IR 87-3609

CANCELLED

UNAVAILABLE FOR BINDING

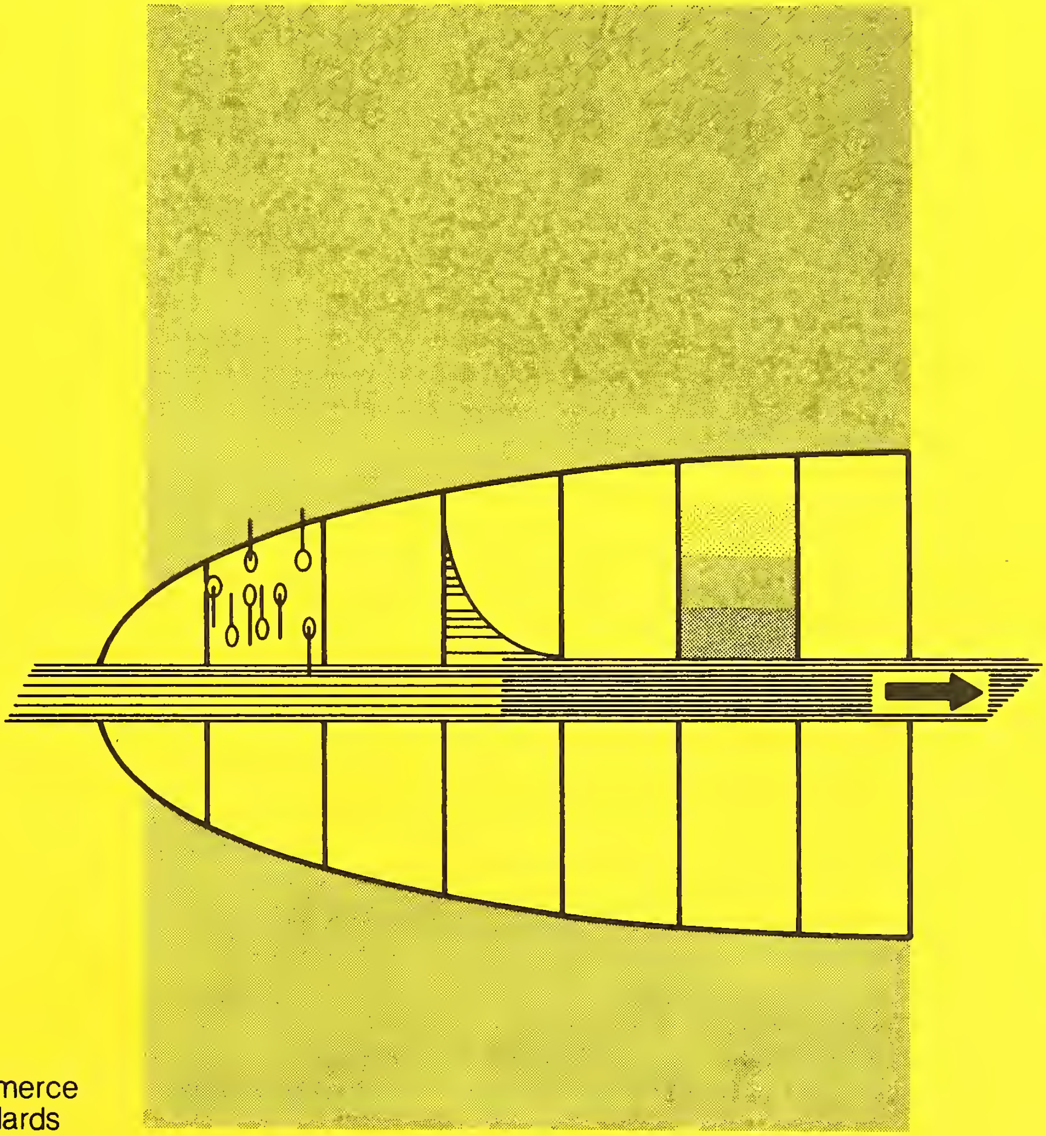
IMSE

Institute for Materials Science and Engineering

ANNUAL REPORT

1987

NAS-NRC
Assessment Panel
January 21-22, 1988



NBSIR 87-3610
U.S. Department of Commerce
National Bureau of Standards

Electrochemical phenomena play a fundamental role in providing essential materials and devices for modern society. In the manufacture of high performance metal matrix composites, problems in their processing technology include the high cost of fabrication and difficulty in controlling the nature of the fiber-matrix interfaces. The figure illustrates a theoretical model of high speed deposition of alloys onto continuously moving fibers and wires. This model, developed by researchers in the Institute's Electrodeposition Group, allows the structure of the interfacial regions to be tailored or controlled on nearly an atomic scale. Illustration courtesy of C.R. Beauchamp, Metallurgy Division.

IMSE

Institute for Materials Science and Engineering

ANNUAL REPORT

1987

L.H. Schwartz, Director

U.S. Department of Commerce
National Bureau of Standards

OFFICE OF THE DIRECTOR

INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

<u>DIRECTOR</u>

Lyle H. Schwartz
(301) 975-5658

<u>ASSOCIATE DIRECTOR FOR RESOURCES AND OPERATIONS</u>

Ronald B. Johnson
(301) 975-5658

<u>SCIENTIFIC ASSISTANTS</u>

Daniel B. Butrymowicz
Samuel J. Schneider
(301) 975-5655

TABLE OF CONTENTS

PREFACE

The National Academy of Sciences-National Research Council (NAS-NRC) Board on Assessment of NBS Programs, and in particular the Panel for Materials Science and Engineering, performs an important role in the programs and success of the Institute for Materials Science and Engineering (IMSE). 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 Institute. In addition to this Institute-wide Panel, we also have an Evaluation Panel for the Nondestructive Evaluation Program and just recently we established a Panel for Reactor Radiation.

The 1987 Annual Report was prepared for the NAS-NRC Board of Assessment of the Institute for Materials Science and Engineering. It consists of two parts: the first (this volume) contains background information on resources, activities, and representative highlights of the Institute. The second part details the technical activities of the Institute and is published separately as National Bureau of Standards Internal Reports (NBSIR) for each Division/Office.

We look forward to your input and advice in both the evaluation and formulation process of our management decisions at all levels in the Institute. During this last year, I know that you have spent time in visiting our Institute 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 7, 1987

OVERVIEW

OVERVIEW

I. Introduction

The Institute for Materials Science and Engineering (IMSE) 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 IMSE support a wide base of generic technologies in materials, in order to provide their safe, efficient, and economical use in service. The research activities of the Institute address the science base underlying both advanced materials and conventional materials technologies, together with the associated measurement methodology.

The Institute consists of five technical Divisions: Ceramics, Fracture and Deformation (located at our Boulder, Colorado laboratories), Polymers, Metallurgy, and Reactor Radiation; and one independent Office: Nondestructive Evaluation, which sponsors cross-cutting research throughout NBS. Our budget in FY 1987 was approximately $40 million, including capital equipment acquisitions. IMSE has an NBS staff of 389, of which 88 percent are in scientific or technical support positions. Seventy percent of our scientists and engineers have Ph.D. degrees. The average age of our full-time scientist and engineer staff is 47 years, compared to 48 years in 1985. This certainly reverses an aging trend we have been experiencing.

