Energy Materials Coordinating Committee (EMACC)

Fiscal Year 1978

Annual Technical Report

U.S. Department of Energy

DOE/US-0002

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CHAIRMAN'S REPORT

The Department of Energy Materials Coordinating Committee (EMACC) completed its first year of activity in FY 1978. A list of members is attached as Table I. The Committee initiated in ERDA in FY 1976 provides an exchange point for the coordination of interdepartmental materials projects. The Committee normally meets for two hours each month to discuss materials R&D and hear materials-related presentations by members and guest speakers. Overview presentations have been given by the following members (see Table II). Remaining divisions program overviews have been scheduled through December of 1978.

The following guest speakers gave presentations this year.

(1) Dr. Karl Stahlkop Electric Power Research Institute "Overview of EPRI Nondestructive Testing Programs"

(2) Dr. Frank La Que "Corrosion and Scaling in OTEC Systems"

(3) Dr. Ed Zebroski Electric Power Research Institute "Overview of EPRI Nuclear Materials Programs"

(4) Dr. Paul Pemsler, EIC Corporation "Improved Copper Hydrometallurgy"

A major project during the year was to conduct a survey of topical areas and prepare the report, Survey and Analysis of Selected Topics within the Department of Energy's Materials Research and Development Programs. Seven topics selected were those that had a high level of Divisional interest and supplement those reported in FY 1977 in DOE/ET-0006. The topics and the EMACC panel leaders in charge of compiling information were:

1. Joining of Materials, E.E. Hoffman and E. Dalder
2. Elastomers R. Nelson
3. Catalysts and Catalytic Effects R. Epple
4. Radiation Effects K. Zwilsky
5. Superconductivity W. Clinton
6. Cement and Concrete L. Kukacka BNL/R. Reeber
7. Alternate Materials R.R. Reeber

The report summarizes over 250 projects in these areas and completes the initial review started by James Swisher FY 1977 EMACC Chairman.

Although efforts were made to make the report as comprehensive as possible some inputs from Non-EMACC Divisions may be omitted. A small contract was awarded to Brookhaven National Laboratory for assistance in preparing the final draft of this study. Publication is scheduled for October of 1978.

The second major activity was to compile a set of program summaries as part of the annual report. Table III contains funding levels for materials projects reported to the committee. Many of the summaries include estimates of materials support as in some divisions such work is not easily separable from engineering development activities.

A one day retreat was held at the National Bureau of Standards for the purpose of reviewing the Committee's prior and present activities in the DOE. At this meeting the Terms of Reference for the Committee were reviewed as were methods for implementation of these within DOE. Membership on the Committee increased during the year from 17 to 23 members. Additional recommendations and activities have been summarized in the Chairman's report for the Secretary.

The FY 1979 Chairman, Louis C. Ianniello, was elected in July and will take office at the September 1978 meeting.

Robert R. Reeber
1978 Chairman
DOE Energy
Materials Coordinating
Committee

Table I. FY 1978 Membership of DOE Materials Coordinating Committee

Division	Representative
Electrical Energy Systems (EES)	A. David Allen
Biomedical and Environmental Research (BER)	Robert L. Butenhoff
Industrial Energy Conservation (INDUS)	J. Collins
Environmental Control Technology (ECT)	J. Counts
Fossil Energy	T. Cox
Procurement (P)	J. Releford
Power Systems	J. Fairbanks
Fossil Energy	H. E. Frankel
Solar/ET	M. Gutstein
Reactor Development and Demonstration (RDD)	Eugene E. Hoffman
DMA	(CDR) F. Hughes
Solid Fuel Mining	N. Jensen
Nuclear Research and Applications (NRA)	A. Litman
Solar/CS	M. Maybaum
Magnetohydrodynamics	A. W. Postlethwaite
Geothermal	Robert R. Reeber
Buildings and Community Systems (BCS)	K. Riegel
Laser Fusion (LF)	C. E. Rossi
Naval Reactors	R. H. Steele
Ast for Policy and Evaluation	J. Stekert (Ad Hoc)
Basic Energy Sciences (BES)	D. K. Stevens
Energy Storage System (STOR)	J. Swisher
Uranium Enrichment	L. Willett
Magnetic Fusion Energy (MFE)	K. M. Zwilsky

Table II

Speaker	Program Overview	Date
M. McNeil	Industrial Conservation	December 8, 1977
K. Horton	Reactor Elastomers and Seals Dev	March 2, 1978
E. Kinelski	Solar/Otec	April 6, 1978
L. Willett	UF_6 Centrifuge Separation Plan	April 6, 1978
R. Butenhoff	Biomedical and Environment	May 4, 1978
T. Cox	Fossil (University Affairs)	June 1, 1978
W. Bokker	Coal Gasification	July 6, 1978
Frank Hughes	Military Applications	July 6, 1978
E. Hoffman	Breeder Reactor Materials Technology	July 6, 1978

TABLE III - FUNDING LEVELS

Program	Operating Budget Authority (M$)
Materials Sciences	64.0
Advanced Systems and Materials Production	4.6
Reactor Research and Technology	39.0
Nuclear Power Development	10.4
Naval Reactors	35.0
Fusion Energy	9.3
Coal Conversion	6.5
Magnetohydrodynamics	3.5
Fuel Utilization	20.0
Electric Energy Systems	2.5
Energy Storage	5.9
Solar Technology	23.2
Geothermal Energy	4.5
Nuclear Waste Management	1.0
Military Application	78.6
Laser Fusion	5.0
Biomedical and Environmental Research	1.0
Environmental Control Technology	0.1
Industrial Energy Conservation	1.0
Solar Applications	6.0
	321.1

DIVISION OF MATERIALS SCIENCES

(Under the Director, Office of Energy Research)

The Materials Sciences Division supports basic research on materials properties and phenomena important to all energy systems. The aim is to provide the necessary base of materials knowledge required to advance the nation's energy programs. Emphasis is placed in areas where problems are known to exist or are anticipated, and where significant improvements in performance must depend on the selection of materials (and engineering design) based on improved understanding of the underlying mechanisms. The research includes a very broad spectrum of materials research from which: new solutions and new materials will emerge to apply to existing problems; insight will be provided to identify future materials trouble spots; and working models will be formulated to deal with unpredicted problems or phenomena when encountered.

The Materials Sciences Division is located in the Office of Basic Energy Sciences which reports to the Director of Energy Research. The program is divided into three main activities: Metallurgy and Ceramics, Solid State Physics and Materials Chemistry.

These reflect both the technical content and the primary discipline employed. Much of the research is conducted at the DOE multiprogram laboratories in close proximity to applied programs. In this manner, the transfer of new information and techniques into technology is facilitated; at the same time, the needs of the applied programs are brought to the attention of the basic research community. A contract research program exists to support unsolicited proposals (primarily from universities). The support of university-based research programs is desirable not only for the excellent work performed at universities, but also for the development of manpower highly trained in the critical area of materials science and its application to energy technologies.

For FY 1978, the funding level for the Materials Sciences Division amounted to 64.0 M$ in operating funds, budget authority: Metallurgy and Ceramics - 27.5 M$; Solid State Physics - 27.0 M$; Materials Chemistry - 9.5 M$.

The distribution of funds by contractor is the following:

Contractor	Funding Level Percentage of FY 1978
Ames Laboratory	9.4
Argonne National Laboratory	21.8
Brookhaven National Laboratory	10.9
Idaho National Engineering Laboratory	0.5
University of Illinois	3.0
Lawrence Berkeley Laboratory	7.5
Lawrence Livermore Laboratory	1.7
Los Alamos Scientific Laboratory	2.0
Mound Laboratory	0.4
Oak Ridge National Laboratory	22.6
Pacific Northwest Laboratory	2.5
Sandia Laboratory	2.0
Contract Research (Primarily Universities)	15.7
	100.0

Further information on the Materials Science programs is available in the report, Materials Sciences Programs, FY 1977, ERDA-77-123, or by contacting Dr. D. K. Stevens, 301/353-3428, Acting Division Director.

1. Metallurgy and Ceramics

FY 1978 Funding: $27.5 million

Contractors: Ames, Argonne, Brookhaven, University of Illinois, Rockwell International, U. S. Steel, LASL, LBL, LLL, Mound, ORNL, PNL, Sandia, Universities

Under the Metallurgy and Ceramics category, research is conducted to better understand the relationship between materials properties and structure. Understanding this relationship is the key to improving present materials and creating new materials to meet the demanding needs of future energy systems. Important properties of materials such as fracture, plastic flow, superconductivity, corrosion resistance, radiation resistance, and transport phenomena all depend on structure. As our understanding becomes more complete and our ability to create the beneficial structures increases, it will be possible to design materials to meet engineering requirements - a task not always possible at the present time. This research will ultimately enable designers to more accurately predict the behavior of materials and changes in material properties as a function of time, stress, and exposure to a variety of environments. Although basic in nature, the program is centered around research areas deemed to be of greatest interest for energy systems. For example, there is within the metallurgy and ceramics category a strong emphasis on hydrogen effects, radiation effects, high-temperature ceramics, refractory metals, and superconductivity, all important topics for energy systems.

There are five budget areas under the Metallurgy and Ceramics category: structure of materials, mechanical properties, physical properties, radiation effects, and engineering materials.

The structure of materials area supports research designed to enhance our understanding of the atomic, electronic, defect and physical structure of materials, how they are affected by composition and processing, and how they relate to material properties.

The budget area of mechanical properties is concerned with material behavior related to structural integrity requirements of all energy systems. Research in this detail addresses the understanding of strength at high and low temperatures, creep, fatigue, elastic constants, micro- and macrostrain, fracture, and mechanical-chemical effects in hostile environments.

Research under the physical properties area is directed toward understanding the fundamental phenomena controlling thermal, optical, mass transport, and electrical properties of materials, how they can be altered by various heat treatments or other processing steps, and how they are affected by external variables such as temperature and pressure.

The radiation effects area encompasses research delineating radiation-induced changes of materials properties important to fusion and fission reactors. Research problems are centered on materials, and their improvement depends on better theoretical and experimental understanding of defect production, interaction, diffusion, agglomeration, and annihilation at microstructural features, and the resulting structural stability and mechanical properties.

In the engineering materials area, research is aimed at understanding more fully the fundamental materials science on which engineering systems should be based. Some of the topics under study or planned include: erosion, friction and wear, mechanics, engineering design with materials sciences, joining and welding, nondestructive evaluation, extraction processes, and the forming and processing of materials. In general, this detail will provide the link to engineering systems by studying more complex materials systems and phenomena.

2. Solid-State Physics

FY 1978 Funding: $27.0 million

Contractors: Ames, Argonne, Brookhaven, University of Illinois, LASL, LBL, LLL, ORNL, PNL, Sandia, Universities

The solid-state physics category is directed toward fundamental research on matter in the condensed state, wherein the interactions of electrons, atoms, and defects are tracked with the purpose of determining the critical properties of solids. These interactions are the ultimate source of all materials properties. Research under this category includes a broad spectrum of experimental and theoretical efforts, which contribute basic solid-state knowledge important to all energy technologies. Accelerated progress is made in this field through the rapid advancements in unique experimental tools and their coupling with high-speed computer systems. Through these efforts, fundamental understanding of matter in the condensed state contributes broadly to characterizing material properties and processes important for all energy technologies.

There are five budget areas within the solid-state physics category: neutron scattering, experimental research, theoretical research, particle-solid interactions, and engineering physics.

The neutron scattering area supports research of a unique kind, namely, the use of the neutron as an analytical probe of the properties of solids and liquids. With this probe, fundamental parameters of superconductors, magnets, hydrides, and solid imperfections are determined in a manner that cannot be accomplished by any other technique. The exploitation of this probe is being advanced by recent development of more efficient monochromators and wider use of longer wavelength probes. The bulk of the Nation's efforts in this important area has historically been supported at DOE laboratories, where the advanced research reactors are in operation.

The experimental research area is very broad and includes all fundamental investigations, experimental in concept, on liquids and solids of metals, alloys, semiconductors, insulators, and compounds. The area of high-temperature materials in both metals and nonmetals, especially in relation to MHD electrodes and insulators as well as other high-temperature energy systems, is being pursued. Ion implantation and backscattering research is being used to learn how to improve superconductor and photovoltaic performance. Hydrogen and hydrides are under study through ultrahigh-pressure and spectroscopic techniques. Synchrotron radiation will be utilized in characterizing surfaces with particular relation to catalytic response. Lifetime and recombination processes in important solar materials is under study, and a search is being made for unusual thermal and electrical properties in new materials.

With nearly all these experimental areas, a highly advanced theoretical research program is closely coupled. A large part of the theoretical effort is directed towards dynamic processes in solids and liquids and requires extensive use of DOE's most advanced computer complexes.

Under particle-solid interactions, a major effort is under way to correlate the complex effects of particles of different mass, energy, and charge, not only on surfaces but in bulk materials as well.

The engineering physics area supports research to fulfill the much needed goal of utilizing solid state physics expertise in engineering research for which it has a unique capability, and in areas where it is not felt a gap exists. Typical of the work to be initiated are research laboratory investigations of novel processing techniques with mass spectrometer-computer control for complex material preparation, such as solar materials and superconducting alloys, where large areas or very long lengths are required. Another area is the extension of cryogenic and refrigeration techniques to new fluid systems that hold promise for the utilization of low-grade heat.

3. Materials Chemistry

FY 1978 Funding: $9.5 million

Contractors: Ames, Argonne, Brookhaven, INEL, LBL, LLL, LASL, ORNL, Stanford Research Institute, Universities

The materials chemistry category provides support for research directed toward developing our understanding of the chemical properties of materials as determined by their composition, structure, and environment (pressure, temperature, etc.) and to show how the laws of chemistry may be used to understand physical as well as chemical properties and phenomena. Included, for example, are studies of energy changes accompanying transformations, the influence of varying physical conditions on rates of transformations, and the manner in which the structure of atomic groupings influences both properties and reactivity.

Chemical concepts coupled with physical experimental techniques are used to study the kinetics of reactions of solids and liquids, the interaction and/or penetration of species in adjacent media, corrosion and scaling, and the stability of high-temperature materials of interest to fossil and geothermal technologies. The program also includes research on the chemical thermodynamics of fission products and their interactions with fuels and cladding materials. Electrochemical research important to storage batteries, fuel cells, and hydrogen generation is an important aspect of research supported under this category. Research involving elastomers and polymers is also being pursued.

There are three budget areas in the materials chemistry category: structural chemistry, engineering chemistry, and high-temperature and surface chemistry.

Structural chemistry involves studies of a wide variety of problems where a knowledge of the relationship between the atomic structures of materials and their reactivity is required. Important examples of these effects include the influence of different chemical environments on the catalytic properties of metals. Changes in both the crystal and magnetic structures of compounds are correlated with their specific roles in fuel synthesis, for example.

The methods of engineering chemistry are applied to problems that are currently limiting the efficiency of energy conversion systems. Examples of research underway include: structural and morphological changes that arise during the electrochemical incorporation of lithium into aluminum during charge-discharge cycles of the high-temperature battery; measurement of equilibria between tritium and candidate blanket materials; and studies of tritium permeation of oxide films.

The high-temperature and surface chemistry area includes programs on fundamental studies of the influence of surface properties on reactivity and for the correlation of mass transport and thermodynamic properties of molten salts in high-temperature battery systems. Chemical studies of scaling in geothermal environments and the influence of micro-inclusions such as sulfides on the formation of pits and crevices to determine whether these inclusions play a significant role in the initiation of stress-corrosion cracking are examples of research underway.

DIVISION OF ADVANCED SYSTEMS AND MATERIALS PRODUCTION

(Under the Assistant Secretary for Energy Technology)

The realignment of all energy activities in the nation under the cognizance of the Department of Energy resulted in numerous programmatic reorganizations including abolishment of the ERDA Division of Nuclear Research and Applications (NRA) and creation of the Advanced Systems and Materials Production Division (ASMP). This unit comprises three offices, two of which, Space and Terrestrial Systems (STS) and Advanced Isotope Separation (AIS), are carry overs from NRA. In addition, the Office of Materials Production (MP), formerly in the Division of Waste Management, Production and Reprocessing, was incorporated into ASMP. At the same time as the above changes were effected, the NRA materials programs associated with thermal gas-cooled reactors were transferred to the Nuclear Power Development Division. All of these divisions report to the Acting Program Director for Nuclear Energy who reports to the Assistant Secretary for Energy Technology.

For FY 1978, approximately $4.6 million in materials R&D was sponsored by the Advanced Systems and Materials Production Division all under the auspices of OSTS.

1. General Purpose Heat Source Project

FY 1978 Funding: $1.47 million

Contractor: LASL

This project involves the design, development, and proof of technology readiness for flight development of a general-purpose plutonium-238 fueled heat source in time for a mid-1980's space mission. The heat source will have the following attributes:

a. Highly modular design enabling utilization of the heat source, with a minimum of modifications, for space and terrestrial applications in static and dynamic conversion systems, for space shuttle or ground launching;

b. Improved safety characteristics as exemplified by a safety index goal of 10^{-6} or less;

c. Improved performance and lower weight with a goal of 75 W(t) per pound and 7.5 W(t)/in.^{3};

d. Improved reliability as proved by systematic analysis plus confirming tests on full size fueled modules;

e. Lower indicated fabrication costs as compared with the present Multi-hundred Watt isotope heat source.

In 1978 the project selected two (2) inherently different module designs and subjected these to a further series of analyses, which will enable convergence upon a prototype design early in the next fiscal period. Aerothermal reentry analysis and impact studies, plus launch abort testing will assist in this selection. Development of capsule hardware and evaluation of module graphites will parallel this activity.

2. <u>Advanced Isotope Power Fuels</u>

FY 1978 Funding: $0.15 million

Contractor: ORNL

The objective of the Advanced Isotopic Power Fuels Program is to continue to provide a reduced level-of-effort on $^{244}Cm_2O_3$ and container materials leading to a systematic close-out of this program. Emphasis in FY 1978 was placed on continuing a key compatibility/mechanical properties test series and completion of a study on chemical recovery and characterization of the isotopic fuel.

3. <u>High Temperature Alloy Development
Physical and Mechanical Metallurgy</u>

FY 1978 Funding: $0.7 million

Contractor: ORNL

Objective: A major objective of this program is to develop special alloys for both space and terrestrial isotope power systems which must operate in hostile environments. Noble metal alloys such as Ir, Pt-30%, Rh-8%W, and Rh-Ru have been emphasized due to their inherent stability in contact with graphite or isotopic fuels at temperatures to 1440°C. Advanced facilities have been developed under this program to permit creep and stability testing of refractory, noble metal, or superalloy materials at high temperatures in CO, CH_4, impure helium or vacuum.

During FY 1978 a family of long-range-ordered alloys which show a five- to sevenfold superiority in both ductibility and creep strength relative to Hastelloy X at 900°C was further characterized. The new alloys have inherently low vapor pressures and have significantly higher moduli than commercial superalloys.

In view of the wide potential applicability of such alloys, funding support for non-space oriented hardware effort has been provided through the Office of Energy Research.

4. TRIP Steels for Energy Absorption Restrainers for Protecting Reactors in Seismic Events

FY 1978 Funding: $0.125 million

Contractor: LBL

Commercial steels exhibiting the TRIP phenomena (strain induced phase transformation) are being evaluated for energy absorption in new devices (snubbers, pipe hangers, etc.), for protecting reactors from seismic events. The program includes measurements of the total energy absorption in cyclic plastic strain under normal reactor operating conditions. In practice, on-site inspection of the new devices will be simplified by use of ferro-magnetic field strength surveys ince plastic strain transforms the original non-magnetic to a ferro-magnetic structure.

During FY 1978, program emphasis is being shifted to computer modeling and evaluation of site-specific reactor components, which will lead to definition of materials requirements.

5. Strontium-90 Heat Source Development

FY 1978 Funding: $0.3 million

Contractor: PNL

The objective of the Strontium Heat Source Program is to develop the data required for qualification and licensing of $^{90}SrF_2$ from the Hanford Waste Encapsulation and Storage Facility (WESF). Utilization of the $^{90}SrF_2$ will be as fuel in heat sources for terrestrial and undersea isotopic power conversion systems.

In FY 1978, experimental studies were successful in demonstrating the value of hot-pressed $^{90}SrF_2$ as an isotopic heat source fuel. Continued progress was made in determining the relative compatibility of Hastelloy C-276 toward SrF_2 at 750-800°C. Design studies are underway to establish a new WESF outer capsule, to evaluate heat transfer and metal-metal compatibility, and to establish stability toward the seawater corrosion and air oxidation, to meet qualification requirements. Also, in FY 1978 a data sheet, BNWL-2284, was issued on $^{90}SrF_2$.

6. Heat Source Component Evaluation

FY 1978 Funding: $0.15 million

Contractor: Battelle-Columbus Laboratories

The objectives of this program are (1) to complete development of improved nonselective helium vents and to supply a sufficient number for evaluation in the General Purpose Heat Source Trial Designs;

(2) to evaluate analytically the reentry performance of LASL GPHS designs, including trial designs selected on the basis of prior analyses, employing two-dimensional or three-dimensional approaches, as appropriate; and (3) to plan the reentry experimental verification program, including facilities, specimen materials, schedules and costs. Accomplishment of these objectives will lead to a prototype design and verification testing of a modular heat source adaptable to space or terrestrial applications.

7. Thermoelectric Conversion Materials Development

FY 1978 Funding: $1.7 million

Contractors: 3M Company and General Atomic

The objective of this program is the development and proof-of-principle of a new class of higher conversion efficiency thermoelectric materials based on the selenides. In general, the p-type thermoelectric material is composed of copper, silver, and selenium in proportions similar to $Cu_{1.97}Ag_{0.03}Se_{1.0045}$ while the n-type composition is a combination of gadolinium and selenium in proportions similar to $GdSe_{1.49}$. These selenide-base materials derive their useful thermoelectric properties from a unique defect doping mechanism in a nonstoichiometric crystal lattice structure. In contrast to the state-of-the-art compositions, these materials remain extrinsic conductors to 1000°C and have superior thermoelectric material figure-of merit values.

The program efforts at 3M Company include alloy synthesis and processing; element, couple and power module fabrication; thermodynamic stability and chemical compatibility studies; mechanical property characterization; and couple and power module performance evaluations. General Atomic continues to develop element bonding materials and sublimination suppression coatings.

In FY 1978 a 156 thermocouple, 100 watt$_{(e)}$, ground demonstration converter was delivered to a space systems contractor for test evaluation. This unit is a precursor to the selenide RTG's to be used in the NASA 1982 Galileo space flight mission.

DIVISION OF REACTOR RESEARCH AND TECHNOLOGY

(Under the Assistant Secretary for Energy Technology)

Title: Materials Development Program for Sodium Cooled Fast Breeder Reactors (Non Core Materials)

FY '78 Funding: B/O \$8.9M

Objectives/Goals: The objectives of this materials program are to establish the operational limits of current component materials and to develop improved fabrication methods, inspection methods and materials in order to ensure more economic, safe and reliable LMFBRs. The goals of the program include: develop the mechanical property data needed for high temperature design methods and for inclusion in the Nuclear Systems Materials Handbook; develop alternate structural and hardfacing alloys and seal materials; develop dissimilar-metal welded joints; establish the coolant effects on the advanced fuel cladding alloys; and develop sensitive, reliable nondestructive testing methods for use during fabrication and in-service inspection.

Program Content: The commercial materials under evaluation for near-term applications include the following: 304 SS, 316 SS, 2¼ Cr-1 Mo, alloys 718, 16-8-2, 308, stellite 6, carbide and aluminized coatings, and elastomers (buna-N, silicone rubbers). For longer range applications, developmental alloys such as a modified 9 Cr-1 Mo ferritic steel and specially alloyed iron-nickel-chromium alloys resistant to neutron induced swelling are being evaluated.

Metallic material evaluations are heavily concentrated on high temperature (up to 1300°F) mechanical property determinations such as creep/fatigue interactions and very long-term creep rupture data. Emphasis is also being placed on welding pipe joints, dissimilar metal welds, and pipe fitting fabrication methods. For the elastomeric materials the properties of interest include permeability and compression set. The environments of interest for the above property determinations are sodium, sodium vapor, argon, air and a fast neutron flux.

In the nondestructive testing methods development emphasis is placed on ultrasonic techniques, specifically for elevated temperature, in-service inspection of austenitic pipe welds.

Participants: The contractors and the areas of their involvement are as follows:

ANL: Mechanical properties (including sodium effects), NDT

AI: Elastomer seals

CE: 9 Cr-1 Mo alloy development

Materials Development Program for Sodium Cooled Fast Breeder Reactors (Non Core Materials), cont'd

GE:	Dissimilar metal welded joints, mechanical properties
HEDL:	Mechanical properties, hardfacing alloys, advanced fuel cladding sodium compatibility, NDT, Nuclear Systems Materials Handbook
INEL:	Mechanical properties, pipe welding processes
LMEC:	Hardfacing alloys
NRL:	Mechanical properties (irradiation effects)
ORNL:	Mechanical properties, NDT, pipe fitting and fabrication methods, 9 Cr-1 Mo alloy development, weld metal properties, dissimilar metal welded joints
WARD:	Mechanical properties, advanced fuel cladding sodium compatibility
WRL:	Advanced fuel cladding sodium compatibility

Contact: For information on the above programs the DOE point of contact is Mr. E. E. Hoffman on (301) 353-4120 or FTS 233-4120.

Title: Cladding/Duct Materials Development for Fast Breeder Reactors

Location: Assistant Secretary for Energy Technology, Division of Reactor Research and Technology

FY'78 Funding: B/O $7.8M

Objectives/Goals: The objectives of this materials program are to develop reference (20% cold worked 316 SS) cladding and duct technology for use in early core LMFBR applications and to develop advanced alloys for cladding and duct applications for fuel systems with peak burnup capabilities up to 150,000 MWd/T with doubling times of 10 to 15 years and for use with alternative fuel systems.

The goals of the program include determining the effects of irradiation on the mechanical properties, creep, and swelling behavior of 20% cold-worked 316 SS and to reduce the materials property data to equations which can be utilized in reactor design; to characterize swelling, in-reactor creep, and mechanical properties in selected alloys, to optimize the performance of these alloys through compositional and thermomechanical processing treatments, to assess the compatibility of these alloys with liquid sodium, to provide fully qualified duct and cladding product forms for in-reactor performance testing as subassembly ducts and fuel pin cladding, to develop the necessary industrial fabrication technology for production of advanced alloy core components and to develop the necessary fundamental understanding of the factors controlling in-reactor creep, swelling and reduction of ductility to provide the basis for improving the alloys and predicting their behavior under irradiation with confidence.

Program Content: Detailed design data covering the temperature range from 800-1400^{o}F (426-760^{o}C) and fluences up to 1.3×10^{23} n/cm^2 are being obtained to establish the operational limit for the reference material. Data include in-reactor creep, swelling, tensile properties, creep in bending, fracture toughness, in-reactor stress rupture, cumulative damage, deformation of prototype components, variability of properties due to fabrication and composition variables, effects of stress and temperature history on creep and swelling, and mechanical properties under simulated reactor transient operating conditions.

Advanced alloys including Inconel 706, PE-16, M-813, HT-9 as well as a number of specially developed alloys are under study. Swelling, in-reactor creep, post-irradiation tensile and ductility properties, sodium corrosion resistance, fabricability and weldability are being investigated to provide a data base to select the alloys exhibiting the best performance for LMFBR applications.

Cladding/Duct Materials Development for Fast Breeder Reactors, cont'd

Participants:

Major contractors in this program include:

HEDL, GE, WARD, ORNL and ANL

Contact: For information on the above programs the DOE point of contact is Mr. J. W. Bennett on (301) 353-4471 or FTS 233-4471.

Title: Fuel Materials Development for Fast Breeder Reactors

Location: Assistant Secretary for Energy Technology, Division of Reactor Research and Technology

FY'78 Funding: B/O $22.3M

Objectives/Goals: The objectives of these materials programs are to:

(1) obtain statistically valid fuel pin steady-state and off-normal transient performance data to allow the safe and reliable operation of the FFTF,

(2) determine the mode and consequences of cladding breach and any limitations on continued operation past the time of breach, for the reference FFTF fuel pin.

(3) define the parameters limiting performance of the reference FFTF fuel as a basis for innovative improvements and design changes,

(4) determine the steady-state and transient irradiation performance, endurance capability and cladding breach modes of alternative breeder fuels as well as fuel pins with advanced cladding and duct materials so as to form a basis for alternative breeder reactor fuel cycles,

(5) provide by late FY 1979 an adequate data base (from EBR-II and TREAT irradiation tests, and fuel properties studies) for selection of a carbide ór nitride fuel concept for detailed design and development.

Program Content: The fuel materials under investigation include:

(1) mixed uranium-plutonium oxides (U, PuO_2) (emphasis is on the FFTF reference fuel design - with some consideration of improved designs),

(2) mixed uranium-plutonium carbides and nitride (U, PuC, and U, PuN),

(3) mixed thorium-plutonium oxides and carbides (Th, PuO_2, and Th, PuC),

(4) denatured uranium fuels ($^{233}U/^{238}UO_2$, $^{233}U/^{238}UC$ - with ^{235}U in place of ^{233}U for most testing),

(5) mixed uranium-throium fuel (U, ThO_2, U, ThC),

(6) metal fuel alloys based on U, U-Th and Th-Pu.

Fuel Materials Development for Fast Breeder Reactors, cont'd

Oxide fuels are being tested at peak power ratings up to 25 kw/ft., peak clad temperatures up to 1400°F, and burnups in excess of 100,000 MWD/T. Carbide/nitride fuels are being tested at linear power ratings up to 34 kw/ft., peak clad temperatures to 1200°F, and burnups in excess of 100,000 MWD/T.

Most experimental fuel pins are clad with 316 SS, 20% cold worked. However, limited numbers of irradiations have and will include other commercial cladding materials as Inconel 706, PE-16, HT-9, as well as some specially developed alloys.

Performance features that are being evaluated include:

(1) fission gas release and retention

(2) migration of solid and volatile fission products

(3) fuel component migration (both fissile and non-fissile)

(4) fuel-clad compatibility

(5) fuel-clad mechanical interaction

(6) cladding performance

(7) pin-to-pin and pin bundle-duct interactions

In addition to irradiation testing, which is the core of the fuel development program, supporting efforts, such as development of comprehensive fuel performance analysis models and fuel property investigations, are also included.

Participants:

The principal contractors and the areas of their involvement are as follows:

ANL metal fuel studies and carbide fuel testing under off-normal conditions

AI carbide fuel and fuel performance code development

GE oxide fuels testing, fuel property studies and fuel performance code development

WARD oxide fuel testing, carbide fuels fabrication and testing including alternative fuels, fuel performance code development

LASL carbide fuel fabrication and testing

Fuel Materials Development for Fast Breeder Reactors, cont'd

HEDL	oxide fuel development including steady-state and transient irradiation performance on reference, improved FFTF fuels, and alternative fuels, fuel property studies, and performance code development
BMI	nitride fuel development
ORNL	particulate fuel development

Contact: For information on the above program, the DOE point of contact is Mr. J. W. Bennett, Chief, Fuel Systems Branch, (301) 353-4471, or FTS 233-4471.

DIVISION OF NUCLEAR POWER DEVELOPMENT

(Under the Assistant Secretary for Energy Technology)

Thermal Gas Cooled Reactor Materials Programs

1. Fuels and Fuel Element Development

FY 1978 Funding: $5.33 million

Contractors: General Atomic, ORNL

a) To perform the specific development work required to qualify low- or medium-enrichment uranium fuel for use in proliferation-resistant fuel cycles in HTGRs (steam cycle, process heat, and gas turbine). This includes the preparation of fuel specifications and performance demonstrations under the most severe anticipated operating conditions by means of accelerated and non-accelerated irradiation tests.

b) To complete the generic data base needed for both low- and high-enrichment uranium fuel systems to qualify reference fuel use in HTGRs and to develop improvements which enhance performance and safety.

c) To complete the accelerated irradiation tests in progress, document the results, and issue a specification for the current reference high-enrichment uranium (HEU) fuel. This will advance qualification of HEU fuel to the point of irradiation proof testing.

This activity involves two programs at General Atomic (GA) and one at ORNL. The HTGR Fuel Development and Engineering program at GA is the major effort ($2230K) and involves work on each of the three objectives. The Fueled Graphite program at ORNL is the next largest effort ($1745K) and is supplementary to and well coordinated with the GA program. The Fort St. Vrain MEU Fuel program at GA is the smallest effort ($1350K) and is specifically aimed at the development, preparation and testing of proliferation-resistant MEU fuels in the Fort St. Vrain (FSV) reactor.

The major work areas covered by these programs include the following: development and updating of product specifications for MEU and HEU fuels, accelerated irradiation testing of coated fuel particles and graphite-matrix fuel rods in HFIR and ORR, integral fuel system irradiation testing of fuel test elements (FTEs) in the FSV reactor, and pre- and post-irradiation laboratory testing and evaluations to assess fuel performance and identify the potential and candidate methods for improvement. This activity also includes several cooperative laboratory and irradiation testing efforts with the Federal Republic of Germany.

2. Structural Materials Development

FY 1978 Funding: $4.05 million

Contractors: General Atomic, General Electric, ORNL

The primary objectives of this activity are to conduct screening evaluations of the candidate alloys for structural applications in thermal gas cooled reactor steam-cycle and advanced systems, and to complete development of the data bases required to support selection of reference materials for the various steam-cycle systems components.

The General Atomic (GA) program is the major effort ($2020K) and includes work on both steam cycle and advanced systems materials. Approximately one-fourth of this effort is directed toward the screening of candidate materials for advanced systems (direct cycle and process heat) and the remainder is primarily devoted to the generation of data on reference materials for steam generators, primary circuit hot ducts and thermal barriers. Work elements of the overall program include the effects of helium on corrosion and mechanical properties (creep and fatigue), effects of aging and cold work, friction and wear behavior, weld and forging properties, and thermal barrier ceramic properties.

The General Electric (GE) program is the next largest effort ($1400K) and is currently devoted to screening evaluations of candidate alloys for advanced HTGR systems. Testing of approximately 20 high temperature alloys is scheduled to begin in August 1978 in a new recirculating helium loop. The initial screening phase of the program will evaluate the effects of helium on creep properties, corrosion and thermal stability.

The ORNL program is the smallest effort ($630K) and is primarily devoted to development of the data bases required for reference HTGR steam-cycle materials (Hastelloy X, 2¼ Cr-1 Mo Steel and Incoloy 800H). Supplementing the GA work, this program also includes creep and fatigue testing in helium and determinations of weldment properties. The unique features of this program are the evaluation of candidate materials in a steam corrosion loop and the determination of crack growth rates in helium and steam environments.

3. Graphite Development

FY 1978 Funding: $1.01 million

Contractors: General Atomic, ORNL

The objective of this activity is to evaluate the available grades of graphite and select those that best satisfy the requirements for use in HTGR steam cycle and advanced systems. The evaluation and testing tasks are designed to provide the physical, mechanical, chemical and irradiation effects data necessary to qualify at least one graphite grade for each of the following HTGR components: replaceable fuel and reflector blocks, permanent reflector blocks, core support blocks and posts, and control rods.

The General Atomic (GA) program is the major activity ($560K) with tasks coverning characterization testing, fracture mechanics, oxidation studies, structural integrity verification and irradiation testing. The primary emphasis under this program has shifted from irradiation testing of replaceable fuel and reflector block graphites to irradiation testing of permanent reflector block graphites and oxidation studies of core support block and post graphites.

The ORNL program is a slightly smaller effort ($450K) concentrated on the generation of irradiation creep data on two reference fuel block graphites. A series of instrumented capsules is being tested in HFIR to provide data at temperatures of 600, 900 and 1250^{o}C and fluences up to the maximum anticipated for core graphites (8 x 10^{21} n/cm^{2}). The second and third capsules of a total of 12 are scheduled for irradiation this fiscal year.

DIVISION OF NAVAL REACTORS

(Under the Assistant Secretary for Energy Technology)

The Materials Research and Development Program in the Division of Naval Reactors is in support of the development and operation of improved and longer life reactors and pressurized water reactor plants for naval nuclear propulsion. In addition, this program supports the Light Water Breeder Reactor (LWBR) currently operating in the Shippingport Atomic Power Station and the Advanced Water Breeder Activity to develop technical information that will assist U.S. industry in evaluating the LWBR for commercial scale applications.

The objective of the materials program is to develop and apply in operating service materials capable of use in the high power density and long life required of naval ship propulsion systems. This work includes irradiation testing of reactor fuel, poison, and cladding materials in the Advanced Test Reactor at the Idaho National Engineering Laboratory. This testing and associated examination and design analysis demonstrates the performance characteristics of existing materials as well as defining the operating limits for new materials.

Corrosion, mechanical property, and wear testing is also conducted on reactor plant structural materials under both primary reactor and secondary steam plant conditions to confirm the acceptability of these materials for the ship life. This testing is conducted primarily at two Government laboratories - Bettis Atomic Power Laboratory in Pittsburgh and Knolls Atomic Power Laboratory in Schenectady, New York.

One result of the work on reactor plant structural material is the issuance of specifications defining the processing and final product requirements for materials used in naval propulsion plants. These specifications also cover the areas of welding and nondestructive testing.

The materials program effort applied to the Water Breeder Reactor program includes irradiation testing of fuel rods utilizing the thorium-uranium-233 fuel cycle, which has the potential for providing appreciably more energy than the current design of water reactors. This testing provides the basis for the development of analytical models for use in calculating the performance of fuel rods in pressurized water reactors.

Funding for this materials program is incorporated in naval projects jointly funded by the Department of Defense and the Department of Energy and the Water Breeder Reactor program funded by the Department of Energy. This funding amounts to approximately $35 million dollars in FY 1978, including about $15 million as the cost for irradiation testing in the Advanced Test Reactor.

OFFICE OF FUSION ENERGY

(Under the Assistant Secretary for Energy Technology)

Title of Program: Materials Development for Fusion Reactors

Location Within DOE and Organizational Structure: The program is chartered within the Materials and Radiation Effects Branch of the Office of Fusion Energy

The ETM Materials and Radiation Effects program is divided into five research and development areas as follows:

1. Alloy Development for Irradiation Performance
2. Plasma-Materials Interaction
3. Special Purpose Materials Development
4. Damage Analysis and Dosimetry
5. Radiation Source Development and Operation

FY 78 Operating Level: $7.8M

Overall Program Objective and Goals: The objectives of the program are to develop the materials and technology for commercial fusion power generation. This includes the development of new radiation-resistant first wall structural alloys, as well as the development and testing of other materials such as insulators, moderator and breeding materials, and materials for energy and power-conversion systems.

Program Content:

1. Alloy Development for Irradiation Performance

Contractors: HEDL, LLL, LASL, ORNL, PNL, Universities

The objective of the Alloy Development for Irradiation Performance area is to provide the materials development for structural materials that are subject to significant radiation damage. The prime technical objective is the development of a structural material for the first wall and structural elements for the blanket and shield of a commercial fusion power reactor.

2. Plasma-Materials Interaction

Contractors: ANL, General Atomic, ORNL, PNL, Sandia, Universities

One of the objectives of the Plasma-Materials Interaction area is to support the Alloy Development and Irradiation Performance task. The scope of Plasma-Materials Interactions, however, is much broader since the impact of this technical area is very important in near-term confinement systems, such as tokamaks. The approach is to treat the plasma-wall interaction as an integral problem convering both the effects on the plasma and the effects on the first wall.

3. Special Purpose Materials Development

Contractors: LASL, ORNL, LLL, PNL

This technical area covers the development of materials other than first wall structural materials described previously. Included are the following materials applications:

- Insulators in structural applications
- Insulators for components such as neutral beams and superconducting magnets
- Moderator and breeding materials
- Materials for heat transfer systems and power-conversion (secondary) systems

4. Damage Analysis and Dosimetry

Contractors: AI, ANL, BNL, HEDL, LASL, ORNL, Universities

The objectives of the Damage Analysis and Dosimetry area are to characterize available irradiation test environments and to establish a basis for predicting materials performance under irradiation in a fusion reactor environment. This will be accomplished by materials irradiation data obtained in fission reactors, accelerator-based neutron test environments, and charged particle irradiations.

5. Radiation Source Development and Operation

Contractors: ANL, HEDL, LASL, LLL,

The objectives of this area are to define the radiation environment of fusion reactors and to pursue the development of neutron and plasma sources to simulate this environment for materials testing. Since fusion reactors are not now available for testing, high-energy neutron and plasma sources are needed to develop materials for commercial fusion power.

High-energy neutron sources are based on the deuterium-tritium (DT) reaction to produce 14-MeV neutrons and on the Li(d,n) and Be(d,n) stripping reactions to produce a broad spectrum of high-energy neutrons. One DT neutron source authorized for construction by Congress is the Rotating Target Neutron Source, RTNS-II, being built at LLL. The RTNS is designed for 14-MeV neutron fluxes on the order of 2×10^{17} n/m^{2}s at the specimen. Authorization for a Li(d,n) neutron source with a maximum flux of 10^{19} n/m^{2}s to be built at HEDL will be requested in the future. This source will have a 1 liter volume and distributed spectrum, which has been shown in the past year to be an excellent simulation of the fusion reactor damage spectrum.

Fission reactors are used in the program for testing of nickel-bearing materials because of the two-stage reaction for helium production in mixed fast and thermal reactor spectra. Thus, fission reactors permit simulation of helium/dpa damage accumulation similar to what will occur in fusion reactors. Unfortunately, this statement is true only for nickel-bearing alloys, and high-energy neutron sources are needed for all other materials.

More Information:

(1) Draft program plans in the areas of Alloy Development for Irradiation Performance, Damage Analysis and Dosimetry, Special Purpose Materials, and Plasma-Materials Interactions are available, call 353-5514.

(2) Technical Assessments in the areas of Alloy Development for Irradiation Performance and Special Purpose Materials have been published and are available by calling 353-5514.

(3) Six Materials Program Bulletins have been published and are available on request. The titles are as follows:

Bulletin 1: *Overview of Fusion Materials Program*
Bulletin 2: *First Wall Structural Goal for Economic Fusion Power*
Bulletin 3: *Alloy Development to Meet First Wall Structural Goals for Economic Fusion Power*
Bulletin 4: *Plasma-Materials Interactions*
Bulletin 5: *Neutron Radiation Facilities*
Bulletin 6: *Special Purpose Materials*

These are also available by calling 353-5514.

(4) Information may be had by calling the following people for the specific areas below:

Alloy Development for Irradiation Performance	- T. C. Reuther	353-4963
Damage Analysis and Dosimetry	- T. C. Reuther	" "
Plasma-Materials Interaction	- C. R. Finfgeld	353-4962
Special Purpose Materials	- M. M. Cohen	353-4253
Radiation Facilities	- M. M. Cohen	" "

Title of Program: Materials Development for Magnet Systems

Materials research is also underway on superconducting materials and other materials for magnet systems. Most of the materials work is intimately tied to magnet development for plasma containment. More information can be obtained from E. Dalder 353-4964. The level of funding is about 1.5M$.

OFFICE OF UNIVERSITY ACTIVITIES
FOSSIL ENERGY PROGRAM

The Office of University Activities is a division level office in the Fossil Energy Program with responsibility for all university research sponsored by Fossil Energy.

FY 78 total funding for university research in Fossil Energy is $30M of which $1.5M is in materials research and development.

All university projects sponsored by Fossil Energy provide applied research and development in direct support of the program divisions of Fossil Energy. The objective of the university program is to provide a substantial portion of the advanced technology and research and development base for the fossil technologies.

The university materials program includes projects in refractroy technology, environmental attack, erosion and wear, alloy development, welding and MHD materials development. All projects are the result of unsolicited proposals which undergo extensive peer review.

DIVISION OF COAL CONVERSION

(Under the Assistant Secretary for Energy Technology)

Materials Branch:

The successful development of advanced coal conversion and utilization processes will depend upon the ability of the materials of construction to withstand the adverse environments of gasification and liquefaction processes. The gasification process temperatures range up to 1650°C (3000°F) with pressures of 10 MPa (1500 psi) and damaging gaseous species such as H_2, H_2O, H_2S and CO, while liquefaction temperatures range to 540°C (1000°F) with hydrogen pressures up to 28 MPa (4000 psi).

Currently the data base for the behavior of materials in these complex environments is small, and where data exist, the abilities of commercially available materials to perform adequately are limited. The materials technology base must be expanded to ensure the successful development of the advanced coal conversion and utilization processes.

To achieve the materials data base necessary to develop the advanced coal technologies, a comprehensive research and development program has been established in the following technology areas:

- alloy development
- refractories,
- corrosion,
- hydrogen in materials,
- mechanical properties at elevated temperatures,
- erosion,
- failure analysis and technology transfer,
- fabrication technology.

For more information, contact W. T. Bakker, Acting Branch Chief, 202-376-9376

1. Alloy Development

FY 1978 Funding: $0.96 million
Contractors: UCBC, Sandia, U.S. Bureau of Mines, Lockheed, Solar, INCO, ORNL

The alloy development program is directed towards providing new alloys, weld overlays, and coatings for use in coal gasification plants. The program addresses the question of substituting various alloying elements for chromium while maintaining suitable resistance to oxidation and sulfidation. In addition, the program is endeavoring to produce a structural steel that will not require postweld heat treatment in thick sections for use in field-erected coal gasification pressure vessels. New wear-resistant alloys are also being developed.

2. Refractories

FY 1978 Funding: $1.38 million
Contractors: Battelle Memorial Institute, NBS, U.S. Bureau of Mines, Babcock and Wilcox, University of Utah, University of Missouri, Pennsylvania State University, Argonne, Virginia Polytechnic Institute, Iowa State University

The refractories program is designed to provide data on the behavior of commercially available refractories in gasifier environments. Also, the program is developing a systematic technique for designing the refractory linings in coal gasifiers to avoid mechanical failure. The fracture behavior of refractories is also being investigated.

3. Corrosion

FY 1978 Funding: $1.54 million
Contractors: Battelle Memorial Institute, NBS, EPRI, Argonne, GE, Westinghouse, Exxon, Combustion Engineering, University of Pittsburgh, ORNL

The corrosion program evaluates currently available materials in laboratory and plant tests. The program addresses the problems of corrosion in coal gasifiers and quench systems, turbines burning synthetic fuels, and advanced systems for direct combustion of coal.

4. Hydrogen in Materials

FY 1978 Funding: $0.51 million
Contractors: Lehigh University, Ames Laboratory, ORNL, Westinghouse, UCSB, MIT

The hydrogen effects program sponsored by the Division of Materials and Exploratory Research seeks to define the behavior of existing engineering alloys in the hydrogeneous environments encountered in coal liquefaction and gasification processes.

5. Mechanical Properties at Elevated Temperatures

FY 1978 Funding: $0.40 million
Contractors: Metal Properties Council, INEL

The mechanical properties program involves laboratory testing of commercially available alloys and weldments under coal gasification environments. The materials being tested are those high-alloy grades that will be used for internal components in gasifiers.

6. Erosion

FY 1978 Funding: $1.07 million
Contractors: Metal Properties Council, Argonne, LBL, U.S. Bureau of Mines, NBS, Notre Dame University

The erosion program involves laboratory and plant testing of materials exposed to gasifier and liquefaction environments. Hardfacing alloys are investigated for pump and valve applications. All the work is aimed at the erosion of components by the particulate matter in coal gasification environments and the coal-oil slurries encountered in liquefaction.

7. Failure Analysis and Technology Transfer

FY 1978 Funding: $0.65 million
Contractors: ORNL, Argonne, NBS, Battelle Memorial Institute

The program involves monitoring the operating coal conversion pilot plants for failures, analysis of the failures, prescribing remedies, and disseminating information regarding material behavior in coal conversion and utilization environments. These ends are accomplished by using several failure analysis laboratories coordinated from a central collection point and the publication of a coal conversion materials newsletter.

8. Fabricating Technology

FY 1978 Funding: $1.03 million
Contractors: Babcock and Wilcox, Westinghouse, ORNL

The fabricating technology program presently is concerned mainly with thick section welding of pressure vessel steels, using narrow gap and electronbeam welding techniques. Cladding of pressure vessel steels with stainless steel weld overlays is also being studied.

DIVISION OF MAGNETOHYDRODYNAMICS

(Under the Assistant Secretary for Energy Technology)

MHD Material Problems

The coal-fired, open-cycle MHD generator has no established precursor in engineering practice. There is, therefore, no directly relevant technology base that can be tapped to provide a firm starting point for development. Despite this, work was started and progress has been made toward demonstration of technical feasibility. The work so far, has been very useful in identifying basic materials and design requirements and in pointing the way ahead.

