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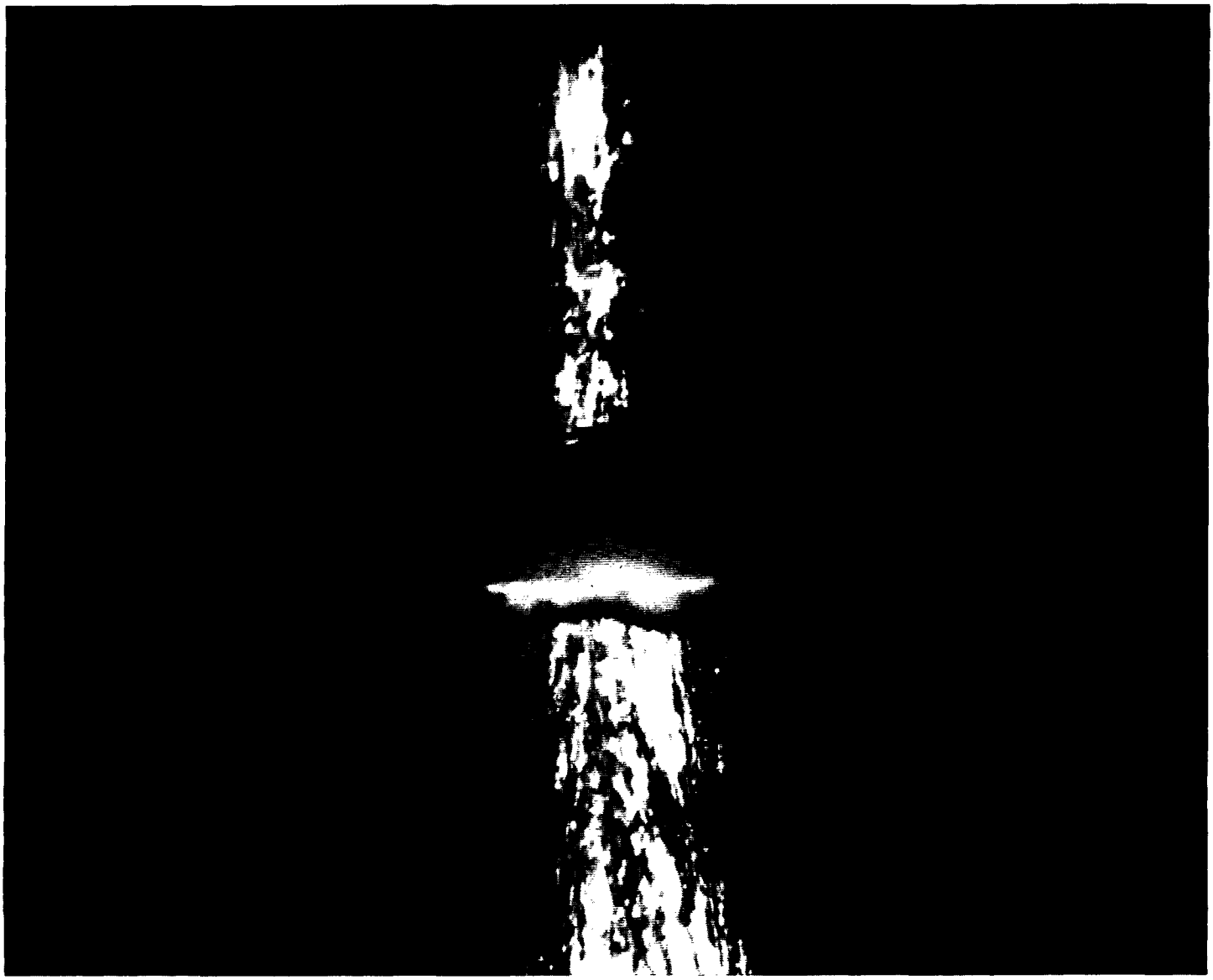
Advanced Energy Projects FY 1991 Research Summaries

September 1991



U.S. Department of Energy
Office of Energy Research
Office of Basic Energy Sciences
Division of Advanced Energy Projects

Cover photograph courtesy of Robert S. Feigelson, Center for Materials Research, Stanford University

Superconducting fiber (600 microns in diameter) growing upward at 5 mm/hr from a melt of composition $Bi_2Sr_2CaCu_2O_8$. The melt is formed by a focused CO_2 laser which is incident along the bright horizontal line.

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U.S. Department of Energy
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Division of Advanced Energy Projects
Washington, DC 20585

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DIVISION OF ADVANCED ENERGY PROJECTS

PROGRAM OVERVIEW

CHARTER

The Division of Advanced Energy Projects (AEP) provides support to explore the feasibility of novel, energy-related concepts that evolve from advances in basic research. These concepts are typically at an early stage of scientific definition and, therefore, beyond the scope of ongoing applied research or technology development programs. The AEP also supports high-risk, exploratory concepts that do not readily fit into a program area but appear to have applications that may span several scientific or technical disciplines.

The Division provides a mechanism for converting basic research findings to applications that eventually could impact the Nation's energy economy. AEP does not support either ongoing, evolutionary research or large scale demonstration projects.

FUNDING

Projects are supported for a finite period of time, which is typically three years. Annual funding levels for projects can vary from approximately $50,000 to $500,000. It is expected that, following AEP support, each concept will be sufficiently developed and promising to attract further funding from other sources in order to realize its full potential.

SUBMISSION GUIDELINES

Unsolicited proposals can be submitted by universities, industrial organizations, non-profit research institutions or private individuals. The Division also considers ideas or concepts submitted by researchers at national laboratories. **Before a formal proposal is prepared**, the proposer should submit a brief summary (2-3 pages) of the proposed work to the Division. However, the summary should be sufficiently detailed to enable an informed decision as to whether the proposed work would be programmatically suited to the charter of the Division of Advanced Energy Projects.

After the AEP programmatic interest has been established, a proposal must be submitted consistent with the guidelines specified in the Office of Energy Research document, DOE/ER-0249, "Application and Guide for the Special Research Grant Program." Each proposal must contain:

- A cover page.

- A 200-300 word abstract describing the essence of the project in terms understandable to a layman. The abstract should be in a form suitable for inclusion in DOE publications, such as this program book. Technical jargon and equations should be avoided.

- A technical discussion of the proposed concept and a description of the proposed work. While the discussion should be brief, there is no formal limitation on the number of pages allotted to this section of the proposal. Since this section provides the basis for the evaluations by technical reviewers, the proposer is urged to make certain that all aspects of the proposed project which are relevant to forming a judgment of the project's overall merit are adequately covered.

- A statement of work specifying all tasks to be performed in the course of the proposed work. A sample statement of work can be found on page 39.

- Description of available facilities.

- Resumes of key personnel.

- Detailed information on any support for the proposed or related work, past, present or anticipated, including proposals submitted, or about to be submitted, to other organizations.

- A cost estimate for the proposed effort.

PROPOSAL EVALUATION

Awards are based on the results of an evaluation process which usually involves a review by external reviewers. Regardless of the outcome of the evaluation, proposers receive copies of reviewers' reports.

Questions asked of the reviewers depend on the subject of the proposal. Some typical questions are listed below:

1. Is the proposed concept new? How does it compare with other work in the field?

2. Are there basic flaws in the scientific or technical arguments underlying the concept?

3. Are the technological requirements of the proposed concept, including material requirements, within the realm of either present or near term future capabilities?

4. Is there anything about the concept which makes its economics manifestly untenable, even under reasonably optimistic assumptions?

5. Is the anticipated benefit to the public high enough to warrant the Government's involvement in the R&D effort?

FURTHER INFORMATION

Inquiries should be directed to:

Dr. Walter M. Polansky, Director
Division of Advanced Energy Projects
ER-16, GTN
U.S. Department of Energy
Washington, D.C. 20585

Phone: 301-353-5995
Fax: 301-353-7363 (see page 55).

This book was compiled by Sue Ellen Stottlemyer.

DIVISION OF ADVANCED ENERGY PROJECTS

SUMMARIES OF PROJECTS ACTIVE IN FY 1991

This section contains abstracts of the projects active in the Division of Advanced Energy Projects during Fiscal Year 1991 (October 1, 1990 - September 30, 1991). The intent of this compilation is to provide a convenient means for quickly acquainting the reader with the program in Advanced Energy Projects. More detailed information on a specific project may be obtained by contacting the principal investigator identified below the project title. Please note that some projects will have reached the end of their AEP funding period by the time this book appears, and will, therefore, no longer be active. Those cases in which work was completed during FY 1991 are indicated by the footnote: *Project completed.

Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

1. Application of Aqueous Biphasic Extraction to Radioactive Waste Treatment

David S. Chaiko, Chemical Technology Division

	Funding Profile
Date Started: December 1, 1990	FY 91 - $475,000
Anticipated Duration: 3 Years	FY 92 - $485,000
	FY 93 - $495,000

Aqueous biphase extraction systems will be developed as a means of treating radioactive wastes. The separation concept involves the selective partitioning of either solutes or colloid-size particles between two immiscible aqueous phases. Wet grinding of plutonium residues to an average particle size of one micron will be used to liberate the plutonium from the bulk of the particle matrix. The processing goal is to produce a plutonium concentrate that will more effectively integrate with existing and developing chemical recovery processes. Coupling physical beneficiation with chemical processing will result in a substantial reduction in the volume of mixed wastes generated from dissolution recovery processes. As part of this project, applications of aqueous biphase extraction will be explored that include the separation and recovery of dissolved species such as metal ions and water-soluble organics.

Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

2. New Ion Exchange Materials for Environmental Restoration and Waste Management

E. Philip Horwitz, Chemistry Division

Date Started: December 1, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $440,000

FY 92 - $430,000

FY 93 - $435,000

The objective of this program is to synthesize, characterize, and evaluate a new class of cation exchange resins. The new resins will contain the geminally substituted diphosphonic acid functional group. Ion exchange resins containing geminally substituted diphosphonic acid groups should have vastly superior properties compared to commercially available cation exchange resins and should find wide-scale applications in environmental restoration (e.g., groundwater cleanup) and in waste management (e.g., minimization of waste volume). Alkyl-1,1-diphosphonic acids are among the most powerful complexing agents for polyvalent metal ions in aqueous solution, particularly at pH<2. But, heretofore, it has not been possible to synthesize resins containing diphosphonic acid groups, because of the difficulty of introducing this group into a preformed polymer matrix. The synthesis of resins with the diphosphonic acid groups will be accomplished by the polymerization of vinylidene-1,1-diphosphonic acid (VDPA) or by the copolymerization of VDPA with suitable comonomers (e.g., acrylamide/bis-acrylamide or styrene/divinylbenzene). This approach represents a major departure from the traditional methods for preparing ion exchange materials whereby the exchangeable functional groups are introduced onto a preformed polymer matrix.

Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

3. Production of Fuels and Chemicals From Methane

Victor A. Maroni, Chemical Technology Division

Date Started: July 1, 1989

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $250,000

FY 90 - $247,000

FY 91 - $350,000

In this project research is being carried out to develop novel bifunctional catalysts (BFCs) that can convert methane to fuels (e.g., liquefied petroleum gas or gasoline) and large volume industrial chemicals. The goal is to produce a catalyst that operates efficiently under moderate conditions of temperature (<500°C) and pressure (<10 atm), and for extended periods of time, without need for frequent regeneration or replacement. The BFC concept involves integrating into one material the properties of C-H bond activation and product-selective chemical synthesis. Several types of C-H bond activation catalysts that rely on unique oxidation state chemistries and coordination geometries are employed in combination with molecular sieve materials having well defined intracrystalline pores and channels that constrain the size and shape of the active catalytic species contained therein and the chemical species formed therein. This research is expected to culminate in a demonstration of the feasibility of efficient conversion of methane to a liquid fuel and/or to one or more of the top fifty commodity chemicals.

University of Arizona
Tucson, AZ 85721

4. Damage Limitation of Oil Spills by Combustion With Liquid Oxygen

Peter A. Franken, Optical Sciences Center

Date Started: January 15, 1990

Anticipated Duration: 22 Months*

Funding Profile

FY 90 - $574,000

This program is intended to evaluate the feasibility of destroying oil slicks and beached oil by combustion with liquid oxygen (LOX). Initial experiments will be performed on a variety of oil slicks up to 10 meters in diameter which will be prepared at carefully controlled and instrumented inland sites. The parameters for ignition, as well as an evaluation of combustion products, will be measured with the view towards planning larger scale experiments. Beach clean-up problems will be addressed with simulations prepared by coating weathered oil on rocks and determining the extent that LOX assisted combustion is successful in removing this contamination. Combustion products and thermal effects on the sub-lying flora and fauna will be determined. On the basis of these experimental studies the feasibility of larger scale simulations will be evaluated, together with a preliminary design of actual field research.

* Includes 4 month no cost extension

University of Arizona
Tucson, AZ 85721

5. Energy Related Applications of Elementary Particle Physics*

Johann Rafelski, Department of Physics

Date Started: March 1, 1988

Anticipated Duration: 3 Years

Funding Profile

FY 88 - $298,000

FY 89 - $386,000

FY 90 - $309,000

Muon catalyzed fusion proceeds via a cycle of complex quantum mechanical processes and leads to at least 150 d-t fusions per muon, releasing an energy equivalent of more than 30 times the mass of the muon. The economical applications thus demand that a method be found facilitating efficient muon production in elementary particle processes. Another way of improving the economics of the muon catalyzed fusion process is to accelerate the reactions by the proper choice of density, target composition, and magnetic fields. The influence on the cycle dynamics of vacuum polarization splitting in the excited muonic atom levels needs to be ascertained. Muon regeneration processes after muons are bound ('stuck') to alpha particles are important in determining the maximum number of fusions a muon can facilitate. In particular, regeneration in low temperature plasmas is an open issue. The greatest puzzle of muon catalyzed fusion is the exact understanding of the sticking process, which is a complex atomic/nuclear phenomenon, in which the 'spectator' of the fusion is caught by the nuclear fusion product. Both the theoretical formulation and numerical analysis of this process present formidable challenges to the understanding of few body reactions. Because antiprotons can be viewed as the only 'stable' storage of muons due to their annihilation into pions which decay into muons, antiproton annihilation phenomena may play a major role in future muon catalyzed fusion applications. In this context it is important to understand the processes leading to the deposition of annihilation energy in matter and the interactions of low energy antiprotons with matter and nuclei.

*Project Completed

Brigham Young University
Provo, Utah 84602

6. Investigation of Cold Nuclear Fusion in Condensed Matter*

Steven E. Jones, Department of Physics & Astronomy

	Funding Profile
Date Started: March 15, 1990	FY 90 - $374,000
Anticipated Duration: 18 Months	FY 91 - $177,000

Neutron emissions are seen during deuterium infusion into metals, implying the occurrence of nuclear fusion at low rates near room temperature. The phenomenon has been demonstrated in collaborative experiments at Brigham Young University, at the Gran Sasso Laboratory in Italy, and at the Los Alamos National Laboratory. The random neutron source rate is approximately 0.1 neutrons per second for 5-50g of partially deuterided metal, consistent in both electrochemical and gas-pressure techniques. Emissions of $\approx 10^2$ neutrons in bursts lasting less than 128 μs are also observed using both techniques. The effect will be carefully scrutinized with a view to potential applications and better understanding of fusion processes. Laboratory and geophysical experiments will complement theoretical efforts to understand the observations.

*Project Completed

Brookhaven National Laboratory
Upton, NY 11973

7. Energy Related Applications of Cluster Impacts

Lewis Friedman, Chemistry Department

Date Started: April 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $440,000

FY 92 - $585,000

FY 93 - $490,000

The impacts of accelerated cluster ions on solid surfaces generate transient highly compressed assemblies of energetic atoms. These atomic assemblies are unique in that very large amounts of energy are concentrated in the motion of the atoms rather than in the atomic electrons so that cooling processes are slower than with systems heated by lasers, electron beams or high-velocity ion beams. The direct deposition of energy into the motion of target atoms produces a non-random directional distribution of translational energy in the target atoms. As a consequence a very small fraction of the target atoms may acquire sufficient translational and/or vibrational energy to drive nuclear fusion reactions. A study of the effects of cluster impacts on solid surfaces in economical laboratory scale experiments can illuminate mechanisms of the ablative processes normally relied upon to compress and heat plasmas in inertially confined fusion. In addition, the direct application of cluster beams in place of heavy ion beams to heat inertially confined plasmas can be investigated. Most of the proposed experimental work will build on the foundation already established in studies of fusion reactions induced by singly-charged accelerated cluster ions. Studies will focus on the exploitation of multicharged ions to extend the range of velocities and sizes of the projectiles used to initiate cluster impact phenomena. The major objectives of this project are to study the properties of condensed matter under extreme conditions of pressure and energy density and to evaluate the potential of cluster impacts for use in the economical development of fusion energy.