In addition to the NBS staff, we had 374 visiting scientists and engineers during 1987 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 IMSE ranged from several weeks to the entire year and their salaries and associated costs were covered by the parent organization.

II. Major Organizational and Programmatic Events

1987 has been a significant year for the Institute. The Advanced Ceramics Program is nearing full strength in both staff and facilities. The Cold Neutron Research Facility is proceeding as planned: the source was inserted in the reactor vessel in August 1987, the contract for the guide hall was signed in October, and the groundbreaking ceremony was held on November 20 with Deputy Commerce Secretary Brown and Congresswoman Morella (R, MD) in attendance, along with other dignitaries. In regard to FY 1988, we received endorsement from both the Department of Commerce and the Office of Management and Budget on our initiative involving High Performance Composites. We, likewise, have been endorsed as contributors to the NBS FY 1988 initiatives involving High Temperature Superconductors and Advanced Semiconductors. Funds for these activities are included under our appropriation bill for FY 1988, and as we go to print with this report, we are awaiting the decisions by Congress and the White House in regard to reconciling the 1988 Budget. These will be covered in more detail at one of the sessions of the Panel meeting.

In regard to FY 1989, we hope to expand the High Performance Composites initiative. During this year, we have been involved in formulating a comprehensive budget initiative for 1990, which will involve all organizations of IMSE. The theme of this proposal on the Automated Processing of Materials will be presented at the Panel meeting.

We also have had a very busy year in regard to organizational matters. First, we all mourned the tragic death of Secretary Baldrige, who had been a strong advocate for NBS. We look forward to working with new Commerce Secretary Verity, who also has expressed strong support for the activities of NBS. Congress has taken a strong interest in NBS and introduced legislation which will result in major expansions in both our activities and mission. This will be explained in detail at the Panel meeting. In the FY 1987 authorization act, Congress instructed NBS to establish a Personnel Demonstration Project to be conducted over a five-year period commencing January 1, 1988. This is an alternative personnel management system (to that which we now have) designed to help NBS attract, retain, and motivate highly qualified staff. We have spent this year in developing the new system and we will discuss this at the meeting.

During this year, we have had some changes affecting management positions. Dick Reed asked to step down as Chief of the Fracture and Deformation Division in order to catch up with his science endeavors. Harry McHenry has been appointed as the new Chief of the Division. Les Smith is on detail from his position as Chief of the Polymers Division to that of Chief, NBS Program Office. This temporary action provides assurance of NBS maintaining continuity of relations with Commerce, OMB, Congress, and others. During Les' detail, Bruno Fanconi will serve as Chief, Polymers Division.

We have been active, likewise, in realigning some of our Group-level activities. The wear program in the Metallurgy Division was combined with the similar activity in the Ceramics Division; the Synchrotron Radiation Analysis Group was reassigned from the Metallurgy Division to Ceramics; the High Temperature Chemistry Group was reassigned from Ceramics Division to Metallurgy; the Chemistry and Bioprocessing Group was transferred from Ceramics to Polymers; and, just recently, the time-dependent fracture activities of the Fracture and Deformation Division were combined with similar programs in the Metallurgy Division. All of these realignments were in the interest of program cohesiveness and more effective direction of the concerned research activities.

III. Program Areas

The materials science and engineering programs of the Institute cover the major classes of materials: metals, ceramics, polymers, and composites and these involve the Divisions at various levels of intensity in four areas of technology:

MATERIALS PROCESSING

- Solidification
- Phase Diagrams for Metals, Ceramics, and Polymer Blends
- Coatings and Thin Films
- Welding
- Diffusion
- Chemical Synthesis of Ceramics

MICROSTRUCTURE CHARACTERIZATION

- Nondestructive Evaluation
- Neutron Scattering
- Analytic Electron Microscopy
- Image Analysis
- Synchrotron X-rays

PROPERTIES

- Mechanical, Optical, and Electrical Properties
- Wear and Erosion

PERFORMANCE

- Time Dependent Fracture
- Environmentally Enhanced Fracture
- Corrosion and Chemical Durability

The following are some of the highlights of 1987 and are representative of all accomplishments for the year. Please refer to the individual Division and Office reports for more detailed information on programs, progress, and achievements:

- An industrial consortium was established with Crucible Materials Corporation, Hoeganaes Corporation, and General Electric in a three year program to develop an intelligent processing technology for rapidly solidified metal powders. Involves the development of in-situ sensors, process models, an expert computer system, and control devices

- The Cahn-Hilliard-Cook equation has for the first time been proven to be quantitatively correct. The equation was applied to spinodal decomposition of a polystyrene/poly(vinylmethylether) blend system. Data verifying its accuracy came from time resolved temperature jump and reverse quench light scattering techniques, and from a structure factor measured by a SANS experiment

- In collaboration with AT&T Bell Laboratories and the Naval Research Laboratory, we provided some of the first and most accurate results on the atomic scale structure, oxygen arrangements, and phonon density of states in new high TC superconductors. Key information also was obtained on the oxygen chains whose removal is associated with the loss of superconductivity

- Established an ultra-clean ceramic processing laboratory for producing powders and sample materials with controlled levels of impurities and dopants. The laboratory, which has several work areas where different experiments can be conducted simultaneously without cross contamination, includes a laminar flow work area with class 10 clean room condition, and such equipment as a rotary evaporator, drying oven, a press for making pellets, and controlled atmosphere furnace. This will be available for use by industry, academe, and other agencies

- A collaborative program with the Aluminum Association resulted in the successful testing of a prototype eddy current sensor for determining body temperature of aluminum during extrusion. A modified version of the sensor also has been used to sense density in-situ during hot isostatic pressing of aluminum, copper, high TC superconductors, and titanium-aluminide intermetallic alloys

- Constructed a simulator to study the thermomechanical processing of steels in order to develop improved procedures for controlled welding and accelerated cooling of high-strength steels

- Computer graphics software developed earlier for binary systems has been extended to ternary systems and successfully implemented with the computer production of Volume 6 of "Phase Diagrams for Ceramists". A prototype PC graphics database has been developed and demonstrated to the American Ceramics Society, industrial groups, and phase diagram users. This prototype is one of the most advanced graphics databases developed worldwide and should greatly enhance the marketability and utility of the various NBS-American Ceramics Society phase diagram hardcopy and computerized products

- Two polyurethane Standard Reference Materials are being produced with support from the Food and Drug Administration and the NBS Office of Standard Reference Materials. These SRMs, with certified values of weight-average molecular weight, will help meet a growing need for better methods of characterizing polyurethane used in medical devices, both before use and after degradation following implantation

- Conditions were discovered which greatly increase the stability against precipitate coarsening of precipitation-strengthened aluminum-iron-base powder alloys. This stability depends on formation of phase sequences involving an amorphous phase, similar to sequences previously encountered in NBS quasicrystal studies. This result provides the prospect that bulk parts can be made from these powder alloys without loss of the useful properties imparted by their original rapid solidification

- A theory to explain the observed rising fracture toughness (R-curve) of monophase ceramic materials with growing crack size has been further developed. The source of the toughness of ceramic materials originates in interlocking grains and unbroken ligaments that cross between the crack faces. These apply a closure force to the crack that must be overcome for fracture to proceed. This theory implies that the toughness of ceramic materials can be enhanced by microstructural design to increase the degree of interlocking of fracture surfaces. Materials are currently being fabricated to optimize the toughness characteristics

- A single crystal aluminum-silicon carbide fiber sample preparation technique has been perfected to allow fundamental studies of interfacial effects on fracture of metal matrix composites. This approach has allowed determination of the role of processing variables upon the cohesion and load transfer properties of aluminum-silicon carbide composites.