Magnetohydrodynamic systems demand a different class of materials than conventional power conversion systems. There is no rotating machinery imposed between the thermal source and the electric power takeoff, as in turbines or internal combustion engine generators. The only moving "part" is the high-temperature, high-velocity gas stream. The emphasis on mechanical properties, elastic and plastic, required in high-speed rotating machinery design, is, therefore, not required by MHD applications. The emphasis instead is on high-temperature electrical, chemical, and physical properties. A disadvantage is that established materials and manufacturing technologies developed for modern, advanced power conversion machinery are not applicable to the MHD designer. Against this, there is a major advantage in that MHD permits much wider exploitation of materials technology. The outstanding advancements made in support of nuclear, space, and selected industrial processes is thus available for exploitation by MHD designers.

The MHD combustor materials requirements are: (1) good insulative performance, (2) slag-seed compatability, (3) high-temperature stability, and (4) satisfactory erosion resistance. The generator presents highly selective electrical property requirements in electrodes and insulators. Electronic conductance is needed in the electrodes while the insulators must be highly resistive. Thermal diffusivity requirements are important to both applications and, of course, both must provide durable service in a highly erosive, corrosive slag-seed environment. Air heater (regenerator) refractories will have to combine slag-seed compatibility with thermal shock (thermal fatigue) resistance. Boiler materials must be resistant to severe hot corrosion and erosion conditions. Finally, the slag-seed separating step will require careful tailoring of material properties to fit design requirements.

Stagnation temperatures along the gas stream path will approach 2850K in the combustor and channel.

Development of MHD will lean heavily on materials technology. Problems of high-temperature chemical compatibility at both the wall-slag interface and the electrode-insulator and other solid interfaces in the generator construction will be critical.

It is important, in planning detailed materials development evaluations, that the design environment is clearly defined.

Technology Similarities

There are parallels between MHD requirements and certain segments of previous reentry, thermionic, and nuclear materials development.

These earlier programs, in a sense, started from "scratch." Like MHD, there was no established engineered precursor. Material efforts originated, grew, expanded, and adjusted as design decisions required. Progress depended upon close integration of all development elements: analytical design, parametric engineering studies, experimental design evaluation, component fabrication development, etc. Similarly, MHD materials research, development, and engineering must be closely integrated with design and hardware activities to ensure successful development.

At the present stage of MHD development, materials activities may be considered to be mainly in the engineering evaluation phase. Present activities center principally upon screening evaluations of potential materials of construction. Some of the effort is directed toward slag-seed compatibility evaluations. Other activities are directed toward the generation of basic properties data of critical importance to preliminary design. Limited engineering rig evaluation is being conducted. This work is considered as a step toward preliminary development of component materials. Much more intensive work is needed to: (1) determine design and material limitations and (2) to work toward optimization of design configurations, materials, and fabrication.

Design and Material Considerations

Following is a brief description of design constraints that most strongly influence materials evaluation and selection procedures.

A. Combustor

Magnetohydrodynamic combustors face the problems of temperatures approaching 2850^{o}K, high coal slag contents, stream velocities up to 300 m/sec, and the need to minimize heat transfer losses. Classical water wall construction with frozen "slag" insulation on a sacrificial rammed insulation is the expected solution. However, test linings in subscale equipment with both prefired and rammed linings in magnesia, zirconia, magnesium chromite, etc., are being evaluated.

B. Generator

1. Insulation

Insulation requirements of first-order design function concern are:

- Continuous voltage standoff - 30 V
- Maximum transient standoff - 90 V
- Rapid heat dissipation (high thermal diffusivity)

- o High-temperature electochemical stability with seed-slag
- o Good thermal shock resistance
- o No surface-connected porosity
- o Long life
- o High-temperature structural stability
- o High-temperature compatibility with electrode materials

Typical Conditions

- o Surface temperature up to approximately 2000^{o}C
- o Continuous exposure to slag and seed
- o High heat flux (up to 3 MW/m^{2})
- o High fluid velocities up to 2000 m/s

Materials Under Test

- o Dense M_gO
- o Dense Al_2O_3
- o Castable Ceramics
- o Boron nitride
- o Magnesium chromite spinel
- o Magnesium aluminate spinel

2. Electrodes

Electrode requirements of first-order design function concern are:

- o Electric current transport
- o Slag-seed compatibility
- o High thermal diffusivity
- o High resistance to oxidation (anode) and potassium-calcium (cathode)
- o High-temperature structural stability
- o Compatibility with adjacent insulator

Typical Conditions

- o Current density - 10 kA/m^{2}
- o Hall field - 3000 V/m
- o Temperature (surface) up to 1700^{o}C
- o Heat flux - up to 4 MW/m^{2}
- o Electrochemical oxidation (anode)
- o Dynamic slag-seed coating
- o Electrochemical K and Ca Attack

Materials Under Test

Ceramics

- o Magnesium-chromite spinel with up to 30 mol % Fe_3O_4

- $FeAl_2O-Fe_3O_4$ spinel
- Doped $LaCrO_3$
- ZrO_2-CeO_2
- $ZrO_2-Y_2O_3$
- $ZrO_2-CeO_2-Ta_2O_5$

Metals

- Copper and copper-base alloys
- Nickel base
- Cobalt base
- Iron base
- Refractory-metal base
- Noble metal cladding particularly on anode surfaces

(Note: It should be pointed out that high-temperature ceramic electrode materials are in direct engineering test competition with lower temperature metallic electrodes with current data favoring platinum clad copper alloys.)

C. Air Heater

The air preheaters for the base-line 2000-MW MHD plant are projected to be of the regenerative type and directly heated by the downstream gases from the MHD channel. These brickwork honeycombs will be alternatively exposed to the hot combustion gases containing coal ash particles and potassium salt vapors and liquid droplets and to the incoming air. Materials and designs for this rigorous service are being tested under DOE contracts. The best performance so far has resulted with magnesia-base materials. Chrome magnesia and magnesia bonded magnesia-alumina spinels have been tested in simulated cycling service at temperatures up to 1850^{o}K (2800^{o}F).

D. Summary of Relevant Work Breakdown Structure and Contractors

In the MHD program, the work breakdown structure does not define any element in which materials work is separated from component design and performance and durability testing. Certain general categories with significant materials aspects can be identified as design properties and design support engineering component research and to a lesser extent component engineering and development.

Contractors

ANL, PERC, BNWL, NBS, AVCO, Westinghouse, GE, Fluidyne, MERDI, MIT, Mississippi State University, Stanford University, UTSI, Montana State University, Montana College of Mineral Science and Technology, University of Tennessee Space Institute

The funding level for the activities classified as materials (with primary emphasis on test evaluation as opposed to engineering design and fabrication) is estimated to be $3.5 million dollars.

DIVISION OF FOSSIL FUEL UTILIZATION

(Under the Assistant Secretary for Energy Technology)

The mission of this division is to develop fossil fuel utilization technology to ensure a smooth transition from oil and gas to alternate fuels in energy conversion equipment. The development of materials for this equipment which can produce extended durability combined with flexibility to use a wide range of fuels and operation at improved efficiencies is a vital part of the fossil fuel utilization R&D effort.

The Division of Fossil Fuel Utilization is comprised of three branches. The Heat Engines and Heat Recovery Branch is responsible for the development of high efficiency engine cycles, intermediate and baseload utility power generation, advanced cogeneration technologies and technology for cost effective recovery of reject heat. The Combustion Systems Branch is developing combustion technology to improve conventional and fluidized-bed combustion of coal and to develop combustion of alternate fuels. This branch also has responsibilities for improving combustion equipment efficiency such as engine combustors, space heaters and industrial furnaces. The Fuel Cell Branch is developing fuel cell powerplants for electric power generation, in a variety of simple cycle, cogeneration and waste conversion configurations.

The materials technology being developed in the Division's programs are strongly applications oriented. Thus, coating development involves mechanical integrity with component, composition and microstructure optimization for thermal excursions and corrosion environment. Component improvement development inherently involves material development. Use of ceramics involves development of novel joining, installation design. Component cooling and operating conditions influence material development. Heat engine efficiencies are related to materials high temperature properties. Thermal steady state and ramp conditions, corrosion and erosion are development trade-off considerations for durability, fuel flexibility and efficiency.

Engine development work emphasizes extending engine durability with minimally processed coal derived liquid fuels compared with the severly restricted engine life with current materials projected from laboratory and early engine data. Near term work will be done with either residual fuels or blended residual fuels as many of the corrosion/erosion problems are similar to those anticipated with minimally processed coal derived liquid fuels. The economic factors involved in the results of this work will have a profound impact in the cost of power to residential and commercial concerns in this country when coal becomes widely used in heat engines. This cost impact results from the difference in processing cost between a coal derived liquid fuel minimally processed such that it is similar to a No. 6 residual petroleum fuel and hydrogenating it to the equivalent of a No. 2 light distillate petroleum fuel. Thus, major efforts of the Division are directed at developing the capability to operate heat engines with the more aggressive hot-corrosion combustion zones encountered operating with the minimally processed liquid coal derived fuels while maintaining reasonable equipment life and operating with equivalent or improved efficiency. Materials developments are at the core of these programs.

Historically, materials development is an integral part of heat engine development. Advanced materials technology directly supporting advanced engine development is also integrated with respect to the demanding series of hot-corrosion, high temperature strength, creep and fatigue requirements often in an interelative design effort with changes in component geometry and alloy composition and processing. Therefore, materials R&D funding does not appear as a budget line item in the Divisions programs. Materials development costs presented represent estimates by the cognizant Program Managers.

The total funding level for materials development for the Division in FY'78 is approximately $20 million. The materials development work of the Divisions programs is summarized as follows:

A. HEAT ENGINES AND HEAT RECOVERY

1. Ceramic Coating Development for Heat Engine Combustion Zones.

The objectives of the ceramic coating, or thermal barrier coating, program are to first significantly enhance utility/industrial gas turbine and diesel engine durability with multi-fuel capability and then to obtain the insulative advantages respect to improved engine efficiency. A major competitive program is currently in process and ten support technology efforts are underway as follows:

a - Ceramic Coating Development Program Project Management -

NASA-Lewis Research Center - FY'78 $ 812K

This program has been limited to gas turbine engine manufacturers to ensure earliest commercialization. Emphasis is on the turbine airfoils, the most difficult ceramic coating application. Phase I encourages development of innovative coating concepts to provide sufficient data for the Phase II component coating development. The RFP was released in July, 1978. Multiple contracts are anticipated to be awarded by November, 1978.

b - Ceramic Coating Support Technology

1 - Contractor - Battelle-Northwest FY'78 - 90K

Battelle-Northwest is developing the multi-layer coating concept comprised of alternate ceramic-metallic layers deposited with DC-RF sputtering. Initial depositions subjected to mechanical flexing and thermal cycling were very encouraging.

2 - Contractor - Battelle-Northwest FY'78 - 90K

Battelle-Northwest is investigating improvements in maintaining mechanical integrity of a ceramic coating by developing high aspect ratio cones on the metallic bond layer surface immediately prior to ceramic outer-layer deposition. This sputter deposition approach is directed at distributing the thermal mismatch stresses over a greater area. The cones will also enhance formation of columnar microstructures perpendicular to the surface which should limit crack propogation. This project is just starting.

3 - Contractor - Linde Division of Union Carbide FY'78 - 70K

Linde is investigating the effects of plasma spray seposition parameter variations and Cr intermediate layer on ceramic coating integrity under gas turbine engine operating conditions. Emphasis is placed on reducing the porosity of the ceramic outerlayer which has been identified as a problem with plasma sprayed ceramic or thermal barrier coatings which has lead to coating spallation. This work started in August 1978.

4 - Contractor - United Technologies FY'78 - 75 K

United Technologies has developed a ceramic coating deposited by the electron beam physical vapor deposit-ion PVD and sputtering processes which has a controlled segmented ceramic outerlayer. Initial work with this columnar segmented microstructure coating has demonstrated excellent resistance to spallation. The initial phase of the program involves a comparative evaluation of microstructures and durability of these coatings compared with the NASA-Lewis type plasma sprayed thermal barrier coatings. Yttria stabilized zirconia + CoCRAlY coating systems will be evaluated. Compositional flexibility will be exmined primarily with PVD process.

5 - Contractor - University of Minnesota FY'78 - 40K

Dr. Wehner is investigating the mechanical property influence of graded metallic ceramic coatings and ceramic coatings with high aspect ratio cones on the metallic bond coat surface. Coating specimens are obtained by using dual sputtering targets with appropriate shielding such that a single specimen has a linear gradation of 0 to 100% in the compositional variation of the metallic/ceramic. This work is directed at further understanding of the mechanical property relationship of ceramic coatings.

6 - Contractor - General Electric FY'78 - None (Work Accomplished in FY'78 on FY'77 funding).

The overall objective of the General Electric program is to assess and evaluate the early NASA-Lewis type Plasma sprayed thermal barrier coating for hot-corrosion resistance. Burner rig testing was conducted with Na_2SO_4 condensate on coated disc specimens. In general, hot-corrosion condensates penetrated to the sustrate metal by diffusion through the continuous porosity of the yttria-stabilized zirconia outerlayer. Intrinsically there did not appear to be any corrosive attack on the ziroconia itself. However, penetration of corrosive products to the substrate resulted in both substrate attack and spallation of the ceramic coating.

7 - Contractor - United Technologies FY'78 - 60K

The mechanism of hot-corrosion attack on a range of candidate ceramic coatings will be investigated by United Technologies Laboratory testing will be done with Na_2SO_4, SO_3 and V_2O_5. Bulk materials will be initially tested then coatings will be developed from the more promising candidates. Emphasis will be placed on microstructure influence and the stability of stabilizing additives to the zirconia.

8 - Contractor - Naval Research Laboratory FY'78 - 70K

The Naval Research Lab is providing characterization and fracture mechanics analysis support for candidate ceramic coatings developed in DOE program. Consultation is also provided on DOE programs using ceramics in heat engine and heat recovery programs. In addition, NRL is providing support in the identifaction and organization of advanced ceramic development programs.

9 - Contractor - Central Institute for Advanced Research FY'78 - 10K

The Central Institute for Advanced Research in Oslo, Norway has reported considerable success with plasma sprayed ceramic coatings applied to diesel engine piston crowns, valves, fuel nozzles, etc. These coatings have tripled component life operating on residual fuel at-sea. This contract involves in-depth compilation of lab data, deposition procedures, engine experience plus consulting to effect technology evaluation and transfer for US heat engine uses.

10 - Contractor - Deposits and Composites FY'78 - 62K

This program involves investigation of the chemical vapor deposition (CVD) process to deposit smooth, dense ceramic coatings or thin outerlayers over plasma sprayed ceramic coating. The aerodynamic advantages of the smooth CVD coating on turbine airfoils and the resistance to diffusion of corrosion agents because of porosity along with excellent erosion resistence are potential advantages of the CVD process.

2. Metallic Coating Development for Heat Engine Combustion Zones

The objectives of the metallic coating program is to obtain improved engine durability with multi-fuel capability. This program is competitive with the ceramic coating. The decision to undertake a major metallic coating development program is dependent on sucesses in these support program, EPRI and NAVSEA programs and the ceramic coating program.

a - Metallic Coating Support Technology

1 - Contractor - Battelle-Northwest FY'78 - 50K

Conduct development with high rate triode sputtering for improved turbine airfoil coatings. Coating optimization involves compositional gradient variations of CR and Al in MCrAlY coating systems. Hf, Pt and Pt-Hf will be added to promising candidate coatings in a single deposition step. Advantages beyond that obtainable by other processes, precise control of deposition and coating reproducibility.

2 - Contractor - AIRCO-Temescal FY'78 - 60K

Develop MCrAlY coating systems deposited by electron beam physical vapor deposition with 5th element additions. Coatings will be tested and evaluated in an iterative coating development. Dual source codeposition will be conducted. Coating composition, Microstructure and compositional grading will be optimized for hot-corrosion/erosion resistance.

3 - Contractor - Battelle-Columbus FY'78 - 30K

Investigation of use of Peierl's stress concept to obtain improved erosion resistance by enhancing coating hardness through increased modulus. Also, improved coating ductility by this approach with the metallic bond coat component of ceramic coating system should improve mechanical integrity on turbine airfoil - a major problem at this time.

4 - Contractor - General Electric-Evendale FY'78 - 30K

Analyze and improve the vanadium attack resistance provided by Hf additions to the M CrAl coating systems. This resistance to vanadium induced hot-corrosion shall be developed as an engine durability trade-off with the more severe sulfidation corrosion and erosion.

5 - Contractor-United Technologies FY'78 - 80K

Investigate and optimize the vanadium, sulfidation and erosion resistance of Cr, Si and NiCrSi coating systems. Screening testing will be done in furnace with Na_2SO_4, V_2O_5 and SO_3 environments. This is a classical iterative test - analysis coating optimization.

3. Monolithic Ceramic Technology

a - Heat Engines

1 - Contractor - Westinghouse, Garrett-AiResearch FY'78 - 2,

Two parallel contracts are in Phase I - Program Definition stage wherein conceptual designs to advantageously use monolithic ceramic materials in industrial/utility gas turbine engines are being developed and analyzed. There studies are using state-of-the-art silicon carbide and silicon intride manufactured by hot-pressing, reaction bonding, sintering and chemical vapor deposition.

b - Ceramic Support Technology

1 - Contractor - Morgantown Energy Research Center FY'78 - 1M

MERC is in the process of fabricating, installing and checking out corrosion/erosion test equipment for screening monolithic ceramic. Initial testing is scheduled for September '78. Typical test conditions for the Low BTU gas are 2500^{o} to 2600^{o} for 1000 to 2000 hours duration.

2 - Contractor - NASA-Lewis Research Center FY'78 - 600K

Develop metallic bond coating and zirconia outerlayer of ceramic coating systems. Conduct hot-corrosion testing of superalloys and coatings under a range of contaminants at temperatures and duration relevant to gas turbine operation.

3 - Contractor - IITRI FY'78 - 150K

DOE participation in joint interagency ceramic materials test and evaluation program.

4 - Contractor - National Bureau of Standards FY'78 - 150K

Develop proof testing for ceramic materials.

5 - Contractor - Stanford Research Institute FY'78 - 150K

SRI is developing sintered silicon nitride with yttria and alumina additions. Densities greater than 95% have been achieved. Specimens with 4 point bend strength above 90 KSI from temperature to 1000°C have been tested. Creep tests at 1250°C have been conducted with no failures and only small plastic strains for times up to 100 hours at 10 KSI.

c - Heat Recovery

1 - Contractor - Solar Division of International Harvester
FY'78 - 180K

Develop joining materials and methods for ceramic heat exchanger tubes and/or gas turbine hot-section components. Complaint layer joints using both glass and Si based brazing of columium foil for up to 2000°F operation are being developed.

4. High Temperature Turbine Technology (HTTT)

1 - Contractor - General Electric-Schenectady FY'78 - 2.7M

G.E. is developing water cooled turbine airfoils and combustor design to accomodate 2600°F turbine inlet temperatures. Considerable effort is involved in developing fabrication techniques. The approach is to imbed a superalloy spar and cooling tubes (A286) in a Cu layer with a IN 617 skin. Cladding surround the outersurface. Sintering, electroetch and HIP processes are being assessed.

2 - Contractor - Curtiss-Wright FY'78 - 1.8M

C.W. is pursuing transpirational turbine airfoil cooling to accomodate up to 3000°F turbine inlet temperatures. Transpirational cooled turbine airfoil fabrication has been the core of the program to date. Material corrosion and mechanical property testing to support the development has been conducted. Initial airfoil testing is scheduled for late FY'78.

5. Primary Heater Program for District Heating (Cogeneration) Applications

1 - Contractors - Airesearch, Rocketdyne FY'78 - 1.0M

This work involves the assessment of Closed Cycle Gas Turbine Primary Heater designs burning coal. Included in this work are metallic designs for systems operated up to 1550°F turbine inlet temperatures and ceramic designs providing turbine inlet temperatures of 1750°F and higher. Major emphasis is placed on the selection of primary heater designs and materials selection which provide a cost effective power conversion system for cogeneration (power and district heating) applications. Major problem areas are the heater design and selection of materials which can withstand the high temperature corrosive environment of coal combustion.

B. FUEL CELLS

Platinum Properties - Brookhaven National Laboratory
Stonehart Associates, Inc. FY'78 - 300K

Objective - Investigate the platinum sintering (loss of surface area) phenomenon to determine the mechanism and warp in order to reduce its occurrence. Sintering of small platinum catalyst crystals on carbon fuel cell electrodes causes a deep in cell voltage and reduces powerplant efficiency.

Platinum Substitutes - National Bureau of Standards, ECO Inc., Stonehart Associated FY'78 - 200K

Objective - Investigate fuel cell catalyst materials to find a cost-effective alternative to platinum in terms of cost and electrode activity. Possible alternative include tungsten carbide and cobalt tetraazannulene.

Carbon Substrates - Stonehart Associates, Energy Research Corp., United Technologies Corp. FY'78 - 1.01M

Objective - Determine the suitability of various carbon substrates for fabrication into fuel cell electrodes with supported platinum catalysts. Evaluate electrochemical activity, resistance to corrosion, strength, density, porosity and conductivity of substrates made from different carbons and by different fabrication procedures.

Molten Carbonate Fuel Cells - Institute of Gas Technology, General Electric Co. FY'78 - 500K

Structural Materials Corrosion Rates. Cell components fabricated from stainless steel sheet metal are being assessed. Corrosion - resistant bipolar separators are being fabricated and tested. Nickel and nickel alloys are being fabricated into high-surface area electrodes that are stable and resistant to contaminants in the fuel streams.

Fabrication & Development of Ceramic Matrix Materials
Institute of Gas Technology, General Electric Co., FY'78 - 2.0M

Stable or renewable electrolyte structures are being developed in an effort to reduce cell decay due to loss of electolyte (including effect of lost corrosive electrolyte on other components). The core of this work is to define and test optimal electrolyte compositions.

Solid Oxide Fuel Cells (1000°C)

Westinghouse, Brookhaven National Lab, Montana Energy and MHD Research and Development Institute Inc., National Bureau of Standards FY'78 - 300K

Evaluate electronic and ionic conductivities of solid oxide electrolute materials (ZrO_2, CeO_2) to determine sintability for use in fuel cells.

Interconnector Materials - Westinghouse, Montana Energy and MHD Research and Development Institute Inc. and Brookhaven National Lab. FY'78 - 400K

Evaluate pertinent chemical and electronic properties of interconnector materials used to provide the cell-to-all series connection in the solid oxide fuel cell.

Porous Support Tube - Westinghouse FY'78 - 100K

Refine fabrication techniques for extrusion of zirconia porous support tubes to the following specification:

- o tensile strength of 5,000 - 10,000 psi,
- o open porosity of 20-30 volume percent, and
- o no surface power larger than 10 mm in diameter

COMBUSTION

1. Fireside Corrosion Projects

a - Evaluation of Gas Turbine Alloys in Coal-Derived Fuels (Fireside I)

1 - Contractor - General Electric, Schenectady, NY FY'78 - 0

The objective of this program is to evaluate the potential for corrosion, erosion, and fouling of gas turbine alloys in the combustion products of coal-derived fuels. Testing for relatively short time shows that potential fouling problems exist with the use of coal-derived liquids having high ash levels and that a potential hot- corrosion problem exists with the use of coal-derived low-Btu gas. No erosion is foreseen.

b.- Evaluation of Gas Turbine and Heat Exchanger Alloys in Fluidized-Bed Combustion Applications (Fireside II)

1 - Contractor - General Electric, Westinghouse, Exxon, Battelle Columbus Labs FY'78 - 0

The first portion of this program was to investigate the corrosion/erosion of heat exchanger alloys in an atmospheric fluidized bed coal combustor. Data from test times up to 1500 hours was gathered and indicated that at temperatures approaching that of the bed (1650°F) corrosion could be a serious problem. Erosion was seen at all test temperatures with the most severe attack noted at very low temperatures in bed (Tm 500°F).

The second portion of this program consists of testing heat exchanger and turbine materials in a pressurized fluidized bed combustor for times up to 1000 hours. Tests are now underway.

c - Evaluation of Advanced Heat Exchanger Alloys in Pulverized Coal Application (Fireside III)

1 - Contractor - Combustion Engineering FY'78 - 0

The objective of this program is to examine alloys for use as heat exchangers at metal temperatures up to 1700°F in pulverized coal boilers. Test times up to 8000 hours has been gathered on four coals burned in four different boilers. Testing is completed with final analysis now underway.

2. Pressurized Fluidized Bed (PFB) Combustor

The objective of this program is to assess the performance of alloys for fabrication of tube banks, fouling of gas turbine blades and the performance of gas cleaning equipment in combined cycle power plant operating on coal.

a - Contractor - PFBC Test Program at Leatherhead, England FY'78 1.5M (Contract thru NRDC)

A series of ten 100 hour test runs on the 36 inches x 24 inches PFB combustor are being conducted. Metallographic examination of duplicate specimens. Sufficient sampling conducted to assess gas cleanup equipment.

b - Contractor - Curtiss-Wright FY'78 - 2.8M

Phase I of the C.W. program involves testing in a PFB to evaluate and establish selection of critical materials as a logical step in a Pilot Plant design. Candidate heat exchanger tube materials, turbine airfoil materials and transpirational cooled blades will be tested for up to 2000 hours with turbine inlet temperatures of up to 1600°F. The intent is to develop accurate life predicts for these materials.

c - Contractor - General Electric - Schenectady FY'78 - 300K

The G.E. objective is to evaluate most promising turbine alloys under realistic PFB conditions. Twenty-four air-cooled airfoil shape specimens will be tested at with 5 to 8 coatings/claddings in the 10 x 100 hour test at CURL (leatherhead, England). In depth post-test metallographic examination will be conducted. Two identical sets of specimens will be tested in CURL and the Exxon Miniplant and analytically compared. Formability and bonding studies will be performed with candidate claddings for turbine airfoils. Candidate Ni, Co and FE base claddings are planned to be modified to optimize durability in the PFB environment.

DIVISION OF ELECTRIC ENERGY SYSTEMS

(Under the Assistant Secretary for Energy Technology)

1. Electric Energy Systems Program

2. EES reports to the Program Director for Solar, Geothermal, Electric and Storage Systems, under the Assistant Secretary for Energy Technology.

3. The EES Division manages their funds in two sub-program areas, namely

   (a) Power Delivery, and
   (b) Power Supply Integration.

   The combined budget managed in $46.3M.

   The portion of the effort that is judged to be materials research and development corresponds to a budget of $2.5M.

4. The vast quantity and numerous types of materials required for the production of electrical equipment to meet expanding electrical energy demands poses a major long-lead-time problem area for electrical energy systems. Coupled with other driving forces - such as esthetics and scarcity of land for transmission rights-of-way, among others - materials research has become an integral part of many development projects of the Electric Energy Systems Division.

5. Program Content

   (a) Underground Transmission

   FY '78 Funding: $6,070,000

   Contractors: Westinghouse Electric Co., Reynolds Metals Corp., Power Technologies Corp., Phelps Dodge Cable & Wire Co., MIT, Battelle Columbus Labs., General Electric Co., Brookhaven Nat. Lab., Oak Ridge Nat. Lab.,

   Subject Areas:

   - Investigation of Dielectric Strength of Epoxy Insulators for compressed gas systems.
   - Irradiated XLPE Cable Development
   - Development of a Glass Insulated Transmission System
   - Optimum insulation for use in $\pm$600kV dc cable. Evaluating insulation oils and papers.

- Study of gas dielectrics and cable insulators.
- Basic study of aging process in solid dielectric cables.
- Resistive cryogenic cable viability.
- AC Superconducting Power Transmission Cable Development.
- Breakdown strengths of Gaseous Dielectrics.
- Synthetic tape development (polyethylene).

(b) AC Transmission

FY '78 Funding: $1,710,000

Contractors: National Bureau of Standards, Research Consulting Associates, Phoenix Electric Corporation, General Electric Co., Westinghouse Electric Corp.,

Subject Areas:

- Optimal Measurements for Interfacial Conduction and Breakdown in Insulating Systems (epoxies, mineral oil, cellulosic kraft, polyethylene, SF_6 Gas).
- Dynamic load model study for overhead transmission lines (steel, aluminum).
- Operational surge protective device (copper, silicon steel).
- Silicon fluids for transformers.
- Advanced technologies for power transformers (polymer sheet windings - compressed gas insulation).
- 1200kV compact AC Circuit-Breaker [materials involved are composite metals (beryilium, phosphor-bronze, silver, copper, aluminum, steel, SF6 gas).

6. Program Coordinator: Mr. A. David Allen, (202) 376-4727.

DIVISION OF ENERGY STORAGE

(Under the Assistant Secretary for Energy Technology)

The principal function of energy storage technology is to permit more efficient and more economic use of intermittent energy sources. The development of new and improved materials is a vital part of the energy storage R&D effort.

The energy storage activities include materials development, fabrication, characterization and data base compilation. Because most of these activities are part of the component development projects, materials R&D does not appear as a line item in the budget.

The total funding level for materials R&D in FY78 is approximately $5.9 million.

Described below are the materials R&D efforts of the six subprograms of the Division.

1. THERMAL STORAGE

FY78 FUNDING: $ 2.0 million

CONTRACTORS: Rocket Research, Sandia Livermore, EIC, University of Delaware, Institute of Gas Technology, Suntek, Dow Chemical, Monsanto, NRL, Brookhaven

Heat energy is stored through sensible heat in materials, phase changes in materials (mainly melting and solidification), and reversible chemical reactions. Molten salt mixtures and fusible metal alloys are being investigated as both sensible and phase-change thermal storage media. Thermal properties, expansivity, and corrosivity are all important properties. A major thrust of the program is the incorporation of constituents that change phase near ambient temperature in materials of construction for buildings. Reversible chemical reactions such as SO_3 decomposition and steam reforming of methane are attractive for long-term storage combined with heat transmission. The materials problems are catalyst development and performance and corrosion of container materials.

2. CHEMICAL AND HYDROGEN STORAGE

FY78 FUNDING: $ 0.6 million

CONTRACTORS: Sandia Livermore, Brookhaven, Virginia Polytechnic, NASA Ames, Pratt and Whitney, GE, University of Georgia, Energy Concepts Co.

Work on the behavior of hydrogen in materials includes structural steels for the containment of hydrogen gas, hydrides as storage media, direct reduction of iron-titanium ores to produce hydride forming alloys, solid polymer electrolytes for producing hydrogen from water, and catalysts for both thermochemical and electrolytic hydrogen production. In other projects in chemical energy storage, sensitizers and catalysts are being developed for the storage of solar energy through phase changes in organic compounds. Also molten-salt systems are being evaluated for separating oxygen from air.

3. MECHANICAL ENERGY STORAGE

FY78 FUNDING: $ 1 million

CONTRACTORS: Sandia (Albuquerque), LLL

The primary emphasis is on flywheels for regenerative braking. Of particular interest is the use of high strength-to-weight materials such as "Kevlar" and "tire wire." Potential problem areas are stress rupture, creep and vacuum outgassing. Both advanced magnetic and low-loss conventional bearings are also being investigated.

4. SUPERCONDUCTING MAGNETIC ENERGY STORAGE

FY78 FUNDING: $ 0.5 million

CONTRACTORS: LASL, University of Wisconsin

The overall objective is to develop technology for both large scale (1000 MWh) diurnal energy storage plants and small scale (10 KWh) utility system stabilization devices. The major emphasis is on low-cost polyester-glass support structure for cryogenic service and high-purity aluminum stabilized conductor.

5. BATTERIES AND ELECTROCHEMISTRY

FY78 FUNDING: $ 1.5 million

CONTRACTORS: Argonne, Ford, University of Utah, Ceramatec, EDA, Diamond Shamrock, Stanford University, M.I.T.

Lithium-iron sulfide and sodium sulfur batteries operate at temperatures of several hundred degrees Celsius. Corrosion of container materials is a concern, as are materials for current collectors, separators, and seals. Of special importance is the development of processing techniques to make beta-alumina parts with reproducible properties for use in sodium-sulfur batteries. Improvements in lead-acid batteries are being made, and new zinc-chlorine and more advanced batteries are under study. Materials R&D for these includes electrode materials and new solid electrolytes. New materials for an air electrode are also being investigated.

6. TECHNICAL AND ECONOMIC ANALYSIS

FY78 FUNDING: $ 0.3 million

CONTRACTOR: LLL

A project to collect and develop evaluation data on properties of energy storage materials will be completed in FY78 for flywheel, battery, electrolyzer and thermal energy storage technologies.

DIVISION OF SOLAR TECHNOLOGY

(Under the Assistant Secretary for Energy Technology)

The Division of Solar Technology is actively involved in applied materials research and development necessary to demonstrate the technological feasibility of advanced solar systems as well as increase the cost effectiveness and efficiency of established concepts. This development of new materials is required to meet the needs of systems, subsystems and components desired to perform under actual operational conditions. Although the technology is in large part an extension of that developed in other industries, further developmental efforts are necessary to meet system cost and efficiency goals. As a result of these requirements, applied materials research and development is an integral part of all the major branches of the Division of Solar Technology and in industrial programs, material research is of critical importance to long term program success.

The total DST funding of material research is $23.2M for FY 78. These funds cover ongoing research in each of the five major areas of the DST: Solar Thermal Power Systems, Ocean Systems, Biomass, Wind Systems, and Photovoltaic Systems.

Solar Thermal Power Systems Materials Development

FY 1978 Funding: 2.0 Million

The major emphasis of the TPS materials development program is to conduct research in absorber coatings, reflective materials and substrates, high temperature containment materials, and a variety of other substances designed to improve the operating efficiency of heliostats and receivers. Projects are currently underway to develop selective and non-selective absorber coatings for use in a variety of receiver applications, with emphasis on coating durability for solar systems scheduled for completion in the 1978-1985 time period. In the area of reflective materials for heliostats, emphasis will again be placed on the development of high-reflectivity, long-life materials, durable glass and plastic protective materials and light weight, low cost substrates.

Ocean Systems Materials Development

FY 1978 Funding: 4.0 Million

The objective of material development in the Ocean Systems Branch is to select and develop materials suitable for ocean thermal power production. Material needs are defined by the heat transfer enhancement, working fluid characteristics, compatibility and behavior in the ocean environment. These provide a focus for the specific materials selection necessary for ocean thermal electric conversion and non-electric missions of ocean thermal conversion. The program evaluates potential applications of various materials for specific system, subsystem and component application. These materials are required for: (a) power system development, (b) ocean engineering systems development, (c) transmission/distribution system development.

In conjunction with the development of materials with the necessary physical properties for the various OTEC subsystems and compoents effort is required to establish corrosion resistance data and biofouling prevention methods to ensure that OTEC generating facilities will have an acceptable operating life expectancy.

Major ongoing materials efforts in the ocean system area are: (1) development of antifouling marine concrete, (2) development of low density concrete, (3) study of heat exchanger joining methods, (4) development of a plastic heat exchanger, and (5) rubber cold water pipe development. In a program so heavily tied to the success of materials development, each of these studies assumes the importance of a major system component.

Biomass Materials Development

The current effort in Biomass conversion is concentrated on identifying catalysts of a biochemical nature that may prove useful in the conversion of biological material into more usable forms of energy.

Wind Systems Material Development

FY 1978 Funding: 0.5 Million

The primary objective of the materials research and development effort is to achieve major cost reductions in the production of large wind turbine rotors. Though the technical feasibility and potential high efficiency of wind turbines using off-the-shelf technology is well established, the rotor remains a high cost component. At the present time, research is centered on several low-cost rotor development efforts described below: (1) 150 foot wind turbine blade project using filament around glass fiber, (2) prestressed concrete blade study to determine the feasibility of using this technology for the production of low-cost blades, (3) wood blade study to determine the feasibility of using epoxy impregnated laminated wood for blade construction, and (4) a new study of low cost rotor designs utilizing materials not yet defined.

Photovoltaics Systems Materials Development

FY 1978 Funding: 16.7 Million

The Photovoltaics Program includes extensive applied materials research and development as part of the Technology Development and Research and Advanced Development elements. The large scale production of low cost solar arrays with twenty year life expectancy requires low cost photovoltaic materials, specialized ceramics for new production processes, and durable, transparent polymers and glasses for encapsulation. Silicon solar cell technology is the most mature of the photovoltaic technology options; however, in order to reduce the price, it is necessary that either a different process be developed for semiconductor-grade silicon production or a less costly, less pure "solar grade" silicon be shown to be utilizable. The program investigates advanced materials and thin film approaches for potential mid- to far-term cost reductions. Finally, since service life of a cell is determined in large part by the choice of the encapsulant, materials will be identified and tested to develop a high reliability encapsulation system.

Silicon material studies will pursue improved low-cost processes for production of bulk silicon and large area silicon sheets suitable for solar cells. The silicon materials task will demonstrate the technical feasibility and practicality of several processes for high volume production of semiconductor-grade and solar-grade silicon at markedly reduced cost. The large-area silicon sheet task investigates techniques for growth of silicon crystalline material in a geometry which does not require cutting to achieve proper thickness, thus eliminating costly processing and material waste. Characterization of the structural, chemical and electrical properties of the crystalline silicon is a significant part of this study. Although it may be possible to use solar-grade silicon, this material still must be exceptionally pure by all but semiconductor industry standards. Analyses will correlate the kind and level of impurities with crystal quality and device performance. In addition to the purity required, the crystal must be relatively free of lattice defects. Several studies investigate methods to prevent cracking due to thermal stress during cool-down after formation of large sheets.

In addition to the investigation of the silicon, the production processes require research and development of refractory materials for crucibles, dies and substrates which have the desired characteristics (thermal expansion coefficient, wetted by molten silicon, electrical conductivity, etc.), can withstand the environment, and do not contaminate the silicon.

The element of the encapsulation system for the sunlit side of a solar array must maintain high transparency for the 20-year lifetime, while also providing protection from adverse environments. Various glasses, polymers and laminated structures are under investigation. The scope of these activities includes: (1) Identification of candidate encapsulant materials, (2) Evaluation of encapsulant material properties, (3) Analysis of accelerated/abbreviated encapsulant test methods.

The Technology Development element is also investigating single crystal silicon, gallium arsenide and gallium aluminum arsenide for application in concentrator arrays. The operation of solar cells in concentrated sunlight shifts the emphais, with respect to technology, from cell cost to cell performance. This research on these high quality materials extends the technology base of the semiconductor industry through its emphasis on uniformity over much larger areas than have typically been considered. The objective of the advanced materials effort is to investigate the wide variety of known photovoltaic materials, other than single crystal silicon and gallium arsenide, with the potential for providing solar arrays at significantly lower cost. Cadmium sulfide, gallium arsenide, amorphous silicon and polycrystalline silicon are established materials selected for near term development. Emerging materials, such as Zn_3P_2, $ZnSiAs_2$, Cu_2O, and CdTe, will be investigated to determine their potential for meeting the long-term goals of the program. The task studies fabrication and characterization of thin film solar cells of homojunction, heterojunction and Schottky barrier structures. These approaches may reduce future array costs through lower material consumption, less expensive materials and less costly processing.

DIVISION OF GEOTHERMAL ENERGY

(Under the Assistant Secretary for Energy Technology)

Applied materials research and development, field testing and failure analysis coordination are important components of the Geothermal Energy Program. The objective of the materials work is to provide materials for geothermal applications that minimize geothermal conversion system life cycle costs. The program develops and field tests new substitutes where they have significant potential for cost reductions. Because of the large variations in fluid chemistry, important efforts are concerned with standard field test development and fluid sampling and characterization.

The materials technology required for geothermal development in large part is an extension of that developed for other industries. Subprogram efforts evaluate available materials for geothermal conditions while parallel applied research efforts assess the applicability of new developments for situations where the state of the art may not be adequate. The program is cooperating with various concerned sectors of industry and appropriate technical societies. These groups will eventually set consensus testing and materials specification standards for the geothermal industry. They also provide assessments of industrial and public geothermal needs.

The Division is initiating a significant amount of electric and nonelectric field projects in FY 78-79. These include schools, hospitals, multipurpose farms and food processors. Spin-off materials, chemistry, and failure analysis information from these projects are being combined with applied materials R&D results for a materials selection and design handbook.

The total DGE program for materials-related work is funded at $4.5 million in FY 1978. Of this is approximately $2.4 million for materials selection/ design studies directly related to systems development for drilling, well logging, electric and nonelectric applications. Additional to these are approximately $850,000 of fluid sampling, chemistry, scale characterization, and instrument development (corrosion meters, pH and CO_2 sensors, etc.) that are required to ascertain the site-specific nature of the corrosive environments.

Materials development projects fall into several categories. These include:

1. <u>Downhole high temperature cements</u>

   810K
   Contractors: Brookhaven, Dowell, NBS, Southwest Research Institute, Battelle Columbus, Universities (Penn State, Rhode Island, and Colorado School of Mines).

2. <u>High temperature elastomeric seal and cable materials</u>

   450K
   Contractors: JPL, L'Garde, Hughes Aircraft, Terra Tek.

3. Materials selection and test development

   645K
   Contractors: Radian, Battelle NW, Case Western Reserve, Daedalean.

4. Alternate materials development

   220K
   Contractors: Brookhaven, Burns & Roe Industrial Services.

OFFICE OF NUCLEAR WASTE MANAGEMENT

(Under the Assistant Secretary for Energy Technology)

There are three technical divisions in this program: Waste Isolation (commercial waste), Waste Products (defense and interim storage) and Fuel Storage and Transfer. No separately identified materials program exists within the organization. However, some materials testing and development work is underway connected with the various processes being examined. Materials work is conducted related to glass suitable for radioactive waste containment, canister materials testing and corrosion/materials compatibility studies. The estimate for materials studies is about 1.0 million dollars.

OFFICE OF MILITARY APPLICATION

(Under the Assistant Secretary for Defense Programs)

The Office of Military Application, under the Assistant Secretary of Defense Programs, directs the research and development, testing, and production of nuclear weapons. Weapon research and development is conducted primarily at the Department of Energy's three nuclear weapon laboratories: Lawrence Livermore Laboratory (LLL), Livermore, California; Los Alamos Scientific Laboratory (LASL), Los Alamos, New Mexico; and Sandia Laboratories at Albuquerque, New Mexico (SLA) and Livermore, California (SLL). Weapons production is conducted at seven government-owned, contractor-operated plants.

The total MA materials program is estimated at $78.6 million in FY 1978 which includes both classified and unclassified research projects.

The objectives of the program are to develop materials and materials technology for national security uses. The research is directed toward basic material science, the understanding and development of advanced materials and fabrication technology, and the development of materials and processes required to produce nuclear and nonnuclear parts. The program is divided into three major areas under the following budget output categories:

1. Supporting Research
2. Materials and Fabrication Technology
3. Process Development

1. Supporting Research

The objective of the Supporting Research area is to pursue basic and applied research which is fundamental to weapon development. Work is directed toward development of analytical procedures and nondestructive test methods to support ongoing weapons development programs and toward development and characterization of materials. Supporting materials research is required where the design engineer's ability to apply materials is limited to lack of understanding of basic materials phenomena. This category of research is performed at the three nuclear weapon laboratories -- LASL, LLL, and Sandia.

Typical research areas include: plutonium and actinide research, chemical high explosives, inorganic material synthesis, chemical characterization support, material characterization studies, surface studies, theoretical material research, equation of state, nondestructive testing, structural materials, and electronic materials.

2. Materials and Fabrication Technology

The objectives of the Materials and Fabrication Technology area are to provide well characterized materials that have physical and mechanical properties compatible with current and advanced weapon designs and that enable the weapon complex to keep abreast of and to respond promptly to new process and fabrication methods required to fabricate systems components and to complement the advanced materials developments. The advanced materials development and characterization efforts include the support of metallurgy, chemistry, metallography, scanning electron microscopy, electron and ion microprobes, thermal and pressure dilatometry, and the most modern analytical techniques, and involve the determination of thermal properties, elastic-plastic properties, mechanical properties, phase equilibria, and chemical characterization. Process and fabrication development efforts include the use of technological capabilities of the laboratories in a wide variety of materials including ceramics, polymerics, and both organics and inorganics, in conventional metal-working processes, and in the welding and joining of materials using one of several techniques including gas-tungsten-arc processes, electron-beam processes, laser techniques, and brazing processes. These capabilities are augmented by extensive computer modeling, systems analysis, and design engineering. This program is carried out at the three nuclear weapon laboratories -- LASL, LLL, and Sandia.

3. Process Development

The objective of the Process Development area is the development of the material processes required to produce nuclear and nonnuclear parts. Development work is performed by the production plants on new materials and production processes for weapons concepts in advanced development, engineering development, and production phases. This area also includes manufacturing research and development work to improve existing processes for efficiency and safety. This program is conducted by the seven production contractors forming a part of the weapon complex -- Bendix, Rockwell International, Monsanto, General Electric, Mason and Hanger, Union Carbide, and duPont.

Typical research areas include: improved resin systems; advanced mold coating materials; polystyrene and urethane foams; alumina ceramics, cermets, and glass ceramics; adhesives; composites; the characterization, pressing, machining, and testing of high explosives; hydrogen absorption and transport in metals; and the fabrication of uranium and plutonium components.

More detailed information about the MA materials program can be requested through the Research Branch of the Office of Military Application (Telephone -- 301/353-5494).

OFFICE OF LASER FUSION

(Under the Assistant Secretary for Defense Programs)

The Office of Laser Fusion is sponsoring research programs to:

1) develop and characterize advanced optical materials for use in high power lasers;

2) develop and characterize high quality glass microspheres of various compositions for use as laser fusion fuel pellets;

3) study the irradiation effects in structural materials which might be used in commercial inertial confinement fusion power plants;

4) develop fabrication and quality control techniques for miscellaneous electronic and optical components required for inertial confinement fusion experiments.

Included in the optical materials research program are efforts at several industrial organizations and national laboratories to develop improved optical materials and coatings. These are being developed for potential laser applications; for example, rods, disks, lenses, windows, polarizer substrates, and Faraday rotators. Glasses with the desired properties for laser fusion applications, for example, are not commonly used and have many properties that are dissimilar with the more routinely melted silicate glasses. Therefore, extensive research is necessary to develop and optimize glass compositions for laser applications.

Inertial confinement fusion target fuel pellets require high-quality glass microspheres of various compositions and with various coatings to contain the deuterium-tritium fuel. The density, thickness, diameter, and local defects of the pellet microspheres must be within close tolerances. For this reason, research on both fabrication and quality control techniques is being performed.

The x-rays, neutrons, and other particles generated in the inertial confinement fusion reaction have energy spectra and time behaviors which differ considerably from those whose effects on possible structural materials have been evaluated. The overall objective of the research on irradiation effects is to determine materials and geometries which can eventually be used for reactor cavity structures in inertial confinement fusion power plants.

Many areas of the inertial confinment fusion program involve the use of advanced, sophisticated electronic or optical components. Thus, research to develop fabrication and quality control techniques for these components is supported.

In summary, the materials-related work being supported by the Office of Laser Fusion is primarily for the purpose of developing materials having desired properties for specific applications and consists of many relatively small efforts.

The materials research effort in the inertial confinement fusion program has a funding of approximately $5.0 million in 1978.

DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH

(Under the Assistant Secretary for Environment)

ELECTRONIC PROPERTIES OF LIQUIDS

L. R. Painter, R. D. Birkhoff and J. M. Heller, Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37916

Work performed under DOE Contract No. EY-76-S-05-3861. FY 1978 operating funding level: $32,000

Techniques have been developed for measuring the electronic structure of condensed materials. These techniques have been used in the study of water, two silicone diffusion pump oils, two linear hydrocarbons, glycerol, bovine albumin, DNA and several low vapor pressure organic solvents as well as on solutions of fucose, cholesterol, and the phospholipid lecithin.

Additional information may be obtained by writing directly to Dr. Linda Painter at the University of Tennessee or by contacting the DOE Technical Representative, Dr. Frank Hudson, Physical and Technological Programs, Division of Biomedical and Environmental Research/EV, U. S. Department of Energy, Washington, D. C. 20545; Phone: (301)353-4066.

INTERACTION OF RADIATION WITH MATTER

W. Brandt and M. Pope, Physics Department, New York University, 4 Washington Place, New York, New York 10003

The work is conducted under DOE Contract No. EY-76-S-02-2386. FY 1978 operational funding level: $335,000

The project studies energy conversion processes in organic systems and investigates the interaction of heavy ions with matter. A summary of work proposed for the current contract period is as follows:

A. Energy Conversion Processes in Organic Systems. Three areas will be investigated:

1. High energy radiation: studies will be made on the origin of supertails found in the α-particle induced damage profile in anthracence.

2. Exciton dynamics: magnetic field studies will be made on triplet exciton fusion in organic crystal alloys.

3. Photophysics and photochemistry of PAH interaction: the interaction of positive carriers in anthracence with HSO_3- in aqueous systems will be investigated.

B. Heavy Ion Physics. The following topics will be investigated:

1. Partition rule of stopping power: penetration measurements with ion clusters will give first direct evidence of this basic phenomenon of many-body physics.