University of California, Los Angeles
405 Hilgard Avenue
Los Angeles, CA 90024

8. Experimental, Theoretical and Computational Study of Frequency Upshift of Electromagnetic Radiation Using Plasma Techniques

Chan J. Joshi, Electrical Engineering Department

Date Started: January 15, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $250,000

FY 92 - $250,000

FY 93 - $250,000

In this project a new class of coherent electromagnetic radiation generation devices that, in principle, can cover the range of frequencies from microwaves to the vacuum ultra-violet will be investigated both theoretically and experimentally. In this method the frequency of the incident e.m. wave is upshifted by suddenly lowering the refractive index of the medium through which the wave is propagating. This can be done by rapidly ionizing the medium and forming a plasma. Various regimes will be investigated: *a) Spatially uniform ionization (or flash ionization).* If the source wave (ω_s,k_s) is propagating through a medium that is uniformly ionized in time, then the wavenumber of this source wave k_s is fixed, but the frequency can change to $\omega = \sqrt{\omega_s^2+\omega_p^2(t)}$ where ω_p is the plasma angular frequency. This technique is particularly useful for generating tunable e.m. radiation in the mm wave range. *b) Frequency upshift by a moving ionization front.* By sending an ionization front it is also possible to upshift the source wave frequency. If the plasma is underdense in the fronts frame, the upshifted frequency is $\omega = \omega_s(1+\frac{\omega_p^2}{4\omega_s^2})$. If the plasma frequency is greater than the source frequency, this technique can generate frequency upshifts that are much greater than the flash ionization technique. This technique is suited to generate far-infrared and infrared radiation. An applications study will also be undertaken to identify technologies which would likely be impacted by these sources.

University of Colorado
Boulder, CO 80309

9. Parallel Nanometer Scale Fabrication

Kenneth Douglas, Department of Physics

Date Started: September 15, 1989

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $359,000

FY 90 - $279,000

FY 91 - $300,000

The thrust of this research is to explore fabrication of structures at the highest possible spatial resolution in which features are defined on the nanometer length scale by single molecules. Two-dimensional protein crystals will be used as the patterning elements for nanometer fabrication, employing masking and templating operations. Hundreds of two-dimensional biomolecular arrays, having lattice parameters in the 3-30 nanometer range, are available as patterning elements. The nanostructures to be fabricated will include patterned 1 nanometer thick metal films having, for example, arrays of 10 nanometer dimension holes, metal island arrays of nanometer periodicity, and biomolecular-solid state nanohetero- structures. By employing periodic patterns, structural fluctuations and defects can be effectively investigated, for example the placement of 1 nanometer dimension metal grains by molecules of the template. The research goal is to understand phenomena which limit nanometer fabrication at the molecular level, to extend the limits of fabrication resolution, and to develop applications of molecular fabricated nanostructures. This parallel technology will enable the efficient parallel manipulation of surfaces. The ability to structure surfaces on the nanometer molecular length scale makes it possible to profoundly alter their fundamental properties such as chemical reactivity, adsorption characteristics, and electrical and optical behavior. Such a technology would contribute broadly to the advance of interfacial chemistry, physics, and materials science.

Colorado State University
Fort Collins, CO 80523

10. Capillary Discharge Extreme Ultraviolet Lasers

Jorge J. Rocca, Electrical Engineering Department

Date Started: December 15, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $170,000

FY 92 - $130,000

FY 93 - $130,000

The project objective is to explore the generation of soft x-ray laser radiation in a capillary discharge. A hot and highly ionized plasma column with a large length-to-diameter ratio (l/d=10-100) will be generated by a rapid discharge into a capillary structure. A compact 800kV, 150 kA pulser will provide the excitation. At the end of the current pulse rapid cooling of the plasma is expected to occur as a consequence of electron heat conduction to the capillary walls and plasma radiation. Under optimized plasma conditions collisional recombination of the capillary plasma is expected to lead to amplification at extreme ultraviolet and soft x-ray wavelengths. Experiments will be conducted to demonstrate gain, focusing first in the 3-2 transition of hydrogenic ions. The initial experiment will explore gain in the 18.2 nm transition of hydrogenic carbon in a polyethylene capillary. The proposed capillary laser scheme offers the potential for compact, simple and efficient soft x-ray laser sources.

University of Houston
Houston, TX 77204-5502

11. Research on Magnet Replicas and the Very Incomplete Meissner Effect

Roy Weinstein, Institute for Particle Beam Dynamics

Date Started: January 15, 1991

Anticipated Duration: 2 Years

Funding Profile

FY 91 - $351,000

FY 92 - $341,000

The aim of this project is to produce permanent magnets comprised of superconductors (SC's) which work at or near liquid nitrogen temperatures (77°K). These magnets show promise for applications in motors, generators, charged particle beam steering, industrial particle separators, MRI, and other constant field applications. One advantage of these magnets is that much higher fields are possible than for ferromagnets. A second is that the SC magnets can accurately copy the fields used to activate them, thus making possible magnet replicas. In addition, SC magnets are lighter than iron, cost less than an electromagnet, and consume negligible energy. The SC magnet replicas are made of bulk pieces of high temperature superconductor, and so do not require the availability of wire, which is difficult to produce from these materials. Both chemical and radiation methods are being used to produce materials capable of storing high field. Stored fields have been increased by factors of over 1,000 in the past two years. Presently, stored fields in 1 cm^3 samples are already three-times stronger than samarium-cobalt magnets. Methods of improving stability have been found. A small motor has been run using a magnet replica.

University of Illinois at Chicago
Chicago, IL 60680

12. Molecular Design Concept for X-Ray Laser Research

Charles K. Rhodes, Department of Physics

Date Started: December 15, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $300,000

FY 92 - $300,000

FY 93 - $300,000

The goal of the project is the construction of an x-ray laser in the kilovolt regime. Recent experimental results indicate that a new technique for the generation of strong amplification of x-ray wavelengths is feasible. It involves the combination of (1) a new ultrahigh brightness subpicosecond laser technology and (2) a recently discovered unique mode of strong-field interaction, particularly applicable to molecules. A concept of molecular x-ray laser design emerges from these considerations which matches the mode of excitation to the structure of the molecular system. The molecular approach enables the combination of very highly electronically excited conditions with an environment characteristic of dense cold matter, a general situation exceptionally conducive to x-ray amplification. Both high efficiency and wavelength tunability are intrinsic features of this method. A program of research is being conducted to evaluate this method for the production of x-ray amplification in the kilovolt region.

Lawrence Berkeley Laboratory
Berkeley, CA 94720

13. Metallic Multilayer and Thin Film Fabrication

Ian G. Brown

Date Started: April 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $288,000

FY 92 - $337,000

FY 93 - $270,000

The application of pulsed metal plasma gun techniques to the fabrication of metallic superlattices, multilayers and thin films will be investigated. Multilayer structures will be synthesized that are of relevance to x-ray optical devices, to magnetic and magneto-optical recording media, and to the fabrication of high temperature superconducting thin films. The quality and characteristics of the thin film structures formed in this way will be explored. This means of fabrication of metallic multilayer systems is new and has not yet been examined except in preliminary testing at this laboratory. At the same time, interest in artificial metallic superlattices from a fundamental scientific perspective, and in metallic multilayer structures from the standpoint of applied technology, is growing rapidly. It is important to explore and develop the application of this new technique to these fields. The proposed program will make immediate application of the method within the three fields mentioned above (x-ray optics, magneto-optics and superconducting thin films) via collaborations with materials science research groups at this laboratory.

Lawrence Berkeley Laboratory
Berkeley, CA 94720

14. Cyclotron Mass Spectrometer for Tracer Studies

Ka-Ngo Leung

Date Started: April 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $290,000

FY 92 - $245,000

FY 93 - $225,000

A compact research cyclotron will be developed which uses permanent magnets and axial ion injection. The new instrument will be used as an ultrasensitive accelerator mass spectrometer (AMS) for applied tracer studies. This device can take the place of bulky, cumbersome and much more expensive tandem Van de Graaff accelerators usually employed in AMS applications, and in fact can be made "portable". Thus this new machine has the potential for great practical benefit primarily by permitting detection or monitoring of minute quantities of hazardous substances and contaminants in exhausts and effluents. Moreover, the instrument is predicted to have sufficient sensitivity to detect ^{14}C isotopes as tracers after enormous dilution, opening the door to a large variety of environmental, biomedical and archeological applications. To facilitate ^{14}C tracer work, the effort also includes optimization of a C^- ion source that uses gaseous CO or CO_2 instead of solid graphite sputtering. It is expected that at the end of the project, the cyclotron mass spectrometer system will be developed well enough and its utility demonstrated to permit transfer to industry.