PERSONNEL

SUMMARY OF STAFF

Full Time Permanent		1985	1986	1987
Physicist		68	67	65
Chemist		54	49	45
Metallurgist/Matls. Scientist		38	44	39
Engineer		29	31	32
Other		3	3	3
	Subtotal	192	194	184
Technical Support		31	33	35
Reactor Operators		15	15	16
Management Support		5	5	7
Secretarial		25	27	31
	Subtotal	76	80	89
	TOTAL FTP	**268**	**274**	**273**
Other				
Postdoctorals		13	16	14
Part-Time and Temporary		29	42	43
Academic (Student and Faculty)		95	78	59
	Subtotal	137	136	116
	TOTAL STAFF	**405**	**410**	**389**

FY 1987 Postdoctoral Program

Unit	Name	Degree	School	Position Title	Advisor	Status
Ceramics	Cline, James	Ceramics	Alfred U.	Cer Engr	Hubbard	Continuing
	Coyle, Thomas W.	Matls Sci	MIT	Cer Engr	Wiederhorn	Temp. Appt. (11-8-87)
	Davidson, Paula	Earth/ Space Sci	SUNY	Res Chem	Hastie	Univ. of Chicago
	Roach, David	Ceramics	Case West.	Cer Engr	Lawn	duPont
	Swanson, Peter	Geophy	U. CO	Phys Scient	Freiman	Bureau of Mines
Fracture & Deformation	Heylinger, Paul	Engrg Sci/ Mech	VPI	Matls Res Engr	McHenry	Continuing
Polymers	Clark, John	Chem Eng	U. Minn.	Chem Engr	Han	Continuing
	Lee, Andre	Matls Sci	U. IL	Phys Scient	Wu	Continuing
	Marquesse, Jeffrey	Chemistry	MIT	Res Chem	Han	Inst. for Def. Anal.
	Shibata, John	Chemistry	U. Wash.	Res Chem	Wang	Univ. of Tennessee
Metallurgy	Johnson, Ward	Physics	U. IL	Physicist	Wadley	Continuing
	Moffat, David	Matl Sci	U. Wisc.	Metallurgist	Clark	Newman Lab
	Rottman, Craig	Physics	U. IL	Physicist	Cahn	N. Dakota St. Univ.
Reactor Radiation	Erwin, Ross	Math	U. MD	Physicist	Rhyne	Career Appt. (1-18-87)

FY 1987 ACADEMIC PROGRAM

	Appointments		
	Students	Permanent* Faculty	Totals
NDE	1	--	1
Ceramics	19	3	22
Fract & Deform	5	1	6
Polymers	6	4	10
Metallurgy	16	1	17
Reactor Radiation	2	1	3
Totals	49	10	59

* Consultants (part-time)

VISITING SCIENTIST PROGRAM

Guest Researchers	FY 1986	FY 1987
Domestic		
Federal	30	34
Academic	68	66
Industry	42	42
Self-Employed	17	17
Subtotal	157	159
Foreign	122	129
Subtotal	279	288
Research Associates		
Federal	4	4
Academic	1	1
Industry	89	79
Subtotal	94	84
Intergovernmental Personnel Act (Academic)	4	2
TOTAL	377	374

HONORS AND AWARDS

DEPARTMENT OF COMMERCE AWARDS

1985-1987

GOLD MEDAL (Exceptional Service)

Charles C. Han for his innovative use of small angle neutron scattering to address significant problems in polymer science. (1986)

James J. Rhyne for international leadership in critical research on advanced magnetic materials for high-technology products and devices. (1987)

Robert S. Roth for meritorious authorship in the field of ceramic phase equilibria, including editorship of the internationally renown Phase Diagrams for Ceramists volumes. (1986)

Robb M. Thomson for outstanding contributions as a world leader in the field of fracture in materials. (1987)

SILVER MEDAL (Meritorious Service)

Stephen W. Freiman for outstanding research and leadership in relating the structure and processing of ceramic materials to final properties. (1987)

Brian R. Lawn for innovative research on the fracture of brittle materials and for pioneering work in the field of fracture mechanics. (1986)

Harry I. McHenry for leading research and supervision in elastic-plastic fracture mechanics, leading to new fitness-for-service criteria. (1986)

Tawfik M. Raby for skillful management and leadership in doubling the power of the NBS reactor from ten to twenty megawatts. (1985)

Wen-li Wu for the development of a unique and powerful technique for analyzing the molecular structure of polymers used in composites. (1987)

BRONZE MEDAL (Superior Service)

Norman F. Berk	for major contributions to the theory of small angle scattering methods for the measurement of materials microstructure. (1985)
Alfred V. Clark	for outstanding contributions to the nondestructive evaluation of materials and components. (1987)
James G. Early	for developing guidelines to compare domestic and foreign specifications for alloys used in the construction of ships. (1986)
Richard J. Fields	for establishing the only database in the world to predict large-scale crack arrest behavior of nuclear-grade steels. (1985)
Charles M. Guttman	for outstanding contributions to theoretical studies of fundamental problems in polymer science. (1987)
Roseann M. Hayes	for contribution to the NBS Alloy Phase Diagram Data Program through on-line database administration and system management. (1985)
Camden R. Hubbard	for extensive accomplishment in improving materials characterization by x-ray powder diffraction. (1986)
Chia-Soon Ku	for development of oxidation measurements and standards for the Nation's petroleum and transportation industries. (1987)
David S. Lashmore	for contributions to the development of electrodeposited composition modulated alloys. (1986)
J. David McColskey	for developing experimental methods, instrumentation, and fixtures which put NBS at the forefront of fracture mechanics research. (1986)
Gregory B. McKenna	for contributions to descriptions of the mechanical response of polymers and leadership of the rubber SRM program. (1985)
Gregory J. Olson	for important contributions to inorganic materials biotechnology and bioengineering. (1986)

Edwin J. Parks	for imaginative use of unique tailored organometallic materials to advance technologies servicing national needs. (1985)
John A. Tesk	for his exceptional leadership of a highly diverse program that has improved the performance of dental materials. (1986)
S. Michael Thomas	for consistently outstanding contributions to the administrative and fiscal operation of the Polymers Division. (1986)
Francis Wei-Yu Wang	for creative application of fluorescence spectroscopy to fundamental problems of polymer science. (1985)

