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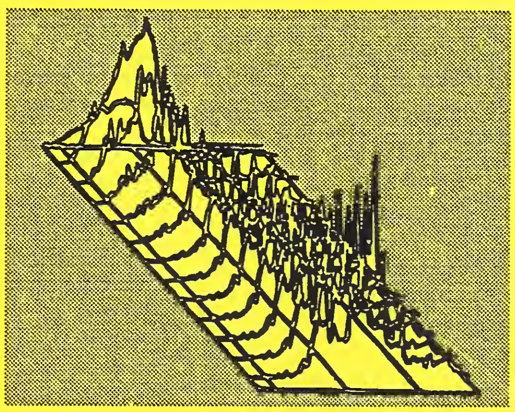
NIST PUBLICATIONS

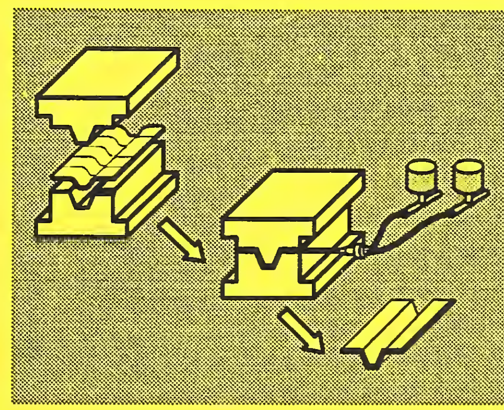
MSEL

Materials Science and Engineering Laboratory

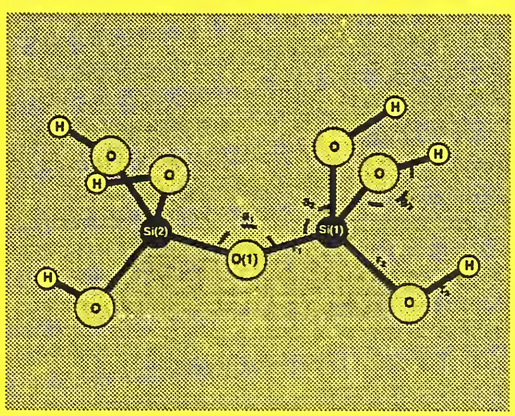
ANNUAL REPORT

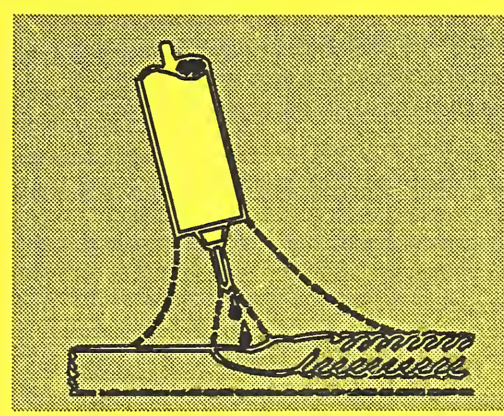
1991

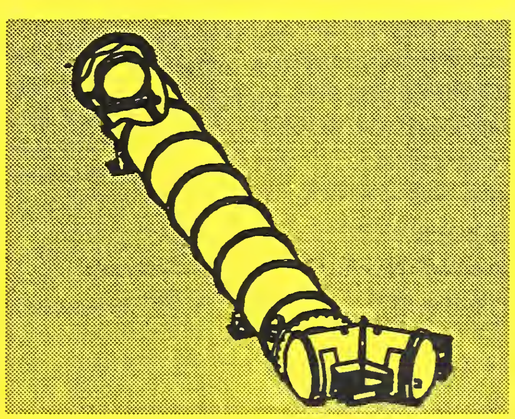


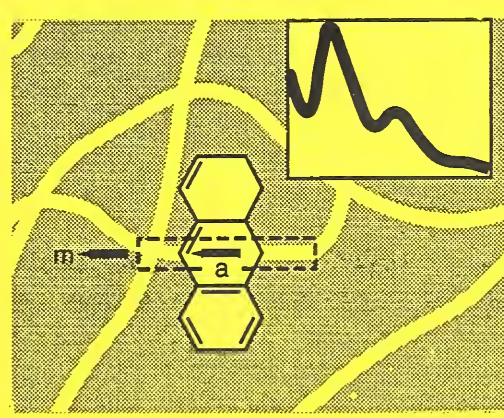


NAS-NRC
Assessment Panel
Feb 13-14, 1992









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U.S. Department of Commerce
Technology Administration
National Institute of Standards and Technology

Annual report covers for the operating divisions of the Materials Science and Engineering Laboratory and its Office of Intelligent Processing of Materials. These annual reports describe in detail the technical activities of each of the Laboratory's major units and are available on request.

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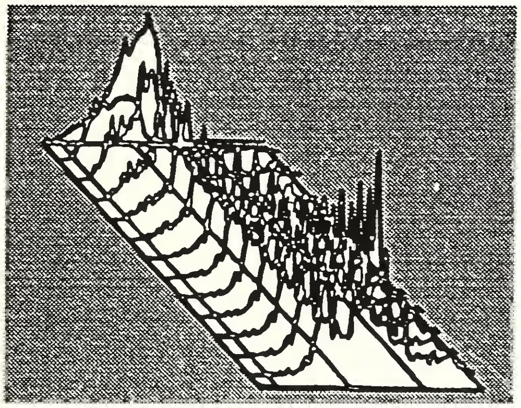

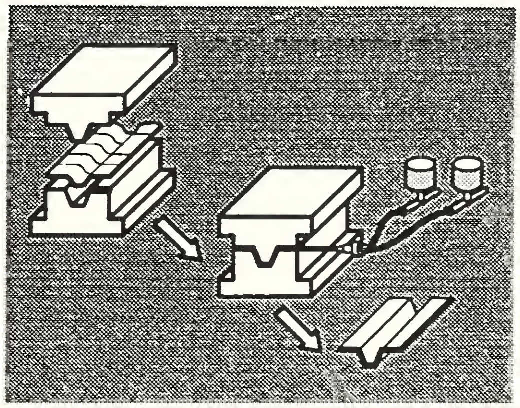

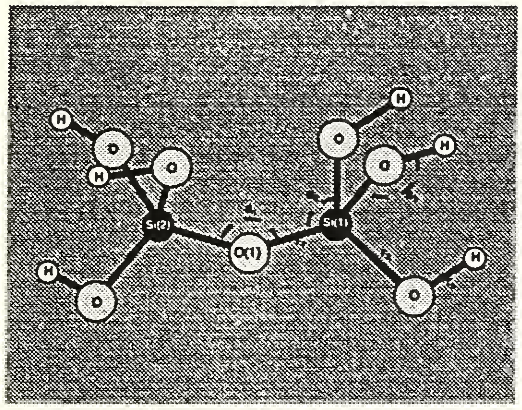

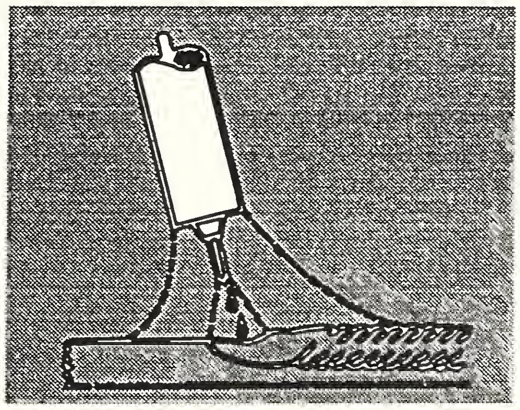

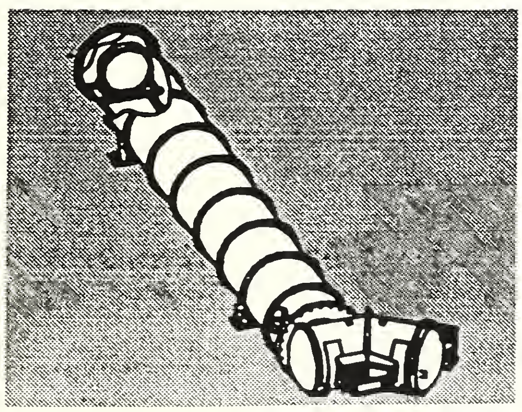

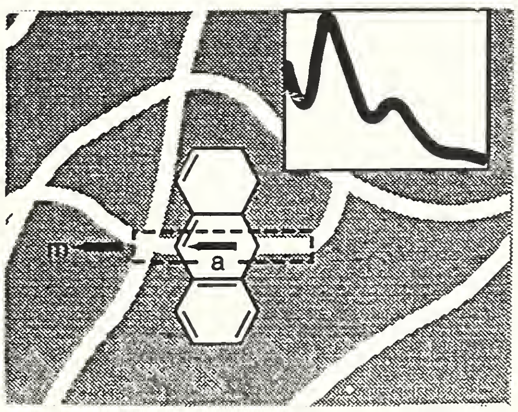

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L.H. Schwartz, Chief
H.L. Rook, Deputy

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NISTIR 4692
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Technical Activities 1991

U.S. DEPARTMENT OF COMMERCE, Robert A. Mosbacher, Secretary
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National Institute of Standards and Technology, John W. Lyons, Director

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AGENDA

BOARD OF ASSESSMENT OF NIST PROGRAMS FOR THE
MATERIALS SCIENCE AND ENGINEERING LABORATORY (MSEL)

Wednesday, February 12, 1992

8:00 p.m.	Panel Orientation Meeting and Charge to Panel at the Washingtonian A Room of the Holiday Inn (L. H. Schwartz, H. L. Rook, D. B. Butrymowicz, J. G. Early, S. J. Schneider, and Panel Members)	

Thursday, February 13, 1992

8:00 a.m.	Panel meets the NIST van in front of the Holiday Inn for ride to Administration Building, NIST	

Lecture Room A, Administration Building

8:15 a.m.	Coffee and Donuts	
8:30 a.m.	Opening Remarks	B. Kear
8:50 a.m.	MSEL Overview	L. Schwartz
9:50 a.m.	Discussion	
10:10 a.m.	Break	
10:30 a.m.	Overview of the Office of Intelligent Processing of Materials	T. Yolken
10:45 a.m.	Discussion	
10:55 a.m.	Overview of Metallurgy Division Programs	N. Pugh
11:10 a.m.	Discussion	
11:20 a.m.	Overview of Ceramics Division Programs	S. Freiman
11:35 a.m.	Discussion	
11:45 a.m.	Lunch - Dining Room C Panel Members, L. Schwartz, H. Rook, D. Butrymowicz, J. Early, and S. Schneider	

Lecture Room B

12:45 p.m.	Poster Presentations on Laboratory Research	

"Materials Synthesis and Processing"

Lecture Room A

1:45 p.m.	Overview of Materials Reliability Division Programs	H. McHenry
2:00 p.m.	Discussion	
2:10 p.m.	Overview of Polymers Division Programs	B. Fanconi
2:25 p.m.	Discussion	
2:35 p.m.	Overview of Reactor Radiation Division Programs	M. Rowe
2:50 p.m.	Discussion	
3:00 p.m.	Executive Session -- MSEL Director on call (coffee and soda available)	
5:00 p.m.	Meet with MSEL Director	
5:30 p.m.	Panel meets NIST van in front of Materials Building for ride to Holiday Inn	
6:15 p.m.	Panel meets NIST van in front of Holiday Inn for ride to Golden Bull Restaurant	
6:30 p.m.	Social Hour and Dinner - Division Chiefs, L. Schwartz, H. Rook, D. Butrymowicz, J. Early, and S. Schneider	
9:30 p.m.	Panel members ride back to Holiday Inn with Division Chiefs	

Friday, February 14, 1992

8:00 a.m.	Panel meets NIST van in front of Holiday Inn for ride to Administration Building, NIST

Dining Room C

8:30 a.m.	Executive Session (Panel Only) - Draft Report Coffee and donuts available before and during the executive session
12:00 p.m.	Lunch with Division Chiefs, L. Schwartz, H. Rook, D. Butrymowicz, J. Early, and S. Schneider
1:00 p.m.	Panel Chairman meets with L. Schwartz and H. Rook Materials Building, Room B310
1:15 p.m.	Panel meets NIST van in front of Administration Building for ride to Holiday Inn
2:00 p.m.	Panel Chairman meets with John W. Lyons, Director, NIST Administration Building, Room A1134

Panel members have an open schedule after lunchtime on Friday, Feb. 14.

Panel members requiring special arrangements to airport on Friday, Feb. 14, should contact Dan Butrymowicz/Linda Leaman on Thursday, February 13.

OFFICE OF THE DIRECTOR

MATERIALS SCIENCE AND ENGINEERING LABORATORY

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PREFACE

The National Academy of Sciences-National Research Council (NAS-NRC) Board on Assessment of NIST Programs, and in particular, the Panel for Materials Science and Engineering, performs an important role in the programs and success of the Materials Science and Engineering Laboratory (MSEL). The Panel is one of our most effective means for assuring a continuous interaction between our staff and counterparts in the scientific and engineering communities of U.S. industry and academe. Each of the Panel members is selected by the National Research Council on the basis of expertise and extensive experience in the areas of research and technology conducted by the Laboratory. In addition to this Laboratory-wide Panel, we also have an Evaluation Panel for the Reactor Radiation Division.

The 1991 Annual Report was prepared for the NAS-NRC Board of Assessment of the MSEL. The Report contains background information on resources, activities, and representative highlights of the Laboratory. The report includes a brief statement of the strategic plan of MSEL, and the technical areas proposed for future emphasis. A second series of reports on detailed technical accomplishments are published separately as National Institute of Standards and Technology Internal Reports (NISTIR) for each Division/Office. These reports are available to members reviewing individual Divisions.

We look forward to your input and advice in both the evaluation and formulation process of our management decisions at all levels in the Laboratory. During this last year, I know that you have spent time in visiting our Laboratory and discussing programs, progress and plans with our staff. I appreciate the time that you give and look forward to working with you in the future.

Lyle H. Schwartz

December 15, 1991

OVERVIEW

OVERVIEW

I. Introduction

The Materials Science and Engineering Laboratory (MSEL) is responsible for providing the nation with measurement methodology and technology, standards, concepts, reference materials, critically evaluated data, and other technical information on the fundamental aspects of processing, structure, properties, and performance of materials. These outputs are directed to the needs of U.S. industry, government agencies, academic institutions, and other scientific and technical organizations. The programs of MSEL support a wide base of generic technologies in materials, in order to provide for their safe, efficient, and economical use in service. The research activities of the Laboratory address the science base underlying both advanced materials and conventional materials technologies, together with the associated measurement methodology.

The Laboratory consists of five technical division: Ceramics, Materials Reliability (located at the Boulder, Colorado laboratories), Metallurgy, Polymers, and Reactor Radiation; and one independent office, Intelligent Processing of Materials, which sponsors cross-cutting research throughout NIST. The MSEL budget in FY 1991 was approximately $51 million, including capital equipment acquisitions. MSEL has a total staff of 375, of which 88 percent are in scientific or technical support positions.

In addition to the NIST staff, we had 516 visiting scientists and engineers during 1991 involved in collaborative research or utilization of our special facilities (e.g. research reactor). These visitors represented U.S. industry, academe, other Federal agencies, and foreign institutions. Their stay at MSEL ranged from weeks to the entire year, and their salaries and associated costs were covered by the sponsor organization. These non-NIST researchers provide significant leverage of MSEL staff and resources.

II. Major Organizational and Programmatic Events

Continuing the trend of recent years, 1991 was another year of significant change for the staff of the National Institute of Standards and Technology (NIST) and for the members of the Materials Science and Engineering Laboratory (MSEL). As the recently confirmed (February 1990) NIST Director, Dr. John Lyons moved expeditiously to position NIST to not only strengthen the research programs in measurement technology to support expanding quality assurance programs in industry, but to continue its increased emphasis on generic or pre-competitive research in newly emerging technologies critical to the national economy. On February 10, 1991, a substantial reorganization of the NIST major operating units was implemented. Replacing the former National Measurement Laboratory (NML), National Engineering Laboratory (NEL), Materials Science and Engineering Laboratory, and the National Computer Systems Laboratory units are eight laboratory-based operating units, and a ninth unit, Technology Services, containing standards services, measurement services, information services, technology evaluation, assessment, and commercialization, and the manufacturing technology centers program. The directors of these nine units together with the director of the Advanced Technology Program report to the NIST Director. The staff, programs, and name of the former Materials Science and Engineering Laboratory remained unchanged.

The Laboratory has continued to expand facilities and research opportunities, especially in high performance composites, intelligent processing of materials, and the Cold Neutron Research Facility (CNRF). In the CNRF, three neutron beam lines have been installed into the guide hall, and a fourth partially installed. The prompt gamma facility, cold neutron depth profiling facility, a focussed beam research station, the 8-m Small Angle Neutron Scattering (SANS) station, the NIST/Exxon/U Minn. 30-m SANS, and the fundamental physics station are operational. The medium resolution time-of-flight spectrometer, the NSF-funded 30-m SANS, a triple-axis spectrometer, the neutron interferometry station, and the cold neutron reflectometer are at various stages of fabrication and installation. The high resolution time-of-flight spectrometer is well into the design and procurement stage, while the back scattering and spin echo spectrometers are entering the detailed design phase. The formal user program was initiated for the CNRF, with the first call for proposals going out to over 2000 researchers for time on the SANS, depth profiling and prompt gamma facilities. All of the proposals were sent out for peer review; the Program Advisory Committee met in November 1991 and allocated time for successful proposals. This project is now entering the final construction phase, and in coming years will have to be more oriented to operating the facility as a national resource. After FY 1992, all of the facility construction funds will be in hand, and by the end of FY 1993, all instruments should be in the final commissioning stage. As this transition takes place, the character of the group will necessarily change, and planning is now well underway for long term operations.

