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Advanced Energy Projects FY 1982 Research Summaries

October 1982

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

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Washington, D.C. 20545

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OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS (AEP)

Program Description

What projects are supported?

This Division supports exploratory research on novel concepts related to energy. The research is usually aimed at establishing the scientific feasibility of a concept and, where appropriate, also at estimating its economic viability. Because projects supported inevitably involve a high degree of risk, an indication of a high potential payoff is required. An immediate, specific application of the concept is not an absolute prerequisite for consideration; thus, for example, proposers of schemes leading to the development of x-ray lasers are not required to justify their proposals by discussing potential applications of such lasers.

The concepts supported are typically at too early a stage of scientific verification to qualify for funding by DOE programs responsible for technology development. Where doubt exists, such programs are consulted, prior to proposal consideration by AEP, in order to establish their possible interest in the project.

Projects not supported

The AEP Division does not support ongoing, evolutionary research. Neither does it support large scale demonstration projects.

Period of support

By design the period of support is finite, generally not exceeding three years. It is expected that, following such a period, the concept will either be at a stage where it can be supported by a technologically appropriate organization or branch of DOE, or else it will be dropped.

Funding levels

The size of a contract in FY '82 varied between $60,000 and $325,000 per annum.

Who can propose?

Unsolicited proposals can be submitted by universities, industrial organizations, nonprofit research institutions or private individuals. Consideration is also given to ideas submitted by scientists working at national laboratories.

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 (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?

Preproposals desired

It is suggested that before a formal proposal is prepared, the proposer should submit a brief outline of the proposed work. The outline should provide enough background information to enable a decision as to whether or not the proposed work programmatically fits the mission of AEP.

Proposals

Once a programmatic interest of AEP in the proposed project has been established, a proposal should be submitted along the guidelines specified in DOE/PR-0010, "Guide for the Submission of Unsolicited Proposals." Each proposal must contain:

- A cover page, prepared in a format specified in DOE/PR-0010, Appendix B.

- A 200-300 word abstract, written in plain English, describing the essence of the project in terms understandable to a layman. The abstract should be in a form suitable for inclusion in DOE program presentations.

- A technical discussion of the proposed concept and a description of the proposed work. While the discussion should be kept brief, there is no formal limitation on the number of pages allotted to this section of the proposal. Since it is this section that will form 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 merits are adequately covered.

- A statement of work specifying all tasks to be performed in the course of the proposed work.

- 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.

Further Information

Inquiries should be addressed to:

Dr. Ryszard Gajewski, Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences
ER-16, GTN
Department of Energy
Washington, D.C. 20545

Phone: 301/353-5995

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

Summaries of Projects Active in FY 1982

This section contains brief summaries of all projects active in this Division during Fiscal Year 1982 (October 1, 1981-September 30, 1982). The intent of this compilation is to provide a convenient means for quickly acquainting an interested reader with the program in Advanced Energy Projects. More detailed information on research activities in a particular project may be obtained by contacting directly the principal investigator shown below the project title. Some projects will have reached the end of their contract periods by the time this book appears, and will therefore no longer be active. Those cases in which work was completed prior to July 1, 1982 are indicated by the footnote: *Project completed.

1. THERMOCHEMICAL CONVERSION OF BIOMASS TO ETHANOL

BATTELLE COLUMBUS LABORATORIES
Columbus, Ohio 43201

William J. Huffman

Date Started: September 30, 1980

Funding: FY '82 $39,000 for 6 months

Anticipated Duration: 2 years+

The objective of this project is to test a new, proprietary process for converting sugars to ethanol. In the program, the basic chemistry and kinetics of the non-fermentation process will be investigated. The ultimate goal is to develop a process which is capable of using wood or other sources of cellulose. During FY '82, good conversion of both hexose and pentose sugars was demonstrated and high conversion of key intermediate-to-fuel chemicals was shown. The importance of a reaction solvent was established.

+Includes unfunded extension

2. THE CONTINUOUS MEMBRANE COLUMN: A LOW ENERGY ALTERNATIVE TO DISTILLATION

BEND RESEARCH, INC.
64550 Research Road
Bend, Oregon 97701-8599

Walter C. Babcock
Membrane Separations Division

Date Started: February 5, 1982

Funding: FY '82 $110,000 for 12 months

Anticipated Duration: 3 years

This program is directed toward evaluating membrane separations as an energy-efficient alternative to distillation. Commercially important separations currently performed by distillation that are under investigation include acetic acid from water, methanol from water, and soybean oil from hexane. Research is currently underway to develop membranes that exhibit the proper selectivity to perform the desired separations and that are chemically resistant to the compounds to be separated. Once such membranes are developed, they will be evaluated in a "continuous column" module configuration. This configuration overcomes the problem of the very high pressures that would otherwise be required to separate the compounds.

3. LIQUID MEMBRANES FOR THE PRODUCTION OF OXYGEN-ENRICHED AIR

BEND RESEARCH, INC.
64550 Research Road
Bend, Oregon 97701-8599

Harold K. Lonsdale

Date Started: April 16, 1979

Funding: FY '82 $325,000 for 15 months

Anticipated Duration: 5 years

This program is directed toward the development of novel membranes for the production of oxygen-enriched air. With membranes of suitable performance, the energy efficiency and reduced cost of an oxygen-enrichment process would justify the use of such upgraded air supplies in standard combustion processes--thus extending and conserving available fossil fuel supplies--as well as in other industrial processes, including synfuels production. The approach involves the use of liquid membranes held by capillary forces in the pores of a microporous support membrane. Oxygen is preferentially transported across these membranes by facilitated transport. Oxygen permeabilities greater than twice that of the most permeable polymeric membranes have been achieved. Oxygen-to-nitrogen selectivities as high as 30 have been obtained, enabling the production of 88% oxygen in a single pass. Research is currently focused on improving long-term performance and on scale-up studies.

4. FREE ELECTRON LASER TEST,
NATIONAL SYNCHROTRON LIGHT SOURCE

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

C. Pellegrini and A. van Steenbergen
National Synchrotron Light Source

Date Started: May 1, 1980

Funding: FY '82 $298,000 for 12 months

Anticipated Duration: 3 1/2 years

The purpose of this program is to develop a free electron laser test module driven by the circulating beam of a storage ring. The program will explore the effect of the free electron laser on the parameters of the storage ring as well as involve the development of a coherent wiggler to provide the appropriate mechanism for electromagnetic radiation amplification due to repeated interactions of the laser field and the transversely oscillating electrons in the undulator (coherent wiggler). It is anticipated that a basic design for a tunable high average power ultraviolet source with a narrow spectral bandwidth may result from these studies.

5. MEQALAC CLUSTER
ION FUSION

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

Lewis Friedman and Alfred Maschke
Chemistry & Accelerator Departments

Date Started: January 15, 1981

Funding: FY '82 $240,000 for 12 months

Anticipated Duration: 3 years

Proof-of-principle experiments are proposed to demonstrate that isotopic hydrogen molecule cluster ions can be prepared and accelerated. Singly charged hydrogen cluster ions with atomic weight between 1,000 and 10,000 will be generated with a sufficiently narrow mass distribution to be accelerated economically to fuel and heat plasmas. The long range goal of these experiments is the utilization of plasmas produced by accelerated cluster ions for the production of thermonuclear reactions. The research program involves the development of a cluster ion source and the demonstration that the clusters can be electrostatically focused and accelerated in a pulsed drift tube accelerator. Investigation of bunching and space charge neutralization of cluster ion beams accelerated to a few million electron volts will be undertaken to determine optiumum values for a break even fusion experiment.