2. Molecule formation by clusters emerging from solid surfaces.

3. Radiation-induced carbon formation on solid surfaces.

4. Theory of electron capture cross sections for innershell excitations and surface-ion interactions.

HIGH-PURITY GERMANIUM FOR GAMMA DETECTORS

R. N. Hall and T. J. Soltys, General Electric Corporate Research and Development, General Electric Company, P. O. Box 8, Schenectady, New York 12301

FY 1978 operating funding level: $38,000

The objectives of the past efforts have been to establish improved methods for the fabrication of large volume coaxial detectors made from high purity germanium and to obtain a better understanding of detector operating characteristics.

Under the current effort a new study has been initiated to investigate the role played by hydrogen in producing fast quenching defects. Hydrogen diffusion coefficients will be determined for high purity germanium single crystals and the effects of hydrogen concentration's or hydrogen gradients on germanium solid-state detector properties will be determined.

Additional information may be obtained by writing directly to the Principal Investigator, Dr. Robert N. Hall at GE or by contacting the DOE Technical Representative, Mr. Robert L. Butenhoff, Physical and Technological Programs, Division of Biomedical and Environmental Research/EV, E-201, U. S. Department of Energy, Washington, D. C. 20545; Phone: (301)353-5349. Several annual reports are available, "High Purity Germanium for Gamma Detectors," Report Nos., CH-3193-1, -2, -3, and -4. Also, refer to R. N. Hall and T. J. Soltys, IEEE Trans. Nucl. Sci. NS-23 No. 1, p. 88 (1976), and R. N. Hall, IEEE Trans. Nucl. Sci. NS-19 No. 3, 266 (1972). The work described above was performed under DOE Contract No. E(11-1)-3193.

CHARACTERISTIC X-RAY SPECTRA OF SODIUM AND MAGNESIUM MEASURED AT ROOM TEMPERATURE USING MECURIC IODIDE DETECTORS

A. J. Dabrowski, G. C. Huth, M. Singh, (University of Southern California, School of Medicine, 4676 Admiralty Way, Marina del Rey, California 90291), and T. E. Economou and A. L. Turkevich (Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637)

Research performed under DOE Contract No. EY-76-S-03-0113. FY 1978 operating funding level: $350,000

The purpose of this portion of the contract at the University of Southern California (USC) is to explore the usefulness of this selection of high purity mercuric iodide crystals as room temperature operable detectors or spectrometers for X-rays in the low energy X-ray region (e.g., less than 5 KeV).

Additional information may be obtained from Dr. Gerald C. Huth at USC or by contacting the DOE Technical Representative, Mr. Robert L. Butenhoff, Physical and Technological Programs, Division of Biomedical and Environmental Research/EV, U. S. Department of Energy, Washington, D. C. 20545; Phone: (301)353-5349. Other reports one may refer to are: M. Slapa, G. Huth, et al, IEEE Trans. Nucl. Sci. NS-23 No. 1, 102-111 (1972); W. Seibt, M. Slappa, G. Huth, Nucl. Instr. Meth. 135, 573-576 (1976); and A. Dabrowski and G. Huth, IEEE Trans. Nucl Sci. NS-25, No. 1, 205-211 (1978).

LIQUID CRYSTAL MAGNETIC DOSIMETER

N. M. Amer, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

FY 1978 operating funding level: $70,000

Liquid crystal materials are being studied. Non-spherical magnetic grains incorporated into a liquid crystal matrix allows the nematic and cholesteric molecular orientation to be coupled to very weak external magnetic fields. This coupling, which is mechanical in nature, is due to the elastic properties of the liquid-crystalline phase and provides the physical basis for the development of a magnetic field dosimeter.

Additional information may be obtained by writing directly to the Principal Investigator, Dr. Nabil M. Amer at LBL or by contacting the DOE Program Manager, Dr. Robert W. Wood, BER (E-201), Washington, D.C. 20545; Phone (301) 353-3213. Available reports are: Amer, N.M., "Ferrocholesteric Liquid Crystals," submitted to Phys. Rev. Letters; Amers, N.M., "Instrumentation for Environmental Monitoring," Vol. IV, LBL-1 (1977). The work described above was performed under DOE Contract No. W-7405-ENG-48, Task No. 4786-2.

RADIATION DETECTOR MATERIALS AND DETECTORS

E. E. Haller, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

FY-1978 Operation funding level: $171,000

The purpose of this effort is to develop and evaluate detector materials and detectors. The project covers both the development of the basic technology of radiation detectors and materials and the associated measurement techniques required for a broad range of radiation measurements. The major portion of the effort is concerned with understanding the basic parameters of detector materials, particularly high-purity germanium, and developing suitable purification and crystal growing techniques. Effort is also devoted to development of new types of detectors that can be used for environmental measurements as well as biomedical and medical instrumentation.

Studies during FY 1978 included work on ultra-pure germanium, ion-implanted semiconductor electrical contacts, thin window low energy loss semiconductor detector surfaces, ultra-pure germanium field effect transistors, identification of semiconductor impurity complexes and the effects of oxygen and hydrogen on the formation of acceptors and donors, and the solid-state physics of radiation damage in germanium by neutrons and protons.

Additional information may be obtained by writing directly to the Principal Investigator, Dr. Eugene E. Haller at LBL or by contacting the DOE Program Manager, Dr. Robert W. Wood, BER (E-201), Washington, D. C. 20545. Phone (301) 353-3213.

The following recent publications have resulted from this effort:

E. E. Haller, "Photoelectric Spectroscopy of Residual Impurities in Ultra-Pure Germanium and Silicon," Proc. of the First Seminar on Photoelectric Spectroscopy of Semiconductors, Moscow, USSR, May 23-25, 1977; Report No. LBL-6431.

E. E. Haller and G. S. Hubbard, "Impurity Complex Formation in Ultra-Pure Germanium," Proc. of the First Seminar on Photoelectric Spectroscopy of Semiconductors, Moscow, USSR, May 23-25, 1977; Report No. LBL-6432.

E. E. Haller, "Isotope Shifts in the Ground State of Shallow, Hydrogenic Centers in Pure Germanium," to be published in Phys. Rev. Letters; Report No. LBL-6148.

G. S. Hubbard, E. E. Haller, and W. L. Hansen, "Zone Refining High-Purity Germanium," IEEE Trans. Nucl. Sci., NS-25, Vol. 1, (1978); Report No. LBL-6441.

E. E. Haller, "A New Method to Determine the Chemical Composition and Structure of Non-Elemental Acceptor and Donor Centers in Ultra-Pure Germanium," IEEE Trans. Nucl. Sci., NS-25, Vol. 1, (1978); Report No. LBL-7217.

E. E. Haller, "Recent Advances in Common Semiconductor Radiation Detectors Materials," IEEE Trans. Nucl. Sci., NS-25, Vol. 2, (1978); Report No. LBL- 7280.

E. E. Haller and F. S. Goulding, "Semiconductor Nuclear Radiation Detectors," chapter in Handbook of Semiconductors, ed., C. Hilsum, to be published in 1978.

R. H. Pehl, "Germanium γ-ray Detectors," Physics Today, November 1977.

A. G. Kazanskii, P. L. Richards, and E. E. Haller, "Far Infrared Red Photoconductivity of Uniaxially Stressed Ge," App. Phy. Letters, 31, (1977) 496.

A. G. Kazanskii, P. L. Richards, and E. E. Haller, "Photoionization of Acceptors in Uniaxally Stressed Ge," to be published in Solid State Communications, 1978.

The above work was performed under DOE Contract No. W-7405-ENG-48, Task No. 2.

DIVISION OF ENVIRONMENTAL CONTROL TECHNOLOGY

(Under the Assistant Secretary for Environment)

Development of material constitutive descriptions for environmental and safety control assessments of energy material shipping container systems.

Funding Level FY 1978 - $60,000 (New Project)

The objective of the project is to assess the value of endochronic plasticity theory for use in impact (dynamic accident) analysis tools being developed by other ECT contractors. The goal of several coordinated ECT projects is to develop efficient finite element codes to predict the impact response of nuclear energy material shipping containers including regulatory conditions and containment failure modes.

Endochronic plasticity does not require yield surfaces; loading-unloading is easy to accommodate, as are strain-rate effects. Because the elastic region is inherently nonlinear in the theory, material dissipation is automatically included. Several dynamic structural response problems have agreed well with experimental results; and computer code efficiency has been improved.

- DOE Project Manager: Dr. Jerry Counts, ECT
  FTS: 233-5487

- ANL Project Manager: Dr. Rich Valentin
  FTS: 972-6143

DIVISION OF INDUSTRIAL ENERGY CONSERVATION

(Under the Assistant Secretary for Conservation and Solar Applications)

Direct Reduction of Aluminum

The program is in the High Temperature Processes Branch of the Division of Industrial Energy Conservation. In 1978, approximately $850,000 has been budgeted for this project. The object of the program is to develop a direct carbothermic reduction process to produce commercially pure aluminum from available ores. This is done by reducing a mixture of bauxite and aluminum silicate ore with coke in a shaft furnace, producing an aluminum-silicon alloy which is then refined. The prime contractor is Alcoa. Funding is also provided for measurement support at the National Bureau of Standards, and Alcoa is subcontracting needed phase diagram work to Carnegie-Mellon University.

The DOE contracting officer is Mr. Ralph Sheneman and the project manager at Alcoa is Mr. Noel Jarrett. The principal investigator in the subcontract is Professor William Philbrook of the Department of Metallurgical Engineering at Carnegie-Mellon.

Energy Conservation Through the Use of Slag and Fly Ash in Cement and Concrete

- Program management by the Alternative Materials Utilization Branch, Division of Industrial Energy Conservation, CS.

- FY 78 funding level: $130,000.

- The objective of this project is to conserve energy in the cement and concrete industries by stimulating the partial substitution of cement by slag and fly ash.

- The National Bureau of Standards is the contractor, performing the following tasks:

  a. To modify the ASTM blended cement specifications to allow a broaden range of substitution.

  b. To develop a more performance oriented standard for blended cement.

  c. To develop a more meaningful sulfate resistance test.

  d. To develop reactivity tests for slag and fly ash.

  e. Industry workshop and publications.

- For more information contact: Dr. Jerome Collins, Chief
Alternative Materials Utilization Branch

DIVISION OF SOLAR APPLICATIONS

(Under the Assistant Secretary for Conservation and Solar Applications)

The specific objective of the directed research and development program for solar heating and cooling is to provide the solar industry and other users with the materials, components, and information needed for cost-effective solar heating and cooling systems. The directed research and development plan defines promising approaches, called paths, for achieving this objective and outlines a systematic program for providing materials, components, and systems designed to establish the cost effectiveness of each approach as rapidly as possible. The directed research and development plan contains ten paths, two for hot water and four each for space heating and cooling. Each path links a method of solar energy collection or rejection with a specific application. A number of tasks have been identified and placed in five categories: collectors, storage and heat exchangers, air conditioning and heat pumps, systems and controls, and non-engineering aspects. The necessity for the development of improved materials is implied in many of these tasks.

Research is underway on concrete materials, improved cover plates, evaluation of coatings, sealants, fluids for solar absorption, insulation materials, protection of glazing materials, polymer coatings, corrosion evaluation and other areas. Further information may be obtained from report DOE/CS-0010, Solar Heating and Cooling Research and Development Project Summaries, Division of Solar Applications, May, 1978. The funding level for these materials projects is approximately $6.0 million.

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EMaCC
FY-1978 Topical Area Report

Published April 1979

U.S. Department of Energy
Assistant Secretary for
Energy Technology
Energy Materials Coordinating Committee
Washington, D.C., 20585

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EMaCC
FY-1978 Topical Area Report

Published April 1979

U.S. Department of Energy
Assistant Secretary for
Energy Technology
Energy Materials Coordinating Committee

Summary and Analysis of Energy

Materials Research and Development

Programs on Selected Topics

FOREWORD

The Energy Materials Coordinating Committee (EMaCC) meets each month to exchange information, discuss materials research and development issues in the energy program, and be briefed by guest materials experts on topics of current and general interest. Members are most generally the DOE project managers with direct programmatic responsibility for materials R&D in their respective divisions.

A special project of the Committee in Fiscal Year 1978 was to conduct an overview survey of contracts managed by member divisions in specific topical areas. Topics reviewed and the panel leaders responsible for coordinating inputs are listed in Table 1. A list of committee members and materials funding levels as reported in the EMaCC Annual Report DOE/US-0002 are given in Tables 2 and 3 respectively.

Table 1

Joining of Materials	E. Hoffman, DOE and A. VanEcho, DOE
Elastomers	R. Nelson, DOE/L. Kukacka, BNL
Catalysts and Catalytic Effects	R. Epple, DOE/D. van Rooyen, BNL
Radiation Effects	K. Zwilsky, DOE
Superconductivity	D. Clinton, DOE/M. Suenaga and D.H. Gurinsky, BNL
Cement and Concrete	L. Kukacka, BNL/R. Reeber, DOE
Alternate Materials	R. Reeber, DOE

This report generally follows the same format as the Fiscal Year 1977 Topical Area Report, DOE/ET-0006 published in January 1978. The report is intended to serve as a chronological documentation of the general level of Fiscal Year 1978 Materials R&D activity in areas above.

Each topic is reviewed in a separate chapter. In addition to an introductory section, each chapter contains an inventory by sponsoring divisions of all contracts. When available, the title, laboratory, principal investigator, DOE program manager, topical area funding, project start and completion dates, an objective or description and some selected key words are given for each project. Funding for National Laboratory activities are generally given for Fiscal year 1978. Industrial and University contractor funding may in some cases be the total over the whole contract period. In a large number of Programs or projects the topical area work is a small portion of the larger effort. For most of these, estimates have been made only of the funding directed toward the topical area.

Preceding the inventory chapters is a chapter called DOE Materials R&D Relationships. This identifies subtopics and interfaces where close coordination between two or more divisions is especially important.

To facilitate acquiring information and editing the report, an EMaCC panel leader was appointed for each topical area. The Chairman edited the report and arranged for the Brookhaven National Laboratory to prepare the final draft and Materials R&D Relationships Chapter.

Most of the materials research and development activities sponsored by DOE are managed by EMaCC member divisions. Additionally in the change from ERDA to DOE several units were reorganized and new units formed. Therefore, some activities managed by non-member divisions are not covered in this report.

This EMaCC report provides a good opportunity, for the DOE divisions involved, to review the overall scope of their topical R&D and to insure the continuation of a sound, comprehensive effort in areas of great significance to energy planning. It also provides the necessary information exchange needed to cross reference related processes and materials. Furthermore, it provides a useful summary to assist in the coordination of the logical and uninterruped progression of new materials through the fundamental and developmental stages to useful industrial applications.

In preparing the report several issues surfaced that were not easily reconcilable with the report format and individual members views. Although not in any way representative of DOE policy or the consensus views of the EMaCC Committee it was felt useful to briefly list the more important of these. They include questions related to:

(1) Formal versus informal coordination between

a. Basic and applied re search projects
b. Applied R&D and mission-Projects.

(2) The present and optimum balance of DOE laboratory/DOE-affiliated University/industry/ and other university funding for basic, applied, and mission Programs.

(3) Most effective means of technology transfer from DOE projects and to DOE projects from the private sector (Aspects of this have been discussed in depth by Teich and Lambright, Federal Laboratories and Technology Transfer: An Interorganizational Perspective, p 425 in Technology Innovation, Westview Press Boulder, Colorado 1977 and The President's Task Force on Technology Innovation, Department of Commerce).

(4) DOE-sponsored technical program review task forces and their integration with national technical society groups and other interest groups.

(5) The effects of limited markets on industrial R&D efforts (this relates to essential high-cost materials developments that affect many energy systems (i.e. high temperature seals, high performance cement and concrete, novel joining methods etc.).

(6) Identification of materials R&D gaps and problems in a consensus document of this nature.

Robert R. Reeber
1978 EMaCC Chairman

Table 2 FY 1978 Membership of DOE Materials Coordinating Committee

Division	Representative
Electrical Energy Systems (EES) Health and Environmental Research (OHER)	A. David Allen
	R.L. Butenhoff
Industrial Energy Conservation (INDUS)	J. Collins
Environmental Control Technology (ECT)	J. Counts
Fossil Energy	T. Cox
Procurement (P)	J. Releford
Power Systems	J. Fairbanks
Fossil Energy	H.E. Frankel
Solar/ET	M. Gutstein
Reactor Development and Demonstration (RRT)	E.E. Hoffman
DMA	(CDR) F. Hughes
Solid Fuel Mining	N. Jensen
Advanced Nuclear Systems and Projects (ANSP)	A.P. Litman
Solar/CS	M. Maybaum
Magnetohydrodynamics	A.W. Postlethwaite
Geothermal	R.R. Reeber
Buildings and Community Systems (BCS)	K. Riegel
Laser Fusion (LF)	C.E. Rossi
Naval Reactors	R.H. Steele
Ast for Policy and Evaluation	J. Stekert (Ad Hoc)
Basic Energy Sciences (BES)	D.K. Stevens
Energy Storage System (STOR)	J. Swisher
Uranium Enrichment	L. Willett
Magnetic Fusion Energy (MFE)	K.M. Zwilsky

Table 3 Funding Levels

Program	Operating Budget Authority (M$)
Materials Sciences	64.0
Advanced Nuclear Systems and Projects	4.6
Reactor Research and Technology	39.0
Nuclear Power Development	10.4
Naval Reactors	35.0
Fusion Energy	9.3
Coal Conversion	6.5
Magnetohydrodynamics	3.5
Fuel Utilization	20.0
Electric Energy Systems	2.5
Energy Storage	5.9
Solar Technology	23.2
Geothermal Energy	4.5
Nuclear Waste Management	1.0
Military Application	78.6
Laser Fusion	5.0
Biomedical and Environmental Research	1.0
Environmental Control Technology	0.1
Industrial Energy Conservation	1.0
Solar Applications	6.0
	321.1

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CHAPTER 1

DOE MATERIALS R&D RELATIONSHIPS

ALTERNATE MATERIALS

Alternate materials as used in this section include R&D projects that can be classified into several categories. These include the following:

1. life-cycle-cost-effective substitutes for existing materials
2. replacements for critical and strategic materials whose supply may be curtailed
3. alternate materials options where materials performance is essential for energy system success
4. the utilization of waste products from energy systems.

Although no single DOE Program is totally dedicated to alternate materials development, alternate materials subprograms are major or minor components of most applied Programs. These alternate materials developments, with a few exceptions, are generally focused at the finished product and utilization end of the materials cycle. Exceptions include the fundamental research activities, waste recycling for polymer/glass pipe, geothermal scale, and fly-ash in cements.

This project compilation of DOE-sponsored work complements and supplements the structural ceramics work reported as a topical area in the FY 1977 EMaCC report DOE/0006 published in January, 1978.

Cement, concrete, and elastomers, being significant subcategories of alternate materials, are discussed in two separate sections of this report.

Although alternate materials as defined above is primarily an applied R&D activity it is indirectly supported by the fundamental research Program. The Materials Sciences Division has 16 projects for composites as listed in Materials Sciences Programs ERDA-77-123, (the FY 1978 report is DOE/ER-0013). Out of \$2.7M for this work, \$1.2M is oriented toward superconductor development. Many additional projects (approximately 48 funded at \$8.M look at fundamental aspects of ceramics and glasses (i.e. structural, sintering, electrical, fracture, etc.). In the same report, 25 projects (\$3.7M) cover photovoltaic and photothermal phenomena. As indicated in DOE/ER0013, this work is in DOE laboratories and universities.

Table 1a gives a cross-section of alternate materials subject areas with associated funding. Four groups, Central Solar, Distributed Solar, Laser Fusion and Military Applications programs, account for \$27.8M, or more than 49% of the alternate materials funding reported. Additional to heat engine work, for which only a summary is available, two large developmental activities are directed at improved photovoltaics and laser fusion target materials. Other specific efforts ($2.1M in Laser Fusion and $1.1M in Military Applications) are in support of laser system development (laser glass and glass fusion targets) and explosives, respectively.

Industrial Energy Conservation has a diversified sub-program with five projects funded for $535K. The remaining projects are fragmented with eight divisions having one each and geothermal two. Table 1b summarizes the funding levels for the various DOE organizations reporting.

Basic research is co-located with applied research at DOE laboratories when possible and appropriate to encourage communication and enhance the transfer of understanding or needs to the respective programs. For the area of ceramic heat engines, additional coordination occurs at the interagency level by means of an annual review meeting.

The Materials Science Division has held several workshops which have brought together industry, university, and DOE laboratory personnel to evaluate specific basic research needs. The most recent, a panel on High Temperature Ceramics will issue their report in April, 1979. Coordination of projects within divisions takes place through a variety of task groups and panels. Materials Sciences Division and Systems Engineering projects are advised by a Research Assistance Task Force and a Fossil Energy Materials Advisory Task Force respectively. Other divisions (i.e. Solar (SERI), Fossil Fuel Utilization, Geothermal, Reactor Research and Technology, etc.) use a variety of industrial, national technical society, and other groups for consultation. These include the Federation of Materials Societies (FMS), ASTM, ASHRAE, ACI, Metals Properties Council, API, ASM, The Engineering Societies Commission on Energy, Inc. and the National Materials Advisory Board.

The recent origins of alternate materials as an uncentralized DOE activity has not permitted significant coordination yet to develop between the various sponsoring groups.

In view of the large diversification of alternate materials work among DOE units involved with near term technologies, this compilation should be especially useful as a first step in identifying related projects and objectives. Increased coordination can improve the cost-effectiveness of all activities. A closer appraisal of successes and failures of present projects can help identify necessary applied R&D important for the development of cost-effective new materials. There also may be an opportunity to benefit from work done other than under DOE sponsorship. In most cases, commercial application will require standards development involving different interest groups.

Table 1a

Alternate Materials Subject Area

Alternate Materials	No. of Projects	Funding ($K)	Divisions**
Heat Engine Materials	-	$ 17,000	O,P
Photovoltaics*	3	16,700	C
Fuel Cell Materials	-	4,230	O
Laser Fusion Targets	5	4,050	I
Composites	14	3,566	C,D,E,I,J,K,L,M
Coatings	16	2,744	C,I,M
Plastics	9	2,772	I
Glass	12	2,102	M
Explosives	6	1,145	C,F,P
Ceramics (Heat Exchangers)	4	1,092.5	C
Large Systems Support	6	915.5	B,K
Insulation	3	850	A,C,H,I,N
Metals and Alloys	7	764.4	A,K,J
Waste Utilization	2	560	G,O,L
Polymers (Tertiary Recovery)	2	819	C,I,f
Misc.	5	503	

*Subcontracts are significant parts of the overall effort.

**See Table 1b for abbreviations

Table 1b DOE Funding Levels for Alternate Materials

	No. of Projects	Approximate Funding, FY 1978 (in thousands)
Division of Advanced Systems and Materials Production (A)	1	$ 50
Division of Building and Community Systems (B)	1	600
Division of Central Solar Technology (C)	23 (1, no funding)	13,181
Division of Distributed Solar Technology (D)	4	10,697
Division of Energy Storage Systems (E)	1	100
Division of Electric Energy Systems (f)	1	150
Office of Fossil Energy, Division of Systems Engineering (F)	1	303
Division of Fossil Fuel Extraction (G)	1	350
Division of Fossil Fuel Processing (H)	1	290.4
Office of Laser Fusion (I)	25	5,560.3
Division of Geothermal Energy (J)	2	230
Division of Industrial Energy Conservation (K)	5	535
Division of Materials Sciences (L)	15**(some partly Alt. Matls)	916
Division of Military Application (M)	9	2,020
Division of Reactor Research and Technology (N)	1	200
Division of Fossil Fuel Utilization (O)	-	12,169
Division of Transportation Conservation (P)	-	9,200
Total	91*	$56,552

*Projects for (O) and (P) summarized in Table (9), Chapter 2.

RADIATION EFFECTS

The nuclear technologies have created new environments for materials in service. The DOE effort related to radiation effects involves a broad variety of programs. Table 2 lists the groups participating in the present survey, the technical areas funded, the number of active projects, and the approximate funding levels of each group.

Most of the 71 projects listed are associated with improving resistance to radiation damage and radiation-enhanced deterioration of fuels, components, electronics, and structural materials. This work is directed toward solving specific problems associated with systems being developed or in service. The projects vary from short term investigations seeking performance improvements for materials in existing systems to long range projects in fusion evaluating radiation effects on first-wall candidate materials. Two other projects (Electric Energy Systems and Advanced Nuclear Systems and Projects), involve the development of irradiated cross-linked polyethylene cables and rhodium-ruthenium alloys. They have been cross-listed with the alternate materials section. Comprehensive basic research activity in the Division of Materials Science includes funding for studies whose object is to obtain a fundamental understanding of radiation effects. They provide strong support for the applied and developmental projects that comprise the majority of work for this problem area.

The studies of radiation effects on metals, cladding, and structural materials sponsored primarily by the Division of Materials Sciences, the Division of Reactor Research and Technology, and the Office of Fusion Energy are reinforcing, since they span the spectrum from the fundamentals of radiation damage to immediate applications in the fission and long term applications in fusion reactor environments. Mechanisms to coordinate this effort exist within the Department of Energy, e.g., EMaCC. These also include joint irradiation experiments, participation in the same task groups, workshops, and exchange of publications. Fuel composition burnup, shape, and radiation environment vary greatly for the different reactor applications. Each technology is responsible for solving the problems unique to its system.

CATALYSTS AND CATALYTIC EFFECTS

The Department of Energy supports research on catalysts and catalysis at a cost estimated at $16M for FY 1978, as shown in Table 3. The listing includes some projects devoted only partly to catalysts. There are larger development projects where some catalyst research also takes place, but they have been omitted from the listing.

Table 2. DOE Funding Levels for Work in Progress on Radiation Effects

Participating group	Subject area covered	No. of projects	Approximate funding, FY 1978 (in thousands)
Division of Electric Energy Systems	Irradiation of polyethylene cable	1	$ 150
Office of Fusion Energy, Division of Development and Technology	Radiation effects on candidate first-wall materials	10	2,800
Office of Laser Fusion	Laser reactor materials	2	160
Division of Materials Sciences	Fundamental studies of neutron irradiation, electron irradiation, defects in metals, defects in nonmetallic systems, electron microscopy, optical properties, void nucleation and growth, ceramics, theory of condensed matter, low-temperature effects, kinetics	31	9,500
Office of Military Application	Integrated circuits, metallic glasses, radiation-enhanced stress corrosion	3	620
Division of Nuclear Power Development	LWR fuel performance	3	5,600
	HTGR fuel development and graphite	3	3,400
Division of Reactor Research and Technology	GCFR fuels and materials engineering	2	1,600
	LMFBR advanced fuels	3	680
	LMFBR absorbers	1	1,450
	LMFBR cladding and structural materials	11	8,450
	Waste fuels recovery	1	50
Total		71	$34,560

Table 3. DOE Funding Levels for Research on Catalysts and Catalytic Effects

	No. of Projects	Approximate funding, FY 1978 (in thousands)
Division of Chemical Sciences	34	$ 3,943
Division of Energy Storage Systems	3	599
Office of Fossil Energy		
Division of Fossil Fuel Processing		
100% Catalyst	10	2,270
Substantially Catalyst	14	3,011
Division of Program Control and Support, University Programs		
100% Catalyst	18	1,316
Substantially Catalyst	7	872
Division of Materials Sciences	18	4,003
Office of Military Application	1	70
Total	107	$ 16,084

As seen in Table 3, DOE emphasizes catalyst R&D for Fossil Fuel conversion. Almost half of the total of $16M was spent on applied work through two divisions of the Office of Fossil Energy i.e. Fossil Fuel Processing and Program Control and Support. Practically all of this work involves actual applications or improvements in existing or potential industrial processes, often at the small pilot plant stage. (In addition, many of the fundamental programs, discussed separately, also will have a strong longer-range influence on fossil fuel utilization). At least 85% of the $5.3M funding by the Division of Fossil Fuel Processing is oriented towards direct application, and this is about equally divided between improving specific coal conversion processes and improving the catalysts used. Approximately 10% is devoted to a study of the mechanism of the overall chemical reactions, and a small effort involves the mechanisms of catalysis as such.

The Division of Program Control and Support, University Programs, supports 25 projects, with an outlay of about $2.2M. The bulk (75%) of funding is for studies of coal conversion, consisting of direct, process oriented R&D on gasification and/or liquefaction. Catalyst development, mechanistic aspects and purification studies (removal of nitrogen and sulfur) make up the balance.

There is no sharp line of demarcation between the 3 phases of catalyst research, i.e. fundamental characterization of catalysts, their basic behavior under idealized conditions and their practical application.

Basic characterization of parameters involved in catalytic reactions, catalyst structure, and adsorbed species are supported on a broad front by the Division of Materials Sciences. Out of some 27 related programs, 18 were sufficiently confined to catalyst research for inclusion in this EMaCC report. An additional 9 programs are included in the Materials Sciences Programs compiled and issued in September, 1978, where catalysts are involved only to a lesser degree in larger diversified programs. The latter include studies involving crystallography, solid state bonding, charge transfer, structure, new or modified compounds, surfaces, interfaces, and specific experimental techniques. The application-oriented catalyst research programs include a variety of catalytic materials, metallic, intermetallic, semi-conductors, ceramics, composites, thin films etc.): the evaluation of electron-atomic, molecular- and crystal structure, adsorption, thermodynamics, electrochemical effects, as well as the use of sophisticated tools for studying and characterizing catalysts and catalytic reactions.

A small research effort is in process evaluating catalytic activity enhancement with radiation effects. If this approach shows potential, there is a significant opportunity for more interaction between sub-programs on general radiation effects and catalysts.

New efforts toward technology transfer of basic work are underway in the Chemical Sciences Division, which sponsors 34 projects at $3.9M. The scope includes the chemical and energy states of adsorbates on catalytic surfaces, kinetics, catalyst preparation, catalyst activity, and catalyst selectivity. For these projects, the properties of catalysts are being related to specific processes, such as the synthesis of hydrocarbon fuels, chemical processing, and conversion reactions. More detailed information is contained in FY 1977 project summaries (Research in Chemical Sciences, DOE/ER-0002, February, 1978).

SUPERCONDUCTORS

The obvious practical significance of superconductors has opened up several areas of interest to the DOE. (See Tables 4a and 4b for details of degree of support). A large magnet development effort is supported by the Office of Fusion Energy (over $10 million) of which about $3.8 million is for materials, with one of the main objectives being the development of superconducting magnets to support the fabrication of test coils for TNS ("The Next Step") in the 1980's and the Experimental Power Reactor in the 1990's. Coordination is essential here to get the desired balance between design, analysis and fabrication, properties of materials, and testing of coils so that an industrial fabrication (large coil) project can produce the hardware needed for future use.

Other large DOE Superconducting Projects include the Intersecting Storage Accelerator (ISABELLE) and the one hundred meter ac Superconducting Power Transmission facility at the Brookhaven National Laboratory, the Energy Doubler/Saver at the Fermi National Laboratory, and the Tokamak Large Coil Test Facility at the Oak Ridge National Laboratory.

Although not DOE funded, close coordination is maintained with the National Science Foundation sponsored Heavy Ion Cyclotron facility at the Michigan State University and superconducting generator work sponsored by the Navy, Air Force, and the Electric Power Research Institute (EPRI).

Funding for the High Energy Physics and Magnetohydrodynamics superconducting projects also supported by DOE are not included in the listing. Other DOE applications for superconductors are associated with energy storage; work on alternating current generators, and superconducting materials for direct current homopolar high current sources.

In addition, many basic aspects of superconductivity (e.g. degradation, ductility, effects of stress and radiation, development of new designs, processing and materials) are supported by the Materials Science Division ($5.1 million). There is potential application of this work to other energy systems. Supporting the total R&D effort on superconductors, there are supporting engineering developments and research on materials systems and refrigeration in the Division of Electric Energy Systems ($2.5M). Since the EPRI has recently funded an effort ($19.0M) to build a superconducting generator and in view of the broad scope of

Table 4a DOE Funding Levels for Research on Superconductor Materials

Participating Group	No. of Projects	Approximate** Funding, FY 1978 (in thousands)
Division of Electric Energy Systems	1	$ 200
Office of Fusion Energy, Division of Development and Technology	11	3845
Division of Energy Storage Systems	2	195
Division of Material Sciences	33	5,114
Totals	47	$9,354**

Note: *11 out of these 33 form part of large projects where the scope is not confined to superconductivity. Rough estimates of the fraction of funding actually used for superconductivity were made, and are included in the FY 1978 totals.

**Does not include the large scale devices that use superconducting components, which are discussed in the text.

Table 4b*

Funding for Superconductor Projects

Superconductivity Subsections	# of Projects	Funding* $ (Thousands)	Division of Support
Processing and Fabrication	9	4176	DEES DDT DMS
Properties			
1) general	7	1855	
2) magnetic	5	800	DMS
3) electronic	6	665	
4) effect of metallurgical structure	7	1050	
5) low temperature	4	137 4,507	
Radiation Effects	2	276	DMS, DDT
SQUID	1	200	DMS
Energy Storage	2	195	ESS

*Does not include the large scale superconducting devices discussed in the text, such as for ISABELLE and MHD.

DOE activities, it is important to maintain a high level of information exchange to ensure timely technology transfer between all National Programs. Co-locating basic research with applied research for this work has enhanced communication. An excellent example of this would be the commercialization of the Brookhaven method for superconducting wire manufacture initiated with basic materials support. Other information exchange has included an EMaCC industry meeting held in 1975.

(The foreword of a book, Metallurgy of Superconducting Materials, Academic Press (1979) recently written by T. Luhman and D. Dew-Hughes was very useful in preparing the above summary on Superconductors).

CEMENT AND CONCRETE

Cement and concrete are important materials because they are durable and inexpensive. Most often these materials are manufactured on or near the construction site with methods that have changed little over the past forty years. Concrete chemistry is complex, and because of lack of control in the manufacturing process, concrete properties are generally much more variable than other engineering materials. Large scale applications require careful control despite increasingly diversified raw material supplies.

Because of their initially low cost per pound, these materials have an inherent advantage when examined for their potential cost-benefit to the user. Significant investments are being made by 26 DOE-sponsored projects in FY 1978. Organizations funding this work within DOE are shown in Table 5. The work can be best characterized as spanning the spectrum between applied R&D and demonstration. A small basic research effort is being carried out within the Industrial Conservation Division. This is strongly influenced by the large energy requirements for cement manufacture.

The present work is short to medium term applied R&D and mission oriented. There is potential application of this work in a number of other energy systems. Opportunities are available for U.S. commercialization of European light-weight insulating concrete technologies. Such work would profit from the inputs and needs of existing projects.

Some fundamental research opportunities have been previously identified in the Materials Sciences Overview Workshop on Engineering. A complete review of the state of cement and concrete R&D is discussed and documented in a National Materials Advisory Board Report, Status of Cement and Concrete R&D in the United States to be published in late summer of 1979.

Table 5. DOE Funding Levels for the Development of Cement and Concrete

Participating Group	No. of Projects	Approximate Funding, FY 1978 (in thousands)
Division of Central Solar Technology and Ocean Thermal Systems	1	$ 75
Division of Solar Applications	2	313
Division of Energy Storage Systems	1	302
Division of Geothermal Energy	8	1,066
Division of Industrial Energy Conservation	7	785
Division of Nuclear Power Development	1	600
Division of Reactor Research and Technology	2	1,450
Office of Waste Isolation, Division of Waste Products	4	770
Total	26	$5,361

A technology transfer initiative accomplished has been the formation of an American Petroleum Institute Task Group for geothermal well cement standards. This includes the National Bureau of Standards, a broad cross-section of the well cementing industry, well users, and university experts.

JOINING METHODS

R&D efforts on joining methods are required for a multitude of reasons, including obtaining better performance of components, improving existing joining methods, introducing more efficient techniques, providing sound joints from repairs made in the field, and keeping pace with new developments where special materials and exposure to different conditions and environments become necessary. The list of projects that are sponsored in this area by DOE are divided into 1) specific divisions, Table 6a, 2) materials and processes, Table 6b, and 3) specific industrial or other applications, Table 6c. The tables provide a basis for improved transfer of technology between different DOE Divisions, as well as for analyzing the balance of funding between the different categories listed. The work now underway covers some near-term as well as several long-term applications.

Joining problems cut across Programs. Improved methods can significantly affect all energy systems reliabilities as well as their overall costs. Work planned or ongoing includes joining applied R&D for improved transition joints, fuel assemblies, non-metals in solar collectors, metal to non-metals for specialized properties, the annealing of welds and the standardization of methods. New methods developments are being considered such as pulsed magnetic and laser methods, explosive, electrochemical, and electron beam techniques.

Substantial expertise has been developed by the nuclear industry in the field of metal joining. Technology transfer to other industries and external to DOE has been taking place through American Welding Society and American Society for Metals Committees sponsored in large part by the reactor development Program.

The Materials Sciences Division's work on welding is co-located with applied efforts at the DOE laboratories to help enhance the technology transfer. Also, the Materials Sciences Division has initiated a contractor's meeting and a newsletter on this subject.

Table 6a DOE Funding Levels for Joining Methods Project

Participating Group	No. of Projects	Approximate funding, FY 1978 (in thousands)
Division of Advanced Systems and Materials Production, ETN (a)	3	$ 164
Division of Central Solar Technology, OTEC (b)	2	60
Office of Conversation and Solar Application (c)	3	306
Division of Energy Storage Systems, ETN (d)	1	76
Division of Fossil Fuel Processing, ETN (e)	1	230
Office of Fusion Energy, ETM Division of Development and Technology (f)	1	60
Division of Planning and Projects (g)	4	74
Office of Military Application, DP (h)	4	390
Division of Materials Sciences, ER (i)	6	449
Division of Nuclear Power Development, ETN (j)	1	52
Division of Reactor Research and Technology, ETN (k)	8	1,710
Division of Fossil Fuel Extraction (l)	1	390
Total	34	$3,961

Table 6b

Joining Methods Funding by Category of Application

Category	# of Projects**	FY 1978 Funding (Thousands)	Divisions Involved*
Special Techniques (Laser, Electron beam, diffusion, electrochemical electroslag, explosive pulsed magnetic)	7.5	526	d,g,h,i,k
Specific Applications (Transition joints heavy section for pressure vessel drilling techniques)	6	1525	k,e,l
General Materials (Fe & Ni base)	9.5	846	a,b,i,j,k
Special Metals (Ir, Ti, Be, Mo, U)	4	232	a,g,h
Non-Metals	4.5	333	c,g,h
Special Properties (Stress corrosion, structure, embrittlement, low stress	4.5	499	f,i,k
Total	36	3,961	

*See Table #7a for code

** ½ Project counted in each of two categories.

Table 6c

Joining Methods Funding by Area of Application

Application	# of Projects	FY 1978 Funding (Thousands)	Divisions Involved
Pu-Fuel	3	164	a
Ocean Technology	2	60	b
Solar	3	306	c
H_2 Transmission	1	76	d
Fossil Fuel	1	230	e
Superconductivity	1	60	f
Fusion	4	74	g
Military (New methods)	4	390	h
Basic	6	449	i
Nuclear	1	52	j
Breeder	8	1710	k
Drilling Technology	1	390	l

ELASTOMERS

Elastomeric materials are of importance in many energy-related applications. Experience has shown that there is an urgent need for improved retention of properties under some field conditions. As is evident from the summary, Tables 7a and 7b, a little over $1M is being spent by six DOE Divisions. This primarily supports applied and developmental work on elastomers for specific applications or environments.

Elastomers for drilling technology and production well fluid control form a common interest between the Office of Fossil Energy, the Division of Geothermal Energy, and the Division of Fossil Fuel Extraction. Nearly one-half of the total support in elastomers is from this group. This work will be useful for other Programs with drilling needs such as Nuclear Waste Management and the Office of Basic Energy Sciences.

Seal resistance to elevated temperature and chemicals is sought to improve drill bit, downhole pump, and packer performance. One of the DGE projects includes as a specific objective evaluation of the state-of-the-art and technology transfer. This is important where many different groups within and outside of the DOE are involved. Solar energy storage has one project. Another effort is devoted to evaluating and improving radiation resistance. Here embrittlement can be a problem with many elastomers and polymers. Additives and composites are being examined in order to obtain improved materials and performance. The remaining projects deal with basic properties such as aging, pressure-temperature-time effects on elastomer behavior, and stress relaxation.

An example of where a specific initiative has been made to increase technology transfer, and more directly, involve users and suppliers in the developmental process has been accomplished through formation of an ASTM Geothermal Seals Subcommittee and arranging workshop sessions. Proceedings of a joint ASTM-DOE industrial state-of-the-art workshop has been distributed to participants and will be published as a DOE report in the spring of 1979. Also, a workshop was sponsored by DOE/DMS in June 1978 at Case Western Reserve on the basic needs for energy applications of polymers; the complete proceedings of this workshop were published in August of 1978: "Polymer Materials Basic Research Needs for Energy Applications," Conf. No. 780643.

Table 7a DOE Funding Levels for Elastomer Development

Participating Group	No. of Projects	Approximate funding, FY 1978 (in thousands)
Division of Energy Storage Systems	1	$ 175
Office of Fossil Energy, Division of Systems Engineering	1	60
Division of Geothermal Energy	4	418.5
Division of Materials Sciences	1	96
Office of Military Application	3	250
Division of Reactor Research and Technology	1	120
Total	11	1119.5

Table 7b

ELASTOMERS

FY 1978 Funding Levels Application

Area of Interest	No. of Projects	$ Funding in FY 1978 (Thousands)	Division Involved
Drilling Technology	5	478.5	DGE, Off, Foss. En.
Solar Energy Storage	1	175	ESS
Basic Properties, Composites	3	246	DMA, DMS
Radiation Exposure Accelerated Aging	2	220	RRT, DMA
Total	11	1,119.5	-

Table 8 lists totals for the seven materials categories in this report. The report completes the survey (initiated with FY 1977 Topical Area Report DOE/ET 0006) of topics considered by EMaCC to be of important programmatic interest for energy development.

Table 8 Summary of Funding for the 7 Categories in the 1978 Report

Category	Approximate Total Funding, Millions
Alternate Materials	$ 56.6
Radiation Effects	34.6
Catalysts and Electrocatalysts	16.1
Superconductors	9.4
Cement and Concrete	5.4
Joining Methods	4.0
Elastomers	1.1
Total (approx.)	$ 127 million

CHAPTER 2

DETAILS OF DOE MATERIALS PROGRAMS

ALTERNATE MATERIALS

Introduction

Alternate materials include those under development as cost-effective substitutes for existing materials, as replacements for critical and strategic materials, and as end products for the consumption of energy conversion or processing system wastes. Although this activity primarily involves non-metallics, some metal and alloy development is included. Materials such as plastics, glasses, ceramics, composites, insulators, and explosives are discussed below; cement, concrete, and elastomers, are reviewed in separate sections of this report. Structural ceramics was covered as a topical area of the FY 1977 report, DOE/ET-0006 published in January 1978. Some major additional activities not reported there are summarized in this report.

This project compilation of DOE-sponsored work was made to assist DOE and others in identifying the current distribution of DOE funding in this materials area.

The approximate DOE funding for alternate materials in FY 1978, included in this section was $56.6 million. A short synopsis of basic research supporting this activity is also given. Further information on the Materials Science Program can be obtained from the summary booklet Materials Science Programs, ERDA-77-123, November 16, 1977. The FY 1978 operating level for projects in this Division was $59.7 million in outlays.

Large projects are directed at improved photovoltaics, laser fusion target materials, and ceramics for heat and/or transportation applications. Other specific efforts are directed toward laser system developments and explosives respectively. A significant part of laser fusion target materials (1 project $1.4M) can also be summarized under plastics. The remaining projects in this category (8 totaling $1.2M) are funded by four other divisions.

A large portion of work reported for composites (3 projects totaling $2M) is directed toward the development of large windmills. The remainder (11 projects involving $1.5M) is diversified among eight other divisions. Coating activities are primarily funded by Fossil Fuel Utilization ($1.6M), the Office of Fusion Energy (4 projects totaling $1.5M), and Central Solar (11 projects totaling $1M). Central Solar had several larger projects involving fused salt and liquid metal heat exchanger systems. A fraction of the total budgets for these projects (ranging from 10 to 30%) was associated with alternate materials development. This work and ceramic heat exchanger development involved about $1.8M. The remainder, as reported, included materials made from waste products, insulation materials, polymers for tertiary oil recovery and miscellaneous other projects involving liquids, etc.

The Divisions of Fossil Fuel Utilization, formerly Conservation Research and Technology, and Transportation Conservation did not participate in this survey. Because of the significance of their projects a summary table, (Table 9), has been compiled from available information concerning their work. A total of $12.2 million for ceramic and metallic coatings, monolithic ceramics technology, metallic surface fabrication technology and fuel cell materials activity as reported by Fossil Fuel Utilization, EMACC FY 1978 Annual Technical Report/DOE/US-0002, August 1978, is identified as alternate materials activities. A minimum of $50.1 million over a FY 1977-1981 time frame has been estimated for Transportation Conservation's heat engine systems projects. The greater portion of this, $43 million, is ceramic component testing for improved performance of the Detroit Diesel Allison IGT 404 gas turbine engine. A very approximate breakdown of this funding is given in the two tables that follow, which include the effort devoted to materials and materials testing for this systems-oriented project.

TABLE 9a

Approximate Funding Distribution for Phased Development

	(K)
Materials Development	$ 900
Component Design	900
Part Testing	2,050
Evaluation	1,250
Metal-related problems	2,200
FY 1979 Total	$ 8.3 million

TABLE 9b

Summary Table* of Additional DOE Alternate Materials Projects with Approximate Funding Levels

<u>Division of Fossil Fuel Utilization**</u>

		(K)
1.	Ceramic Coatings NASA Lewis and subcontractors	$ 812
2.	Ceramic Coating Support Technology	567
3.	Monolithic Coating Development	250
4.	Monolithic Ceramic Technology	4,230
5.	Metallic Surface Fabrication Technology	2,700

*Approximate funding levels as obtained from Interagency Ceramic Turbine Review Meeting.

**Project descriptions given in DOE/US-0002, August 1978.

Division of Fossil Fuel Utilization (Cont'd)

6. Fuel Cell Materials

Platinum substitutes	$ 200
Zirconia porous tubes	100
Ceramic matrix materials	2,000
Carbon substrates	1,010
Solid oxide electrolyte materials	300
Approximate Subtotal FY 1978	$ 12.2 million

Division of Transportation Conservation

		FY 1979	FY 1978
1.	Ceramic Applications in Turbine Engines Detroit Diesel Allison	$ 8,300	$ ~6,000
2.	Development of Ceramic Regenerator Systems for Gas Turbine Engines Ford	634	1,356
3.	Evaluation of Ceramics for Stator Applications	400	900
4.	Ceramic Heat Exchanger Fabrication	400	200
5.	Fracture Toughness Tests for Ceramics NASA	150	250
6.	Sialon Materials Development United Technologies Research Center	60	60
7.	Improved Ceramic Heat Exchanger Materials General Electric	60	60
8.	Advanced RSSN Development Ford	125	125
9.	Ultrasonic Characterization of Ceramics NASA-Lewis	70	
10.	Analysis & Evaluation of Data and Specimens from 3500 hr. Durability Tests NASA-Lewis	40	
11.	3500 hr. Durability Testing of Commercial Ceramic Materials AIRResearch	182	270

Approximate Subtotal FY 1977-81 $ 50.1 million

Approximate Subtotal FY 1978 $ 9.2 million

Estimated Total Additional DOE Alternate Materials for Heat Engines $ 21.4 million

Division of Materials Sciences

Office of Energy Research

Alternate Materials

The Materials Sciences projects support research aimed at understanding basic materials phenomena and properties important to the energy technologies. It is fundamental research and its prime objective is not the development of alternate materials. However, this research underpins the materials development efforts, and hence the entire activity could be considered as ultimately directed toward the discovery of alternate materials.

Research is undertaken primarily at national laboratories and at universities, with minor participation by industrial laboratories where appropriate. Significant efforts are under way on ceramic materials (both electrical and mechanical properties), composites, hydrides (mechanical properties and hydrogen storage), liquid and amorphous alloys, refractory and ferrous alloys, rare-earth metals and compounds, polymers, and semiconductors. Neutron scattering is used to study the structure and dynamics of materials at unique reactor facilities. The effect of all types of radiation on the behavior of the materials is a subject of continuing study. Research on the phenomenon of superconductivity has led to a number of alternative methods of preparing multifilamentary superconductors for magnetic applications and electrical transmission applications. Alternative radiation-resistant materials and methods for preparing solar energy conversion materials have resulted from the basic research support provided by this Program.

Division of Advanced Nuclear Systems and Projects

Title: Rhodium-Ruthenium Alloy Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: A. S. Schaffhauser   DOE Program Manager: C. O. Tarr

Topical Area Funding: $50,000

Project Starting Date: FY 1975   Completion Date: FY 1980

Objective or Description: Lower cost replacements for iridium and platinum-base alloys are required for heat sources in space and terrestrial isotopic power systems. The new alternate materials should have lower densities, equivalent compatibility with graphite and fuel to 1400°C, plus good high strain rate impact strength and fabricability. Rh and Ru could be available in quantity from a national nuclear fuel recycle program. This would alleviate a strategic materials problem.