Working with multi-year funding (FY 1988, 1991) from the high performance composites initiative, the polymer composites program has been developed to assist industry in expanding the use of composites beyond defense and aerospace into mass-market, civilian applications. The major barriers are the high cost of fabrication and deficiencies in predictive capabilities for performance. The program objective is to provide industry with generic science and technology: (1) to monitor, understand, model, and ultimately control the chemical and physical changes occurring during processing in order to achieve more rapid and reliable fabrication, and (2) to establish the processing-microstructure-property relationship needed to improve performance and performance prediction. The program is divided into two task areas: Processing Science; Processing-Microstructure-Property Relationships. The projects generally focus on one of three classes of materials: vinyl esters which are of interest for automotive applications, epoxies which are the basis for printed wire circuit boards, and thermoplastics which were identified by industry workshops at NIST as having great potential for the future. The Processing Science task has focused on liquid molding. This processing method includes both resin transfer molding (RTM) and structural reaction injection molding (SRIM) which is a high speed, process similar to RTM. In addition, a small effort is continuing on process monitoring. The Processing-Microstructure-

Property-Relationship task is focused in two areas: first, the fiber-matrix interface itself or very thin layers where the interface has a major effect on properties, and second, the resin or resin dominated properties in the composites. The projects in this task address one or more of the following objectives: develop test methods to characterize microstructure and properties, apply these techniques to selected materials with known processing histories, and develop understandings that can generate processing-microstructure-property relationships. For the second consecutive year, the NIST Director has selected an MSEL proposal for a five year commitment of funding to develop a new scientific competence. This new program focuses on developing microstructural and physical characterization techniques necessary to link defect characteristics to electro-optical properties of thin film materials such as ferroelectric oxides for high-speed photonic devices. It joins other on-going MSEL competencies efforts in metal matrix composites and polymer blends to establish areas of excellence in science and technology contributing to the NIST mission.

MSEL continued its leadership role in the development of the concept of intelligent processing of materials (IPM) based on the integration of in-situ sensing, process modelling, and computer-based systems to control the evolution of materials microstructures. Working with first year (FY 1991) funding from the MSEL IPM initiative, the program focuses on the dual goals of developing the generic scientific and technological underpinning for IPM and by means of selected pilot projects, to encourage industry to pursue and adopt this powerful new approach to materials processing. Initial efforts are directed toward intelligent processing for advanced steelmaking in cooperation with The American Iron and Steel Institute and its member companies, and to intelligent processing of metal powders through a NIST/industry consortium with four companies and The Department of Energy. The metal powder project builds on a successfully completed three-year NIST/industry pilot consortium project on the application of IPM concepts to inert gas atomization of metal powders.

Programmatic objectives of these and other core programs of the Laboratory have been reviewed by the individual Divisional subpanels and executive summaries of their findings are presented in this report as an overview for all panel members. Selected highlights of this years' programs follow in a summary format. These highlights are representative of Laboratory programs but are not meant to be all-inclusive. A more comprehensive review of the individual Division's programmatic outputs are given in the Division's Annual Reports.

The prospects for 1992 represent continued growth in program expansion over 1991. Although the second funding increment for the Intelligent Processing of Materials initiative was not appropriated for FY 1992, limited, non-permanent funding was received from the Advanced Semiconductor initiative to enhance the modest MSEL program in electronic packaging materials. The new funds will be used to initiate projects in three areas: (1) to develop metrology to measure in the processing environment the degree of cure of thermosets used in microelectronic packagings; (2) to develop measurement and test methods to determine component solderability and the optimization of production-line soldering conditions; and (3) to develop the measurement technology to determine mechanical properties of thin-film materials typically used in fabrication of electronic packages and interconnections.

As reported last year, a series of events associated with planning for materials science and engineering have occurred, and MSEL positioned itself to contribute to and take advantage of these activities in the development of its blueprint for the future. As input to the preparation of a NIST strategic plan, MSEL developed its own comprehensive strategic plan. The MSEL plan, approved by the NIST Director in July 1991, calls for: (1) extension of traditional strengths in structural materials to encompass advanced materials; (2) expansion of programs in materials processing, including sensor development and process modelling, leading to intelligent processing of materials; (3) broadening materials coverage to include materials utilized for their electronic, optical, and magnetic properties in information and communications applications; and (4) increased interactions with industry in areas of high mutual priority by mechanisms of joint technology development. A summary of the NIST-approved MSEL plan, titled Strategic Directions, is included in this document.

During 1991, MSEL has played a leadership role in the development of federal materials strategy through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), a cabinet-level interagency committee. The FCCSET and its supporting committees are responsible for coordinating science, engineering and technology programs affecting more than one Federal agency, including developing and reviewing annual and long-range Federal budget plans in selected cross-cutting areas. Areas selected for budget crosscut reviews transcend the mission of any single agency, underscoring the need to review these programs on an integrated interagency basis to ensure that multi-agency investments yield the maximum return to the public and avoid unnecessary duplication. The central purpose of the crosscut review is to develop a planning framework, program priorities and budget options for consideration by individual agencies, OMB, and ultimately the President. The crosscut reviews provide information and analysis to the agencies prior to final agency decisions on their budget requests. This process enables the President, cabinet members, and other senior advisors to make more informed decisions on important cross-agency R&D programs, while retaining sufficient flexibility for agencies to consider their internal needs and priorities. OMB acceptance of a budget crosscut may result in a Presidential initiative in a specific crosscut area and inclusion in the President's annual budget. Dr. Lyle Schwartz, MSEL Director, named chairman of the Committee on Materials (COMAT) in December 1990, was asked by the FCCSET to conduct an inventory on the total federal expenditure in materials R&D and to develop an interagency response to existing and future national planning initiatives in materials as part of a crosscut review of advanced materials and processing. The COMAT effort is based on the recommendations in the National Research Council report "Materials Science and Engineering for the 1990s". The COMAT report is expected to be released early in 1992.

Selected Highlights

- A unique high-resolution NMR imaging facility has been established at NIST to provide a material diagnostic technique by internal mapping. It has been successfully used to study binder distribution in a green ceramic. Such results will be used to develop models for the intelligent processing of ceramics.

- A new research consortium of 4 companies (General Electric, Aircraft Engines, United Technology Pratt & Whitney, Crucible Materials Corporation, Martin Marietta Energy Systems), and DOE was formed with NIST to demonstrate intelligent process control of particle size for high pressure gas atomization of Inconel 625 powders. Research was initiated to analyze and model the breakup of the liquid metal in the atomization die, improve accuracy of the Fraunhofer diffraction system for on-line particle size sensing, and modification of the atomizer.

- The sensing of the resistivity of carbon-carbon composite sheets by through-transmission eddy current methods at temperatures up to 850°C was shown to be feasible and practical, and a simple mechanism for describing the temperature dependence of the electrical conductivity of carbon-carbon was formulated. The electrical conductivity data obtained by the eddy current sensor during carbon-carbon processing will be used to adjust the time-temperature cycles used for processing and help increase the yield of high quality products. This research was carried out jointly by the General Dynamic Corporation and NIST researchers in the Metallurgy Division.

- The Structural Ceramics Database Version 1.0 (SCD 1.0) became available in October 1990 as NIST Standard Reference Database Number 30. This system is the first collection of evaluated thermal and mechanical property data for advanced ceramics that has been made available to the public in a computerized, user-friendly format. More than fifty industries, government laboratories, and academic research facilities purchased SCD 1.0 during fiscal year 1991.

- Two of the most common observed luminescence emission bands of CVD diamond occur in the red and blue-violet regions of the visible spectrum. Spectrally resolved cathodoluminescence imaging of isolated diamond particles has shown that, for some choices of deposition conditions, the red emission band is associated with (111) crystal growth sectors, and the blue-violet emission band is associated with (100) sectors. It may thus be possible to control the color of the luminescence by controlling the crystal growth habit. This is of interest for potential applications of CVD diamond in full-color luminescent displays.

- The Ceramics Division in collaboration with the participants of the IEA powder characterization program, has developed 25 procedures for analysis of ceramic powder properties. Using these procedures, the participants have analyzed five powders, (silicon nitride, silicon carbide, zirconia and aluminum nitride). The data collected by all participants have been compiled and organized into a report. These data will provide a basis for powder specifications required for international commerce.

- A high-pressure, gas-coupled acoustic microscope was designed, built and demonstrated. Proof-of-concept experiments on silicon wafers showed excellent signal-to-noise and resolution potential below 10 micrometers.

- A physical model has been developed to mathematically describe the flow behavior of microalloyed steels at high temperatures and high strain rates.

- An arc sensor module with algorithms for detecting various causes of weld defects has been developed for delivery to Babcock and Wilcox for integration into a programmable arc welding system.

- As part of a Cooperative Research and Development Agreement with the Automotive Composites Consortium, a computer simulation was performed to model resin flow in liquid molding of the front end structure of a Ford Escort. The initial results show the ability of the simulation to predict features like venting locations and clamping forces as a function of injection gate positions, resin viscosity, and preform permeability. Such results provide the information necessary for process optimization.

- A unique new tool has been developed to study the physics involved in the adhesion between a polymer and a solid surface like glass. The technique, based on neutron reflectivity, was shown to provide data on the density of molecular segments near such an interface. The theoretical framework to interpret the reflectivity results has also been developed.

- The apparent "shift" in polymer blend phase separation temperature T_c, under shear flow has been interpreted with the mode-coupling theory for mean-field polymer blend systems. This hydrodynamics theory predicts no true shift of T_c; the apparent shift of T_c along the flow direction arises from suppression of fluctuations along the direction of flow. Upon dilution of the polymer blend, fluctuation effects become important and mean-field theory no longer applies. The shift in T_c in diluted blends is consistent with a crossover from mean-field to Ising critical behavior upon dilution.

- A new method has been developed that predicts the growth patterns of solid particles forming from a melt during alloy solidification. This method treats the system as a whole using a continuous field variable to describe the state (liquid or solid) of the various regions of the system. Calculation of growth patterns and their Ostwald ripening is now possible for alloys and yields the composition segregation pattern left in final solid products. These segregation patterns are responsible for defects which limit the mechanical and corrosion properties of many alloys.

- A unified approach, which uses crystallographic symmetry group/subgroup relations between phases, was developed to predict the complex transformation paths that change the high temperature BCC and ordered BCC into the low temperature hexagonal, orthorhombic and omega-type phases in the Ti-Al-Nb system. Knowledge of these paths will permit an optimization of the heat treatments used for these alloys which have great potential for reduced density and higher temperature performance in aerospace propulsion systems.

- The growth of copper-tin intermetallic compounds in electronic solder connections was modeled analytically. The model confirms the experimental observation that the Cu_6Sn_5 intermetallic grows much more rapidly than the Cu_3Sn intermetallic, and shows that very large stresses are developed around the Cu_6Sn_5 intermetallic layer.

- Neutron group scientists have completed the first neutron elastic and inelastic scattering research on buckminster fullerene (C_{60}) worldwide. This work has established the character of the orientational disorder and dynamics in both low temperature and high temperature phases and have shed important light on the nature of the phase transition and the details of the intramolecular forces in this new molecular architecture.

- Using the thermal neutron reflectometer, neutron scattering group scientists, in collaboration with researchers from the University of Massachusetts and the University of Pennsylvania, have demonstrated that a dissolved polymer, in this case carboxylic acid terminated polystyrene, forms a weakly stretched "brush" with a parabolic concentration profile when adsorbed on a silicon surface. This fundamental experiment confirms theoretical predictions and is important for understanding the interaction of polymer molecules with surfaces.

- In the Crystal Data Program in the Reactor Radiation Division, the On-Line Search System has been greatly augmented to include new search and analysis tools, additional indexed parameters, and new data. With data on over 170,000 materials, the System is widely used by the industrial community in materials research, in compound identification, and for statistical studies on the solid state.

STRATEGIC DIRECTIONS

Materials Science and Engineering Laboratory

November 1990, Rev. July 1991

Materials are the keystone building blocks of modern society and are central to the reliable and efficient functioning of engineering structures, components, devices, and machines and thus technological progress in such diverse fields as electronics, construction, energy, communications, and transportation hinges on the development of materials with properties and performance characteristics far superior to materials used today. The functioning of devices and machines is often more limited by their component materials than by design; and the useful life of components and structures is nearly always limited by the materials properties. The essence of materials science and engineering is the study and exploitation of the interrelationships between synthesis, processing, composition, structure, properties, and performance of materials.

Mission, Policy and National Trends

The Materials Science and Engineering Laboratory (MSEL) is the Federal Government's central resource for measurement-related materials research in support of industrial needs. The Laboratory's program is directed towards facilitating the development and application of science and technology in U.S. industry by developing the scientific bases and critically needed measurement methods, calibration standards and reference data required for processing and using new advanced materials as well as existing materials more reliably and at lower cost.

The Laboratory plans it's programs in response to the NIST enabling legislation, Executive and Congressional policies and with an understanding and close tie to national trends in industrial and manufacturing technologies. During the past decade, a concurrent change in Presidential policy and Congressional focus on enhanced industrial competitiveness in the international arena has led NIST to expand on its traditional role. New programs have been enacted by Congress which will aid U. S. industries in developing new products or in improving current product quality, performance and cost, thus improving competitiveness within the international community. A major emphasis in the Laboratory's planning process has been to utilize close cooperation with industry to obtain input on national trends in materials research, measurement methods, data, and standards necessary to support manufacturing technologies. With this planning information, the Laboratory identifies gaps in current materials science research, data, and standards and develops plans whereby the Laboratory can make the broadest impact on major industrial sectors of the U. S. economy.

Macro Trends in Materials Science

Three major trends in the materials science community are fundamentally changing research and the translation of research outputs into industrially utilized materials. The first trend is the shift in balance from the traditional commodity materials to new, high technology, high value added materials which are developed specifically to satisfy one or more unique functional or structural needs. The technological and economic goals of many other countries are also tied to advances in materials, setting the stage for intense international competition. Industries which can rapidly and successfully adopt new materials into their manufacturing processes to improve performance, reliability, or cost will be in a position to develop a worldwide edge in competitiveness. A major factor in the MSEL response is the utilization of the Laboratory's scientific and technical strengths in characterizing materials and developing test methods, data, and standards for evaluating materials being developed by the U. S. materials science research community and aiding industry in using that information to improve materials performance in U. S. manufactured products.

The second trend reflects the evolutionary shift in industrial R&D leadership away from primary materials producers to materials utilization industries. For metals, especially for aerospace and transportation applications, the users or fabricators of modern, highly specialized alloys are increasingly responsible for specifying alloy performance requirements and alloy development. The highly disaggregated producers of advanced ceramics cannot support the integrated research effort needed to commercialize advanced materials. In the composites community, the fabrication or lay-up of high performance composites is often carried out on-site by the component user. This change in R&D focus in materials has led MSEL to develop increasingly closer ties with the materials users and has highlighted the need for MSEL to carefully select industrial partners in order to ensure the implementation and ultimate impact of the results from NIST programs.

The final trend in materials science, recognizing the rapid development of new high technology materials, is the increased reliance industry will have on materials processing with remote sensing of materials characteristics to provide real time feedback to a knowledge-based computer control system to insure product quality and to improve cost competitiveness with both conventional and newer high technology materials. Research in materials processing (intelligent processing) will depend greatly on developing reliable data, process models, and computer process simulation to bring insight into the relationship between the physical and chemical properties of the material during processing and the functional or structural properties of the specific end-product material. This shift to real time materials characterization during processing will necessitate a strong and integrated Laboratory program in measurement research, materials data, modeling, nondestructive materials sensing, and the use of real time materials evaluation data in processing.

Focus on Customers

The MSEL industrial customer base is broad and includes primary materials, aerospace, ground vehicle, electronics and communications industries. Taking advantage of NIST's traditional role as facilitator or focal point for bringing together divergent or competing industries and companies and the expanded authority granted to Federal laboratories by the Federal Technology Transfer Act of 1986 and Executive Order 12591, MSEL successfully serves as the interface between materials producers, such as the steel companies, and materials users, such as the automotive manufacturers. In response to the shift in materials R&D leadership to utilization/manufacturing industries, the Laboratory has significantly increased its linkages to these larger, technology-driven companies within critical industrial sectors. Working through these companies, MSEL has also been able to interact with and have a greater impact on the difficult to reach small business community through the vendors/suppliers to the high technology firms. The Laboratory continuously monitors and evaluates the impact and value of its programs on the industry segments with which it is currently collaborating, and as financial and staffing resources permit, enhances these activities or re-directs programs into collaborations with new partners.

MSEL Plan - Near Term

The Laboratory has recognized and participated in the worldwide shift in materials research to complement incremental improvements in basic commodity materials by research into new and advanced materials designed specifically to satisfy functional or structural needs. To continue it's leadership role in materials science research and it's ability to respond to national priorities and needs, MSEL has developed a plan to: (1) extend traditional strengths in structural materials to encompass advanced materials; (2) expand programs in materials processing including sensor development and process modeling; (3) broaden materials coverage including those utilized for their electronic, optical, and magnetic properties; and (4) increase interactions with industry in areas of high mutual priority by the mechanism of joint technology development. Near-term efforts have focused on: Advanced Materials; Materials Manufacturing; Functional Materials; and Materials Characterization.

ADVANCED MATERIALS

One of the principal goals established by NIST and the Department of Commerce is to promote the rapid and competitive introduction by U. S. firms of products based upon emerging technologies. Advanced materials has been identified in a number of studies, including the 1989 DOD Critical Technologies Plan and by a recent department-wide study of Emerging Technologies, as prominent among these technologies. Unquestionably, there is a shift in the balance of materials usage to the manufacturing of high-technology, high-value-added materials such as composites and advanced ceramics.

