amount: $999,999

The semiconductor contacts on segmented germanium planar detectors require improvement to commercially supply better detectors at lower cost with faster delivery. In addition, this improvement will result in the utilization of significantly more high-purity germanium crystals for detector fabrication. The DOE operates user facilities for Nuclear Physics research that require such detectors for gamma-ray measurements. New viable semiconductor-detector contacts were experimentally developed during Phase I. These contacts will be further refined and adapted for use on full sized detectors for Nuclear Physics research during Phase II. To accomplish these goals, numerous germanium detectors will be fabricated and tested. A new version of the NPX detector product line based on this technology will become available, in modest quantities, by the end of Phase II. Several new germanium-detector contacts were fabricated and tested. One particular contact experimentally demonstrated the essential physical properties needed to be an extremely useful segmented germanium-detector contact. The contact technology will be fine-tuned and evolved to become amenable to full-sized NPX segmented germanium-detector fabrication. This new contact will be the basis for a new product line to become available by the end of the Phase II. The physical mechanisms of the contact will be studied to gain a better fundamental understanding.

Commercial Applications and Other Benefits: Better germanium detector contacts will enable these detector systems to enter new realms of sensitivity and commercial viability. These systems will have immediate applications in research taking place at DOE user facilities including work in Nuclear Physics, positron-annihilation spectroscopy, astrophysics, and rare-particle detection. Moreover, these detector systems will enable germanium detectors to enter commercially active fields currently unoccupied by germanium detectors. The most important of these fields is nuclear medicine. Unlike many other position-sensitive gamma-ray detector technologies, germanium-detector technology is scalable to larger sizes and can be manufactured in mass. All technical steps of manufacture, including crystal growth detector fabrication, and system integration will remain viable in the United States for the foreseeable future. The process will always require an environment including the presence of scientists, engineers, technicians, and close association with research scientists at DOE laboratories. All the work supported by this SBIR will be performed by PHDs Co. in Oak Ridge, TN. PHDs Co. is a 100% domestic corporation.

91406S09-II

Carbon Stripper Foil for the Next Generation Rare Isotope Beam Facility—Applied Nanotech, Inc., 3006 Longhorn Blvd. Suite 107, Austin, TX 78758-7631; 512-339-5020
Dr. Richard Fink, Principal Investigator; dfink@appliednanotech.net
Dr. Richard Fink, Business Official; dfink@appliednanotech.net
DOE Grant No. DE-FG02-09ER85272
Amount: $771,812

The Facility for Rare Isotope Beams (FRIB) will be a key tool for nuclear science that promises to change the way we view and describe the nucleus. A charge stripper foil is an essential device in a heavy-ion accelerator; they increase the variety of acceleration schemes and decrease the accelerator construction cost. The FRIB facility will require a stripper foil that can sustain a beam power loss of 1 kW. To handle such a high power load over a small beam size (about 1 mm diameter), the design of the stripper foil includes a need for large area, robust carbon foils. These foils are typically expensive to make, are fragile and are difficult to make over large area (eventually we may need to scale to 30 cm diameter). There is a need for a stripper foil in the range of 0.5 mg/cm^2 that is low-Z, thermally conductive, mechanically robust, has high uniformity and can be fabricated over large areas at low cost. In addition, researchers at the ATLAS accelerator at Argonne National Laboratory have a need to replace metal foils as windows for gas targets such as are currently used for in-beam reactions to generate secondary radioactive beams. The overall goal of this two phase program is to develop robust carbon foils that can be made over large areas at low cost for stripper foil and windows for gas targets. We will address this problem by using vacuum filtration methods to make carbon foils from graphene and carbon nanotubes. The Phase I effort demonstrated that graphene foils are feasible materials for ion stripper foil applications. The methods used can be scaled to large area and they show superior uniformity. We also demonstrated feasibility to use this foils for gas target window application. The overall technical objective of this Phase II program will be to increase the foil diameter to > 15 cm, demonstrate uniformity over this area and demonstrate mechanical robustness of the foils, even when taken to high temperature.

Commercial Applications and Other Benefits: FRIB will produce key new rare isotopes of atomic nuclei that are essential for our understanding of the universe. It is the overall consensus of the international nuclear structure and nuclear astrophysics communities that the future of the study of atomic nuclei centers on and requires advanced facilities for access to exotic nuclei. FRIB will have profound benefits to society; it will play an important role in the 21st Century's advances in modern technology (advanced materials), medicine (new radioisotopes from targeted treatment and functional diagnosis), the environment (better nuclear reactor designs), and national security (nuclear weapon stockpile security). Significant improvements in stripper foil performance are needed for this next generation of accelerators; this program is intended to provide these improvements.

91411B09-II

Recovery Act - Optimization of the PETSc Library for Clusters of MultiCore Processors—RNET Technologies, Inc., 240 West Elmwood Drive, Suite 2010, Dayton, OH 45459-4248; 937-433-2886
Dr. Gerald M. Sabin, Principal Investigator; gsabin@rnet-tech.com
Dr. Vaidnathan Nagarajan, Business Official; vnagarajan@rnet-tech.com
DOE Grant No. DE-FG02-09ER85426
Amount: $999,999

PETSc is used in a wide range of science applications, many of which are developed and/or used by the DOE (including PFLOTRAN, VULCAN/2D, and GTC). The stagnation of single core hardware performance, and the resulting multi-tiered supercomputer architecture require codes to be modified to leverage the unified memory access available on each multicore/GPGPU accelerated node. Many PETSc codes are based on structured grids, but are required to use "generic" PETSc data structures such as compressed sparse row (CSR). The introduction of a structured grid data structure into PETSc will improve the performance of many PETSc applications and allow them to leverage a multi-tiered (e.g., MPI and Open MP/GPU) architecture in an application transparent manner. The Phase I results demonstrate the difficulty of tuning PETSc application performance for next generation supercomputers using existing data structures and modifying user callback functions to improve instruction level parallelism (ILP). However, by modifying the PETSc underlying data structure it is possible to improve the performance of PETSc applications. In addition, the data structure modifications allow the applications to better leverage GPGPUs and multicore architectures. In Phase II the structured grid data structures will be fully implemented in PETSc to allow applications to easily leverage the new data structures, with either no or very minimal application changes. GPU optimizations will also be made using the structured grid data structures, allowing transparent performance improvements. Additional data structures will also be investigated to target multi-tiered (e.g., multicore and cluster) architectures. We'll puruse a complementary investigation into optimizing the PETSc-invoked user routines implementing function and Jacobian evaluation to exploit multicore architectures. We will also create an easily installable and updateable version of PETSc that contains commonly used third-party libraries and tools, that will be packaged for scientific and commercial users.

Commercial Applications and Other Benefits: The tools developed will provide a mechanism for efficient parallelization of many science codes (including application relying on PETSc). This will allow many government and commercial HPC users to better scale applications that are running on the recently emerging supercomputers based on multicore compute nodes.

91412B09-II

Interoperable Components to Support Unstructured Mesh Simulations on Massively Parallel Computers—Simmetrix, Inc., 10 Executive Park Drive, Clifton Park, NY 12065-5630; 518-348-1639

Dr. Mark Beall, Principal Investigator; mbeall@simmetrix.com
Dr. Mark Beall, Business Official; mbeall@simmetrix.com

DOE Grant No. DE-FG02-09ER85437
Amount: $816,061

Government and industry have made large investments in the development of mesh-based analysis software to address a wide range of mathematical physics simulations. Critical applications of these technologies involve geometrically complex situations and require massively parallel computers to achieve the necessary level of accuracy. This requires the ability to automatically generate and adaptively control the meshes for the analysis software on massively parallel computers. Building on DOE efforts to develop interoperable interfaces to mesh and geometry information, this project will provide a direct linkage to simulation automation technologies giving access to commercially proven, robust capabilities for parallel mesh generation and adaptivity. Further efforts will be made to provide the ability to use the full suite of tools on massively parallel computers with a particular focus on parallel interactions with the domain geometry. These capabilities will be demonstrated through the development of adaptive simulations operating on massively parallel computers. The Phase I project demonstrated implemented interoperable interfaces for the tools and demonstrated some key aspects of the new functionality for distributing geometry in parallel. Demonstrations of parallel, adaptive simulations using some of the new capabilities where done. Phase II will further develop the distributed geometry and parallel adaptivity capabilities required for these types of simulations. A major focus will be on efficient performance on both current and near future massively parallel computers. Demonstrations of the full capabilities will be done on problems of relevance to the DOE mission.