SENIOR EXECUTIVE SERVICE

BONUS AWARD

Robert S. Carter (1985)
Richard P. Reed (1985, 1986)
John J. Rush (1985)
Lyle H. Schwartz (1985, 1986)
Robb M. Thomson (1986)
H. Thomas Yolken (1985)

PRESIDENTIAL RANK OF MERITORIOUS EXECUTIVE

John J. Rush (1986)

NBS AWARDS

1985-1987

STRATTON (Outstanding scientific or engineering achievements)

John Cahn	for outstanding achievements in the field of physical metallurgy. (1986)

EQUAL EMPLOYMENT OPPORTUNITY (For exceptionally significant accomplishments and contributions to EEO and Affirmative Action goals)

Jonice S. Harris	for outstanding contributions to the NBS and IMSE EEO/Affirmative Action Programs. (1986)

CRITTENDEN (Superior accomplishments by support staff)

David R. Kelly	for outstanding and unique electroplating services to the NBS staff. (1986)

SAFETY (Significant contributions to Safety Program)

Mario J. Cellarosi	for outstanding contributions to the IMSE/NBS Occupational Health and Safety Program. (1985)
Ralph F. Krause	for outstanding tenure as Ceramics Division Safety Officer, enhancing safety awareness and maintaining an excellent safety record. (1987)
Elizabeth S. Sweitzer	for outstanding contributions to the IMSE/NBS Occupational Health and Safety Program. (1985)

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

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

NATIONAL RECOGNITION

1985-1987

Ugo Bertocci	14th William Blum Award, National Capital Section of the Electrochemical Society for his work on electrochemical noise to study the stability of passive films (1986).
John Cahn	von Hippel Award of the Materials Research Society for his lifelong achievement in materials research (1985).
	Elected Fellow of the American Society of Metals (1985).
Robert S. Carter	Elected Fellow of the American Nuclear Society (1986).
	Steering Committee for an Advanced Steady-State Neutron Source in the U.S. (1986).
J. Beverley Clark	Elected Fellow of American Society for Metals (1986).
Edwin Fuller	Ross Coffin Purdy Award of the American Ceramic Society for his valuable contribution to the ceramic technical literature (1987).
Charles Guttman	Elected Fellow of the American Physical Society (1987).
Charles Interrante	George Kimball Burgess Memorial Award by the American Society for Metals for significant contributions to the field of metallurgy (1987).
David S. Lashmore	Elected Vice President of Electrodeposition Division of the Electrochemical Society (1986).
Brian Lawn	Elected Fellow of American Ceramic Society (1986).
M. Linzer, H. Wadley, D. Kupperman (Argonne), L. Spivak (Magnaflux)	I-R 100 Award for development of an Ultrasound Pipe Porosity Sensor given by Research and Development magazine (1987).
John R. Manning	Elected Fellow of American Society for Metals (1986).
Fielding Ogburn	ASTM Award of Merit for research in the field of electrodeposition and international standardization (1985).

Elio Passaglia	ASTM Award of Merit for outstanding contributions to the advancement of voluntary standardization (1987).
Marshall Peterson	ASME Mayo D. Hersey Award of the Society of Tribologists and Lubrication Engineers for outstanding contributions in lubrication research and development (1987).
Lyle H. Schwartz	Elected Fellow of ASM International (1987).
Samuel J. Schneider	American Ceramics Society T.J. Planje-St. Louis Refractories Award for distinguished achievements in the field of refractory materials (1985).
Dan Shechtman	International Prize for New Materials by the American Physical Society for his experimental discovery of phases of matter that exhibit icosohedral symmetry (1987).
T. Siewert P. Purtscher R. Trevisan	International Metallographic Society Award for their development of a metallographic technique that analyzes welds and welding processes by completely exposing the weld fusion line (1986).
Gilbert M. Ugiansky	Elected President of Federation of Materials Societies (1987-88).
Sheldon M. Wiederhorn	American Ceramics Society Sosman Lecturer in recognition of pioneering work in fracture mechanics (1985).
H. Thomas Yolken	Congressional Science Fellowship with Rep. Don Ritter (R-PA) (1985).

TECHNOLOGY TRANSFER

CONFERENCE PROGRAM
(SPONSOR OR CO-SPONSOR)

FISCAL YEARS 1986 AND 1987

Workshop on the Investigation of Fundamental Interactions with Cold Neutrons
November 14-15, 1985 (M. Rowe-Reactor Radiation)
150 attendees

Fundamental physics and metrology opportunities using cold neutron beams.

Workshop on an Advanced Steady State Neutron Facility
December 16-17, 1985 (J. Rush-Reactor Radiation)
50 attendees

Address the research and technological applications of a new advanced steady state neutron source and consider a variety of different engineering approaches for providing such a source in the U.S. before the year 2000.

A National Forum on the Future of Automated Materials Processing in U.S. Industry--The Role of Sensors
December 16-17, 1985 (T. Yolken-Office of Nondestructive Evaluation)
115 attendees

To identify and assess important issues affecting the competitive position of U.S. industry related to its ability to automate production processes for basic and advanced materials and to develop approaches for improved capability through cooperative R&D and associated efforts.

ISO/TC 107/SC 3 on Coatings and Surface Finishings
April 7-11, 1986 (D. Lashmore-Metallurgy)
40 attendees

Establish international standards and test methods concerned with metallic and inorganic coatings with specific interest to critical metals and corrosion protection.

Crack Arrest Technology
April 10-11, 1986 (R. deWit- Fracture & Deformation)
40 attendees

Review the technological developments in dynamic fracture and crack arrrest. Transfer this information to electric power and gas industry.

NBS Analytical Chemistry/Materials Science Workshop
April 13-18, 1986 (J. Harris-Metallurgy)
50 attendees

To expose students and faculty of Historically Black Colleges and Universities to state-of-the-art research and analytical methods in chemistry and to present overview of current research activities in materials science and engineering.

Seminar on Micro-Analytical Techniques in Materials
April 21-22, 1986 (R. Fields-Fracture & Deformation)
40 attendees

Addresses current state of technology for determining microstructure and composition of metallic materials.

ASTM C14 on Glass and Glass Products Workshop
April 22-24, 1986 (M. Cellarosi-Ceramics)
40 attendees

To discuss cooperative standardization/measurement programs with NBS.

Interagency Coordinating Committee on Ceramics Meeting
May 6-7, 1986 (S. Hsu-Ceramics)
46 attendees

Review of current government sponsored programs in structural ceramics by government program managers.

Joint Services Technical Coordinating Group on Nondestructive Inspection (JRCG/NDI) Specifications and Standards Subgroup
May 6-7, 1986 (L. Mordfin-Office of Nondestructive Evaluation)
15 attendees

To review progress on military standards and specifications for NDE.

IMSE Advanced Materials Symposium Series: Advanced Materials Characterization Using Synchrotron Radiation
May 28, 1986 (M. Kuriyama-Ceramics)
100 attendees

To describe the recently commissioned IMSE x-ray beamline at the National Synchrotron Light Source to the scientific community of prospective users. The capabilities of the Light Source and the beamline instrumentation will be illustrated using recent research results.