Key Words: Rhodium, ruthenium, Rh-Ru alloys, isotopic power, strategic materials, noble metal alloys.

Division of Central Solar Technology

Title: Cost-Effective Textured Amorphous Silicon Thin-Film Coating for Solar Thermal Conversion.

Contractor: Argonne National Laboratory

Contract or Grant No.: W-31-109-ENG-38

Principal Investigator: R. Griffith   DOE Program Manager: M. Gutstein

Topical Area Funding: $75,000

Project Starting Date: 5/19/76   Completion Date: 6/30/77

Objective or Description: To increase the absorptance of present silicon, metal-selective absorber stacks from about 0.8 to better than 0.9. The potential application is for absorption up to about 600°C for future-generation solar thermal receivers. Improved performance is to be accomplished by investigating the unique properties of doped amorphous silicon rather than pure crystalline silicon as absorber layer.

Key Words: Thin-film coating, silicon coating, selective absorber, doping, absorptance.

Title: Optical Properties of Metallic Surfaces, Small Particles, and Composite Coatings

Contractor: Cornell University

Contract or Grant No.: 26-775-03-1456

Principal Investigator: A. J. Sievers   DOE Program Manager: M. Gutstein

Topical Area Funding: $160,000

Project Starting Date: 3/14/77   Completion Date: 4/1/78

Objective or Description: To investigate the optical and physical properties of metals, alloys, and composite coatings.

Key Words: Metals, alloys, composite coatings, thin-film coating, multiple scattering theory, selective absorbers.

Title: Silicon Coatings for the Protection of Reflective Surfaces

Contractor: Dow Corning Corporation

Contract or Grant No.: ET 78-C-02-4614

Principal Investigator: W. E. Dennis   DOE Program Manager: M. Gutstein

Topical Area Funding: FY 1978: $71,000

Project Starting Date: 1/78   Completion Date: 1/80

Objective or Description: To identify a durable, cost-effective coating for solar concentrators.

Key Words: Silicon coating, thin-film coating, optical properties, reflective surfaces, weathering.

Title: Development of Plastic Heat Exchangers for OTEC

Contractor: DSS Engineers, Inc. Fort Lauderdale, Florida

Contract or Grant No.: EY-76-C-05-5165

Principal Investigator: G. K. Hart DOE Program Manager: E. Kinelski

Topical Area Funding: $280,000 for 2 yrs.

Project Starting Date: 8/24/76 Completion Date: 10/23/78

Objective or Description: This project provides an in-depth review of polymeric materials and material composites that have been proposed for plastic heat exchangers. Test apparatus is being designed to achieve accurate and significant tests for predicted durablity and performance of plastic heat exchangers in an OTEC environment. Properties such as long-term strength, service life, thermal conductivity, permeability of heat transfer surface to working fluid and sea water, and anti-fouling potential are involved.

Key Words: Plastic, composites, polymeric materials, thermal conductivity, heat transfer, core test condenser, ammonia, sea water.

Title: Improved Absorber Coatings for Thermal Utilization of Solar Energy

Contractor: Engelhart Minerals and Chemicals Corporation, Edison, New Jersey

Contract or Grant No.: AER-75-17470

Principal Investigator: R. Farrauto DOE Program Manager: M. Gutstein

Topical Area Funding: $254,000

Project Starting Date: 7/76 Completion Date: 7/78

Objective or Description: To develop selectively absorbing films prepared by thermal decomposition of metallo-organic solutions for solar receivers at 300 to 700°C.

Key Words: Selectively absorbing films, thermal decomposition, metallo-organic solutions, thin-film coating, silver.

Title: Optimization of Exxon's High-Temperature Coating for Solar Applications

Contractor: Exxon Research and Engineering Co., Linden, New Jersey

Contract or Grant No.: EG-77-C-02-4270A000

Principal Investigator: A. H. Muenker DOE Program Manager: M. Gutstein

Topical Area Funding: $79,251

Project Starting Date: 7/15/77 Completion Date: 5/15/78

Objective or Description: To develop a low-cost solar-receiver coating that can be applied by using conventional paint-spraying methods, that has a solar absorptance $\alpha_s \geq 0.95$, and has optical and mechanical stability up to 700°C.

Key Words: Solar receiver, thin-film coating, paint spraying, stability, optical properties.

Title: Liquid Sodium/Central Receiver Development

Contractor: General Electric Corporate Research and Development

Contract or Grant No.: EY(FY)-C-03-1725

Principal Investigator: G. R. Fox DOE Program Manager: G. Kaplan

Total Area Funding: $675,000; Topical Estimate: 10%

Project Starting Date: 2/78 Completion Date: 12/78

Objective or Description: To develop a central receiver which uses liquid sodium to transfer power from a lower to a Rankine-cycle power conversion system.

Key Words: Central receiver, liquid sodium, liquid metal, Rankine cycle, thermal properties.

Title: Low-Cost Silicon Solar Array

Contractor: Jet Propulsion Laboatory (NASA)

Contract or Grant No.: EX-76-A-29-1012

Principal Investigator: R. Forney DOE Program Manager: M. Prince

Topical Area Funding: $2 million

Project Starting Date: Completion Date: Ongoing

Objective or Description: Research and development of low-cost transparent encapsulant materials for terrestrial solar arrays.

Key Words: Optical properties, moisture barrier, hermetic seal, permeability, durability.

Title: Low-Cost Silicon Solar Array

Contractor: Jet Propulsion Laboratory (NASA)

Contract or Grant No.: EX-76-A-29-1012

Principal Investigator: R. Forney DOE Program Manager: M. Prince

Topical Area Funding: $6 million

Project Starting Date: Completion Date:

Objective or Description: Development of low-cost silicon production processes and crystal growth techniques for producing large-area silicon sheets.

Key Words: Solar-grade silicon, crystal quality, impurities, structural properties, chemical properties, electrical properties, microcracks, thermal stress.

Title: Molten Salt/Central Receiver Development

Cotractor: Martin-Marietta Corporation

Contract or Grant No.: EG-77-C-03-1724

Principal Investigator: T. R. Tracey DOE Program Manager: G. Kaplan

Total Funding: $631,000; Topical Estimate: 20%

Project Starting Date: 9/77 Completion Date: 9/78

Objective or Description: To develop a conceptual design for a cost-effective advanced central receiver power plant which utilizes a molten-salt heat transfer system which achieves thermal to mechanical efficiencies within five percent of state-of-the-art Rankine turbine efficiencies.

Key Words: Molten salt, heat receiver, thermal properties, high temperature, central receiver, direct absorption.

Title: Storage Fluid Evaluation

Contractor: Martin-Marietta Corporation

Contract or Grant No.: EY-76-C-03-1110

Principal Investigator: T. R. Heaton DOE Program Manager: G. Kaplan

Topical Area Funding: FY 1978: $168,000

Project Starting Date: 9/77 Completion Date: 9/78

Objective or Description: To study the stability of Caloria HT-43 at high temperatures, evaluate effects of removal of high and low boiling components of oil on soil stability, and perform measurements to better understand the chemistry involved (MM4 Sandia).

Key Words: Oil, soil stability boiling point, oil components, Caloria HT-43 stability

Title: Thermochemical Central Receiver

Contractor: Naval Research Laboratory

Contract or Grant No.: EG-77A-29-1105

Principal Investigator: A. Chubb

DOE Program Manager: M. Gutstein

Topical Area Funding: FY 1978: $220,000

Project Starting Date: 9/77

Completion Date: Continuing

Objective or Description: The Naval Research Laboratory has developed a solar thermal heat receiver design for decomposing SO_3 based on ceramic honeycomb extrusion technology. This technology may be used for chemical energy storage of solar thermal energy.

Key Words: Central receiver, thermochemical receiver, thermal properties, ceramics, chemical energy storage, sulfur oxides.

Title: Development of Granular Semiconductors as Selective Absorbers

Contractor: RCA Laboratories, David Sarnoff Research Center

Contract or Grant No.: EG-77-C-02-4557

Principal Investigator: J. I. Gittlehan

DOE Program Manager: M. Gutstein

Topical Area Funding: $100,000

Project Starting Date: 7/77

Completion Date: 7/78

Objective or Description: To study and develop selective absorbers composed of dispersions of silicon and germanium in a transparent matirx.

Key Words: Selective absorber, granular semiconductor, Si, Ge, CaF_2, thin-film coating.

Title: Thermal Storage Fluid Testing

Contractor: Rocketdyne

Contract or Grant No.:

Principal Investigator: DOE Program Manager: G. Kaplan

Topical Area Funding: N.A. (Small program)

Project Starting Date: Completion Date:

Objective or Description: Prequalification testing of four hydrocarbon fluids. Tests on fluid-flow loop system.

Key Words: Hydrocarbon fluids, storage fluids, storage systems, fluid-flow systems.

Title: Liquid Sodium/Central Receiver Development

Contractor: Rockwell International

Contract or Grant No.: EG-77-C-03-1483

Principal Investigator: T. Springer DOE Program Manager: G. Kaplan

Total Funding: $656,000; Topical Estimate: 20% FY 1978

Project Starting Date: 9/77 Completion Date: 11/78

Objective or Description: A conceptual study for an advanced receiver utilizing liquid sodium.

Key Words: Liquid metal, liquid sodium, central receiver, steam generators, thermal properties.

Title: 1/4-MW_{th} Solar Brayton Receiver Design, Construction and Testing

Contractor: Sanders Associates, Atlanta, Georgia

Contract or Grant No.: EG-77-C-03-1533

Principal Investigator: A. Poirir DOE Program Manager: M. Gutstein

Total Funding: $1,232,000; Topical Estimate: 30% FY 1978

Project Starting Date: 7/77 Completion Date: Continuing

Objective or Description: To fabricate and test a 250-kW_{th} silicon carbide honeycomb receiver at atmospheric pressure + 2000°F.

Key Words: Silicon carbide, hot air receivers, ceramics, Brayton cycle.

Title: Black Cobalt Selective Absorbers

Contractor: Solar Energy Research Institute, Golden, Colorado

Contract or Grant No.: EG-77-C-01-4042

Principal Investigator: P. Call DOE Program Manager: M. Gutstein

Topical Area Funding: $60,000

Project Starting Date: 5/1/78 Completion Date: 10/31/78

Objective or Description: Black chrome selective solar absorbs degrade above 300°C. Black cobalt coatings do not appear to present this problem, but data to substantiate this statement do not exist. A program to prepare, characterize, and test electrodeposited black cobalt coatings has been initiated to determine whether this material would be a suitable replacement for electrodeposited black chrome.

Key Words: Electrodeposited black cobalt, characterization preparation, high temperature stability.

Title: Plastic-Protected Silvered Mirrors

Contractor: Solar Energy Research Institute, Golden, Colorado

Contract or Grant No.: EG-77-C-01-4042

Principal Investigator: K. Masterson   DOE Program Manager: M. Gutstein

Topical Area Funding: $40,000

Project Starting Date: 3/1/78   Completion Date: 10/31/79

Objective or Description: Plastic films or coatings have been unable to protect silver from weathering. This project is aimed at understanding more stable silver alloys and alternate plastic coatings and laminated films. Environmentally stable silvered plastic mirrors of 95% specular reflectivity are sought, to compete with silvered glass.

Key Words: Solar reflectors, mirror, silver, polymer coatings, polymer films, multilayered polymer films.

Title: High-Temperature Optical Properties of Alloys for Central-Receiver Solar Power Systems

Contractor: University of Arizona

Contract or Grant No.: E(29-2)-3673

Principal Investigator: K. D. Masterson and H. S. Gurey   DOE Program Manager: M. Gutstein

Topical Area Funding: $90,000

Project Starting Date: 7/7/77   Completion Date:

Objective or Description: To select alloys suitable for central-receiver boiler tube applications (based on oxidation resistance, fabricability, and mechanical properties), to prepare surface oxides on these alloys, and to measure the optical properties and the durability of surface oxides. The project has four phases: (1) selection of suitable alloys, (2) preparation of alloy surface, (3) determination of total hemispherical emittance and spectral reflectance, and (4) testing of optical properties and durability.

Key Words: Alloy, central receiver, boiler tubes, absorption characteristics, emission characteristics, optical properties.

Title: Chemical Vapor Deposition of Spectrally Selective Absorbers

Contractor: University of Arizona

Contract or Grant No.: E(29-2)3709/EY-76-S-04-3709/DMR75-01267

Principal Investigator: B. O. Saraphin DOE Program Manager: M. Gutstein

Topical Area Funding: $94,630

Project Starting Date: 1/1/73 Completion Date: 5/30/78

Objective or Description: To develop selective absorbers of Si-metal "stack" type for use in high-temperature receivers (700°C).

Key Words: Thin-film coatings, selective absorbers, receivers, absorptance, vapor deposition.

Title: Surface Morphologies of Efficient Solar Absorbing Materials

Contractor: University of Houston

Contract or Grant No.: EG-77-C-04-3974

Principal Investigator: A. Jgratiev DOE Program Manager: M. Gutstein

Topical Area Funding: $80,000

Project Starting Date: 6/1/77 Completion Date: 6/1/78

Objective or Description: To determine the role of surface morphology and microstructure in defining the optical absorption and emission of absorber coatings. To compare the optical properties of laboratory and commercial gold, chrome, and nickel blacks.

Key Words: Energy absorbers, gold, chrome, nickel, thin-film coating, surface morphology, optical properties.

Title: Comparative Profiling of Solar Coatings and Materials With AES and ESCA

Contractor: University of Minnesota

Contract or Grant No.: EC(11-1)2953

Principal Investigator: G. K. Wehner DOE Program Manager: M. Gutstein

Topical Area Funding: $54,971

Project Starting Date: 4/15/76 Completion Date: 4/15/78

Objective or Description: To provide analytical support for other absorber surface contractors and to investigate sputtering techniques for producing surfaces with high solar absorptance and high temperature stability.

Key Words: AES, ESCA, solar coatings, thin-film coatings, optical properties, high absorptance, sputter technology.

Title: Liquid Metal Feasibility Study

Contractor: University of Houston

Contract or Grant No.: G-S-03-1426

Principal Investigator: A. Hildebrand DOE Program Manager: G. Kaplan

Topical Area Funding: FY 1978: $160,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: To define the conceptual design and determine the technical feasibility and cost of a 100-MW_e sodium-cooled solar central receiver system.

Key Words: Liquid metal, liquid sodium, central receiver.

Division of Building and Community Systems

Title: Thermal Envelope Systems and Insulation Materials

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: T. S. Lundy

DOE Program Manager: E. L. Bales

Topical Area Funding: FY 1978: $600,000

Project Starting Date: FY 1978

Completion Date: FY 1983

Objective or Description: This is a management effort delegated to ORNL to carry out subcontracting with various research and development organizations to meet the goal of promoting safe and effective use of thermal insulation and innovative envelope systems to conserve energy.

Key Words: Mineral wool, cellulose, UF foam, fiberglass, thermal properties, fire properties, corrosion properties.

Division of Distributed Solar Technology

Title: Advanced Materials Research and Development

Contractor: Solar Energy Research Institute, Boulder, Colorado

Contract or Grant No.: SERI Subcontracts

Principal Investigator:

SERI Program Manager: D. L. Feucht

Topical Area Funding: $8.7 million

Project Starting Date: FY 1977

Completion Date: Continuing

Objective or Description: The investigation of alternate photovoltaic materials for potential cost reduction of solar arrays.

Key Words: CdS/Cu_2S, GaAs, polycrystalline silicon, amorphous silicon, $ZnSiAs_2$, Zn_3P_2, Cu_2O, CdS/InP, copper ternaries, conducting oxide, CdTe.

Title: Wood Blade Study

Contractor: Gougeon Brothers, Big City, Michigan

Contract or Grant No.: E(49-26)-1028

Principal Investigator: M. Gougeon   DOE Program Manager: D. Ancona

Topical Area Funding: $36,426

Project Starting Date: 11/77   Completion Date: 3/78

Objective or Description: The objective of this study is to determine the feasibility of utilizing epoxy impregnated, laminated wood in the construction of low-cost wind turbine rotor blades. Detailed cost estimates will be provided for various production quantities of the blade.

Key Words: Wind, rotor, blade, spar, glass fiber, wood, laminated wood.

Title: 150-ft Wind Turbine Blade Project

Contractor: Kaman Aerospace Corporation, Bloomfield, Connecticut

Contract or Grant No.: E(49-26)-1028

Principal Investigator: H. Gewehr   DOE Program Manager: D. Ancona

Topical Area Funding: $1,917,159

Project Starting Date: 2/77   Completion Date: 8/78

Objective or Description: The objective of this project is to design, fabricate, test, and evaluate a potentially low-cost blade for a 300-ft-diam. rotor used on a baseline wind turbine. The objective includes providing a technological base for blades of this size and identifying those fundamental characteristics of the blade and design criteria that could be altered to improve both the low-cost potential and technical performance. A detailed assessment will be made of the design technology developed under this contract. Test results and fabrication cost analyses are to be developed for various production quantities of the blade.

Key Words: Wind, rotor, blade, spar, glass fiber, paper, honeycomb.

Title: Prestressed Concrete Block Study

Contractor: Tuthill Pump Company of California, San Rafael, California

Contract or Grant No.: E(49-26)-1028

Principal Investigator: D. Furlong — DOE Program Manager: D. Ancona

Topical Area Funding: $43,448

Project Starting Date: 8/77 — Completion Date: 1/78

Objective or Description: The objective of this is to determine the feasibility of low-cost wind turbine blades utilizing a prestressed concrete D-spar, fiberglass trailing edge, and commercial-grade steel root-end. A detailed fabrication cost analysis is being performed for procurement of blades in various production quantities.

Key Words: Wind, rotor, blade, spar, concrete, fiberglass.

Division of Energy Storage Systems

Title: Superconducting Magnetic Energy Storage

Contractor: University of Wisconsin

Contract or Grant No.: EY-76-C-02-2844

Principal Investigator: R. W. Boom — DOE Program Manager: R. W. Derby

Topical Area Funding: $100,000

Project Starting Date: 1/76 — Completion Date: 12/78

Objective or Description: To investigate the use of inexpensive substitutes for epoxy-fiberglass support in very large magnets.

Key Words: Polymer matrix composites, structural materials.

Division of Electric Energy Systems

Title: 230-kV Irradiation XLPE Cable

Contractor: Reynolds Metal Company

Contract or Grant No.: E(49-18)-2056

Principal Investigator: DOE Program Manager: S. Walldorf

Topical Area Funding: $150,000

Project Starting Date: 9/75 Completion Date: 12/79

Objective or Description: To develop 138-kV and 230-kV irradiated cross-linked polyethylene cables. This requires development of a toroidal electron radiator capable of uniformly irradiating the thick-wall polyethylene cable.

Key Words: Irradiation, cross-link, polyethylene cable.

Office of Fossil Energy
Division of Systems Engineering

Title: Development of a Ceramic-Tube Heat Exchanger With Relaxing Joint

Contractor: Solar Turbines International, San Diego, California

Contract or Grant No.: EF-77-C-01-2556

Principal Investigator: M. E. Ward DOE Program Manager: J. J. Dapkunas

Topical Area Funding: $302,500

Project Starting Date: 1/17/77 Completion Date: 5/16/79

Objective or Description: To develop a ceramic-tube heat exchanger using relaxing joints to allow stress reduction. The unit is to be capable of providing air at 2200 to 2500°F with combustion of "dirty" fuel such as coal and residual petroleum products.

Key Words: Heat exchanger, ceramics, silicon carbide, coal, relaxing joint.

Division of Fossil Fuel Extraction

Title: Improved Polymers for Enhanced Oil Recovery: Synthesis and Rheology

Contractor: University of Southern Mississippi

Contract or Grant No.: EG-77-S-05-5603

Principal Investigator: C. McCormick DOE Program Manager: H. Finke

Topical Area Funding: $350,000

Project Starting Date: 11/77 Completion Date: 11/80

Objective or Description: To synthesize and investigate rheological properties of water-soluble copolymer systems to function as mobility-control agents to enhance oil recovery. The purpose of the study is to attack problems at a fundamental level, beginning with macromolecular structure and proceeding to macroscopic flow properties. It involves polymer synthesis, characterization, and solution rheology.

Key Words: Copolymers, synthesis, rheology, oil recovery.

Division of Fossil Fuel Processing

Title: Sulfidation-Resistant Alloy for Coal Gasification Service

Contractor: Lockheed Palo Alto Research Laboratory

Contract or Grant No.: E(49-18)-2299

Principal Investigator: R. A. Perkins DOE Program Manager: S. J. Dapkunas

Topical Area Funding: $290,431

Project Starting Date: 1976 Completion Date: 1978

Objective or Description: To develop a low-chromium-content iron-base alloy with a corrosion rate of <20 mils/year in a coal gasification environment at 1800°F.

Key Words: Coal gasification, chromium, alloy development, sulfidation, iron-base alloy.

Office of Laser Fusion

Title: Laser Glass Development

Contractor: Battelle Memorial Institute

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: R. Bennett DOE Program Manager: O. Lewis

Topical Area Funding: $150,000; FY 1978: $85,000

Project Starting Date: 9/77 Completion Date: 3/78

Objective or Description: Development of edge-cladding glass to be used in Nd laser amplifiers to suppress parasitic oscillations in amplifier glass disks. The cladding must be index-matched to fluorophosphate glass and must strongly absorb 1.05 μm and 1.34 μm light. Additional constraints on the cladding material are that it be matched in thermal expansion to the substrate glass and that it does not induce any birefringence. Cu^{2+} is the dopant ion employed in cladding glass, although Fe^{2+}, V^{3+}, Sm^{3+}, Dy^{3+}, and Pr^{3+} are also under investigation.

Key Words: Cu^{2+}-doped glass, edge-cladding glass, amplifier parasitic suppression, fluorophosphate glass, phosphate glass, Fe^{2+}, V^{3+}, Sm^{3+}, Dy^{3+}, and Pr^{3+} dopants ions.

Title: Research Development of Fluoride Glasses for Laser Fusion

Contractor: Corning Glass Works

Contract or Grant No.: EY-76-C-02-4079

Principal Investigator: W. Dumbaugh DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $225,000

Project Starting Date: 9/76 Completion Date: 9/79

Objective or Description: To identify and develop fluoride glasses (beryllium containing) suitable for use in optical elements in high-power lasers for laser fusion experiments. The glasses should possess a nonlinear index of refraction, $n_2 < 0.4 \times 10^{-13}$ esu, and should be capable of scaling to sizes (>30 cm).

Key Words: Glass, fluoride glass, beryllium fluoride, optical materials.

Title: Solid-State Laser Components

Contractor: Eyring Research Institute, Provo, Utah

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: J. M. Thorne DOE Program Manager: O. Lewis

Topical Area Funding: $6,039

Project Starting Date: 7/28/77 Completion Date: 12/77

Objective or Description: This research was undertaken to discover a liquid of moderate electrical conductivity for use a an electrode material for KD_2Po_4 (KDP) Pockels cells. The liquid was required to have a very high optical transmission at 1.06 m, a resistivity of about 10 ohm cm, a low nonlinear refractive index, and a reasonable index match to quartz and KDP, and to be incapable of dissolving KDP. The final report described several suitable solutions. One, which had the same refractive index as KDP, was a 0.65 molar solution of silver perchlorate hydrate in a mixture of 24 vol % acrylonitrile in benzonitrile. It had a conductivity of 48.5 ohm cm. Other compositions had the same refractive index as fused quartz or were intermediate between KDP and fused quartz. The liquids had optical transmissions >99.9% at 1.06 m for thicknesses <0.1 mm. The nonlinear refractive index of the liquids appeared to be $<5 \times 10^{-13}$ esu. The parameters that are important in developing liquid ribbon electrodes were identified and gauged with a limited amount of data. The best solvents and electrolytes for liquid ribbon electrodes were identified and listed. Although the search was not exhaustive, it was deemed unlikely that dramatic improvement in conduction could be expected from as yet untested combinations.

Key Words: KDP Pockels cell, liquid electrode, organic solvent, electrolyte.

Title: Laser Glass Development

Contractor: GTE Laboratories, Washington, D. C.

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: L. A. Riseberg DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978, $50,000

Project Starting Date: Prior to 1975 Completion Date: 12/78

Objective or Description: Laser-induced fluorescence line-narrowing techniques are applied to investigate site-to-site variations in the energy levels and the radiative and nonradiative transition probabilities of paramagnetic ions in glass. Rare-earth ions are used as fluorescing probes. From line-narrowed spectra, local field parameters are derived and related to structural coordination models. Data on energy levels and relaxation rates are used to understand the operation of amplifying glass in high power lasers.

Key Words: Laser glass, silicate phosphate, fluorophosphate, fluoroberyllate glasses, rare-earth dopants - Nd^{3+}, Eu^{3+}, laser-induced fluroescence line-narrowing, energy levels, transition probabilities, quantum efficiency, structure of glass.

Title: Development of Low N_2 Glass Containing Fluoride

Contractor: Hoya Optics, Menlo Park

Contract or Grant No.: ES-77-C-03-1448

Principal Investigator: D. Segawa DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $200,000

Project Starting Date: 9/77 Completion Date: 9/78

Objective or Description: To identify and develop fluorophosphate glass compositions suitable for use in optical elements in high-power lasers for laser fusion experiments. The glasses should have a nonlinear index of refraction, $n_2 < 0.8 \times 10^{-13}$ esu, and a cross section for stimulated emission, when doped with neodymium of 2 to 3×10^{-20} cm^2 and should be capable of being scaled to large sizes (>30 cm). Also included in this effort is research on fluorophosphate glasses containing large quantities of paramagentic ions suitable for use in devices utilizing the Faraday effect.

Key Words: Glass, nonlinear index of refraction, optical materials, laser glass, Faraday effect, Faraday rotators.

Title: Laser-Fusion Target Fabrication: Cryogenic Hydrogen Layers

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: C. D. Hendricks DOE Program Manager: L. S. Levine

Topical Area Funding: $700,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The Target Fabrication Project provides targets for the Laser Fusion Program. Some target designs require high-quality cryogenic deuterium-tritium layers inside hollow glass microspheres. Solid D-T layers of several μm thickness have been produced inside microspheres that are typically 70 μm i.d. Interferometric characterization techniques were also developed that verified the layer uniformities to be better than ± 10%.

Key Words: Laser-fusion targets, cryogenic hydrogen layers, deuterium-tritium, microspheres.

Title: Laser-Fusion Target Fabrication: Glass Sphere Fabrication

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: C. D. Hendricks DOE Program Manager: L. S. Levine

Topical Area Funding: $700,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The targets provided for the Laser Fusion Program by the Target Fabrication Project require high-quality glass microspheres to contain the fusion fuel. Very-high-quality glass microspheres of various compositions have been produced by the liquid-droplet and blown-frit techniques in sizes ranging from <20 to >500 m in diameter, with wall uniformities better than $\pm$ 1% and thickness from <0.5 to >20 m.

Key Words: Laser-fusion targets, glass fabrication, glass microspheres, liquid-droplet glass, blown-frit glass, hollow microspheres.

Title: Laser-Fusion Target Fabrication: Material Characterization

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: C. D. Hendricks DOE Program Manager: L. S. Levine

Topical Area Funding: $1,050,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: This project provides targets for the Laser Fusion Program. Characterization of the targets requires complete 4π steradian measurements of the density, thickness, diameter, and local defects of spherical microspheres of <20- μm diameter to an accuracy down to 100Å. Automated manipulators have been made and measurements taken with interferometers and scanning electron microscopes for complete spatial characterization of spherical components.

Key Words: Laser-fusion targets, spherical material characterization, microsphere, microinterferometry.

Title: Laser-Fusion Target Fabrication: Polymer Coatings

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: C. D. Hendricks DOE Program Manager: L. S. Levine

Topical Area Funding: $1,400,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: In this project, which provides targets for the Laser Fusion Program, many target designs require high-quality coatings of various materials on microspheres. Polymer coatings up to 20 μm thick have been deposited on spheres ranging in size from <70 to 140 μm in diameter. Coatings have average surface defects of <300Å peak-to-valley, with no individual defect >1000Å high. Thickness uniformity is better than ± 5%.

Key Words: Laser-fusion targets, polymer coatings, spherical coatings, microspheres.

Title: Laser Glass Development

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: S. Stokowski DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $100,000

Project Starting Date: FY 1974 Completion Date: FY 1979

Objective or Description: To develop improved glasses for use in high-power, high-energy lasers, such as Nova. Laser glasses doped with Nd^{3+} are being investigated for composition effects on the spectroscopic properties important in laser performance. Optical properties, primarily nonlinear indices, are being studied. Sensitization studies for improved pumping efficiency are concentrating on Cr^{3+} and Ce^{3+} ions. Laser gain measurements are modeled from the spectroscopic properties at Lawrence Livermore Laboratory.

Key Words: Laser glass, sensitization, fluorophosphate glass, phosphate glass, fluoroberyllate glass, silicate glass, nonlinear refractive index, Nd^{3+}-dopant, Nd^{3+}-Ce^{3+} codopants, laser glass gain, concentration quenching, fluorescence in Nd glass, absorption in Nd glass.

Title: Laser Glass Devlopment

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: M. J. Weber   DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $100,000

Project Starting Date: FY 1976   Completion Date: FY 1979

Objective or Description: To discover and develop improved Faraday rotator matrials for isolators in Nd: glass fusion lasers. Both glasses and crystals are investigated; rare-earths are used for the paramagentic ion. Fluoride materials are of interest because of their small refractive-index nonlinearities. Measurements are made of Verdet constant and nonlinear refractive index. Outside firms are funded to prepare samples for testing and evaluation.

Key Words: Faraday rotator materials, paramagnetic glasses, fluoride crystals, KTb_3F_{10}, Caf_2-CeF_3, $LiTbF_y$, Verdet constant, nonlinear refractive index, isolators for fusion lasers.

Title: Laser Mirror Coatings

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: J. Swingle   DOE Program Manager: P. Hoff

Topical Area Funding: $5,000

Project Starting Date: 10/1/77   Completion Date: 12/30/77

Objective or Description: Production and reflectance testing of LaF_3/MgF_2 dielectric coatings for the vacuum ultraviolet.

Key Words: Dielectric, LaF_3, mirror, ultraviolet.

Title: Laser Oscillator Development

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: D. Kuizenga DOE Program Manager: O. Lewis

Topical Area Funding: $50,000

Project Starting Date: Nov. 1977 Completion Date: 1979

Objective or Description: The development and testing of new Nd-doped crystals to obtain a short-pulse laser oscillator in the wavelength range of 1.050 to 1.053 μ to match the new glasses being developed for Nova. The first crystal tested is Nd:YLF at 1.053 μ. Performance is comparable to that of Nd:YAG.

Key Words: ND:YLF, ND:YAG, short-pulse oscillator.

Title: Photocathode Materials/Electron X-Ray Physics

Contractor: Lawrence Livermore Laboratory and the University of Hawaii

Contract or Grant No.: E(04-3) 235/PA14 (Renewal)

Principal Investigator: D. T. Attwood and B. L. Henke DOE Program Manager: O. Lewis

Topical Area Funding: $40,000

Project Starting Date: 3/1/78 Completion Date: 3/1/79

Objective or Description: This is a research and development program to discover and quantify performance of materials as x-ray photocathodes for application to high-speed x-ray streak and framing cameras. Interest is in the areas of quantum efficiency and photoelectron energy dispersion over a large range of x-ray input energies and mechanical properties for fabrication and stability.

Key Words: X-ray photocathodes, photoelectron emission, x-ray physics, electron physics.

Title: Photocathode Materials S-1 Photocathode

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: L. W. Coleman and S. W. Thomas

DOE Program Manager: O. Lewis

Topical Area Funding: $9,000

Project Starting Date: 11/1/77

Completion Date: 5/1/78

Objective or Description: This work is an effort to demonstrate techniques for providing S-1 photocathodes in image converts tubes via a remote processing technique. Particular emphasis here is on sensitivity and stability of the photocathodes in the near-infrared spectral region (1.06 μm) in order that the tubes may be useful in streak and framing cameras for diagnosing the performance of Nd:glass lasers.

Key Words: S-1 photocathodes, image tubes, infrared sensitivity, photocathodes stability, streak and framing cameras.

Title: Antireflection Coatings on NaCl Windows

Contractor: Optical Coating Laboratories

Contract or Grant No.: PR 83500 (LASL Subcontract)

Principal Investigator: W. H. Reichelt

DOE Program Manager: O. Lewis

Topical Area Funding: $50,000

Project Starting Date: 5/1/78

Completion Date: 9/30/78

Objective or Description: Fresnel reflection losses at the output window result in an energy loss of ~10% in CO_2 laser systems. In addition, Fresnel reflections may cause parasitic oscillations in the laser system. Antireflection coatings can reduce the reflections and their effects. The result is improved laser performance. This program is designed to develop suitable antireflection coatings on NaCl windows. These will be single-layer 1/4 λ coatings.

Key Words: Antireflection coatings, NaCl, CO_2 lasers.

Title: LiF Coatings

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.: Pending Purchase Request

Principal Investigator: W. Turner and D. Swanson

DOE Program Manager: E. Braunschweig

Topical Area Funding: $20,000

Project Starting Date: 1/1/78

Completion Date: 10/1/78

Objective or Description: To develop methods for plasma-spraying coating with LiF for infrared light absorption.

Key Words: LiF, infrared light absorption.

Title: High-Strength Spark Gaps

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.: LT7-8801C, LG7-8813C

Principal Investigator: W. Turner and K. Riepe

DOE Program Manager: E. Braunschweig

Topical Area Funding: $7,500

Project Starting Date: 10/1/77

Completion Date: 10/1/78

Objective or Description: To develop the proper composite for spark-gap components. Properties needed are electrical and thermal conductivity, corrosion resistance, and modest ductility.

Key Words: High-strength spark gaps.

Title: Production of High-Strength Titanium Foil

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.: (L-1) KS8-8741E

Principal Investigator: W. C. Turner DOE Program Manager: E. Braunschweig

Topical Area Funding: $4,000

Project Starting Date: 7/1/76 Completion Date: 4/1/78

Objective or Description: To upgrade existing processes in order to achieve reliable titanium foil with high strength (90K psi yield) and reasonable ductility (6%).

Key Words: Titanium, foil.

Title: NaCl Crystal Growth and Forging Study

Contractor: Harshaw Chemical Company, Cleveland, Ohio

Contract or Grant No.: L47-92363 (LASL Subcontract)

Principal Investigator: W. H. Reichelt DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $51,800

Project Starting Date: 9/1/78 Completion Date: 2/1/78

Objective or Description: Large numbers of big NaCl windows are required for CO_2 laser fusion experiments. More cost-effective window production can result from improved crystal-growth techniques. This contract is designed to investigate crystal growth by means of a Kyropolous/Czochralski technique. Recent successful developments in this program constitute a breakthrough in growth technology in that crystals 17 in. in diameter by 7 to 9 in. in length have been grown.

Key Words: CO_2 laser windows, NaCl, Kyropolous/Czochralski growth

Title: Inorganic Glass Section: Laser Glass Research

Contractor: National Bureau of Standards

Contract or Grant No.: EA-77-A-01-6010

Principal Investigator: W. K. Haller DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $40,000

Project Starting Date: 10/77 Completion Date: 9/78

Objective or Description: To determine the optical, physical, and chemical properties of fluorophosphate glasses being melted at the National Bureau of Standards and by other contractors.

Key Words: Glass, fluorophosphate glass, physical properties of glass.

Title: Laser Glass Development

Contractor: National Bureau of Standards

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: H. Haller DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978: $22,000

Project Starting Date: 1974 Completion Date: 1979

Objective or Description: The preparation and characterization of Nd^{3+}-doped laser glasses. The objective is to determine the effects of composition on the spectroscopic and optical properties (measured at Lawrence Livermore Laboratory). Primary interest is in low nonlinear index laser glasses with high energy storage.

Key Words: Fluorophosphate glasses, neodymium laser glasses, low nonlinear index glasses, low index glasses, low dispersion glasses, glass preparation, silicate glasses, phosphate glasses.

Title: Research on the Melting and Casting of Fluorophosphate Laser Glass

Contractor: Owen-Illinois

Contract or Grant No.: EY-76-C-02-4080

Principal Investigator: P. Vergano

DOE Program Manager: O. Lewis

Topical Area Funding: FY 1978 $300,000

Project Starting Date: 9/76

Completion Date: 8/78

Objective or Description: To identify and develop fluorophosphate glass compositions suitable for use in optical elements in high-power lasers for laser fusion experiments. The glasses should have a nonlinear index of refraction, $n_2 < 0.8 \times 10^{-13}$ esu, and a cross section for stimulated emission, when doped with neodymium, of 2 to 3 $\times 10^{-20}$ cm^2 and should be capable of being scaled to large sizes (> 30 cm).

Key Words: Glass, nonlinear index of refraction, optical materials, laser glass.

Title: Development of Active and Passive Glass for Optical Elements of High-Power Laser Systems

Contractor: Schott Optical Glass, Duryea, Pennsylvania

Contract or Grant No.: ED-78-C-02-4616

Principal Investigator: K. Mader DOE Program Manager: O. Lewis

Topical Area Funding: $250,000

Project Starting Date: 6/77 Completion Date: 9/78

Objective or Description: To identify and develop fluorophosphate glass compositions suitable for use in optical elements in high-power lasers for laser fusion experiments. The glasses should have a nonlinear index of refraction, $n_2 < 0.8 \times 10^{-13}$ esu, and a cross section for stimulated emission, when doped with neodymium, of 2 to 3 $\times 10^{-20}$ cm^2 and should be capable of being scaled to large sizes (> 30 cm).

Key Words: Glass, nonlinear index of refraction, optical materials, laser glass.

Title: Laser Glass Development

Contractor: University of California at Los Angeles

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: J. D. Mackenzie DOE Program Manager: O. Lewis

Topical Area Funding: $30,000

Project Starting Date: 1975 Completion Date: 3/78

Objective or Description: (1) Preparation and characterization of samples of binary and ternary fluoride glasses doped with Nd^{3+} and other ions for solid-state laser amplifiers. Beryllium fluoride-based glasses are of principal interest. (2) Effects of composition on spectroscopic properties (measured at Lawrence Livermore Laboratory). (3) Spectrochemical analysis and measurements of expansion coefficient, chemical durability, annealing temperature, and density are made at UCLA. (4) Vacuum distillation of BeF_2 material to increase purity.

Key Words: Fluoride glasses, beryllium fluoride, rare-earth dopants, laser glass, vacuum distillation, glass preparation.

Division of Geothermal Energy

Title: Alternate Materials of Construction

Contractor: Brookhaven National Laboratory

Contract or Grant No.: CO 20016* 10201

Principal Investigator: L. Kukacka DOE Program Manager: R. R. Reeber

Topical Area Funding: $180,000

Project Starting Date: 1976 Completion Date: 1981

Objective or Description: The objectives of this program are (1) to make a systematic evaluation of the technical and economic feasibility of using nonmetallic materials of construction for geothermal energy conversion processes and (2) to test and develop durable and economical materials. The program will involve inhouse, subcontract, and industrial research and development and is aimed at reducing process materials costs 10 to 20 percent by 1985.

Key Words: Polymer concrete, alternate materials, geothermal, plastic and ceramic pipe.

Title: Alternate Materials of Construction Subcontracts

Contractor: Burns & Roe, New York

Contract or Grant No.: CO 20016* 1208 (Brookhaven Subcontract)

Principal Investigator: L. Kukacka DOE Program Manager: R. R. Reeber

Topical Area Funding: $50,000

Project Starting Date: 1977 Completion Date: 1978

Objective or Description: The objective is to develop low-cost durable materials of construction for low-temperature hydrothermal reservoir utilization. A definition study has summarized the economic potential for the use of nonmetallic materials as a partial replacement for carbon steel in pilot-scale electric processes. A contract has been awarded to Burns and Roe Industrial Services Corporation to perform a non-electric applications definition.

Key Words: Alternate materials, polymer concrete, geothermal, ceramics, plastics, pressure vessels, shallow well casings, pressure vessels, piping systems.

Division of Industrial Energy Conservation

Title: Development of a Glass-polymer Composite Sewer Pipe From Waste Glass

Contractor: Brookhaven National Laboratory

Contract or Grant No.: C4-01-01-03-1

Principal Investigator: L. Kukacka DOE Program Manager: J. F. Collins

Topical Area Funding: FY 1977: $55,000; FY 1978: $100,000

Project Starting Date: 1976 Completion Date: 1978

Objective or Description: Conservation of energy by the recycling of municipal solid waste. Methods for incorporating waste glass into composites that can be used for construction purposes as replacements for more expensive and energy-intensive materials will be developed.

Key Words: Composite, conservation, durability, energy, glass, pipe, polymer, strength.

Title: Effects of Alternate Fuels on Refractories and Refractory Insulations

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: V. J. Tennery DOE Program Manager: G. R. Garbarini

Topical Area Funding: $150,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: This project concerns the identification and analysis of detrimental reactions in commercial refractories and refractory insulations due to conversion from natural gas to alternate fuels such as residual oils or coal in industrial processes. A major objective is to identify key fuel impurities refractory composition/structure relationships in order to promote successful industrial conversion to alternate fuels.

Key Words: Refractories, refractory insulations, alternate fuels.

Title: Industrial Insulation Evaluation

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: D. L. McElroy

DOE Program Manager: G. R. Garbarini

Topical Area Funding: $100,000

Project Starting Date: 1977

Completion Date: Continuing

Objective or Description: This program will provide the needed data and demonstrate the energy conservation potential of thermal insulations by characterization of selected thermal insulations, measurement of thermal performance factors, and evaluation of existing test methods for specifications.

Key Words: Insulation, industrial insulations, high-temperature insulations.

Title: Materials for Energy Recouperators

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: V. J. Tennery

DOE Program Manager: J. Osborne

Topical Area Funding: $130,000

Project Starting Date: 1977

Completion Date: Continuing

Objective or Description: This project consists of materials analysis support to the Division of Industrial Energy Conservation in the area of high-temperature recouperators and other advanced conservation technologies. This support includes assessment of current recouperator materials technology, including state-of-the-art metal and ceramic recouperator materials, candidate advanced materials, and recouperator design, testing, and performance characteristics. Support is also provided to the contractors as consultation on materials selected for use in the demonstration recouperators.

Key Words: Recouperators, high-temperature materials.

Title: Maximizing the Life Cycle of Plastics

Contractor: Plastics Institute of America at Stevens Institute of Technology

Contract or Grant No.: EC-77-S-03-1809

Principal Investigator: U. L. Hawkins DOE Program Manager: G. R. Garbarini

Topical Area Funding: $100,000

Project Starting Date: 9/15/77 Completion Date: 9/30/79

Objective or Description: The Plastics Institute of America will conduct several research tasks through several universities with the objective of maximizing the life cycle of plastics by separation and compatibilization techniques. The various studies are (1) investigation of recycling of mixed plastics by optimization of cryogenic milling and separation, (2) investigation of compatibilization of mixtures of plastic scrap by formation of block and graft copolymers, (3) investigation of polymer compatibility in hydrogen bonding systems, and (4) separation and recycling of thermoplastic polymer waste by solvent techniques.

Key Words: Polymers, recycling, polymer stabilization.

Division of Materials Sciences

Title: Probabilistic Models of the Stress-Rupture of Composite Materials

Contractor: Cornell University

Contract or Grant No.: EY-76-S-02-4027

Principal Investigator: S. L. Phoenix DOE Program Manager: S. Wolf

Topical Area Funding: $49,000

Project Starting Date: 6/15/76 Completion Date: Continuing

Objective or Description: The project mathematically models the time-independent tensile strength of fiber-reinforced composites. This includes the time dependence of load concentration factors, incorporating fiber stress rupture and matrix viscoelasticity behavior.

Key Words: Composites, viscoelasticity, mathematical modeling, stress-rupture.

Title: Diffusion Mechanisms and Degradation of Environmentally Sensitive Composite Materials

Contractor: Illinois Institute of Technology

Contract or Grant No.: EG-77-S-02-4440

Principal Investigator: L. J. Broutman DOE Program Manager: S. Wolf

Topical Area Funding: $48,000

Project Starting Date: 7/1/77 Completion Date:

Objective or Description: This project measures moisture diffusion in polymers and graphite-fiber-reinforced polymer composites and its effect on their mechanical properties. This includes correlations on bonding and microstructure. The research includes determining the glass transition temperature and investigating tensile stress-strain behavior.

Key Words: Moisture diffusion, graphite-fiber-reinforced polymers, mechanical properties, transitions.

Title: Miscellaneous Polymers at National Laboratories and Universities (11 programs or parts of programs)

Contractor:

Contract or Grant No.:

Principal Investigator: DOE Program Manager: L. C. Ianniello

Topical Area Funding: FY 1978: $642,000 (Includes estimated fractions of a few large programs partly devoted to alternate materials)

Project Starting Date: Completion Date:

Objective or Description: Fundamental studies are being conducted on a broad spectrum of polymers at all the National Laboratories and Universities. For index of programs, see Office of Energy Research, Materials Sciences Programs, Sept. 1978, p.A12.

Key Words: Thermal expansion, neutron scattering, nuclear magnetic resonance, viscoelasticity, colorimetry, structure, phase transformations, optical properties.

Title: Synthesis and Characterization of Novel Polymers From Non-Petroleum Sources

Contractor: University of Florida

Contract or Grant No.: EY-76-S-05-4947

Principal Investigator: G. B. Butler DOE Program Manager: R. Epple

Topical Area Funding: $70,000

Project Starting Date: 7/1/78 Completion Date:

Objective or Description: The purpose of the project is to synthesize novel polymers for evaluation and characterization. Characterization includes determination of molecular weight, molecular weight distribution, and viscosity. Polymer properties and structure will be correlated.

Key Words: Polymers, oil-enhanced recovery, viscoelasticity synthesis.

Title: Synthesis of New Functionalized Fluorocarbon Polymers for Use as Battery Separators and Membrances

Contractor: University of Texas

Contract or Grant No.: EG-77-S-05-5462

Principal Investigator: R. J. Lagow DOE Program Manager: R. Epple

Topical Area Funding: $107,000

Project Starting Date: 5/1/77 Completion Date:

Objective or Description: This project is concerned with the synthesis of perfluorocarbon polymers and oxygen-containing perfluorocarbons from their hydrogen analogs. The major thrust is to prepare and characterize a number of polymers suitable for inert battery separators.

Key Words: Perfluorocarbon polymers, battery separators, membranes.

Office of Military Application

Title: Cellular Silicones and Potting Materials

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: H. G. Hammon DOE Program Manager: F. W. Hughes

Topical Area Funding: $250,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: Commercial producers are no longer making certain cellular silicone and potting materials. The objective of this project is to synthesize silicone polymers from basic materials. First-phase compounds are being formulated from commercially available materials; second-phase polymers will be synthesized from materials developed at Lawrence Livermore Laboratory. All synthesis, formulating, and processing technologies will be transferred to production agencies.

Key Words: Cushions, potting materials, packaging.

Title: Characterization of Fiber Composite Pressure Vessels

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: T. T. Chiao DOE Program Manager: F. W. Hughes

Topical Area Funding: $300,000

Project Starting Date: Before 1975 Completion Date: Continuing

Objective or Description: The objectives are to characterize fiber composite materials and to improve the high burst performance and long fatigue life of fiber composite pressure vessels. Stress rupture testing of fiber strands is being correlated with pressure vessel performance.

Key Words: Pressure vessels, fiber composites, fatigue life, high burst performance.

Title: Development of TATB PBX With Improved Propeties

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: J. Humphrey DOE Program Manager: F. W. Hughes

Topical Area Funding: $125,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: The objective is to develop an improved plastic-bonded TATB explosive through understanding and optimization of TATB particle shape and size, wetting agents, and polymeric binders. Improvements in strength and dimensional stability over a wide temperature range will be pursued.

Key Words: Polymeric binders, wetting and sizing agents, TATB, plastic-bonded explosives.

Title: Reaction in Shock Waves

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: E. L. Lee DOE Progra... Manager: F. W. Hughes

Topical Area Funding: $200,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: An experimental and theoretical study is being conducted to explain shock-induced reaction histories that vary from the smallest detectable extent of reaction to fully developed detonation. This, in turn, will lead to an understanding of the basic processes that control initiation, deflagration, and development of detonation.

Key Words: Explosives, initiation, deflagration, detonation, reaction histories.

Title: Safe High-Energy Explosive Development

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: M. Finger

DOE Program Manager: F. W. Hughes

Topical Area Funding: $700,000

Project Starting Date: 1976

Completion Date: Continuing

Objective or Description: The objective is to develop main charge explosives that are more energetic than HMX and approach the safety characteristics of TATB.

Key Words: Explosives, energetic materials.