6. TWO-PHASE TURBINES FOR EFFICIENT WASTE-HEAT RECOVERY

CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
Pasadena, California 91109

David G. Elliott

Date Started: September 15, 1980

Funding: FY '81 $100,000 for 12 months

Anticipated Duration: 2 years

The concept of two-phase engines is aimed at increasing the efficiencies attainable in low grade heat recovery. It is based on a novel thermal cycle, the efficiency of which exceeds that of a Rankine cycle with sensible-heat sources. This is so because in a two-phase engine the working fluid is heated entirely in the liquid phase, thus permitting the heat exchanger to operate with a constant small temperature difference between the working fluid and the source fluid. In addition to improved efficiencies, the two-phase cycle results in reduced turbine speeds -- an advantage from the point of view of material requirements. An experimental two-phase turbine was tested with Refrigerant 22 as the working fluid. The R-22 was fed to the turbine as saturated liquid at 1.0 MPa (145 psia) pressure. The 24-kW turbine, using two stages of impulse rotors to minimize liquid friction, produced 58 percent efficiency with the R-22 expanding to atmospheric pressure and flashing to 26 percent vapor. This was the highest efficiency attained to date with two-phase turbines.

7. HIGH CURRENT BETATRON FOR A FREE ELECTRON LASER

UNIVERSITY OF CALIFORNIA
Irvine, California 92717

Norman Rostoker and Amnon Fisher
Department of Physics

Date Started: August 1, 1981

Funding: FY '81 $685,000 for 3 years

Anticipated Duration: 3 years

A modified Betatron with a toroidal magnetic field can in principle accelerate very high currents, much higher than a conventional Betatron. One way to charge a modified Betatron is to employ inductive charging. Inductive charging produces an electron cloud trapped in the torus but these electrons have large transverse energy. A free electron laser requires an electron beam quality which might not be compatible with inductive charging. In the last year a modified Betatron has been constructed utilizing a different approach to electron injection. The scheme resembles an Astron configuration where an electron beam drifts into an elongated chamber and is resistively or inductively stopped. The apparatus has been built and it is in its final stage of testing. Actual trapping and accelerating experiments will start soon.

8.* INTEGRATED FUNCTION NONIMAGING CONCENTRATING COLLECTOR TUBE FOR SOLAR THERMAL ENERGY

UNIVERSITY OF CHICAGO
5801 South Ellis Avenue
Chicago, Illinois 60637

Roland Winston
The Enrico Fermi Institute

Dated Started: December 1, 1979

Funding: FY '82 $100,000 for 6 months

Duration: 2 1/2 years

An advanced high temperature solar collector has been developed which uses nonimaging concentration integrated directly into a shaped evacuated tube such that no tracking or tilt adjustments are required. During regular testing the prototype panel has routinely and reliably achieved operating efficiencies typically 50 percent or better at 200°C collection temperature. Performance by this fully stationary collector comparable to that for a tracking line focus trough in the range 100°C to better than 250°C has been demonstrated.

*Project completed

9.* EXTREMELY HIGH TEMPERATURE PLASMA RESEARCH

COLUMBIA UNIVERSITY
New York, New York 10027

Robert A. Gross and Thomas C. Marshall
Applied Physics and Nuclear Engineering

Date Started: June 1, 1980

Funding: FY '81 $97,000 for 12 months

Anticipated Duration: 2 1/3 years+

Theoretical and experimental studies of a superfast Z pinch implosion ($dI_z/dt \sim 10^{14}$ A/sec) in low pressure D_2 (0.1 torr) have been made. An experiment was done on the Sandia 0.2 TW, 0.25 ohm Ripple machine and resulted in the creation of a hot (few keV), 1 cm diameter plasma for a few nsec. Numerical simulation of the experiment, taking into account circuit parameters, has been done using kinetic-hybrid and MHD codes; agreement between experiment and the hybrid code is best. Extrapolation of these studies show the possibility of creating 100 keV ion temperature, neutron yield of 2×10^{10} (in D_2), using existing state-of-the-art pulse power machines.

+Includes unfunded extension
*Project completed

10. COLLECTIVE ACCELERATION OF IONS USING HIGH CURRENT RELATIVISTIC ELECTRON BEAMS

CORNELL UNIVERSITY
Ithaca, New York 14853

John A. Nation

Date Started: January 1, 1980

Funding: FY '82 $151,000 for 12 months

Anticipated Duration: 3 1/3 years

This project studies a collective acceleration system which uses an adiabatic increase in the phase velocity of a large amplitude slow space charge wave as a means of accelerating protons trapped in the wave. The objective is to accelerate protons from about 15-20 MeV to between 25 and 30 MeV and hence to demonstrate the feasibility of the proposed approach to the acceleration of high fluxes of protons to high energy.

11. EJECTOR-TURBINE HEAT ENGINE

UNIV. OF DAYTON RESEARCH INSTITUTE
300 College Park Avenue
Dayton, Ohio 45469

John E. Minardi
Aerodynamics/Energy Conversion Group

Date Started: August 1, 1979

Funding: FY '82 $60,000

Anticipated Duration: 3 1/4 years

The objective of this project is to test the feasibility of a novel low-power Rankine turbine concept which promises low cost, significant reduction in rpm over similarly rated turbines, and low maintance, long-life operation at competitive efficiencies. This is accomplished through the use of an efficient two-fluid ejector which lowers the pressure and temperature operating conditions seen by the turbine. Ejector tests have been run that are in substantial agreement with the theory. A turbine has been constructed to operate with a two-fluid ejector, using hot CO_2 and air. Tests of this turbine are under way. Potential applications for a successful turbine of this type would include the generation of electricity and air conditioning of homes. The concept permits engine cycles that cover a broad range of peak temperatures, including those corresponding to stoichiometric combustion of hydrocarbon fuels, waste heat sources, and solar.

12. DEVELOPMENT OF A BIOCHEMICAL PROCESS FOR PRODUCTION OF ALCOHOL FUEL FROM PEAT

DYNATECH R/D COMPANY
99 Erie Street
Cambridge, Massachusetts 02139

Donald L. Wise

Date Started: June 1, 1981

Funding: FY '82 $227,000 for 12 months

Anticipated Duration: 2 years

Peat reserves in the United States represent a significant untapped energy source (1400 quads). This program is directed toward development of a wet process for utilization of peat as the feedstock in liquid fuel production. The process requires solubilization and partial oxidation of the peat (processed at 8% solids) to produce dissolved aromatics which are suitable substrates for adapted anaerobic bacteria. Fermentation parameters are adjusted so that organic acids are the product which can be removed and concentrated by liquid-liquid extraction. The acid salts of the fermentation products can then be electrolytically oxidized to form mixed olefins. A mixed alcohol product, suitable for blending with gasoline can be produced by hydration of the olefins.