Commercial Applications and Other Benefits: A summary of the general benefits expected as a result of this project, and continued development, include: Speeding the development of new simulation tools within the DOE and other research organizations, providing a seamless mechanism to be able to transition new simulation technologies to a broader user community and to be able to support the effective coupling of multiple simulation tools to address complete applications, provide industry with the means to apply new simulation technologies in the design and production of new products for a broad range of industries from aerospace to consumer products.

91413S09-II

Extending Chombo with PETSc—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856

Dr. Alexander Pletzer, Principal Investigator; pletzer@txcorp.com
Mr. Laurence D. Nelson, Business Official; lnelson@txcorp.com

DOE Grant No. DE-FG02-09ER85510
Amount: $999,749

Computer simulations of physical phenomena in nuclear fusion, combustion, climate science, and hydrodynamics often rely on advancing parabolic/heat-like equations implicitly in time. The multi-grid method, which has been shown to scale to 10,000 or more processes, is widely regarded as one of the most efficient numerical method available today for solving such problems. However, standard multi-grid is known to fail in some non-ideal conditions, in particular when the heat conductivity is highly anisotropic. Thus, there is a need to develop methodologies that exploit the natural advantages of multi-grid, while at the same time offer improved robustness over the standard smoothing/relaxation method. We propose to interface two DOE developed software libraries: Chombo for Adaptive Mesh Refinement (AMR), and PETSc for its collection of sparse system solvers and preconditioners. This will involve developing capability to assemble the sparse matrix system representing a differential operator discretized on a hierarchy of block-structured grids. We have demonstrated a multi-grid interface to solvers that is more robust than the native Chombo geometric multi-grid solver (without line relaxation or semi-coarsening), and have shown that PETSc/Hypre-BoomerAMG solves can produce high performance without sacrificing robustness. We will implement high performance C++, multi-grid/multi-block matrix assembly code for Poisson type operators. This will allow Chombo to interface with all available PETSc solvers and preconditioners.

Commercial Applications and Other Benefits: The proposed work will benefit DOE related research in new energy research and fluid hydrodynamics where equations can be highly nonlinear and for which the need for robust and efficient numerical methods is paramount. Through an interface to PETSc, Chombo users will gain access to many solution procedures, including direct, Krylov, and algebraic multi-grid.

91418S09-II

2D Switchable/Multiview Autostereoscopic 3D Display—Dimension Technologies, Inc., 315 Mount Read Boulevard, Rochester, NY 14611-1982; 585-436-3530
Dr. Jesse Eichenlaub, Principal Investigator; jbe@dti3d.com
Dr. Jesse Eichenlaub, Business Official; jbe@dti3d.com
DOE Grant No. DE-FG02-09ER85328
Amount: $999,973

Dimension Technologies Inc. Large Autostereoscopic Multiview 2D/3D Switchable Desktop Monitor Principal Investigator: Jesse Eichenlaub Topic 51: Scientific Visualization and Data Understanding, Subtopic a) Collaborative Data Analysis and Visualization Scientists and engineers must view increasingly complex computer generated multi- dimensional data sets and simulations based on those data sets, often in collaborative environments where several researchers at remote locations are viewing the data. This is true in energy related fields such as oil and gas exploration and efficient engine design. Such data sets are usually rendered in three dimensions, and due to their complexity it is often necessary for researchers to view them in stereoscopic (3D) form to gain the sense of depth required to see where various points, structures, and other representations are positioned and oriented relative to one another. At present, researchers typically wear 3D glasses to view such representations. This tried and true stereo viewing technique has many limitations, including its inability to render distortion free images for more than one person in one position. Autostereoscopic displays also exist, but existing models either introduce observer position restrictions or else sacrifice the resolution to create 3D images. The goal of this Phase II project is to build prototype autostereoscopic (3D without glasses) displays capable of two to three times the 3D resolution of existing autostereoscopic 3D images. The displays will allow several observers to observe immersive high resolution 3D images from across a wide area. The Phase I program proved the feasibility of both the innovative autostereoscopic technology and its compatibility with existing PC technology. The proposed Phase II program will be used to build and test two prototypes: the first will be a 22” model and the second a scaled up large screen (living room TV size) version. Immediate markets and access exist for the 22” display described in this proposal.

Commercial Applications and Other Benefits: The gaming and casino industries and dental displays for chairside and waiting rooms are two such areas. Other markets include: Point of Sale (retail); Trade Shows & Exhibition Industry; Regulated medical market; Entertainment industry; Military and security applications; and Consumer products requiring LCD technology including games. The proposed display should find wide use within a host of engineering applications including analysis and interaction with complex data sets, and simulation of air or coolant flow through and around engines, aircraft, vehicles, and buildings. Due to its ability to produce 3D images for a small audience, it may be a viable candidate for eventual home television use.

91427S09-II

Recovery Act - Multi-Resolution Streaming for Remote Scalable Visualization--Kitware, Inc., 28 Corporate Drive, , Clifton Park, NY 12065-8688; 518-881-4902
Dr. Charles Law, Principal Investigator
Dr. William J. Schroeder, Business Official
DOE Grant No. DE-FG02-09ER85461
Amount: $999,999

Multi-resolution streaming is a proven approach to visualize extremely large remote 2-D images and surfaces. We will extend this technique to 3-D Adaptive Mesh Refinement data by adding features to the scalable Paraview visualization application. This load on demand feature will allow researchers to visualize the largest AMR data with modest computing resources. The software will be developed as a freely available open-source cross-platform application.
The goal of this project is to extend our C++ visualization toolkit (VTK) and our turn-key general-purpose visualization application Paraview to process and visualize extremely large AMR data using limited computing resources. The final application will load blocks on demand. The application will use low-resolutions blocks to guide users to regions of interest. High-resolution blocks will only be loaded when the view zooms into a specific region. The application will be extended to handle acquired structured data. Preprocessing will convert scanned volumes into a multi-resolution format.

91370S09-II

FPGA-Based End-Station Security for High-Performance Networking—Acadia Optronics, LLC, 1395 Piccard Drive, Suite 210, Rockville, MD 20850-4348; 240-731-1300
Mr. Karthick Ramu, Principal Investigator; karthickramu@acadiaoptronics.com
Dr. Edward Hagley, Business Official; edwardhagley@acadiaoptronics.com
DOE Grant No. DE-FG02-09ER85240
Amount: $999,914

Traditional enterprise cyber-security methods are inadequate to address the increasing number of threats, particularly within larger and higher-performance networks. Several government and third party organizations report consistent failures within corporate and federal, state, and local government networks. A key point of failure in securing these networks is the centralized security architecture which relies heavily on single-point-offailure network appliances such as firewalls, while insufficiently protecting the end systems. Several commercial off the shelf (COTS) solutions provide distributed security functions for standard networks operating at data rates up to 1 Gb/s. However, to date, no distributed solution has emerged that supports the requirements of high-performance networks operating at 10 Gb/s and beyond. To that end, we propose to address these problems by developing a distributed security platform designed specifically for high-performance networks. This system will consist of a Secure Network Interface Controller (sNIC) card designed for use in high performance end systems, clusters, storage area networks, etc., along with software for management and support. It will be designed to meet or exceed the security guidelines established by NIST Federal Information Processing Standards (FIPS) Publication 200. In Phase I, Acadia proved the feasibility of an FPGA-based sNIC card capable of operating at 10 Gb/s and beyond. An alpha prototype system which incorporates industry-standard security features such as SSL Encryption Engine, Firewall Engine, and Quality of Service (QoS) Engine operating at 10 Gb/s and a secure Authentication, Authorization, Accounting, and Auditing (AAAA) channel was developed. A thorough study was undertaken to examine the compatibility of widely available remote management and monitoring tools with the proposed system. In Phase 2, Acadia will transition the Phase-I feasibility study and the prototype hardware demonstration into a complete system ready for commercialization. We will deliver a complete distributed security solution for high-performance systems on an FPGA-based Secure Network Interface Controller (sNIC) card. The system envisioned here is especially well suited for large-scale high performance enterprise networks such as those in use in DOE and in large corporations.