Los Alamos National Laboratory
Los Alamos, NM 87545

15. Pulsed Microwigglers for Innovative Free-Electron Lasers

Roger W. Warren

Date Started: June 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $300,000

FY 92 - $350,000

FY 93 - $350,000

A pulsed microwiggler will generate a very strong wiggler field of short period. It will allow light of short wavelength to be generated by an FEL system that uses an unusually low energy accelerator that is, therefore, compact and inexpensive. This will lead to a new generation of FELs, revolutionizing the technology. The development will enable new applications for which FELs were previously considered too expensive and cumbersome. Development of such a wiggler will require extensive computer simulations, novel wiggler designs (both to generate fields of the required shape and magnitude and to allow heat to be extracted efficiently), advanced fabrication techniques (to achieve the required precision), state of the art power supplies (high, pulsed currents), and unusual test equipment (to measure fields inside the small wigglers). These developments can be divided into several stages that can be attacked sequentially. It is planned to design, build, and test such a microwiggler and use it in an existing FEL system at Los Alamos to generate UV light.

Massachusetts Institute of Technology
Cambridge, MA 02139

16. High Frequency CARM Driver for RF Linacs

Bruce G. Danly, Plasma Fusion Center

Date Started: September 15, 1989

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $450,000

FY 90 - $448,000

FY 91 - $645,000

Future linear colliders will require high frequency rf sources together with high gradient accelerating structures in order to be economically feasible. The cyclotron autoresonance maser (CARM) is a promising source for application as an rf accelerator driver. This project will investigate and evaluate the CARM amplifier as an efficient source of high peak power microwaves capable of fulfilling this future requirement. Experiments at a frequency of 17 GHz will be performed using two different technologies for generation of the high voltage electron beam required by the CARM. A long pulse (1 μs), 700kV pulse modulator and a short pulse (50 ns), 1.2 MeV induction accelerator will be employed for generation of the electron beam. This will allow a comparison of two alternate methods for producing the high peak power, ≈50 ns microwave pulses required by the high gradient structures. A long pulse modulator-driven CARM together with pulse compression techniques, or an induction linac driven CARM are both capable in principle of delivering the required rf pulses to the structure. In both experiments, the details of CARM amplifier operation will be investigated, including linear and nonlinear gain, stability, efficiency, and phase sensitivity.

Massachusetts Institute of Technology
Cambridge, MA 02139

17. Development of a Collisional EUV Laser Using Ni-Like and Nd-Like Ions

Peter L. Hagelstein, Research Laboratory of Electronics

Date Started: May 1, 1989

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $448,000

FY 90 - $223,000

FY 91 - $539,000

It is proposed to construct a small scale extreme ultraviolet (EUV) laser at 200-300 Å based on electron collisional excitation in low-Z, nickel-like ions. The laser is to be pumped by a 10 joule Nd:glass laser pulse train, consisting of about 5 short 100 picosecond (2 joule) pulses spaced every several nanoseconds. The short wavelength amplifier will be well-adapted to cavity studies, and both multi-layer and whisper gallery optics will be explored. The use of a glass slab power amplifier in this system will allow for a repetition rate which is high (0.1 Hertz) for EUV lasers. As a result, the proposed system will be especially well suited for applications. Future systems could be based on high average power slab lasers and operate at the 1-10 Hertz regime. Applications of short wavelength lasers will be explored which at present includes EUV nonlinear spectroscopy and phase sensitive thin film and surface probing. New short wavelength laser schemes will be explored including the extension of the collisional excitation scheme to Nd-like (60 electron) ions.

Membrane Technology and Research, Inc.
1360 Willow Road
Menlo Park, CA 94025

18. Separation of Organic Azeotropic Mixtures by Pervaporation*

Richard W. Baker

	Funding Profile
Date Started: September 1, 1989	FY 89 - $169,000
Anticipated Duration: 2 Years	FY 90 - $136,000

This program concerns the development of improved membranes and modules that could be used to separate organic/organic mixtures by pervaporation. In pervaporation, a liquid mixture is introduced into an array of membrane modules. One or more components pass preferentially through the membrane as a vapor and, after condensation, are removed as a concentrated permeate. The remaining non-permeating components are removed as the liquid residue. Pervaporation has so far been developed commercially for the separation of aqueous/organic solutions. The process has not been applied to organic/organic separations because of the lack of suitable solvent-resistant membranes and modules. The performance of existing membranes and modules with important organic/organic mixtures found in the chemical processing industry will be examined. The data thus generated will be used to guide research into higher performance membranes that can withstand prolonged exposure to organic mixtures. Module design will be tailored to enable components to withstand a harsh chemical environment. The program will conclude with a study of the technical and economic feasibility of commercial-scale pervaporation systems for organic/organic separations. Single and multi-stage designs will be evaluated, and a cost comparison with rival separation technologies will be made.

*Project Completed

University of Michigan
Ann Arbor, MI 48109

19. Development and Applications of the Positron Microscope

David W. Gidley, Department of Physics

Date Started: January 15, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 90 - $173,000

FY 91 - $175,000

FY 92 - $175,000

The operation of the first positron microscopes in 1988 demonstrated a totally new contrast mechanism for microscopic imaging. Specifically, the positron reemission microscope images anti-matter positrons that have been implanted into a sample and subsequently reemitted from its surface. Image contrast, determined by the sample's positron reemission probability, depends on the unique behavior of positrons in solids. The goal of this research is to move this new technology beyond the current demonstration phase (3,000-10,000 Å resolution) by constructing and operating a 100 Å resolution instrument. This device would allow the assessment of the technique's ultimate capabilities, as well as allow investigation of several outstanding problems which the proposed microscope should make a unique contribution to solving. These problems include: (1) analysis of sub-25 Å films by positron tunneling microscopy, (2) unique applications in surface catalysis including, for example, analysis of systems with high Z substrates where electron microscopic techniques fail, (3) analysis of operation and failure modes of microelectronic devices, and (4) imaging of selected biological systems such as lipids and proteins in cell membranes. A program complementary to this has been initiated at the Idaho National Engineering Laboratory to construct a positron beam with a minimum intensity of 10^{10} positrons/sec. A beam of such intensity would be required for several applications including use in a sub-10 Å resolution microscope which would be constructed if, based on the results of this project, it is judged to be feasible and useful.

University of Missouri
Columbia, MO 65211

20. A Study of Potential High Band-Gap Photovoltaic Materials for a Two Step Photon Intermediate Technique in Fission Energy Conversion

Mark A. Prelas, Nuclear Engineering Program

Date Started: December 1, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $305,000

FY 92 - $294,000

FY 93 - $317,000

The efficiency of modern day power plants is limited by the steam cycle that they employ. Future power plants may be able to improve upon the efficiency of the steam cycle provided that other energy conversion techniques become available. One such energy conversion method is excimer channeling. Excimer channeling is a method of efficiently creating a narrow band photon spectrum directly from the products of nuclear reactions. This narrow band photon spectrum can be used in an energy conversion cycle based upon photovoltaic reactions. This project addresses the issue of photovoltaic materials that can interface with the narrow band photon spectrum in the excimer channeling energy conversion method. Photovoltaics are generally thought to be inefficient because of their association with solar cells. Solar cells are photovoltaic cells that convert the broad band photon spectrum of the sun directly into electricity at an efficiency of 10% to as much as 20%. Conversion of photons into electricity could be very efficient (as high as 85%) if the photon spectrum were sufficiently narrow, such as that produced by excimer channeling, and matched to the bandgap of the photovoltaic material. Development of high bandgap photovoltaic materials that match the excimer channeling photon spectrum is the goal of this research program. This effort centers on materials with bandgaps exceeding 5 eV. High bandgap crystals will be synthesized, doped to form P-N junctions, characterized by various surface analysis methods, made into photovoltaic cells, the cells' characteristics tested, and the cells' tolerance to various types of electromagnetic radiation assessed.