13. INVESTIGATION OF THE EXTRACTION OF HYDROCARBONS FROM SHALE ORE USING SUPERCRITICAL CARBON DIOXIDE

ENERGY & ENVIRONMENTAL ENGINEERING, INC.
675 Massachusetts Avenue
Cambridge, Massachusetts 02139

James H. Porter

Date Started: July 15, 1982

Funding: FY '82 $110,000 for 12 months

Anticipated Duration: 1 year

This project is an experimental investigation of a method to extract the hydrocarbons contained in shale ore using supercritical carbon dioxide. Carbon dioxide has demonstrated solvent properties for organic materials at temperatures and pressures near its critical point: 31°C and 72.8 atmospheres. At these conditions, small changes in pressure have large effects on the density and thus the solvent power of CO_2. The cycle of extraction and precipitation of liquid hydrocarbons from shale ore, achieved by pressurizing and expanding supercritical CO_2, could provide an alternative to shale oil thermal retorting. The conditions (temperature, pressure, time, shale particle size, solvent composition) under which supercritical CO_2 best extracts hydrocarbons from shale ore will be examined.

14. ULTRASONIC COALESCENCE FOR SCRUBBING OF FLUE GAS POLLUTANTS

ENERGY & MINERALS RESEARCH COMPANY
964 E. Swedesford Road
Exton, Pennsylvania 19341

Scott R. Taylor

Date Started: September 1, 1981

Funding: FY '81 $111,000 for 12 months

Anticipated Duration: 1 year

Sub-micron particulates may be effectively trapped by using standing waves to differentially move larger aerosol droplets and pollutant particulates, so that the aerosol serves as a collecting surface. In the flue-gas application, this technology can simultaneously be used to collect gaseous pollutants such as SO_x and NO_x using reactive collector aerosols. A reactive aerosol of sodium hydroxide has been produced and demonstrated to be at least twice as reactive in the presence of standing waves than without. Particulate coalescence in conjunction with reactive aerosol scrubbing has also been demonstrated. Evaluation of ultrasonic coalescence of typical gaseous and particulate flue-gas pollutants, at the ranges of temperature and gas stream flow rates encountered in an operating utility or industrial boiler flue, is underway.

15. RESEARCH AND DEVELOPMENT PROGRAM ON A SODIUM HEAT ENGINE

FORD MOTOR COMPANY
Room 2016, P.O. Box 2053
Dearborn, Michigan 48121

Thomas Hunt and Neil Weber
Advanced Components and Energy Systems

Date Started: January 2, 1979

Funding: FY '82 $49,000 for 4 months

Anticipated Duration: 3 2/3 years

The sodium heat engine (SHE) is a new device for direct thermal to electrical energy conversion. It uses the ionically conducting ceramic β"-alumina, to form a high temperature concentration cell for elemental sodium. The vapor pressure (activity) gradient across the cell is maintained by a high temperature heat source on one side of a beta-alumina membrane and a low temperature condenser on the other side. The high temperature region operates in the range of 600-1000°C with the low temperature region at 100-200°C. Theoretical analysis of the SHE shows that under quasi-reversible conditions the efficiency should be more than 90% of Carnot efficiency. Specific output powers in the range of 0.5-1.0 W/cm^2 have been achieved. The SHE has achieved an efficiency of 19% and is projected to reach overall thermal efficiencies of 20-40%. The goal of this project is a quantitive understanding of the SHE electrodes and the electrical and mass transport at the electrode-beta-alumina interface.

16. PHOTOCHEMICAL URANIUM ENRICHMENT IN SOLIDS

GENERAL ATOMIC COMPANY
P.O. Box 81608
San Diego, California 92138

Earl S. Ensberg

Date Started: July 1, 1981

Funding: FY '82 $275,000 for 12 months

Anticipated Duration: 2 years

Experiments at General Atomic Company have established the existence of resolvable isotopic shifts in the visible absorption bands of photochemically active uranium salts at 10 K, established the conditions for achieving two-photon photoreaction at that temperature, and obtained limited but consistent isotope separation. Although the presently achieved separation is impractically small, this static, high-concentration approach offers many technical advantages as a method of uranium enrichment. The present program is directed to the scientific assessment of the potential process. Measurements of excitation transfer between isotopes as a function of time indicate that the rate of resonant transfer in the first electronically excited state is high enough to explain the loss of selectivity. Solid solutions in which the uranyl separation distance is continuously increased have been developed in which this transfer may be controlled. The absorption spectrum in these materials will be determined. The quantum yield and energy utilization for the process will be measured and the investigations extended to alternative uranium salts and materials.

17. RESEARCH AND DEVELOPMENT OF A MASS ACCELERATOR (MAID) AS A DRIVER FOR IMPACT FUSION

GT-DEVICES
5705A General Washington Drive
Alexandria, Virginia 22312

Derek Tidman and Shyke Goldstein

Date Started: May 6, 1981

Funding: FY '82 $285,000 for 12 months

Anticipated Duration: 3 years

The objective of this program is to construct a small scale mass accelerator consisting of 10 plasma discharge modules, and perform experiments and analysis with the system so that reliable scaling laws can be obtained for the device. The effort is directed to determining whether a large scale version of such a plasma driven mass accelerator could be used as a driver for inertial fusion, or other energy-related applications. The basic concept is to accelerate a projectile via a series of momentum kicks provided by directing high pressure plasma jets onto the rear projectile surface. A 100 kilojoule 10 module accelerator has been constructed and a number of experiments are underway.

18. DEVELOPMENT OF MATERIALS FOR LUMINESCENT SOLAR COLLECTORS

GTE LABORATORIES, INC.
40 Sylvan Road
Waltham, Massachusetts 02254

Alexander Lempicki
Electro-Optics Laboratory

Date Started: September 1, 1978

Funding: FY '82 $243,000 for 12 months

Anticipated Duration: 4 years

A luminescent solar collector consists of a panel absorbing light, ideally, across the solar spectrum. The light is then re-emitted, within the panel at wavelengths optimal for photo-conversion. It propagates by internal reflections towards the edges of the panel, where it is coupled to a photovoltaic converter. The aim of this project has been to develop materials for luminescent collectors by exploiting properties of metal ions in inorganic glasses. The ion exhibiting best spectroscopic properties is Cr^{3+}. In crystalline hosts the efficiency of luminescence is very high, but in a glass matrix it is too low. The solution to this problem is the development of glass ceramics or suspensions of submicron crystallites containing Cr^{3+} in glass. The development of transparent, high luminescent yield ceramics, appears to offer the best approach to the solution of the material problem for the collector. Substantial progress is being made along this line.

19. MEASUREMENT OF THE EFFICIENCY OF MUON-CATALYZED FUSION

IDAHO NATIONAL ENGINEERING LABORATORY
EG&G Idaho, Inc., P.O. Box 1625
Idaho Falls, Idaho 83415

Steven E. Jones
Scientific Information Division

Date Started: March 8, 1982

Funding: FY '82 $132,000 for 7 months

Anticipated Duration: 17 months

The purpose of this research is to measure the efficiency of the muon-catalyzed fusion reaction $\mu^- + d + t \rightarrow \mu^- + {}^4He + n + 17.6$ MeV. That is, the average number of fusion reaction cycles induced by a muon (μ^-) during its lifetime will be determined, as a function of deuterium (d)-tritium (t) mixture density, temperature, and tritium concentration. The probability of muon retention by the synthesized helium ion (^4He) will also be measured, along with other quantities affecting the efficiency of muon catalysis. The experimental technique involves measurement of the yields and time distributions of fast neutrons (n). The experiment will be performed at the Biomedical Channel of the Los Alamos Meson Physics Facility. This research will provide answers to recurring questions regarding the usefulness of muon-catalyzed fusion as a practical energy source.