91435B09-II

Enhancement of GridFTP Performance through GMPLS Integration and Hardware Offloading—RNET Technologies, Inc., 240 West Elmwood Drive, Suite 2010, Dayton, OH 45459-4248; 937-433-2886

Dr. Gerald M. Sabin, Principal Investigator; gsabin@rnet-tech.com
Dr. Vaidnathan Nagarajan, Business Official; vnagarajan@rnet-trch.com

DOE Grant No. DE-FG02-09ER85427
Amount: $999,999

Many scientists rely on transport protocols such as GridFTP to transfer very large files, ranging from Megabytes to Terabytes. These users are increasingly using high-bandwidth, high-latency optical networks. The user experience will be improved by the integration of end-to-end scheduling into GridFTP, improved networking for GridFTP, and improved usability. GridFTP allows network security, but at the cost of a very degraded networking throughput. A GridFTP transport protocol to support high bandwidth, high latency links is required. Application/Function aware offloading will be used to improve the performance of a UDP based transport protocol (UDT) and an RDMA XIO module designed for high-bandwidth, high-latency optical links, and to improve the host resource usage and network throughput for encrypted GridFTP connections. The GridFTP FTP protocols, and hence the Globus.org cloud service, will be modified to support end-to-end reservations from systems such as TeraPaths and DRAGON to allow runtime allocation of links on the emerging optical networks. An RPM based distribution of GridFTP with light weight security will be created for distribution to the wider scientific community, including maintenance and support contracts. A GridFTP GUI will be developed. A preliminary version of a UDT offload to the Cavium OCTEON based NICs was developed. The capability of the OCTEON based hardware to perform high performance encryption during data transfer was demonstrated to be able to support 10 GigE throughputs at line rate. GridFTP protocol design changes required to support end-to-end network reservations, e.g., TeraPaths or DRAGON, where investigated. The protocol changes in GridFTP will be made to allow integration with existing end-to-end network reservations systems such as DRAGON and TeraPaths. GridFTP XIO Drivers will be written to leverage an offloaded UDT and an RDMA over Ethernet capable NIC. A crypto library will be offloaded to OCTEON to allow high performance 10 and 40 Gbps line-rate encrypted data transfers. OS-native packages of SSH-based GridFTP and a GridFTP GUI will be created and distributed.

Commercial Applications and Other Benefits: The GridFTP enhancements will improve the data transfer mechanism used by large government agencies to transfer very large files over the optical links. This will reduce the data transfer time between and during experiments and simulations, improving the compute utilization of clusters and reducing the time between experiments. This will allow domain scientists to improve the quality and quantity of scientific results. OS-native distribution of GridFTP with light weight security will increase the community of users who are able to benefit from the GridFTP data transfers.

91440B09-II

Physical Layer Network Management Tools Based on Automated Fiber Optic Patch-Panels—Telescent Inc., 2118 Wilshire Blvd. #1001, Santa Monica, CA 90403-5784; 310-694-8218

Dr. Anthony Kewitsch, Principal Investigator; kewitsch@telescent.com
Dr. Anthony Kewitsch, Business Official; kewitsch@telescent.com

DOE Grant No. DE-FG02-09ER85524
Amount: $999,942

Low cost, massively scalable, automated fiber optic patch-panels are the key network elements of the future, enabling software driven control, monitoring and mapping of the fiber optic physical network layer. Physical layer automation promises to dramatically improve the reliability and agility of high bandwidth communications services. Considering that the cost to operate today's networks exceeds 60% of the carriers' revenue and the staffing costs to manage data centers exceed $250B per year, the ability to automate provisioning, reconfiguration and testing has profound economic benefits. A fleet of some 200,000 service vehicles in the U.S. alone are needed to operate these increasingly complex networks. This Small Business Innovation Research Phase II program will demonstrate an all-fiber automated patch-panel prototype that promises to replace manual network management processes with high-level software control. The automated patch-panel is based on a novel all-fiber, latching matrix switch utilizing sophisticated control algorithms and intelligence based on the Theory of Knots and Braids. Fiber interconnections can be arbitrarily reconfigured in a non-blocking fashion using compact robotics and unique fiber optic strand topologies. The size and complexity of this all-fiber switch scales favorably as N, the number of ports, rather than the usual N^2 scaling, vastly reducing the complexity and size. Utilizing this unique switching system in combination with new network management software tools, automated physical layer validation testing, provisioning and discovery across a federated network will be demonstrated. During the Phase I SBIR program, a small-scale, 144-port automated patch-panel proofof-principle has been designed and unlimited reconfigurations have been demonstrated. This system successfully automated the provisioning and restoration of a 10 Gbps link within a network test bed. In Phase II, a prototype 1000-port automated fiber optic patch-panel system and network management software will be developed. Advanced Braid Theory reconfiguration algorithms and an improved switch engine design will be developed to demonstrate the largest fiber switch ever produced. The system will be tested and operated within a production network under an advanced system of network management software that automates the configuration and restoration of high bandwidth links. The development of this prototype system lays the groundwork for Phase III, in which automated fiber optic patch-panels and physical layer network management software for telecom and enterprise networks will be commercialized.

91441B09-II

RFID Overlay Network for Automated Discovery at the Physical Network Layer—Telescent Inc., 2118 Wilshire Blvd. #1001, Santa Monica, CA 90403-5784; 310-694-8218
Dr. Anthony Kewitsch, Principal Investigator; kewitsch@telescent.com
Dr. Anthony Kewitsch, Business Official; kewitsch@telescent.com
DOE Grant No. DE-FG02-09ER85525
Amount: $999,865

Today's communication network mapping tools are effective at discovering logical topology, but they do not offer visibility down to the level of individual fiber optic interconnections. Since fiber optic interconnects like those at patch-panels and network devices are currently invisible to network management systems and can number in the hundreds of millions, they are extremely challenging to manage and track. This Small Business Innovation Research Phase II program will develop a massively scalable RFID overlay network technology that is capable of automating the discovery and configuration management of all physical network connections. Inexpensive, networked RFID readers within fiber optic patch-panels are interfaced to multiplexed reader antennas adjacent each patch-panel connector port. RFID tags attached to the ports of network devices are read back at the patch-panel through the very fiber optic cables linking them. The fiber optic cables are integrated with resonant RF transmission lines that propagate the RF excitation signal down the cable, traversing multiple air gaps, and energizing the tag so that it generates a unique RF code that is detected by the RFID reader. This system exemplifies the wireless transfer of energy across long distances through resonant electromagnetic coupling. During the Phase I SBIR program, the resonant RF transmission of RFID signals across greater than 10 meters of fiber optic cable has been demonstrated. The size of passive RFID tags and reader antennas have been miniaturized to fit on standard high-density fiber optic connectors and receptacles. An RF coupling approach with high spatial discrimination has been developed to eliminate crosstalk between closely spaced RFID enabled cables and ports. This system was used to interrogate tags automatically and error-free within a small-scale network test bed. The goal of the Phase II effort is to demonstrate a large-scale prototype RFID overlay network consisting of over 1000 interconnections. Resonant transmission across a 1 km span will be demonstrated. Electronics and network management software will be developed to achieve fast Layer-0 discovery of large federated networks, independent of the number of interconnections. "Virtualization" will be extended to the physical layer through automated network discovery and the development of photorealistic software representations of Layer-0. In this fashion, the exact physical layer topology of how all ports are interconnected to one another can be reconstructed in near real time.

Commercial Applications and Other Benefits: During Phase III, RFID enabled interconnects and network management appliances based on this large-scale prototype system will be commercialized. By representing all interconnects by software agents within a virtualized software environment, the massive number of interconnections across a federated network can be discovered, monitored and managed through software. This system will eliminate downtime, reduce the cost to operate networks, improve accuracy and enhance security.

91455S09-II

Grid 2.0: Collaboration and Sharing on the Grid—Galois, Inc., 421 SW Sixth Avenue, Suite 300, Portland, OR 97204-1629; 503-626-6616

Dr. Michael Isaac Jones, Principal Investigator; ijones@galois.com
Dr.Anne Marie McClaran, Business Official; anne@galois.com

DOE Grant No. DE-FG02-09ER85398
Amount: $999,888

Grid computing, the application of many loosely-coupled computers in federation to provideshared resources, makes significant compute or storage capabilities accessible to distributedteams of researchers. In doing so, it also poses a challenge: How do distributed teams collaborate effectively with these resources? This project will determine how best to apply socialand collaboration software techniques to improve the efficiency of collaboration between distributed teams working on grid computing systems. To determine the feasibility of bringing open collaboration tools to grid researchers, we conducted a test case for the integration of off-the-shelf collaboration software tools with grid infrastructure. We developed a prototype software architecture and prototype integration of atypical web-based collaboration application with an open source grid computing system. Weidentified those features of existing grid infrastructure that limit the adoption of collaboration tools in this environment. In Phase II, we directly address the weakest component: open,standardized protocols for identity management, authorization, and delegation on the grid, viaa federated identity management system providing support for software authorization and delegation. In Phase I, we conducted a feasibility study for running collaboration-oriented web applicationson grid systems, developed a prototype architecture for integrating them, and a proof-ofconcept implementation. We conducted market research with members of the grid research anduser communities to assess the core requirements for collaboration in research. Phase I uncovered the critical need for open, standard identity management infrastructure for grid federations – standardized login, authentication, and delegation components. In Phase II,we propose to address this need directly by developing an open source bridge between theidentity management layer of an existing grid system and the required federated identitymanagement systems needed for web applications.