Title: Small-Scale Controlled Friction-Impact (SKID) Test

Contractor: Lawrence Livermore Laboatory

Contract or Grant No.:

Principal Investigator: J. K. Lepper

DOE Program Manager: F. W. Hughes

Topical Area Funding: $70,000

Project Starting Date: 1978

Completion Date: 1979

Objective or Description: The objective is to develop a laboratory-size controlled friction-impact (SKID) test to predict the sensitivity of an explosive from a 20-gram charge.

Key Words: Sensitivity tests, explosives, small-scale friction-impact test, small-scale SKID test.

Title: Kinetics and Mechanisms of Explosive Thermal Decomposition

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: R. R. McGuire DOE Program Manager: F. W. Hughes

Topical Area Funding: $50,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: The long-range objective is to model and predict the kinetics and mechanisms of thermal decomposition of high explosives. Results from one-dimensional time-to-explosion tests are being correlated with kinetic parameters determined from isothermal differential calorimetry.

Key Words: Explosive thermal decomposition, one-dimensional time-to-explosion test.

Title: Materials Damage Prediction for Fiber Composites

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: R. M. Christensen DOE Program Manager: F. W. Hughes

Topical Area Funding: $125,000

Project Starting Date: Completion Date: Continuing

Objective or Description: The objective is to develop a thermomechanical theory of flaw growth in polymers and composites with experimental corroboration to predict the failure of polymeric adhesive joints and fiber composites. Molecular spectroscopies are being used to determine the chemical changes that accompany mechanical damage and aging. To date, theory and experiments are in good agreement.

Key Words: Thermomechanical theory, flaw growth, adhesive joints, fiber composites.

Title: Polymeric Coatings of Laser Targets

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: S. A. Letts and L. E. Lorensen

DOE Program Manager: F. W. Hughes

Topical Area Funding: $200,000

Project Starting Date: 1977

Completion Date: Continuing

Objective or Description: Plasma polymerization techniques are being developed to obtain smooth coatings of uniform thickness on microballon laser targets.

Key Words: Plasma polymerization, laser targets, microballons, coatings, vapor decomposition.

Division of Reactor Research and Technology

Title: Alternate Breeder Reactor Structural Materials

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: ORNL 189a No. OH038

Principal Investigator: P. Patriarca

DOE Program Manager: E. E. Hoffman

Topical Area Funding: FY 1978 $200,000

Project Starting Date: 1975

Completion Date: Continuing

Objective or Description: To develop an alternate 9 Cr - 1 Mo stabilized steel with optimum properties (high strength, resistance to chloride and caustic attack, easy fabrication) for use in steam generators and other structural applications.

Key Words: Ferritic steel, structural alloy, steam generators, Cr-Mo steel.

Division of Transportation Conservation

Title: Durability Testing of Structural Ceramics

Contractor: Army Materials and Mechanics Research Center

Contract or Grant No.: DAAG46-77-C-0030

Principal Investigator: G. D. Quinn DOE Program Manager:

Topical Area Funding: FY 1978: $90,000 (included in Table 9)

Project Starting Date: 9/76 Completion Date: 12/80

Objective or Description: To obtain data on the retained strength of turbine ceramics after exposure to combined thermal exposure, thermal shock, and stress rupture in oxidizing environments.

Key Words: Turbine ceramics, thermal cvcling, thermal shock, strength, oxidation, stress rupture.

Title: Development of Sinterable Si_3N_4

Contractor: Army Materials and Mechanics Research Center

Contract or Grant No.:

Principal Investigator: R. N. Katz DOE Program Manager:

Topical Area Funding: FY 1978: $180,000 (included in Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To develop a sintered silicon nitride (Si_3N_4) which could provide a low cost, production route to high strength, oxidation resistant turbine components.

Key Words: Silicon nitride, sintering, high strength, turbine components, oxidation resistance.

Title: Proof Testing Methodology

Contractor: Army Materials and Mechanics Research Center

Contract or Grant No.:

Principal Investigator: E. S. Wright DOE Program Manager:

Topical Area Funding: FY 1978: $400,000 (included in Table 9)

Project Starting Date: 9/76 Completion Date: 12/80

Objective or Description: The major objective of this task is to improve the reliability of ceramic turbo-machinery components via mechanical and thermal proof testing.

Key Words: Strength characteristics, subcritical crack growth, fracture testing techniques.

Title: Characterization, Screening, and Property Data of Ceramics

Contractor: Air Force Materials Laboratory

Contract or Grant No.:

Principal Investigator: R. Ruh DOE Program Manager:

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To accomplish mircrostructural and mechanical property characterization of current and promising new ceramic turbine engine materials for all types of turbine applications. These data are made available to all government organizations and commercial companies and will be published in the open literature.

Key Words: Ceramics, flexure, creep, stress rupture, fracture toughness, thermal shock, expansion, diffusivity, metallography, chemical analysis, fractography.

Title: Ceramic Applications in Turbine Engines

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: R. C. Evans DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To advance the state-of-the-art of highway vehicle gas turbine engines through the utilization of ceramic hot flow path components.

Key Words: Gas turbine engine, modifications, ceramic components, inlet temperature, fuel economy.

Title: Development of Ceramic Regenerator Systems for Gas Turbine Engines

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: T. Miller DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To develop and demonstrate reliable ceramic regenerator systems for automotive gas turbine applications. Specific objectives are to demonstrate a regenerator B_{10}-life of 10,000 hours at a temperature of 800°C (1472°F) using diesel fuel; to demonstrate at least 3500 hours of operation at a temperature of 1000°C (1832°F) on one or more cores; and to evaluate materials and designs for advanced applications up to 1200°C (2192°F) regenerator inlet temperature. This work also has application in Stirling engines.

Key Words: Regenerator assemblies, ceramic materials, heat transfer geometries, stress-relieving techniques, gas turbine engines, automotive.

Title: Evaluation of Ceramics for Stator Applications

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: G. Watson DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: The objectives of this program are to evaluate the potential of current ceramics for stator applications in automotive turbine engines and to assess reliability prediction capabilities for ceramic engine components.

Key Words: Reliability prediction, ceramic stator, silicon nitride, silicon carbide, stators.

Title: Ceramic Heat Exchanger Fabrication

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: J. A. Misencik DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: Determine the feasibility of fabricating high performance heat exchange structures for service at temperatures greater than 1100°C.

Key Words: Recuperators, ceramic materials, SiALON, SiC, Si_3N_4, prototype units.

Title: Fracture Toughness Test for Ceramics

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: J. L. Shannon, Jr. DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To develop the technology base necessary for the formulation of a National Standard for determining fracture toughness of ceramics and other brittle materials.

Key Words: Review of literature, test program, mathematical model, varify results, precracking, triangular notch specimen.

Title: 3500-Hour Durability Testing of Commercial Ceramic Materials

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: W. A. Sanders DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To expose selected commercial ceramic materials to a simulated automotive gas turbine cycle for times up to 3500 hours, and to perform mechanical property tests on exposed specimens.

Key Words: Ceramic materials, Si_3N_4, sintered-SiC, siliconized SiC, mechanical properties.

Title: Ceramic Durability Rig Testing

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: A. Arias DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To expose ceramic specimens to a high temperature environment to determine long time effects of temperature, oxidation, and thermal cycling on mechanical properties.

Key Words: Multiple station rigs, ceramic specimens, property changes.

Title: Analysis and Evaluation of Data and Specimens from 3500-Hour Durability Testing Contract

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: W. A. Sanders DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To determine the effect of long time exposure (to 3500 hours) to a simulated automotive gas turbine cycle on the mechanical properties of commercial ceramic materials.

Key Words: Durability testing, failure mechanisms.

Title: Advanced RSSN Development

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: S. Dutta   DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: Develop the technology for producing a moldable RSSN product at densities approaching 90% of theoretical (2.8 + gm/cc).

Key Words: Silicon particle size, distribution, powder purity, additives, improved moldability, sinterability, nitriding gas.

Title: Improved Ceramic Heat Exchanger Material (MAS)

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: T. P. Herbell   DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date: Completion Date: Continuing

Objective or Description: To provide the development and evaluation required to make LAS/MAS materials such as the GE-3200 material fully suitable for regenerator applications.

Key Words: Thermal expansion, thermal stability, fabrication processes, calendering and extrusion, cost study.

Title: Hot Isostatic Pressing of Silicon Carbide and Silicon Nitride Based Materials

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: S. Dutta and T. J. Moore

DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date:

Completion Date: Continuing

Objective or Description: To determine the potential of HIP process for consolidation of ceramics (SiC, Si_3N_4, and SiALON) and to investigate the microstructure - property relationships.

Key Words: Hot pressing, reaction sintering, Si_3N_4, initial densities, SiC, higher strength, high temperatures.

Title: Improved Silicon Powder Preparation for RSSN

Contractor: NASA-Lewis Research Center

Contract or Grant No.:

Principal Investigator: T. P. Herbell

DOE Program Manager: R. Schulz

Topical Area Funding: FY 1978: (see Table 9)

Project Starting Date:

Completion Date: Continuing

Objective or Description: To evaluate attritor grinding of silicon powder as a means of particle size reduction to produce materials with improved asnitrided strength.

Key Words: Attrition milling, size, shape, distribution, purity, nitrided density, strength.

RADIATION EFFECTS

Introduction

In compiling data on work in progress on radiation effects, a relatively broad definition was adopted. Included are fundamental damage studies; radiation effects in cladding and structural materials: LWR, HTGR, GCFR, and LMFBR fuels, graphite and boron carbide; optical materials; and integrated circuits. Table 1 in Chapter 1 lists the groups participating in the survey, the technical subject area funded, active projects, and the approximate funding level, (total $34.5M). A brief synopsis follows of the 71 studies involved.

The Division of Electric Energy Systems has a single project to develop 138- and 230-kV irradiated cross-lined polyethylene cables. The Division of Materials Sciences sponsors a comprehensive effort on fundamental radiation effects in metals and nonmetals. The 31 projects listed, at a funding level of $9.5 million, span the whole array of radiation damage problems and support every energy technology, at least in part. The Division of Nuclear Power Development is engaged in studies on LWR fuel, including higher burnup fuel and improved resistance to pellet-clad interaction. In addition, work is in progress on coated-particle fissile and fertile fuels and irradiation creep of graphite for gas-cooled thermal reactors. The Division of Reactor Research and Technology sponsors radiation effects work in several technologies, including GCFR fuels and materials, LMFBR advanced fuels and absorbers, and LMFBR cladding and structural materials. The Office of Laser Fusion is sponsoring a fundamental study related to the production and migration of point defects in materials that are candidates for the wall of a laser fusion reactor. The Office of Fusion Energy, Division of Development and Technology, funds ten projects related to radiation damage on candidate first-wall materials. Included are neutron-, ion-, and electron-irradiation studies on stainless steels, nickel-base alloys, and refractory metals. The Office of Military Application sponsors two projects on radiation damage related to specialty materials - (1) integrated circuits, and (2) metallic alloy glasses - and one project on the effect of radiation on stress corrosion cracking.

Division of Electric Energy Systems

Title: 230-kV Irradiation XLPE Cable

Contractor: Reynolds Metal Company

Contract or Grant No.: E(49-18)-2056

Principal Investigator: DOE Program Manager: S. Walldorf

Topical Area Funding: $150,000

Project Starting Date: 9/75 Completion Date: 12/79

Objective or Description: To develop 138-kV and 230-kV irradiated cross-linked polyethylene cables. This requires development of a toroidal electron radiator capable of uniformly irradiating the thick-wall polyethylene cable.

Key Words: Irradiation, cross-link, polyethylene cable.

Office of Fusion Energy
Division of Development and Technology

Title: Effects of Irradiation on Fusion Reactor Materials

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: F. V. Nolfi, Jr. DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $240,000

Project Starting Date: FY 1974 Completion Date: Continuing

Objective or Description: The program consists of three tasks addressing various effects of a fusion-reactor (FR) irradiation environment on potential first-wall materials. These are (a) Microstructure of Irradiated FR First-wall Materials, with special emphasis on the effects of high helium production on microstructural evolution; (b) Damage Correlation, with emphasis on correlating the net point-defect production rates obtained during light-ion and various neutron irradiations; (c) Effects of Irradiation and Irradiation Microstructure on Mechanical Behavior, with special emphasis on helium effects.

Key Words: Fusion reactors, irradiation effects, first-wall materials, stainless steel, refractory/reactive alloys, helium production.

Title: Alloy Development for Irradiation Performance

Contractor: Battelle Pacific Northwest Laboratories

Contract or Grant No.: EY-76-C-96-1830

Principal Investigator: R. H. Jones DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $150,000

Project Starting Date: 7/74 Completion Date: Continuing

Objective or Description: The displacement damage produced in MRC Marz-grade nickel and niobium and reactor-grade 316 SS by 16-MeV p^+ and (D,T) and (D,Be) neutrons is being correlated on the basis of cluster size, density, and yield strength. The effects of steady-state flux and temperature and of cyclic flux, temperature and stress on the microstructure and flow properties, and the relationships between the radiation-induced microstructure and flow properties are also being studied.

Key Words: Nickel, stainless steel, niobium, foils, wires, 14-MeV neutrons, 16-MeV protons, damage, microstructure, mechanical properties.

Title: Alloy Development for Irradiation Performance in Fusion Reactor Development

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.:

Principal Investigator: J. J. Holmes DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $280,000

Project Starting Date: 7/75 Completion Date: Continuing

Objective or Description: The purpose of this effort is to develop and characterize improved materials for magnetic fusion reactor first-wall applications. Emphasis will be placed upon evaluation of irradiation effects on properties relevant to first-wall performance, and the response of these properties to metallurgical parameters such as composition and microstructure. Properties of interest include irradiation-induced swelling and creep, tensile strength and ductility, fatigue properties, stress rupture, and creep-fatigue interaction. Specific materials and test parameters will be selected through interaction with the national task group established by the Division of Magnetic Fusion of DOE to coordinate the national effort on alloy development for improved first-wall performance.

Key Words: Fe-Ni-Cr alloys, irradiation effects, swelling creep, fatigue, first walls, Tokamak, ductility, stress rupture.

Title: 14-MeV Neutron Irradiation Studies

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: 189 No: 14

Principal Investigator: R. Vandervoort

DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $360,000

Project Starting Date: FY 1974

Completion Date: Continuing

Objective or Description: This project has three principal objectives. The first is to study and characterize phenomena that are typical of 14-MeV neutron damage, including the primary damage state and the nucleation and growth of radiation-induced defects that are visible with use of transmission electron microscopy techniques. The second is to determine the relationship between mechanical behavior and microstructure of materials irradiated with 14-MeV neutrons and compare these data with corresponding results obtained on materials irradiated with Be(d,n) neutrons and fission reactor neutrons. The third is to model 14-MeV neutron damage with use of computer programs and relate theory to the experimental observations of high-energy neutron damage.

Key Words: 14-MeV neutron damage, microstructure, mechanical properties, helium effects.

Title: Experimental and Theoretical Studies of Radiation Damage

Contractor: Massachusetts Institute of Technology

Contract or Grant No.:

Principal Investigator: O. K. Harling and K. C. Russell

DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $90,000

Project Starting Date: 1/1/78

Completion Date: Continuing

Objective or Description: (1) To investigate the effects of near-surface displacement damage and implanted gas upon the performance of the first wall and on coolant ducts. (2) To develop a technique for synergistic helium and damage production which will make fission reactors suitable for testing a wide range of fusion reactor alloys. (3) To study the effects of irradiation and temperature upon phase stability, nucleation, and growth in candidate fusion-reactor materials.

Key Words: Near-surface damage and helium, first-wall performance, synergistic damage and helium production, fission reactors, irradiation and temperature, phase stability.

Title: Effects of Irradiation on Fatigue and Fatigue-Crack Propagation in MFE Alloy Development

Contractor: Naval Research Laboratory

Contract or Grant No.: EX-76-A-34-1011

Principal Investigators: J. A. Sprague, D. J. Michel

DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $100,000

Project Starting Date: 10/1/77

Completion Date: Continuing

Objective or Description: To conduct studies on the effect of neutron irradiation on the fatigue, fatigue-crack propagation, and general deformation and fracture behavior of structural alloys for development and application to fusion reactor systems. The scope of the work includes the construction and irradiation in the ORR of subassemblies containing ADIP path A (type 316 stainles steel), path B (alloy PE-16 and alloy 706), and path C (titanium alloys) materials, and the testing of the materials, pre- and postirradiation, for fatigue-crack propagation to determine performance.

Key Words: Fatigue, crack propagation, deformation, neutron irradiation, helium effects, type 316, stainless steel, alloy PE-16, alloy 706, titanium alloys.

Title: Alloy Development for Fusion Reactor Application

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26 (189 00031)

Principal Investigator: E. E. Bloom

DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $1,240,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: The primary objective of this program is to develop materials for use in regions of high neutron flux in commercial fusion reactors. A secondary, but important, objective is to provide materials data for near-term experimental and prototype reactors. The major emphasis is on developing a material to withstand the effects of fusion-reactor neutron irradiation (i.e., the reaction of large amounts of lattice damage and insoluble helium). Other problems such as corrosion of the structural materials by cooling and/or breeding fluids are also addressed.

Key Words: Fusion reactor, first wall, stainless steels, nickel-base superalloys, titanium alloys, niobium alloys, vanadium alloys, irradiation effects, mechanical properties, phase stability, swelling, irradiation creep, corrosion.

Title: Simulating the CTR Environment in the HVEM

Contractor: University of Virginia

Contract or Grant No.: E(40-1)-5013

Principal Investigator: D. Kuhlmann-Wilsdorf   DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $90,000

Project Starting Date: 10/1/77   Completion Date: Continuing

Objective or Description: To study the mechanisms involved in helium embrittlement by conducting high-voltage electron microscope in situ tensile tests on such candidate first-wall materials as 316 stainless steel. To determine the influence of microstructure on tensile tests by employing in situ helium bombardment and/or neutron preirradiated samples. To observe and characterize the role of helium in the development of microstructure during irradiation.

Key Words: 316 stainless steel, helium effects, mechanical behavior.

Title: Radiation Damage Studies for Fusion Reactors

Contractor: University of Wisconsin

Contract or Grant No.: ET-74-S-02-4640

Principal Investigator: G. L. Kulcinski   DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $100,000

Project Starting Date: FY 1976   Completion Date: Continuing

Objective or Description: The use of heavy ion bombardment to simulate high damage levels in pure metals and alloys has been studied, with particular attention paid to the formation and growth of voids. Analyses of the unique requirements for materials in fusion reactors have been made with respect to useful reactor lifetimes.

Key Words: Irradiation, heavy ion simulation, voids, Ni alloys, Mo alloys, Ti alloys, phase transformations, systems studies, first-wall lifetimes.

Title: Radiation Response of Candidate First-Wall Materials

Contractor: Westinghouse Research and Development Center

Contract or Grant No.: EG-77-C-02-4467

Principal Investigator: J. A. Spitznagel and W. J. Choyke

DOE Program Manager: K. M. Zwilsky

Topical Area Funding: $150,000

Project Starting Date: 10/1/77

Completion Date: Continuing

Objective or Description: The objective of this program is to develop the phenomenology and mechanistic understanding of microstructural evolution in model materials under anticipated CTR first-wall conditions. Co-impinging ion beams from two Van de Graaff accelerators are used to study the effects of systematic variations in damage rate, irradiation temperature, fluence, a ppm helium/dpa ratio, and impurity pickup from the atmosphere.

Key Words: Fusion, first wall, stainless steel, vanadium, simultaneous, ion beams, helium, damage, microstructure, phenomenology, mechanisms, impurities, atmosphere.

Office of Laser Fusion

Title: Solid-State Laser Components

Contractor: Optical Coating Laboratory, Inc. Santa Rosa, California

Contract or Grant No.: W-7405-ENG-48 (Lawrence Livermore subcontract)

Principal Investigator: J. H. Apfel

DOE Program Manager: J. Weiss

Topical Area Funding: $60,000

Project Starting Date: 3/1/78

Completion Date: FY 1978

Objective or Description: This phase of the program has the following objectives: (a) to study Al_2O_3/SiO_2 AR coating and Shiva AR coating on BK-7; (b) to compare damage resistance of SiO_2/TiO_2 AR coating with thin and thick layers: (c) to study Al_2O_3/SiO_2 AR coating and Shiva AR coating on SiO_2; (d) to determine dependence of damage resistance of SiO_2 films on condition of starting material: (e) to vary deposition parameters of TiO_2 $\lambda/2$ films, measure film absorption, and correlate deposition parameters and absorption with the laser damage threshold; and (f) to produce coatings as required by Lawrence Livermore Laboratory, within the financial limits imposed, designed to resolve basic questions about laser damage in optical films.

Key Words: Optical coatings, damage, antireflection coatings, silica-titania.

Title: Irradiation Effects to Materials in Laser Fusion Reactors

Contractor: University of Wisconsin

Contract or Grant No.: ES-77-S-02-4296

Principal Investigator: G. L. Kulcinski DOE Program Manager: C. E. Rossi

Topical Area Funding: $99,790

Project Starting Date: 3/1/77 Completion Date: 10/1/78

Objective or Description: The objective of this work is to describe, both chronologically and spatially, the production, migration, and agglomeration of point defects in the material walls of laser fusion reactors. The models developed to describe these phenomena shall be sufficiently general to accept arbitrary fuel-pellet output spectra.

Key Words: Radiation effects, point defects, laser fusion, reactor.

Division of Materials Sciences

Title: Radiation Effects

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigator: C. W. Chen and M. S. Wechsler DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $100,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Studies of the clustering of radiation-induced point defects in Nb and V and of the effects of annealing on these defect clusters. Annealing studies of irradiated BCC metals and considerations of the effects of impurities upon the observed annealing behavior. Characterization of the recovery mechanisms operating in neutron-irradiated and cold-worked Th. Determination of the effects of irradiation on the mechanical properties of Th and void formation in irradiated BCC metals.

Key Words: Clustering, radiation effects point defects, Nb, V, Th, annealing, BCC metals, impurities, recovery mechanisms, dopants.

Title: Charged-Particle Irradiation Studies

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: K. L. Merkel | DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $650,000

Project Starting Date: Prior to 1977 | Completion Date: Continuing

Objective or Description: Work in progress is listed below: Studies of defect structures and recrystallization in ion-implanted solar materials; ion beam analysis of radiation-induced compositional changes and defect distributions. Correlation between 14-MeV neutron damage and heavy ion damage in metals. Properties of self-interstitials. Damage function studies by HVEM and ion irradiation. Studies of energy density effects in energetic cascades. TEM and HVEM of displacement cascades in binary alloys. Theory of subcascade formation. Interatomic potential calculations. Theoretical and experimental studies of properties of hydrogen and helium in metals. Effect of crystallinity on defect production. Application of channeling techniques to defect reactions. Defect cluster formation by HVEM.

Major experimental facilities include the 300-kV heavy ion accelerator, the 14-MeV neutron source at Lawrence Livermore Laboratory, and the high-voltage electron microscope (being installed) with ion interface capability. In the future, a 2-MV ion accelerator and a low-energy ion injector will be available for *in situ* HVEM studies.

Key Words: Irradiation, defect structures, ion-implanted solar materials, ion beam, compositional changes, 14-MeV, cascades, theoretical and experimental studies, defect clusters, HVEM.

Title: Defects of Nonmetallic Systems

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: P. Yuster | DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $200,000

Project Starting Date: Prior to 1977 | Completion Date: Continuing

Objective or Description: Defects and impurities in nonmetallic crystals and the processes caused by exposure of insulators to ionizing radiation are under study. Areas of current interest include the production and motion of vacancies and interstitials; excitation, tunneling recombination, and luminescence processes in heavy-metal centers in insulators; structure and reorientation dynamics of molecular-ion centers (F_2^-, Cl_2^-, $BrCl^-$) in alkali halides; ESR studies of F_2^- centers in alkali fluorides thallium in alkali chlorides, and manganese in calcite; and production and motion of interstitial molecular-ion species (FCl^-, $BrCl^-$, and ICl^-) in alkali halides.

Key Words: Irradiation, defects, impurities, non-metals, insulators, vacancies, interstitials, tunneling, luminescence, ESR, halides.

Title: Kinetic Studies

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: H. Wiedersich DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $760,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Investigations are being made of the forces and mechanisms that lead to the formation of defect aggregates and precipitates and other inhomogeneous distributions of atoms in solids, without and with displacement-producing irradiation; the agglomeration of gaseous compounds, e.g., CH_4, which can lead to "hydrogen attack" in pressure vessels used in coal gasification; solute segregation to voids and free surfaces during irradiation; the effect of irradiation on the microstructure of two-phase alloys - dynamic dissolution and reprecipitation; the effect of fine precipitate dispersions, solute additions, and helium on void formation during ion bombardment; and damage structure produced during high-temperature ion bombardment of oxides.

Radiation sources include the 300-keV heavy-ion accelerator, the 4-MeV dynamic-2-MeV Van de Graaff dual-ion-beam facility, and the high-voltage electron microscope (being installed).

Key Words: Irradiation, defect aggregates, precipitates, methane, solute segregation, voids, microstructure, 2-phase alloys, He, HVEM.

Title: Neutron Irradiation

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: T. H. Blewitt DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $600,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: This program includes work on point-defect production, annihilation, and clustering, radiation effects in superconductors; neutron sputtering; flux pinning of superconductors by defect clusters and voids; void nucleation in nickel and 316 stainless steel; replacement collision sequences; saturation effects and the recombination volume; and void swelling in niobium and Nb-Zr alloys as a function of dose, temperature, and oxygen content during simultaneous irradiation with 4-MeV Ni^+ and He^+ ions. Radiation sources include the CP-5 low-temperature facility and the 4-MeV dynamitron.

Key Words: Irradiation, point defects, clustering, superconductors, flux pinning, nickel, stainless steel, voids, swelling, Nb-Zr alloys.

Title: Particle Solid Interactions

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: J. Jackson and W. Primak

DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $300,000

Project Starting Date: Prior to 1977

Completion Date: Continuing

Objective or Description: Studies are being made of the production and recovery of radiation damage by ions, electrons, and neutrons in metals and insulators; elementary defects and their interactions; defect production and trapping rates; distribution of defects; and the properties of divancancies and self-interstitial atom clusters and associated strain fields. Metals under study include platinum, rhodium, nickel, and indium.

Other areas under study are electromigration at high temperatures in glasses and nonmetal MHD electrodes; studies of surface radiation damage in insulators, including work on lithium niobate, sapphire, spinel, lucalox, barium titinate, quartz, vitreous silica, and glasses; studies of optical and electrical effects and dimensional changes; stress formation and relief migration of implanted ions to surfaces and voids; and blister formation and spallation in materials of CTR interest, such as silicon nitride, zirconium oxides, silicon carbide, boron carbide, and titanium boride.

Key Words: Irradiation, metals, insulators, defects, trapping, clusters, Pt, Rh, Ni, In, eletromigration, glasses, MHD-electrodes.

Title: Physical and Surface Chemistry

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: D. M. Gruen DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $400,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: The subjects covered under this program include compound formation resulting from the bombardment and implantation of energetic reactive particles such as kilovolt H^+, D^+, O^+, and N^+; the effects of surface chemistry on state, state of excitation, energy, and angular distribution of sputtered surface atoms, molecules and ions; simultaneous energy-analyzed secondary-ion mass spectrometry and Auger analysis, together with in situ XPS on clean and oxygen-covered Ti surfaces; quantitative measurments of ion sputtering yields; glancing angle energy-dispersive x-ray diffraction, TEM electron diffraction, and SIMS profiling characterization of ion-nitrided Ti and Zr; ion bombardment-induced photon emission (SCANIIR) measurements on Ti and Be surfaces; matrix-isolation spectroscopic studies of Au and Ag atoms in solid D_2 matrices and of MoN and ZrN molecules in Ar matrices; factors such as configurational entropies, determining the stabilities of AB_5 hydrides; cell-volume stability correlations leading to the development of the new $AB_{5-x}Al_x$ ternary systems for hydrogen storage and chemical heat-pump applications; vibrational and electronic spectroscopy of organic molecules in fused salt solutions; laser Raman profiling of ion-bombarded surfaces to study amorphization and annealing of displacement damage in surface and near-surface regions.

Key Words: Radiation effects, compound formation, surface chemistry, SIMS, AES, XPS, TEM, Ti, Zr, photon emission

Title: Optical and Laser Material Study

Contractor: Battelle Pacific Northwest Laboratories

Contract or Grant No.:

Principal Investigator: J. S. Hartmanl   DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $120,000

Project Starting Date: Prior to 1977   Completion Date: Continuing

Objective or Description: To examine the validity of theory describing scattering of light from rough surfaces by using visible wavelengths and controllably roughened single-crystal surfaces; optical scattering; controllably roughened surfaces; sample topography evaluation using modified Nomarski microscopy; examination of the effects of radiation damage on the optical properties of reflectors appropriate for laser fusion applications; laser fusion reflectors; radiation damage to reflectors; copper reflectors; *in situ* measurements of mirror optical properties during irradiation.

Key Words: Topography, Nomarski microscopy, radiation damage, laser fusion, reflectors, rough surfaces.

Title: Radiation Effects on Metals

Contractor: Battelle Pacific Northwest Laboratories

Contract or Grant No.:

Principal Investigator: J. L. Brimhall   DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $400,000

Project Starting Date: Prior to 1977   Completion Date: Continuing

Objective or Description: Production migration and interaction of irradiation-produced defects; effect of helium on void nucleation in refractory metals and high-purity nickel alloys; theoretical analysis of void nucleation and growth behavior; analysis of annealing behavior in irradiated molybdenum; simulation of neutron-radiation-enhanced creep by light ions.

Key Words: Radiation damage, defects, voids, refractory metals, Ni-alloys, high priority, Mo, creep.

Title: Particle-Solid Interactions: Alternation and Analysis of Solids by Ion Beams

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigator: A. N. Goland DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $80,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Alloy formation and modification by ion implantation, high-resolution Rutherford backscattering for analysis, ion-induced lattice damage, channeling phenomena, and studies of defect structure of A-15 superconductors.

Key Words: Ion implantation, alloy formation, backscattering, lattice damage, defect structure, superconductors.

Title: Particle-Solid Interactions: Properties of Real Solids

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigator: A. N. Goland DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $500,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Utilization of particle-solid interactions as diagnostic probes in solid-state physics investigations; electron states in solids by positron-annihilation measurements, development of slow-positron beam for surface studies; investigation of point defects and dislocations in annealed and deformed metals by positron-annihilation lifetime and Doppler broadening measurements; channeling of protons in very thin single crystals; applications of μ^+SR to defect problems in solids; and geophysics of mineral thermoluminescence.

Key Words: Particle-solid interactions, slow-positron beam, surface studies, point defects, dislocations, Doppler effects, thermoluminescence.

Title: Particle-Solid Interactions: Radiation Effects Research

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigator: A. N. Goland DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $520,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Studies of neutron- and electron-irradiated metals and alloys employing positron-annihilation lifetime and Doppler-broadening measurements; simultaneous optical absorption and luminescence measurements during electron irradiation of ceramics, glasses, and alkali halides; radiation-damage analysis of fusion and fission reactor materials studies.

Key Words: Neutrons, electrons, irradiation, metals, alloys, Doppler effects, optical absorption, luminescence, non-metals, halides.

Title: Radiation Damage

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigator: C. L. Snead and S. Moehlecke DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $190,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Effects of different types of irradiation on the critical properties of type II superconductors; electron, reactor neutron, 14-MeV neutron, and 17-MeV, 800-MeV, and 30-GeV proton irradiations; Nb-Ti and A-15 superconductors; defect and microstructure changes in irradiated materials; enhanced diffusion applied to A-15 superconductors by solid-state process; application of positron annihilation to defect studies; voids and gases in metals.

Key Words: Radiation damage, superconductors, neutrons, proton irradiation, defects, microstructure, diffusion, voids.

Title: Defects in Metal Crystals

Contractor: Cornell University

Contract or Grant No.:

Principal Investigator: D. N. Seidman DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $195,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Properties of self-interstitial atoms, aggregates of self-interstitial atoms, interaction with solute atoms, nonequilibrium segregation of solute atoms to voids, migration energy of interstitial helium in tungsten, range of helium in tungsten, range of focusing collision sequences in pure metals and ordered alloys; field-ion microscopy, atom-probe field-ion radiation, electron microscopy; transmission sputtering of Au; depleted zones in Pt-Au; effect of N on self-ion damage in Ta; and void formation in stainless steel.

Key Words: Defects, metals, interstitial atoms, aggregates, He, W, field ion microscopy, electron microscopy, sputtering, void formation.

Title: Chemistry and Materials Problems in Energy Production Technologies

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigator: D. Olander DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $125,000

Project Starting Date: Prior 1977 Completion Date: Continuing

Objective or Description: The chemical and physical behavior of materials in environments characteristic of energy production devices, with major emphasis on fission and fusion reactors. Experiments are designed to develop insight into the mechanisms of phenomena involved: the high-temperature behavior of uranium dioxide, molecular beam studies of gas-solid reactions, and radiation-enhanced stress corrosion cracking of metals.

Key Words: Fission, fusion, reactors, radiation, stress corrosion cracking, materials.

Title: Ion Bombardment

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: B. R. Appleton DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $255,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Positive-ion-channeling characterization of reordered surface structures of Au single crystals; characterization of stoichiometry and thickness of oxide layers on Nb single crystal by ion channeling techniques; radiative electron-capture measurements as a function of path length for fully stripped oxygen ions channeled in Ag single crystals; measurements of concentration and depth distribution for hydrogen in hard Au films and in various minerals by resonant nuclear reaction techniques; characterization of hydrogen concentration and depth distributions in amorphous silicon films by resonant nuclear reaction techniques and comparison with SIMS measurements; detailed analysis of hard He ions hyperchanneled in Ag and Au thin single crystals.

Key Words: Positive-ion-channeling, Au, single crystals, Nb, Ag, H_2, resonant nuclear reaction, amorphous Si, SIMS.

Title: Low-Temperature Radiation Effects

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: R. R. Coltman DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $475,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Interlaboratory program on 4°K damage rates in V, Nb, and Mo alloys; fission-neutron damage rates at 4°K in Cu, Ni, and stainless steel; irradiation methods for neutron scattering study of 4.9°K irradiated Cu; low-temperature recovery studies of thermal-neutron-irradiated high-purity V, Mo, and stainless steel; resistance and magnetoresistance measurements of fast-neutron-irradiated pure and commercial Cu; correlation of ion damage with fission-neutron damage in Al at 4°K; resistivity studies of production and recovery of damage in Cu, Nb, and Pt irradiated at 4.2°K by high-energy d-Be neutrons.

Key Words: Radiation effects, low temperature, 4°K, Cu, Ni, Nb, Pt, stainless steel, neutron scattering, V, Mo, magneto-resistance, fission neutron damage, ion damage, Al.

Title: 1.5-MeV Electron Microscope

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigator: K. Westmacott DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $100,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Point-defect clusters: the objective of this research is to understand in detail the nature of point-defect clusters and the factors that affect the formation of various types of secondary defect. HVEM equipment plans: the 650-kV microscope will be modified to adopt a side-entry specimen stage and an environmental chamber for new research programs. Future programs involve the planning and management of the new 1.5-MeV microscope (installation expected in 1978/79).

Key Words: Point-defect clusters, HVEM, 650 KV, experimentation.

Title: Relations Between Dislocations, Point Defects, and Properties of Metals

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigator: J. Washburn DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $230,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Elevated-temperature radiation-damage effects in metals and alloys: fundamental understanding of the factors that affect radiation-induced swelling and creep, based on high-voltage electron microscope observations of dislocation climb and glide motion. Ion implanatation effects in silicon: point defect clustering, dopant element precipitation, mechanisms of mass transport, and effects of defects on electrical properties. Improved materials for solar energy utilization: the effects of substitution of Zn for some of the Cd in the conventional Cds-Cu_x-S solar cells. Structure and recrystallization behavior of "amorphous" silicon layers. Investigation of the relation between structure and spectral selectivity of "black chrome" solar absorber coatings.

Key Words: Radiation damage, metals, swelling, creep HVEM, ion-implantation, Si, point defects, clusterings, dopant, solar cells, structure, photovoltaics.

Title: Optically Induced Damage in Transparent Dielectric Materials

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: S. Milam and M. Weber

DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $60,000

Project Starting Date: Prior to 1977

Completion Date: Continuing

Objective or Description: Laser damage in transparent dielectric materials as a function of pulse duration at 1064, 532, 355, and 266 nm; materials include optical glasses, alkali halides and fluorides, and thin films. Studies of electron avalanche, multiphoton absorption, bulk absorption, and nonlinear absorption.

Key Words: Transparent di-electric, laser damage, optical glasses, alkali halides, thin films, absorption, electron avalanche.

Title: Effect of Point Defects on Mechanical Properties of Metals

Contractor: Northwestern University

Contract or Grant No.:

Principal Investigator: M. Meshii

DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $56,600

Project Starting Date: Prior to 1977

Completion Date: Continuing

Objective or Description: Experimental study of the yield and flow behavior of ductile materials (Fe and Nb), the effects of surface films (Ni-coated Fe), self-interstitials (induced by electron irradiation), impurities, and crystallographic orientation.

Key Words: Point defects, yield, flow, ductile metals, surface films, electron irradiation, self-interstitials, impurities.

Title: Ion Implantation

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: B. R. Appleton DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $80,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Ion implantation of boron in single-crystal and polycrystalline NTD Si for solar cells; lattice location of implanted O in Nb; radiation-damage effects associated with ion implantation; effects of ion implantation on superconducting properties of Nb.

Key Words: Ion implantation, B, solar cells, Si, Nb, radiation damage, superconductors

Title: Physical Properties of Ceramics

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: E. Sonder DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $535,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Effects of high temperature and particle and ionizing radiation on defect structures of crystalline and noncrystalline refractory materials such as MgO, Al_2O_3, $MgAl_2O_4$, and SiO_2; optical and electrical properties of refractories and and solid-state electrolytes; determinations of ground and excited-state configurations of impurities and defects; and effects of impurities and defects on radiation damage rates and electrical properties.

Key Words: Defect structures, refractory materials, particle radiation, ionizing radiation, solid-state-electrolytes, impurities, defects, measuring techniques.

Title: Radiation Effects

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: J. O. Steigler
DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $1,330,000

Project Starting Date: Prior to 1977
Completion Date: Continuing

Objective or Description: Void and interstitial loop formation as functions of neutron fluence, spectra, and irradiation temperature; development of quantitative relationship between neutron and heavy-ion bombardment; irradiation of Al, Ni, and V with self ions and α-particles in the Van de Graaff and ORIC; effect of composition on swelling and loss of ductility in Al and Fe-Cr-Ni systems; *in situ* studies by HVEM; theoretical treatment of nucleation and growth of defect clusters, kinetic effects of accelerated irradiation, and stress effects of swelling; simulation of radiation creep; effects of high gas contents on structure and properties; solute segregation during irradiation; effects on phase stability; development of analytical electron microscopy; *in situ* HVEM studies using an environmental cell with straining stage.

Key Words: Void formation, radiation effects, neutron fluence, spectra, temperature, heavy ion bombardment, Van de Graaff, ORIC, swelling, HVEM, creep, gas content.

Title: Theory of Condensed Matter

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: R. F. Wood
DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $690,000

Project Starting Date: Prior to 1977
Completion Date: Continuing

Objective or Description: Band-structure calculations in metals and insulators; electronic properties of rare-earth and actinide compounds; electronic structure and optical properties of defects in insulators; superionic conductivity and solid electrolytes; high-temperature oxides and carbides; reflection of light atoms from surfaces; near-surface diffraction of Auger electrons; interpretation of low energy electron diffraction (LEED) data; surface studies with back-scattered ions; lattice vibrations in disordered alloys; the coherent potential approximation; vibrational properties around substitutional impurities in insulators; neutron scattering from self-intersititials in fcc metals; electron screening and phonon spectra; lattice dynamics of high T_c superconductors; ferromagnetism in transition metals; spin-wave calculations in Ni and Fe; Brillouin zone integration; Heisenberg spin systems; computer simulation of radiation damage and sputtering; radiation-damage analysis procedures; correlation of neutron damage with ion bombardment.

Key Words: Band structure, metals, insulators, rare earths, actinides, defects, insulators, oxides, carbides, Auger, LEED, vibrations, superconductors, radiation, damage.

Title: X-Ray Diffraction and Electron Microscopy

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: T. S. Noggle   DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $315,000

Project Starting Date: Prior to 1977   Completion Date: Continuing

Objective or Description: Radiation damage due to reactor neutrons; 14-MeV neutron and ion irradiations of Au, Cu, Ni, Si, Nb, and stainless steel; transmission electron microscopy; x-ray diffuse scattering; single-crystal films; anisotropic elasticity theory of dislocation loops, computer simulation of electron microscopy images; theory of interactions of electrons and x-rays with defects in solids.

Key Words: X-ray diffraction, EM, radiation damage, reactor and other neutrons, ions, metals, TEM, computer simulation, defects.

Title: Radiation Effects to BCC Refractory Metals and Alloys

Contractor: University of Cincinnati

Contract or Grant No.:

Principal Investigator: J. Moteff   DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Prior to 1977   Completion Date: Continuing

Objective or Description: Microstructure and high-temperature strength of refractory metals (Mo and Nb alloys); comparison of neutron and heavy-ion effects. Techniques used: hot hardness, creep electrical resistivity, and transmission electron microscopy.

Key Words: Radiation effects, BCC refractory metals, alloys, microstructure, neutrons, heavy ions, creep, resistivity, TEM.

Title: Radiation Damage to Solids

Contractor: University of Illinois

Contract or Grant No.:

Principal Investigator: J. S. Koehler DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $130,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Mechanisms of generation and annealing of point defects produced by radiation damage in metals and semiconductors. Structure of point defects and effect on physical properties.

Key Words: Point defects, radiation damage, metals, semi-conductors structure, point defects, physical properties.

Title: Response of Solids to Electromagnetic Radiation

Contractor: University of Illinois

Contract or Grant No.:

Principal Investigator: J. Dow DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $60,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Optical properties of III-V semiconductor compound laser materials. Effect of synchrotron radiation on metals. Nature of intercalation in transition metal dichalcogenides.

Key Words: Electromagnetic radiation, semiconductor compound lasers, synchrotron radiation, metals, transition metals.

Title: An Investigation of Irradiation Strengthening of BCC Metals and Solid Solutions

Contractor: University of Maryland

Contract or Grant No.:

Principal Investigator: R. J. Arsenault DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $53,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Determination of irradiation-induced defects on refractory metals, specifically the yield and flow behavior of vanadium containing various oxygen impurity levels and the effect of helium on the high-temperature behavior of niobium.

Key Words: Radiation, defects, refractory metals, yield, flow, V, oxygen impurities, Nb.

Title: Void Nucleation and Growth in Heavy-Ion and Electron-Bombarded Pure Metals

Contractor: University of Wisconsin

Contract or Grant No.:

Principal Investigator: G. L. Kulcinski DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $75,000

Project Starting Date: Prior to 1977 Completion Date: Continuing

Objective or Description: Effects of irradiation variables and material parameters influencing void formation in metals; dilatometric studies of irradiation-damage annealing; heavy-ion and electron simulation of neutron-irradiating effects of temperature, fluence, flux, and interstitial impurities; electron microscopy and swelling; high-voltage electron microscopy; 18-MeV copper bombardment of V; 1-MeV electron bombardment of Al.

Key Words: Void, heavy ion bombardment, electron bombardment, pure metals, irradiation, impurities, HVEM.

Office of Military Application

Title: Metallic Glass Alloys

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48

Principal Investigator: C. Cline and R. Hopper

DOE Program Manager: F. W. Hughes

Topical Area Funding: $20,000

Project Starting Date: FY 1977

Completion Date: Continuing

Objective or Description: To evaluate the stability of metallic alloy glasses to radiation. Specific emphasis is on mechanical and thermal properties. Neutron irradiation studies are under way. Study of fission fragment damage from U^{235} will begin and be completed this fiscal year.

Key Words: Radiation stability, metallic glass alloys, ferrous base metallic glasses, neutron irradiation.

Title: Radiation-Enhanced Stress Corrosion Cracking

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: V. P. Gede

DOE Program Manager: F. W. Hughes

Topical Area Funding: $300,000

Project Starting Date: 1976

Completion Date: Continuing

Objective or Description: Tritium has been shown to cause severe stress-corrosion cracking in 316 stainless steel when Teflon and a small amount of moisture are present. Deuterium, under the same conditions, does not. Efforts are now directed toward understanding the mechanism.

Key Words: Stress corrosion, 316 stainless steel, Teflon, tritium, radiolysis.

Title: Radiation Hardening of Integrated Circuits

Contractor: Sandia Laboratories

Contract or Grant No.: AT-(29-1)-789

Principal Investigator: B. L. Gregory DOE Program Manager: F. W. Hughes

Topical Area Funding: $300,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Future DOE systems will require integrated circuits of significantly increased complexity for guidance, fusing, and C^3 functions. This program is to characterize and understand radiation effects in such large-scale integrations (LSI) and to translate this knowledge into new radiation-hardened integrated circuit technologies to meet DOE requirements. Technologies being developed are metal gate and silicon gate CMOS for logic, MNOS for nonvolatile memories, and advanced process techniques suitable for hardened VSLI (very-large-scale integrations).

Key Words: Integrated circuits, LSI, VLSI, CMOS, MNOS, radiation hardening processing.

Division of Nuclear Power Development

Title: PCI-Resistant Fuel Demonstration Planning

Contractor: Commonwealth Edison Company

Contract or Grant No.: E-(11-1)-4473

Principal Investigator: D. O'Boyle DOE Program Manager: P. Lang

Topical Area Funding: $2,600,000

Project Starting Date: 12/77 Completion Date: Continuing

Objective or Description: To conduct detailed physics design, test reactor ramp testing, and other planning activities culminating in a subsequent demonstration of an improved light-water-reactor fuel design resistant to pellet cladding interaction (PCI) failures. Emphasis of the program will be on the development of a barrier fuel designs (fuels with a metal liner that provides a barrier between the pellet and the cladding). The objective of the development effort is to improve uranium utilization and reactor productivity.

Key Words: Light-water reactors, fuel, pellet-clad interaction, barrier fuels, copper, zirconium, uranium utilization, lined fuels.

Title: Development and Demonstration of LWR Fuel Concepts with Improved Performance Capabilities

Contractor: Consumers Power Company, Jackson, Michigan

Contract or Grant No.: E-(11-1)-4066

Principal Investigator: F. Buckman   DOE Program Manager: P. Lang

Topical Area Funding: $2,500,000

Project Starting Date: 6/76   Completion Date: Continuing

Objective or Description: To develop and demonstrate, through irradiation testing, improved light-water-reactor fuel concepts which will have improved resistance to pellet-cladding interaction (PCI), which can cause fuel failures. The overall goal is to improve uranium utilization by reducing the incidence of premature fuel failure and improve reactor productivity by alleviating current restrictions on fuel performance.

Key Words: Light-water reactors, fuel, pellet-cladding interaction, Sphere-Pak fuel, annular fuel, graphite-coated fuel, uranium utilization.

Title: Development and Demonstration of Extended Burnup Fuel

Contractor: Duke Power Company and Arkansas Power & Light Company

Contract or Grant No.:

Principal Investigator: M. Baylor and O. Cypret   DOE Program Manager: P. Lang

Topical Area Funding: $500,000

Project Starting Date: 4/78   Completion Date: Continuing

Objective or Description: To develop and demonstrate light-water-reactor fuel designs capable of higher burnup than commercially available fuel, which will allow available uranium resources to be extended on the basis of a stow-away fuel cycle.

Key Words: Light-water reactor, fuel, extended burnup, uranium utilization.

Title: HTGR Fuel Development and Engineering

Contractor: General Atomic Company

Contract or Grant No.: EY-76-C-03-0167 (P.A. No. 17)

Principal Investigator: T. D. Gulden and O. M. Stansfield

DOE Program Manager: J. E. Fox

Topical Area Funding: $1,575,000

Project Starting Date: 1962

Completion Date: Continuing

Objective or Description: To develop coated-particle fissile and fertile fuels for gas-cooled thermal reactors. This program includes work on medium-enriched ($\leq$ 20% U^{235}) uranium fuel for use in proliferation-resistant fuel cycles and limited termination work on the previous reference fuel, highly enriched (93% U^{235}) uranium.

Key Words: Coated particles, UC_2, UO_2, UCO, $(U,Th)O_2$, ThO_2, HTGR, HFIR.

Title: Fueled Graphite Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: F. J. Homan

DOE Program Manager: J. E. Fox

Topical Area Funding: $1,300,000

Project Starting Date: 1963

Completion Date: Continuing

Objective or Description: To develop coated-particle fissile and fertile fuels for gas-cooled thermal reactors. This program includes work on medium-enriched ($\leq$ 20% U^{235}) uranium fuel for use in proliferation-resistant fuel cycles and limited termination work on the previous reference fuel, highly enriched (93% U^{235}) uranium.