Northeastern University
Boston, MA 02115

21. Further Development of the Pneumatic Method to Harness Low-Head Hydropower and of its Experimental Implementation in the State of Maine

Alexander M. Gorlov

	Funding Profile
Date Started: December 15, 1990	FY 91 - $94,000
Anticipated Duration: 2 years	FY 92 - $81,000

The objective of the project is a further theoretical study of the pneumatic method to harness low and ultra low head hydropower and to demonstrate that such an approach can be economically and environmentally efficient for riverine power installation. The concept was originally offered in 1978-1980 for harnessing tidal power. The principal idea of the method is to utilize air turbines instead of conventional hydroturbines by means of converting energy of the flowing water into energy of compressed air. A pneumatic hydropower plant would cause minimal environmental distortion in the river and require substantially less land taking for a water pool than a conventional hydroturbine installation. There are two primary aspects of the research project: 1) to complete an analysis of air chamber parameters, mechanical and energy losses, air turbine operation; 2) to perform a feasibility study of a pneumatic power installation for a selected riverine site in the state of Maine.

Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831

22. The Emulsion-Phase Contactor: An Innovative Approach to Enhanced Efficiency in Solvent Extraction*

Charles H. Byers, Chemical Technology Division

Date Started: October 1, 1988

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $317,000

FY 90 - $330,000

FY 91 - $351,000

The use of electric fields is explored to drive continuous liquid-liquid solvent extraction processes. Pulsed electric fields can be used to efficiently create interfacial mass transfer surface area, to help induce countercurrent motion between the dispersed and continuous phases, and to promote droplet coalescence and phase separation. These combine to produce enhanced continuous multistage solvent extraction operations. The effort is directed towards understanding the controlling phenomena in electrified liquid-liquid emulsification and coalescence processes and demonstrating latitude of operational capabilities which are suitable for industrial development. This electrohydrodynamic behavior shows every indication of being capable of becoming the basis for a new solvent extraction concept which is far more efficient in both energy utilization and mass transfer performance than present day systems.

*Project Completed

Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831

23. Synthesis of Advanced Composite Ceramic Precursor Powders by the Electric Dispersion Reactor

Timothy C. Scott, Chemical Technology Division

Date Started: July 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $201,000

FY 92 - $179,000

FY 93 - $365,000

FY 94 - $325,000

The use of high-intensity-pulsed electric fields for droplet size control in dispersed liquid systems is being investigated. This technology has been utilized in a device called the electric dispersion reactor (EDR) to carry out the synthesis of micron-sized particles for the production of precursor powders of advanced ceramic materials. In this approach, pulsed electric fields are employed to create dispersions of microscopic conducting (aqueous-based) drops in nonconducting (organic) liquids. Each of these droplets becomes a localized microreactor where reactants in the organic phase diffuse into the aqueous droplets in which precipitation and gelation occur, while water and reaction products diffuse into the organic phase. The particle morphology is altered by varying reactant compositions in the liquid-liquid system while achieving intraparticle stoichiometric consistency. This leads to the production of high-quality precursor powders which, in turn, yields dense, consistent green-body material. Furthermore, this method requires far less energy expenditures than conventional approaches which rely on such inefficient operations as solids blending, mixing, and grinding to accomplish the formation of mixed-oxide precursor material.

Pacific Northwest Laboratory
Richland, WA 99352

24. Electricity Enhanced Fluidized Bed Heat Exchanger*

Delbert L. Lessor, Energy Sciences Department

Date Started: October 1, 1988

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $169,000

FY 90 - $145,000

FY 91 - $143,000

The objective of the proposed work is to demonstrate the contact-charging, electrically-enhanced fluidized bed heat exchanger concept. In this concept, bed particles are of two material types, which acquire different signs of electric charge on contact with each other or with other materials present. An alternating electric field is applied to increase particle motion, erode thermally-resistive boundary layers, and improve thermal contact between particles and heat exchanger tubes. Increased heat transfer should result. Increased heat transfer rates in fluidized beds should allow lower equipment costs, lower pressure drops, better energy recovery, and a broader spectrum of energy recovery applications. To test the concept, a series of bench-scale experiments and a modeling effort are being done. The experiments and modeling will seek to: 1) demonstrate that heat transfer enhancement can be achieved, and 2) provide insights for achieving or optimizing the effect by choices of materials composition, size, field strength, frequency, and flow velocity.

*Project Completed

Rensselaer Polytechnic Institute
Troy, NY 12180-3590

25. Cationically Polymerizable Monomers Derived From Renewable Sources

James V. Crivello, Department of Chemistry

Date Started: February 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $310,000

FY 92 - $235,000

FY 93 - $248,000

The objective of this project is to make use of a wide range of products obtained from plant sources as monomers for the direct production of polymers which can be used for a wide range of plastic applications. In particular, high volume American agricultural products such as soybean, cotton or linseed oils or forestry products such as lignin and cellulose are targeted for use either directly or with very slight modification for the production of the plastics. The monomers thus obtained, will be rapidly and efficiently converted to polymers using ultraviolet light or heat employing unique catalysts developed in this laboratory. It is expected that these catalysts provide a low energy and pollution-free means for the direct fabrication of the plastics. Furthermore, the polymers which are formed are expected to be prone to biodegradation and to pose little long term accumulation or pollution hazard.

Schmitt Technology Associates
25 Science Park
New Haven, CT 06511

26. Gas Jet Deposition of Metallic, Semiconducting and Insulating Films*

Bret Halpern

Date Started: November 15, 1987
Anticipated Duration: 3 Years

Funding Profile
FY 88 - $244,000
FY 89 - $154,000
FY 90 - $150,000

Gas Jet Deposition (GJD) is a new method for depositing thin films at high rate and controlled energy. The basic physics of GJD will be investigated in order to develop its technological capabilities. GJD deposits films by "seeding" atoms or molecules into a free jet expansion, e.g., of helium, and directing the jet at a substrate at relatively high pressure. GJD promises many advantages over established methods. Deposition rates of 10 microns per minute have been attained, and microns per second should be within range. The impact energy of depositing species can be gasdynamically controlled over a range of electron volts, so that film properties can be influenced during deposition. The substrate, which can be almost any material, can remain cool during deposition. Film composition and doping profile can be easily varied. Clusters can be deposited as well as atoms and molecules. GJD is flexible, and any metal, semiconductor, or insulator that can be seeded in the free jet can be deposited. The combination of these features in one method makes GJD singularly versatile. The goal of this project is to explore the feasibility of GJD as the basis of a usable technology. To do this, the fundamentals of GJD will be investigated, in particular its high rate and impact energy control, and the GJD apparatus will be refined. The properties of the films produced will be determined.

*Project Completed

Science Research Laboratory
1150 Ballena Boulevard, Suite 100
Alameda, CA 94501

27. The Plasma Centrifuge (A Compact, Low Cost, Stable Isotope Separator)

Mahadevan Krishnan

Date Started: August 15, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $495,000

FY 92 - $441,000

FY 93 - $317,000

The objective of this project is to make practical a new type of isotope separator called the Plasma Centrifuge. The Plasma Centrifuge is based on the concept of a cylinder of ionized matter (plasma) contained by a magnetic field and set into rotation by application of an electromagnetic body force. The typical embodiment consists of a rotating column that is fed by a vacuum arc plasma source at one end. As the plasma streams towards the other end of the chamber, centrifugal forces cause the heavier isotopes of the plasma ions to move nearer the periphery of the rotating column, resulting in partial separation between the constituent isotopes. Collectors placed at the other end of the column can collect either the outer portion that is enriched in the heavier isotope, or the inner portion that is enriched in the lighter isotope, as desired. This Plasma Centrifuge apparatus fits into a small room and can enrich dozens of isotopes with a throughput of about 1-3 grams/hour of enriched product. Such a capability would make this centrifuge a useful new separator to supply the US demand for a variety of enriched isotopes that are badly needed in these quantities in the fields of basic research in physics/chemistry/ geology/medicine and in medical diagnostics radiological practice. The cost, modularity and size of this approach makes the Plasma Centrifuge a potential replacement for CALUTRONS, which are today's primary source of supply of enriched isotopes.

Stanford University
Stanford, CA 94305

28. Growth of High T_c Superconducting Fibers Using a Miniaturized Laser-Heated Float Zone Process

Robert S. Feigelson, Center for Materials Research

Date Started: January 15, 1989

Anticipated Duration: 3 Years

Funding Profile

FY 89 - $478,000

FY 90 - $375,000

FY 91 - $355,000

The primary objective of this project is to thoroughly explore the potential of the laser-heated pedestal (float zone) growth method for the preparation of flexible wires (fibers) of the new copper-oxide ceramic superconductors, in particular, the Bi containing compounds which are capable of carrying high currents at temperatures above 77°K. This method, which involves drawing wires directly from a melt, has many advantages over other methods, most important of which is that it allows precise control of the growth process through the control of melt composition. Critical issues which will be considered in this superconducting fiber program include: 1) determining the most suitable compositions to be grown, 2) the maximum allowable growth velocity which can be used to grow fibers with high T_c, and 3) the maximum length of fiber which can be produced. To address these issues, the program will involve an in-depth study of: 1) the thermodynamic and kinetic factors which affect growth rate and the properties of the fibers produced, 2) the development of an advanced fiber growth system which will permit better control of system parameters, and 3) the development of techniques to enhance fiber throughput via increased growth velocity, postgrowth heat treatments, and the possibility of growing many fibers simultaneously.