20.*AN H-ATOM INITIATED RAPID COAL GASIFICATION STUDY

IIT RESEARCH INSTITUTE
10 West 35th Street
Chicago, Illinois 60616

Alan Snelson
Chemistry Research Section

Date Started: May 12, 1980

Funding: FY '80 $84,000 for 12 months

Duration: 1 1/2 years+

The purpose of this study is to investigate a scheme for coal gasification using iodine as a catalyst to generate a finite steady state concentration of H-atoms from molecular hydrogen to aid the reduction process at temperatures and pressures up to 700°C and 2000 psi, respectively. A flow reactor has been built and experiments run at contact times less than 1 minute. It has been shown that iodine does catalyze the coal reduction but not nearly to the degree expected.

+Includes unfunded extension
*Project completed

21.*LASER EXCITATION OF HIGH LYING ATOMIC AND MOLECULAR STATES BY ULTRAVIOLET MULTIQUANTUM PROCESSES

UNIVERSITY OF ILLINOIS
AT CHICAGO CIRCLE
Chicago, Illinois 60680

Charles K. Rhodes
Department of Physics

Date Started: January 1, 1979

Funding: FY '81 $70,000 for 6 months

Duration: 3 years

Recent experimental studies show that bright tunable radiation in the 10 nm to 100 nm spectral range can be generated with the use of high brightness rare gas halogen (RGH) laser systems. Fundamentally, this approach is predicated on the extraordinary advances made in the spectral brightness of RGH media in recent times. Since nonlinear coupling is common to all processes involving frequency up-conversion of RGH radation, a premium value is placed on the ability to produce pulsed outputs of maximal power and intensity. For this reason, current experimental efforts are concentrating on the generation of spectrally bright picosecond RGH systems. Presently, an instrument developing a power of 4 GW at 193 nm (ArF*) in 10 psec is being used in the examination of physical processes suitable for wavelength conversion to the XUV range. Both nonlinear scattering and direct amplification in inverted media can be used for conversion to short wavelengths. For the former, the maximum powers observed at the third harmonic (64 nm) and the fifth harmonic (39 nm) were ∿20 kW and 200 W, respectively. With respect to the latter, stimulated emission in H_2 at 128 nm, 134 nm, 140 nm, and 146 nm with a power of ∿10 MW has been observed.

*Project completed

22. FREE ELECTRON LASER AT THE ETA*

LAWRENCE BERKELEY LABORATORY
University of California
Berkeley, California

A.M. Sessler and D. Prosnitz

Date Started: February 8, 1982

Funding: FY '82 $300,000 for 8 months

Anticipated Duration: 20 months

The purpose of this experiment is to develop a tapered-wiggler Free Electron Laser (FEL) as an efficient microwave source between 35 and 140 GHz. One important application of this source is in electron cyclotron resonance heating of thermonuclear plasmas. The Lawrence Livermore National Laboratory's Experimental Test Accelerator will provide the high-current, high-voltage (1 kA, 4 MeV) low emittance electron beam used to drive the FEL amplifier. Experiments will be conducted at 2, 4 and 8 mm wavelengths, thus enabling exploration of both single particle and collective operating regimes. Microwave output power and spectrum will be measured as functions of input electron beam parameters (energy, emittance) and microwave input conditions (power, frequency) in an attempt to clarify the physics of a high-gain, tapered-wiggler FEL amplifier.

*Experimental Test Accelerator at Lawrence Livermore National Laboratory

23. AN APPROACH TO RECOVER STRATEGIC METALS FROM BRINE

LAWRENCE LIVERMORE NATIONAL LABORATORY
P. O. Box 808
Livermore, California 94550

Ellen Raber
Earth Sciences Department

Date Started: February 1, 1982

Funding: FY '82 $60,000 for 8 months

Anticipated Duration: 8 months

The objective of this project is to evaluate natural brines obtained from salt domes and geothermal sources as possible resources for some strategic metals. This research was suggested because several previous analyses of brine from geothermal wells in the Imperial Valley, California and from Gulf Coast salt domes indicate the possibility of near-commercial values for platinum concentrations as well as for other metals (particularly gold and silver). Project efforts have been directed towards determining whether the concentrations of these metals are indeed sufficiently high to warrant further effort in a development of extraction methods. Subsamples of collected brines will be processed in various ways so that concentrations of the elements of interest can be determined.

24.*DETECTION AND ENRICHMENT OF FRACTIONALLY CHARGED PARTICLES IN MATTER

LAWRENCE LIVERMORE NATIONAL LABORATORY
P. O. Box 808, L-482
Livermore, California 94550

Charles D. Hendricks
Y Division

Date Started: May 1, 1982

Funding: FY '82 $100,000 for 5 months

Anticipated Duration: 3 1/2 years

The detection, separation and enrichment of fractionally charged particles in matter is a combined experimental and theoretical project. A stream of uniform liquid drops will be generated in a vacuum and passed vertically downward through a transverse constant electric field. The individual drops will be deflected a distance depending on the charge on the drops. Drop arrival position at the bottom of the deflecting field is therefore a measure of the drop charge. It is expected that the charge on a drop can be measured by this technique to a resolution less than 0.02e. A wide variety of materials will be assayed for fractional charges and the relative abundance of fractional charges in the various materials will be determined. Drops with different charges will be geometrically separated at the ends of their trajectories and any drops containing fractional charges will be collected and isolated to be recirculated through the system.

*Projects 24 and 25 are cooperative interlaboratory projects

25.*DETECTION AND ENRICHMENT OF FRACTIONALLY CHARGED PARTICLES IN MATTER

LOS ALAMOS NATIONAL LABORATORY
P.O. Box 1663
Los Alamos, New Mexico 87545

George Zweig
Theoretical Division

Date Started: May 1, 1982

Funding: FY '82 $50,000 for 5 months

Anticipated Duration: 3 1/2 years

The basic unit of electric charge is one third that of the electron. It is therefore natural to ask if isolated particles of fractional charges $\pm$ 1/3e, $\pm$ 2/3e, $\pm$ 4/3e,...exist freely as elements of the earth. William Fairbank's group at Stanford University has unequivocally concluded that they do. Negative fractionally charged particles are interesting because they could replace electrons in atoms, molecules and solids, leading to super-dense states of matter. Under certain circumstances they would even catalyze fusion reactions. This project is a combined theoretical and experimental effort to search for fractionally charged particles in a wide variety of materials, to determine which materials are most abundant in fractionally charged particles, and to enrich the fractional charge content of sample materials. The crystal chemistry of fractionally charged particles will be theoretically developed and those materials most likely to contain enhanced concentrations of fractionally charged atoms will be identified. These materials will then be obtained, analyzed and used as samples for the experimental studies.