Key Words: Coated particles, UC_2, UO_2, UCO, $(U,Th)O_2$, ThO_2, HTGR, HFIR.

Title: Graphite Irradiation Creep and Dimensional Stability

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: F. J. Homan and W. P. Eatherly

DOE Program Manager: J. E. Fox

Topical Area Funding: $525,000

Project Starting Date: 1975

Completion Date: Continuing

Objective or Description: To provide design and performance data on irradiation creep of candidate graphites in the temperature and fluence ranges of interest for current gas-cooled thermal reactor designs. To determine dimensional stability of several German reflector graphites.

Key Words: Graphite, grades H-451, H-327, irradiation creep, dimensional stability, HFIR/ORR

Division of Reactor Research and Technology

Title: GCFR Fuels and Materials Development

Contractor: Argonne National Laboratory, West Idaho Falls, Idaho

Contract or Grant No.: AG-04-03-01 189a #01345

Principal Investigator: S. Greenberg

DOE Program Manager: R. C. Wunderlich

Topical Area Funding: Gas-Cooled Fast Reactor Program: $900,000

Project Starting Date: Prior to 1975

Completion Date: Continuing

Objective or Description: The objective of this work is to determine the performance of GCFR materials and prototypic components. Specifically, the goal is to (1) provide fuel-pin fabrication services for the in-reactor experimental program, (2) obtain fuel-pin performance data to establish a data base, (3) determine the mechanical properties of surface-roughened cladding in a helium environment, and (4) perform in-depth postirradiation examinations of prototypic GCFR fuel pins.

Key Words: Gas-Cooled Fast Reactor, mixed oxide fuel chemistry, helium environment, fast flux irradiation, fuel element performance, postirradiation examination.

Title: LMFBR Cladding/Duct Materials Development: Reference Clad/Duct Development

Contractor: Argonne National Laboratory

Contract or Grant No.: CA 080

Principal Investigator: M. Walters DOE Program Manager: F. A. Smidt

Topical Area Funding: $323,000

Project Starting Date: Prior to 1975 Completion Date: FY 1979

Objective or Description: To participate in a national program to characterize the mechanical properties, in-reactor creep, and swelling of 20% CW 316 SS.

Key Words: Irradiation creep, swelling, 20% CW 316 SS, LMFBR, cladding, duct.

Title: GCFR Fuels and Materials Engineering

Contractor: General Atomic Company

Contract or Grant No.: AG-04-03-01 189a #00583

Principal Investigator: S. Langer DOE Program Manager: R. C. Wunderlich

Topical Area Funding: Gas-Cooled Fast Reactor Program: $700,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The purpose of this work is (1) to develop materials for the fuel, blanket, and control rods of the gas-cooled fast reactor (GCFR), (2) to extend breeder materials technology to conditions and design features specific to the GCFR, and (3) to provide a basis for the GCFR irradiation test program.

Key Words: Gas-Cooled Fast Reactor, cladding materials, duct materials, helium environment, fast flux irradiation, creep rupture tests, mixed oxide fuels.

Title: Fuel-Pin Transient Performance Limits

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: 189a #FF020

Principal Investigator: T. Hikido DOE Program Manager: E. C. Norman

Topical Area Funding: $374,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To conduct out-of-reactor tests (fuel cladding transient tester, FCTT) of the mechanical properties of cladding to provide data for correlation of analytic methods and to determine fuel-pin cladding characteristics.

Key Words: Nuclear energy, breeder reactor, 20% cold-worked 316 stainless postirradiation mechanical properties.

Title: LMFBR Cladding/Duct Materials Development: Advanced Alloy Development

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: FF101

Principal Investigator: J. J. Laidler DOE Program Manager: F. A. Smidt

Topical Area Funding: $3,040,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To coordinate and participate in a national program to identify and develop advanced alloys with improved performance for cladding and duct use.

Key Words: Swelling, irradiation creep, mechanical properties, LMFBR, cladding, duct, electron irradiation, Inconel 706, PE-16, M-813, developmental alloys.

Title: LMFBR Cladding/Duct Materials Development: Advanced Alloy Development

Contractor: Naval Research Laboratory

Contract or Grant No.: HH016

Principal Investigator: J. A. Sprague — DOE Program Manager: F. A. Smidt

Topical Area Funding: $30,000

Project Starting Date: 1975 — Completion Date: Continuing

Objective or Description: To participate in a national program to identify and develop advanced alloys with improved performance for cladding and duct use.

Key Words: LMFBR, cladding, duct, swelling, fracture toughness, HT-9, simulation, ferritic alloys.

Title: LMFBR Cladding/Duct Materials Development: FBR Advanced Alloy Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: OH037

Principal Investigator: A. F. Rowcliffe — DOE Program Manager: F. A. Smidt

Topical Area Funding: $632,000

Project Starting Date: Prior to 1975 — Completion Date: Continuing

Objective or Description: To participate in a national program to identify and develop advanced alloys with improved performance for cladding and duct use.

Key Words: LMFBR, cladding, duct, swelling, mechanical properties, simulation, austenitic stainless steels, developmental alloys.

Title: LMFBR Cladding/Duct Materials Development: FBRD Advanced Alloy Development

Contractor: General Electric Company, Fast Breeder Reactor Division, Sunnyvale, California

Contract or Grant No.: SG013

Principal Investigator: W. K. Appleby DOE Program Manager: F. A. Smidt

Topical Area Funding: $200,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To participate in the National Alloy Development Program to identify and develop advanced alloys with improved performance for cladding and duct use.

Key Words: Swelling, irradiation creep, simulation, LMFBR, cladding, duct, Inconel 706.

Title: LMFBR Cladding/Duct Materials Development: MOTA Design and Construction

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: FF236

Principal Investigator: J. L. Straalsund DOE Program Manager: F. A. Smidt

Topical Area Funding: $900,000

Project Starting Date: 1977 Completion Date: 1982

Objective or Description: To design and fabricate instrumented (MOTA) subassemblies for irradiation of structural materials in the FFTF and to develop the capabilities required for examination and reconstitution of these experiments.

Key Words: LMFBR, MOTA, FFTF, irradiation vehicle.

*Title: LMFBR Cladding/Duct Materials Development: Reference Clad/Duct Development

Contractor: General Electric Company, Fast Breeder Reactor Division, Sunnyvale, California

Contract or Grant No.: SG044

Principal Investigator: W. K. Appleby DOE Program Manager: F. A. Smidt

Topical Area Funding: $530,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To participate in a national program to characterize the mechanical properties, in-reactor creep and swelling of 20% CW 316 SS.

Key Words: Swelling, irradiation creep, LMFBR, cladding, duct, 20% CW 316 SS.

Title: LMFBR Cladding/Duct Materials Development: Reference Clad/Duct Development

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: FF027

Principal Investigator: J. J. Holmes DOE Program Manager: F. A. Smidt

Topical Area Funding: $1,450,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To participate in a national program to characterize the mechanical properties, in-reactor creep and swelling of 20% CW 316 SS.

Key Words: Swelling, irradiation creep, mechanical properties, LMFBR, cladding duct, 20% CW 316 SS.

Title: LMFBR Neutron Absorber Control Development: FF231/GLT, Absorber Pin and Assembly Development

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: EY-76-C-14-2170 189a No. FF231

Principal Investigator: D. E. Mahagin, Mgr. DOE Program Manager: F. Kerze, Jr.

Topical Area Funding: FY 1978: $1,450,000 (see under Objective, below)

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The objective is to develop safe, economical, and reliable neutron absorber control assemblies for the LMFBR. The basic design involves an array of 316 SS pins containing boron carbide pellets. Note that the irradiation testing in EBR-II is only one part of the overall control assembly and duct development.

Key Words: Boron carbide, europium hexaboride, neutron absorber, reactor control, irradiation effects, breeder reactor.

Title: Radiation Effects on Structural Materials

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: HEDL - 189a No. FF125

Principal Investigator: R. L. Knecht DOE Program Manager: A. Van Echo

Topical Area Funding: $625,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To provide irradiated and unirradiated material property data for design, operations support, and safety analysis of breeder reactor components and structures. (1) Components and structural materials irradiations: plan, design, and fabricate EBR-II and FTR irradiation experiments to provide irradiated base and weld materials for mechanical property evaluation. (2) Tensile, creep, complex load and low cycle fatigue properties: analyze, interpret, and document test results to provide material behavior descriptions to designers and structural analysts. (3) Crack propagation and fracture toughness properties: measure crack growth, fracture toughness, and other fracture mechanisms properties. (4) Data storage and retrieval system input.

Key Words: Fast neutron irradiation, structural materials, components, tensile, creep, complex load, low cycle fatigue, crack propagation, fracture toughness, monotonic, cyclic load.

Title: Breeder Reactor Advanced Fuels Program: Advanced BPR Fuel Development

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.: 189a AL002

Principal Investigator: J. Green DOE Program Manager: M. L. Matthews

Topical Area Funding: $175,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Surveillance, evaluation, and analysis of steady-state tests of advanced fuels in EBR-II.

Key Words: Advanced fuels, carbide, fuel, EBR-II test program.

Title: Neutron Effects on Structural Materials

Contractor: Naval Research Laboratory

Contract or Grant No.: NRL - 189a No. HH010

Principal Investigator: L. E. Steele DOE Program Manager: A. Van Echo

Topical Area Funding: $245,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To provide guidelines for producing improved and radiation-resistant structural materials for structural integrity. This requires characterization of the structural materials performance in terms of crack propagation resistance, deformation behavior, fracture resistance and alloy stability under service environments and conditions of temperature, neutron fluence, alloy thermomechanical history and composition, and strain rate. (1) High-temperature deformation behavior, (2) structural integrity and failure characteristics, (3) radiation damage and failure mechanisms, (4) data storage and retrieval system.

Key Words: Structural materials, radiation resistance, integrity, deformation behavior, crack propagation, fracture resistance, alloy stability, fast-neutron fluence, mechanical history, composition, strain rate, fatigue, creep-fatigue, tensile, creep, elastic-plastic fracture toughness, J-integral.

Title: LMFBR Cladding/Duct Materials Development: FBR Advanced Alloy Development

Contractor: Westinghouse Advanced Reactor Division, Madison, Pennsylvania

Contract or Grant No.: CW071

Principal Investigator: M. L. Bleiberg DOE Program Manager: F. A. Smidt

Topical Area Funding: $480,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To participate in a national program to identify and develop advanced alloys with improved performance for cladding and duct use.

Key Words: Swelling, tensile tests, LMFBR, cladding, duct, PE-16, M-813, simulation, developmental alloys.

Title: Breeder Reactor Advanced Fuels Program: Analysis and Evaluation of Advanced Fuels

Contractor: Westinghouse Advanced Reactor Division, Madison, Pennsylvania

Contract or Grant No.: 189a CW 075

Principal Investigator: A. Boltax DOE Program Manager: M. L. Matthews

Topical Area Funding: $130,000

Project Starting Date: 1975 Completion Date: Continuing

Objective or Description: The survellance, evaluation, and analysis of steady-state EBR-II irradiation tests of advanced fuels.

Key Words: Advanced fuels, carbide fuel, EBR-II test program.

Division of Advanced Nuclear Systems and Projects

Title: Rhodium-Ruthenium Alloy Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: A. S. Schaffhauser   DOE Program Manager: C. O. Tarr

Topical Area Funding: $50,000

Project Starting Date: FY 1975   Completion Date: Continuing

Objective or Description: Lower cost replacement for iridium and platinum-base alloys are required for heat sources in space and terrestrial isotopic power systems. The new alternate materials should have lower densities, equivalent compatibility with graphite and fuel to 1400°C, plus good high strain rate impact strength and fabricability. Rh and Ru could be available in quantity from a national nuclear fuel recycle program. This would alleviate a strategic material problem.

Key Words: Rhodium, ruthenium, Rh-Ru alloys, isotopic power, strategic materials, noble metal alloys.

CATALYSTS AND CATALYTIC EFFECTS

Introduction

A total of 107 projects devoted to research and development on catalysts has been listed in this summary of current efforts in various offices of the Department of Energy. These efforts can be classified as belonging to one of three kinds, according to the scientific disciplines and purposes for which they were designed, as below. Table 3 of Chapter 1 gives a detailed breakdown by DOE Division, of the funding levels. These include:

1. Fundamental characterization of catalysts, employing the disciplines associated with the sciences of metallurgy and ceramics, solid-state physics, and chemistry. These studies are designed to acquire basic information about the constitution of catalytic substances, with minimal attention directed toward their use in processes or their modification in manufacturing processes. Research of this kind is carried out principally in the Division of Materials Sciences. In FY 1978, there were 18 such studies, with funds totaling $4 million.

2. Fundamental research on the behavior of catalysts in relatively idealized surroundings. These studies include the specific role that actual chemical conversions introduce into the use of catalysts, and in this sense are nearer to actual practical applications than the first category. Kinetic studies are made and mechanisms of chemical reactivity are studied, the relationships between composition, structure, and selectivity are evaluated, and fundamental information on such factors as poisoning and metal-support interactions is obtained. Research of this kind is carried out principally in the Division of Chemical Sciences. In FY 1978, there were 34 such projects with a total of $3.9 million devoted to these efforts.

3. Activities that are more directly connected with actual applications to industrial processes, often at the stage of a small pilot plant. Studies of this kind attempt to include the effects of routine operation with actual industrial materials. During the past year, 49 such projects covering a wide range of catalytic studies applied to the conversion of fossil fuels were carried out by the Division of Materials and Exploratory Research in the Office of Fossil Energy. These efforts are now being continued by the Division of Fossil Fuel Processing and the Division of Program Control and Support.

A small number of other projects are supported by other offices of the Department; these are included, along with brief descriptions, in this summary.

Division of Chemical Sciences

Title: Homogeneous and Heterogeneous Catalysts (collective title for the first 33 of the projects sponsored by this division).

Contractor: See entries below.

Contract or Grant No.: See entries below

Principal Investigator: See entries below DOE Program Manager: F. D. Stevenson

Topical Area Funding: $3,943,000 (for 33 projects following)

Project Starting Date: Various Completion Date: Continuing

Objective or Description: SUMMARY The objective of these catalysis research studies is to obtain fundamental understanding of the structure and electronic states of chemical species and their surfaces; theoretical modeling of chemisorption on metals, alloys, and clusters; kinetics of adsorption, desorption, dissociation, and surface migration of adsorbates; and the effects of crystal-lite size and metal-support interactions. The research also includes the preparation and characteriztion of catalysts, the study of the relationships between the composition and structure of catalysts and their activity and selectivity, the study of surface complexes and reaction intermediates to establish reaction mechanisms and to establish mechanisms of catalyst poisoning and regeneration, especially for hydrogenation and hydrogenolysis reactions and synthesis of hydrocarbon fuels and chemical intermediates. The catalysis research also includes the organometallic chemistry of homogeneous catalysts; their synthesis, structure, reactivity, and selectivity; and modes of heterogenizing, including such effects on catalytic properties. Particular emphasis is on fuel synthesis and related conversion reactions. These studies include phase transfer, interfacial and enzyme catalyst systems.

For more information on particular projects, refer to the corresponding entries in Summaries of FY 1977 Research in the Chemical Sciences, DOE/ER-0002, February, 1978.

Key Words: Heterogeneous and homogeneous catalysis, synthesis, theoretical modeling, activity, selectivity, chemisorption, poisoning, reaction mechanisms.

Title: Organometallic Complexes in Homogeneous Catalysis of Coal-Derived Compounds

Contractor: Ames Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Angelici DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $40,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Organometallic complexes, homogeneous catalysis, coal, coal derivations.

Title: Statistical Mechanics of Gaseous Systems

Contractor: Ames Laboratory

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Hoffman DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $80,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysis, gaseous systems, statistical mechanics.

Title: Fluid Catalysis

Contractor: Argonne National Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Feder

DOE Program Manager: F. D. Stevens

Topical Area Funding: FY 1978: $140,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Word: Fluid catalysis

Title: A Fundamental Investigation of Homogeneous Catalytic Systems for the Synthesis of Hydrocarbons from Synthesis Gas

Contractor: Battelle Pacific Northwest Laboratories

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Cox

DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $100,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Homogeneous catalysis, synthesis gas, hydrocarbons, fundamental study.

Title: Enzyme and Organic Mechanisms and Energy Storage in Enzyme Systems

Contractor: Brookhaven National Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Seltzer DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $180,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysis, enzyme and organic mechanisms, energy storage.

Title: Interactions of Molecules With Surfaces

Contractor: Brown University

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Greene DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $55,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, surface interaction, surface molecules

Title: ESR Studies of Surface Adsorption and Catalysts Under Ultra High Vacuum

Contractor: Cornell University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: J. H. Freed DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $60,000

Project Starting Date: Sept. 1, 1978 Completion Date: 1980 (18 months)

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, surface adsorption, electron spin resonance, ultra-high vacuum.

Title: Conversion of Coal to Clean Liquid and Gaseous Fuels

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Somorjai and Bell DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $165,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Coal conversion, catalysis, liquid fuels, gaseous fuels.

Title: Crossed Molecular Beams

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Lee

DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $410,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, crossed molecular beams.

Title: Energy Transfer and Structural Studies of Molecules on Surface

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Harris

DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $140,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, energy transfer, structural studies, surface molecules.

Title: Photoelectron Spectroscopy

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Shirley DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $650,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, photoelectron spectroscopy.

Title: Potential Energy Surfaces for Chemical Reactions

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Schaefer DOE Program Manager: F. D. Stevenson

Topical Area Funding: RY 1978: $75,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, chemical reactions, surface energy.

Title: Selective Hydrogenation of Coal

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Grens and Vermeulen DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $55,000 (catalytic fraction of program)

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Coal, hydrogenation, catalysts.

Title: Solid-Phase Catalysis and Reagents

Contractor: Marquette University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Regen DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $40,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Solid-phase catalysis, reagents, catalysts.

Title: Theory of Chemical and Physical Kinetics

Contractor: Massachusetts Institute of Technology

Contract or Grant No.: AK-01-03-01-2

Principal Investigator: Ross DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $55,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, theory, chemical kinetics, physical kinetics.

Title: Study of the Catalytic Methanation Reaction Over Well-Characterized Ni Catalysts

Contractor: National Bureau of Standards

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Yates DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $102,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, methanation, nickel.

Title: The Properties of Supported Metal Catalysts

Contractor: Northwestern University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Butt, et al. DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $85,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Supported catalysts, catalysis.

Title: Solid State Surface and Catalytic Studies of Oxides

Contractor: Northwestern University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Kung and Stair DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $56,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Iron oxides, solid state, catalysts, oxides, surface studies.

Title: Chemical Kinetics of Enzyme-Catalyzed Production of H_2

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Egan DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $120,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, chemical kinetics, enzymes, hydrogen production.

Title: Heterogeneous Catalysis Related to Energy Systems

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Taylor, et al. DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $310,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Heterogeneous catalysts, catalysis, energy systems.

Title: Molten Salt Catalysis for Clean Fuel Synthesis

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Smith and Narten DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $280,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, molten salts, clean fuel, synthesis.

Title: Crystallite Size and Support Interactions on CO Hydrogenation Reactions

Contractor: Pennsylvania State University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Vannice DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $44,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, crystallites, support, hydrogenation.

Title: Supported Catalyst Synthesis and Characterization

Contractor: Princeton University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Turkevich | DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $72,000

Project Starting Date: | Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Supported catalyst, synthesis, characterization.

Title: Thermodynamics of Sulfur Adsorbates on Metal Catalyst Surfaces

Contractor: Stanford Research Institute

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Wise | DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $60,000

Project Starting Date: | Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, metal surfaces, sulfur adsorbates, thermodynamics, surfaces.

Title: The Application of Functional Polymers in Catalysis

Contractor: Texas A & M University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Bergbreiter DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $30,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysis, functional polymers.

Title: Catalytic Methanation

Contractor: Texas A & M University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Lunsford DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, methanation.

Title: The Influence of Electron Configuration on Catalytic Properties of Lanthanide Oxide

Contractor: Texas A & M University

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: M. P. Rosynek DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, electron configuration, lanthanide oxides.

Title: Homogeneous Catalysis of the Water Gas Shift Reaction

Contractor: University of California at Santa Barbara

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Ford DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysis, homogeneous, water gas shift.

Title: Transport and Reaction in Supported Liquid

Contractor: University of California at Santa Barbara

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Rinker DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $30,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysis, liquid, supported, transport, reaction.

Title: Synthesis, Chemistry and Catalytic Activity of Complexes of Lanthanide and Actinide Metals in Unusual Oxidation States and Coordination Environments

Contractor: University of Chicago

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Evans DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $38,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, synthesis, lanthanide and actinide metals, coordinations, oxidation states.

Title: Transition Metal Chemistry Under High Carbon Monoxide Pressure: An Infrared Spectroscopic Study of Catalysis in the Fischer-Tropsch Reaction

Contractor: University of Georgia

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: King and King DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $64,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, transition metals, chemistry, carbon monoxide, spectroscopic study, Fischer-Tropsch.

Title: Auger and Reaction Studies of Poisoning by Sulfur and Regeneration of Metal Synthesis Gas Catalysts

Contractor: University of Delaware

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Katzer DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978: $139,000

Project Starting Date: Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, synthesis gas, sulfur, poisoning, auger spectroscopy, regeneration.

Title: Mechanistic Studies Related to the Metal-Catalyzed Hydrogenation of Carbon Monoxide to Hydrocarbons

Contractor: University of Wisconsin

Contract or Grant No.: AK-01-03-02-1

Principal Investigator: Casey

DOE Program Manager: F. D. Stevenson

Topical Area Funding: FY 1978, $60,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: See summary of "Objective" as given above for all 33 projects. For more information on this particular program, refer to corresponding entry in the reference cited in the summary.

Key Words: Catalysts, hydrocarbons, carbon monoxide, metals hydrogenation.

Title: Flash Photochemical Studies of Transient Electrode Processes

Contractor: Purdue University

Contract or Grant No.:

Principal Investigator: S. Perone

DOE Program Manager: R. J. Kandel

Topical Area Funding: FY 1978: $58,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: The study of transient electrode processes important in solar energy conversion by means of flash illumination.

Key Words: Transient, electrode, photochemistry, electrolysis, solar.

Division of Energy Storage Systems

Title: Materials for Advanced Water Electrolyzers

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigator: S. Srinivasan

DOE Program Manager: B. J. Berger

Topical Area Funding: $200,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: The development of advanced water electrolyzers is currently aimed at further increases in energy efficiency, reduced capital costs, and prolonged lifetime. Efforts have been directed toward finding stable materials for cell construction and searching for better electrocatalysts to serve as the hydrogen and oxygen electrodes. Oxide catalysts of spinel of perovskite structure such as $NiCo_2O_4$ and Ba_2MnReO_6 have been investigated as oxygen electrodes. Nickel boride and $NiCo_2O_4$ show higher catalytic activities than nickel for the hydrogen and oxygen evolution, respectively, particularly for the long-term operation. Materials for separators, gaskets, seals, and cell frame have been evaluated in single cells, operating at temperatures up to 150°C.

Key Words: Hydrogen, electrolysis, electrocatalysts, spinels, perovskites, separators, gaskets, seals, nickel oxide, cobalt oxide, polysulfone, polytrifluorostyrene, solid polymer electrolyte.

Title: Oxygen Electrodes for Energy Conversion and Storage

Contractor: Diamond Shamrock Corporation

Contract or Grant No.: EC-77-C-02-4146

Principal Investigator: D. F. Lieb

DOE Program Manager: S. Ruby

Topical Area Funding: $300,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: The identification of effective electrocatalysts for oxygen cathodes and electrode structures for chlor-alkali cells. The specific target for the first year is an oxygen cathode operating CO_2-free air at a current density of 300 mA/cm^2 and a voltage of $\geq$ 0.8 V (vs. RHE) at 85°C with a life expectancy of $\geq$ 10,000 hr in a membrance cell at 8 $\underline{M}$ NaOH.

Key Words: Oxygen electrode, electrocatalysis, silver, intercalated graphite, transition-metal phthalocyanines, platinum, chlor-alkali cells.

Title: Development of Catalytic Electrodes

Contractor: Prototech Company

Contract or Grant No.: To be negotiated

Principal Investigator: W. Juda DOE Program Manager: S. Ruby

Topical Area Funding: $99,000

Project Starting Date: Completion Date: Continuing

Objective or Description: To develop catalytic electrodes with a very low platinum loading. Electrodes will be designed for use as hydrogen electrodes in zinc electrowinning cells and as air electrodes in lithium/water/air batteries and chlor-alkali cells.

Key Words: Oxygen electrode, hydrogen electrode, electrocatalysis, platinum, metal winning, zinc, batteries, chlor-alkali cells.

Office of Fossil Energy

Title: Deuterium Tracer Method for Investigating the Chemistry of Coal Liquefaction

Contractor: Atomics International

Contract or Grant No.: EX-76-C-01-2323

Principal Investigator: L. A. Heredy DOE Program Manager: L. M. Kindley

Topical Area Funding: FY 1978: $125,415

Project Starting Date: 6/29/76 Completion Date: 6/28/78

Objective or Description: To apply the deuterium tracer method to the investigation of three important aspects of coal liquefaction: donor solvent hydrogenation of coal, catalytic hydrogenation of coal, and reactivity of model compounds.

Key Words: Catalysts, deuterium tracer, coal liquefaction, hdyrogenation.

Title: Catalyst Development for Liquefaction of Coal

Contractor: Battelle Columbus Laboratories

Contract or Grant No.: E(49-18)-2321

Principal Investigator: D. Berry DOE Program Manager: H. Podall

Topical Area Funding: FY 1978: $700,000

Project Starting Date: 6/76 Completion Date: 5/78

Objective or Description: To screen and evaluate potential catalysts for catalytic coal hydroliquefaction. The program has involved two facets: catalyst screening in an autoclave and longer term testing in a fixed-bed mode very similar to the Synthoil process. The autoclave screening has focused on determining which catalysts provide higher oil/asphaltene selectivities.

Key Words: Catalyst, liquefaction, coal, Synthoil process, Co/Mo catalysts, Ni/Mo catalysts, hydrogenation, asphaltenes.

Title: Development of an Improved Catalyst for the Synthoil Process

Contractor: Battelle Memorial Institute

Contract or Grant No.: EX-76-C-01-2321

Principal Investigator: L. J. Hillenbrand DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $406,200

Project Starting Date: 5/28/76 Completion Date: 5/31/78

Objective or Description: To develop one or more catalysts for the Synthoil process with demonstrated performance superior to the currently used Co-Mo catalyst. Performance criteria are (a) stability of asphaltene conversion and (b) ability to liquefy coal at a lower pressure. Selected catalyst(s) should be capable of being manufactured at reasonable cost in large volume.

Key Words: Catalysts, Synthoil process, Co-Mo catalyst, improved catalyst, asphaltene, coal liquefaction.

Title: A Novel Approach to Coal Gasification Using Chemically Incorporated Catalysts

Contractor: Battelle Memorial Institute

Contract or Grant No.: W-7405-ENG-92, Task 79

Principal Investigator: H. F. Feldmann and S. P. Chauhan   DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $186,900

Project Starting Date: 7/1/75   Completion Date: 2/28/78

Objective or Description: To determine the technical practicality and economic incentive to chemically incorporate catalytic agents into the coal to enhance reactivity for gasification and to eliminate the the tendency for caking.

Key Words: Catalysts, coal gasificaiton, caking.

Title: Sulfur-Resistant Methanation Catalyst

Contractor: Catalysts and Chemicals, Inc., Louisville, Kentucky

Contract or Grant No.: EX-767-C-01-2032

Principal Investigator: A. Hausberger   DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $13,155

Project Starting Date: 6/6/75   Completion Date: 1/30/78

Objective or Description: To prepare and test a carefully selected series of catalyst combinations in an effort to develop commercializable sulfur-resistant methanation catalysts for conversion of synthesis gas from coal to SNG.

Key Words: Catlayst, synthesis gas conversion, coal gasificaiton, SNG.

Title: Evaluation of Fossil Energy Research Programs in Catalysis for Coal Gasification and Liquefaction Processes

Contractor: Catalytical Associates, Inc., Palo Alto, California

Contract or Grant No.: EF-77-C-01-2536

Principal Investigator: J. A. Cushmano DOE Program Manager: L. Kindley

Topical Area Funding: FY 1978: $70,000; FY 1979: $100,000

Project Starting Date: Sept. 14, 1977 Completion Date: Continuing

Objective or Description: To critically evaluate on-going programs in catalysis research sponsored by the Division of Fossile Fuel Processing.

Key Words: Catalysts, coal liquefaction, coal gasification, program evaluation, fossile fuel programs.

Title: Catalyst Development for Coal Liquefaction

Contractor: Engelhard Industries Division, Menlo Park, New Jersey

Contract or Grant No.: EF-76-C-01-2335

Principal Investigator: E. Stern DOE Program Manager: H. Podall

Topical Area Funding: FY 1978: $292,000

Project Starting Date: 6/76 Completion Date: 5/79

Objective or Description: To screen various potential catalysts for the purpose of developing a superior catalyst for coal hydroliquefaction, as in the H-Coal process. Most of the work involves screening of catalysts in an autoclave for initial activity for conversion to ashphaltenes and oil and selectivity to oil production.

Key Words: Catalyst, liquefaction, H-Coal process, Co/Mo catalysts, coal, hydrogenation, hyrodesulfurizaiton, asphaltenes.

Title: Catalytic Coal Gasification

Contractor: Exxon Research and Engineering Company

Contract or Grant No.: EX-76-C-01-2369

Principal Investigator: T. Kalina DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $395,475

Project Starting Date: 6/30/76 Completion Date: 12/31/77

Objective or Description: To assess the technical feasibility and evaluate the economic potential of a catalytic gasification process for converting coal and steam directly to synthetic natural gas.

Key Words: Catalysts, synthetic natural gas, coal gasification.

Title: An Improved Methanation System for Use in Coal Gasification

Contractor: Midland-Ross Corporation, Toledo, Ohio

Contract or Grant No.: EX-76-C-01-2351

Principal Investigator: K. H. Hemsath DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $75,000

Project Starting Date: 6/24/76 Completion Date: 6/23/78

Objective or Description: To obtain and verify design and engineering information necessary to protect process economics and to build and test a modular catalytic insert methanator for in-field evaluation.

Key Words: Catalysts, coal gasificaiton, methanation, process economics, field test, modular methanator.

Title: Development Studies on Selected Conversion of Synthesis Gas from Coal to High-Octane Gasoline

Contractor: Mobil Research and Development Corporation

Contract or Grant No.: EX-76-C-01-2276

Principal Investigator: J. J. Wise DOE Program Manager: B. M. Harney

Topical Area Funding: FY 1978: $523,827

Project Starting Date: 6/29/76 Completion Date: 6/30/78

Objective or Description: To determine the optimum process conditions for the catalytic conversion of synthesis gas of the type produced in coal gasificaiton to a high-octane gasoline and obtain sufficient data to prepare a conceptual design for a 100-bbl/day pilot plant.

Key Words: Catalytic conversion, synthesis gas, coal gasification, gasoline, pilot plant.

Title: Research on the Deactivation of Thermally Sprayed Raney Nickel Catalyst

Contractor: National Bureau of Standards

Contract or Grant No.: E(49-1)-3800

Principal Investigator: T. Yates DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $22,500

Project Starting Date: 10/1/76 Completion Date: 9/30/78

Objective or Description: To perform detailed analysis of a variety of spent Raney nickel catalysts by using modern surface and bulk measurement techniques to identify and quantify the agent(s) responsible for catalyst deactivation. To indicate the cause(s) of catalyst deactivation and suggest the best approach to reducing this problem.

Key Words: Catalyst, Raney nickel, deactivation.

Title: Advanced Hydroliquefaction Catalyst Research

Contractor: Pittsburg Energy Research Center

Contract or Grant No.: Project 7005

Principal Investigator: R. E. Tischer   DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $250,000

Project Starting Date: 10/1/76   Completion Date: 9/30/78

Objective or Description: To develop improved heterogeneous catalysts for coal liquefaction. Work will involve screening catalysts in an autoclave unit and testing catalyst life in a continuous unit. In addition to convention catalysts, disposable catalysts will be investigated.

Key Words: Fossil energy, coal liquefaction, catalyst supports and promoters, pore volume and size distribution, iron sulfides, Ill. No. 6 coal, coal conversion to the THF solubles.

Title: Advanced Synthesis Gas Conversion

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7091

Principal Investigator: R. A. Diffenbach   DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $250,000

Project Starting Date: 7/1/75   Completion Date: 9/30/78

Objective or Description: The objective is to develop a highly selective catalytic process for the conversion of synthesis gas into C_2 - C_4 olefins, low molecular weight _n_-alkanes, high octane gasoline, and diesel fuel. Catalysts to be investigated include Raney catalysts with various alloys, multimetallic catalysts, and zeolites.

Key Words: Fossil energy, indirect coal liquefaction, Raney catalyst, multimetallic catalyst, zeolite, microreactor, reactor, $C_2/C/_4$ selectivity, conversion.

Title: Advanced Process for Conversion of Coal to Synthetic Gasoline and Other Distillate Motor Fuels

Contractor: Sun Ventures, Marcus Hook, Pennsylvania

Contract or Grant No.: EX-76-C-01-2306

Principal Investigator: A. Schneider

DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $291,200

Project Starting Date: 5/7/75

Completion Date: 5/6/81

Objective or Description: To develop a process for the catalytic hydrogenation of coal or ash-containing solvent refined coal or solvent refined lignite to a liquid syncrude that can be readily refined to a distillate motor fuel by using a molybdenum oxide on bauxite or other selected, inexpensive, expendable catalysts in slurry form.

Key Words: Catalytic hydrogenation, coal, solvent refined, lignite, motor fuel, molybdenum oxide, bauxite, slurries.

Title: Basic and Exploratory Research on Coal and Coal Conversion

Contractor: Stanford Research Institute

Contract or Grant No.: EX-76-C-01-2202

Principal Investigator: D. Ross

DOE Program Manager: L. M. Kindley

Topical Area Funding: FY 1978: $49,548

Project Starting Date: 12/8/75

Completion Date: 12/7/77

Objective or Description: To develop leads to an advanced and more efficient process for the liquefaction of coal or refining of a coal-derived syncrude in one step to distillate fuels under relatively mild reaction conditions.

Key Words: Catalytic coal liquefaction, refining syncrude.

Title: Synthesis of Liquids and Pipeline Gas by Fischer-Tropsch

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7090

Principal Investigator: R. R. Schehl DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $200,000

Project Starting Date: 1974 Completion Date: Continuing

Objective or Description: The objective is to improve catalyst activity, life, and selectivity by conducting tests to determine the best promoters to be added to the iron catalyst as well as to determine the optimum conditions for Fischer-Tropsch reaction. Work will be carried out in a bench-scale unit using tube wall reactors.

Key Words: Fossil energy, indirect coal liquefaction, Fischer-Tropsch, synthesis gas, gasoline yield, heavy hydrocarbons, tube wall reactor, talconite, K and Cu promoters, catalyst life, catalyst activity.

Title: Synthesis of Liquid Fuels and Pipeline Gas by Fischer-Tropsch Synthesis

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7090

Principal Investigator: M. F. Zarochak DOE Program Manager: B. M. Harney

Topical Area Funding: FY 1978: $24,666

Project Starting Date: 7/1/75 Completion Date: 9/30/78

Objective or Description: To make a crude oil and a gas of 800 to 900 Btu/cu ft by means of the Fischer-Tropsch reaction on gas derived from coal gasification.

Key Words: Catalytic synthesis, liquid fuels, Fischer-Tropsch, crude oil, gas coal gasification.

Title: Support Research in Catalytic Coal Gasification

Contractor: Pittsburg Energy Research Center

Contract or Grant No.: Project 7351

Principal Investigator: W. P. Haynes   DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $150,000

Project Starting Date: 10/1/76   Completion Date: 9/30/78

Objective or Description: To provide support for DOE contracts on catalytic gasification by testing treated coals in the Synthane gasifier and determining basic reactivity data for catalytic hydrogasification in bench-scale equipment.

Key Words: Catalytic coal gasification, Synthane gasified, basic reactivity data.

Title: Structural Changes During Coal Liquefaction

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7096

Principal Investigator: A. G. Sharkey, Jr.   DOE Program Manager: L. M. Kindley

Topical Area Funding: FY 1978: $249,240

Project Starting Date: 7/1/75   Completion Date: 9/30/78

Objective or Description: To apply advanced analytical techniques to the solution of problems related to the use of coal. To develop methods involving various instrumental techniques to provide specialized investigative support to other projects, including studies of catalysts and products relating to catalyst activity.

Key Words: Catalytic coal conversion, analytical techniques, activity.

Title: Methanation Catalyst Research

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7094

Principal Investigator: C. L. Kibby DOE Program Manager: K. E. Woodcock

Topical Area Funding: FY 1978: $150,000

Project Starting Date: 7/1/78 Completion Date: 9/30/78

Objective or Description: To determine the factors affecting the life and activity of methanation catalysts and, in particular, to assist in developing stable methanation catalysts for use in the Synthane process.

Key Words: Catalyst life, activity, Synthane process.

Title: Mechanisms of Coal Liquefaction

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7088

Principal Investigator: B. O. Bockrath DOE Program Manager: L. M. Kindley

Topical Area Funding: $256,920

Project Starting Date: 7/1/75 Completion Date: 9/30/78

Objective or Description: To determine the mechanism of coal liquefaction and catalyst deactivation to provide a basis for further improvements in coal liquefaction technology.

Key Words: Catalysts, coal liquefaction, catalyst deactivation.

Title: Homogeneous Catalytic Reactions of H_2 + CO

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7093

Principal Investigator: I. Wender and F. W. Steffgen

Program Manager: B. M. Harney

Topical Area Funding: FY 1978: $69,500

Project Starting Date: 7/1/75

Completion Date: 9/30/78

Objective or Description: To develop the chemistry and catalysis of reacting hydrogen and carbon monoxide via homogeneous systems to produce useful, low molecular weight carbon compounds upon which the technology of converting coal to chemicals and fuels could be based.

Key Words: Homogeneous catalysts, hydrogen, carbon monoxide, carbon compounds, synthesis, coal conversion.

Title: Homogeneous Catalytic Reactions

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7093

Principal Investigator: S. Metlin

DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $100,000

Project Starting Date: 1975

Completion Date: Continuing

Objective or Description: The objective is to develop the methanol homologation reaction by using homogeneous catalysts to produce ethanol and other low molecular weight compounds; ethanol can be dehydrated to ethylene by known technology. Cobalt carbonyls with various additives will be used as the catalysts.

Key Words: Fossil energy, indirect coal liquefaction, methanol conversion, ethanol selectivity, cobalt carbonyls, phosphines and phosphine complexes, solvents, rocking autoclave.

Title: Coal Liquids Upgrading

Contractor: Pittsburgh Energy Research Center

Contract or Grant No.: Project 7007

Principal Investigator: Y. C. Fu DOE Program Manager: J. Shen

Topical Area Funding: FY 1978: $400,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: The overall objective is to develop and demonstate the processing technology for upgrading coal-derived liquids to distillate fuel types that will meet the necessary specifications for residential, transportation, and industrial applications. Work will be carried out in a continuous fixed-bed unit. Catalyst screening tests will also be included.

Key Words: Fossil energy, coal liquids upgrading, Ni-Mo and Ni-W catalysts, 2-stage hydroprocessing, flow microreactors, process variable study, optimization, nitrogen removal, fixed bed catalyst.

Title: Effect of Methanation Catalyst Properties Upon Resistance to Deactivation

Contractor: Brigham Young University

Contract or Grant No.: EF-77-C-01-2729

Principal Investigator: C. H. Bartholomew, Jr. DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $80,000

Project Starting Date: 4/75 Completion Date: Continuing

Objective or Description: To develop more active and stable sulfur and sintering-resistant catalysts through alloying of other catalytic metals with nickel and iron. To investigate the application of monolith-supported catalysts for methanation in a fixed-bed reactor.

Key Words: Catalyst, methanation, deactivation, iron, nickel, sulfur, sintering, alloys.

Title: Catalytic Synthesis of Gaseous Hydrocarbons

Contractor: Carnegie-Mellon University

Contract or Grant No.: EX-76-C-01-1814

Principal Investigator: A. L. Dent

DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $25,028

Project Starting Date: 5/7/75

Completion Date: 2/6/78

Objective or Description: To develop improved methanation catalyst systems. To investigate intermediates formed on catalyst surface in methanation process. To seek potential catalysts for combined shift conversion/methanation reactions. To investigate and evaluate the catalyst systems.

Key Words: Catalytic synthesis, methanation, intermediates.

Title: Research in the Conversion of Coal to Clean Distillate Fuels

Contractor: Montana State University

Contract or Grant No.: EX-76-C-01-2034

Principal Investigator: L. Berg and F. P. McCandless

DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $39,123

Project Starting Date: 6/18/75

Completion Date: 6/30/78

Objective or Description: To develop a catalytic process for hydrogenating heavy liquids derived from bituminous coal to produce clean distillate fuels.

Key Words: Hydrogenation, catalyst, coal conversion, distillate.

Title: Thermal Effcts During Material Conversion and Catalytic Processes

Contractor: New York University

Contract or Grant No.: EX-76-S-01-2317

Principal Investigator: M. J. D. Low DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $59,320

Project Starting Date: 3/15/76 Completion Date: 3/14/79

Objective or Description: To perform a series of experiments to measure surface temperatures, both average and transient, on coal conversion catalysts by means of a contactless, radiometric method.

Key Words: Catalyst, thermal effects, coal conversion, radiometry, surface temperature measurement.

Title: Catalysts for Upgrading Coal-Derived Liquids

Contractor: Oklahoma State University

Contract or Grant No.: EX-76-C-01-2011

Principal Investigator: B. L. Crynes DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $16,816

Project Starting Date: 6/9/75 Completion Date: 12/8/77

Objective or Description: To perform catalyst investigations to upgrade liquids from coal-to-oil processes under hydrogen pressure to remove sulfur, nitrogen, and oxygen.

Key Words: Catalyst, upgrading purity, sulfur, nitrogen, oxygen, coal-to-oil process.

Title: The Characteristics of American Coals in Relation to Their Conversion to Clean Energy Fuels

Contractor: Pennsylvania State University

Contract or Grant No.: EX-76-C-01-2030

Principal Investigator: W. H. Spackman

DOE Program Manager: P. A. Barnes

Topical Area Funding: FY 1978: $772,968

Project Starting Date: 6/26/75

Completion Date: 8/25/76

Objective or Description: To acquire the capability of predicting, from a knowledge of coal composition, the behavior of any coal in preconversion processing and coal gasification and liquefaction processes.

Key Words: Catalyst, coal conversion, coal characteristics

Title: Transition-Metal Cluster Complexes as Catalysts for the Conversion of Coal-Derived Synthesis Gas into Organic Feedstocks and Fuels

Contractor: Pennsylvania State University

Contract or Grant No.: EF-77-G-01-2740

Principal Investigator: G. L. Geoffrey

DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $20,000

Project Starting Date: 7/27/77

Completion Date: 7/26/79

Objective or Description: To develop selective and efficient catalysts for the conversion of coal-derived synthesis gas into useful organic feedstocks and fuels.

Key Words: Transition metals, cluster complexes, catalyst, coal conversion, synthesis gas, organic feedstocks, fuels.

Title: Formation and Control of Fuel-Nitrogen Pollutants in Catalytic Combustion of Coal-Derived Gases

Contractor: Princeton University

Contract or Grant No.: EF-77-C-01-2762

Principal Investigator: F. V. Bracco DOE Program Manager: H. G. Jacobson

Topical Area Funding: FY 1978: $60,000

Project Starting Date: Completion Date:

Objective or Description: To examine and control the conversion of fuel-nitrogen to pollutant gases (e.g., NO_x) during the catalytic combustion of low- and intermediate-Btu gases derived from coal.

Key Words: Catalyst, nitrogen oxides, pollution control, coal combustion, gaseous catalysis.

Title: Desulfurization with Transition-Metal Catalysts

Contractor: State University of New York at Binghamton

Contract or Grant No.: EF-77-G-01-2739

Principal Investigator: J. J. Esch DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $20,000

Project Starting Date: 7/28/77 Completion Date: 7/27/79

Objective or Description: To study the mechanism and scope of desulfurization of organic sulfur compounds by using a novel nickel (0) catalyst.

Key Words: Catalytic desulfurizaiton, transition metals, sulfur compounds, nickel.

Title: Direct Catalytic Hydrodesulfurizaiton of Coal

Contractor: State University of New York at Buffalo

Contract or Grant No.: EX-76-C-01-2013

Principal Investigator: S. W. Weller DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $54,120

Project Starting Date: 6/10/75 Completion Date: 6/9/78

Objective or Description: To investigate catalyst support systems for hydrodesulfurization of coal with emphasis on monolith supported catalysts of different, but controlled, pore sizes.

Key Words: Catalytic hydrodesulfurization, coal, pore size.

Title: Rapidly Solidified, Non-equilibrium Alloys as Catalysts for Fossile Fuel Processing

Contractor: Southern Illinois University

Contract or Grant No.: EF-77-G-01-2734

Principal Investigator: W. E. Brower, Jr. DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978, $20,000

Project Starting Date: 7/27/77 Completion Date: 7/26/79

Objective or Description: To determine whether lower cost, more effective catalysts can be produced by means of rapidly solidified, non-equilibrium alloys.

Key Words: Catalyst, rapid solidification, non-equilibrium alloys.

Title: Transition Metal-Graphite Catalysts for Production of Light Hydracarbons from Synthesis Gas

Contractor: Texas A & M University

Contract or Grant No.: EX-76-C-01-2467

Principal Investigator: M. P. Rosynek DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $29,306

Project Starting Date: 8/1/76 Completion Date: 7/31/79

Objective or Description: To develop a novel process for the production of petrochemical feedstocks based on coal or other carbonaceous materials, by using transition metal-graphite catalysts to produce light hydrocarbons from synthesis gas via Fischer-Tropsch synthesis.

Key Words: Catalyst, transition metal, graphite, synthesis gas, Fischer-Tropsch, petrochemical feedstocks.

Title: Coal Hydrogenation via Bonding of Metallic Compounds to Coal

Contractor: University of Cincinnati

Contract or Grant No.: EX-76-S-01-2308

Principal Investigator: M. Orchin DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $80,000

Project Starting Date: 4/1/76 Completion Date: 3/31/79

Objective or Description: To investigate a novel homogeneous catalytic system for coal hydrogenation, based on chemisorption principles.

Key Words: Catalyst, coal hydrogeneration, chemisorption, bonding, homogeneous catalysis.

Title: Development of Sulfur-Tolerant Catalysts for the Methanation of Coal Gasification Products.

Contractor: University of Colorado

Contract or Grant No.: EF-77-G-01-2730

Principal Investigator: M. C. Rakowski

DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $20,000

Project Starting Date: 7/26/77

Completion Date: 7/25/79

Objective or Description: To develop effective methanation catalysts, which are not subject to sulfur poisoning, for use in single-stage coal gasification processes.

Key Words: Catalyst, sulfur-tolerant, methanation, coal gasification.

Title: Kinetics and Mechanisms of Desulfurization and Denitrogenation of Coal-Derived Liquids

Contractor: University of Delaware

Contract or Grant No.: EX-76-C-01-2028

Principal Investigator: B. C. Gates and J. R. Katzer

DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $164,403

Project Starting Date: 6/20/75

Completion Date: 6/19/78

Objective or Description: To determine reaction kinetics and mechanisms for catalytic hydrodesulfurization and hydrodenitrogenation of compounds found or believed to be present in coal-derived liquids. To recommend improved catalytic processes for hydrodesulfurization and hydrodenitrogenation.

Key Words: Catalyst, coal liquefaction, purification, nitrogen, sulfur.

Title: Catalytic Activity of Coal Mineral Matter

Contractor: University of Kentucky

Contract or Grant No.: EX-76-C-01-2233

Principal Investigator: C. Hamrin DOE Program Manager: P. A. Barnes

Topical Area Funding: FY 1978: $11,750

Project Starting Date: 1/1/76 Completion Date: 12/31/77

Objective or Description: To determine the ability of naturally occurring mineral matter found in coal to catalytically desulfurize and denitrogenate model sulfur- and nitrogen-containing coal compounds.

Key Words: Catalyst, natural minerals, coal compounds, purify, sulfur, nitrogen.

Title: Surface Structure and Mechanisms of Gasification Catalyst Deactivation

Contractor: University of Kentucky

Contract or Grant No.: EX-76-C-01-2229

Principal Investigator: P. J. Reucroft DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978, $131,428

Project Starting Date: 2/1/76 Completion Date: 1/31/79

Objective or Description: To characterize the surface structure of methanation catalysts in order to relate structural features to catalytic activity.

Key Words: Catalyst, surface structure, cool gasification, deactivation.