Workshop on Materials Characterization by X-Ray Scattering
June 23-24, 1986 (C. Hubbard-Ceramics)
175 attendees

Status and future of industrial needs in materials characterization by quantitative x-ray powder diffraction methods.

Steel Sensor Workshop
July 16, 1986 (H. Wadley-Metallurgy)
30 attendees

Reported progress made on top priority sensor needs for the steel industry and outlined new directions for the steel sensor program.

Gordon Research Conference--Solid State Studies in Ceramics
August 11-15, 1986 (B. Lawn-Ceramics)
100 attendees

Assessment of forefront developments in surface forces and microstructures as they apply to cracks and interfaces in ceramics.

ASM Materials Week 86--Sessions on the Effect of Coal Cleaning on Materials Performance
October 12, 1986 (S. Dapkunas-Ceramics)
20 attendees

Review the economics, technology, and science of coal cleaning and its effect on the performance of materials in coal combustion and gasification systems.

Universities Space Research Association Metals and Alloys Discipline Working Group
October 23-24, 1986 (S. Coriell-Metallurgy)
20 attendees

Discussions of metals and alloys research for microgravity science and applications.

41st MFPG Meeting - Detection, Diagnosis and Prognosis of Rotating Machinery
October 28-30, 1986 (R. Shives-Fracture & Deformation)
200 attendees

To improve reliability, maintainability, and readiness through the application of new and innovative techniques.

Workshop on Automated Processing of Rapidly Solidified Metal Powders by High Pressure Inert Gas Atomization
October 30-31, 1986 (H. Yolken/L. Mordfin-Nondestructive Evaluation and N. Pugh-Metallurgy)
40 attendees

To brief attendees and to solicit their views on establishing a consortium to develop a major new program on automated technology for the production of rapidly solidified metal powders.

2nd Interagency Tribology Research Coordinating Meeting
December 4, 1986 (S. Jahanmir-Ceramics)
20 attendees

Assessment of government programs in tribology and establishment of cooperative research plans.

IMSE Symposium Series on Composites: Fracture Behavior of Fiber Reinforced, Ceramic Matrix, Composites
March 19, 1987 (S. Freiman-Ceramics)
40 attendees

New test techniques were described which can be used to quantitatively determine fiber/matrix interface properties and to ascertain the role of crack/fiber interactions in governing the strength of the composite.

Workshop to Establish Standardization Plan for Real-Time Radioscopy
April 2-3, 1987 (T. Siewert-Fracture and Deformation)
25 attendees

To enhance the quantitative capabilities of industrial real-time radioscopy and to make its measurements traceable to recognized standards.

NBS-BAM Symposium on Corrosion and Wear
April 13-14, 1987 (W. Ruff-Metallurgy)
50 attendees

To offer communication between staff of the two organizations on research programs and projects. In addition, other professional individuals are made aware of research activities.

Interagency Coordinating Committee on Structural Ceramics
May 6-7, 1987 (S. Hsu-Ceramics)
45 attendees

To coordinate central objective of various Federal agencies on structural ceramic programs.

Third Annual Heavy Section Steel Technology Program Workshop on Dynamic Fracture and Crack-Arrest Technology
May 13-15, 1987 (R. Fields-Fracture & Deformation)
65 attendees

Results from on-going dynamic-fracture and crack-arrest studies around the world will be presented and discussed to stimulate technology transfer to US industry.

Joint Services Technical Coordinating Group on Nondestructive Inspection (JRCG/NDI) Specifications and Standards Subgroup
June 1-2, 1987 (L. Mordfin-Nondestructive Evaluation)
12 attendees

To discuss progress and plans and to coordinate interagency efforts to develop new and improved military standards and specifications for nondestructive evaluation.

COMAT Subcommittee on Superconductors
June 12, 1987 (S. Dapkunas-Ceramics)
40 attendees

Coordination of Government Sponsored Research on High Temperature Superconductors

ONR/NBS Workshop on Surface Forces
September 2-3, 1987 (B. Lawn/S. Wiederhorn-Ceramics)
25 attendees

Discussions on the application of new measurement technique to materials science.

U.S.-China Symposium on Advanced Ceramics Materials
September 8-11, 1987 (S. Freiman-Ceramics)
50 attendees

To exchange scientific information on advanced ceramic materials.

Workshop for U.S. Participants in IEA/Annex II Interlaboratory Comparison of Powder Characterization Methods
September 15-16, 1987 (A. Dragoo-Ceramics)
12 attendees

Discussion of technical issues related to physical and chemical characterization of ceramic powders.

ISO/TC164, Standards for Hardness, Uniaxial, and Fracture Testing
September 14-25, 1987 (R. Fields-Fracture & Deformation)
60 attendees

To establish international standards for mechanical testing.

42nd MFPG Meeting - Technology Innovation - Key to International Competitiveness
September 15-17, 1987 (R. Shives-Fracture & Deformation)
75 attendees

To provide a forum for the discussion of improving the position of the United States in the world market through the utilization of technology innovation.

ASTM E-49 Workshop on Ceramic Specification for Property Databases
September 29, 1987 (C. Hubbard-Ceramics)
10 attendees

To develop draft guidelines for specification of advanced ceramics for entry into a proposed materials property database.

STANDARDS COMMITTEES MEMBERSHIP

Unit	Staff	Committee* Assignments
Institute Office	3	5
Nondestructive Evaluation	1	12
Ceramics	16	68
Fracture & Deformation	11	31
Polymers	12	42
Metallurgy	21	79
Reactor Radiation	2	4
TOTAL	66	241

*Includes: 26 chairs
2 secretaries
1 director

Representation

Organization	Assignments
American National Standards Institute	24
American Nuclear Society	2
American Society for Mechanical Engineers	2
American Society for Testing and Materials	189
Department of Defense/Technical Coordination/NDE	1
Electronic Industries Association	2
International Institute of Welding	1
International Standards Organization	11
Joint Committee on Powder Diffraction Standards	4
National Association of Corrosion Engineers	1
Safety Glazing Certification Council	1
Welding Research Council	3
TOTAL	241

Source: Directory of NBS Standards Committee Activities, 1987.

RESEARCH DISSEMINATION
FY 1987

UNIT	PUBLISHED PAPERS	INVITED TALKS	PATENTS*	SRMs*	MONOGRAPHS*
INSTITUTE OFFICE	18	31	--	--	--
OFFICE OF NONDESTRUCTIVE EVALUATION	5	13	--	--	--
CERAMICS	199	158	4	4	--
FRACTURE AND DEFORMATION	75	30	--	--	1
POLYMERS	113	85	6	3	--
METALLURGY	173	112	2	2	2
REACTOR RADIATION	83	25	--	--	1
TOTAL	666	454	12	9	4

*Listing on following pages.