Advanced Ceramics

Advanced ceramics are a new generation of high-performance materials which have begun to provide the basis for high technology applications in both new and established industries. The special properties attainable in advanced ceramics (such as high dielectric strength, and resistance to high temperature, corrosion, and wear) make them the preferred, or only, materials suitable for a broad range of high-performance uses in electronics, optics, structures, cutting tools, and advanced heat engines. The major technical barrier impeding competitive commercialization of advanced ceramics is the inability to produce components reliably at reasonable cost. This lack of reliability stems from the sensitivity of ceramic performance to small microstructural defects (1 nanometer to 100 micrometers). The MSEL program addresses these technical issues through measurement-oriented research designed to understand, predict, and control the origin and fate of these performance-limiting features, and to establish those critical linkages between processing variables, microstructures, material properties and performance that will markedly improve ceramic reliability.

High-Performance Composites

Composites are attractive substitutes for traditional engineering materials because of their high specific strength and stiffness, corrosion resistance, design and manufacturing flexibility, and effectiveness in conserving critical raw materials. Key technical barriers that limit full exploitation of composite materials are the high cost of fabrication and lack of understanding and predictive capabilities for performance. The initial polymer matrix program addressed processing since advances in processing science and implementation of on-line process control are the keys to more rapid and reliable processing/fabrication. Efforts are assisted by a newly developed composites fabrication facility, continued development of advanced sensors for process control, and research on resin transfer molding, identified by an industry workshop as a future key fabrication method. A significant industrial collaboration has been initiated with the Automobile Composites Consortium (Ford, GM, Chrysler) in which MSEL is developing critical resin flow models to describe the filing of molds containing composite preforms. Recent program expansion is directed toward the study of properties and performance. The emphasis is on establishing the processing-structure-property relationships that are needed to improve our ability to understand failure mechanisms and predict performance.

MATERIALS MANUFACTURING

Advanced manufacturing techniques increasingly demand materials of greater reliability and uniformity -- i.e., higher quality. Specific demands for properties and performance can be met by control of the processing of the desired material from synthesis to forming to joining stages.

Intelligent Processing of Materials

Intelligent Processing incorporates five elements: a process model which relates specific materials properties at each stage of the process to the final realized properties; sensors which can measure the appropriate materials properties during processing; materials property data which must be coupled with the limited real time measurements in the process model; rapid computational capability to enable incorporation of sensor data, process model evaluation; and process variable control through a knowledge-based computer control system -- all in real time -- to ensure optimum process control, or true intelligent processing of materials. The MSEL plan is to develop generic programs which integrate robust in-process materials property sensors with process models to achieve a high level of material control. Multidisciplinary teams of investigators from appropriate parts of MSEL and throughout NIST will be assembled, with close cooperation from industry materials producers from planning through program implementation, and coordinated with related programs at other Federal agencies. Following successful workshops with ceramics, polymers, composites and metal materials industries, and the successful completion of a pilot industrial consortium program in metal powder atomization, the current program is focused in two areas. First, a NIST-led industrial consortium on rapidly solidified metal powder processing where the technical focus is to demonstrate on-line powder particle size control in the MSEL supersonic inert gas metal atomizer (SiGMA). Second, working with the American Iron and Steel Institute (AISI) as a follow-up to the 1989 NIST/DOE/AISI workshop on intelligent processing, MSEL has initiated a program on intelligent processing of steel including in-process sensors and expert control systems for sheet texture, in-process sensors for mechanical properties and solidification control, and modelling of deformation processes and microstructural evolution.

Electronic Packaging

The loss of U. S. leadership in the electronics industry results from the inability to manufacture advanced electronic components of high quality at low cost. This leadership loss also affects the competitiveness of U. S. industry in rapidly advancing technologies such as telecommunications. Fabricating complex, advanced microcircuits on a commercial scale requires significant improvement in current manufacturing processes in part because of critical problems in connecting or packaging these devices with other parts of the component. As design trends demand smaller, thinner, and more complex packaging and interconnection systems, problems of thermal load management and material properties that change with scale from bulk values to values for thin films and interfaces become important. This challenge of electronic packaging and interconnections affects the reliability of the resulting product. As part of a NIST response, MSEL has outlined a multiple approach which builds on budget initiatives and potential industrial collaboration through organizations such as the Semiconductor Research Corporation, the National Center for Manufacturing Sciences (NCMC), MCNC (formerly the Microelectronics Center of North Carolina), and the Microelectronic and Computer Technology Corporation (MCC). The MSEL role is to develop the measurement tools necessary to define the realistic electronic, mechanical, thermal, and chemical properties of packaging and interconnection materials.

FUNCTIONAL MATERIALS

Functional materials are those classes of materials which are used in various technological applications because of their specific functional purposes -- for example, electrical, magnetic, or optical functions. They play an enabling role in some of the key techno-economic areas such as the electronics industry, telecommunications, and in contemporary information technology.

Superconductors

This new technology will ultimately have an impact on many fields traditionally supported by the Laboratory. The development of a practical high temperature superconductor technology, however, is limited by a number of technical problems, including difficulty of fabricating components and the inability of these materials to carry the necessary large electric currents. A NIST-wide coordinated program supports this embryonic industry with the development of basic technology in a number of areas, including composition and structure analysis, measurement methods for electrical and magnetic characterization, data for design and control of fabrication processes, and development of superconducting devices for measurement systems. Using the unique combination of facilities and expertise, the MSEL program component has already made significant contribution to the analysis of composition and structure of experimental high temperature superconductor materials, the development of guides for processing ceramic superconductors, and the development of a technique to prepare twin-free crystals and bicrystals for flux pinning research. Expanded efforts will be directed towards neutron studies of magnetic and near-surface oxygen differences in superconducting thin films, effects of chemical dopants on flux pinning in twin-free crystals and bicrystals, expansion of phase equilibria studies to guide the design of fabrication processes for new multicomponent systems, and the determination of critical mechanical characteristics of ceramic superconductors for potential large scale applications.

Magnetic Materials

Magnetic information storage technology has been targeted by Japan as a key industry in the struggle for world market dominance in information technology and supercomputers. Over the last decade, major advances have been made in magnetic materials not only for magnetic recording but for applications in advanced electronic systems and the transmission and distribution of electric power. U. S. industry has difficulty in competing because many companies cannot support a sufficiently large research and development effort to keep pace in this rapidly changing technology. A NIST-wide program has been outlined that will provide critical new measurement techniques and standards for structural characterization and growth of new magnetic thin films and media for high quality magnetic recording and the determination of key surface and microscopic properties affecting the performance of recording tape and devices. The Laboratory has planned an extensive long-term program in research and method development on new high-technology magnetic materials and thin films. A broad measurement-based effort is utilized to characterize microstructural information from neutron scattering measurements in the NIST reactor, couple magnetic property measurements with structural defect analysis and control of wear at submicrometer dimensions.

MATERIALS CHARACTERIZATION

MSEL has an integrated program in microstructural characterization utilizing a wide array of techniques and associated instrumentation for the spatially resolved measurement of materials. MSEL facilities include optical and electron microscopy; optical, x-ray, electron scattering and diffraction, including a major facility at the National Light Source at Brookhaven Laboratory; and an array of nuclear beam techniques utilizing the NIST Research Reactor, including the Cold Neutron Research Facility as a national user facility.

Cold Neutron Research Facility

A multi-year program for the development of an internationally competitive cold neutron research capability (facility) has been initiated to provide U. S. scientific and industrial communities with the most advanced facility for measurement of materials at both atomic and macromolecular levels using neutron techniques. This measurement facility, coupled with other state-of-the-art measurement capabilities within MSEL and other NIST Laboratories provide scientists with world class measurement capability with which to study the composition/structure/property relationships of newly developed materials. These advanced measurement technologies have broad application in basic and applied science directly relevant to the materials, information and communication, transportation, chemical, electronics, and biotechnology industries. Access to a cold neutron research facility is an important step toward allowing U. S. materials based industries to compete successfully with other industrialized nations in the development of new and improved materials and products. Fifteen state-of-the-art research stations are in planning, design, or under construction. Strong industrial financial and scientific support has been obtained for the development and operation of several of these instrument systems.

MSEL Plan - Longer Term

Because the rapid pace of technological change in materials technologies continues, new, interdisciplinary topics with high impact potential have been identified as future areas of MSEL focus. Significant industrial measurement needs are anticipated in some of these areas, while others offer exciting new science opportunities. These topics include: coatings/surfaces/interfaces; photonic materials; nanostructured materials; infrastructure materials; metal and ceramic matrix composites; and modelling/theory/computation.

Currently, limited exploratory programs are underway in MSEL in these targets of opportunity but the efforts lack critical mass and are not yet capable of responding to significant extramural demands.

Coatings/surfaces/interfaces or functional gradient materials represent typically two dimensional systems and offer the challenge of combining neutron scattering strengths with other nondestructive evaluation techniques in studying metal, ceramic, polymer, and composite materials. The promise of optical technology to bring dramatic improvements in telecommunications, information processing and storage is the major driving force for commercialization of photonic technology based on using thin films and multilayers. Nanostructured materials or nanocomposites represent material classes whose properties are influenced by the small scale ($<$100 nm) of the material features. Facilitating the introduction of new materials in revitalizing the Nation's infrastructure is important in order to reduce the likelihood of rebuilding with outdated materials or imported materials. Consumer industries have not benefited from the aerospace/defense-oriented research programs for metal and ceramic matrix composites because the materials of military R&D interest are too expensive for most commercial applications. Finally, the rapidly changing materials scene can greatly benefit from fresh approaches to condensed matter theory and modelling of the solid state that are now feasible because of the ready availability of high speed computers and computation methods.

Summary

The materials industry today is in the midst of a technological explosion that is creating major economic opportunities for those nations willing to commit scientific and engineering resources to capture them. With these opportunities being driven by market demand and scientific understanding, a whole host of industries are designing sophisticated and efficient products to be made from materials that are today still in the laboratory. NIST can play a major role in assisting U. S. industry to develop some of the capabilities needed for the commercialization of many of these materials. The rapid advancement in understanding the fundamental relationship between materials and their structures in the last 15 years can now be applied to the development of a new body of knowledge about the design, characterization, testing and, in particular, the processing and manufacturing of a new generation of advanced materials.

The Materials Science and Engineering Laboratory has a number of unique strengths. It has great breadth and expertise in all classes of engineering materials, including metals, ceramics, polymers, and composites. Major facilities have been developed and continually enhanced and upgraded to provide in one organization a unique, world class combination of X-ray, electron, and neutron methods and techniques for materials interrogation and characterization. Industrial collaborations with MSEL and its predecessors stretch back more than 80 years to shortly after the National Bureau of Standards was created. These very early efforts, as today, were in support of U.S. industry's efforts to improve materials quality for the developing transportation infrastructure of that era. The resulting historical focus has been in structural materials where a nationally recognized program in structure/properties/performance relationships of materials has been developed. The importance of materials data is recognized by the location within MSEL of a number of significant national data evaluation programs often in collaboration with professional societies, including metals and ceramics phase diagrams, structural ceramics, crystal structure, corrosion, and tribology. A NIST-wide program in intelligent processing of materials is located in MSEL through which a coordinated program is directed that supports research ranging from development of advanced materials processing sensors and models for in-process control to development of test methods and standards for post manufacture inspection.

These strengths are offset in part by weaknesses that hinder the pace of movement into new, promising materials areas. Currently, the total capability in functional materials is inadequate with a wide variation in levels of support among high temperature superconductivity and electronic packaging and thin film applications in magnetic, optical, and other non-structural applications. The increasing demands on producing materials with properties for specific applications or materials by design requires a strongly coupled effort in modeling, not only processes, but the fundamental behavior of the solid state. This capability is at a marginal level currently and must be strengthened, especially in support of functional materials. Finally, MSEL faces the chronic NIST problem of equipment modernization. This is particularly acute as the focus of our industrial interactions shift from intrinsic materials measurements and data toward materials processing/manufacturing and control, and the time frame available to provide needed information to industry shrinks.

PERSONNEL

SUMMARY OF MSEL STAFF

Full Time Permanent	1989	1990	1991
Physicist	61	59	58
Chemist	43	52	50
Metallurgist/Matls. Scientist	54	48	44
Engineer	41	33	34
Other	12	12	15
Subtotal	211	204	201
Technical Support	32	38	38
Reactor Operators	16	17	15
Management Support	11	8	8
Secretarial/Admin. Support	31	35	35
Subtotal	90	98	96
TOTAL FTP	**301**	**302**	**297**
Other			
NRC-NAS Postdoctorals	9	14	16
Part-Time and Temporary	27	20	30
Academic (Student and Faculty)	42	51	32
Subtotal	79	85	76
TOTAL STAFF	**380**	**387**	**375**

FY 1991 MSEL POSTDOCTORAL PROGRAM

Unit	Name	Degree	School	Position Title	Advisor
Lab Office	Leueke, William	Matls. Sci	Cornell U.	Matls Res Engr	Wiederhorn
Ceramics	Carter, Craig	Engineering	U. of CA	Matls Res Engr	Fuller
	Grabbe, Alexis	Chemistry	U. of NC	Res Chemist	Horn
	Lindsay, Curtis	Geology	VPI & SU	Phys Scientist	Roth
Polymers	Campbell, Gordon	Chemistry	Texas A&M	Chemist	VanderHart
	Dadmun, Mark	Pol Sci/Eng	U. oif MA	Matls Res Engr	Han
	Hair, Dennis	Chemistry	USC	Res Chemist	Han
	Jackson, C.	Poly Sci	U. of CT	Gen Phy Scient	McKenna
	Orts, William	Chem Engr	Queens U. Ont. Canada	Physicist	Wu
	Santore, Maria	Chem Engr	Princeton	Chem Engr	McKenna
	Waldow, Dean	Chemistry	U. of WI	Res Chemist	Han
Metallurgy	McMichael, Robert	Physics	Ohio State	Physicist	Bennett
	Moran, James	Matls Engr	U. of VA	Metallurgist	Lashmore
	Sandlin, Allison	Matls Engr	U. of AL	Metallurgist	Schaefer
Reactor	Borchers, Julie	Physics	U. of IL	Physicist	Erwin
	Robertson, Jack	Physics	U. of Hous.	Physicist	Rush

FY 1991 MSEL ACADEMIC PROGRAM

Appointments

	Students	NAS/NAS Postdoctorals	Faculty	Totals
Laboratory Office	1	1	0	2
Ceramics	5	3	0	8
Materials Reliability	7	0	0	7
Polymers	6	7	1	14
Metallurgy	10	3	1	14
Reactor Radiation	0	2	1	3
Totals	29	16	3	48

MSEL VISITING SCIENTIST PROGRAM

Guest Researchers	FY 1989	FY 1990	FY 1991
Domestic			
Federal	54	59	47
Academic	79	76	92
Industry	29	43	46
Self-Employed	20	18	20
Subtotal	182	196	205
Foreign	136	167	164
Subtotal	318	363	369
Research Associates			
Federal	3	6	4
Academic	4	0	0
Industry	82	45	53
Research Agreements			
Federal	*	1	0
Academic	*	3	0
Industry	*	22	20
Subtotal	89	77	77
Intergovernmental Personnel Act (Academic)	1	0	2
TOTAL	408	440	448

* Not available as separate line item

HONORS AND AWARDS

DEPARTMENT OF COMMERCE AWARDS

1989-1991

GOLD MEDAL (Exceptional Service)

Edward Prince	for development of maximum entropy techniques for the solution of biological structures from X-ray scattering data. (1991)
Tawfik M. Raby	for leadership in operation of the NIST Research Reactor as a major national measurement resource for U.S. science and industry (1991)
George Birnbaum	for highly distinguished authorship and editorship in molecular spectroscopy and for his unusually outstanding scientific leadership in the NDE program. (1989)

SILVER MEDAL (Meritorious Service)

Stephen D. Ridder **Francis S. Biancaniello** **George E. Mattingly** **Cary Presser** **Pedro I. Espina** **Stephen A. Osella**	for outstanding contribution to the development and demonstration of intelligent processing technology in the production of rapidly solidified metal powders. (1991)
Alan Dragoo **Stephen Hsu** **Subhasch Malghan**	for leadership of the International Round Robin on Ceramic Powder Characterization to advance standards for characterization of advanced ceramic powders. (1990)
Roger Horn **Douglas Smith**	for development of surface force measurement technology using chemically reactive surfaces (silica). (1990)

Donald Hunston	for outstanding scientific and managerial leadership in the investigation of adhesion and the processing and performance of polymer composites. (1990)
Ivan Schroder	for outstanding contributions to the Department and nation through his innovative design and development of the neutron guide tube network at the Cold Neutron Research Facility (CNRF). (1990)
E. Neville Pugh and Ugo Bertocci	for significant advances in the understanding of environment induced cracking of engineering metals and alloys. (1989)
Reactor Operations Group	for excellence in all aspects of the operation of the NIST Reactor. (1989)

<u>BRONZE MEDAL</u> (Superior Service)

Dan A. Neumann	for leadership in neutron research on key molecular scale properties of new layered materials for improved chemical processing and separation. (1991)
David T. Read	for developing a fracture mechanics approach to assessing the reliability of electronic packages. (1991)
Richard E. Ricker	for pioneering research on the corrosion and environment-induced cracking of advanced intermetallic alloys. (1991)
Thomas A. Siewert	for developing a materials research program that contributes to the quality, reliability, and safety of welded structures. (1991)
Robert Briber	for significant contributions in the area of complex phase behavior of polymer blends, including determination of the phase diagram and dynamics of crystallization. (1990)