Commercial Applications and Other Benefits: Grid systems have lowered the barrier to science at scale, by allowing the construction of powerful systems by combining smaller systems into a federation. Making it easier to bringcollaboration systems to the grid will allow new efficiencies in the conduct of science, while ashared identity subsystem will make cross-institutional collaboration easier, and will makesignificant steps towards securing grid infrastructure from emerging cyber threats.

91472S09-II

Recovery Act - Optimization and Simulated Testing of Flow Channel Inserts for Dual-Coolant ITER Test Blanket Modules—Ultramet, 12173 Montague Street, Pacoima, CA 91331-2210; 818-899-0236
Mr. Brian E. Williams, Principal Investigator; brian.williams@ultramet.com
Mr. Craig N. Ward, Business Official; craig.ward@ultramet.com
DOE Grant No. DE-FG02-09ER85536
Amount: $931,649

The reactor blanket design proposed by the U.S. for testing in the International Thermonuclear Experimental Reactor (ITER) program requires development of advanced materials for flow channel inserts (FCI) that will allow a high lead-lithium alloy tritium breeder exit temperature of ~700°C, which will increase overall plant efficiency. The primary requirements for the flow channel insert are low thermal and electrical conductivity, resistance to thermally induced stress, and impermeability and non-reactivity with the lead-lithium alloy. In previous work, Ultramet and Digital Materials Solutions made substantial progress in the development and demonstration of a manufacturable flow channel insert consisting of silicon carbide open-cell structural foam with solid silicon carbide facesheets. An Ultramet FCI structure is the first to demonstrate zero ingress while under pressure. The proposed project will further optimize FCI design, materials, and scaleup, with particular attention to development of a non-structural insulating material to fill the void space in the structural foam insulator and prevent lead-lithium ingress in the event of facesheet damage. Silicon carbide foam/silicon carbide facesheet FCI development specimens were fabricated with varying internal filler materials to completely fill the void space within the foam. Specimens were subjected to multiple cycles of testing in molten lead-lithium up to 700°C at 0.7 MPa for a total of 200 hours with no metal ingress in all but one case. The filler materials' inert behavior and ability to block metal ingress were similarly demonstrated through direct sample immersion in molten lead-lithium while under pressure. The primary objective of Phase II is to expand upon the success of previous work and address two primary areas: development of an internal filler material to allow the FCI to continue functioning in the event of damage, and continued design optimization and prototype component fabrication for testing in a representative, flowing lead-lithium environment, the first such testing of any type of FCI component ever performed.

Commercial Applications and Other Benefits: Nuclear fusion offers a replacement for increasingly scarce fossil fuel energy sources. Alternatives to fossil fuels (e.g. wind, solar, geothermal) cannot generate sufficient energy to meet current needs. Fusion, with its low generation of radioactive waste, is ideal for large-scale energy generation. Practical application is absolutely dependent on development of advanced materials.

91475S09-II

High JC, Low AC Loss Nb3Sn Superconductor for 14-20T Fusion Application—Hyper Tech Research, Inc., 539 Industrial Mile Road, Columbus, OH 43228-2412; 614-481-8050
Dr. Xuan Peng, Principal Investigator; xpeng@hypertechresearch.com
Mr. Lawrence Walley, Business Official; elwalley@hypertechresearch.com
DOE Grant No. DE-FG02-09ER85418
Amount: $999,999

This proposal is in answer to Topic 55, Advanced Technologies and Materials for Fusion Energy Systems, subtopic (c) Superconducting Magnets and Materials. Work has started world wide for the design of an advanced fusion project beyond the present funded ITER demonstration. The future fusion reactor design will require lower cost, much higher performing superconductor wires in the 14-20 T range. For this higher performance strand, it will require a totally different design Nb3Sn superconductor, very high *Jc*'s at 15T are needed, but we still need to maintain the low AC loss of present ITER fusion superconductors. This proposal Phase II will continue to develop the lower cost, high *Jc*, low AC loss Nb3Sn superconductor that can meet the needs of future fusion applications. For this SBIR Phase II we will demonstrate a Nb3Sn strand that will have 3 times the *Jc* performance of present day ITER superconductors at 12-15T, but with AC losses at or below present day fusion strands. In the Phase I we achieved a Jc of 2000 A/mm^2 12T-4.2K, 2.5 times the present 800 A/mm^2 minimum for current ITER specification, with AC losses less of 866 mJ/cm^3 which is below the current ITER specification of 1000 mJ/cm^3. In the Phase II we plan to achieve, and demonstrate in long lengths, *Jc*s greater than 2400 A/mm^2 at 12T-4K on the wire (three times the present ITER minimum specification at 12T-4K and 1500 A/mm^2 at 15T-4K. By achieving the 10 micron filament size, the strands are expected to have losses equivalent to or less than present day ITER wire specifications.

Commercial Applications and Other Benefits: The largest market will be for fusion magnets. Tons of strands are needed for the ITER type fusion projects. The other commercial applications besides fusion are high field 7-11T MRI, NMR systems, superconducting accelerators - protron radiation for cancer treatment, SMES, and high field magnetic separation.

91449S09-II

Multi-Band Power Source for ITER Reflectometry—Virginia Diodes, Inc., 979 Second Street SE, Charlottesville, VA 22902-6172; 434-297-3257
Dr. Jeffrey L. Hesler, Principal Investigator; Hesler@VADiodes.com
Dr. Thomas W. Crowe, Business Official; Crowe@VADiodes.com
DOE Grant No. DE-FG02-09ER85544
Amount: $999,999

The US role in ITER is focused on the key diagnostic instruments, such as the Low Field Side (LFS) Reflectometer. Present concepts for this instrument require an all-solidstate source that can be swept across the frequency band 50-170GHz in a timescale of order ten microseconds with an output power of ~100mW. Presently available millimeter-wave sources are unable to meet this requirement.VDI proposes a system of five sources whose output power will be combined through a pair of waveguide diplexers and a quasi-optical triplexer, and then coupled into a circular corrugated waveguide (CCW) for coupling to the ITER plasma. Each of the sources will be based on a microwave oscillator, power amplifiers and VDI's broadband frequency multipliers. Virginia Diodes demonstrated that the proposed source technology can achieve the required power output, tuning bandwidth and frequency sweep rate for one of the sub-bands. VDI also developed an initial design of the waveguide diplexer and collaborated with a manufacturer on the development of the quasi-optical triplexer. The Phase 1 succeeded in demonstrating that the proposed technologies are feasible and that the technological specification for the LFS Reflectometer source can be achieved. The Phase 2 plan culminates in the demonstration and delivery of a functional prototype for the ITER LFS Reflectometer Source (ILRS). The primary research involves the development of the five amplifier–multiplier chains (50-75GHz, 75-93GHz, 93-110GHz, 110140GHz, 140-170GHz, the development of the electronic system to control the frequency sweeps, the development of the two waveguide diplexers (W- and D-Band) and the development of the Quasi-Optical Triplexer.

Commercial Applications and Other Benefits: Terahertz technology is an emerging field with a broad array of scientific, military, medical and commercial applications. The development of broadly tunable sources with greater output power is a primary requirement for the continued growth of this field.

91490S09-II

Development of a 2 MW CW Waterload for Electron Cyclotron Heating Systems—Calabazas Creek Research, Inc., 690 Port Drive, San Mateo, CA 94404-1010; 650-312-9575
Dr. Robert Lawrence Ives, Principal Investigator; rli@calcreek.com
Dr. Robert Lawrence Ives, Business Official; rli@calcreek.com
DOE Grant No. DE-FG02-09ER85297
Amount: $499,995

Gyrotrons are being developed for ITER and other fusion systems that produce 2 MW CW of RF power for electron cyclotron heating. Currently there are no waterloads available to test gyrotrons at this power level. The U.S. also is responsible for providing 1.5 MW loads and 2.0 MW loads for ITER. Calabazas Creek Research, Inc. developed prelimnary designs in Phase I that efficiently distributes 2 MW of RF power over a lossy surface without incurring excessive power densities. The design implements rotating structures to avoid excessive power densities due to constructive interference, which is a known issue with static loads.