*Projects 24 and 25 are cooperative interlaboratory projects

26. MAGNETIC REFRIGERATION FOR EFFICIENT CRYOGEN LIQUEFACTION

LOS ALAMOS NATIONAL LABORATORY
P. O. Box 1663, MS M764
Los Alamos, New Mexico 87545

John A. Barclay
Group P-10

Date Started: February 1, 1982

Funding: FY '82 $200,000 for 8 months

Anticipated Duration: 3 1/2 years

The objective of this work is to initiate conceptual designs, test models of those designs, and develop a data base for compact, reliable, high-Carnot-efficiency magnetic refrigeration, with special emphasis on applying this technology to liquefaction of cryogens. Experiments are conducted to determine the magneto-caloric effect and the thermal conductivity of suitable solid magnetic working materials as well as the heat and fluid flow through porous beds of these materials, over the temperature range 1 to 300 K and at magnetic fields up to 9 T. Additional efforts are directed toward: determination of parasitic heat losses; optimization of magnetic field configuration; design of heat exchangers, cryogenic pumps, fluid entrainment suppressors; and development of new concepts (other than the wheel and reciprocating devices) for moving magnetic material into and out of the magnetic field.

27. COGENERATION OF ELECTRIC ENERGY AND USEFUL CHEMICALS IN A FUEL CELL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Costas G. Vayenas and J. Wei
Department of Chemical Engineering

Date Started: September 1, 1980

Funding: FY '82 $100,000 for 12 months

Anticipated Duration: 3 years

The conversion of the heat released by exothermic chemical reactions into electrical energy is becoming increasingly important in chemicals manufacture. Unfortunately, the conversion efficiency of traditional thermal cogeneration systems is thermodynamically limited and practical efficiencies may be quite small. Electrochemical cogeneration, in which a useful chemical product and electricity are produced simultaneously in a fuel cell, is not subject to this limitation. The present project investigates the concurrent electrochemical production of electricity with the oxidative dehydrogenation of ethylbenzene to styrene and butane to butadiene in zirconia fuel cells with appropriate catalytic electrodes.

28. ZONE-MELTING RECRYSTALLIZATION FOR SOLAR CELLS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Henry I. Smith
Electrical Engineering & Computer Science

Date Started: September 1, 1982

Funding: FY '82 $200,000 for 24 months

Anticipated Duration: 2 years

The objective of this project is to develop a process for producing oriented silicon films, 10 to 100 μm thick, suitable for low-cost solar cells. A new technique, zone-melting-recrystallization, has been developed which produces high-quality crystalline Si films having mobilities close to bulk values. A molten zone is scanned through a film confined between a substrate and an encapsulation layer. Films of a single crystallographic orientation are produced by passing the molten zone through a lithographically defined planar constriction. Lithographically defined patterns are also used to confine grain boundaries, dislocations and impurities to a set of narrow, parallel rejection channels spaced $\gtrsim$50 μm apart. The zone-melting-recrystallization technique holds the promise of accomplishing grain boundary placement, zone refining, and recrystallization in a single low-cost process.

29. DEVELOPMENT OF DIRECT-CONTACT, HIGH EFFECTIVENESS DROPLET HEAT EXCHANGERS

MATHEMATICAL SCIENCES NORTHWEST, INC.
2755 Northup Way
Bellevue, Washington 98004

William J. Thayer III
Flow Technology Group

Date Started: July 1, 1981

Funding: FY '82 $278,000 for 12 months

Anticipated Duration: 3 years

A reliable technique for transferring heat between gas and liquid streams in the 1500-2000 K temperature range could greatly improve the efficiency of current power generation systems. Heat transfer between media in direct contact may eliminate many limitations of conventional heat exchangers which require intervening solid walls. The objective of this program is to characterize and evaluate techniques for providing high effectiveness heat transfer between high temperature droplets and counterflowing gas streams. A computer code has been developed for evaluating two-dimensional flow aspects of droplet and gas injection, column flow, and collection, convective and radiative heat transfer, and wall losses for direct-contact heat exchanger configurations. Tests have been conducted to characterize and evaluate processes which control the formation of uniform droplets of very viscous fluids which simulate molten refractories. Analysis and experiments are continuing to evaluate heat transfer and flow processes, materials issues, design constraints, and the economic impact of the direct-contact heat exchanger for several high temperature applications.

30. EXPERIMENTAL RESEARCH IN HIGH TEMPERATURE SOLAR THERMOCHEMICAL PROCESSING. HYDROGEN AND SULFUR FROM HYDROGEN SULFIDE

UNIVERSITY OF MINNESOTA
111 Church Street, S.E.
Minneapolis, Minnesota 55455

Edward A. Fletcher
Department of Mechanical Engineering

Date Started: July 16, 1982

Funding: FY '82 $229,000 for 24 months

Anticipated Duration: 2 years

Highly concentrated sunlight is uniquely suited for supplying process heat at very high temperatures. The efficiency with which process heat is used to effect endothermic processes increases as the temperature at which the heat is added increases. This project makes use of a highly-concentrating solar furnace to study the production of hydrogen and sulfur from hydrogen sulfide in a high-temperature effusional process. Inner structural and membrane materials for the construction of a reactor-separator are being studied, and a reactor-separator is being fabricated. Experiments to test the efficacy of the process are to be conducted, and the results will be used to evaluate cost benefits which may be achievable by the use of processes such as these vis-a-vis conventional methods of dealing with hydrogen sulfide.

31. HOLOGRAPHIC TECHNOLOGY FOR SOLAR ENERGY CONCENTRATION

NATIONAL TECHNICAL SYTEMS
12511 Beatrice Street
Los Angeles, California 90066

Hla N. Tin
Research Division

Date Started: June 1, 1981

Funding: FY '82 $219,000 for 12 months

Anticipated Duration: 3 years

Research in this project is aimed at establishing the practical feasibility of using holographic technology (diffractive optics) for solar energy concentration. Very high reflection concentrators were fabricated in the first phase of the program and extinction ratios of over 90% were achieved for on-axis holograms for the visible range. The objective during the second year is to build a prototype photovoltaic solar energy conversion device using a holographic solar concentrator. Holographic solar concentrators with high concentration ratios will be fabricated with dichromated gelatin films. Measurements will be made on this system for system efficiency. Theoretical analysis is being conducted for nontracking type holoconcentrators and they will be fabricated in the third phase of this program.

32.*GENERATION OF AN EXTENDED ION SOURCE FOR SHORT-WAVELENGTH LASERS

NAVAL RESEARCH LABORATORY
Washington, D.C. 20375

Raymond Elton
Optical Sciences Division

Date Started: July 27, 1978

Funding: Fy '81 $225,000 for 15 months

Duration: 3 3/4 years

In experiments concluded at the Naval Research Laboratory under this contract, the plasma channeling and cumulation effects discovered earlier for forming a linear laser plasma medium have been analyzed experimentally and theoretically. There is direct evidence that the highly stripped ions survive at high densities following forced collection, and some heating may be gained from decreased kinetic energy as a bonus. Gain at 520 A has also been measured under this contract using high-lying near-uv lines as absolute references in a branching-ratio calibration technique involving only a single ion species. Threshold gains for cavity operation have been achieved as a milestone, and increased density for even higher gains has been demonstrated with increased pumping. Straight-forward physical modeling gives excellent agreement with experimental results and predicts threshold gains for non-cavity amplified spontaneous emission at somewhat reduced temperatures, that is, enhanced cooling outside of the channeled region.