Title: Mass Transport Characteristics of Zeolite Cracking Catalysts

Contractor: University of Mississippi

Contract or Grant No.: EF-77-C-01-2727

Principal Investigator: H. W. Haynes DOE Program Manager: W. R. K. Wu

Topical Area Funding: $235,000 for 2 years ($118,000 pa)

Project Starting Date: 1977 Completion Date: 1979

Objective or Description: To assess the significance of intracrystalline pore diffusion limitations when processing coal-derived syncrudes over zeolite cracking catalysts. To test various zeolite catalysts for their ability to crack coal-derived syncrudes to naphtha.

Key Words: Catalyst, mass transport, cracking, zeolite, pore size, coal, syncrude, naphtha.

Title: Direct Conversion of Lignite to Chemical Feedstocks via a Combination of Molten-Salt Catalysis and Solvent-Refining Techniques

Contractor: University of North Dakota

Contract or Grant No.: EF-77-G-01-2736

Principal Investigator: W. P. Scarrah DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $16,580

Project Starting Date: 7/27/77 Completion Date: 7/26/78

Objective or Description: To determine the potential for directly converting lignite to chemical feedstocks by a process combining technologies from molten-salt catalysis and solvent refining.

Key Words: Catalyst, direct coal conversion, feedstocks, molten salt, solvent refining.

Title: Chemistry and Structure of Coal-Derived Asphaltenes

Contractor: University of Southern California

Contract or Grant No.: EX-76-C-01-2031

Principal Investigator: T. F. Yen | DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY: 1978: $65,232

Project Starting Date: 6/20/75 | Completion Date: 6/19/78

Objective or Description: To procure, isolate, and characterize asphaltene fractions from major U.S. coal liquefaction projects. To correlate structural asphaltene data with process conditions at the projects sampled to define the role of asphaltenes in the conversion process.

Key Words: Catalyst, asphaltene, coal liquefaction, structural data.

Title: Catalysts for *in situ* Hydroliquefaction of Coal

Contractor: University of Tennessee

Contract or Grant No.: EY-76-S-02-0066

Principal Investigator: J. W. Larsen | DOE Program Manager: W. R. K. Wu

Topical Area Funding: FY 1978: $4,612

Project Starting Date: 5/1/75 | Completion Date: 11/30/77

Objective or Description: To develop homogeneous catalysts for low-temperature hydrogenation of coal to be used in *in situ* hydroliquefaction.

Key Words: Catalyst, coal, *in situ* hydroliquefaction, homogeneous, low temperature.

Title: Chemical Constitution of Alkylated and Depolymerized Products of Coal

Contractor: University of Tennessee

Contract or Grant No.: EY-77-S-05-5394

Principal Investigator: J. W. Larsen DOE Program Manager: W. R. K. Wu

Topical Area Funding: $142,000 for 3 years ($47,000 pa)

Project Starting Date: Completion Date:

Objective or Description: To find new catalysts and reaction conditions for converting coal liquids to large volume chemicals, such as low molecular weight olefins, aromatics, and phenolics. To prepare and test new catalytic compositions that can be used to produce chemicals from coal liquids.

Key Words: Catalyst, coal conversion, liquids, chemicals, olefins, aromatics, phenolics compounds.

Title: Processes for Liquefaction and Gasification of Western Coals

Contractor: University of Utah

Contract or Grant No.: EX-76-C-01-2006

Principal Investigator: W. H. Wiser DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $618,924

Project Starting Date: 5/30/75 Completion Date: 7/29/79

Objective or Description: To evaluate process concepts, perform catalytic studies, investigate fundamental processes, and evaluate products related to gasification and liquefaction of western coals.

Key Words: Catalyst, process concepts, coal gasification, coal liquefaction, western coals.

Title: Metal-Catalyzed Reactions of Polyaromatic Compounds

Contractor: University of Wisconsin

Contract or Grant No.: EF-77-G-01-2737

Principal Investigator: P. M. Treichel, Jr. DOE Program Manager: P. C. Scott

Topical Area Funding: FY 1978: $20,000

Project Starting Date: 7/27/77 Completion Date: 7/26/79

Objective or Description: Develop reaction chemistry of metal complexes of polycyclic aromatic hydrocarbons.

Key Words: Catalyst, polyaromatic compounds, metal complexes, hydrocarbons, reaction chemistry.

Title: Kinetics and Mechanisms of Catalytic Hydroliquefaction and Hydrogasification of Lignite

Contractor: Worcester Polytechnic Institute

Contract or Grant No.: EF-77-C-01-2702

Principal Investigator: A. H. Weiss DOE Program Manager: W. R. K. Wu

Topical Area Funding: $100,000 for 2 years ($50,000 pa)

Project Starting Date: Completion Date:

Objective or Description: To study the overall conversion rate and elemental transformation of lignite into products under surface-reaction conditions. To postulate the reaction mechanisms of catalytic hydroliquefaction and hydrogasification of liquids.

Key Words: Catalyst, kinetics, lignite, coal gasification, coal liquefaction.

Division of Materials Sciences

Title: Optical and Surface Physics Theory

Contractor: Ames Laboratory

Contract or Grant No.: W-7405-ENG-82

Principal Investigator: K. L. Kliewer DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $157,500

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To study optical properties of metals, semiconductors, and insulators; studies of surfaces, thin films, layered systems, small particles, and powders; effects of surface roughness; photoemission with emphasis on effects associated with the presence of a surface. Photoemission into liquid electrolytes and related catalytic, electrochemical, adsorption, and corrosion effects.

Key Words: Photoemission, electrochemical photovoltaic cells, photolysis, surfaces, films, layered systems, solar energy, high temperature absorbers.

Title: Chemistry of Heavy Transition Metals

Contractor: Ames Laboratory

Contract or Grant No.: W-7405-ENG-82

Principal Investigator: J. D. Corbett DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $129,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To investigate the preparation and characterization of dimeric and cluster compounds of heavy transition elements with strong metal-metal bonds having a potential for energy storage and catalytic applications.

Key Words: Dimer, cluster, metal-metal bonds, energy storage, catalysis.

Title: Surface Chemistry and Catalysis

Contractor: Ames Laboratory

Contract or Grant No.: W-7405-ENG-82

Principal Investigator: R. S. Hansen DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $293,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: This program comprises work on heterogeneous catalysis by metals and semiconductors, clean surfaces, reactions associated with coal liquefaction and gasification. Single-crystal-face catalysis and the electronic structure and motion of adsorbed species by pulse and multiple-pulse NMR spectroscopy are also under study.

Key Words: Heterogeneous catalysis, surfaces, crystal face, adsorption, multiple pulse NMR.

Title: Catalysis and Surface Studies

Contractor: Argonne National Laboratory

Contract or Grant No.: W-31-109-ENG-38

Principal Investigator: M. B. Brodsky DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $191,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: To study the use of intermetallic compounds as catalysts, the electronic and atomic structure of intermetallic compound surfaces, the effects of gases on surface properties, and x-ray photoelectron, and Auger electron spectroscopy of surfaces.

Key Words: Intermetallic, surfaces, x-ray, photoelectron, and Auger electron spectroscopy, low energy electron diffraction.

Title: Catalysis and Surface Studies

Contractor: Argonne National Laboratory

Contract or Grant No.: W-31-ENG-38

Principal Investigator: D. O'Reilly DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $274,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: This program is concerned with the properties and dynamics of atoms and molecules adsorbed on surfaces as studied with NMR, ESR, and ENDOR spectroscopy; adsorbed species and catalysis in zeolites, silica gel, zinc and copper chromite systems, and supported metal catalysts; inelastic electron tunneling through submonolayers of organic molecules; and atomic beam scattering from surfaces.

Key Words: Surfaces, catalysis, adsorbed species, zeolites, silica gel, zinc (and) copper chromite, tunneling.

Title: Solid-State Theory

Contractor: Argonne National Laboratory

Contract or Grant No.: W-31-109-ENG-38

Principal Investigator: T. Arai DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $470,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: To study molecular dynamics and computer simulation of solids and liquids; electronic structure and properties of metals and intermetallic compounds; structure and interaction of atoms in condensed matter; surface phenomena including surface structure, physisorption, chemisorption and catalysis; and the electronic structure of perovskites.

Key Words: Dynamics, surface structure, intermetallics, physisorption, chemisorption, perovskites.

Title: Molten Salt Chemistry

Contractor: Argonne National Laboratory

Contract or Grant No.: W-31-109-ENG-38

Principal Investigator: F. Cafasso DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $115,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The use of fundamental solution theory to estimate thermodynamic properties of molten salt systems is being investigated. Also under study are phase diagrams, solubilities of oxides and sulfides in molten salts; spectroscopic properties of salt vapors, associated vapor species between acidic salts (e.g., $AlCl_3$ or $ZnCl_2$) and other salts; catalytic activity of molten salts; and chemical transport and separations by vapor mechanisms.

Key Words: Phase diagrams, solubility, transport, separation, vapor, catalysis, molten salts, spectroscopy of salt vapors.

Title: Experimental Research: Surface Studies

Contractor: Brookhaven National Laboratory

Contract or Grant No.: EY-76-C-02-0016

Principal Investigator: R. J. Smith DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $132,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: The study of chemical reactions on surfaces of single-crystal or polycrystalline group VIII metals and metallic oxides, under high vacuum conditions; chemisorption studies by secondary ion mass spectrometry; correlation with chemisorption bonds and surface phases. Interaction of low-energy ions with surfaces.

Key Words: Surfaces, single crystal, polycrystalline, oxides, chemisorption.

Title: Physical and Catalytic Properties of Catalysts

Contractor: University of Illinois

Contract or Grant No.: EY-76-C-02-1198

Principal Investigator: H. J. Stapleton DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $63,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: Investigation of the La-Co-O system as a model for rare-earth perovskite catalysts. Defect structures and oxygen mobility, as related to catalytic activity.

Key Words: Perovskite, catalyst, defect, mobility.

Title: Nuclear Magnetic Resonance in Solids

Contractor: University of Illinois

Contract or Grant No.: EY-76-C-02-1198

Principal Investigator: C. P. Slichter DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $130,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Nuclear magnetic resonance investigations of layered compounds and of platinum-silica hydrocarbon reforming catalysts.

Key Words: NMR, catalysts, hydrocarbon, reforming, layered compounds.

Title: Physical Properties of Transition Metal Carbides

Contractor: University of Illinois

Contract or Grant No.: EY-76-C-02-1198

Principal Investigator: W. S. Williams DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $77,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The study of the physical properties of the transition metal carbides, with emphasis on hardness, catalytic properties, and possible use as a photothermal solar energy converter.

Key Words: Carbides, catalyst, transition metal, physical properties, photothermal converter.

Title: Theoretical Studies of Metals and Alloys

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: J. S. Faulkner DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $380,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Subjects under investigation are multiple-scattering cluster program for electronic states of Cu, and Ni, Fe atoms, effects of surfaces; thermal and electrical transport in transition metals; band-theory calculation of electronic states in periodic crystals; nonstoichiometric compounds.

Key Words: Clusters, electronic states, band theory, periodic crystals, copper, nickel, iron, thermal transport, electric transport.

Title: Surface Studies and Catalysis

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: L. H. Jenkins DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $500,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description:

Key Words: Surfaces, LEED, vibronic structure, Auger electron spectroscopy, chemisorption, angular dependence, electron-loss spectroscopy, overlayers, sub strates.

Title: Chemical Structure of Energy-Related Materials

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: W. R. Busing DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $730,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: The determination of atomic and molecular arrangements in crystals and liquids by neutron and x-ray diffraction studies. Materials studied include molten salt catalysts for clean fuel synthesis, salt hydrates for thermal energy storage, macromolecular catalysts for hydrogen production; sterically hindered hydrocarbons, and compounds derived from coal research or tertiary oil recovery programs.

Key Words: Neutron and x-ray diffraction, molten salts, catalysts, synthetic fuel, storage, hdyrogen, coal, tertiary oil recovery.

Title: Chemical Poisoning in Heterogeneously Catalyzed Reactions

Contractor: Princeton University

Contract or Grant No.:

Principal Investigator: S. L. Bernasek DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $48,000

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: Poisoning of single-crystal catalytic surfaces by nitrogen and sulfur compounds. Surface spectroscopy by LEED and ESCA to examine catalytic activity.

Key Words: Hydrogenation, poisoning, LEED, ESCA, catalysis, heterogeneous catalysis.

Title: Hydrogen and Methane Syntheses Through Radiation Catalysis

Contractor: Colorado School of Mines

Contract or Grant No.:

Principal Investigator: J. G. Morse DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $161,990

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: The study of radiation-induced catalysis involving energy transfer from the catalyst to its adsorbed reactant in an ionizing radiation environment.

Key Words: Radiation, catalysis, ionizing radiation.

Title: Surface Characterization of Catalytically Active Metal Alloy and Compound Films

Contractor: Syracuse University

Contract or Grant No.:

Principal Investigator: R. W. Vook DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $83,400

Project Starting Date: 1977 Completion Date: Continuing

Objective or Description: The correlation of structural, microstructural, and chemical parameters of thin epitaxial surface layers with their catalytic activities. Effects of ledges, strains, dislocations, crystal orientation, and surface composition on catalytic activity.

Key Words: Microstructure, epitaxial layer, catalysis, dislocations, orientation, surface composition.

Title: Studies of Fundamental Factors Controlling Catalyzation of Reactions of Gases with Carbonaceous Solids

Contractor: U. S. Steel Corporation

Contract or Grant No.:

Principal Investigator: R. M Fisher DOE Program Manager: D. K. Stevens

Topical Area Funding: FY 1978: $67,940

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: Studies of the mechanism of graphite catalyzed with Fe particles; in situ observations using high-voltage electron microscopy; crystallographic observations coupled with reaction-rate studies.

Key Words: Graphite, catalysis, electron microscopy, reaction-rate studies.

Office of Military Application

Title: Surface Studies

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.:

Principal Investigator: W. P. Ellis

DOE Program Manager: F. W. Hughes

Topical Area Funding: $70,000/yr.

Project Starting Date: FY 1976

Completion Date: Continuing

Objective or Description: The most modern techniques of low energy electron diffraction (LEED), and photoelectron spectroscopy (PES) are used to characterize surface structures, detect and identify surface impurities, and obtain information about valence band electrons in studies of catalysis of reactions of gases by solid surfaces.

Key Words: Catalysis, surface structures, surface impurities, valence band electrons, LEED, Auger/Loss, PES.

SUPERCONDUCTORS

Introduction

The work on superconductors and superconducting systems is funded for FY 1978 by three DOE divisions: Electric Energy Systems, Materials Sciences, Energy Storage and Development and Technology (Office of Fusion Energy), at a combined operating cost total for materials of about $9.4 million, (as also summarized in Table 4, Chapter 1). The total cost including systems design and development is much larger, and involves many large scale applications of superconductors, as outlined in Chapter 1.

The Division of Electric Energy Systems is supporting the development of a flexible a.c. superconducting cable system based on Nb_3Sn and a plastic tape dielectric. The project includes in-house research at BNL, which also manages supporting research on materials and refrigeration. This comprehensive activity has a budget of $2.5 million* in FY 1978, of which $200,000 is taken to represent work on materials.

The Division of Material Sciences has most of their 33 projects entirely devoted to superconducting materials, with a few partly so; 8 are at universities ($0.8 million) and the rest at national laboratories (Total $5.1 million). The work, detailed in DOE/ER-0013, Materials Sciences Programs, September, 1978, includes the study of binary compounds, order parameters, electron-dislocation interactions, flux pinning and flux flow, alloy structures, metallurgical properties, impurity content of alloys, deposition by sputtering and chemical vapor decomposition wires, multifilamentary wires, tapes, non-equilibrium effects, kinetics of diffusion, radiation damage, tunneling, theory of vortices, electron states, phonon interactions, fabrication techniques, and so forth.

Energy Storage accounts for 2 projects and a total FY 1978 expenditure of $195,000.

The Office of Fusion Energy, Division of Development and Technology has 11 projects, including 3 at a university, 8 at national laboratories. Objectives include development of high-field superconducting wire with improved ductility, Nb_3Sn and NbTi alloy conductors and optimization does not contain details of the work sponsored at BMI (Columbus), General Atomic, NBS, and Cornell University. This subtotal amounts to $700,000, out of a total of $9.8 million* for the 11 projects. The largest project is at ORNL ($7.3 million)* and is for work to develop superconducting magnets. This project is in support of test coils for the TNS (1980s) and the Experimental Magnetic Fusion Power Reactor (1990s). In addition to the operating expenses, an allocation of $2.6 million* was distributed for capital equipment, the bulk ($1.9 million) to ORNL.* Energy Storage also uses superconductor technology.

Among large scale applications in research and industry that are not specifically included in the details that follow are the Intersecting Storage Accelerator (ISABELLE) at BNL, the Energy Doubler/Saver at Fermi National Laboratory, the Mirror Fusion Test Facility at LLL, the Tokamak Large Coil Test Facility at ORNL, and large scale magnet-hydro-dynamics applications.

Note: *It is assumed that only one-tenth of these amounts is materials research oriented, and 10% was used in compiling the total used in this EMACC report.

Division of Electric Energy Systems

Title: AC Superconducting Power Transmission Cable Development

Contractor: Brookhaven National Laboratory

Contract or Grant No.: E(30-1)-16

Principal Investigator: M. Suenaga DOE Program Manager: R. W. Flugum

Topical Area Funding: $200,000

Project Starting Date: 1973 Completion Date: 1983

Objective or Description: Development of a flexible ac superconducting cable system based on Nb_3Sn conductor and a tape dielectric. The project includes management of all supporting research on materials for the power transmission project.

Key Words: Superconducting, niobium-tin, ac, cable, underground, refrigerator, cryogenic.

Office of Fusion Energy
Division of Development and Technology

Title: Investigation of a Novel Approach to the Design of a Ductile Superconducting Wire

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigator: J. W. Morris, Jr. DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978: $35,000

Project Starting Date: 10/77 Completion Date: 10/80

Objective or Description: The goal of this research is to develop a high-field superconducting wire which retains some useful plastic ductility in liquid helium. Available superconducting materials are brittle, which could cause difficulties in the construction and operation of large superconducting magnets. The technical approach followed in this research is to use advanced metallurgical processing techniques to introduce a superconducting phase in the form of a dispersion of extremely fine superconducting particles (the A-15 phase) within a ductile metallic matrix. If the distribution of the particles can be precisely controlled it is possible to develop a superconducting wire that combines good superconducting properties with useful plasticity in liquid helium.

Key Words: A-15, superconductors, magnetic fusion energy.

Title: Development of Nb-Ti Conductors for 10T-14T Operation

Contractor: Magnetic Corporation of America, Waltham, Massachusetts

Contract or Grant No.: EG-77-C-02-4180

Principal Investigator: Z. J. J. Stekly DOE Program Manager: E. Dalder

Topical Area Funding: $100,000

Project Starting Date: 10/76 Completion Date: Uncertain

Objective or Description: This 2-year development program consists of the following tasks: (1) Survey of the use of Nb-Ti alloy conductor and coil performance at fields >8 T. (2) Optimization of production-type conductor processing using two compositions in current production (Nb-46 Ti, Nb-50 Ti) (10-in.-diam billets). (3) Preliminary examination of the problems associated with conductor operation at temperatures below 4.2 K. (4) Optimization of composition and processing using small-scale (4-in.-diam) billets. (5) Fabrication of a production-size billet into fully transposed cable capable of being used as a low copper-to-superconductor core as a building block for conductors for large high-field Tokamaks.

Key Words: Nb-Ti alloys, magnetic fusion energy.

Title: Fabrication and Properties of Conductors for MFE Magnets

Contractor: Brookhaven National Laboratory

Contract or Grant No.: EY-76-C-02-0016

Principal Investigator: M. Suenaga DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978: $200,000

Project Starting Date: 10/77 Completion Date: Continuing

Objective or Description: Development of composite Nb_3Sn superconductors requires an understanding and control of all aspects of fabrication and assembly. Thus, this program focuses on (a) determination of the degradation mechanisms of Nb_3Sn superconductors subjected to mechanical strains and development of processing procedures for making superconductors (Nb_3Sn) with improved ductility, (b) development of composite conductors and fabrication methods to minimize degradation, and (c) development of other, more attractive high-field conductors.

Key Words: Nb_3Sn, Cu, bronze, diffusion, magnetic fusion energy.

Title: Fabrication of Superconducting Wire Composites by Directional Solidification

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigators: D.K. Finnemore & J. Verhoeven DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978, $50,000

Project Starting Date: 1/77 Completion Date: 1/78

Objective or Description: The goal of this research is to utilize the directional solidification technique to develop a ductile composite superconducting wire consisting of Nb_3Sn filaments in a Cu matrix. Techniques will be developed to directionally solidify binary alloys of Cu-Nb so that an array of very fine Nb dendrites extends along the axis of the alloy rod. Successful development will produce Nb dendrite arrays that are continuous along the entire length of the alloy rod. The rods will then be drawn down to dimensions of about 10 mils (0.25 mm) and coated with a layer of tin. Heat treatment will then diffuse the Sn into the alloy and form Nb_3Sn on the Nb dendrite filaments.

Key Words: Nb_3Sn, Nb, Sn, Cu, superconductivity, magnetic fusion energy.

Title: Superconducting Magnet Development

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: D. Cornish DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978, $1,400,000

Project Starting Date: FY 1974 Completion Date:

Objective or Description: The objectives here are to develop Nb-Ti superconductors for a mirror fusion test facility, to study the technological requirements of likely "next generation" mirror devices, to assist in conceptual designs, and to carry out a development program so that the feasibility of the devices can be assured and the preproject work can be limited to the development and proving of prototypes.

The niobium-tin program is scheduled to develop, in conjunction with industry, a conductor suitable for the machine to follow the mirror fusion test facility.

Key Words: Nb_3Sn, Nb-Ti, superconductors, magnetic fusion energy.

Title: Superconducting Magnet Development Program

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: 189

Principal Investigator: M. Lubell DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978: Total 2.3M; 45% materials related (= $1,035,000)

Project Starting Date: FY 1974 Completion Date:

Objective or Description: The Superconducting Magnet Development Program is the basic development activity needed to support the fabrication of test coils for the TNS to be built in the mid-1980s and the Experimental Power Reactor for the 1990s. The basic program contains the tasks necessary to develop conductors, develop methods of stress analysis and fabrication, and measure materials properties leading to the design, fabrication, and testing of intermediate-size coils. An industrial fabrication program (the Large Coil Project, 189 No. 00012) is being conducted parallel to and integrated with this basic program. These two programs will provide demonstrated scaling relations and fabrication and testing experience needed to ensure the capability to design and fabricate the large coils required for the TNS and Experimental Power Reactors.

Key Words: Nb_3Sn, Nb-Ti, superconductors, magnetic fusion energy.

Title: Force-Cooled Superconductor Development

Contractor: Massachusetts Institute of Technology

Contract or Grant No.:

Principal Investigator: M. Hoenig DOE Program Manager: E. Dalder

Topical Area Funding: To date: $300,000

Project Starting Date: FY 1974 Completion Date: FY 1980

Objective or Description: The objective of this program is to develop the forced-cooled superconductor concept through analysis and testing of progressively larger test coils, culminating in the development of an advanced-design toroidal forced-cooled Nb_3Sn superconducting coil, its fabrication, and operation in a cluster of toroidal coils at the Kern-Forschungs-Zentrum in Karlsruhe, West Germany.

Key Words: Nb_3Sn, Nb-Ti, forced-cooled superconductor, magnetic fusion energy.

Title: Radiation Effects on Insulators for Superconducting Magnets

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-ENG-26

Principal Investigator: J. L. Scott DOE Program Manager: M. Cohen

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Completion Date:

Objective or Description: To determine the radiation lifetime of insulators for superconducting magnets. Primarily, this program is to irradiate commercial composites that are used in manufacturing superconducting magnets. Irradiations are being done at 4°K in a cryostat in the bulk-shielding reactor. Irradiating is being done on materials such as aluminum-coated Mylar, Mylar tape, Raplon, and several types of epoxy resins.

Key Words: Composites, polymers, Mylar, resins, irradiation, superconducting magnets, insulators.

Title: Novel Composite Superconductive Wire

Contractor: Massachusetts Institute of Technology

Contract or Grant No.:

Principal Investigator: Dr. Foner DOE Program Manager: M. Johnson

Topical Area Funding: FY 1979: $300,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Develop of novel composite superconductive wire by _in situ_ and powder metallurgy techniques. Wires fabricated with _in situ_ technology have superior mechanical properties to conventional multifilamentary NbSn wire.

Key Words: Superconductive wire, powder metallurgy, in situ technology, superior mechanical properties.

Title: Low Loss Supercnductors

Contractor: Los Alamos Laboratory

Contract or Grant No.:

Principal Investigator: J. Rogers DOE Program Manager: D. Beard

Topical Area Funding: FY 1978: $175,000 (part of a larger project)

Project Starting Date: Completion Date: Continuing

Objective or Description: Develop low loss superconducting mixed matrix material for Toroidal fuel coil systems.

Key Words: Superconductor, low loss, mixed matrix, Toroidal fuel coil.

Title: Superconductivity Magnet Technology

Contractor: Massachusetts Institute of Technology

Contract or Grant No.:

Principal Investigator: P. Marston DOE Program Manager: G. Rudins

Topical Area Funding: FY 1978: $200,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Systems project developing superconductivity magnet technology for MHD power production materials portion directed at NbTi behavior under high currents.

Key Words: Superconductivity magnet technology, MHD, production, NbTi.

Division of Energy Storage Systems

Title: Aluminum Clad with Copper

Contractor: Los Alamos Laboratory (Sub-contract: Airco)

Contract or Grant No.:

Principal Investigator: DOE Program Manager:

Topical Area Funding: FY 1978: $15,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Cladding aluminum with copper.

Key Words: Cladding, Al, Cu, superconductors.

Title: Multistrand Cable

Contractor: Los Alamos Laboratory, and others

Contract or Grant No.:

Principal Investigator: DOE Program Manager:

Topical Area Funding: FY 1978: $180,000

Project Starting Date: 1978 Completion Date: 1981

Objective or Description: Fabrication and testing of multistrand 2 stage cable for transmission line stabilization for Bonneville Power Complex by inductive energy storage.

Key Words: Multistrand 2 stage cable, transmission line, Bonneville Power Complex, inductive energy storage.

Division of Materials Sciences

Title: Superconducting and Semiconducting Properties of Electron-Beam Evaporated Materials

Contractor: Stanford University

Contract or Grant No.: EY-76-S-03-0326-043

Principal Investigator: Geballe and Beasley DOE Program Manager: M. C. Wittels

Topical Area Funding: FY 1978: $86,400

Project Starting Date: N.A. Completion Date: Continuing

Objective or Description: To study the high magnetic field properties of superconducting films, prepared using newly developed electron beam co-evaporation techniques; such as Nb_3Sn; ductile alloys; strain tolerance; micro-hardness and high temperature mechanical deformation as a function of composition andd microstructure.

Key Words: A-15s, high field, ternary compounds, electron co-deposition, strain tolerance, superconductivity.

Title: Experimental Investigations in Solid-State and Low-Temperature Physics

Contractor: University of Minnesota

Contract or Grant No.: EY-76-S-02-1569

Principal Investigator: A. Goldman DOE Program Manager: M. C. Wittels

Topical Area Funding: FY 1978: $190,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Measurements of pair-field susceptibility; fluctuation phenomena; interaction of long-range magnetic order and superconductivity; metal-nonmetal transition in Hg_xSe_{1-x}; magnetic studies in the 1-100 mK range; static and dynamic properties of weak magnetic materials; paramagnetic materials for magnetic refrigerators.

Key Words: Order parameter, dynamics, fluctuations, normal to S.C. transition, superconductivity.

Title: Experimental Determination of the Temperature Dependence of Metallic Work Functions at Low Temperatures

Contractor: Dartmouth College

Contract or Grant No.:

Principal Investigator: P. B. Pipes | DOE Program Manager:

Topical Area Funding: FY 1978: $30,809

Project Starting Date: | Completion Date: Continuing

Objective or Description: The effect of the superconducting transition on the temperature dependence of the contact potential in niobium will be studied as a function of magnetic field and surface preparation to determine the relative importance of bulk and surface effects. The influence of adsorbed ^{4}He will also be studied.

Key Words: Metallic work functions, transition, temperature dependence, contact potential, niobium, adsorbed.

Title: Electron-Dislocation Interactions at Low Temperatures

Contractor: University of Connecticut

Contract or Grant No.: EY-76-S-02-2305

Principal Investigator: J. Galligan | DOE Program Manager: L. C. Ianniello

Topical Area Funding: FY 1978: $51,218

Project Starting Date: | Completion Date: Continuing

Objective or Description: Electron and phonon drag on dislocations; superconductor-normal transition to alter electronic state; dislocation-fluxoid interactions; flow stress-field interactions in normal metals; dislocation-interstitial interactions; orientation effects; Pb, Pb-Sn, Pb-Ag, Cu, and Zn.

Key Words; Dislocations, fluxoids, interactions, interstitials, Pb, Pb-Sn, Pb-Ag, Cu, Nb, superconductivity.

Title: Flux Pinning and Flux Flow Studies in Superconductors Using Flux Flow Noise Techniques

Contractor: University of Cincinnati

Contract or Grant No.: EY-76-S-02-2890

Principal Investigator: W. C. H. Joiner

DOE Program Manager: M. C. Wittels

Topical Area Funding: FY 1978: $51,508

Project Starting Date:

Completion Date: Continuing

Objective or Description: Flux pinning and the dynamics of flux flow in type II superconductors; metallurgical defects; defect structure and the flux flow noise power spectrum; transit time; pinning forces and other flux flow parameters; magnetic field dependence; flux pinning sites; pining force curve; surface pinning effects; surface grooving.

Key Words: Flux flow, noise, flux pinning, noise power spectrum.

Title: Studies of Alloy Structures and Properties

Contractor: California Institute of Technology

Contract or Grant No.: EY-76-S-03-0822

Principal Investigator: W. L. Johnson

DOE Program Manager: L. C. Ianniello

Topical Area Funding: FY 1978: $140,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: Properties and structure of amorphous magnetic or superconducting alloys; ternary amorphous alloys covering the range from ferromagnetism to superconductivity; flux pinning by crystalline phase precipitates embeded in an amorphous superconducting matrix; Fe-P-B amorphous alloys; high temperature amorphous superconductors based on Zr, Mo or Nb; amorphous Gd-La-Au alloys; low temperature specific heat measurements; superconducting tunneling experiments.

Key Words: Amorphous alloys, magnetic and metallurgical properties.

Title: The Response of Superconductors to Variations in Impurity Content and Applied Pressure

Contractor: University of California, San Diego

Contract or Grant No.: EY-76-S-03-0034-227

Principal Investigator: M.B. Maple   DOE Program Manager: M.C. Wittels

Topical Area Funding: FY 1978 $154,356

Project Starting Date: Completion Date: Continuing

Objective or Description: Experimental response of superconductivity to variations in impurity content; range of solute magnetic character, and applied pressure; A-15's, ternary molybdenum chalcogenides; new rare earth compounds such as $ErRh_4B_4$ and $ErMo_6Se_8$; re-entrant and coexistence phenomena.

Key Words: A'15's, Mo ternary chalcogenides, magnetic impurities.

Title: Theoretical Aspects of Superconductor Behavior

Contractor: University of California/Riverside

Contract or Grant No.:

Principal Investigator: E. Simanek   DOE Program Manager:

Topical Area Funding: FY 1978 $48,127

Project Starting Date: Completion Date: Continuing

Objective or Description: Theoretical study of the properties of inhomogeneous superconducting films and aggregates of ultrafine metallic particles; temperature dependence of the order parameter to be calculated from the model of random superconductivity to interpret tunneling studies of Al films; effects of Josephson coupling between particles in aggregates

Key Words: Superconducting, films, aggregates, metallic particles, tunneling, Josephson coupling.

Title: Sputter-Deposited Superconductors

Contractor: Battelle Pacific Northwest Laboratories

Contract or Grant No.:

Principal Investigator: S.D. Dahlgren DOE Program Manager: L.C. Ianniello

Topical Area Funding: FY 1978 $130,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Cathodic sputtering; synthesis of new superconducting materials; structure and stability of sputter deposits; heat treatment under high pressure; atomic volume; heats of transformation; relation of critical current and flux pinning force to grain size; role of additives; A-15 compounds; Nb_3Al, $Nb_3(Al\text{-}Ge)$, Nb_3Ge, Nb_3Sn, Nb_3Si; effect of substrate.

Key Words: A-15's, sputtering, deposition, flux pinning, grain size.

Title: Metallurgy of Superconducting Materials

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: C.J. McHargue DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $300,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Flux pinning in Nb bicrystals, calculations of pinning force in Hf-Nb and Ta-Nb alloys; stress effects on superconducting parameters in Nb_3Sn and V_3Ga; ac loss mechanism; preparation and properties of $PbMo_6S_8$; amorphous, microcrystalline and metastable phases.

Key Words: Flux pinning, Nb bicrystals, pinning force Hf-Nb and Ta-Nb alloys; stress effects in Nb_3Sn and V_3Ga; $PbMo_6S_8$.

Title: Physical Properties of Superconductors

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: M.K. Wilkinson   DOE Program Manager:

Topical Area Funding: FY 1978 $405,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Studies of fluxoid arrays, flux flow, flux creep, fluxoid-defect interactions, and anisotropy in Nb-, V-, and Ta-base alloys and superconducting compounds (A15 and B1); dc magnetization, ac magnetic permeability, critical currents, and normal-state electrical transport; small-angle neutron scattering by fluxoid lattices in superconductors; low-temperature ion damage, ion implantation, and ion backscattering in superconductors; inelastic neutron-scattering studies of high-transition-temperature superconductors.

Key Words: Fluxoid arrays, Nb-, V-, and Ta-base alloys, (A15 and B1); magnetization, neutron scattering, ion damage, ion implantation.

Title: Properties of Defects, Superconductors, and Hydrides

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: M.K. Wilkinson   DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 Est. 40% of $525,000 (=$210,000)

Project Starting Date: Completion Date: Continuing

Objective or Description: Elastic, inelastic, and small angle scattering of neutrons by superconductors, phonon spectra of superconductors; α-U, Mo-Re, Al-15 type compounds; electron-phonon interactions in Nb and Mo; phase transitions in ^{7}LiD; phonon densities of states; crystal field excitations in reentrant superconductors; lattice dynamics and diffusive motion in silver halides; high resolution small-angle diffraction studies of fluxoid lattice morphology and anisotropy in high T_c superconductors.

Key Words: Scattering of neutrons by superconductors, phonon spectra, Al-15, electron-phonon interactions in Nb and Mo; phonon densities of states; reentrant superconductors; lattice dynamics and diffusive motion in silver halides; fluxoid lattice morphology and anisotropy in high T_c superconductors.

Title: Theoretical Studies of Metals and Alloys

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: C.J. McHargue DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 Est. 30% of $380,000
(= $114,000)

Project Starting Date: Completion Date: Continuing

Objective or Description: Electronic states in random alloys; (Cu-Ni, Cu-Zn, Cu-Al, Nb-Mo); layer and cluster calculations for surfaces; superconducting transition temperature phonon linewidth calculation of binding energies in solids.

Key Words: Electronic states, Cu-Ni, Cu-Zn, Cu-Al, Nb-Mo; layer and cluster calculations; transition temperature; phonon linewidth; binding energies.

Title: Theory of Condensed Matter

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: M.K. Wilkinson DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 Est. 5% of $760,000
(= $38,000)

Project Starting Date: Completion Date: Continuing

Objective or Description: Band structure calculations in metals and insulators; electron screening and phonon spectra; lattice dynamics of high T_c superconductors.

Key Words: Band structure, phonon spectra; lattice dynamics, high T_c superconductors.

Title: Low-Temperature Radiation Effects

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigators: M.W. Wilkinson DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 Est. 5% of \$515,000
(= \$25,750)

Project Starting Date: Completion Date: Continuing

Objective or Description: Fission-neutron damage rates in metals and alloys at 4.7°K; effects on insulators for superconducting magnets irradiated at 4.7°K.

Key Words: Fission-neutron damage rates, 4.7°K, insulators for superconducting magnets.

Title: Superconductivity Effects - High Field Superconductivity

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigators: M. Pickus DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 \$220,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Design of multifilamentary superconducting tape or wire; filaments of A-15 compounds such as Nb_3Sn, Nb_3Al, Nb_3 (Al, Ge) and Nb_3Ge; use of powder metallurgy; use of high temperature solid solubilities and preferential precipitation sites.

Key Words: Multifilamentary superconducting tape or wire; A-15 compounds; powder metallurgy.

Title: Superconductivity, Superconducting Devices and 1/f Noise

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigators: J. Clarke DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $200,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Development of Superconducting Quantum Interference Devices (SQUIDS) for measuring small fluctuations in magnetic fields, using integrated thin-film technology; use of SQUIDS in magnetotelluric measurements; nonequilibrium superconductivity: enhancement of the superconducting energy gap and transition temperature by microwaves; enhancement of the energy gap by tunnel injection; response of superconducting films to pulsed perturbations; measurement of the electron-phonon relaxation times in aluminum, tin, and lead.

Key Words: Superconducting Quantum Interference Devices (SQUIDS); magnetotelluric measurements; nonequilibrium superconductivity; microwaves; tunnel injection; pulsed perturbations; electron-phonon relaxation times.

Title: Theoretical Solid State

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigators: M.L. Cohen DOE Program Manager:

Topical Area Funding: FY 1978 Est. 20% of $60,000
(= $12,000)

Project Starting Date: Completion Date: Continuing

Objective or Description: Theoretical approaches and computer calculations to explain measured properties and to predict new properties of solids; surface energy states; semiconductors and transition metals; adsorbates on solids; electrons at interfaces; bulk electronic properties; phonon and non-phonon mechanisms for superconductivity and properties of high transition temperature A15 superconductors; development of pseudopotential theory.

Key Words: Computer calculations, predict new properties, phonon mechanisms; A15 superconductors.

Title: Low Temperature Properties of Materials

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigators: N.E. Phillips DOE Program Manager:

Topical Area Funding: FY 1978 Est. 30% of $115,000
(= $ 34,500)

Project Starting Date: Completion Date: Continuing

Objective or Description: Relations between atomic properties and the macroscopic properties of materials; normal and superconducting metals; super-fluids; dielectric solids; and magnetic materials; heat capacity measurements below 25K establishment of a temperature scale for the region from 0.06 to 25K based on germanium resistance thermometers.

Key Words: Atomic properties; macroscopic properties; heat capacity.

Title: Impurities in Superconductors

Contractor: University of Illinois

Contract or Grant No.:

Principal Investigator: D. Ginsberg DOE Program Manager: M.C. Wittels

Topical Area Funding: FY 1978 $43,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Tunneling measurements to investigate the effect of hydrogen and magnetic impurities on the electronic and dynamical properties of superconductors.

Key Words: Hydrogen and magnetic impurities, physical properties.

Title: Superconductivity

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigators: M. Blume and D. Gurinsky

DOE Program Manager: M.C. Wittels, L.C. Ianniello

Topical Area Funding: FY 1978 $650,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: Fundamental properties of high critical temperature superconductors; order parameter, phase stability, stoichiometry, heat capacity measurements, neutron irradiation, x-ray and neutron diffraction, and normal state resistivity. Preparation of high critical field, high critical current and critical temperature superconductors: Kinetics and mechanism of A15 superconductor formation in solid state diffusion process: Mechanical deformation process in A15 superconductors: Hydrogen embrittlement and hydrogen attack in Fe and steels: Use of small angle neutron scattering for examination of materials.

Key Words: A-15's, kinetics of diffusion, physical properties, structure, radiation damage.

Title: Radiation Damage

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigators: C.L. Snead, Jr.

DOE Program Manager: M.C. Wittels, L.C. Ianniello

Topical Area Funding: FY 1978 $200,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: Different types of irradiation on critical properties of type II superconductors; electron, reactor neutron, 14 MeV neutron, 17 MeV, 800 MeV, and 30 GeV proton irradiations: Nb-Ti, and A15 superconductors; enhanced diffusion applied to A15 superconductors.

Key Words: Irradiation, type II superconductors; electron, reactor neutron, proton, Nb-Ti, A15 superconductors.

Title: Engineering Physics - Superconductivity

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigators: M. Blume

DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $398,000

Project Starting Date:

Completion Date: Continuing

Objective or Description: Superconductivity and transport properties in A-15 films; "saturation" of resistance at high temperatures and anomalous temperature dependence of the resistivity of low temperatures; studies of the density of states in disordered A-15's; density of states; T_c changes; transport measurements in highly disordered and amorphous materials. Photoconductivity and electrical conductivity measurements on hydrogenated amorphous silicon; new techniques for making hydrogenated a-silicon.

Key Words: A-15 films; disordered A-15's; transport measurements; photoconductivity.

Title: Particle-Solid Interactions - Alteration and Analysis of Solids by Ion Beams

Contractor: Brookhaven National Laboratory

Contract or Grant No.:

Principal Investigators: M. Blume

DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 Est. 30% of $106,000
(= $ 31,000)

Project Starting Date:

Completion Date: Continuing

Objective or Description: High resolution Rutherford backscattering for materials analysis, materials modification by ion implantation, channeling phenomena in thin single crystals, charge-states of channeled heavy ions, ion-induced lattice damage and studies of the relationship between defect structure and superconducting properties of thin-film A-15 superconductors.

Key Words: Ion implantation, channeling phenomena, charge-states, defect structure, thin-film A-15.

Title: Superconductivity Studies

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigators: D.L. Price DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $308,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Research in nonequilibrium processes in superconductors; superconducting properties in type II materials; quantum interference effects; magnetic structures and transport properties; energy gap enhancement by microwaves; thermoelectric transport coefficients in the superconducting state; preparation of high T_c materials by sputtering; flux pinning; radiation damage; the development of high-temperature SQUIDS and superconducting switches.

Key Words: Nonequilibrium processes, type II materials, magnetic structures, transport properties; sputtering; flux pinning; SQUIDS; switches.

Title: Superconductivity

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigators: B.R.T. Frost DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $243,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Theoretical and experimental research on the electron-phonon interactions; electron and phonon spectra in intermetallic compounds; NMR and Mossbauer effect; interaction of magnetic ions and superconducting electrons; effects of defects on superconducting properties of A-15 compound V_3Ga; electron-phonon coupling in C-15 compounds; isotope effect in PdH(D) superconductors.

Key Words: Electron-phonon interaction; NMR; and Mossbauer; magnetic ions; A-15; C-15.

Title: Neutron Scattering Studies

Contractor: Argonne National Laboratory

Contrac. or Grant No.:

Principal Investigator: D.L. Price DOE Program Manager:

Topical Area Funding: FY 1978 Est. 5% of $1,243,000
(= $62,150)

Project Starting Date: Completion Date: Continuing

Objective or Description: Wide range of research, including work on dynamics of superconductors and solid electrolytes.

Key Words: Dynamics of superconductors

Title: Low Temperature Studies

Contractor: Argonne National Laboratory

Contract or Grant No.:

Principal Investigator: D.L. Price DOE Program Manager

Topical Area Funding: FY 1978 Est. 10% of $209,000
(= $20,900)

Project Starting Date: Completion Date: Continuing

Objective or Description: Studies at low temperatures, including some work on SQUID, NMR techniques and triplet or P-wave superconductivity in metals.

Key Words: SQUID, NMR, triplet, P-wave.

Title: Superconductivity

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigators: K.L. Kliewer   DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $320,700

Project Starting Date: Completion Date: Continuing

Objective or Description: Superconductivity in A-15 composites; electron tunneling of strong-coupling transition metal, transition-metal alloy, and transition-metal compound superconductors using ultra-thin normal-superconductor proximity junctions; composites by directional solidification; critical currents and critical magnetic fields in Nb-Th and Nb-Y composites; flux pinning and thermal transport; Auger analysis and photoemission of A-15 superconducting films.

Key Words: Electron tunneling, A-15's, flux pinning, theory of vortices.

Title: Control of Microstructure and Solidification Studies

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigator: J.D. Verhoeven   DOE Program Manager: M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $181,000

Project Starting Date: Completion Date: Continuing

Objective or Description: Development of methods for the production of superconducting wire; solidification techniques and phase transformation control; Nb_3Sn and Nb_3Sn-Cu; Pd-Cd, Nb-Ti-Th, and Nb-Ti-Y alloys.

Key Words: Superconducting wire, composites, alloys.

Title: Superconductivity Theory

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigator: K.L. Kliewer

DOE Program Manager. M.C. Wittels
L.C. Ianniello

Topical Area Funding: FY 1978 $66,800

Project Starting Date:

Completion Date: Continuing

Objective or Description: Magnetic flux in type-I and type-II superconductors; induced voltages and energy dissipation due to flux motion, flux vortex nucleation; surface pinning; non-parallel vortices; inhomogeneous superconductors; instabilities; ac losses; reduced dimensionality of highly anisotropic systems; new mechanisms for superconductivity in linear conductors; triplet superocnductivity; static and dynamic properties of spin glasses.

Key Words: Flux motion, flux vortex, surface pinning; systems; new mechanisms; linear conductors; triplet superconductivity.

Title: Neutron Scattering

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigator: K.L. Kliewer

DOE Program Manager:

Topical Area Funding: FY 1978 Est. 25% of $340,000
(= $85,000)

Project Starting Date:

Completion Date: Continuing

Objective or Description: Wide range of studies, including work on electron-phonon interaction and its relation to superconductivity (La_3S_4, La).

Key Words: Electron-phonon interaction; (La_3S_4; La).

Title: Alloying and Phase Control Studies

Contractor: Ames Laboratory

Contract or Grant No.:

Principal Investigator: K.A. Gschneidner DOE Program Manager:

Topical Area Funding: FY 1978 Est. 50% of $135,000
(= $62,500)

Project Starting Date: Completion Date: Continuing

Objective or Description: Studies of several items including low temperature heat capacity measurements of $(La_{3-x}R_x)$ $(In_{1-y}M_y)$ materials at zero and high magnetic fields to determine effects of alloying and magnetic field on the superconducting transition temperature.

Key Words: Heat capacity; magnetic fields; alloying; transition temperature.

CEMENT AND CONCRETE

Introduction

Twenty-six DOE-sponsored projects on the development of cement and concrete were in progress during FY 1978. The funding for the work was ~$5.4 million. This total includes some FY 1977 and FY 1979 as indicated. Approximately $4.7 million of this was FY 1978 funds. Details of funding are given in Table 5 of Chapter 1.

Cement research is primarily sponsored by three DOE Groups: the Divisions of Geothermal Energy and Industrial Energy Conservation, and the Office of Military Application. The largest effort (~$1.1 million) is committed by the Division of Geothermal Energy to the development of high-temperature cements for use in geothermal well completion systems. Related to this effort is work sponsored by the Office of Military Application for the development of cements for use in plugging boreholes. FY 1978 funding for this work was $80,000.

The effort in the Division of Industrial Energy Conservation, funded at ~$785,000, is focused on reducing the energy requirements for the production of cement and the development of new materials that can be used as a cement or as a partial replacement for portland cement in blended cements.

Concrete research activity is in three general areas: nuclear pressure vessel development, thermal energy storage, and ocean thermal energy conversion. The largest efforts (~$2.1 million) are directed toward measuring the thermal and strength properties of concrete at operating conditions of PCRVs and LMFBR comonents. This work is sponsored by the Division of Reactor Research and Technology and the Division of Nuclear Power Development.

Projects to develop concrete components for use in energy storage devices are being sponsored by the Divisions of Energy Storage Systems and Central Solar Technology. The latter also is sponsoring work on protective coatings for concrete used in ocean thermal energy conversion processes. The total funding for work in these areas is ~$945,000.

Concrete and cements are also being used in studies where the feasibility of encapsulation and isolation of nuclear waste for long term storage is being evaluated. The Division of Water Products and the Office of Waste Isolation are sponsoring developmental and applied research efforts in this area for $690,000 in FY 1978. This DOE work should be coordinated with NRC projects in the same direction which are active at Savannah River.

Division of Solar Technology and Ocean Thermal Systems

Title: Antifouling Marine Concrete

Contractor: U.S. Naval Construction Battalion Center, Port Hueneme, California

Contract or Grant No.: IAG-EG-77-A-29-1104

Principal Investigator: H.P. Vind DOE Program Manager: E.H. Kinelski

Topical Area Funding: FY 1978: 1/2($150,000) = 75,000

Project Starting Date: 7/12/77 Completion Date: 9/30/79

Objective or Description: To develop a long-lasting, structurally strong, and environmentally safe antifouling marine concrete. The concrete will be used to line the inner surface of the seawater intake ducts and to form the basic floating structure of an ocean thermal energy conversion (OTEC) plant.

Key Words: Antifouling, portland cement, expanded shale aggregate impregnated with antifouling chemicals, concrete.