Commercial Applications and Other Benefits: Waterloads are required at all fusion research centers using electron cyclotron heating to test gyrotrons. Such centers are located in the United States, Japan, Germany, Russia, Switzerland, and France. ITER will require 24 loads in its initial configuration with the possiblity of 24 more at a later date. Currently, there are no loads capable of operation with the 2 MW CW gyrotrons currently in development in the United State, Europe, and Japan. The United States is responsible for providing waterloads for ITER under international agreement. The load proposed here would satisfy the ITER requirement, resulting in a minimum procurement of 24 loads at a total estimated value of $4 M. Commercial opportunities would also exist at other fusion research centers incorporating this new generation of 2 MW gyrotrons.

91501S09-II

Parallel Validation Tools for Fusion Simulations—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856

Dr. Svetlana Shasharina, Principal Investigator; sveta@txcorp.com
Mr. Laurence D. Nelson, Business Official; lnelson@txcorp.com

DOE Grant No. DE-FG02-09ER85505
Amount: $699,352

Numerical simulations play a critical role in exploration of new experimental regimes needed for design and operation of new fusion devices such as ITER. Hence, simulations must be carefully validated against experiments. Validation of fusion codes is overly difficult due to incompatibilities of data representation used in simulations and experiments, and the workflow issues that arise when the codes run remotely at leadership class computing facilities. There is a need for tools that would standardize and streamline the routine portion of the overall validation efforts by taking advantage of modern data formats, available network tools, and by better exploiting available and upcoming supercomputing resources. Tech-X therefore proposes to develop a data standard to describe data from a subset of fusion codes and diagnostics allowing their validation, implement common data and format transformations needed for merging these simulation and diagnostics data, and enable composing workflows for running the related synthetic diagnostics in local and remote high-performance environment. Prototype standards for describing GYRO and NIMROD data and BES and Soft X-Ray diagnostics data were developed using a self described data format (HDF5). Methods for simplifying the workflow for synthetic diagnostic calculation for GYRO/BES and NIMROD/Soft X-Ray were explored. Methods for integrating these methods into an established visualization tool (VisIt) were examined.

Commercial Applications and Other Benefits: The software infrastructure built in this project will streamline validation of fusion codes against experiment. It could bring Tech-X consulting business opportunities with companies such as General Atomics and international customers involved in fusion projects (ITER, KSTAR, and JT-60). The GUI and data transformation library also add value to the commercial plasma physics codes developed at Tech-X.

91504S09-II

A Robust Modular IGBT Power Supply for Innovative Confinement Concepts—Eagle Harbor Technologies, Inc., Suite D3, #179, 321 High School Rd. NE, Bainbridge Island, WA 98110-1619; 206-780-3667

Dr. Timothy Ziemba, Principal Investigator; ziemba@eagleharbortech.com
Dr. Timothy Ziemba, Business Official; ziemba@eagleharbortech.com

DOE Grant No. DE-FG02-09ER85336
Amount: $860,226

A present challenge facing the fusion energy community and particularly the ICC community in its support of the main line tokamak program is the ability to generate increased power levels for pulsed magnets, arc plasma sources, radio frequency heating, and current drive schemes, at reasonable cost. Continuous wave (CW) tube based power supplies are typically large and expensive, making them prohibitive for smaller experimental facilities or not cost effective when only pulsed input power is required. Continued research and development of next generation solid state power supplies could allow for multiple applications with a single well developed, low cost module that could be configured in many ways. The proposed work will continue to develop, build, and test a modular solid state power supply based on Insulate Gate Bi-polar Transistor (IGBT) technologies, technologies that have seen a dramatic increases in operational parameters over the past decade. In this effort, Eagle Harbor Technologies would continue the Phase I work, which successfully developed a modular, low cost, high power IGBT based system that can be assembled in multiple ways to address a wide range of applications. In the Phase I program a low cost IGBT modular system prototype was successfully modeled, designed, built, and bench tested. The testing results demonstrated the prototype could be arranged in both parallel and series configurations for both high current and/or high voltage operation. The prototype cost was shown to be significantly lower than older generation power supplies for similar applications. In the Phase II work plan we will upgrade the Phase I IGBT modular prototype and fully characterize its nominal operational parameters in preparation for commercialization of the system. Additionally, two full power supply units that represent the greatest need to the ICC community will be built and tested to demonstrate system performance and cost benefit.

Commercial Applications and Other Benefits: There are a large number of applications where a suitable low cost, highly configurable, high current, high voltage, solid state pulsed power supply would be beneficial. These include the noted applications in the fusion science community including wave heating schemes, active feedback and control for plasma stabilization systems, current drive, plasma arc sources and ignitron replacements. Other areas of interest include suitable pulsed power supplies for linear accelerators, high voltage trigger systems, in-space electric thrusters, pulse width modulation amplification, and semiconductor fabrication applications.

91518S09-II

Plasma Jet Modeling for MIF—Tech-X Corporation, 5621 Arapahoe Ave, Boulder, CO 80303-1379; 720-974-1856

Dr. John Loverich, Principal Investigator; loverich@txcorp.com
Mr. Laurence D. Nelson, Business Official; lnelson@txcorp.com

DOE Grant No. DE-FG02-09ER85506
Amount: $999,718

Los Alamos National Lab has a new experiment for modeling plasma jet merging and liner formation where the long term application would be the use of plasma jets for imploding magnetized targets for fusion energy. The physics of this experiment is extremely complicated stretching from the regime of low temperature plasmas to fusion conditions. Modeling is required to assist in the investigation of the physics. Tech-X has a code TxFluids which has demonstrated the ability to model plasma jets in a vacuum chamber. Physics includes various flavors of magneto-hydrodynamics and simple radiation modeling capability. The focus of this phase II project will be to continue modeling plasma jet relevant experiments while adding more physics to TxFluids to increase the fidelity of the simulations. Ultimately TxFluids will have applications to all sorts of high energy density plasma physics applications. TxFluids distinguishes itself from other codes as it is professionally maintained, developed, supported and documented. This is important as fusion energy is to be pushed out of the realm of scientific curiosity and into the realm where commercial reactors are being explored. During the phase I it was shown that TxFluids could be used to model plasma jet merging with and without magnetized targets. In order to get good results in the presence of vacuum an Euler/MHD algorithm was implemented. Simulations were performed with argon jets and an argon target. When radiation was included huge fields on the order ~300 Tesla were observed though with low peak pressure as a result of radiative losses in the target. When radiation was not included, significant compression of the target was observed, before Rayleigh Taylor instabilities set in. A paper was submitted to the Journal of Fusion Energy outlining the results.During the Phase II, 3D simulations of the plasma jet merging experiment and accretion disk experiment will be performed. Radiation models will be improved by adding a gray approximation and later, multigroup approximation. Atomic physics capability will be improved with assistance from University of Alabama through the use/development of LTE, and non-LTE atomic physics libraries. Comparisons of TxFluids with smooth particle hydrodynamics results will be performed to determine any algorithm dependent problems that might arise and to gain confidence with the numerical results.

Commercial Applications and Other Benefits: TxFluids has applications in the plasma and fusion research communities as well as problems of interest to NASA and the DOD, including hypersonic vehicles, pulsed power and beamed energy.

91527T09-II

STTR Project - Single Mode Long-Wave Infrared (LWIR) Waveguides—Opto-Knowledge Systems, Inc. (OKSI), 19805 Hamilton Ave., Torrance, CA 90502-1341; 310-756-0520
Dr. Jason Michael Kriesel, Principal Investigator; jason@oksi.com
Dr. Nahum Gat, Business Official; nahum@oksi.com
DOE Grant No. DE-FG02-09ER86403
Amount: $750,000

Research Institution
Rutgers, The State University of New Jersey

Spectroscopy in the long-wave infrared (LWIR) wavelength region (8 to 12 μm) is useful for detecting trace chemical compounds, such as those indicative of weapons of mass destruction (WMD). To enable the development of field portable systems for anti-proliferation efforts, current spectroscopy systems need to be made more robust, convenient, and practical (e.g., miniaturized). Fiber optics that can operate in the LWIR region are a key enabling technology needed to improve the utility and effectiveness of such systems. However, such fibers must be able to deliver single mode Gaussian beams with low loss in the LWIR region, which is a capability not currently available in typical IR fiber optics.The solution is to use hollow core waveguides, which can transmit with minimal loss over the whole range from 8 to 12 μm (in fact they can go well beyond 18 μm). In addition, such waveguides have been shown to deliver high quality single mode radiation in the LWIR wavelength range. Furthermore, these hollow core waveguides are much easier to work with and much more robust than solid core (i.e., Chalcogenide glass fibers), which are often used at shorter wavelengths (e.g., 3 to 8 μm).In Phase I, sample hollow waveguides spanning a range of parameters were fabricated, tested, and demonstrated to deliver single mode beams with low-loss, even when bent. Samples waveguides were also delivered to DoE/PNNL personnel for internal evaluation. In addition, example waveguides cables were packaged with suitable protective jackets and connectors for ease of operation, demonstrating a complete path toward commercialization.In Phase II, the waveguide performance will be further improved, including a reduction in loss, smaller spot size, and less dependence on bending. Optimized solutions will be developed specifically for DoE and commercial applications. The manufacturing process will be improved and scaled up, enabling higher volume, better production efficiency, and better quality control.