*Project completed

33. MODIFICATION OF THE SURFACE TEMPERATURE BY AN ARTICIFIAL CIRRUS CLOUD

STATE UNIVERSITY OF NEW YORK
Albany New York 12222

Bernard Vonnegut and Petr Chylek
Atmospheric Sciences Research Center

Date Started: September 1, 1980

Funding: FY '80 $244,000 for 36 months

Anticipated Duration: 3 years

The objective of this project is to explore the practicality of using artificially formed cirrus clouds to achieve significant energy savings in densely populated areas. Meteorological data for about 10 years in the Albany area have been analysed to determine how often the situation favorable for formation of an artificial cirrus cloud occurs. Preliminary results indicate that a suitable situation in the middle and upper troposphere occurs about 10 times per cold season. The combined effect of clearing clouds during the daytime and making cirrus clouds during nighttime gives a benefit-to-cost ratio of about 4/1 for the Albany area. For large metropolitan areas the benefit-to-cost ratio may be up to 40/1. Experimental work carried out at the University of Alaska's site at Fairbanks was concerned with observing the details of how light is scattered by clouds of water droplets and ice crystals. Analysis has also been carried out on about 10 years of data showing the effect of cirrus clouds over Mauna Loa on hourly average diffuse and direct solar radiation. This analysis can be used to suggest what effects artificial cirrus clouds would have on solar radiation reaching the surface. A radiative-convective climate model has been used to estimate the effect of increased cloudiness on the surface temperature, and radiative properties of ice clouds have been studied.

34. *A NOVEL APPROACH TO THE EXPLOITATION OF TIDAL ENERGY

NORTHEASTERN UNIVERSITY
Boston, Massachusetts 02115

Alexander M. Gorlov
Department of Mechanical Engineering

Date Started: July 1, 1979

Funding: FY '79 $131,000 for 2 1/2 years

Duration: 2 1/2 years

The objective of this project has been to develop theoretically, and analyse, a new approach to harnessing tidal energy. This approach is based on replacement of conventional rigid dams with light, flexible plastic barriers, and on converting tidal energy into the energy of compressed air. Results obtained indicate that the concept should be technically feasible on a practical basis in some applications.

*Project completed

35. ENERGY SYSTEMS BASED ON POLYACETYLENE: RECHARGEABLE STORAGE BATTERIES AND SCHOTTKY BARRIER SOLAR CELLS

UNIVERSITY OF PENNSYLVANIA
3451 Walnut Street
Philadelphia, Pennsylvania 19104

A. J. Heeger and A. G. MacDiarmid
Departments of Physics and Chemistry

Date Started: March 1, 1981

Funding: FY '82 $101,000

Anticipated Duration: 3 years

The objective of this project is to investigate the chemical, electrochemical, electrical and optical properties of the novel conducting polymer $(CH)_x$, polyacetylene, with a view toward applications in two areas: rechargeable storage batteries made with $(CH)_x$ electrodes, and Schottky barrier solar cells made with $(CH)_x$. Work during FY 1982 focussed on the rapid progress in the area of $(CH)_x$ batteries. The relationship of cell potential to degree of oxidation, coulombic and energy efficiencies, constant current discharge characteristics, energy density and maximum power density of a partly oxidized polyacetylene, $[CH(ClO_4)_y]$, $(y \leq 0.07)$ cathode in a cell of the type $[CH(ClO_4)_y]_x/LiClO_4/Li$ were determined. Coulombic efficiencies ranging from 100% to 86% and energy efficiencies ranging from 81% to 68% during a charge-discharge cycle are found at oxidation levels ranging from 1.54% to 6.0%. Energy densities of 255 watt-hr/kg (based on the weights of the electroactive materials involved in the discharge process) are obtained for 7.0% oxidized polyacetylene cathodes under constant current discharge conditions. Maximum power densities of $\sim$30 kW/kg are observed. Fundamental studies of the $(CH)_x$ electrode were carried out using electrochemical voltage spectroscopy. The results were used to determine the energy gap of trans-$(CH)_x$. The results, furthermore, indicate hysteresis in the cell voltage vs. charge, which is interpreted as arising from charge injection via polarons and charge removal via solitons.

36. IMPLODING PLASMA
X-RAY LASER

PHYSICS INTERNATIONAL
2700 Merced Street
San Leandro, California 95477

Raymond Dukart

Date Started: September 1, 1981

Funding: FY '81 $246,000 for 12 months

Anticipated Duration: 2 1/2 years

A collisionally pumped VUV neon-like laser scheme is being extended into the soft x-ray region for krypton (83 eV) and, in the future, molybdenum (128 eV) using an imploding plasma source ($\sim$4 cm x 0.5 mm). The implosion is driven by the DNA 5 TW Defense Nuclear Agency PITHON electrical pulse generator. The spatial and temporal characteristics of a z-pinch krypton plasma have been studied extensively during the past year providing data on plasma uniformity, density ($\sim 10^{21}$ electrons/cm^3), and temperature (T_e $\sim$1000 eV). According to theories developed at Lawrence Livermore National Laboratory, these plasma conditions are nearly optimal for lasing in six candidate lines. Three one-meter, grazing incidence spectrometers recorded radially, axially, and z-resolved spectra in the 30 to 1000 eV region. Concave curved crystal spectrometers recorded spectra in the 1 to 10 keV region. Analysis of krypton plasmas obtained this year will provide input into the LLNL theory for computing the gain for the observed plasmas. Significant advances were made in improving the spatial and temporal characteristics of the plasma during this last year. In collaboration with scientists at LLNL a time-resolved x-ray framing camera showed up to 2.4 cm of plasma radiating during 2 ns.

37.*DEMONSTRATION OF SCIENTIFIC
AND ECONOMIC FEASIBILITY OF
A SOLID-STATE HEAT ENGINE

POWER CONVERSION TECHNOLOGY, INC.
11588 Sorrento Valley Road
San Diego, California 92121

Randall Olsen

Date Started: November 7, 1977

Funding: FY '81 $400,000 for 15 1/2 months

Anticipated Duration: 4 1/2 years+

The use of the pyroelectric effect as a means for direct conversion of heat to electrical energy has been studied in this project. The active material employed in the conversion experiments was a ferroelectric ceramic, PZST, lead zirconate modified with Sn^{4+} and Ti^{4+}, $Pb_{.99}Nb_{.02}(Zr_{.68}Sn_{.25}Ti_{.07})_{.98}O_3$. Following a series of pilot experiments with very low-power single-stage devices, a multi-stage model with regenerative heat flow was assembled which yielded an output power of 1.6 watts (33 W/liter of active PZST) and a measured efficiency of 0.5% (about one-tenth Carnot limit). Near the end of the contract period, a new polymeric pyroelectric material became available. This material, a copolymer of vinylidene fluoride-trifluoroethylene, has a potential cycle energy density 10 to 35 times greater than the PZST ceramic. Extrapolating the PZST results to this more favorable material, economics for pyroelectric conversion with the copolymer would appear to be very attractive for converting low grade heat (sources at 200^{o}C and less) to electricity. Capital costs for systems $>5kW_e$ can then be estimated at less than a dollar per watt.