The University of Texas at Austin
Austin, TX 78712

29. Photoassisted Oxidation of Oil Films on Water

Adam Heller, Department of Chemical Engineering

Date Started: January 1, 1990

Anticipated Duration: 3 Years

Funding Profile

FY 90 - $333,000

FY 91 - $297,000

FY 92 - $297,000

The objective of this project is to develop a new environmentally safe technology for eliminating crude oil slicks from oil spills. To accomplish this, microbeads that float on oil slicks are used. Under solar illumination, the microbeads accelerate the oxidation of the oil. The low-cost, hollow glass microbeads will be partially coated with a layer of titanium dioxide, a known photocatalyst for oxidation of contacting organic compounds. The beads will harvest light from areas substantially larger than their own, because oil films between air and water trap and propagate light, waveguiding it to the beads, which, in turn, waveguide it to the titanium dioxide photocatalyst particles. The waveguiding is associated with increasing indices of refraction. The required coverage of oil slicks with microbeads depends on their optical properties, increasing for heavier crudes. Coverage of 1% of the surface with microbeads is projected to be adequate for the photodissolution, under average solar illumination, in 1 month, even for the heavy crude spills.

The University of Texas at Austin
Austin, TX 78712

30. Synthesis of New High Performance Lubricants and Solid Lubricants

Richard J. Lagow, Department of Chemistry

Date Started: June 1, 1991

Anticipated Duration: 3 Years

Funding Profile

FY 91 - $377,000

FY 92 - $272,000

FY 93 - $218,000

Work will be conducted on the synthesis and characterization of perfluoropolyethers, an extraordinary class of high performance lubricants, by a relatively new technique, direct fluorination, which is emerging as the best way to prepare perfluoropolyethers. Many new and important classes of perfluoropolyethers will be prepared with very significant potential as lubricants. Currently the highest obtainable molecular weight perfluoropolyether synthesized using conventional polymerization processes is 50,000. This fluid with a molecular weight of 50,000 has a viscous syrup-like consistency. High molecular weight solids with a perfluoropolyether backbone have not been attained using methods other than direct fluorination technology. There exists now the capability to synthesize perfluoropolyethers with molecular weights over 1,000,000. Thus solid perfluoropolyether lubricants are accessible for the first time. A feature of direct fluorination technology where hydrocarbon structures are converted to fluorocarbon structures is that the organic precursors are converted to fluorocarbon fluids and solids without substantial cross-linking and without increased or decreases in degree of polymerization. The synthesis of hydrocarbon polymers as starting materials has many other advantages and introduces great flexibility and capabilities not attainable using polymerization processes with various perfluorinated ethylene oxides. Work will be done on many generic classes of solid fluorocarbon lubricants. The capability to make perfluoropolyethers soluble (miscible) with less expensive hydrocarbon lubricants and poly alpha olefins has recently been developed. One of the most important and promising prospects of this research is the synthesis of chlorinated perfluoropolyether fluids which are very compatible and soluble in hydrocarbons offering potential as high performance lubrication additives.

The University of Texas at Austin
Austin, TX 78712-1063

31. The Railplug: Development of a New Ignitor For Internal Combustion Engines

Ronald D. Matthews, Department of Mechanical Engineering

Date Started: January 15, 1991

Anticipated Duration: 3 Years

Funding Prifile

FY 91 - $500,000

FY 92 - $500,000

FY 93 - $500,000

Although conventional spark plugs appear to be entirely suitable for spark ignition (SI) engines, the design of the SI engine is limited by the characteristics of the ignitors. That is, if superior ignitors were available, the SI engine could be designed in a manner that would yield reduced emissions and improved fuel economy. Similarly, the design of virtually all types of internal combustion engines is limited in one way or another by the characteristics of the available ignitors. In this project a new type of ignitor is being investigated that operates on a much different principle than either conventional ignitors or any of the other advanced ignitor concepts that have been studied recently. Technology is being transferred from "star wars" to the automotive industry--railguns (a kinetic energy defense weapon) are being miniaturized to generate a new ignitor for internal combustion engines. Two characteristics make the miniaturized railgun, or "railplug", highly attractive as a replacement for conventional ignitors: a relatively large mass of plasma is generated and the plasma leaving the muzzle of the railplug has a high velocity. The advantages of using a railplug ignition system in three different engine applications are being investigated: replacement of spark plugs in both conventional SI engines and in dilute homogeneous charge SI engines, and replacement of glow plugs in indirect injection diesels to improve cold start characteristics. The primary objectives of the research are to improve internal combustion engine performance and fuel economy and to reduce emissions.

Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

32. Electrocatalytic Hydrocracking*

Donald R. van der Vaart, Department of Chemical Engineering

Funding Profile

Date Started: April 15, 1990

FY 90 - $115,000

Anticipated Duration: 1 Year

Conventional hydrocrackers rely on extremely high hydrogen partial pressures (>1500 psi) both to facilitate hydrogenation and reduce coke formation on the catalyst surface. In an electrochemical cell using a proton selective solid electrolyte, protons formed on the counter electrode can, as charge carriers, be transported through the electrolyte to the surface of the working electrode which is exposed to the liquid hydrocarbon at ambient pressure. The dual functionality required of hydrocracking catalysts is provided by this hydrogenating/ dehydrogenating (metal) site and the cracking sites of the solid electrolyte. The ready supply of hydrogen delivered directly to the reaction interface should limit coke formation and, hence, greatly reduce the operating pressure requirements. This decrease in the rate of surface deactivation would enable lower quality (heavier) feeds to be (electrocatalytically) hydrocracked to produce gasoline and middle distillates at significantly lower costs.

*Project Completed

SAMPLE

Statement of Work

1) Project Objective

The proposer shall investigate the electrocatalytic oxidative dehydrogenation of ethylbenzene and butane in solid electrolyte fuel cells. The effort is directed toward defining optimal operating conditions for achieving high yields of styrene and butadiene with simultaneous electric energy generation.

2) The work to be performed consists of the following tasks:

2.1. Construction of tubular stabilized zirconia fuel cells with a platinum cathode and an iron oxide or platinum anode. Both anode materials are quite promising and a decision between the two will be made after preliminary runs.

2.2. Measurement of the styrene cell activity and yield as a function of temperature, inlet ethylbenzene concentration and external resistive load.

2.3. Measurement of the cell electric power output and overpotential as a function of the operating parameters described in 2.2.

2.4. Determination of the nature of the overpotential according to the results of 2.3. If ohmic overpotential dominates, a small well mixed cell with thin (150 microns) electrolyte discs will be constructed to increase power density.

2.5. Development of correlation for styrene yield and electrical power output in terms of operating and design parameters for use in future scale up.

2.6. Repeat tasks 2.2. through 2.5. using butane and/or butene as the fuel.

2.7. Preliminary engineering and economic analysis according to the results of 2.2. through 2.6.

3) Deliverables

The proposer shall provide the data of experiments performed according to paragraphs 2.2., 2.3., 2.4., 2.5. and 2.6. along with analyses and conclusions based on this data.