Commercial Applications and Other Benefits: The resulting technology can be used in LWIR laser systems with applications ranging from chemical detection to laser surgery. The result of the project will include the ability to have a fiber coupled LWIR laser, which can both (a) improve the convenience and utility of current systems and (b) open up new applications that were previously inaccessible.

91539S09-II

Spectrally-Assisted Tracking of Moving Vehicles—Space Computer Corporation, 12121 Wilshire Boulevard, Suite 910, Los Angeles, CA 90025-1123; 310-481-6000
Dr. Pierre Villeneuve, Principal Investigator; villeneuve@spcaecomputer.com
Ms. Kelley E. Aaron, Business Official; aaron@spacecomputer.com
DOE Grant No. DE-FG02-09ER85443
Amount: $950,574

Statement of the problem being addressed: Long-term continuous moving-target surveillance from airborne electro-optical sensors provides critical information for tactical awareness situations. Tracking civilian vehicles in urban environments is a challenging problem for existing systems, which generally rely on high-resolution video imagery to identify targets by their spatial characteristics. It is difficult for current spatial-based trackers to re-acquire target lock once the subject has been obscured from view for even moderate lengths of time. General statement of how this problem is being addressed: The goal of this effort is to demonstrate the exploitation of a vehicle target's unique spectral signature as a means to improve overall tracker performance. An example solution is to leverage the combined strengths of both spatial and spectral feature matching capabilities into a generalized multiple-hypothesis tracker system. Summary of Phase I effort: Preliminary results indicate that hyperspectral data does support the use of vehicle signatures as a means to improve target nomination and association for tracking applications. Example multi-look LWIR data from the SEBASS sensor over a parking lot provided numerous examples of both well-resolved and sub-pixel civilian vehicle targets. Initial investigation revealed that LWIR signatures from vehicles do show statistically significant contrast relative to both the background and other nearby vehicles. Objectives for Phase II: The objective of the proposed effort is to incorporate spectrally-aided feature matching (VNIR/SWIR and LWIR) into a prototype multi-hypothesis tracking system. Our goal is to demonstrate improved target vehicle tracking performance in complex environments where traditional spatial tracker systems may show reduced performance. We plan to collaborate with DOE laboratories and partners to develop a Phase III transition path to support future sensor programs.

Commercial Applications and Other Benefits: A successful Phase II program will result in a prototype processing system for real-time target tracking with both high-resolution video and hyperspectral data. Potential military applications include: (1) real-time detection, tracking and ID of designated target vehicles and dismounts, (2) improved wide-area persistent surveillance from remote airborne platforms.

91548S09-II

Compact, Electronic Blood Irradiator—RadiaBeam Technologies LLC, 1717 Stewart Street, Santa Monica, CA 90404-4021; 310-822-5845
Dr. Xiaodong Ding, Principal Investigator; ding@radiabeam.com
Dr. Salime Boucher, Business Official; boucher@radiabeam.com
DOE Grant No. DE-FG02-09ER85361
Amount: $996,877

Blood irradiators are commonly used around the world to treat blood to prevent Transfusion-associated Graft-Versus-Host-Disease, a possible side effect to transfusions. Most blood irradiators currently use Cs-137, which is a highly dangerous radioactive substance. The National Research Council has identified as a priority the replacement of such high-activity sources with alternative technologies, in order to prevent them from falling into the hands of terrorists for use in a Radiological Dispersal Device ("dirty bomb"). A novel, compact, low-cost accelerator – called the MicroLinac – will be developed for use in blood irradiators, in order to effectively replace Cs-137 in such devices. The innovation of the MicroLinac is the use of an inexpensive, low-power magnetron to power the structure, which not only greatly reduces cost compared to other linacs, but reduces the heat deposited and thus eliminates the need for water-cooling. In Phase I of this project, the MicroLinac based blood irradiator was designed with extensive simulations. The feasibility of building the linac within the required cost was verified. A plan to for prototype fabrication and testing was developed, including a partnership with a commercial irradiator manufacturer. In Phase II of the project, we will complete the engineering of the MicroLinac blood irradiator, and build and test the prototype, in collaboration with a commercial irradiator manufacturer.

Commercial Applications and Other Benefits: Approximately 5,000 devices containing 55,000 high-activity radionuclide sources are in use in the United States today, in applications such as blood irradiation, medical research, industrial radiography and oil well logging. The MicroLinac would be a feasible replacement for many of these sources, and thus it may have a wide-ranging potential to reduce the use of radioisotopes and increase our nation's nuclear security.

91624S09-II

A Software Toolbox for Systematic Evaluation of Seismometer-Digitizer System Responses—Weston Geophysical Corp., 181 Bedford St., Suite 1, Lexington, MA 02420-4430; 781-860-0127
Dr. Jessie Bonner, Principal Investigator; jes-bonner@yahoo.com
Mr. James Lewkowicz, Business Official; jiml@westongeophysical.com
DOE Grant No. DE-FG02-09ER85548
Amount: $998,718

Measurement of the absolute amplitudes of a seismic signal requires accurate knowledge of the seismometer-digitizer response. In some cases, particularly for historic data or data from denied regions, the response may be unknown or incorrectly known. Under the DOE SBIR/STTR FY 2009 Phase I program (Grant DE-FG02-09ER85548) Weston Geophysical Corp., in partnership with Dr. Robert Herrmann (St. Louis University) have developed a set of software tools that can recover the sensor/digitizer response function from raw seismic data. These software tools include: a) SACPSD, a power spectral density (PSD) estimator for background noise spectra at a seismic station which is used to monitor network performance and metadata validity, and b) NOISETRAN, a prototype method of estimating the broadband seismic system response for a seismic station based on the background noise at a nearby reference station. We have developed Graphical User Interfaces (GUIs) that provide seismologists with easy access to the software and databases in the system response recovery toolbox. In Phase II we propose to fully develop and Alpha and Beta test our software toolbox so that it can be easily used by seismologists to monitor the data quality recorded on worldwide seismic networks.

91564S09-II

Model-Based Renewable Resource Risk Assessment Analysis and Simulation—Electrical Distribution Design, Inc., 311 Cherokee Drive, Blacksburg, VA 24060; 540-951-2753
Dr. Jeffrey Thompson, Principal Investigator; jeff-thompson@edd-us.com
Mr. Kevin Russell, Business Official; Kevin-russell@edd-us.com
DOE Grant No. DE-FG02-09ER85345
Amount: $998,769

Competing cost, load growth, reliability, security and environmental issues are pushing power system design, operation and control to new levels of complexity. What is needed is a multidiscipline, multi-fidelity integrated analysis and information management approach that can be used to combine new technology together with legacy systems in a reliable and cost effective way. Risk assessment and simulation for renewable generation development is a good example of this type of problem. This problem will be addressed through development of a new model-based real-time renewable generation operations risk assessment analysis and mitigation system that will include live data links to Supervisory Control and Data Acquisition (SCADA) and web based state-of-the-art Photo Voltaic performance data services. The prototype system will be tested using existing integrated transmission and distribution models for a real power utility system. The system includes a significant level of Photo Voltaic (PV) sites and will be modeled to a level of detail that includes one-to-one correspondence with real system components, and all customer connections with 13 months of historical hourly load data. In addition to providing new risk monitoring and analysis capability, the system will be used to develop and test new PV performance and customer load forecasting, which is a significant source of renewable resource use uncertainty. Successful concept development and testing of Graph Trace Analysis Approach (GTA) based operations risk monitoring, mitigation and visualization using a test model and data. Develop and implement a prototype model-based operations management risk analysis, mitigation and visualization system that can be used either by itself or as part of an integrated smart grid solution.

Commercial Applications and Other Benefits: The Graph Trace Analysis software to be used for the project is uniquely suited for development of a new renewable resource risk assessment approach that can be implemented as part of an integrated design, operation and control analysis and information management solution. GTA is currently being used by leading industry, academic and government research organizations to address complex system analysis and information management problems that previously could not be solved. The web based services that will be integrated with the new system is a leader in renewable resource monitoring and analysis. Combining capabilities from these to next generation type capabilities, and then refining them using real system data will significantly increase problem size, level of detail and complexity of renewable resource related analysis that can be performed for both design and real-time operations.