*Project completed
+Includes unfunded extension

38. SOFT X-RAY LASING ACTION IN A CONFINED PLASMA COLUMN

PRINCETON UNIVERSITY
Princeton, New Jersey 08544

Szymon Suckewer
Plasma Physics Laboratory

Date Started: September 13, 1979

Funding: FY '82 $316,000

Anticipated Duration: 4 years

The objective of this project is an experimental investigation of lasing action in the soft x-ray spectrum region at wavelengths 182A, 135A and 520A corresponding to the 3→2, 4→2, and 4→3 transitions in the CVI ion. The basic idea is to use a multi-Z (e.g., carbon, oxygen) thin plasma column confined by a strong longitudinal magnetic field (100kG), first heated by a CO_2 laser and then cooled rapidly by radiation losses. Calculations indicate a total gain in excess of 100 for the 3→2 transition, in excess of 10 for the 4→2 transition, and in excess of 300 for the 4→3 transition for a 10 cm long plasma column heated by a 10-20GW CO_2 laser beam. Experiments showed good plasma confinement in magnetic fields 50-100kG and highly effective radiation cooling of such a plasma, especially with additional small amounts of higher-Z elements such as Ar or Xe. Measurements of gain for CVI 4→3 (520A) and 3→2 (182A) transitions indicate the possibility of obtaining a high gain in the near future for 4→3 transition, and also for the 3→2 transitions with improved CO_2 laser optics.

39. DEPOSITION OF HIGH QUALITY $CuInSe_2$ BY SPRAY PYROLYSIS

RADIATION MONITORING DEVICES, INC.
44 Hunt Street
Watertown, Massachusetts 02172

Gerald Entine

Date Started:

Funding: FY '82 $117,000 for 12 months

Anticipated Duration: 2 years

The ultimate success of any terrestrial photovoltaic energy conversion approach requires that the following factors be satisfied: 1) high individual solar cell conversion efficiency, 2) low cost per unit area to produce the cells, 3) adequate availability of the constituent materials to produce the cells, 4) long term stability. This project is a proof-of-concept effort to show that spray pyrolyzed $CuInSe_2$ can meet all of the requirements. $CuInSe_2$ is a promising solar cell material and spray pyrolysis is a technique well-suited for use in a manufacturing process. Preliminary results have shown that $CuInSe_2$ can in fact be prepared using the modified spray process developed by the contractor.

40. NEW MATERIALS FOR ORGANIC PHOTOVOLTAIC CELLS

RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY
New Brunswick, New Jersey 08903

George Bird
Department of Chemistry

Date Started: July 1, 1979

Funding: FY '79 $223,000 for 3 years

Anticipated Duration: 3 1/4 years+

Experimental photovoltaic cells with organic absorber layers have already given quantum efficiencies of 30% and total solar energy conversion on the order of 1%. Low exciton mobility and limited radiation stability have prevented improvements in performance.. Under this project, new high stability chromophores are being prepared and studied in terms of structure, solid-state packing, electrochemistry and exciton mobility. Promising materials are being fabricated into Al/Al_2O_3/dye/Ag cells for direct measurements.

+Includes unfunded extension

41. IONIZATION FRONT ACCELERATOR

SANDIA NATIONAL LABORATORIES
Albuquerque, New Mexico 87185

Craig L. Olson
Plasma Theory Division - 4241

Date Started: June 1, 1981

Funding: FY '82 $282,000 for 12 months

Anticipated Duration: 3 years

The Ionization Front Accelerator (IFA) uses laser photoionization of a special working gas to control the motion of the potential well at the head of an intense relativistic electron beam (IREB) for the purpose of accelerating ions to high energies. A second generation system (IFA-2) is being constructed to thoroughly test and characterize the IFA concept; this system is designed to produce accelerating fields of 100 MV/m over 1 meter. The IFA-2 IREB machine and IFA-2 laser system are now operational. The IFA offers the potential for a compact, high-gradient, high-power collective ion accelerator with several possible DOE applications.

42. RELIABLE, LOW-COST, LOW POWER CRYOCOOLER TO REACH 4.0 KELVIN

S.H.E. CORPORATION
4174 Sorrento Valley Blvd.
San Diego, California 92121

Ronald E. Sager

Date Started: September 30, 1980

Funding: FY '82 $121,000

Anticipated Duration: 2 1/2 years

The goal of this project is to develop a cryocooler suitable for operating superconducting instrumentation below 5 Kelvin without the requirement for liquid helium cooling. Potential applications include geophysical prospecting using magnetotelluric measurements, magnetic borehole mapping, and interborehole electromagnetic propagation measurements. In the past year the physics of nonmagnetic cryocoolers was investigated, starting from room temperature, and a cooler is now operating at 7 Kelvin. Experiments are underway on innovations which should substantially improve the low temperature performance of the cryocooler and permit mounting a superconducting magnetic sensor on the cryocooler for demonstration purposes. Work has also started on the design of an experimental model cooler which is expected to evolve eventually into a very reliable instrument capable of operating continuously for years without maintenance or failure.

43. APPLICATION OF ARC PLASMA SPRAYING (APS) FOR SOLAR TECHNOLOGY

SOLAMAT, INC
885 Waterman Avenue
East Providence, Rhode Island 02914

Joseph J. Loferski and Barton Roessler

Date Started: September 18, 1978

Funding: FY '81 $175,000 for 12 months

Anticipated Duration: 3 1/4 years+

Arc plasma spraying (APS) is a surface coating technology in which powder of a material is injected into a high temperature, high velocity gas plasma stream and is propelled in a molten or partially molten state against a substrate to form a coating. The purpose of the project has been to explore the application of APS to fabrication of photovoltaic solar cells and selective absorber surfaces for solar thermal collectors. The feasibility of fabricating ohmic contacts to single crystal silicon cells by arc plasma spraying was demonstrated. In these experiments, Ni-P alloy powders were used to produce ohmic contacts to the n-type region and Ni-B-Si alloy powders to the p-type region. Polycrystalline silicon layers intended for use as the photovoltaically active semiconductor in solar cells were deposited by APS on graphite substrates and photovoltaic action was observed in devices made from these silicon layers. Polycrystalline silicon layers deposited by APS on metal substrates were shown to act as selective absorbers which can be utilized in solar thermal collectors.

*Project completed
+Includes unfunded extension

44. PLANAR FLOW CASTING OF SHEET SILICON FOR PHOTOVOLTAIC CELLS

SOLAMAT, INC.
885 Waterman Avenue
East Providence, Rhode Island 02914

Mandayam C. Narasimhan

Date Started: August 1, 1982

Funding: FY '82 $295,000 for 12 months

Anticipated Duration: 2 years

The object of this research program is to develop and demonstrate a process to cast silicon sheets directly from the melt employing planar flow casting methodology. The silicon sheet is solidified on a rapidly moving chill substrate and the melt flow is controlled by the viscous shear forces in the melt at the nozzle and by the applied pressurization. The process will be developed in inert atmosphere and the behavior of silicon melt-substrate interaction will be studied under different processing conditions. The suitability of silicon sheets produced in this way will be evaluated for photovoltaic applications.

45. THERMOELECTRIC ENERGY CONVERSION FOR SOLAR AND OTHER APPLICATIONS

SOLAR ENERGY RESEARCH INSTITUTE
1617 Cole Boulevard
Golden, Colorado 80401

David Benson

Date Started: June 1, 1979

Funding: FY '82 $128,000 for 12 months

Anticipated Duration: 3 1/3 years+

The objective of this project is to examine the option of using either traditional or new thermoelectric materials to produce economical electric power from low grade, thermal resources. Detailed parametric analyses have been used to identify promising thermoelectric generator design options, primarily for Ocean Thermal Energy Conversion. Research is currently directed at the development of proof-of-concept generators based on sputter deposited thin film semiconductors of Bi_2Te_3-Sb_2Te_3-Sb_2Se_3.