PATENTS (In process)

Stress-free sintering of fiber-reinforced ceramic composites
Claudia Ostertag (Ceramics)

Quantitative and qualitative technique for assessing stresses during densification of composites
Claudia Ostertag (Ceramics)

A hermetically sealed inert atmosphere cell for x-ray powder diffraction
Joseph J. Ritter (Ceramics)

Superconducting ceramic composites
Stephen W. Freiman (Ceramics)

Hydrophobic dental composites based on a polyfluorinated dental resin
J.M. Antonucci (Polymers)

Interpenetrating-network polymeric electrolytes
B.J. Bauer, C.K. Chiang, G.T. Davis (Polymers)

Method for obtaining strong adhesive bonding of composites to dentin, enamel, and other substrates
R.L. Bowen (Polymers)

Simplified method for obtaining strong adhesive bonding of composites to dentin, enamel, and other substrates
R.L. Bowen (Polymers)

Transducer hydrophone with filled reservoir
G.R. Harris and A.S. De Reggi (Polymers)

Arc-furnace for the production of small investment castings
R.M. Waterstrat (Polymers)

Method for determining subsurface property value gradients
H.N.G. Wadley (Metallurgy)

Automated device for determining and evaluating the mechanical properties of materials
D.S. Lashmore, J.L. Mullins, C.E. Johnson, R. Polvani (Metallurgy)

SRMs PRODUCED

SRM 660 Profile, 2θ XRD Std.
(Ceramics)

SRM 656 Alpha-Beta Silicon Nitride
(Ceramics)

SRM 658 Tridymite Quantitative SRM
(Ceramics)

SRM 717 Glass Viscosity (Renewal)
(Ceramics)

SRM 1488 Poly(methyl methacrylate)
(Polymers)

SRM 1489 Poly(methyl methacrylate)
(Polymers)

SRM 1497 Pigmented polyethylene gas pipe resin
(Polymers)

MONOGRAPHS

Cryogenics Prop's of Copper and Copper Alloys
(Fracture & Deformation)

Binary Alloy Phase Diagrams, 2 Vols. ASM
(Metallurgy)

Cor*Sur™ Corrosion Data Software Vols. 1 and 2, NBS & NACE
(Metallurgy)

On-line capabilities for crystal data
(Reactor Radiation)

APPENDICES

1987 PANEL MEMBERS

Dr. Francois A. Padovani,
Chairman (1990)
Vice President
Materials and Controls Group
Texas Instruments Incorporated
34 Forest Street, Mail Station 10/13
Attleboro, MA 02703
(617) 699-1102

Dr. Ian F. Hughes (1990)
Director, Product Research
Inland Steel Corporation
3001 E. Columbus Drive
East Chicago, IN 46312
(219) 392-3262

Dr. George R. Irwin (1989)
Department of Mechanical Engineering
University of Maryland
College Park, MD 20742
(301) 454-8856

Prof. Bernard H. Kear (1990)
Dept. of Mechanics and
Materials Science
College of Engineering
Rutgers University
P.O. Box 909
Piscataway, NJ 08855-0909
(201) 932-2245

Dr. R. Glen Kepler (1988)
Manager, Organic and Electronic
Materials Department 1810
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185
(505) 844-7520

Prof. G. S. Kino (1989)
Edward L. Ginzton Laboratory
Stanford University
Stanford, CA 94305-2184
(415) 723-0205

Dr. Robert A. Laudise (1989)
Director, Physical and Inorganic
Chemistry Research
AT&T Bell Laboratories
600 Mountain Avenue, Room 1A-264
Murray Hill, NJ 07974
(201) 582-6220

Dr. William J. MacKnight (1988)
Department of Polymer Science
and Engineering
University of Massachusetts
Amherst, MA 01002
(413) 545-0433

Dr. John P. McTague (1990)
Vice President, Research
Ford Motor Company, Room S-2106
Scientific Research Labs Bldg.
2000 Rotunda Drive
Dearborn, MI 48121-1603
(313) 322-7105

Dr. John L. Mihelich (1989)
General Manager, Commercial
Development
AMAX Speciality Businesses
900 Victors Way, Suite 320
Ann Arbor, MI 48108
(313) 665-0100

Dr. Joseph N. Panzarino (1989)
High Performance Ceramics
Norton Company
Goddard Road
Northboro, MA 01532
(617) 393-5820

R. Byron Pipes, Dean (1988)
College of Engineering
134 du Pont Hall
University of Delaware
Newark, DE 19716
(302) 451-2401

Dr. Maxine L. Savitz (1990)
Director, Ceramic Components Div.
Garrett Processing Company
19800 South Van Ness Avenue
Torrence, CA 90509
(213) 618-7569

Dr. Sunil K. Sinha (1989)
Senior Research Associate
Exxon Research and Engineering
Company
Clinton Township
Route 22, East
Annandale, NJ 08801
(201) 730-2875

Prof. David Turnbull (1988)
Division of Applied Sciences
Harvard University, Pierce Hall 207
29 Oxford Street
Cambridge, MA 02138
(617) 495-2838

Prof. Julia R. Weertman (1990)
Department of Materials Science
and Engineering
Northwestern University
Evanston, IL 60201
(312) 491-5353

AN EVALUATIVE REPORT ON THE INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

Panel Members

Peter Cannon, Rockwell International, Chairman
Peter Bridenbaugh, Aluminum Company of America
William B. Hillig, General Electric Company
George R. Irwin, University of Maryland
R. Glen Kepler, Sandia National Laboratories
Robert A. Laudise, AT&T Bell Laboratories
John L. Mihelich, AMAX of Michigan, Inc.
Francois A. Padovani, Texas Instruments Incorporated
Joseph N. Panzarino, Norton Company
R. Byron Pipes, University of Delaware
Sunil K. Sinha, Exxon Research and Engineering Company
David Turnbull, Harvard University
Julia R. Weertman, Northwestern University

Unable to Attend

William J. MacKnight, University of Massachusetts

This report, submitted for the Panel by the Chairman, Peter Cannon, covers the activities of the Institute for Materials Science and Engineering during the 12 months preceding the Panel meeting on January 20-21, 1987.

Functions of the Institute

The Institute for Materials Science and Engineering (IMSE), a major organizational unit of the National Bureau of Standards (NBS), provides measurements, data, standards, reference materials, concepts, and other technical information fundamental to the processing, structure, properties, and performance of materials. This information is used by industry, government agencies, universities, and other scientific organizations. Much of it is made available through major new cooperative programs with industry which ensure rapid dissemination and application of IMSE technical output and provide IMSE managers with immediate information on industry's needs for measurement science and data. The Institute, jointly with the American Society for Metals and the American Ceramic Society, is creating and disseminating phase diagrams. The societies provide guidance and substantial financial support from industry.

The research programs of IMSE support generic technologies in materials in order to foster their safe, efficient, and economical use. Research in the Institute addresses the science base underlying new advanced materials technologies. Rapid solidification of metals, ceramics processing, alloy coatings, polymer blends, and advanced composites are current examples. IMSE has a beam line at the Brookhaven National Synchrotron Light Source for frontier research in materials transformations, kinetics, and advanced x-ray optics. Other unique facilities are made available to industry and universities in cooperative research projects. These include the NBS research reactor and associated apparatus for the use of neutrons to characterize materials, laboratories for the preparation and characterization of rapidly solidified metal samples, and other state-of-the-art measurement facilities. The Institute collaborates with other NBS Centers and organizations in interdisciplinary programs in materials science.