James Gottas	for outstanding contributions to the Cold Neutron Research Facility through his energy, dedication, and creativity in the development of a Cold Neutron Source at the NIST Reactor. (1990)
Debra Kaiser **Frank Gayle**	for development of a thermomechanical technique to produce twin free single crystals of superconducting, yttrium, barium copper oxide. (1990)
Stephen Norton	for innovative contributions to the use of nondestructive evaluation sensors for materials process control, including development of mathematical approaches that allow sensor data to be converted to useful process information. (1990)
Raymond Schramm	for development of a railroad wheel inspection system based on electromagnetic acoustic transducers, including the signal analysis software, and the associated digital electronics. (1990)
Barry J. Bauer	for outstanding contributions to the synthesis and characterization of cross-linked interpenetrating polymer networks. (1989)
Douglas Blackburn	for development of glasses or glass standards in support of the optical, analytical chemical, and glass industries. (1989)
Carol A. Handwerker	for providing new understanding of interface reactions and processes that cause roughening at interfaces in composite materials. (1989)
Robert H. Williams	for outstanding contributions to the development and operation of the research facilities at the NIST Reactor, and for leadership in the planning and installation of instrumentation at the Cold Neutron Research Facility. (1989)

SPECIAL ACTS

Bruno M. Fanconi	for especially effective action in an emergency situation. (1990)
Edward Begley	for contributions to the development of a computerized structural ceramics database. (1989)
Subhas Malghan	for leadership in formulating an industrially relevant program of research in fine ceramic powder processing. (1989)
Deborah Northup	for extraordinary facility in quickly assuming increased duties as secretary of a much larger group and efficiently carrying out the duties under unusual supervisory circumstances. (1989)

FELLOW AND SENIOR FELLOW (Established by NIST Director to provide recognition to most outstanding scientists)

John Cahn	Elected to Senior Fellow
Brian R. Lawn	Elected to Fellow
John J. Rush	Elected to Fellow
Robb M. Thomson	Elected to Fellow
Sheldon M. Wiederhorn	Elected to Senior Fellow

NIST AWARDS

1989-1991

EDWARD UGLER CONDON (Distinguished achievement in written exposition in science and technology)

Gregory B. McKenna	for his excellent review of the properties and physics of polymer glasses. (1989)

EDWARD BENNETT ROSA (Outstanding achievements in the development of significant standards of practice in the measurement field)

Leonard Mordfin	for outstanding leadership in the standardization of mechanical testing and nondestructive evaluation (NDE) methods and measurements. (1989)

SAMUEL WESLEY STRATTON (Outstanding scientific or engineering achievements in support of NIST objectives)

Charles Han	for his leadership in advancing the science and technology of polymer blends through use of innovative light scattering and neutron scattering techniques to produce benchmark data. (1990)

EUGENE CASSON CRITTENDEN (Outstanding supporting services)

Dale Kauffman	for significant contributions to the synthesis of glass standards of unusual compositions which have supported the optics, medical, and analytical chemistry fields. (1990)

SAFETY (Significant contributions to Safety Program)

Daniel Vigliotti	for leadership of the safety program in the Materials Reliability Division. (1991)
Patricia Salpino	for exceptional and effective efforts in fulfilling duties as the safety officer of the Office of Nondestructive Evaluation. (1989)

<u>MEASUREMENT SERVICES</u> (Achievement in calibration and measurement services)

Dominique Shepherd **Thomas Siewert** **Daniel Vigliotti**	For successful implementation of the certification program for Charpy impact test machines. (1991)

EXTERNAL RECOGNITION

1989-1991

Joseph M. Antonucci	Consultant to NIDR, Small Business Grants Study Section (1984-1991)
	Councilor: American Chemical Society (1990-1991)
	Recipient: Wilmer Souder Award of the International Association for Dental Research for outstanding research and contributions in the field of dental materials (1991)
John W. Cahn	Michelson-Morley Award presented by Case Western University in recognition of pioneering work in materials science (1991)
Craig Carter	Awarded the Ross Coffin Purdy Award by the American Ceramic Society (1991)
Sam Coriell	Elected ASM International Fellow (1991)
Richard Gates **Steven Hsu**	Received the Al Sonntag Award for most outstanding paper published by the Society of Tribologists and Lubrication Engineers (1991)
John Gudas	Received the Federal Laboratory Consortium 1991 Award for Excellence in Technology Transfer (1991)
Donald L. Hunston	Vice President, Adhesion Society (1991)
Brian Lawn **Sheldon Wiederhorn**	Presented the Hobart M. Kraner Award by Lehigh University (1991)
Gregory McKenna	Chairman, Division of High Polymer Physics, American Physical Society (1991)
	Visiting Scientist, Laboratoire d'Ultrasons et de Dynamique des Fluides Complexes, Universite Louis Pasteur, Strasbourg, France (1991)
	Committee Chairman, American Physical Society Prize in High Polymer Physics (1991)
	Editorial Review Board, Journal of Rheology (1991)

Harry Rook	ASTM Award of Merit for distinguished service to the course of voluntary standardization (1991)
Robert Roth	Selected to present the Sosman Award lecture at the Annual Meeting of the American Ceramic Society (1991)
Lyle H. Schwartz	Elected to Board of Trustees, ASM International (1991)
Jeffrey W. Stansbury	Invited chapter to book on Expanding Monomers: Synthesis, Characterization and Applictions (1990-1991)
John A. Tesk	Invited lecturer to Forsyth Dental Center Conference; Industry/University/Government Research Alliances in the Public Interest: Models for the Future (1991)
	Editorial Review Boards: Dental Materials; and Oral Implantology (1991)
	U.S. Expert for ANSI/ISO on Dental Procelain-Metal Systems (1989-1991)
	Visiting Professor, Tokushima University School of Dentistry, Tokushima, Japan (1991)
	Treasurer, Dental Materials Group of the International Association for Dental Research (1991)
	Member, Executive Committee, Dental Materials Academy (1991)
	Invited Lecturer, Third International Kyoto Symposium on Biomedical Engineering, Kyoto, Japan (1991)
Sheldon Wiederhorn	Elected to the National Academy of Engineering (1991)
H. Thomas Yolken	Elected to the Board of Directors for the American Society for Nondestructive Testing (1991)
	Elected Vice Chairman of the Research Council for the American Society for Nondestructive Testing (1991)

	Appointed to Chairman, Working Group on Intelligent Processing of Materials, Committee on Materials, White House, Office of Science and Technology Policy (1991)
George Birnbaum	Visiting Fellow - Johns Hopkins University (1990)
	Appointed Associate Editor of the Research in Nondestructive Evaluation Journal of ASNT (1990)
	Appointed Associate Editor of Journal of Quantitative Spectroscopy and Radiative Transfer (1990)
Frederick Brinckman	Harold A. Iddles Lecturer at Department of Chemistry, University of New Hampshire (1990)
Aime DeReggi	Invited Professor at Ecole Superieure de Physique et de Chimie Industrielles, Paris, France, (1989); (1990)
John Gudas	ASTM Award of Merit for distinguished leadership and exceptional contributions in the promotion and development of elastic plastic test standards. (1990)
Howard P. Layer	Elected Fellow of the American Physical Society (1990)
Gregory B. McKenna	Vice Chairman, Division of High Polymer Physics of the American Physical Society (1990)
Marshall Peterson	Society of Tribologists and Lubrication Engineers - National Award for Significant Scientific Contributions to the Fields of Tribology (1990)
Arthur W. Ruff	Honorary Fellow of ASTM for Dedicated Service (1990)
A.C. Sandlin **R.J. Schaefer** **L.C. Smith**	Fourth place award. Polaroid International Photomicroscopy Competition (1990)
Leonard C. Smith **Debra L. Kaiser** **Frank W. Gayle**	First place award. Crystal Growth Photograph Competition at Eighth American Conference on Crystal Growth (1990)
Lyle H. Schwartz	Presidential Rank Award of Meritorius Executive for outstanding government service (1990)

H. Thomas Yolken	Appointed by President of the American Society for Nondestructive Evaluation to Committee to establish a major new organizational unit for the Society - The Research Council (1990)
L.H. Bennett	Sigma Xi Award (1989)
George Birnbaum	Appointed research professor in the Physics Department of the Catholic University of America (1989)
William Boettinger	Materials Science Division Award of ASM International (1989)
Frederick Brinckman	Harold A. Iddles Lecturer of the Department of Chemistry, University of New Hampshire (1989)
Edmund DiMarzio	Huggins Award - given by Gordon Conference for outstanding work in Polymer Science (1989)
David S. Lashmore	International Electrodeposition Award, Electrochemical Society (1989)
Leonard Mordfin	ASTM Award of Merit and the title of Fellow of the Society for distinguished leadership and exceptional contributions in the promotion, development, and growth of the ASTM Committee on Mechanical Testing (1989)
Gregory B. McKenna	Elected Fellow of the American Physical Society (1989)
H.J. Prask and C.S. Choi (Guest)	Department of Army Research and Development Achievement Award; for developing and applying neutron diffraction to the determination of subsurface residual stress in a variety of military hardware (1989)
Richard P. Reed	Outstanding Scientist/Engineer Award from the Denver Federal Executive Board as part of its annual Excellence in Government Awards Program (1989)
Harry Rook	Elected Chairman of ASTM Committee D-22 Sampling and Analysis of Atmospheres (1989)
	Elected permanent Chairman of ISO TC 146 Subcommittee 3 - Committee on Standards for Atmospheres (1989)

Tom Siewert and Christopher McCowan	Recipients of the American Welding Society McKay-Helm Award, recognizing a substantial contribution in the field of welding, was presented for paper on ferrite phase prediction in stainless steel welds (1989)
Thomas Siewert	Selected as the annual recipient of the American Welding Society Honorary Membership Award (1989)
H. Thomas Yolken	Appointed editor-in-chief of The American Society for Nondestructive Evaluation's (ASNT) new journal, Research in Nondestructive Evaluation (1989)

TECHNOLOGY TRANSFER

STANDARDS COMMITTEES MEMBERSHIP
1991

MSEL Unit	Staff	Memberships
Laboratory Office	8	15
Office of Intelligent Processing of Materials	1	1
Ceramics	19	69
Materials Reliability	6	11
Polymers	13	36
Metallurgy	25	96
Reactor Radiation	2	7
	74*	235

*Includes 45 leadership positions

Representation

Organization

American National Standards Institute (ANSI)
American Nuclear Society (ANS)
American Society for Testing and Materials (ASTM)
Department of Defense/Technical Coordination
Electronic Industries Association (EIA)
International Organization for Standardization (ISO)
National Association of Corrosion Engineers (NACE)
Safety Glazing Certification Council
Technical Association of the Pulp and Paper Industry (TAPPI)
Versailles Project on Advanced Materials and Standards (VAMAS)

RESEARCH DISSEMINATION

FY 1991

UNIT	PAPERS PUBLISHED	TALKS INVITED	PATENTS*	SRMS*	MONOGRAPHS*
LABORATORY OFFICE	10	38	-----	-----	-----
OFFICE OF INTELLIGENT PROCESSING OF MATERIALS	1	5	-----	-----	-----
CERAMICS	133	150	3	3	2
MATERIALS RELIABILITY	108	22	-----	-----	-----
POLYMERS	114	107	7	1	-----
METALLURGY	129	70	8	6	1
REACTOR RADIATION	110	49	-----	-----	-----
	605	441	18	10	3

*Listing on following page.

PATENTS RECEIVED OR PENDING

1989-1991

<u>1991</u>

Diamond Coated Laminates and Methods of Producing Same
Applied For
A. Feldman, E.N. Farabaugh (Ceramics)

High Resolution X-Ray Microtomographic Detector
Applied For
R.D. Spal, M. Kuriyama, R.C. Dobbyn (Ceramics)

Coating of Reinforcing Agents of Ceramic Composites by Collodial Processing
Patent No. 5,039,550
S. Malghan, C. Ostertag (Ceramics)

Process for the Fabrication of Ceramic Monoliths
(By Laser Assisted Chemical Vapor Deposition)
Patent No. 5,001,001
J. Ritter (Ceramics)

2-Dimension Image Quality Indicator for Radioscopy
Disclosure Filed
T.A. Siewert, M.W. Austin (Materials Reliability) and G.K. Lucey, J. Adams (Harry Diamond Labs)

Air Drying Resins and Processes for Preparing Same
Disclosure Filed
B. Dickens, B.J. Bauer (Polymers)

Radiation Curable Resins Based on Hydroxy Acrylates and Acid Dianhydrides
Disclosure Filed
B. Dickens, B.J. Bauer (Polymers)

Radiation Curable Resins Based on Polyethylene Glycol Acrylates and Poly Isocyanates
Disclosure Filed
B. Dickens, B.J. Bauer (Polymers)

An Optical Sensor for the Measurement of Molecular Orientation and Viscosity of Polymeric Materials Based on Fluorescence Radiation
Disclosure Filed
A.J. Bur, S.C. Roth, R.E. Lowry, C.L. Thomas, F.W. Wang (Polymers)

Dental Monomer/Resin Systems Based on Vinyl Metallocarboxylates
Applied For
J.M. Antonucci, J.W. Stansbury, B.O. Fowler (Polymers)

Novel Fluorinated and Siloxame Multifunctional Acrylates and the Synthesis Thereof
Applied For
J.M. Antonucci, Guo Wei Cheng (Polymers)

Thermal Technique for Determining Interface and/or Interply Strength in Composites
Patent No. 4,972,720
W. Wu (Polymers)

A Process for Producing Diamonds
Applied For
N. Wheeler, D. Lashmore, A. Shapiro (Metallurgy)

A Process for Electroplating Metal and Alloys on Cu-W and Other Difficult to Plate Materials
Applied For
D. Lashmore, D. Kelley (Metallurgy)

Low Temperature Consolidation of Ag_3Sn Intermetallics
Disclosure Filed
D. Lashmore, D. Daiel, E. Escalante (Metallurgy), J. Tesk (Polymers)

Intermetallic Ti-Al-Nb Alloy Based on Strengthening of the Orthorhombic Phase by Omega-Type Phase
Applied For
L.A. Bendersky, W.J. Boettinger, F.S. Biancaniello (Metallurgy)

Acoustic Emission Energy Calibration Device
Disclosure Filed
R. Clough, R. Patel (Metallurgy); E. Ives (Shops)

Nitrogenated Metal Alloys via Gas Atomization
Applied For
F.S. Biancaniello, G.M. Janowski, S. Ridder (Metallurgy)

1990

A Process for the Controlled Preparation of a Composite of Ultrafine Magnetic Particles Homogeneously Dispersed in a Dielectric Matrix
Applied For
J. Ritter (Ceramics, R. Shull (Metallurgy)

Novel Synergistic Additive Packages Containing High Molecular Weight Antioxidants for High Temperature Lubricants
Disclosure Filed
S. Hsu, J. Perez, C. Ku, Y. Zhang (Ceramics)

Low Energy (Thermal) Neutron Absorbing Glass
Disclosure Filed
D. Blackburn, C. Stone, D. Cranmer (Ceramics)

Phosphorous Containing Boundary Lubrication Antiwear Additives for Silicon Nitride Ceramic Materials
Disclosure Filed
R. Gates, S. Hsu (Ceramics)

Process for Elimination of Twins in Perovskite-Type Superconducting Single Crystals
Disclosure Filed
D. Kaiser (Ceramics), F. Gayle (Metallurgy)

A Method for Fabrication of Materials from Nano-Sized Particles Using High Pressure and Cryogenic Temperatures
Disclosure Filed
A. Pechenik, G. Piermarini (Ceramics)

Method to Make Transparent Si_3N_4 at Low Temperature Without Additives
Disclosure Filed
A. Pechenik, G. Piermarini, S. Block (Ceramics)

Nondestructive Ultrasonic Evaluation of Formability of Metallic Sheets
Disclosure Filed
A.V. Clark (Materials Reliability)
R.B. Thomson (Iowa State University)

Superconductor - Polymer Composites
Patent No. 4,954,481
A.S. DeReggi, C.K. Chiang, G.T. Davis (Polymers and Ceramics)

Intaglio Ink Resins Which Cure by Oxidation in Air
Disclosure Filed
B. Dickens, B.J. Bauer (Polymers)

Nanocomposite Material for Magnetic Refrigeration and Superparamagnetic Systems Using the Same
Applied For
R. Shull, L. Bennett, L. Swartzendruber (Metallurgy)

Method and Apparatus for Performing Non-Contact Measurements of Temperature, Conductivity, Diameter and Velocity
Applied For
A.H. Kahn, S.J. Norton, M.L. Mester (Metallurgy)

Predetermined Concentration Graded Multi-Layer Alloys and Method for Production Thereof
Patent No. 7,249,531
D. Lashmore, M. Dariel (Metallurgy)

Magnetron Sputtering Apparatus and Process
Patent No. 4,851,095
D. Lashmore (Metallurgy)

1989

Buffered Cell for Sintering of High Tc Thallium Containing Ceramics
Disclosure Filed
L. Cook (Ceramics)

Self Lubricating Ceramic Matrix and Metal Matrix Composite
Disclosure Filed
M. Peterson, A. Ruff, S. Jahanmir (Ceramics)

Ultraviolet Transmitting Glass for Ring Dye Laser
Disclosure Filed
D. Blackburn, D. Cranmer, D. Kaufman (Ceramics)

Diamond Coated Infrared Transmitting Optics
Disclosure Filed
A. Feldman, E. Farabaugh (Ceramics)

Systems for Monitoring Changes in Elastic Stiffness in Composite Materials
Patent No. 4,499,770, February 19, 1985
R. Kriz (Fracture and Deformation)

Non-Aqueous Dental Cements Based on Dimer and Trimer Acids
Patent No. 4,832,745
J. Antonucci (Polymers)

Calcium Methaphosphate Filled Compositions
Applied For
J. Antonucci, B. Fowler, S. Venz (Polymers)