+Includes unfunded extension

46.*LOW HEAT LOSS, LONG LIFETIME, LOW COST, HERMETICALLY SEALED THERMAL PANE WINDOW CONSTRUCTION

SPIRE CORPORATION
Patriots Park
Bedford, Massachusetts 01730

Wallace S. Kreisman

Date Started: April 15, 1981

Funding: FY '81 $46,000 for 6 months

Duration: 6 months

This project has investigated application of the technique of electrostatic bonding to fabrication of aluminum-glass thermal pane windows and doors. It was found possible to bond thin sheets of aluminum about 0.010 inches thick to ordinary window glass at a temperature of 300°C using a voltage of about 1000 volts. After current had been passed through the aluminum and the electrolytically conducting glass for three or four minutes, a strong, pressure tight seal formed between the two materials. Small model thermal pane windows have been fabricated by separating two panes of glass with a square aluminum frame and bonding the glass to the top and bottom of the frame. The leak tightness of the aluminum-glass seals was demonstrated by pressurizing the interior of the windows. If the sealed space of the window is filled with a dry, low thermal conductivity gas, the conductive/convective heat flow between panes will be reduced, and the lifetime of the window will be increased because water vapor will not permeate the aluminum frame as it does through plastic sealed windows.

*Project completed

47.*ELECTROLYTIC DEPOSITION OF LOW COST, HIGH PURITY POLYSILICON SUITABLE FOR USE IN SOLAR CELLS

STANFORD UNIVERSITY
Stanford, California 94305

Robert Feigelson
Center for Materials Research

Date Started: July 1, 1978

Funding: FY '80 $220,000 for 12 months

Anticipated Duration: 3 1/2 years+

The general aim of this investigation was to evaluate the suitability of electrolytic deposition for the production of low-cost polycrystalline silicon for solar cells. Two processes were developed. In the first, silicon of up to 99.999% purity was deposited at ~745°C from a K_2SiF_6/KF/LiF melt as a thin film on a graphite substrate. The grain size and electrical properties of such films are close to values required for solar cell applications. In the second process, silicon of 99.8% purity was deposited at 1460°C, above the melting point of silicon, from a $BaO/BaF_2/SiO_2$ melt. The advantage of depositing above the melting point is that very high deposition rates can be achieved. The material produced in this latter process will probably have to be purified by recrystallization. Both processes appear promising for solar cell application, but further study and development would be necessary.

*Project completed
+Includes unfunded extension

48. MULTIFUNCTION WALL SYSTEM FOR APPLICATION WITH SOLAR HEATING AND GROUND COOLING

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Blacksburg, Virginia 24061

James F. Riley and Gary E. Day
College of Architecture and Urban Studies

Date Started: September 1, 1981

Funding: FY '81 $105,000 for 17 1/2 months

Anticipated Duration: 17 1/2 months

The purpose of this project is to establish the scientific feasibility of the concept of a multifunction wall system (for application with solar heating and ground cooling) as applied to contemporary design and construction methods. The concept of the system is to expand the use of structure and enclosure elements of a building to function additionally as: the duct-work for the solar heated or earth cooled air, the heat transfer membrane between the heated or cooled air and the living environment of the building, the heat storage medium (in winter), and the temperature leveling and control medium. During FY '82 activity has focused on construction and instrumentation of a small scale prototype test building at Va. Tech. The data derived from the testing will be used to generate mathematical performance models relative to the heating and cooling functions.

49.*CUPROUS OXIDE PHOTOVOLTAIC CELLS FOR SOLAR ENERGY CONVERSION

WAYNE STATE UNIVERSITY
Detroit, Michigan 48202

Dan Trivich
Department of Chemistry

Date Started: February 1, 1981

Funding: FY '81 $157,000 for 15 months

Anticipated Duration: 1 1/4 years

Cuprous oxide can be used to make inexpensive photovoltaic cells for solar energy conversion but commercial feasibility depends on increasing the conversion efficiency from $\sim$1% to 4 - 6%. A new method using proton bombardment to produce copper on cuprous oxide cells gives improved voltage but with some loss in current. Low bombardment voltages give better results than high voltages; Auger surface analysis shows this is due to the formation of thinner copper films at the surface. The efficiency of the cells has reached 1.3%. Some initial work using atomic hydrogen to produce copper on cuprous oxide cells also can give thinner copper films but the films are not uniform. To improve this condition, the surface of the cells have been examined in detail by a laser scanner apparatus. Other work has included float zone refining of cuprous oxide, purification of copper by zone refining and electrorefining, and ion implantation into cuprous oxide.

*Project completed

50. A METHOD OF ACHIEVING SUPER-PRESSURES BY ADVANCED GASDYNAMIC TECHNIQUES

UNIVERSITY OF WASHINGTON
Seattle, Washington 98015

A. Hertzberg and A.P. Bruckner
Aerospace and Energetics Research Program

Date Started: September 27, 1982

Funding: FY '82 $175,000 for 12 months

Anticipated Duration: 3 years

A new gasdynamic concept for the generation of isentropic pressure pulses in the range of tens of kilobars to several megabars, with durations of the order of microseconds, will be investigated. The technique involves the generation of an isentropic wave system at relatively low pressures (i.e., less than 5-10 kbar) in a medium of low acoustic impedance (e.g., gaseous hydrogen) and the propagation of this wave system through media of increasing impedance, thereby generating very high pressures in the final, maximum impedance medium. The succession of media may include gases, liquids and solids. This method could be used to measure equation of state data along isentropes at very high pressures. The technique also has the potential for creating heretofore inaccessible states of matter which may have important industrial or energy applications, as well as for applications in controlled thermonuclear fusion.

51.*STRONG FOCUSING OF COHERENT, TERAHERTZ SOUND

WILLIAMS COLLEGE
Williamstown, Massachusetts 01267

Fielding Brown
Department of Physics

Date Started: June 1, 1978

Funding: FY '78 $77,000 for 3 years

Anticipated Duration: 3 1/2 years+

This project has investigated the possibility of generating terahertz sound waves at the surface of a spherically convex crystal of gallium arsenide in order to provide strong focusing of very high frequency acoustic energy. The study has included a theoretical investigation of phase and group velocities in GaAs, an attempt to detect phonons via a phonon-electric effect, an observation of strong long-lasting far infrared photoconductivity in epitaxial GaAs layers, and a measurement of an upper limit of phonon mean free paths at 4 K. It has been found that the relevant mean free path is too short in chromium-doped semi-insulating GaAs to permit the strong focusing originally envisaged.

+Includes unfunded extension
*Project completed

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

Fiscal Year 1982 Program Data

FY '82 Budget

Operating Funds.....$7,310,000

Capital Equipment Funds.....$ 320,000

Distribution of Projects by Institutional Sector*

Universities	39%
Small Business	27
Other Industry	8
DOE Laboratories	22
Federal Laboratories	2
All Other	2
	100%

*With an annual program turnover rate of about one third, as new projects are funded and older ones are completed, these percentages may vary from one year to the next.

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