During fiscal year 1987, the Institute had a staff of about 410, and a total operating budget of $40 million.

Technical Quality

The quality of the staff and the research performed ranges from competent to brilliant. At this point, it is well known that the discovery and characterization of quasicrystals at NBS has had a tremendous effect on solid-state physics, crystallography, and materials science generally. The more recent development in the electrodeposition group of improved understanding of pulsed alloy deposition and its application to form artificially layered structures with short wavelength composition modulations is first-rate materials science. These achievements, along with the more mundane ones, are certainly up to, and perhaps considerably beyond, the norm of those in similar areas at other leading national laboratories.

The new ability through electrodeposition to control accurately alloy compositions over thicknesses of the order of 50 angstroms is truly outstanding. Such development could have significant industrial impact as it should provide an economical process for superlattice formation in contrast to techniques such as molecular-beam epitaxy currently used in the semiconductor industry. Superlattice material will offer industry the ability to tailor material properties essentially at will. Efforts should be directed in the coming year at characterizing these materials and at developing a theoretical basis for their understanding.

The IMSE strength in phase relationship determination, modeling, evaluation, and codification is outstanding and of high importance to American industry.

With respect to the new initiative in basic standards and technology support for advanced ceramics, a high level of efficiency and impact is being achieved with the resource level now committed. Recent achievements include the following:

1. Unique models that fit a wide array of experimental results for ceramic fracture.
2. New models for sintering tested against actual experimental observations in real systems.
3. Models of the matrix-inclusion interface with insights valuable to the understanding and optimization of composites.
4. The design and construction of novel clean-room facilities that will be unique for the preparation of ceramics.
5. The full densification of ZrO_2 at room temperature.

Lack of reliability continues to be a major barrier to successful use of advanced ceramics. This issue is addressed in programs relating to ceramic processing science, ceramic powder characterization, tribology, mechanical properties, and ceramic matrix composites. High-temperature materials research and additional analytical techniques such as the new Fourier transform infrared setup and surface analysis capability demonstrate awareness of the key problems facing advanced ceramics.

Among the areas where continuing programs are on target and producing solid scientific results, the perspective applications of SAXS and related techniques to polymers and the use of synchrotron radiation to map perfection in materials for optical applications are of note.

Fracture and deformation studies cover aspects of fracture and deformation of metals, plastics, and composites. The principal goal of the research is to establish the scientific basis to minimize failure of materials. The work includes developing theories of and models for deformation and fracture, characterization of mechanical performance, and development and application of fracture mechanics. Overall programs are on a solid science base with good progress being made on all fronts. The staff is well managed, enthusiastic, and communicative.

The study of plastic fracture behavior covers fracture mechanics, nondestructive evaluation, and welding. A533B steel plate has been subjected to wide-plate crack-arrest tests, and tests on plate heat treated to simulate radiation embrittlement exhibited cleavage at a temperature above the upper shelf determined by traditional impact testing with important practical implication.

An electromagnetic acoustic transducer system has been developed to accurately measure velocity-and-time interval to a precision of ± 1 ns. The system has been successfully applied to measure residual stresses in welded, thin aluminum plate and in railroad wheels. It appears to be suitable for on-line process control for texture monitoring of aluminum used for can manufacturing.

The programs of the Polymer Division continue to be of the highest technical quality. The Division has a long history of doing outstanding basic research and, as a consequence, can attract people of the highest caliber. By and large, the Polymer Division is in good shape equipment-wise.

The studies of the molecular mechanism for large strain deformations in epoxies is one example of an outstanding program in the Polymer Division. These studies involve neutron scattering and, thus, represent the development of state-of-the-art metrology and the demonstration of the applicability of this state-of-the-art metrology to complex, technologically important polymers like epoxies. This work is also important to an ultimate understanding of the mechanical properties of composites in which epoxies are the matrix, materials that are of great interest to U.S. industry and its industrial competitiveness.

The neutron and light-scattering studies of the binary interaction parameter χ represent another example of forefront high-quality research. The χ parameter is related to polymer miscibility and is thus closely related to industry needs in polymer-blend technologies.

The Reactor Radiation Division (RRD) continues to produce excellent research. The program fits well within the metrology tradition of NBS. Communication with its constituency (industry, government, and university) is being actively carried out. One-on-one contact is made with the substantial number of the RRD's industrial associates. A series of workshops is planned; the first will be held in 1987 and will address applications of small-angle neutron scattering (SANS), reflectometry, and diffuse scattering to obtain information on microstructures and submicrostructures. Each workshop will produce a document laying out opportunities for materials measurements of interest to industry.

The internationally significant initiative of the cold neutron source continues. The cryostat is being tested and will be installed in the early part of 1987. The cold source will greatly increase the flux of long-wavelength neutrons, and will particularly enhance the performance of the SANS and new time-of-flight spectrometers. Planning continues for the new neutron guide hall. Note that three of the first five instruments to be built will be of direct benefit to industrial users: SANS, prompt γ, neutron depth profiling. Prompt γ is the premiere method of measuring trace amounts of elements. With cold neutrons the range of elements that can be detected by neutron depth profiling will be extended and will include oxygen and nitrogen. The lateral resolution will improve to a few micrometers. Currently the depth profiling facility at NBS is so heavily booked that satellite facilities have been set up at reactors at State University of New York at Buffalo, the University of Michigan, and North Carolina State.

Technical Health

In general, the performance of the work of IMSE is excellent and the morale of the staff remains good. The pressure felt by many in the required search for other-agency funds remains a concern of the Panel and is always a threat to morale in situations of excess. The organizational and management changes of the last few years have been well accepted. A balanced though rather restricted topical program has been built, and there is obvious collegiality. The IMSE is probably now ready for its next step to true contemporaneity.

Adequacy of Planning

Both strategic and short-term planning will be required to ensure that IMSE's role is effectively integrated with other national laboratories and centers of research. The Panel has seen much evidence of tactical planning and its beneficial effects on programs, initiatives, and staff recruiting. A significant role of longer-range planning should also be more fully pursued in conjunction with other major laboratories to ensure complementariness, minimum of duplication, sharing/collaboration of resources. In addition, firm, proactive linkages with U.S. industry should be established to foster, for example, the advanced ceramics industry. Billions of dollars are spent and funded each year for materials science research and development, and real interagency strategic planning and resource allocation could bring more efficient use of the dollars available.

A yearly planning function could bring together IMSE management and staff and the Panel for a session more truly responsive to the letter request of the Chairman of the Board on Assessment of NBS Programs to the Panels. The IMSE plan should look forward at least 5 years and could project to 10 years ahead using the broad guidelines available in, for example, the National Academy of Sciences/National Academy of Engineering/National Research Council studies on materials, especially drawing on the industrial inputs to questions like, "What are the trends in materials and what resources will likely be needed?" Then, the time spent to assess the current program and the plan for the next year will have much stronger context.