Resin-modified Glass Ionomer Dental Cements
Disclosure Filed
J. Antonucci, J. McKinney, J. Stansbury (Polymers)

Synthetic Dental Compositions and Bonding Methods
Applied For
J. Stansbury (Polymers)

An Optical Sensor for the Measurement of Molecular Orientation and Viscosity of Polymeric Materials Based on Fluorescence Radiation
Disclosure Filed
A.J. Bur, R.E. Lowry, S.C. Roth, C.L. Thomas, F.W. Wang (Polymers)

Trivalent Chromium Deposition
Patent No. 4,804,446, February 14, 1989
D.S. Lashmore (Metallurgy), E. Namgoong (Korea), I. Weishaus (Israel)

Nanocomposite Material for Magnetic Refrigeration
Disclosure Filed
L.H. Bennett, R.D. Shull, L.J. Swartzendruber (Metallurgy)

New Matrix Approach to Crystal Symmetry
Applied For
A. Mighell; V. Himes (Reactor Radiation)

SRMs PRODUCED

1991

SRM 8501 Lubrication Oxidation Catalysts
(Ceramics)

SRM 1414 Lead-Silica Glass High Temperature Resistivity
(Ceramics)

SRM 7109 Soda-Lime-Silica Glass
(Ceramics)

SRM 1473 Low Density Polyethylene Resin
(Polymers)

SRM 484 SEM Stage Micrometer
(Metallurgy)

SRM 1893 Copper Microhardness (Knoop)
(Metallurgy)

SRM 1894 Copper Microhardness (Vickers)
(Metallurgy)

SRM 1895; 1905; 1906; 1907 Nickel Microhardness (Knoop)
(Metallurgy)

SRM 1896 Nickel Microhardness (Vickers)

SRM 1850 NDE Dye Penetrant Standards
(Metallurgy)

SRM 2350 Step Test Standards
(Metallurgy)

SRM 2321 Lead-Tin Solder Thickness
(Metallurgy)

SRM 1853 Magnetic Particle Test Rings
(Metallurgy)

MONOGRAPHS

1991

Engineered Materials Handbook
Ceramics and Glasses, ASM International
Volume Chairman, S.J. Schneider (Laboratory Office)

Phase Diagrams for Ceramists - Annual '91 - The American Ceramic Society, Westerville, OH
A. McHale, H.F. McMurdie, H.M. Ondik (Ceramics)

Phase Diagrams for High Tc Superconductors - The American Ceramic Society, Westerville, OH
J.D. Whitler, R.S. Roth (Ceramics)

Structural Ceramics Database (SRD 30)
(Ceramics)

Advanced Technologies in Failure Prevention, Cambridge University Press, Cambridge, U.K., Editor, T.R. Shives (Metallurgy)

CONFERENCE PROGRAM
(SPONSOR OR CO-SPONSOR)

FISCAL YEARS 1989 1990, 1991

<u>Seminar on Laser Ultrasonic and Magnetic Sensors for Monitoring Materials</u>
October 4, 1990 (H.T. Yolken-OIPM)
25 attendees

To review recent advances in the application of firstly laser ultrasonic and secondly magnetic sensing methods to engineering materials.

<u>Joint OIPM/Metallurgy Seminar on Advanced Sensors for Process Monitoring and Control of Polymer Composites</u>
November 20, 1990 (H.T. Yolken, OIPM and E. Drescher-Krasicka, Metallurgy)
20 attendees

To discuss techniques for monitoring materials microstructure during the processing of carbon fiber reinforced epoxy/phenolic matrix composites.

<u>Workshop on New Measurements for Polymer Processing</u>
December 3-4, 1990 (A.J. Bur-Polymers)
20 participants

To define real-time measurement needs of the polymer processing industry and to establish a NIST/industry research consortium.

<u>Fundamentals of Carbon/Carbon</u>
December 6-7, 1990 (D. Cranmer-Ceramics)
30 attendees

To review state-of-the-art and future directions of carbon/carbon composites for structural applications.

<u>NASA Microgravity Sciences Diffraction Imaging Program</u>
February 5, 1991 (B. Steiner-Ceramics)
25 attendees

To review program results and develop future directions.

Seminar on the Role of Mathematical Modeling in the Intelligent Processing of Materials
February 15, 1991 (H.T. Yolken-OIPM)
35 attendees

To discuss the methodology of mathematical model development and the relationship of models to experimental work.

Seminar on R&D Activities in Ultrasonics and Acoustic Emission in Japan
February 26, 1991 (G. Birnbaum-OIPM)
10 attendees

A report on the research and development activities of ultrasonics and acoustic emission in various Japanese laboratories.

NIST Workshop in Small Angle X-Ray Scattering
April 3, 1991 (J.D. Barnes and E.S. Clark-Polymers)
15 attendees

To review status and future prospects for the NIST 10 Meter Digital SAXS Camera facility with users and potential users.

ASTM Symposium on Nondestructive Testing Standards
April 4-11, 1991 (L. Mordfin-ONDE)
200 attendees

To review the status and future directions for NDT Standards, and discuss their role in the market places of the future.

Ceramics Bearing Technology Workshop
April 17-18, 1991 (S. Jahanmir-Ceramics)
100 attendees

To review the state-of-the-art in ceramic bearing technology and recommend future research directions.

NIST/Univ. of Minnesota Center for Interfacial Engineering Workshop on Cold Neutron Techniques
May 6-8, 1991 (F. Bates-Univ. of Minn. and C. Glinka-Reactor Radiation)
20 attendees

To familiarize researchers of the Center for Interfacial Research affiliate companies with neutron techniques for interfacial applications.

Microanalysis of Electronics
May 29-30, 1991 (J. Carpenter-Ceramics)
30 attendees

Short course co-sponsored with ASM International to review microscale analysis of electronics.

Workshop on Applications of Cold Neutron Spectroscopy in Chemistry, Biology, and Physics
June 4-5, 1991 (W. Kamitakahara-Reactor Radiation)
150 attendees

To explore some of the exciting new opportunities which will be made available to U.S. researchers when six new high-resolution inelastic scattering spectrometers are completed at the CNRF.

CNRF Researchers' Group Meeting
June 6, 1991 (W. Kamitakahara, Reactor Radiation)
70 attendees

To acquaint potential CNRF researchers with capabilities and procedures relating to utilization of the National Facility.

Joint Services Technical Coordinating Group on Nondestructive Testing and Inspection, Subgroup on Specifications and Standards
July 11, 1991 (L. Mordfin-Metallurgy)
10 attendees

To coordinate NDT standards development activities in the DOD agencies and NIST.

Joint OIPM/Metallurgy Seminar on Ultrasonic Guided Waves in Fluid-Loaded Plates with Application to NDE of Composites
July 11, 1991 (H.T. Yolken, OIPM and R. Clough, Metallurgy)
20 attendees

To review guided wave propagation in fluid-loaded plates.

Symposium on Diamond Options IC at 35th Annual International Technical Symposium on Optical and Optoelectronics
July 21-26, 1991 (A. Feldman-Ceramics)
400 attendees

To review applications of diamonds to optics.

Workshop on the Crystallographic Database for Chemical and Material Analyses
August 7, 1991 at Hilo, Hawaii (A. Mighell-Reactor Radiation, and W. Wong-Ng-Ceramics)
40 attendees

In conjunction with Pacific-International Congress on X-ray Analytical Methods; to acquaint potential users with utility of crystallographic database for chemical and material analysis applications.

Application of Diamond Films and Related Materials, ADC91
August 20-22, 1991 (A. Feldman-Ceramics)
50 attendees

To review applications of the new diamond technology.

Joint American Physical Society-American Chemical Society Symposium on "Thermoreversible Gelation in Polymers"
August 1991 (G.B. McKenna-Polymers)
80 attendees

International symposium on gelation in polymers.

American Chemical Society Symposium of Flow-Induced Structural Changes in Polymers
August 28-29, 1991 (A.I. Nakatani-Polymers)
50 attendees

Special Symposium of the ACS Division of Polymeric Materials Science and Engineering.

High Resolution Diffraction Imaging of Space Related Crystal: The Second Generation
September 9, 1991 (B. Steiner-Ceramics)
20 attendees

To review research results and identify future materials investigations.

Environmental Effects on Advanced Materials
October 7-9, 1991 TMS/ASM Symposium (R.E. Ricker-Metallurgy and R.H. Jones-Battelle)
150 attendees

To discuss status of research into environmental degradation of advanced materials.

NIST Testing Methodology for Glass, Glass-ceramic, and Ceramic Matrix Composites Workshop
February 8, 1990 (D. Cranmer-Ceramics)
35 attendees

To review test methodologies and data requirements for composite property determination.

NIST/ASM Symposium on Intelligent Processing of Materials
March 1, 1990 (J. Carpenter-Ceramics)
30 attendees

To review the state-of-the-art intelligent processing.

Advances in Materials Science and Applications of High Temperature Superconductors
April 2-6, 1990 (L. Bennett-Metallurgy), NASA Goddard Space Flight Center
120 attendees

To review progress in development of high temperature superconductors.

Seminar on Relaxation in Condensed Materials
April 18, 1990 (J. Douglas-Polymers)
50 attendees

To bring together experts on theoretical and experimental aspects of relaxation in condensed materials.

Workshop on Measurements of Properties of Materials in Microelectronic Packaging
May 1-3, 1990 (J. Carpenter-Ceramics)
70 attendees

To determine a research agenda for measurements and properties of microelectronic packaging.

Interagency Coordinating Committee on Structural Ceramics
May 10-11, 1990 (S. Dapkunas-Ceramics)
30 attendees

To coordinate federal agencies research programs in structural ceramics research.

Industry Workshop on Polymer Composite Processing
May 18, 1990 (D. Hunston-Polymers)
26 attendees

To ascertain industry's view of the most important processing methods for the future.

NIST Surface Forces Workshop
May 31-June 1, 1990 (R. Horn; D. Smith-Ceramics)
15 attendees

To exchange results from experimental programs on surface forces research.

International Discussion Meeting on Relaxations in Complex Systems
June 1990 (G.B. McKenna-Polymers), Kraklion, Crete, Greece
300 attendees

International conference to discuss dynamics in condensed systems.

Diamond Optics III at the 34th Annual International Technical Symposium on Optical and Optoelectronic Applied Science and Engineering
July 8-10, 1990 (A. Feldman-Ceramics), San Diego, CA
120 attendees

To review diamond film research.

1990 ASTM Johnson Conference, Our Changing Atmosphere: Challenges in Measurement Technology
July 8-13, 1990 (H. Rook-Laboratory Office)
60 attendees

A comprehensive review of measurement science for the atmosphere and discussions in the areas of environmental and atmospheric measurements.

American Ceramic Society/American Society of Nondestructive Testing Conference NDE of Modern Ceramics
July 9-12, 1990 (G. White-Ceramics), Columbus, OH
130 attendees

To review research on NDE of ceramics.

Eighth American Conference on Crystal Growth
July 15-20, 1990 (D. Kaiser-Ceramics), Vail, CO
350 attendees

To review research on crystal growth and analysis.

Gordon Research Conference
August 13-17, 1990 (J. Antonucci-Polymers), New Hampton, NH
97 attendees

International meeting devoted to the "Science of Adhesion" while focusing on the fracture mechanical aspects of adhesion.

Engineering Foundation Conference on Performance of Dental Biomaterials Based on Engineering and Statistical Methods
August 13-18, 1990 (J. Tesk-Polymers), Santa Barbara, CA
25 attendees

Conference covered an analysis of interactions between dental standards organizations and industry.

Gordon Research Conference
August 14-18, 1990 (J. Antonucci-Polymers), New Hampton, NH
101 attendees

NIST Mechanical Testing Methodology for Ceramic Design and Reliability Workshop
September 5-7, 1990 (D. Cranmer-Ceramics)
50 attendees

To identify data and experimental methodologies required for ceramic design and reliability.

SE Regional Meeting for Materials Science - Workshop on Regional Cooperation
September 10-11, 1990 (R. Thomson-Laboratory Office)
30 attendees

To coordinate priorities in materials science for the SE. The results of this regional meeting will become input to a National Plan in Materials.

Computerization of Welding Information
September 12-14, 1990 (T. Siewert-Materials Reliability), Ypsilanti, MI
60 attendees

Recent advances in off-line planning systems, real-time welding information systems, data standards and case studies of computer applications for welding.

U.S. Assessment of the New Diamond Technology in Japan
September 13, 1990 (A. Feldman-Ceramics), Arlington, VA
50 attendees

To exchange information gained in assessments of Japanese diamond film technology.

NIST Workshop on Ceramic Machining
September 19, 1990 (S. Dapkunas-Ceramics)
35 attendees

To identify research needs in ceramic machining.

4th U.S./Japan Workshop on Low Temperature Structural Materials and Standards
October 1-2, 1990 (H. McHenry-Materials Reliability), Vail, CO
25 attendees

Recent research on alloys and composites to be used in 4-K superconducting magnets for fusion energy devices was reported at the workshop.

Conference on Development of Advanced Materials - Current Issues and Prospects
December 17-19, 1990 (S. Wiederhorn-Laboratory Office)
50 attendees

Polymers West Gordon Conference
January 1-6, 1989, (E. DiMarzio-Polymers), Ventura, CA

International meeting devoted to "Phase Transition in Polymers" with an emphasis on self-assembling systems.

Workshop on Solidification and Microstructure Evaluation
February 2, 1989 (J. Simmons-Metallurgy)
15 attendees

Technical symposium on NDE methods to evaluate microstructure in metallic structures.

Nonconventional Ultrasonic Instrumentation and Methods in Nondestructive Evaluation of Composite Materials and Structures
February 15, 1989 (H.T. Yolken-ONDE)
20 attendees

In this seminar, three nonconventional techniques are described: air-coupling to materials that should not be immersed, high-power ultrasonics to inspect "thick" structures, and broadband signals to measure the frequency dependence of attenuation and velocity.

Engineering Foundation Conference on Structural Ceramics - Science and Technology
March 12-17, 1989 (S. Wiederhorn-Laboratory Office)
54 attendees

The purpose of this conference was to assess the current state of the art/science in structural ceramics with a particular emphasis on automotive and truck applications. Areas for future research, both basic and applied, were identified.

Materials Aspects of High-Temperature Superconductivity
March 20-24, 1989 (E.R. Fuller, Jr.-Ceramics)
240 attendees

These were special focussed sessions organized for the Materials Physics Topical Group and the Division of Condensed Matter Physics as part of the 1989 March Meeting of the American Physical Society held in St. Louis, Missouri.

Alternatives in Glass Research Symposium
March 23, 1989 (M. Cellarosi-Ceramics)
15 attendees

This meeting focused on the critical research issues and alternatives in the glass industry. The meeting was co-sponsored with the Industry University Center for Glass Research at Alfred University (CGR), which comprises industrial interests planning to confront head on the problems facint their industry - competition from foreign manufacturer, competitive materials, and use of glass in high technology applications.

Sixth International Conference on High Temperatures
April 3-7, 1989 (J.W. Hastie-Metallurgy)
150 attendees

Technical symposium on high temperature chemical reactions

Advanced Composite Materials Characterization and Test Methods; NIST-ASM
April 5-6, 1989 (R.E. Ricker-Metallurgy)
60 attendees

Short course on composite properties.

Description of NDE Research and Services Atomic Energy Research Establishment
April 6, 1989 (H.T. Yolken-ONDE)
20 attendees

Air Force Office of Scientific Research (AFOSR) Program Review
April 10-11, 1989 (D. Cranmer-Ceramics)
55 attendees

The purpose of this conference was to review the status and future plans of the current efforts of AFOSR contractors in the ceramics and non-metallics structural materials area. An assessment of future research program areas of interest to AFOSR was also made.

American Chemical Society Symposium on Tribology
April 10-11, 1989 (S.M. Hsu and J. Perez-Ceramics)
50 attendees

The symposium covered several areas in tribology including the use of fractals, surface chemistry and lubrication mechanisms. It was held in the honor of Professor Elmer Klaus who has made significant contributions to lubrication in the past 45 years.

American Chemical Society - Special Symposium on Chemistry and Chemical Engineering in Tribology
April 12, 1989 (S.M. Hsu-Ceramics)
60 attendees

The objective of this symposium was to explore the current state-of-the-art in chemistry at interface.

Society of Tribologists and Lubrication Engineers Annual Meeting

May 1-4, 1989 (S. Jahanmir-Ceramics)
1400 attendees

This is the largest Tribology technical meeting which is held every year. It brings together a large number of people involved in various aspects of tribology, including research, education, sales, marketing, and development. It also includes an industry exhibit.

Third International Conference on Fundamentals of Fracture
May 26-June 16, 1989, (Robb Thomson-Laboratory Office), Trieste, Italy
30 attendees

Workshop organizers through the auspices of the International Centre of Theoretical Physics on the subject on fundamentals of fracture.

Second International Conference on Hot Isostatic Pressing - Theory and Applications
June 7-9, 1989 (R.J. Schaefer-Metallurgy)
115 attendees

Technical symposium on advances in hot-isostatic pressing.

Third International Conference on Fundamentals of Fracture
June 19-24, 1989, (Robb Thomson-Laboratory Office), Irsee, W. Germany
120 attendees

This conference explored the developments on fracture fundamentals for the last three years. Participants were from the disciplines of mechanics, physics, chemistry, metallurgy and ceramics

TTCP Ceramic Matrix Composites Workshop
June 22-23, 1989 (D. Cranmer-Ceramics)
15 attendees

The purpose of the workshop was to assess convenient and affordable room temperature test techniques for measuring tensile, compressive, and shear strength of ceramic composites. A second objective was to provide some initial, reliable values of these strengths.