91640S09-II

Adaptive Predictive Algorithms and Real-Time Decision Support Tools for Renewables Integration—Underground Systems, Inc., 84 Business Park Drive, Suite 109, Armonk, NY 10504; 914-273-8727

Mr. Larry Fish, Principal Investigator; LarryF@usi-power.com
Mr. Paul A Alex, Business Official; PAlex@usi-power.com

DOE Grant No. DE-FG02-09ER85564
Amount: $997,440

The "National Transmission Grid Study" discusses the use of advanced technologies to enhance performance of the nation's electricity transmission and delivery system to safely and reliably transport more electrical energy, however these systems must continue to operate within thermal limits and system stability must be maintained. A Dynamic Line Rating (DLR) system is a decision support system whose output is used to maximize the power flow through a transmission grid. The DLR monitors conductor current, ambient and conductor temperature(s) and environmental factors to analyze and compute the maximum power delivery capability (ampacity) of the system in real time. Transmission operations could be significantly enhanced by providing operators capability to incorporate DLR. This proposal is to develop, field test and bring to commercial readiness a robust DLR software algorithm that will improve the power delivery capability of existing power transmission systems with focus on renewables/distributed generation. The system will monitor conditions in real-time and along with the historical statistical data will predict future behavior under various conditions. Feasibility of developing such a software package with the objective of determining the viability of predicting ampacity one, two and four hours into the future while assigning probabilities to the outcomes was studied in Phase I. Promising results have been achieved in the development of predictive DLR capabilities using intelligent information processing methods. Phase II plans include: Final development, demonstration and evaluation of the software using a large operating demo system already installed to monitor transmission of wind, hydro and thermal renewables; Refinement of the software package using real field results to be ready for commercial applications; Development of a visualization system and performance dash board for system operators. We believe that such a real-time dynamical software package will release additional capacity, and improve the reliability and economic efficiency of the nation's transmission and distribution corridors. The technical benefit to the U.S. includes establishing a leadership role in the development of next-generation smart grid software and instrumentation including applications for renewables, obtaining more throughput by reducing congestion, and conductor safety.

Commercial Applications and Other Benefits: The economic benefit to the U.S. is the potential sale of U.S.-developed technology to the domestic and international utilities, as well as substantial economic benefits to domestic electric transmission utilities through better asset utilization and improved system efficiencies. The availability of advanced sensors, software and systems will enhance our competitive position into a market that is becoming increasingly dominated by foreign-based technologies.

91584S09-II

Deployable Concepts for Discovery of Web Based STEM Education Content and Resources—David Wojick, 391 Flickertail Lane, Star Tannery, VA 22654-1908; 540-858-3136
Dr. David Eugene Wojick, Principal Investigator; dwojick@hughes.net
Dr. David Eugene Wojick, Business Official; dwojick@hughes.net
DOE Grant No. DE-FG02-09ER85325
Amount: $391,980

There is no reasonable way for science education portal developers, or teachers and students, to search on the Web for federally funded science education content, especially Department of Energy content. There are hundreds of small Web collections scattered throughout DOE, and thousands in the federal government. Many more are found in .org and .edu domains. The overall objective is to develop a Findability Toolkit for science education content, based on a combination of proven strategies. Both (a) finding content and (b) making content findable are addressed. Phase I demonstrated the feasibility of combining four distinct strategies to maximize findability. These viable strategies are (a) semantic, (b) grade level stratification (c) organizational and (d) domain bounded. The goal of Phase II is to produce a complete Findability Toolkit for science education content. The findability methods tested in Phase I will be perfected and combined, both for content collection and for content/Website development.

Commercial Applications and Other Benefits: This project has the potential to dramatically improve Web-based science education. Commercial applications include new Web portals and specific content development.

91585S09-II

An Analysis of the Performance Bottlenecks in the Federated Search Information Flow—Deep Web Technologies, LLC, 301 N. Guadalupe, Suite 201, Santa Fe, NM 87501-5501; 505-820-0301

Dr. Dan Heidebrecht, Principal Investigator; dan@deepwebtech.com
Dr. Abe Lederman, Business Official; abe@deepwebtech.com

DOE Grant No. DE-FG02-09ER85327
Amount: $749,245

Performance bottlenecks in federated search limit the benefits of the technology to DOE researchers, to other scientists and to the public. We will assess the performance bottlenecks of Deep Web Technologies' federated search technology in Phase I and make performance improvements in Phase II We performed a rigorous assessment of the information flow in our federated search technology. We identified a number of bottlenecks and assessed the impact of each to prioritize the performance improvement work. We also prototyped technology to improve certain performance bottlenecks. We will design and implement a number of technologies to remove major bottlenecks. The technologies will improve the speed of data access and storage, networking, web access, computation, and connector work.

Commercial Applications and Other Benefits: The future of federated search lies in the ability to cast a wide net over an ever-increasing body of scientific information. It will become more feasible to build large-scale federated search applications for the federal government that simultaneously search thousands of sources.

91595S09-II

A Scalable Distributed Client Based Meta Search and Discovery Infrastructure—WebLib, LLC, 5101 River Road, Apt. 1918, Bethesda, MD 20816-1574; 301-986-5444
Dr. Weizhong Zhu, Principal Investigator; weizz@weblib.com
Mr. Antonio Zamora, Business Official; azamora@weblib.com
DOE Grant No. DE-FG02-09ER85613
Amount: $975,500

Web searching has become a ubiquitous and indispensable activity for a wide spectrum of human endeavors. The success of Google and its competitors depends on extensive software and network infrastructures and costly hardware. Federated search engines, such as Science.gov, WorldWideScience.org and ScienceEducation.gov also run on powerful, albeit much smaller, server clusters that connect to diverse government and non-government information sources. Many desirable federated search and discovery applications would require prohibitively expensive server farms and network bandwidth to provide classroom and home access to high quality educational content in DOE, NASA, NIH and other government scientific and technological databases for millions of students and researchers. Next generation federated search and discovery applications must implement economical and scalable solutions to accommodate new information services for very large numbers of potential users and information sources. The goal of this SBIR project is to find a highly scalable and affordable alternative to the server farms, network bandwidth and performance bottleneck by integrating the federated search application into the web browsers of individual users. Another important goal is to achieve better quality search results by developing a next generation distributed federated search technology with powerful semantic search and personalization capabilities. The Phase I project developed a proof-of-concept prototype running an advanced Web 2.0 federated search engine plug-in inside the Firefox browser. The prototype has hybrid semantic search capabilities that are distributed between the federated search engine client and the remote knowledge base server. The Phase II work will research and implement robust federated search engine plugins and add-ons for the major web browsers. The Phase II research will also develop expanded semantic knowledge bases (e.g. for energy, health, education) and explore how the client-side federated search engine can optimally utilize remote knowledge base web services to support powerful semantic search functions that produce better search results.

Commercial Applications and Other Benefits: The novel client-side federated search architecture, and the innovative semantic search capabilities to be implemented during the Phase II research, will open up significant new commercialization opportunities for very large scale applications in the education, health, science, technology and business markets in Phase III and beyond. At the same time, there will be important opportunities for this new technology to offer public benefits, especially in the form of free access to high quality government and other educational and health resources for tens of millions of students and the general public.

91600B09-II

STTR Projects - An Integrated In Situ Raman and Turbidity Sensor for High Level Waste Tanks—EIC Laboratories, Inc., 111 Downey Street, Norwood, MA 02062-2612; 781-769-9450
Dr. Job Bello, Principal Investigator; bello@eiclabs.com
Dr. David Rauh, Business Official; drauh@eiclabs.com
DOE Grant No. DE-FG02-09ER86386
Amount: $749,967

Research Institution
Pacific Northwest National Laboratory

Stored nuclear waste must be retrieved from storage, treated, separated into low- and high-level waste streams, and finally put into a disposal form that effectively encapsulates the waste and isolates it from the environment for a long period of time. Before waste retrieval can be done, however, waste composition will need to be characterized so that proper safety precautions can be implemented during the retrieval process. In addition, there is a need for active monitoring of the dynamic chemistry of the waste during storage since the composition of the waste can become highly corrosive.A novel fiber optic Raman transmission and light scattering probe will be developed with improved sensitivity and capability to operate in turbid media. The dual Raman and turbidity sensor will provide chemical identification of nuclear waste as well as information concerning the suspended particles in the waste (turbidity, particle size distribution).In Phase I, we successfully demonstrated a new fiber optically coupled probe design and associated instrumentation that allows simultaneous measurement of the Raman spectrum and turbidity using the same laser source. The measurement system returns accurate concentrations of a range of Raman active anions present in HLW under conditions of varying turbidity and also corrects for fluctuations in laser intensity.Based on the prototype Raman/turbidity probe design that was developed in Phase I, a compact, fiber optically coupled, integrated Raman probe and turbidity sensor (RamanTurboProbe™) and fieldable instrument that can be directly deployed in HLW solutions will be developed and tested. Raman analytical processing software using the chemometric algorithms developed at PNNL will be developed to enhance the analytical robustness of the analysis and to allow passive automated deployment of the combined sensor. The Raman/turbidity sensor and instrument will be demonstrated in an HLW retrieval process and in-tank deployment scenarios and evaluated for its performance in characterizing simulated waste solutions.