Division of Solar Applications

Title: Thermal Storage Subsystem

Contractor: Suntek Research Associates, Corte Madera, California

Contract or Grant No.: EM-78-C-02-4702

Principal Investigator: C. Tilford DOE Program Manager: Davis

Topical Area Funding: $133,000

Project Starting Date: 4/1/78 Completion Date: 3/31/79

Objective or Description: This project addresses the problem of developing detailed performance specifications, design criteria, and engineering blueprints for prototype phase-change thermal storage units for low-temperature (7°C to 70°C) solar heating and cooling applications.

Key Words: Phase-change materials, modular foamed cement storage elements coated with epoxy rubber (trade name, Thermocrete).

Title: Lightweight Concrete Materials and Structural Systems for Water Tanks for Thermal Energy Storage

Contractor: Westinghouse Electric Corporation

Contract or Grant No.: EM-78-C-02-4703

Principal Investigator: R.W. Buckman DOE Program Manager: Davis

Topical Area Funding: FY 1978: 1/2($360,000) = $180,000

Project Starting Date: 3/1/78 Completion Date: 2/29/80

Objective or Description: The objective of this project is the development of a water storage system made with precoated or coated-on-site lightweight concrete (structural and insulating) elements possessing the necessary properties and capable of being easily assembled or fabricated especially for retrofitting into and integration with existing residential and other structures.

Key Words: Lightweight structural and insulating concrete for site-assembled thermal energy storage tanks, especially in support of retrofitting.

Division of Energy Storage Systems

Title: Encapsulation of Phase-Change Materials in Concrete Masonry Construction

Contractor: Brookhaven National Laboratory

Contract or Grant No.: 19Y-14279 V

Principal Investigator: L.E. Kukacka DOE Program Manager: C.J. Swet

Topical Area Funding: $302,000

Project Starting Date: 7/77 Completion Date: 9/79

Objective or Description: To develop techniques for incorporating promising phase-change materials (PCM's) in ordinary concrete, polymer-impregnated concrete (PIC), and/or polymer concrete, and to characterize the resulting composites by measurement of the appropriate physical, thermal, and chemical properties. Economic studies and technology transfer efforts will be initiated.

Key Words: Phase-change materials, concrete, polymer concrete, polymer-impregnated concrete, phase transformations, thermal energy storage.

Division of Geothermal Energy

Title: Geothermal Cements Development

Contractor: Battelle Columbus Laboratories

Contract or Grant No.: 420825-S

Principal Investigator: R.S. Kalyoncu DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: 1/2($119,845) = $59,923

Project Starting Date: 9/1/77 Completion Date: 8/31/79

Objective or Description: To develop high-temperature cementing materials for use in the completion of geothermal wells. These materials will meet the requirements of durability, thickening time, and minimum strength and permeability.

Key Words: Cements, high temperature, geothermal energy, materials hydration, setting, cementing.

Title: Cementing of Geothermal Wells

Contractor: Brookhaven National Laboratory

Contract or Grant No.: AE-01-02-01-b

Principal Investigator: L.E. Kukacka DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: $180,000

Project Starting Date: 1976 Completion Date: 1982

Objective or Description: To organize, manage, and perform research in a program to develop high-temperature organic and inorganic cementing materials for use in geothermal well completion systems.

Key Words: Cements, geothermal, high temperature, polymers, wells.

Title: Development of Cement for Use in Geothermal and Deep Oil Wells

Contractor: Colorado School of Mines

Contract or Grant No.: BNL/DOE Contract No. 406003-5

Principal Investigator: G.L. Kalousek DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: $80,581

Project Starting Date: 4/1/77 Completion Date: 9/30/78

Objective or Description: The development of improved calcium silicate cements for use in energy recovery wells at high temperatures and pressures. The following requirements are to be met: consistency, strength, volume stability, cement-rock/steel casing bond, cement-rock compatibility, resistance to saline water attack, and noncorrosive to steel.

Key Words: Cement, calcium silicate hydrates, rocks, admixtures, cement-steel bond, phase transformations, high temperature and pressure, saline water, geothermal.

Title: Development of Geothermal Well Completion Systems

Contractor: Dow Chemical Company, Dowell Division

Contract or Grant No.: EG-77-C-02-4190

Principal Investigator: B.E. Simpson DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: $500,909

Project Starting Date: 7/1/77 Completion Date: 6/30/80

Objective or Description: To develop and evaluate a suitable geothermal-well cementing material through stability measurements, placement measurements, and chemical measurements. Work will center around three areas: portland and modified portland systems, silicate and/or aluminate systems, and "polymer" systems.

Key Words: Portland cement, modified portland, calcium silicates, polymer cements, lightweight cement, phase transformations, strength retrogression, brine erosion, steam erosion, well completions, high temperature, geothermal energy.

Title: Cementing of Geothermal Wells - Property Verification

Contractor: National Bureau of Standards

Contract or Grant No.: EY-76-C-02-0016

Principal Investigator: E.R. Fuller, Jr. DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: 1/2($165,000) = $82,500

Project Starting Date: 4/1/77 Completion Date: 9/30/79

Objective or Description: (1) To assess the strength and durability of cementing materials after exposure to high-pressure, high-temperature geothermal saline fluids; (2) to develop techniques and test procedures for evaluating high-pressure, high-temperature permeability; and (3) to develop techniques and test procedures for measuring high-pressure, high temperature fracture toughness and shear strength of cement-metal and cement-rock interfaces.

Key Words: Materials - cements, concretes; phenomena - strength, corrosion, durability, stress corrosion cracking, permeability, interfacial fracture toughness, interfacial shear; energy systems - geothermal, bond strength.

Title: High-Temperature Materials for Use in the Cementing of Geothermal Wells

Contractor: Pennsylvania State University

Contract or Grant No.: 422272-S

Principal Investigator: D.M. Roy DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: 1/2($120,000) = $60,000

Project Starting Date: 9/1/77 Completion Date: 8/31/79

Objective or Description: The goal of the research is to develop new cements utilizable for geothermal wells at temperatures up to 400°C (725°F). Two aspects are involved: (1) Determination of the hydrothermal stability of new potential cementing compositions, of optional preparation methods, and of the detailed characterization of the compositions, and (2) determination of the mechanical and physical properties of the materials and of their chemical and physical durability in the presence of saline solutions or vapors under high temperature and pressure. Systems studied include $CaO-Al_2O_3-SiO_2-H_2O$ (high alumina-silica compositions), $CaO-MgO-SiO_2-H_2O$, and $CaO-MgO-SiO_2-K_2O-Al_2O_3-H_2O$.

Key Words: Cements, geothermal wells, high temperature, high pressure, composition phase equilibria, calcium magnesium aluminum silicates, stability, durability, mechanical properties, physical properties, corrosive solutions, permeability, reactivity.

Title: Phosphate-Bonded Glass Cements

Contractor: University of Rhode Island

Contract or Grant No.: BNL 418691-S

Principal Investigator: T.J. Rockett DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: 1/2($88,283) = $44,142

Project Starting Date: 7/1/77 Completion Date: 7/79

Objective or Description: To develop a phosphate cement that can be used for completion of geothermal wells. To determine the phosphate phases that are stable at geothermal conditions and can cement grains of high aluminous or siliceous content. This information will be used for the design of new cements, which will be formulated and tested under geothermal conditions.

Key Words: Phosphate cement, phosphate-bonded glasses, hydrothermal stability of phosphates, geothermal cement, the system $CaO-Al_2O_3-P_2O_5-H_2O$.

Title: High-Temperature Materials for Use in the Cementing of Geothermal Wells

Contractor: Southwest Research Institute

Contract or Grant No.: BNL 427964-S

Principal Investigator: D.K. Curtice DOE Program Manager: R.R. Reeber

Topical Area Funding: FY 1978: 1/2($115,210) = $57,605

Project Starting Date: 10/1/77 Completion Date: 9/30/79

Objective or Description: To develop improved cementing materials for use in the completion of geothermal wells. The work will involve selecting one or more candidates from the SWRI family of hydrothermal cements and optimizing the formulations for use in geothermal wells to 750°F.

Key Words: Silica polymer cements, hydrothermal, high temperature, geothermal.

Title: RDF Firing of Cement Kiln

Contractor: BFI, Houston, Texas

Contract or Grant No.: EY-76-C-05-5150

Principal Investigator: R. Jones DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $339,000

Project Starting Date: 1977 Completion Date: 1979

Objective or Description: To evaluate the use of refuse-derived fuel as a partial replacement for natural gas and coal.

Key Words: Cement kiln, refuse-derived fuel.

Title: Cement and Concrete Modeling

Contractor: National Bureau of Standards

Contract or Grant No.: Not signed

Principal Investigator: G. Frohnsdorff DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $50,000

Project Starting Date: 1978 Completion Date: 1980

Objective or Description: To examine the total process, from raw materials and energy flows to finished product.

Key Words: Cement, concrete, portland cement process.

Title: Slag and Fly Ash in Cement and Concrete

Contractor: National Bureau of Standards

Contract or Grant No.: EC-77-A-016010

Principal Investigator: G. Frohnsdorff   DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $130,000

Project Starting Date: 1976   Completion Date: 1982

Objective or Description: To investigate the use of slag and fly ash as a partial substitute for cement, as in blended cement or batch-mixed cement.

Key Words: Slag, fly ash, cement, portland cement, concrete.

Title: Steam Calcination of Lime

Contractor: National Lime Association

Contract or Grant No.: EC-77-601-5055

Principal Investigator: R. Boynton   DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $20,000

Project Starting Date: 1977   Completion Date: 1978

Objective or Description: The use of steam injection in the calcination of lime is being field tested.

Key Words: Calcination, lime, steam calcination.

Title: Sulfate Specifications and Gypsum Substitute

Contractor: Portland Cement Association

Contract or Grant No.: Procurement not completed

Principal Investigator: N.R. Greening   DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $146,000

Project Starting Date: 1978   Completion Date: 1979

Objective or Description: To find a cost-competitive substitute for gypsum that is compatible with high sulfur fuels.

Key Words: Cement, portland cement, gypsum substitute.

Title: Alkali/Aggregate Reaction Research

Contractor: Purdue University

Contract or Grant No.: Procurement not complete

Principal Investigator: Sidney Diamond   DOE Program Manager: J. Collins

Topical Area Funding: FY 1978: $100,000

Project Starting Date: 1978   Completion Date: 1979

Objective or Description: Alkali/aggregate reaction research.

Key Words: Alkali/aggregate reaction, portland cement, concrete.

Title: Nonthermal Cement Process

Contractor: Southwest Research Institute

Contract or Grant No.:

Principal Investigator: U.S. Lindholm DOE Program Manager: J. Collins

Topical Area Funding: $0

Project Starting Date: 1979 Completion Date: ∿1984

Objective or Description: The development of a nonthermal process to produce portland cement.

Key Words: Portland cement.

Office of Military Application

Title: Borehole Plugging, Materials Development Program

Contractor: U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi

Contract or Grant No.: FAO 07-7486

Principal Investigator: C.W. Gulick DOE Program Manager:

Topical Area Funding: $80,000

Project Starting Date: 7/75 Completion Date: Continuing

Objective or Description: To develop and evaluate improved cement grouting mixtures for plugging boreholes at the WIPP site, and to test portland cement, expansive cements, pozzolans and admixtures to achieve maximum durability and reduce permeability while maintaining pumpability. Long-term exposure studies of both laboratory development mixtures and field samples are being made.

Key Words: Cementing materials, durability, expansive cements, grout, permeability, portland cements, pozzolans.

Division of Nuclear Power Development

Title: Prestressed-Concrete Nuclear Pressure Vessel Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: 1331

Principal Investigator: J.P. Callahan DOE Program Manager: K. Laughon

Topical Area Funding: $600,000

Project Starting Date: 1977 Completion Date: 1985

Objective or Description: To develop apparatus and techniques for conducting multiaxial strength tests of PCRV concretes at room and elevated temperatures. Results will be applied to development and/or refinement of concrete models used in computer codes for analysis of PCRVs.

Key Words: Concrete, multiaxial testing, mechanical properties.

Division of Reactor Research and Technology

Title: Comprehensive Testing of Concrete at Elevated Temperature

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: CRBRP-PO PROCUREMENT AUTH. CR 8-3 TASK BH 012

Principal Investigator: P. Callahan DOE Program Manager: E. Chapple

Topical Area Funding: FY 1978: $770,000

Project Starting Date: FY 1977 Completion Date: 3/79

Objective or Description: To define variations in thermal and strength properties of limestone aggregate concrete and lightweight insulating concrete and to develop thermal relationships for use in the analysis of LMFBR reinforced concrete components exposed to elevated temperatures during normal plant operation and postulated large sodium spills in equipment cells.

Key Words: Limestone aggregate concrete, lightweight concrete, thermal properties, elevated temperature strength.

Title: High-Temperature Concrete Testing Program

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: BH012

Principal Investigator: J.P. Callahan DOE Program Manager: D.R. Riley

Topical Area Funding: FY 1978: $680,000

Project Starting Date: 9/1/77 Completion Date: 3/31/79

Objective or Description: Determination of concrete strength, modulus of elasticity, Poisson's ratio, bond, shear, and creep properties of portland cement and insulating concrete to temperatures of 1150°F. Thermal properties (expansion, conductivity, and diffusivity) are also being determined.

Key Words: Concrete, high temperature, mechanical properties, thermal properties.

Office of Waste Isolation
Division of Waste Products

Title: Solidification of Cements for Borehole Plugging

Contractor: Penn State University

Contract or Grant No.:

Principal Investigator: D. Roy DOE Program Manager: R. Walton

Topical Area Funding: FY 1978: $90,000

Project Starting Date: 9/1/77 Completion Date: Continuing

Objective or Description: To examine the characteristics of cements used for plugging boreholes that may be designed to store and isolate nuclear waste. To investigate variables such as solidification, permeability, strength, and other related properties.

Key Words: Cement solidification, boreholes, nuclear waste isolation, permeability, strength.

Title: Cementitious Materials for Waste Isolation

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: A. Lott | DOE Program Manager: R. Walton

Topical Area Funding: FY 1978: $400,000

Project Starting Date: | Completion Date: Continuing

Objective or Description: To investigate methods of encapsulating or embedding/ nuclear waste in cements for long term storage. In one process involved, salts of the waste materials are incorporated as part of the aggregate. Examine properties such as durability, leaching rates, stability.

Key Words: Cement, nuclear waste, encapsulation, leaching rate, stability, long-term storage.

Title: Hydrofracture Grout Mix Studies

Contractor: Oak Ridge National Laboratory

Contract or Grant No.:

Principal Investigator: A. Lott | DOE Program Manager: R. Walton

Topical Area Funding: FY 1978: $200,000

Project Starting Date: | Completion Date: Continuing

Objective or Description: To mix radioactive waste into a cement grout that may be suitable for injection into fissures as a method of long term storage. To evaluate the properties of the grout, including leaching, durability stability.

Key Words: Cement grout, fissure injection, stability, durability, leaching rate.

JOINING METHODS

Introduction

The development of joining methods and techniques is a very important phase of materials technology to a number of DOE Divisions. A broad variety of such projects is being conducted at DOE laboratories and facilities and at a number of universities and contractor organizations under DOE sponsorship. (Table 6 of Chapter 1). The principal objectives of most of the joining development activities are to develop processes and materials for specific energy systems applications. The majority of the projects are directed toward the solution of joining problems in large systems under development in Energy Technology and Defense Programs. Six joining-methods studies sponsored by the Office of Energy Research are aimed at developing basic information on joining methods.

Special-type sealants and cement bonds are being investigated for conservation and solar applications; however, the bulk of the weld-joining efforts are concerned primarily with the development and evaluation of weld materials and with weld processes on ferrous and nickel-base structural materials. The weld processes include electroslag welding (ESW), submerged-arc (SA), shielding metal arc (SMA), gas tungsten arc (GTA), electron-beam (EB), explosive welding for structural-type materials and solid-state or diffusion bonding, brazing, laser welding, pulsed magnetic welding, tungsten inert gas (TIG), and electrochemical joining for thin, small, or special, unique applications. Studies are also under way to develop processes for making dissimilar metal weldments (e.g. ferritic-to-austenitic alloy joints) and to characterize their properties.

Because of the varied and complex nature of the requirements found in the DOE energy Programs and weapons systems, very little duplication or redundancy currently exists. As joining-method development efforts expand to address problems in advanced energy systems, continued coordination and information exchange between DOE project personnel is encouraged to ensure maximum benefits from new developments.

Division of Advanced Nuclear Systems and Projects

Title: Iridium Weld Development Program - Plutonium Fuel Facility

Contractor: du Pont de Nemours and Company, Savannah River Plant

Contract or Grant No.: AT(07-2)-1

Principal Investigator: J.W. Joseph DOE Program Manager: D.L. Plymale

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Prior to 1975 Completion Date: 1978

Objective or Description: Parameters were developed for the remote GTA welding of 0.025 in. thick iridium alloy hemishells over a 1.5 in. diameter 100 watt $^{238}PuO_2$ sphere for isotopic heat sources.

Key Words: Noble metal alloys, iridium alloys, welding, isotope power systems, isotopic heat sources, thin shells.

Title: Inconel 617 Weld Development Program - Stirling Isotope Power System

Contractor: Monsanto Research Corporation, Mound Facility

Contract or Grant No.: At-33-1-GEN-53

Principal Investigator: C.O. Brewer DOE Program Manager: D.L. Plymale

Topical Area Funding: FY 1978: $84,000

Project Starting Date: 1977 Completion Date: 1978

Objective or Description: Parameters are being developed for a one-pass full-penetration manual and automatic GTA and EB welds for a 0.12 in. thick Inconel 617 outer clad member of toroidal configuration for an isotopic heat source.

Key Words: Nickel alloys, welding, Stirling power systems, isotopic power systems, isotopic heat sources.

Title: Welding Methods for Iridium Alloys

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-eng-26

Principal Investigator: A.C Schaffhauser   DOE Program Manager: C.O. Tarr

Topical Area Funding: FY 1978: $30,000

Project Starting Date: 1978   Completion Date: 1979

Objective or Description: In order to maintain the improved high strain rate toughness of advanced iridium alloys being developed for isotopic heat sources, tests show that a full-penetration small-weld bead obtained at relatively fast weld rates is needed. Remote laser welding of 0.025-in. sheet and spherical sections is being evaluated as a replacement for the present electron beam welding technique.

Key Words: Noble metal alloys, iridium alloys, welding isotope power systems, isotopic heat sources.

Division of Central Solar Technology

Title: Heat Exchanger Joinability Study

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: DOE-EA-03-04-00-0

Principal Investigator: G.M. Slaughter   DOE Program Manager: E.H. Kinelski

Topical Area Funding: FY 1978: $30,000

Project Starting Date: 4/11/77   Completion Date: 12/77

Objective or Description: The objective of this project is to provide a technology review of the state-of-the-art of joinability as it relates to OTEC heat exchangers. Shell-and-tube heat exchangers with aluminum, titanium, copper-nickel, and stainless steel tubing are being considered. Plate-fin heat exchangers are also being considered. Joints being considered employ welding, mechanical, brazing, soldering, adhesive, and other methods.

Key Words: Aluminum, titanium, copper-nickel, stainless steel, shell-and-tube, plate-fin, brazing, soldering, adhesive, welding, mechanical joining.

Title: Technology Review of Joinability of Materials for OTEC Heat Exchangers

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: EA-03-04-00-0

Principal Investigator: G.M. Slaughter | DOE Program Manager: E.H. Kinelski

Topical Area Funding: FY 1978: $30,000

Project Starting Date: 4/1/77 | Completion Date:

Objective or Description: OTEC heat exchangers using ammonia as a working fluid cannot tolerate leaks into the sea water because of serious calcium scale deposits. A no-leak requirement is a goal for these units. This technology review will guide future testing and prototype manufacturing.

Key Words: Aluminum, copper-nickel, stainless steel, titanium, joinability, welding, expansion, adhesive bonding, O-ring seals.

Office of Conservation and Solar Application

Title: Solar Collectors: Low-Cost Solar Panel Development Program

Contractor: Acurex Corporation, Aerotherm Division, Mountain View, California

Contract or Grant No.: EG-77-C-04-4121

Principal Investigators: R. Nelson and R. Mawhinney | DOE Program Manager: S. Sargent

Topical Area Funding: FY 1978: $137,000

Project Starting Date: 9/16/77 | Completion Date: 8/30/78 (est.)

Objective or Description: The objective of this project is to develop a low-cost, non-concentrating solar collector fabricated from polymer films by high-speed printing, laminating, and extruding processes. This project is developing processes for high-speed laminating of polyester, polyethylene, and polypropylene films with flow channels between the films.

Key Words: Laminating, polymer films, solar collectors, polyethylene, polypropylene, polyester, fusion bond, adhesion.

Title: Solar Collectors: Low-Cost High-Temperature Cement-Bonded Collector

Contractor: Mega Engineering, Silver Spring, Maryland

Contract or Grant No.: EG-77-C-04-4122

Principal Investigator: R.E. Dame   DOE Program Manager: S. Sargent

Topical Area Funding: FY 1978: $98,000

Project Starting Date: 9/30/77   Completion Date: 11/30/78

Objective or Description: The objective of this project is to design and construct a low-cost, high-temperature, liquid-heating flat-plate collector. The collector design uses low-cost materials bonded to copper circulating tubes by "high-service-temperature, low-outgassing, high-conductivity" adhesives.

Key Words: Solar collector, adhesives, high-conductance adhesives.

Title: Development of 400°F Resistant Sealants for Collectors

Contractor: Products Research and Chemical Corporation, Burbank, California

Contract or Grant No.: Contract not yet negotiated

Principal Investigator: L. Morris   DOE Program Manager: S. Sargent

Topical Area Funding: FY 1978: $71,000

Project Starting Date: 6/78 (approx.)   Completion Date: 5/79 (approx.)

Objective or Description: The objective of this project is to evaluate elevated temperature-resistant sealants based upon silicones, fluorocarbons, acrylic elastomers, and ethylene propylene terpolymers. In addition, sealants prepared from polyethers and polythioethers will be similarly evaluated. Candidates are to be modified to have maximum solids, heat and environmental resistance, and good adhesion retention.

Key Words: Sealants, solar collectors, silicones, fluorocarbons, elastomers, terpolymers, polyethers, polyethylene, polythioethers, adhesion.

Division of Energy Storage Systems

Title: Evaluation of Laser Welding Techniques for H_2 Transmission

Contractor: Pratt & Whitney, West Palm Beach, Florida

Contract or Grant No.: EC-77-C-02-4355

Principal Investigator: J. Mucci DOE Program Manager: B.J. Berger

Topical Area Funding: FY 1978: $76,000

Project Starting Date: 8/78 Completion Date: 5/78

Objective or Description: The evolution of a hydrogen energy system will require major developments in hydrogen transmission pipeline technology. Hydrogen has an unique effect on most metals; it embrittles or degrades properties. Mild and low-alloy steels are being considered because of the economic factor; weldments appear more susceptible to hydrogen degradation (embrittlement) than the parent alloys. In general, welding processes that minimize heat-affected zones are less susceptible to hydrogen degradation.

This program will evaluate the smooth and notched tensile, low-cycle-fatigue, and fracture toughness properties of two pipeline materials, ASTM A312 Grade AISI 304L and ASTM A106 Grade B, in parent and welded (laser, electron beam, and GTA) conditions. Testing in air and 13.8 MPa (2000 psig) gaseous hydrogen will establish the susceptibility of the materials to hydrogen environment effects. Metallurgical analyses of the weldments and fractographic evaluations of failed test specimens will be conducted to supplement the mechanical property characterization and aid in determining whether laser welding is feasible for the hydrogen transmission pipeline application.

Key Words: Laser, welding, hydrogen, embrittlement, transmission, pipeline.

Division of Fossil Fuel Processing

Title: Electron Beam Welding of Thick-Section Pressure Vessels

Contractor: Babcock & Wilcox Research Division, Alliance, Ohio

Contract or Grant No.: EF-77-C-01-2606

Principal Investigator: C.M. Webber   DOE Program Manager: W.T. Bakker

Topical Area Funding: FY 1978: $230,000

Project Starting Date: October 1, 1977   Completion Date: March 1, 1979

Objective or Description: To demonstrate, in the laboratory, that electron beam welding is feasible for field-welding thick-section pressure vessels, with wall thicknesses up to 8 inches.

Key Words: Welding, field fabrication, electron beam welding, thick-section pressure vessels, low-alloy steels.

Office of Fusion Energy
Division of Development and Technology

Title: Material Research in Support of Cryogenic Structural Materials for Superconducting Magnets

Contractor: National Bureau of Standards, Cryogenic Division, Boulder, Colorado

Contract or Grant No.:

Principal Investigator: R.P. Reed   DOE Program Manager: E. Dalder

Topical Area Funding: FY 1978: $60,000

Project Starting Date: October, 1976   Completion Date: October, 1981

Objective or Description: To evaluate the effects of ferrite content on fracture toughness, fatigue-crack growth, and tensile properties of fusion welds in conventional and nitrogen-strengthened austenitic stainless steel.

Key Words: Austenitic, stainless steel, fusion welding, ferrite content, effects of ferrite on fracture properties.

Office of Fusion Energy
Division of Planning and Projects

Title: Brazing of Titanium

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.: Vac Hyd PR 64586, Robert Ray Associates (PR 64557)

Principal Investigator: W.C. Turner DOE Program Manager: E. Braunschweig

Topical Area Funding: FY 1978: $12,000

Project Starting Date: 1/1/77 Completion Date: 12/1/78

Objective or Description: To develop a process for furnace brazing of titanium with no allowable degradation of titanium foil.

Key Words: Titanium, brazing, foil

Title: Diffusion Bonding of Thin Foils/Electron Beam Foils

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: J. Swingle DOE Program Manager: P. Hoff

Topical Area Funding: FY 1978: $10,000

Project Starting Date: 10/1/77 Completion Date: 9/30/78

Objective or Description: Diffusion bonding of nickel and Havor foils of 2.5-μm thickness to stainless steel substrates, with and without intermediary materials.

Key Words: Foils, diffusion bonding, Havor.

Title: Glass-Tape Brewster Window Seals

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: J. Swingle DOE Program Manager: P. Hoff

Topical Area Funding: FY 1978: $2,000

Project Starting Date: 1978 Completion Date:

Objective or Description: The production of reentrant Brewster window seals of fused silica windows to fused silica tubes.

Key Words: Glass tape, quartz.

Title: Solid-State Bonding of Beryllium Foils

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: L.W. Coleman & N.M. Ceglio DOE Program Manager: J. Weiss

Topical Area Funding: FY 1978: $50,000

Project Starting Date: 3/77 Completion Date: 12/78

Objective or Description: To develop and apply techniques for bonding thin (0.3 to 1 mil) beryllium vacuum windows to monel, nickel, and stainless steel support structures. This work is required for photocathode assemblies on image-converter vacuum tubes used for high time-resolution x-ray streak and framing cameras.

Key Words: Solid-state bonding, beryllium, vacuum windows, photocathodes, x-ray cameras, x-ray image converters.

Office of Military Application

Title: Explosive Fabrication of Metallic Glasses

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.: W-7405-ENG-48 and DBES

Principal Investigator: C. Cline DOE Program Manager: F.W. Hughes

Topical Area Funding: FY 1978: $50,000

Project Starting Date: FY 1977 Completion Date: Continuing

Objective or Description: This program includes explosive welding of metallic glass alloy ribbons to steel substrates and to each other, and explosive compaction of metallic glass powders. Explosive parameters such as type of explosive, detonation velocity and pressure, ratio of mass of explosive to mass of metal, and computer modeling of process are also being evaluated.

Key Words: Explosive fabrication, metallic glass fabrication, explosive welding.

Title: Electron Beam Welding Development

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.:

Principal Investigator: D.J Sandstrom DOE Program Manager: F.W. Hughes

Topical Area Funding: FY 1978: $100,000

Project Starting Date: Before 1975 Completion Date: Continuing

Objective or Description: This continuing program is directed at process improvement and development in the area of electron beam welding and joining. Currently under development is a microprocessor-controlled data-acquisition system which monitors critical machine functions and stores these records in memory. The system will be coupled with high-speed photography and nondestructive and destructive techniques for evaluation of weld quality. The correlation of welding machine parameters with specific weld quality will be a significant contribution to the science and technology. The ultimate objective is to develop feedback control systems that will allow full automation of this process.

Key Words: Electron beam welding, microprocessors, data acquisition system, feedback control, weld defects.

Title: Electrochemical Joining

Contractor: Sandia Laboratories

Contract or Grant No.: AT-(29-1)-789

Principal Investigator: D.R. Adolphson DOE Program Manager: F.W. Hughes

Topical Area Funding: FY 1978: $100,000

Project Starting Date: Before 1975 Completion Date: Continuing

Objective or Description: Because of recent advances in surface science and electrochemistry, high-strength metals can now be electroplated on a metallic substrate with an adherence consistent with the bulk strength of the deposit and base metal. These developments have allowed methods to evolve for joining metals that have vastly dissimilar thermophysical and chemical properties. Efforts for FY 1978 and 1979 are directed toward joining uranium to beryllium with use of a nickel-cobalt alloy deposit.

Key Words: Uranium, beryllium, nickel-cobalt alloy-electroplating.

Title: Pulsed Laser Welding of Molybdenum

Contractor: Sandia Laboratories

Contract or Grant No.: AT-(29-1)-789

Principal Investigator: J.L. Ledman DOE Program Manager: F.W. Hughes

Topical Area Funding: FY 1978: $140,000

Project Starting Date: 7/75 Completion Date: 2/79

Objective or Description: Pulsed Nd-YAG lasers are being evaluated for production of hermetic, ultrafine-grained seam welds in molybdenum neutron tube cans. Molybdenum sheet materials with varied carbon and oxygen content are compared. Test specimens of pressurized pillow configuration allow quantitative comparisons of crack extension resistance for weld-process optimization and material selection.

Key Words: Molybdenum, laser, welding.

Title: Ferrous Alloy Metallurgy - Liquid Lithium Corrosion and Welding

Contractor: Colorado School of Mines

Contract or Grant No.: EY-76-S-02-2313

Principal Investigators: D. Olson & D. Matlock   DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $40,000

Project Starting Date: FY 1978   Completion Date: Continuing

Objective or Description: Determination of role of alloying elements in controlling weld-metal microstructures in dissimilar metal joints (e.g., Fe - 2 1/4% Cr - 1% Mo to stainless steel), and in influencing weld mechanical properties.

Key Words: Weldments, fusion welding, solidification, ferrous alloys, dissimilar metal weldments, solution thermodynamics, mechanical properties.

Title: Welding Research

Contractor: Idaho National Engineering Laboratory, EG&G Idaho

Contract or Grant No.: 1570

Principal Investigator: J.F. Key   DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $150,000

Project Starting Date: FY 1978   Completion Date: Continuing

Objective or Description: Modeling of heat-source/molten-pool interactions; post weld embrittling mechanisms; age hardenable nickel base alloys; grain boundary characterization; influence of trace elements and oxygen in the embrittlement process.

Key Words: Weld embrittlement, nickel-base alloys, modeling of welds.

Title: Welding Research

Contractor: Lawrence Berkeley Laboratory

Contract or Grant No.:

Principal Investigator: J.W. Morris DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $50,000

Project Starting Date: FY 1978 Completion Date: Continuing

Objective or Description: Development of ferritic weld wire for welding Fe-(609)Ni cryogenic steels.

Key Words: Ferrous alloys, cryogenic alloys, ferritic steels, weld wire.

Title: A Basic Study of Electroslag Welding

Contractor: Massachusetts Institute of Technology

Contract or Grant No.: Not yet assigned

Principal Investigators: J. Szekeley & T. Eagar DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $60,000

Project Starting Date: FY 1978 Completion Date: Continuing

Objective or Description: Modeling heat and fluid flow in electroslag welding of low alloy steels in both plate and cylinder geometries; microstructural analysis of welds and their mechanical properties.

Key Words: Weldments, electroslag welding, ferrous alloys, low alloy steels, solidification, mechanical properties, heat flow, fluid flow.

Title: Fundamental Studies in Welding

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W7405-Eng,26

Principal Investigator: G.M. Goodwin   DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $100,000

Project Starting Date: FY 1978   Completion Date: Continuing

Objective or Description: Examination of effect of δ-ferrite and residual elements on weld microstructure and properties of austenitic stainless steels; modeling heat and mass transfer in fusion welding.

Key Words: Weldments, fusion welding, solidification, ferrous alloys, austenitic stainless steels, solution thermodynamics, mechanical properties.

Title: The Effect of Welding Variables on the Solidification Substructure, Mechanical Properties and Corrosion Behavior of Austenitic Stainless Steel Weld Metal

Contractor: Rensselaer Polytechnic Institute

Contract or Grant No.: EY-76-S-02-2462

Principal Investigators: D.J. Duquette and W.F. Savage   DOE Program Manager: D.K. Stevens

Topical Area Funding: FY 1978: $49,000

Project Starting Date: FY 1974   Completion Date: Continuing

Objective or Description: Study of corrosion and stress corrosion of austenitic stainless steel weldments and parent metals.

Key Words: Weldment, fusion welding, solidification, ferrous alloys, austenitic stainless steels, corrosion, stress corrosion.

Division of Nuclear Power Development

Title: Welding Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: W-7405-eng-26

Principal Investigator: J.R. DiStefano   DOE Program Manager: J.E. Fox

Topical Area Funding: FY 1978: $52,000

Project Starting Date: 1975   Completion Date: Continuing

Objective or Description: To evaluate the weldability of the candidate HTGR structural materials (Incoloy 800H, Hastelloy X and 2 1/4% Cr - 1% Mo steel) and determine the mechanical properties of weldments of these materials in representative reactor helium environments. Weldments include autogenous welds of the candidate materials plus bi-metal welds of Hastelloy X/800H. Mechanical properties studies include tensile, creep and crack-growth.

Key Words: Weldability, tensile, creep, crack-growth, helium, Incoloy 800H, Hastelloy X, 2 1/4% Cr - 1% Mo.

Division of Reactor Research and Technology

Title: Transition Joint Development

Contractor: General Electric Company, FBRD, San Jose, California

Contract or Grant No.: 189a SGO29

Principal Investigator: C.N. Spalaris   DOE Program Manager: J.R. Hunter

Topical Area Funding: FY 1978: $500,000

Project Starting Date: Prior to 1975   Completion Date: Continuing

Objective or Description: To develop a stainless steel 2 1/4 Cr% - 1% Mo or carbon steel pipe transition joint capable of serving the design life of a fast breeder reactor plant.

Key Words: Pipe welding, stress analysis, dissimilar metal welds, inelastic analysis, differential thermal expansion, weld dilution, embrittlement, hot cracking, decarburization, carbon migration, microfissuring, creep fatigue damage, cold-wire GTA, hot wire GTA, creep rupture.

Title: Laser Welding

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: 189a FF018

Principal Investigator: R.E. Dahl DOE Program Manager: D.E. Bailey

Topical Area Funding: FY 1979-80: $75,000

Project Starting Date: 1976 Completion Date: Continuing

Objective or Description: Automated laser welding is being developed as a potential method for closure of stainless steel fuel pins. Since the weld is produced by a beam of light, welding equipment may be located outside the plutonium containment barrier, with the laser beam focused on the weld joint through a window. This prevents plutonium contamination of the welding apparatus and thus simplifies maintenance and operation. The heating rate at the weld joint may be closely controlled by adjusting the focus of the laser beam. High-quality fusion welds have been produced by this technique.

Key Words: Laser welding, stainless steel, fusion welding, fast breeder reactor fuel pins, welding.

Title: LMFBR Cladding/Duct Materials Development

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: 189a FF101

Principal Investigator: J.J. Laidler DOE Program Manager: F.A. Smidt

Topical Area Funding: FY 1978: $50,000

Project Starting Date: FY 1975 Completion Date: Continuing

Objective or Description: To develop welding methods for alloys under study for advanced cladding/duct materials.

Key Words: LMFBR, advanced alloys, caldding/duct, weld development.

Title: Pulsed Magnetic Welding

Contractor: Hanford Engineering Development Laboratory

Contract or Grant No.: 189a FF018

Principal Investigator: R.E. Dahl DOE Program Manager: D.E. Bailey

Topical Area Funding: FY 1978: $135,000

Porject Starting Date: 1976 Completion Date: Continuing

Objective or Description: Pulsed magnetic welding is being developed as a solid-state welding technique for end closure of stainless steel fuel pins. The method involves rapid discharge of a large capacitor bank, which creates an intense magnetic field within a single-turn indicator. Forces derived from the applied field drive the fuel-pin cladding at high velocity onto the end cap, and produce an impact-type weld. The method is attractive because of its automation potential and the high integrity of the welds produced.

Key Words: Magnetic welding, impact welding, pulsed magnetic, stainless steel, solid-state welding, fuel-pin closure, fast breeder reactor fuel pins, welding.

Title: Welding Technology Development - Pipe Welding

Contractor: Idaho National Engineering Laboratory, EG&G Idaho, Incorporated

Contract or Grant No.: 189a IA007

Principal Investigator: P.W. Turner DOE Program Manager: J.R. Hunter

Topical Area Funding: FY 1978: $280,000

Project Starting Date: FY 1967 Completion Date: Continuing

Objective or Description: To advance welding technology as applied to commercial and developmental nuclear power plants by developing improved welding techniques and procedures which minimize effects of stress intensificaiton; improved ease of nondestructive examination and improved weldment quality and reproducibility.

Key Words: Radial shrinkage, longitudinal shrinkage, pipe welding, automatic welding, narrow groove joints, austenitic steel, ferritic steel, gas tungsten arc, stress intensification, ultrasonic examination.

Title: Joining Technology Development

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: 198a OHO24

Principal Investigators: P. Patriarca & G.M. Goodwin DOE Program Manager: E.E. Hoffman

Topical Area Funding: FY 1978: $340,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Develop methods and materials for making improved welds for breeder reactors and provide design data for these welds. Develop improved austenitic stainless steel welding materials, generate nuclear design code data. Develop 316, 16-8-2, 308 weld wires with controlled residual elements (CRE) for submerged arc (SA) and gas tungsten arc (GTA) welds for creep tests, microstructure stability and long-term thermal aged mechanical property tests. Investigate hard-facing microstructures and deposition techniques for valve and bearings. Evaluate advanced transition joint welds. Input to Data Storage and Retrieval System.

Key Words: Austenitic stainless steel, welds, types 316, 16-8-2 and 308, controlled residual elements (CRE), submerged arc (SA), gas tungsten arc (GTA), sigma phase, ferrite, hard-facings, transition joint welds.

Title: S.G. Materials Development (Transition Joint Weld Development)

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: 189a OHO28

Principal Investigator: P. Patriarca DOE Program Manager: E.E. Hoffman

Topical Area Funding: FY 1978: $50,000

Project Starting Date: Prior to 1975 Completion Date: Continuing

Objective or Description: Subtask B - Weldability - provide consultation and service to SG029 - SG Materials Qualification Program on transition joint welds.

Key Words: Transition joint welds.

Title: Transition Joint Technology - Dissimilar Metal Joining

Contractor: Oak Ridge National Laboratory

Contract or Grant No.: 189a OH103B

Principal Investigator: G.M. Goodwin   DOE Program Manager: J.R. Hunter

Topical Area Funding: FY 1978: $280,000

Project Starting Date: Prior to FY 1975   Completion Date: Continuing

Objective or Description: To develop transition-joint welding techniques, mechanical properties data, and nondestructive examination techniques necessary for the design and fabrication of high-reliability FBR pipe joints between dissimilar metals.

Key Words: Stress-strain curves, constitutive equations, duel-crystal UT, dissimilar metal joints, composite specimens, weldability, cold-wire GTA, hot-wire GTA, weld dilution, embrittlement, decarburization, hot cracking, carbon migration, creep, fatigue, rupture.

Division of Fossil Fuel Extraction

Title: Drilling Technology Development Program

Contractor: Sandia Laboratories

Contract or Grant No.: SL/FE-7248

Principal Investigator: C. F. Huff   DOE Program Manager: J.R. Hunter

Topical Area Funding: FY 1978: $390,000

Project Starting Date: FY 1976   Completion Date: FY 1979

Objective or Description: To design, develop, test, and transfer technology of improved drill bits with use of stratapax cutting and/or other advanced materials.

Key Words: Stratapax, bonding, oil drilling, gas drilling, metallization.

ELASTOMERS

Introduction

Elastomeric materials are needed for high-temperature seals in a variety of energy-related applications. In pursuit of these goals, eleven studies sponsored by six DOE groups were in progress during FY 1978. The funding level for this effort was $1.1 million, shown in Table 7 of Chapter 1.

The largest effort on elastomer development ($418,500) is being conducted by the Division of Geothermal Energy, where sealing materials suitable for use in high-temperature brine and steam are needed.

The projects of the Division of Materials Sciences and the Office of Military Application are directed toward fundamental studies to synthesize new polymeric materials and to study the fundamental aspects of the pressure dependence of elastomer mechanical properties. Four projects with a total funding of $289,000 were in progress during FY 1978.

Small research and development efforts are being supported by the Division of Reactor Research and Technology, the Office of Fossil Energy, and the Division of Energy Storage Systems. The objectives of the work are to develop advanced materials for use in radioactive gas environments, in drilling components, and in energy storage devices. The total funding in FY 1978 for these efforts was $355,000.

Work done on polymers and polymer composites is described in the section on Alternate Materials.

Division of Energy Storage Systems

Title: Form-Stable Polyethylene for Thermal Storage

Contractor: Monsanto Research Company

Contract or Grant No.: EY-76-C-05-5159

Principal Investigator: I. Salyer DOE Program Manager: C. J. Swet

Topical Area Funding: $175,000

Project Starting Date: 7/76 Completion Date: 9/78

Objective or Description: The objective of this project is to develop form-stable crystalline polyehtylene for a thermal-energy-storage (TES) bed material that is useful in the 120 to 140°C temperature range suitable for solar-absorption air-conditioning applications. Best results have been achieved by controlled cross-linking of a high-density polyethylene in pellet form. These pellets retained nearly 100% of their initial heat of fusion through 700 melt/freeze cycles in ethylene glycol and had excellent form stability characteristics with little or no interparticle adhesion. Tests of this pellet material ranged from analytical differential scanning calorimetry to a 60-gallon prototype demonstration unit. The feasibility study was completed and a more detailed cost benefit analysis was initiated.

Key Words: Form-stable polymer, polyethylene, cross-linked polymer, latent heat storage, irradiated polymer.

Office of Fossil Energy, Division of Systems Engineerng

Title: Drilling Technology Development Program

Contractor: Sandia Laboratories

Contract or Grant No.: SL/FE-7248

Principal Investigator: C. F. Huff DOE Program Manager: E. F. Ferrero

Topical Area Funding: $60,000

Project Starting Date: FY 1976 Completion Date: FY 1979

Objective or Description: To develop improved critical drilling components involving both metallic and polymeric materials having superior corrosion and fatigue resistance.

Key Words: Elastomers, plasms polymerization, Teflon coating.

Division of Geothermal Energy

Title: Geothermal Elastomer Screening

Contractor: L'Garde Inc., Newport Beach, California 92663

Contract or Grant No.: CO31308 34201

Principal Investigator: A. R. Hirasuna DOE Program Manager: R. R. Reeber

Topical Area Funding: FY 1978: $220,000

Project Starting Date: 1977 Completion Date: 1978

Objective or Description: This project is concerned with state-of-the-art evaluation of oil and gas seals in geothermal simulation, and the optimization of present materials to maximize technology transfer from related industries.

Key Words: Elastomers, high-temperature seals, goethermal screening, EPDM, fluoroelastomer, perfluoroelastomer, conceptual design, seal failure.

Title: Development of Well Logging Elastomer

Contractor: Hughes Aircraft Company

Contract or Grant No.: CO31325*35601

Principal Investigator: S. Schwartz DOE Program Manager: R. R. Reeber

Topical Area Funding: FY 1978: $43,500

Project Starting Date: 1977 Completion Date: 1978

Objective or Description: Advanced R&D polymer materials will be characterized by mechanical and chemical tests under simulated brine at high temperatures. The objective is to develop an elastomeric material for high-temperature use. Three types of elastomers will be evaluated.

Key Words: Elastomers, cable material, seals, high temperature, geothermal, carborane siloxane, fluorinated siloxane, acetylene-terminated perfloralkylene oxide.

Title: High-Temperature Elastomers

Contractor: Jet Propulsion Laboratory

Contract or Grant No.: A361011*20103

Principal Investigator: W. Mueller DOE Program Manager: R. R. Reeber

Topical Area Funding: $110,000; (FY 1978: $55,000)

Project Starting Date: 1977 Completion Date: 1978

Objective or Description: Advanced R&D polymer materials will be characterized by mechanical and chemical tests under simulated brine conditions at high temperatures. The goal is to provide materials for the design of subsurface safety valves, packer applications, electrical cable insulation, pump seals, and drill bit seals.

Key Words: Elastomers, geothermal, high temperature, seals, fluorocarbon elastomer, reinforced elastomers, block polymers.

Title: Improved Geothermal Drill Bits

Contractor: Terra Tek, Inc., Salt Lake City, Utah

Contract or Grant No.: E(10-1)-1546

Principal Investigator: S. Green DOE Program Manager: C. Carwile

Topical Area Funding: FY 1978: $100,000

Project Starting Date: 5/75 Completion Date: 5/79

Objective or Description: The objective of this project is to design and develop improved three-cone roller bits for geothermal developments. Two types of bits are being studied: unsealed mining rock bits, with the efforts concentrated on incorporating high-strength steels, and sealed journal-bearing bits, with maximum emphasis on developing a suitable elastomeric lubricant seal for a high-temperature steam environment.

Key Words: Elastomers, seals, lubricant, hot hardness, fracture toughness, geothermal drill bits.

Division of Materials Sciences

Title: The Pressure Dependence of the Mechanical Properties of Polymers

Contractor: California Institute of Technology

Contract or Grant No.: EY-76-S-03-0767

Principal Investigator: N. W. Tschoegl DOE Program Manager: S. Wolf

Topical Area Funding: FY 1978: $96,000

Project Starting Date: 8/1/77 Completion Date: Continuing

Objective or Description: This program studies the fundamental aspects of the pressure dependence of elastomer mechanical properties, particularly pressure-temperature-time interrelation. Calculations of fractional free volume are being made with use of the constitutive approach.

Key Words: Elastomers, pressure-temperature-time mechanical properties, constitutive equations.

Office of Military Application

Title: Flexible Resins To Improve Transverse Tensile Strengths of Fiber Composites

Contractor: Lawrence Livermore Laboratory

Contract or Grant No.:

Principal Investigator: R. M. Christensen DOE Program Manager: F. W. Hughes

Topical Area Funding: FY 1978: $125,000

Project Starting Date: 1978 Completion Date: Continuing

Objective or Description: Flexible epoxy matrices are being synthesized, formulated, and characterized for use in fiber-reinforced composites.

Key Words: Fiber composites, flexible epoxy matrices.

Title: Elastomer Evaluation and Development

Contractor: Los Alamos Scientific Laboratory

Contract or Grant No.:

Principal Investigator: D. J. Sandstrom   DOE Program Manager F. W. Hughes

Topical Area Funding: FY 1978: $25,000

Project Starting Date: Before 1975   Completion Date: Continuing

Objective or Description: This continuing research and development program is being conducted to obtain improved elastomeric materials. Most of the evaluation and process development is related to the use of commercially produced elastomers and additives to yield articles of interest with specific mechanical and physical properties. Various curing agents are being investigated for use with polyurethane materials as a replacement for MOCA. The program includes work on a series of polyol materials that provide cured urethanes of various hardnesses and resistances. Other amine curing agents are also being studied.

Key Words: Elastomers, urethanes, polyurethanes, amines, curing agents, silicones, fluorosilicones, polyols.

Title: Stress Relaxation and Aging of Elastomers

Contractor: Sandia Laboratories

Contract or Grant No.: AT-(29-1)-789

Principal Investigator: J. G. Curro

Topical Area Funding: $100,000

Project Starting Date: Before 1975   Completion Date: Continuing

Objective or Description: Predictions of stress relaxation in elastomers based on a recently developed accelerated aging model will be tested with use of stockpile-aged O-rings, and a real-time ambient aging experiment will be started. The effects of longterm physical relaxation on the viscoelastic properties of urethane elastomers will be determined.

Key Words: Urethanes, O-rings, accelerated aging, stress relaxation, viscoelastic properties.

Division of Reactor Research and Technology

Title: Cover Gas Seals

Contractor: Atomics International

Contract or Grant No.: 189a SA007

Principal Investigator: O. P. Steele

DOE Program Manager: D. Cotton

Topical Area Funding: FY 1978: $120,000

Project Starting Date: Prior to 1975

Completion Date: 9/77

Objective or Description: To demonstrate the reliability of commercial and advanced seal forms. To develop advanced materials (elastomers, metal and composites thereof) and seal configurations capable of high-temperature (~300°F) long-life (> 5 year) operation in a radioactive gas environment.

Key Words: Elastomers, seals, seal design, cover gas seals, radioactivity seals.

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