VAMAS Steering Committee Meeting
June 28-30, 1989 (L. Schwartz-Laboratory Office)
30 attendees

To host the annual meeting of the International VAMAS Steering Committee

SDIO/IST-ONR Diamond Technology Initiative Symposium
July 11-13, 1989 (A. Feldman-Ceramics)
305 attendees

Annual meeting sponsored by the SDIO for rviewing the state-of-the-art in all aspects of CVD diamond technology.

Superconductor and Related Materials Session, 1989 Annual Meeting of Crystallographic Association
July 24-29, 1989 (W. Wong-Ng-Ceramics)
80 attendees

This session reviewed current results of studies of the crystallography of high temperature superconductors.

Photothermal Techniques from Technology to Basic Physics
August 4, 1989 (G. Birnbaum-ONDE)
20 attendees

This seminar introduced various possibilities of the photothermal detection technique for the nondestructive characterization of materials and systems.

Symposium on Diamond Optics II, at 33rd Annual International Technical Symposium on Optical and Optoelectronic Applied Science and Engineering
August 7-8, 1989 (A. Feldman-Ceramics)
100 attendees

This meeting was the principal SPIE meeting concerned with diamond as an optical material. It covered both the fundamental aspects of CVD diamond processing, structure and properties as well as applications of diamond and diamondlike carbon.

Intelligent Sensors for Atomization Processing of Molten Metals and Alloys
August 28, 1989 (L. Mordfin-ONDE)
20 attendees

This seminar introduced the principles of atomization processing of molten metals and alloys and proposed opportunities for developing intelligent sensors for monitoring and control of the process.

Intelligent Processing for Primary Metals
August 29-30, 1989 (J. Early-Laboratory Office)
76 attendees

Reviewed recent advances in sensing, modeling, and process control, identified areas of need in the primary metals industries, and developed a strategy for implementation of research results.

NIST/ONR Workshop on Fracture Computations
September 7-8, 1989 (G.S. White-Ceramics and R.M. Thomson-Laboratory Office)
25 attendees

The purpose of this workshop was to review the current status of electronic-, atmosistic-, and micro-scale models for describing the fracture of brittle materials.

Symposium on Applications of Probability Theory to Polymer Science
September 18-19, 1989 (J. Douglas-Polymers)
76 attendees

Symposium sponsored by the Polymers and Applied Mathematics Division of NIST. Methods such as path integrals, fractals, Levy statistics and linear response theory were applied to polymeric problems and to membranes.

APPENDICES

APPENDIX A

1991 PANEL MEMBERS

Prof. Bernard H. Kear
Chairman (1993)
Department of Mechanics and Materials Science
College of Engineering
Rutgers University
PO Box 909
Piscataway, NJ 08855-0909
(201) 932-2245

Dr. Lance Davis (1994)
Vice President - Research
Allied-Signal Inc.
P.O. Box 1021R
Morristown, NJ 07960
(201) 455-2001

Prof. Thomas W. Eager (1993)
Massachusetts Institute of Technology
Room 4-136
77 Massachusetts Avenue
Cambridge, MA 02139
(617) 253-3229

Prof. William W. Graessley (1993)
Department of Chemical Engineering
Princeton University
Princeton, NJ 08544
(609) 258-5721

Prof. Robert E. Green (1992)
Materials Science and Engineering Department
The Johns Hopkins University
Baltimore, MD 21218
(301) 338-6115

Dr. Robert E. Hefner (1993)
Director and CEO
Michigan Molecular Institute
1910 West St. Andrews Road
Midland, MI 48640
(517) 832-5555

Prof. Ronald M. Latanision (1993)
Materials Processing Center
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139
(617) 253-4697

Dr. Robert A. Laudise (1992)
Director
Materials Chemistry Research Lab
AT&T Bell Laboratories
Room 1A-264
600 Mountain Avenue
Murray Hill, NJ 07974
(201) 582-6220

Dr. James E. Nottke (1994)
Central Research and Development
E.I. DuPont de Nemours Co.
Experimental Station, Bldg. 328
P.O. Box 80328
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(302) 695-4920

Dr. Richard A. Page (1993)
Department of Materials and Mechanics
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6220 Culebra Road
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Dr. Neil Paton (1992)
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Dr. Arthur L. Ruoff (1992)
Professor of Materials Science
and Engineering
Department of Materials Science
and Engineering
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(607) 255-4161

Dr. Maxine L. Savitz (1993)
Director, Ceramic Components Div.
Garrett Processing Company
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Torrence, CA 90509
(213) 618-7569

Dr. Harvey W. Schadler (1993)
Manager, Materials Research Center
General Electric Corporate
Research and Development
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APPENDIX B

AN ASSESSMENT OF THE MATERIALS SCIENCE AND ENGINEERING LABORATORY

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This report represents an annual assessment of the activities of Materials Science and Engineering Laboratory based on a meeting of the Panel on January 31 - February 1, 1991.

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Overview

The Materials Science and Engineering Laboratory (MSEL) provides scientific expertise and experimental facilities for measurement technology, standards, reference materials, and other technical information on the fundamental aspects of materials processing, structure, properties and performance. These outputs are directed toward the needs of US industry, government agencies, academic institutions and other scientific and technical organizations. The research activities address the science base underlying both advanced and conventional materials, and the associated measurement technologies.

The Laboratory consists of five technical divisions: Ceramics, Materials Reliability (located at the Boulder, Colorado laboratories), Polymers, Metallurgy, and Reactor Radiation; and one independent Office of Nondestructive Evaluation, which sponsors cross-cutting research throughout NIST. During FY 1990, the Laboratory had an operating budget of approximately $50 million, including capital equipment acquisitions. MSEL has a staff of 387, of which 89 percent are in scientific and technical support positions. Seventy percent of scientists and engineers have Ph.D. degrees.

In addition to the permanent staff, the Laboratory was host to 459 visiting scientists and engineers. These visitors represented US industry, academia, other federal agencies, and foreign institutions. Their stay at MSEL ranged from several weeks to the entire year, and their salaries and associated costs were covered by their parent organizations.

The Laboratory has continued to expand facilities and research programs, despite the absence of new initiative funding for FY 1990. The confinement building and the first three beam-lines of the Cold Neutron Research Facility have been completed on time and within budget. Six new instruments are expected to become operational by early 1991: two small angle neutron scattering facilities; diffuse scattering time-of-flight spectrometer; cold neutron depth-profiling system; cold neutron prompt-gamma activation analysis station; and fundamental physics work station. Working with funding from the high performance composites initiative, the polymer composites program has continued to evolve and develop. A primary objective of the program is to develop the science base for rapid and reliable composite fabrication by pressure molding and resin transfer molding, in order to improve performance and performance prediction. Significant new and expanded programs in

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polymer blends, high performance composites, and Intelligent Processing of Materials (IPM) have received new support, reflecting the high priority being given in the federal government to developing new materials technologies.

For several years, the Laboratory has taken the lead in focussing industry and government attention on using in-situ sensing, process modeling and expert systems to control the evolution of materials microstructures during processing. Such intelligent processing is now expanding beyond its successful application to inert gas atomization of metal powders into other areas of metallurgical practice, such as hot consolidation of powders.

The Laboratory has further strengthened its collaborations with the private sector. Early collaborations with industry, coupled with exchange of research personnel, has resulted in rapid technology transfer. For example, collaborative research with industrial partners in intelligent materials processing has led to successful field trials of sensor systems in production environments.

A series of events, external to MSEL, have placed the Laboratory in a good position to develop its blueprint for action for the future. These events include: initiation of a strategic planning process for NIST by its new director; completion and public presentation of the NRC report on "Materials Science and Engineering for the 1990's", and the Office of Science and Technology (OSTP) effort to implement the recommendations of the NRC report.

A draft document outlining the MSEL vision for the 1990's, entitled "Strategic Directions," has been prepared and is undergoing further elaboration. To continue its leadership role in materials science research and its ability to respond to national priorities and needs, MSEL has developed a plan to: (1) extend traditional strengths in structural materials to encompass advanced materials; (2) expand programs in materials processing including sensor development and process modeling; (3) broaden materials coverage including those utilized for their electronic, optical, and magnetic properties; and (4) increase interactions with industry in areas of high mutual priority by the mechanism of joint technology development. Near-term efforts are focussed on: Advanced Materials; Materials Manufacturing; Functional Materials; and Materials Characterization. Looking further ahead, new initiatives are anticipated in surface coatings, nanostructured materials, and

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particularly computational theory and modeling, because of the ready availability of high speed computers and computation methods.

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Ceramics Division

Mission Statement

The Division addresses fundamental research, applied research, and standards issues pertinent to the advanced ceramics industry. Activities are focused on structural applications, such as in heat engines and heat exchangers, and on functional applications, such as in optical and electronic devices. Extensive and continuing contacts with standards organizations, industrial consortia, technical societies, and industrial firms ensure that the efforts are focused on scientific issues important to problems generic to the advanced ceramics industry. The paramount scientific issues are those concerned with the relations between processing and structure at the atomic, molecular and microscale levels, and the ways in which those structures affect the performance of the ceramics. Primary industrial concerns are cost, durability, and reliability. These concerns are addressed through programs aimed at the development of standards, predictive models and data of mechanical, tribological, electronic and optical performance. Specifically, pre-standards research activities are pursued in surface and fine powder characterization, synthesis of ceramic powders, development of high temperature tensile measurement techniques, ceramic matrix composites and interface characterization, fracture and crack bridging mechanisms, wear analysis and modeling, processing and mechanical properties of superconductors, phase diagrams development for superconductors, surface forces, deposition and defect analysis of diamond films, and synchrotron radiation analysis of photonic materials.

Panel Assessment

The division remains in a position to admirably fulfill its objectives and continues to be well managed. Indeed, it continues to focus on modern ceramics with an increased sensitivity to industry customer needs.

Although we pointed out last year that the ratios of outside agency-industry/core support was dangerously high, approaching 0.50, it is still the same ratio today. We believe a reasonable rate is more like 0.30. Given the alternative between any further increase in that ratio and a shrinkage of manpower on activities, we would support the latter. "Standards Work" is the most important contribution NIST can make to our national competitiveness thrust, and NIST management must view these activities in this light, then convince NIST's government sponsors. We are pleased that the Division has recently hired

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a scientist with experience and interest in standards development.

We are pleased to see that many of our past recommendations have been followed: hiring of a standards person; getting more involved in all aspects of standard development; successfully nominating scientists for awards; holding workshops with industry and other government laboratories; and beginning through the postdoctoral mechanism of finding a replacement for Dr. Roth.

However, there are other areas where we have made recommendations in the past and we are disappointed that they have not been followed: for example, the Division has not encouraged collaboration with the obvious relevant strengths in the Physics Division nor actively sought to hire people with such background.

The ceramic phase diagram activity should obtain more funding from Japan; this would provide relief from NIST base funding equivalent to one person, which would provide seed money for new areas.

Finding outside customers for nonlinear optical programs would be useful in focusing the program and in making the program customer oriented.

Machining of ceramics has been properly identified by industry, NIST, and other national laboratories as an impediment to cost effective manufacturing of ceramics. The elements suggested by NIST: chemically assisted machining, sensors and NDE are very appropriate. This can be done in the traditional NIST mode of base funding, collaborative efforts, etc. Another method may be through a consortium of industrial partners with an interest in the technology. Advantages may accrue through the cooperative activities, but disadvantages may be realized if high entry fees are required, which may reduce the number of participants.

We are pleased to see an increased emphasis on intellectual property matters. We encourage a NIST-wide educational program on patent matters. NIST's new role requires an active and creative effort. This will need technology management expertise and leadership. There must be aggressive and timely interaction with users, in some cases this may require additional testing data to be obtained in a user environment.

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Recommendations

1. The ratio of outside agency-industry/core support is too high, and every effort should be made to bring it down to a more reasonable ratio of about 0.3.
2. The Division should be encouraging more collaborations with other groups in the Laboratory, such as in the Physics Division.
3. The committee feels that the standards work on ceramic materials need to be augmented.

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Metallurgy Division

Mission Statement

The Division studies metals and alloys in order to foster their economical processing and their safe and efficient use. The Division develops and maintains competence in three general areas: (1) metals processing with special emphasis on sensors for process control, (2) characterization of advanced materials with emphasis on metal matrix composites, intermetallic alloys, and superconductors, and (3) properties and performance of metallic materials with emphasis on the durability and structural integrity of metals. The Division serves as a national resource for metallurgical information through the Alloy Phase Diagram Program with ASM International, and the Corrosion Data Program with NACE. The Division provides consultation and assistance to other government agencies and standards organizations in the development of necessary test methods and standards.

Panel Assessment

While maintaining strong programs in materials characterization, data and SRMs, the Division continued to consolidate its thrust in the area of materials processing. The process sensing focus of this activity is well chosen to meet NIST's measurement science mission, and the broader aspects of process modeling and control are particularly appropriate to NIST's mandate to assist U.S. industry in improving competitiveness.

The well integrated program on powder processing continues to lead the way, and, because of the collaborations within NIST and with industrial partners, provides a good model for future processing efforts. In powder atomization, the Consortium with three companies has successfully completed its first three-year program. This has resulted in the installation of a laser diffraction sensor, which can measure particle size and distribution in real time, development of an intelligent controller for the process, and realization of a better understanding of the basic aerodynamics of the atomization process. The success of this project is evident from the fact that a second phase is likely to be undertaken with increased industrial participation. The DARPA-supported project on HIP of titanium alloys and titanium aluminides has also made good progress; shifting emphasis from the kinetics of consolidation to factors influencing shape changes is a logical extension of the scientific effort, and reflects an awareness of industrial needs. While approving the advances in both powder processing projects, the Sub-Panel repeats last year's recommendation that work done on the understanding of atomization be extended to other areas of interest to industry,

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composites make them attractive for use as connecting rods and other reciprocating parts. A barrier to the use of these MMCs is the absence of a mechanical property database for use by design engineers, and, in particular, a lack of detailed information on their fatigue and corrosion behavior. The Mechanical Properties and Performance Group has begun to address these problems, using candidate materials provided by industry. This is clearly an appropriate NIST activity which could have a significant impact on a large commercial market.

As NIST moves into new areas, such as soldering and MMCs for high temperature applications, gas/surface interactions will dominate the failure and reliability. For example, in soldered joints for integrated circuits, corrosion and thermal fatigue are the major problems. Oxidation and hot corrosion also limit the performances of MMCs in gas turbine engines. Increased emphasis on gaseous corrosion phenomena is probably warranted.

Recommendations

1. Expand activities in gas atomization to include spray forming and thermal spraying.
2. Enhance support for establishing a mechanical property and environmental interactions database on MMCs for design engineers.
3. Perform an early evaluation and assessment of economic viability of the magneto-caloric phenomenon.
4. Encourage the evaluation of the mechanical behavior of dispersion strengthened solder before further development of processes of manufacture.
5. Organize a NIST workshop on "Nanostructured Materials."
6. Use Department of Commerce SBIR program to stimulate industrial research in opportunity areas that have been identified by NIST.

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such as thermal spraying and spray forming.

Spray forming lends itself to in-situ monitoring and feedback control. Although several U.S. companies are already engaged in R&D on spray forming, they would probably welcome a NIST initiative in process control and optimization. In order to accomplish this objective, it will be necessary to make a modest investment in new equipment; at the very least there is a need for a rotating/oscillating substrate, which can be heated directly or by making appropriate adjustments in the flow rates of the gas and liquid streams.

In thermal spray technology, there is an urgent need to understand what happens to the feed particles in the flame (or plasma) and, in particular, the nature of the complex gas/solid interactions occurring during the short residence time of the particles in the flame. Several problems need to be addressed: mechanics of particle injection, influence of particle size distribution, gas/particle heat transfer characteristics, and nature of interactions between particles and substrate. Tackling these problems will require the development of new diagnostic probes.

A remarkable and unexpected development this year came out of the Magnetic Materials Group's work on the characterization of nanocomposites. Their research has led to the realization that such ultrafine-scale materials may possess an exceptionally large magneto-caloric effect. The basic concept, plus promising initial experiments on iron-silica gel nanocomposites, was highlighted at a recent conference on nanostructured materials. It was apparent that the work represents a breakthrough in magnetic materials and holds great promise for magnetic refrigeration. In keeping with the Sub-Panel's comments last year about commercialization of new ideas, this discovery creates an obligation for NIST to spearhead the commercialization of this new class of materials. Thus, in addition to pursuing the fundamental aspects of the phenomenon, NIST should identify and collaborate with several end users involved in the design, construction and testing of prototype systems. This is in keeping with NIST's new charter to initiate new technology and to play a continuing role in its full implementation. Perhaps use of the SBIR program under the auspices of the Department of Commerce would be an appropriate vehicle for promoting additional effort on the synthesis and processing of promising magneto-caloric materials.

The Magnetic Materials Group is also collaborating with the High Temperature Materials Chemistry Group on the fabrication of nanostructured materials by vapor deposition, using the latter Group's unique experimental capabilities to gain critically needed

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insights into the process mechanisms. The Magnetic Materials Group is also working with the Electrodeposition Group in a collaborative program with IBM on the characterization of electrodeposited multilayered alloys. In a related project supported by the U.S. Air Force, the Electrodeposition Group is investigating the mechanical properties of these layered structures, working with Institute Scientist, Robb Thomson, and scientists from the Materials Reliability Division. Given these activities, and other relevant expertise at NIST, particularly in the areas of chemical synthesis, it is clear that an opportunity exists for NIST to play a leadership role in the new field of nanostructured materials. Driven by the promise of high performance materials produced at low cost under environmentally benign conditions, this exciting new technology could become the focus of a major national effort in the 90's. A NIST organized workshop on this subject seems warranted, because of the growing interest in academic and industrial circles.