Commercial Applications and Other Benefits: A dual Raman/turbidity sensor can be used to monitor the chemical status of HLW tanks within the DOE environment as well as process monitoring during waste transfer operations, obviating much expensive and hazardous grab sampling and laboratory analysis. The sensor would also have broad use for industrial process monitoring of chemical concentrations in scattering media, e.g. for various chemical reaction monitoring, monitoring paper and pulping media, fermentation vats and electroplating solutions.

91605S09-II

Development of a Compact Fiber Optically Coupled Raman Telescope for the In Situ Standoff Characterization of Residual Wastes—EIC Laboratories, Inc., 111 Downey Street, Norwood, MA 02062-2612; 781-769-9450
Dr. Job Bello, Principal Investigator; bello@eiclabs.com
Dr. David Rauh, Business Official; drauh@eiclabs.com
DOE Grant No. DE-FG02-09ER85338
Amount: $999,990

Stored nuclear waste must be retrieved from storage, treated, separated into low-and high-level waste streams, and finally put into a disposal form that effectively encapsulates the waste and isolates it from the environment for a long period of time. Not all of the waste, however, is effectively removed in the tank during bulk retrieval. Some remain in the tank bottom and walls, and also in the ancillary piping. Removal of residual waste is necessary in order to prevent the remaining waste from possible leaching into the environment. Compact, remote detection techniques are therefore needed that can provide chemical identification of the residual waste so that appropriate dissolution steps can be implemented. A novel, compact fiber optic Raman probe with a telescope focusing and Raman collection front optics will be developed and use as a standoff detection and mapping tool for residual wastes in nuclear waste storage tanks. The compact size of the telescope Raman probe will allow remote deployment in the tight portals of nuclear waste storage tanks. A prototype of the all-fiber optically coupled telescope was completed and fully characterized for measuring Raman spectra of likely residual waste compounds at up to 70 feet, a typical internal tank dimension. The prototype was provided to DOE/SRS who demonstrated it successfully with several mixed waste materials at similar standoff distances, and made recommendations for further improvements in Phase II. The Raman telescope will be further developed to incorporate video, autofocus, shielding for high radiation environments and accommodation with typical storage tank openings. A field portable, ruggedized spectrograph will be developed optimized for the telescope and Raman excitation laser, enabling a high sensitivity and wider spectral range for enhanced compound identification. A database of >100 high resolution, full range Raman spectra will be developed of likely residual tank contaminants, supported by chemometric software for spectral matching.

Commercial Applications and Other Benefits: The fiber optic Raman telescope probe inspection instrument will be useful to the environmental monitoring community as well as first responders. In Hazmat operations, such a device can be used to characterize hazardous chemicals such as chemical spill at a standoff distance and will provide valuable information for the safe handling or remediation of these chemicals.

Key Words:

Raman, telescope, fiber optic, high level nuclear waste, residual nuclear waste, storage tanks, decommissioning

Summary for Members of Congress:

The goal of this research is to develop a fiber optically coupled Raman probe telescope that will be able to detect and identify chemicals at a standoff distance. The telescope Raman probe will be used as a characterization tool for residual wastes in nuclear waste storage tanks.

91609S09-II

Advanced Techniques for On-Line Condition Monitoring and Diagnostics of Digital Rod Position Indication Systems for Existing and Next Generation Nuclear Power Plants—Analysis and Measurement Services Corporation, AMS Technology Center, 9119 Cross Park Drive, Knoxville, TN 37923-4510; 865-692-1756

Mr. Greg W. Morton, Principal Investigator; gmortom@ams-corp.com
Mr. Darrell W. Mitchell, Business Official; mitchell@ams-corp.com

DOE Grant No. DE-FG02-09ER85269
Amount: $999,380

The designs of many existing nuclear power reactors incorporate a digital rod position indication system to monitor the positions of the control and shutdown rods within the reactor. These digital rod position indication systems have been in service for over 30 years in nuclear power stations worldwide. In recent years, however, aging and obsolescence issues have led to an increase in problems with the digital rod position indication systems including analog card failures and coil cable connection problems that, in some cases, may result in unplanned reactor trips. These problems, along with plans for plant life extension, have prompted the nuclear industry to actively seek viable options to monitor the health and accuracy of these digital rod position indication systems in order to ensure reliable plant operations for decades to come. The existing plants will be facing the end of qualified life for several components of the existing digital rod position indication systems during the next decade and are actively seeking replacement options at this time. As such, the objective of this project is to conduct a research and development effort to design, implement and demonstrate an advanced digital rod position indication diagnostic system for existing and new nuclear power reactors. In the Phase I project, the proposing firm demonstrated the feasibility of developing a digital rod position indication monitoring system from commercial parts that not only monitors for system diagnostics, but also provides additional capabilities such as higher resolution rod position indication than is currently available as well as automatic rod drop times. The approach in Phase II is to build on the success of Phase I to construct a prototype digital rod position indication diagnostic system and implement it in an existing nuclear power reactor. The prototype digital rod position indication diagnostic system constructed in the Phase II project will be used as the basis for the design of a digital rod position indication diagnostic system for next generation reactors.

Commercial Applications and Other Benefits: As plants focus on replacing obsolete digital rod position indication system components, this proposal offers a commercial system that will also provide enhanced diagnostic capabilities if carried into Phase II and commercialized in Phase III.

91613T09-II

STTR Project - Nanotechnology-Based Condition Monitoring Sensors for Generation IV Electrical Insulation Systems—Polymer Aging Concepts, Inc., 372 River Drive, Dahlonega, GA 30533-5248; 706-864-6304
Mr. Kenneth S. Watkins, Principal Investigator; kwatkins@PolymerAgingConcepts.com
Mr. Kenneth S. Watkins, Business Official; kwatkins@PolymerAgingConcepts.com
DOE Grant No. DE-FG02-09ER86407
Amount: $749,992

Research Institution
Georgia Tech Research Corporation

Insulation system degradation resulting in component failure 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 there are a number of visual, tactile or electrical tests helpful in detecting insulation problems, there is no current in-situ sensor which continuously tracks the environmentally driven degradation of the insulation. A new degradation sensing technology called AgeAlert, developed by Polymer Aging Concepts, Inc. provides the first in-situ sensor for measurement of environmentally induced insulation degradation in real time. This tiny, low cost sensor installed in the windings of a motor or insulation of a cable responds to actual environmental conditions and accurately predicts remaining insulation life. The Phase I project demonstrated feasibility for use of advanced nanotechnology materials as conductive fillers in AgeAlert sensors. This is important because the resulting improvements in both performance and durability of the sensors optimize use in critical applications such as electrical wiring and equipment in nuclear power plants.The proposed research under this STTR Phase II project will demonstrate the improved performance from nanotechnology materials such as carbon nanotubes (CNT) in prototypes made for several wire and cable and motor insulation systems planned for Generation IV nuclear power plants. The tasks of this proposal will increase commercial viability of AgeAlert technology by improving the performance and durability of AgeAlert sensors to meet strict durability test requirements in the nuclear industry. It will open up additional markets for this new class of simple, low-cost condition monitoring sensors for demanding applications such as remote monitoring of off-shore wind turbines and solar applications where electrical components are subjected to extreme environmental conditions.

Commercial Applications and Other Benefits: Commercialization of AgeAlert technology promotes green technologies by reducing material and energy resources associated with unplanned shutdowns and unnecessary equipment replacement. In the future, AgeAlert sensors can be used to monitor degradation of a wide range of degradable products including tires, aerospace composites, propellants, and even food and pharmaceutical products. Since the sensors are passive and respond to degradation effects without power, they can be incorporated into passive Radio Frequency Identification devices to make “smart shelf-life” labels which not only uniquely identity the item, but automatically adjust the shelf-life based on the actual environment.