4) Performance Schedule

4.1. Complete construction of cells 3 months after start of work.

4.2. Complete ethylbenzene experiments within 12 months after start of work.

4.3. Complete butane and butene experiments and data analysis 20 months after start of work.

4.4. Complete data correlation, economic analysis and final report 24 months after start of work.

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

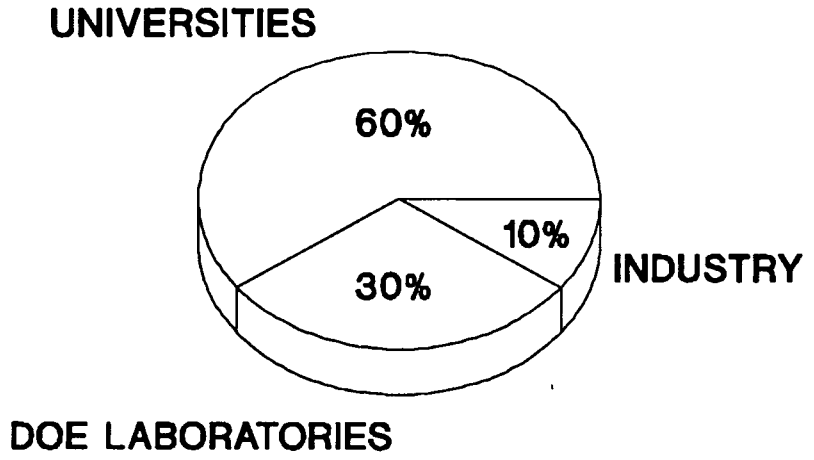
PROGRAM DATA

(EXCLUDES HIFAR AND SBIR)

BUDGET

	FY 1990	FY 1991	FY 1992 (REQUEST)
OPERATING	$9,000,000	$9,100,000	$10,800,000
EQUIPMENT	330,000	300,000	300,000

DISTRIBUTION OF FY 1991 PROJECTS BY SECTOR



DIVISION OF ADVANCED ENERGY PROJECTS
HEAVY ION FUSION ACCELERATOR RESEARCH

In FY 1991, the Division of Advanced Energy Projects also managed the Heavy Ion Fusion Accelerator Research (HIFAR) program, an effort that was not subject to the prevailing three-year funding limit. The HIFAR program is investigating the scientific, technical, and economic feasibility of using a multiple-beam induction linac as a target driver for inertial fusion energy production. In this concept, multiple parallel beams of heavy ions are continually amplified in current and in voltage as they are accelerated to the parameters required to ignite an inertial fusion target (=10 GeV, 500 TW, 10 ns). A central issue for heavy ion fusion is to maintain adequate beam quality through the acceleration and beam manipulation process to permit the beams to be focused onto the small spots required by the fusion targets. The HIFAR approach is through theory, simulation and increasingly sophisticated experiments that model the various accelerator physics issues of a heavy ion driver. The effort is centered at the Lawrence Berkeley Laboratory with important contributions being made by research teams at the Lawrence Livermore National Laboratory, the Naval Research Laboratory, and the Stanford Linear Accelerator Center.

Initial HIFAR experiments established that beams of heavy ions of 100 times better quality (lower emittance) than required by the target could be obtained using large area surface ionization sources. Source work has continued through the course of the research and prototype gas sources as well as arc sources have been developed.

The Single Beam Transport Experiment, completed in 1985, demonstrated that brighter and more intense beams than initially estimated could be transported using electrostatic quadrupoles in a way that preserves beam quality well within the target focus requirements. These experiments and accompanying theoretical understanding have led to simplified and to more cost effective designs of heavy-ion-driven inertial fusion power systems.

A Heavy-Ion Fusion Systems Assessment (HIFSA) was completed in 1987. The study concluded that, in a mature technology, electricity could be produced by a 1000 MW electric power station at costs that appear competitive with other advanced energy options. Furthermore, the heavy ion accelerator/driver accounts for approximately 45% of the capital cost of the power plant.

The Cesium^{+} ion beam experiment MBE-4, completed in April 1991, accelerated four beams from 0.2 MeV to nearly 1.0 MeV within a length of 17 m. In these experiments the current increased during acceleration by factors that could be varied from three to nine. This experiment demonstrated that current amplification in an induction linac is possible and showed that the beams can be controlled longitudinally using the accelerating waveforms. In the experiments very cold, space-charge-dominated ion beams were accelerated with no degradation in beam quality when adequate care was taken to match, center, and align the beams in the transport channel.

Several important features and beam manipulations yet to be encountered in an inertial fusion heavy ion driver will be studied at reduced scale in a sequence of Induction Linac Systems Experiments called ILSE. A design study for ILSE was completed and favorably reviewed in 1987. These experiments will complete the HIFAR accelerator studies and develop technology and accelerator know-how appropriate for a next larger HIF accelerator. The ILSE studies will be performed over the next six to seven years at the Lawrence Berkeley Laboratory.

For several years the HIFAR program has been developing technology for high voltage multi-beam injectors to provide beams at the beginning of a heavy ion driver. An inductively graded, slow-rise Marx generator that supplies 2 MV accelerating potential to a 4-16 beam accelerating column has been developed and voltage tested. Carbon arc ion sources have been studied extensively and used to test the beam optics in the injector. This device will be used as the injector for the ILSE experiments.

As a consequence of recommendations made by the Fusion Policy Advisory Committee, the HIFAR program was transferred from the Office of Basic Energy Sciences' Division of Advanced Energy Projects to the Office of Fusion Energy during FY 1991. HIFAR will be managed by OFE beginning next fiscal year.

HIFAR BUDGET

	FY 1990	FY 1991
OPERATING	**$5,500,000**	**$5,600,000**
EQUIPMENT	**647,000**	**300,000**

SMALL BUSINESS INNOVATION RESEARCH PROJECTS

AEP manages a number of projects in the Small Business Innovation Research Program. The goal of Phase I projects is to determine the feasibility of the proposed concept. Phase II projects are a continuation of successful Phase I projects and are the principal research or research and development effort of the project. The principal investigator is identified below the project title.

PHASE I SBIR PROJECTS

Adelphi Technology, Inc.

285 Hamilton Avenue, Suite 430
Palo Alto, CA 94301

33. Parametric Radiation as an Intense Monochromatic X-Ray Source

Melvin A. Piestrup

Funding Profile

Date Started: September 7, 1991

FY 91 - $49,995

Anticipated Duration: 1 Year

Parametric x-radiation (PXR) is proposed as an intense, monochromatic x-ray source. This radiation is highly collimated, has a bandwidth of 0.1% FWHM and an intensity equal to that of synchrotron radiation on a per electron basis. PXR is produced by a high energy (>1 MeV) electron passing through a crystalline structure; as the electron passes through the planes of a crystal, it will excite the crystalline electrons along the planes. If the path of the incident electron is properly aligned with respect to the planes of the crystal, the radiation given off by the excitations at the successive planes will add coherently, producing directional monochromatic radiation, in a process similar to the Bragg diffraction of x rays. Indeed, the energy and direction of PXR is given by the Bragg relation for the given geometry. Since parametric radiation is emitted at an angle to the electron beam, it is easily separated from the electron beam and bremsstrahlung. This, along with the narrow bandwidth, collimation and intensity of parametric radiation make it a promising x-ray source for noninvasive digital subtraction angiography and other applications which require intense, tunable radiation peaks. The proposed work will consist of: 1) Determine the maximum parametric x-ray intensity that can be achieved from a crystal by analyzing the effect of the crystal composition on the maximum sustainable electron current and the resulting maximum x-ray production. 2) Study the use of layered synthetic media to produce greater intensity through increasing the bandwidth of the radiation. 3) Study the use of multiple crystals to increase the radiation intensity. The results of these calculations will establish the viability of PXR as an intense, collimated, monochromatic x-ray source.

Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303

34. Solid State UV Light Source

David Deacon

Funding Profile

Date Started: September 7, 1991

FY 91 - $50,000

Anticipated Duration: 1 Year

A semiconductor diode based source of coherent radiation in the UV would open up new capability in photolithography, fluorescence based analytical instruments, and research. Presently available sources are inefficient, bulky, and unreliable. Deacon Research has developed the concept for an inexpensive diode laser based solid state light source which could supply tunable radiation at moderate average power levels in the UV. Our approach is based on two critical technologies, one of which we have developed in-house. The harmonic generation step will be combined with this technology and demonstrated experimentally during the Phase I program. We will marry the experimental results with an analysis of the technical limitations on the system and calculate the performance of the device. During Phase II we will construct the prototype, optimize its performance, and search for an industrial partner with whom we will commercialize the technology in Phase III.

Optical Computing International
4192 Kerwood Court
San Diego, CA 92130

35. Harmonic Generation of Semiconductor Laser Bars

Bradley Mells

Funding Profile

Date Started: September 7, 1991

FY 91 - $49,743

Anticipated Duration: 1 Year

An advanced solid state laser development program is proposed which will investigate the nonlinear optical systems applications of the microchannel cooled semiconductor laser bar technology developed at Lawrence Livermore National Laboratories. The proposed research will result in the development of a feed-back controlled injection seeding system which will produce single frequency, diffraction limited performance from the resonant diode bar. This will make possible the direct nonlinear optical processing of the sixty watt diode laser output using the semiconductor laser frequency stabilization techniques already developed by the proposing organization. The substantial power scaling of our current devices provided by this effort will substantially increase the size of the laser markets which are addressed by this company's products. The proposed program considers overall efficiency and low cost manufacturing technology as primary design goals. It is anticipated that the novel approach proposed herein will set new standards for efficiency and frequency stability in short wavelength lasers. This program will pursue resonant second and fourth harmonic generation of the 808 nm injection seeded output to produce approximately thirty watts in the violet (404 nm) or over fifteen watts of highly coherent vacuum ultraviolet (202 nm) radiation.