Several new activities in the Division are also worthy of note. In particular, the work on solderability promises to develop into a major program with great potential for industrial collaboration. The work began with the limited objective of producing bulk samples of the copper-tin intermetallics found in solders to support a broader program on microelectronic packaging outside the Division. Having fabricated these bulk intermetallics by powder methods, scientists in the Metallurgical Processing Group took advantage of this "first" by conducting first-of-their-kind wettability studies on these phases. Furthermore, they became aware of the key role that these intermetallics play in the integrity of the solder-substrate interface and hence on the functionality of the whole device. As a result, the Division is well positioned to make an important contribution to the Microelectronic Packaging Initiative slated for funding in FY92, and to participate in a major industrial consortium to address this problem.

A second important activity begun during the year involves metal matrix composites (MMCs). There is a strong continuing program on these materials in the Division, but this is focused largely on continuous fiber composites with titanium-aluminide matrices. The development of such MMCs is critical to several high temperature aerospace applications, both in engines and airframes. However, there is also a potential application in the automotive industry for an entirely different class of composites. Thus, GM and several Japanese manufacturers are independently developing aluminum alloy MMCs reinforced with either SiC or Al_2O_3 particulates. The low inertial mass and high stiffness of these

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Materials Reliability Division

Mission Statement

The Division conducts materials research to improve the quality, reliability and safety of the Nation's infrastructure, industrial projects, and equipment. The Division fosters the industrial use of advanced materials by developing techniques to measure their quality, and analytical models that relate quality to service performance and reliability. The Division develops measurement methods, sensors, and nondestructive evaluation techniques for process control, quality assurance, and in-service inspection. The Division develops measurement methods, test standards, standard reference materials and reference data on the physical and mechanical properties of materials, particularly at low temperatures. The Division develops and maintains competence in three interdisciplinary fields related to reliability: fracture mechanics, nondestructive evaluation, and joining technology. The Division provides research and technical services to other government agencies and to industry including materials evaluations, failure analyses, reliability and safety assessments, data compilations, consultation and use of NIST facilities.

Panel Assessment

The image of the Materials Reliability Division has changed significantly in recent years, from one of a service organization providing mainly cryogenic testing capabilities, to the current view of a research laboratory specializing in measurement technology, with emphasis on materials reliability. The management of the laboratory has taken advantage of the basic skills existing in the organization and focused these skills in some new areas of interest to government and industry, such as intelligent processing, composites, semiconductor packaging, and superconductors.

Since reorganization of the former Fracture and Deformation Division to form the Materials Reliability Division, the Division has successfully established its new identity, positioned itself firmly within the Materials Science and Engineering Laboratory, and is now optimistically planning for the future.

The direction of each of the major programs is well founded and the reviews showed that some excellent work is being accomplished. The nondestructive evaluation program appears to be making excellent progress, as evidenced by the numerous areas receiving external funding. A general comment, however, on all the programs is that an overall goal for each effort should be more clearly defined, together with interim milestones and a

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schedule. One got the impression, with the welding program for example, and to a lesser extent with the semiconductor packaging program, that there is little sense of urgency to accomplish interim goals. Significant progress was evident in both of these efforts, but the feeling was that critical progress could be achieved relatively easily with proper direction. For example, in the semiconductor packaging program, a relatively simple extension of the current analysis would provide data on the sensitivity of surface mount solder joints to a range of flaw sizes. A plan to accomplish this was stated to be "years away", but it was clear that preliminary results could be achieved through the current analytical approach in a matter of months, and provide very useful data.

Process control research is primarily directed toward welding and thermomechanical processing, although there is considerable overlap with the nondestructive evaluation group, particularly with regard to development of innovative sensors. In addition to development of sensors for intelligent processing of materials, the nondestructive evaluation group is expanding its activities in the composites area emphasizing the development of optimum systems for inspection of thick composites. Fitness-for-purpose standards in the area of electronic packaging are concentrated on high resolution microfocus x-ray laminography of advanced semiconductor microelectronic devices. The unique internationally recognized capability for evaluation of materials for application at cryogenic temperatures continues. In addition, the Division also continues to be one of the most prolific laboratories in the world with regard to measurements of elastic moduli of superconductors and other high tech materials.

Fracture mechanics work continues on the innovative concept of a micromechanical tensile test machine on a silicon chip for direct mechanical property measurement of thin films. The nondestructive evaluation group, and the special activity in NDE of composites, combines to make the Division one of the best NDE research laboratories in the United States. The welding group has completed preliminary assessment of the real-time x-ray laminography system, which is to be installed in the Boulder Laboratory in the near future.

Good use is being made of Guest Workers, mostly from foreign countries, but the panel felt that some discretion should be applied as to the programs in which these workers are permitted to participate. For example, a policy restricting their participation to programs that are not process or product oriented might be advisable.

Overall, the laboratory appears to be making excellent progress and is producing

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measurement techniques and equipment which should make U.S. industry and particularly the transportation industry, safer and more competitive.

Recommendations

1. The Division has numerous areas of interaction with industry and industrial groups, but none of these interactions are supported by formal CRDA's. The panel recommends that Division Management put more emphasis on exploring the possibility of CRDA's in areas where extensive interaction with industry is involved.
2. The work on modelling of fracture surfaces using Green's functions should be extended to include fractals as a means of characterizing these surfaces.
3. The work on dislocation modelling of interfacial fracture has no apparent focus or goal and should be redirected. Dislocations have not been observed at interfaces in semiconductor materials of interest, making the work inappropriate.
4. The effort on process control of MIG welding needs to be focused on specific aspects of the welding parameter control if progress is to be made.
5. The effort on modelling of solder joints and measurement of mechanical properties of semiconductor materials is excellent and should be strengthened.
6. The Materials Science and Engineering Laboratory needs to formulate a meaningful policy on the assignment of non-U.S. citizens Guest Workers. On the one hand, the Department of Commerce is investing in new technology to make U.S. industry more competitive in world markets. At the same time, many non-U.S. scientists are working on critical programs, where the opportunity to export these technologies immediately to foreign countries would defeat the purpose of the program. A policy must be formulated whereby foreign Guest Scientists are permitted to work only on basic science oriented programs. Certain programs such as diamond films, high Tc superconductors, and semiconductor packaging for example, should be specifically excluded.

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Reactor Radiation Division

Mission Statement

The Division operates the research reactor (NISTR) reliably, safely, and in a cost effective manner. The Division develops and operates the CNRF as a National User Facility, providing unique measurement capabilities to U.S. researchers. The Division conducts programs in materials research using cold and thermal neutron methods, while developing and maintaining state-of-the-art instrumentation to ensure the best utilization of the NISTR and CNRF as national resources. Through cooperative arrangements, the Division collaborates with and provides facilities, coordination, guidance, and technical services for all of NIST, other government agencies, universities and industrial programs utilizing the NIST reactor for materials research, nondestructive evaluation (NDE), chemical analysis, neutron standards, dosimetry, radiation metrology, and isotope production.

Panel Assessment

The Reactor Radiation Division (RRD) manages a national center for the development and applications of neutron techniques for materials research in areas of scientific and technological importance. The Division operates a 20 megawatt research reactor, conducts diverse programs of materials research, and maintains extensive collaborations with other NIST divisions, and with outside scientists from industries, universities, and other government laboratories. Major effort is now underway to complete the development of a Cold Neutron Research Facility (CNRF) at the reactor, which will provide 15 new advanced experimental stations and will be operated as a national user facility. With this new facility, scientists will be able to perform a variety of experiments that cannot be performed in the United States at the present time.

During the period from July 1, 1989 to June 30, 1990, the reactor was not operated for over nine months to permit installations of the first three of seven neutron guides for the CNRF. Following restart in April 1990, the reactor has been on-line essentially the entire available operating time and it is now operating smoothly and effectively. This reactor has operated with excellent reliability in past years, at a cost that is low compared to similar facilities. The NIST reactor is presently licensed to the year 2004, and a long-range plan has been initiated in an attempt to ensure that no major operational problems will exist during this licensing period. Members of the Reactor Operations and Engineering Staff are participating actively in the maintenance and repair work on the reactor.

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In spite of the limited operating schedules of the reactor, the past year has been very productive for the Neutron Condensed Matter Science Group. Publications continue to increase in quantity while maintaining high quality, and about 100 organizations outside the RRD participate in the research programs. Highlights of the research include the development and applications of maximum entropy methods for biomolecular crystallography, quasielastic neutron scattering studies of hydrogen in rare earth metals that have revealed the existence of very rapid low temperature "hopping" of protons between sites, research on magnetism and superconductors with high critical temperatures that has provided very interesting insights into the interrelationship between superconductivity and magnetism, and studies of the sheer dependence of critical fluctuations in binary polymer mixtures by small-angle neutron scattering. There has also been excellent development of new neutron instrumentation, and the program on supermirrors is particularly impressive. It is a major breakthrough toward producing supermirror neutron guides that will transport neutron beams with significantly increased intensities relative to conventional guides.

The Cold Neutron Project, which is developing and will operate the CNRF as a national facility, has made excellent progress during the past year. Installation of three neutron guides with coatings of the nickel-58 isotope have been completed and instruments are being installed on these guides. Some instruments are already operational and are providing experimental results that could not have been obtained previously. A Program Advisory Committee (PAC) with representation from universities, industries, and government laboratories, has been appointed by the Director of MSEL, and procedures for users are being established.

Although the operation of the RRD continues to be very impressive, NIST management must give serious consideration to the situation that will occur when support for the five-year construction phase of the CNRF has been completed in FY 1992. For this outstanding facility to provide its full benefit to science in the United States, it is essential that appropriate financial support be provided for the proper operation of the CNRF as a national user facility. In addition to funds for the development, operation, and maintenance of the sophisticated instruments needed in research, it is also necessary that funds be available to maintain a very strong RRD research staff. Unless such funds can be provided, the CNRF will never reach the potential that is currently expected by the scientific community. NIST management should also help in preventing additional delays in the

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construction schedule. Many scientists are anxiously waiting to use the CNRF, and unexpected delays cause a severe strain on everyone concerned.

In order to make the user programs at the CNRF operate effectively, the scientific community must be kept properly informed about this outstanding facility and its complement of instruments. The Neutron Standard should be published and distributed on a regular basis, and a user manual should be prepared and made available to potential users as soon as possible. Some form of travel support should be available to certain users, particularly to first-time users, to academic scientists with very small or no research grants, and to graduate students. If possible, NIST management should try to ease restrictions with regard to off-hours access for certain types of foreign nationals enrolled in graduate schools in the United States. A decision on coatings for the last four neutron guides should be delayed as long as possible to allow use of supermirror coatings, if this technology can be developed in a reasonable time. It is also recommended that a strong interaction be developed between the experimentalists of the RRD and condensed matter theorists. Such interactions would benefit both the research programs of the RRD staff and those in the user community.

Recommendations

1. Plans need to be in place for funding the operation, maintenance and staffing of the CNRF facility, after the 5-year construction phase is over in FY 1992.
2. Some form of travel support should be made available to first-time users, to academic scientists with very small grants, and to their graduate students.

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Polymers Division

Mission Statement

The Polymers Division provides the measurement methods, standards, and data needed for the efficient processing and use of polymers and polymer matrix composites to improve international competitiveness and solve national problems. The Division provides the science base for the industrial development of new polymeric materials and processes. The Division develops measurement methods to predict the electrical, optical, chemical, and mechanical performance of polymers, and composites in service environments. The Division conducts research on the connection between the processing and performance of polymeric materials and provides measurement methods and standard materials to control processing. The Division provides measurement methods and unique facilities for determining the physical and chemical structures of polymers. The Division is also involved in the determination of dental and medical materials properties in order to provide the basis for standards, test methods, and improved materials.

Panel Assessment

The Polymers Division provides standards for physical measurements, measurement methods, generic technology, and fundamental concepts of polymer science to U.S. industries, other agencies of government, standardization bodies, and various technical communities. The technical staff consists of 22 chemists, 9 physicists, 11 material scientists, 6 engineers and 2 microbiologists, a total of 50, of which 42 are PhDs. Fifteen percent of the professional staff are postdoctors and 25 percent are Fellows of the American Physical Society. The Division currently attracts 56 Research Associates and 86 Guest Scientists who contribute 52 staff years of effort. The annual budget is $6 million of which 33 percent is from other federal agencies. The Division has a wide range of special facilities for measuring small angle x-ray scattering, solid-state nuclear magnetic resonance, charge distribution, gas permeation, forced Rayleigh scattering, fluorescence lifetimes, and dielectric spectroscopy. These facilities are shared with qualified external scientists and engineers and in some cases for proprietary measurements. The Division carried out 27 projects for 18 different other federal agencies, was granted 2 patents, and applied for 7 patents. The Division has an impressive array of joint programs and collaborations with 27 firms and

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associations from the private sector.

The Panel strongly supports the division's attention to industrial trends in planning programs to meet future needs. The Division management is advised to focus its attention on serving these industrial needs and to limit outside agency funding, especially if the projects do not have high technical content. Other factors considered in program development include special staff expertise, special equipment available, opportunities for breakthroughs in fundamental science, possibilities for synergy with other programs at NIST, staff relative to the scale of the problem and the resources of other laboratories in the field.

Overall, the Panel is very favorably impressed with the capabilities and programs of the Polymers Division. The Division is one of the strongest polymer physics laboratories in the United States. The Division is very well equipped, has a highly competent staff and seems to be addressing areas of science and engineering needed by the industrial base that it serves. The Panel is impressed with the quality of the new hires; the challenge will be to generate scientific leaders among these new staff members to replace past attrition of truly outstanding personnel.

Industrial Interactions

The Panel is impressed with the number and quality of industrial interactions; the new collaborative project with the Automotive Composites Consortium is a model of the way a government laboratory can assist an industrial sector. It is recommended that the Polymers Division further broaden its contacts within related industries. Suppliers to the automotive industry could provide technical depth and a valuable perspective on technical problems now being pursued in collaboration with the principal automotive companies. Some of the major companies in the fields of interest to the Division have not been involved in collaborative work with the Division and the Panel believes that there are opportunities for fruitful dialogue. More could be done by visits from NIST scientists to industrial research institutions. It is expected that this would result in improved understanding of the problems and areas of science of interest to industry, as well as bringing greater awareness to industry of the capabilities of NIST. Another suggestion is to follow-up the completion of collaborative efforts by contacts with both the visiting scientists and their parent organizations. The intent of such contacts would be to give NIST feedback on how to make

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these assignments more productive for both parties as well as to assess the value of the collaboration. It is further recommended that the Division's university working relationships be expanded.

Computational Facilities

The Panel believes that computation and simulation will have an increasing role in polymer science and technology. While the Division management clearly shares this belief, it would be desirable to have an ongoing assessment of the Division's computer and software needs. The Division should develop a more aggressive position with respect to modeling/simulation through planned upgrading of computation facilities and actively participating in software consortia.

Polymer Blends Thermodynamics and Kinetics

The Panel is impressed by the quality and volume of research in this area. The use of scattering and imaging methods to determine thermodynamic information on blends, the kinetics and morphological features of phase separation, and the influence of flow is first rate science and at the forefront of the field. The panel commends the decision to retain the 8 meter SANS facility to go along with the new 30 meter facility. It will allow this work and many outside collaborations which have been developed to go forward very effectively.

Rheology and Mechanical Properties

Projects addressed in this area deal with important scientific questions that underlie many commercial applications of polymers. The work on mechanical properties of glasses is first rate and is important to durability and reuse. The development of NMR techniques to characterize multiphase polymer structure is impressive and it will be informative to combine this work with studies on the mechanical properties of engineering plastics. With the retirement of a rheology scientist of note, the Polymers Division should emphasize efforts to replace this critical expertise.

Electrical Properties

The Division has made outstanding contributions to understanding the origins of piezoelectric and pyroelectric activities in polymers. Work on dielectric properties are important to the instrumentation, electrical and electronics industries. The thermal pulse measurements are leading to new insights into the distributions of charge and polarization

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within polymer dielectrics and should receive continued emphasis.

Polymer Composites

Although the composites effort at NIST is still relatively new it has taken off nicely. As a potentially big program, it will need contributions from many areas in the Polymers Division. One way of achieving enhanced synergism between the various groups is to use a materials based theme, e.g., thermoplastic-toughened thermosets, or other materials likely to be used by industry during the next five to ten years. Phase separation of polymerizing systems, toughening mechanisms, processing/property relationships, process monitoring, etc., could be elaborated on using the same thermoplastic toughened thermoset material.

The composites program aims to provide a better understanding of composites manufacture and the impact of processing on structure-property relationships for commercial, as opposed to military, applications. Although cooperative efforts with industry are taking root, more contact could be made with universities.

Collaborations with the US automotive industry in the area of structural composites is an intriguing possibility which is strongly endorsed. Modelling of mold-filling flows and studies of fracture toughness are underway. Investigation of fiber wetting phenomena, cure chemistry during flow, and the effect of fibers on the morphology and properties of the cured resin are natural extensions of the work. The polymers Division should consider becoming the focal point for improving the way information is presented in data bases which are needed by designers to do a more effective job of designing with predictability of performance.

Nonlinear Optical Polymers

In the nonlinear optical work, there should be a greater emphasis on measurement than on synthesis of new materials. There are centers of excellence at several universities with which strategic alliances could be developed.

Polymer Processing

The main concern with the program developing fluorescence techniques for monitoring polymer processing is that the techniques may be too sophisticated for broad application by potential users. Fluorescent tags have potential value for providing on-line data on molecular orientation related to stress and resident time distribution in commercial

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processing equipment. The concentrations of the tag needed are minute, and the information is specific and local. The entire question of process monitoring and the appropriateness of the techniques will be answered in an industrial workshop aimed at developing specific collaborations.