X-Ray Optical Systems, Inc.
R.D. 2, Box 372
Cass Hill Road
Voorheesville, NY 12186

36. Kumakhov Lens with Rotating Anode to Obtain An X-ray Source Which is an Advantageous Alternative to Synchrotrons

Igor Y. Ponomarev

Funding Profile

Date Started: September 7, 1991

FY 91 - $46,332

Anticipated Duration: 1 Year

Measurements and calculations made in the Soviet Union indicate the possibility to use a new capillary based X-ray optical system to increase the intensity, and decrease the divergence of laboratory X-ray sources sufficiently for them to compete and in some cases even surpass synchrotron sources for some applications. This project will investigate the feasibility for such systems based on critical calculations of the properties of single capillary and polycapillary fibers, measurement of relevant transmission properties and divergences for single and polycapillary fibers and fiber bundles and modeling of the properties of completed lens structures. The intensity and resolution after transmission through a Bragg monochrometer will also be investigated.

PHASE II SBIR PROJECTS

Adelphi Technology, Inc.
285 Hamilton Avenue, Suite 430
Palo Alto, CA 94301

37. A Pulsed X-Ray Source Using K-Edge Transition Radiation

Melvin A. Piestrup

	Funding Profile
Date Started: February 15, 1991	FY 91 - $292,000
Anticipated Duration: 2 Years	FY 92 - $208,000

The objective of this project is to investigate the use of a novel transition-radiation source to produce a low-cost, laboratory-scale, intense, pulsed x-ray source. By designing transition radiators to emit x-rays at the foil material K-shell photoabsorption edge, the x-ray spectrum is narrowed. The source is thus quasi-monochromatic (40 to 50% bandwidth), directional, intense, and uses an electron beam whose energy is considerably lower than that needed for synchrotron sources. By using a pulsed electron source, foil heating is minimized and high peak currents can be obtained. The radiation produced can be in the soft (0.1 to 5 keV), warm (5 to 15 keV) and hard (> 15 keV) x-ray regions of the spectrum depending upon the foil material used, the foil thicknesses, and the electron-beam energy. Under Phase I the spectral and spatial photon densities from a titanium radiator, whose bandwidth is between 2 and 5 keV, were measured. Using a high current beam, the total power from this radiator, along with a copper radiator whose bandwidth was between 5 and 9 keV, was also measured. Cylindrical and ellipsoidal optics were used to focus the 2 to 5 keV photons to a 1-mm diameter spot 3 m from the radiator. In Phase II a permanent x-ray beamline will be constructed at an existing accelerator. This beamline will then be used to test five radiators at high average and pulsed currents. These radiators will generate x-rays from 5 to 25 keV. Focusing optics will be designed, fabricated, and used to focus the x-rays in the 5 to 10 keV range. Three applications will be studied: (1) Laue diffraction in the study of the static and kinetic structures of protein molecules, (2) the production of x-ray lithographs using soft x-ray emission, and (3) flash soft x-ray emission from pulsed electron sources.

Advanced Fuel Research, Inc.
P.O. Box 380343
East Hartford, CT 06138

38. Low Temperature Processing of High T_c Superconductor of Detector Arrays With Silicon Circuitry

David G. Hamblen

	Funding Profile
Date Started: June 15, 1990	FY 90 - $251,000
Anticipated Duration: 2 Years	FY 91 - $249,000

The discovery of high temperature superconductivity (HTS) has led to renewed interest in the application of superconductivity. One such application is superconducting infrared detectors, either as bolometers or as grain boundary Josephson junctions. Infrared detectors, especially arrays for imaging, are not widely used due to the difficulties in integration with the necessary biasing and readout circuitry. The overall objective of this program is, therefore, integration of infrared detectors, based on HTS films, with silicon substrates on which the associated control and amplifier circuits can also be installed. The achievement of this goal requires the solution to a wide number of problems in the materials' quality control and fabrication (the substrate and buffer-layer surfaces, and HTS films), in device physics to understand and optimize the IR detectors and in electronic processing to integrate the required procedures with circuit fabrication technology. The key Phase I achievements include: 1) the first demonstration of an infrared detector using an HTS film on a silicon substrate, 2) the first demonstration of on-line characterization of the oxygen dependent transition in yttrium-barium-copper-oxygen (YBCO) from an insulating, non-superconducting phase to the metallic superconducting phase using in-situ Fourier Transform Infrared (FT-IR) reflection, 3) demonstration of all required components to show that integration of detectors and silicon circuitry is feasible, and 4) identification of a complete methodology for deposition of high quality YBCO on silicon, using a 700°C substrate deposition temperature and an yttria-stabilized zirconia buffer layer to provide a lattice match and a diffusion barrier between the silicon and the superconductor. The Phase II program will continue this development using in-situ FT-IR to monitor the deposition process (especially the surface temperature and oxygen stoichiometry), and will continue to optimize the integration of the infrared detectors and accompanying circuitry in order to reach the ultimate goal of detector arrays.

Deacon Research
2440 Embarcadero Way
Palo Alto, CA 94303

39. A Precision Undulator Adjustment Tool

David Deacon

Date Started: May 20, 1991

Anticipated Duration: 2 Years

Funding Profile

FY 91 - $236,000

FY 92 - $264,000

The available means for trimming up undulator magnetic fields are inadequate both for free electron lasers (FELs) and advanced synchrotron radiation sources. This problem prevents the generation of short wavelengths with FELs, and limits the beam brightness in synchrotron light sources. This program will produce a measurement tool which measures directly the quantity of interest in undulators, the particle trajectory, rather than calculating it from other quantities. The result will be an improvement in the brightness and coherence of the beam produced by the undulator, and a reduction in the manpower required to achieve it. This technology enables the production of essentially perfect undulators with a length ten times longer than possible now. Such undulators in turn will make possible the production of coherent light in the extreme ultraviolet (XUV) and the x-ray regions of the spectrum. In the Phase I program, the accuracy of the experimental detection system was measured, and the system was shown to perform better than expected. In Phase II, an innovative particle beam/detector system will be built and used to measure one of the high quality undulators being produced at the Lawrence Berkeley Laboratory for the Advanced Light Source. A comparison with the measurements made by conventional means will establish the value of the device.

SFA, Inc.
1401 McCormick Drive
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40. Physical Applications of Channeling Radiation as a Novel, Intense X-Ray Source

Herbert Uberall

Date Started: May 20, 1991

Anticipated Duration: 2 Years

Funding Profile

FY 91 - $230,000

FY 92 - $257,000

The Phase I investigation has shown that in the x-ray region, channeling radiation (CR) can be highly competitive in intensity to contemplated applications with a synchrotron radiation (SR) source or with the proposed transition radiation (TR) source, while from the economic standpoint it is clearly superior: the required 5-20 MeV electron linacs are available for about $1 million, but corresponding 0.5-1 GeV synchrotrons or storage rings are priced from $60 million up. Corresponding electron linacs for TR must have 200 MeV or more, also at much higher cost. Concentrating thus on CR in the x-ray region, a number of prototype experiments will be carried out in Phase II for applications of commercial or medical importance in order to verify the predicted intensity and the effectiveness of CR sources of several keV (perhaps tens of keV) for such applications. Foremost will be x-ray microlithography, where exposure times of only several minutes are expected for 4" x 4" wafers. In addition, angiography experiments on phantoms will be performed, for which a new approach based on calcium deposits will be tested. Further experiments will demonstrate the superiority of CR over conventional sources for applications on the detection of trace elements via fluorescence or on the structural analysis of macromolecules.

INVESTIGATOR INDEX
(Project Numbers)

INSTITUTIONAL INDEX

(Project Numbers)

FACSIMILE

COVER SHEET

DATE:

TO: **Dr. Walter M. Polansky, Director**
Division of Advanced Energy Projects
ER-16, GTN
U.S. Department of Energy
Washington, D.C. 20585

FROM: _____

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ATTACHMENT: **Preproposal** ____ **Other** ____

Message: _____

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