Polymer Recycling and Degradation

The significance of polymer recycling and degradation to society is great. Nonetheless, the Panel shares the view of the Division management that it is difficult to identify technical issues addressable by a laboratory-based organization such as NIST that are central to enhanced polymer recycling. The investigation of biodegradation standards is just getting underway and the Panel is concerned about the appropriate level of effort for NIST. The biodegradation effort should be reviewed at regular intervals and outside support of visiting scientists would be highly desirable. To help integrate the NIST effort into more extensive programs elsewhere, the researchers involved should devote a larger portion of their time at technical meetings and in establishing a network.

Recommendations

1. The Panel strongly supports the Division's attention to industrial trends in planning programs to meet future needs. The Division management is advised to focus its attention on serving these industrial needs and to limit outside agency funding, especially if the projects do not have high technical content.
2. The Panel is impressed with the quality of the new hires; the challenge will be to generate scientific leaders among these new staff members to replace past attrition of truly outstanding personnel.
3. The Panel is impressed with the number and quality of industrial interactions; the new collaborative project with the Automotive Composites Consortium is a model of the way a government laboratory can assist an industrial sector.
4. It is recommended that the Polymers Division further broaden its contacts within related industries.
5. It is further recommended that the Division's university working relationships be expanded.

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6. The Division should develop a more aggressive position with respect to modeling/simulation through planned upgrading of computation facilities and actively participating in software consortia.
7. The Panel commends the decision to retain the 8 meter SANS facility to go along with the new 30 meter facility. It will allow this work and many outside collaborations which have been developed to go forward very effectively.
8. With the retirement of the rheology scientist of note, the Polymers Division should emphasize efforts to replace this critical expertise.
9. The Polymers Division should consider becoming the focal point for improving the way information is presented in databases which are needed by designers to do a more effective job of designing with predictability of performance.
10. The biodegradation effort should be reviewed at regular intervals and outside support of visiting scientists would be highly desirable. To help integrate the NIST effort into more extensive programs elsewhere, the researchers involved should devote a larger portion of their time at technical meetings and in establishing a network.

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Office of Nondestructive Evaluation

Mission Statement

The Office provides the national system for nondestructive evaluation (NDE) measurements needed in the manufacture and use of materials, components, and systems to assure reliability and enhance productivity. The Office develops and provides NDE measurement standards and calibration services. It also conducts research to achieve a better understanding of the relationship between important materials processing or manufacturing characteristics and non-destructive evaluation methods and data.

Panel Assessment

The Office of Nondestructive Evaluation (ONDE) operates under a matrix structure that relies on the support of many of the functional divisions at NIST, such as Metallurgy and Ceramics. Several years ago, the ONDE decided to step aside from supporting NDE programs which followed the more traditional approach of developing techniques for the detection and characterization of flaws and defects in materials, and instead used the expertise and interdisciplinary nature of the activities at NIST to develop nondestructive techniques that could be employed to improve processing and manufacturing of traditional and advanced materials. The Panel is very impressed with the leadership role taken by ONDE in moving toward attainment of this goal. The unusual nature of NIST in supporting U.S. commerce, in having a wide range of experts in materials, testing and sensors, and in being able to develop a team of interdisciplinary researchers provide a unique home for work in this area. The plans that have been established and are now being carried out by ONDE are well constructed and attainable within what should be a relatively short time.

NDE of Metal and Ceramic Powder Production and Consolidation

The previous review praised the team effort of the separate groups on this project. This effort has been maintained and perhaps even strengthened during the past year. The fluid dynamics analysis appears to be complete, but little progress has been made on the overall process model, although many pieces of the model are in place. During the coming year, emphasis should be placed on greater industrial participation and industrial testing of the principles and sensors developed by NIST/ONDE. It is unlikely that successful transfer of the technology to be developed in the Phase II Consortium to start early in 1991 will be

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completed unless one or more industrial champions are found and work closely with NIST.

NDE for Formability of Metals

The most promising project in this area from last year's review was use of eddy-currents to sense the internal temperature of aluminum during hot processing. Although progress has been made in modeling the process, the addition of composite variables and loss of the industrial champion place the ultimate success of this project in doubt, and emphasis this year should address these concerns. The project on ultrasonic measurement of sheet metal texture has made significant progress, the level of research has improved with interaction with industry, and test of equipment in 1991 should prove the future success of the project.

NDE for Composites Processing and Interfaces

This area has expanded markedly during the past year. The work in intelligent processing of Solder Joint Connections is a critical issue and has a significant interdisciplinary component. This work should continue even if the external source of funds is discontinued or decreased. The project on fluorescence spectroscopy for control of polymer processes has developed well and appears ready for industrial trials. Again, one or more champions from industry need to be identified in order to transfer this technology.

Balance of Technical Effort

ONDE has a strong program focused on metals industries and a growing presence in electronic materials. The efforts in ceramics, polymers and composites should be strengthened if funding permits. The programs in acoustics, optics, ultrasonics and electromagnetics are strong, but development of expertise in thermal radiation might be useful. The team expressed some concern about apparent imbalances in the technical effort. One of these is the lack of any visible effort in laser-based ultrasonics, which has been recognized by ONDE and plans are underway to renew work in this area. It is suggested that activities within ONDE be broadened to renew and foster more collaboration with the Center for Building Technology. The importance of NDE to structures such as bridges and tunnels is growing and opportunities exist for collaborative work with FHWA.

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Professional and Administrative Duties of the ONDE Professional Staff

ONDE provides a significant and vital link between scientists in different Divisions at NIST and promotes interdisciplinary approaches to projects. This interdisciplinary approach is a major factor in developing the high quality of the research achieved by ONDE. A potential disadvantage of a small program office is the tendency of the professional staff to concentrate on administrative details to the exclusion of continued professional development. It is recommended that the professional staff of the ONDE continue to budget a portion of their effort to either individual research, active program management, or technical society activities.

Technology Transfer

The issue of technology transfer is of critical importance to ONDE, as well as the rest of NIST, and therefore is highlighted in this part of the assessment. By the term "technology transfer," we refer to all efforts, technical and managerial, directed toward implementing the specific results of a technology development project undertaken in support of industry. Without successful transfer of the technology development projects from NIST to industry, the main thrust of NIST's new mission will be lost. There is a need for strong industrial "champions" who can bring to NIST an in-depth understanding of the problems from the user's perspective, yet work hand-in-hand with the multi-disciplinary teams of NIST researchers to develop NDE methods and techniques which will be viable on the factory floor.

Professional Visibility

The NIST/ONDE program is one of the largest in the United States. We recommend that a greater professional presence be developed within the NDE community in the form of regular contributed technical papers and invited papers at conferences. In addition, since the program is now focusing heavily on intelligent processing of materials, researchers should be encouraged to give talks at materials science and materials processing meetings.

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Recommendations

1. ONDE should continue and enhance efforts to form strong exchanges and partnerships with industrial teams (through the Research Associate program) to facilitate technology transfer.
2. ONDE should enhance and support graduate student research assistantships at NIST to leverage the volume of focused research for greater cost-effectiveness.
3. ONDE should enhance its professional visibility in terms of more frequent technical presentations at national conferences which are focused on NDE and processing.
4. ONDE should provide regular, periodic in-house effort in technical monitoring, input and tactical guidance of programs.
5. Base funding should be expanded to allow one or more senior technical person to be hired to promote program control and guidance.
6. Process modeling expertise should be strengthened.

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Summary

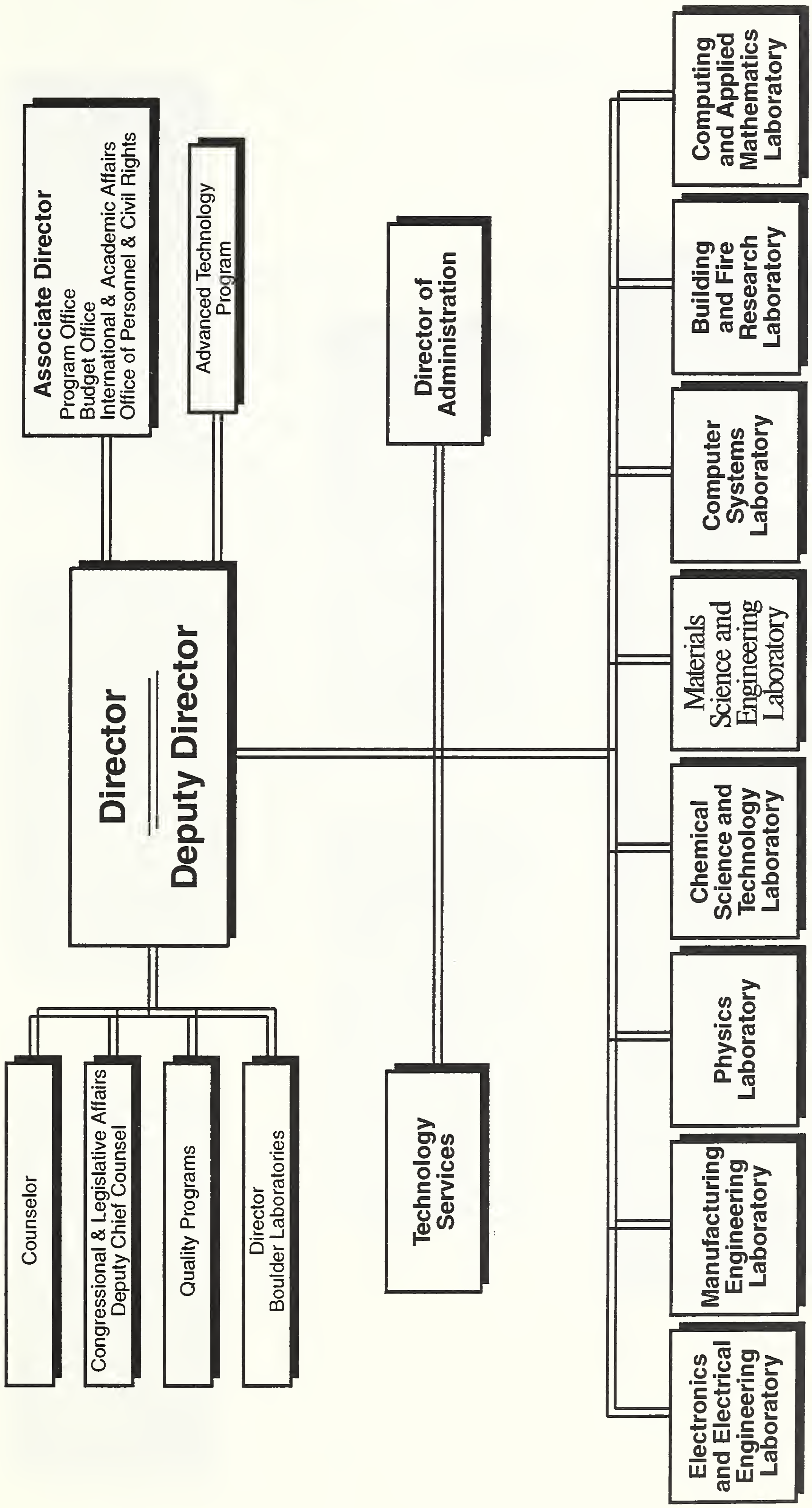
The overall impression gained by this year's Panel is that MSEL has responded well to the new mission of NIST. The Laboratory has done an excellent job in forging ties with industry in well targeted areas of opportunity. Furthermore, by focussing on generic research issues, the Laboratory is making the broadest impact on major segments of US materials-based industries. The emphasis on mission-oriented materials research, measurement methods, data acquisition and dissemination, and standards necessary to support manufacturing technologies is entirely appropriate, and nicely complements and reinforces ongoing research and development in the industrial sector.

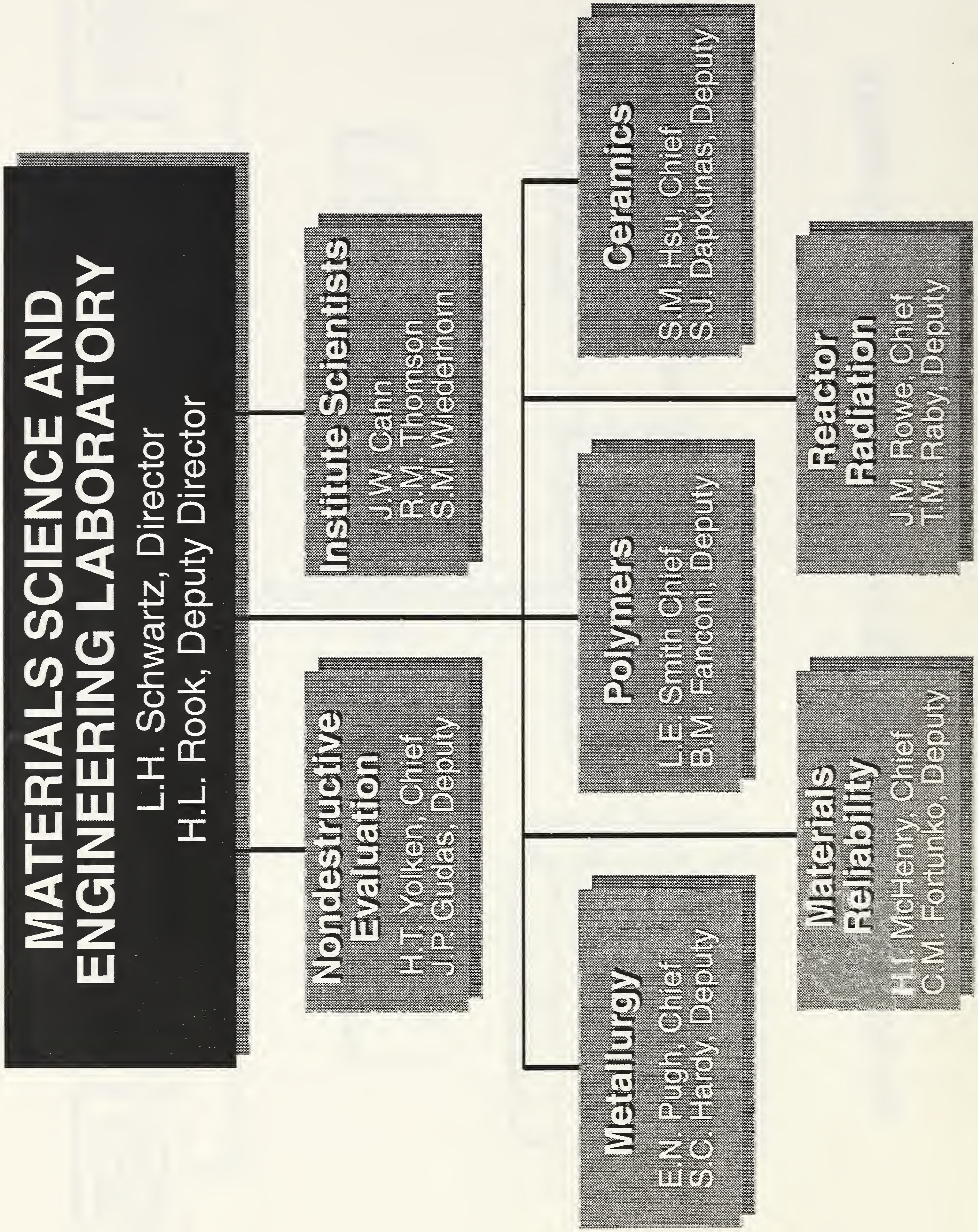
MSEL management has correctly identified three major shifts in US materials technologies: (1) from commodity materials to advanced materials, (2) from research leadership by materials producers to materials users, and (3) from traditional materials processing to intelligent materials processing. These trends have been integrated into a Strategic Plan for MSEL, which is undergoing further elaboration. This new plan will set the stage for (1) extending traditional strengths in structural materials to encompass advanced materials, including those utilized for their electronic, optical and magnetic properties, (2) expansion of programs in materials processing including sensor development and process modeling, and (3) increased interactions with industry in high priority areas by the mechanism of joint technology development.

The Panel strongly endorses this plan, and recommends its adoption and rapid implementation.

NIST AND MSEL ORGANIZATION CHARTS

National Institute of Standards and Technology

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Materials Reliability
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C.M. Fortunko, Deputy

APPENDIX E

FUNCTIONAL STATEMENT

MATERIALS SCIENCE AND ENGINEERING LABORATORY

Develops and maintains the scientific competences and experimental facilities necessary to provide the Nation with a central basis for uniform physical measurements, measurement methodology, and measurement services fundamental to the processing, characterization, properties and performance of materials, and to other essential areas in materials science; provides government, industry, universities, and consumers with standards, measurement methods, data, and quantitative understanding concerning metals, polymers, ceramics, composites, optical materials, and nonequilibrium materials; characterizes the structure of materials, chemical reactions, and physical properties which lead to the safest, most efficient uses of materials, improve materials, technologies, provide the bases for advanced material technologies in basic and high-technology industries; obtains accurate experimental data on behavior and properties of materials under service conditions to assure effective use of raw and manufactured materials, provides technical information such as reference data, materials measurement methods, and standards to processors, designers, and users for selection of cost-effective combinations of materials, processes, designs, and service conditions; uses the unique NIST reactor and cold neutron research facilities to develop neutron measurement methodology, develop sophisticated structure characterization techniques, reference data, and standards; participates in collaborative efforts with other NIST organizational units in the interdisciplinary developments in materials science; and disseminates generic technical information from the divisions to private and public sector scientific organizations through special cooperative institutional arrangements and through conventional distribution mechanisms.

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Materials Science and Engineering Laboratory
Gaithersburg, MD 20899

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

The 1991 Annual Report was prepared for the NAS-NRC Board of Assessment of the Materials Science and Engineering Laboratory. This volume contains background information on resources, activities, and representative highlights of the Laboratory.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

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