Appropriateness of Balanced Planning

The Panel considers that the IMSE has made progress toward a well-balanced scientific research program, and that real progress has been made towards emphasis of contemporary materials, but the Panel wishes to make it clear that a substantially increased effort on longer-range planning and topic selection that would naturally mesh with expected patterns of industry need is not only justified, but very necessary. Newer technologies such as metal and ceramic matrix composites, life prediction methodologies, and a vigorous expansion into electrical and electronic materials are typical of these high-leverage fields of American competitiveness. Intense industrial interest could be expected in well-planned, well-communicated initiatives of this type, especially when coordinated with the massive characterization capabilities of the Department of Energy chain of national laboratories. Early recognition of the technological trends and a commitment to follow the new developments will ensure the responsiveness of IMSE.

The communication of priorities should be with both the external and the internal constituencies. There are some remarkable discrepancies between the expressed and perceived goals of NBS management on the part of the scientific staff; such are normal in any large organization, but at a time of change or stress, extra care and time must be taken to assure uniform communication. Particular care must be taken not to mix up or confound the responsibility of goal management with that of scientific direction, when the overall purpose is to improve the use of the output and to assure its relevance.

Responsiveness to National Needs

NBS was created over 85 years ago and the relation of the newer organization components, like the IMSE, to the charter presents difficulties of definition except in the broad sense of provision of a technical service. A difficult but required task for the IMSE planners is to express a closer relation between the excellent work of scientific discovery and the principal goals of the Bureau dealing with metrology. The IMSE staff constitute a national asset in materials science, and great clarity in expressing expectations for staff achievement is needed to assure the timeliness and prospective industrial relevance of the work in terms of the statutory charter. The same issue arises in particular form throughout the various divisions of the Institute, though some are clearly in possession of excellent industrial constituencies. In general, the IMSE's constituency in academia is excellent.

Assuming that the primary function of NBS is to be supportive to the nation's business and industry, it is important to identify to the extent practicable what the needs are that can be addressed by a public technical institution nominally focused on metrology, having the excellent facilities, staffing, and tradition that make NBS a national resource. The program of the IMSE reflects a technical logic in terms of properties versus structure versus processing, but the underlying logic in terms of the "customer's needs" is less clear.

An approach that could have major industry-wide implications is the provision of design data, on line, for advanced materials. A central clearing house for data, standards, etc., on such materials, particularly composites of all kinds, is sorely needed along with programs both internal and cooperative (such as the International Energy Agency round robin) to fill the data bank and make it accessible. The above are certainly within the charter of NBS and could have major implications for IMSE, along with interesting revenue and proprietary protection and access issues.

Communication with Constituencies

NBS programs necessarily take the lead from industry, but NBS managers should strive to anticipate needs, so as to formulate fast and effective responses to opportunity. In order that industry benefit from the programs of IMSE, it is important that business and the Institute know each other better. Workshops, symposia, talks, and visits are helpful. However, some of the key staff should have longer-term exposure to industrial technical work and its culture. Both junior and senior industrial scientists and engineers do work at NBS as visitors, but the "return match" is played less frequently. Accordingly, a more vigorous, bilateral program of exchange is recommended by the Panel, with the explicit goals of providing a firmer, lengthened planning horizon and a much-improved pattern of use of the resulting cooperative work.

A good model for such exchanges was the exploration of technology transfer opportunities in the domestic automobile industry with the assistance of the Ford Motor Company. A year of interaction in Detroit resulted in a number of recommendations to achieve more efficient use of materials, and a proposed follow-up with the whole industry will occur in 1987. A conscious incorporation of what has been learned into NBS's plans is also called for. The Panel also notes that the IMSE remains home to the only Bureau-wide program of technology transfer, the Office of Nondestructive Evaluation (ONDE), and lessons learned from its operation can usefully be taken up by the Bureau.

Equipment

In general, the IMSE's equipment is acceptably recent and quite appropriate; the IMSE does not match the capital intensity of the best equipped industrial laboratories. A careful scrutiny by NBS management of capital investment per worker by division is needed.

Greatest Needs

Relationship of Science and Metrology

Probably the prime motivation of most of the IMSE staff is to discover novel materials and processes and to develop deeper understanding of structure-property relations. Freedom to pursue these goals is, perhaps, what has enabled IMSE to attract and retain the outstanding scientific talent that it has. There is continuing concern that emphasis of these scientific goals may detract from the metrological achievement, which is the traditional mission of NBS. Most importantly, it should be recognized that good metrology often is motivated by, and follows, good science. When scientific breakthroughs occur, development of new or improved metrology usually is essential for their verification and characterization. For example, in the rapid solidification processing (RSP) area, vital to the U.S. aerospace industry, the NBS discovery of quasicrystals called for a thorough reexamination of diffraction conditions and some of the methods of high-resolution electron microscopy. Also, the high rates of crystal growth in RSP motivated new methods of measuring temperature at the rapidly moving interface. A major initiative available to IMSE is the integration of material science data, including process kinetics, into metrologically based on-line measurement techniques useful in statistical manufacturing process control.

To summarize, good science is symbiotic with good metrology; the two go hand in hand. It should also be made clear, however, that a diligence is needed to bring the new opportunities to application, and that such is essential to the overall health of the enterprise. The best science is useful; the challenge to management is that there is no substitute for first-class scientific discovery--which cannot be predicted, no matter how much care goes into planning. This year's high temperature superconductivity discoveries are an outstanding example. The business of IMSE is discovery and use, and the special responsibility of the managers is anticipation and advocacy of a proper balance.

A Desirable Expansion

In the past, NBS expertise has provided the physical-chemical foundations for, e.g., the exploitation of new families of ferrites, dielectric ceramics, and other high-technology electronic materials. Activities devoted to the understanding of the crystal chemistry of inorganic materials and phase relations should receive continuing and increased support. Opportunities in, for example, superconductors, nonlinear optics (NLOs), and new semiconductors should make the NBS expertise in crystal chemistry-phase equilibria an ideal building block in a new initiative to electronic materials.

The Panel applauds and encourages the IMSE plans to enlarge activities on electronic materials. Electronic materials are the sine qua non of the electronic components and devices that pace the competitiveness of telecommunications and information systems. Thus, electronic materials have high leverage on national competitiveness. The unique metrological strengths of NBS and its new initiatives toward leveraging national competitiveness can be especially profitably focused on electronic materials. The device and electrical standards strengths in other parts of NBS should synergistically reinforce

IMSE's materials strengths. A number of possible areas for emphasis present themselves: for example, (1) semiconductor materials--Si, III-Vs, new semiconductors; (2) dielectric materials--ceramics and organics; (3) optical materials--fibers, EOs, and NLOs; and (4) packaging and lithographic materials.

It is clear that focus on a subset of activities will be essential. This choice should be based on the strengths of staff and on facilities, together with an assessment of new resources that can become available in the near future. Consideration should be given to recruiting at least one senior person to lead such a group. The activity should play to the traditional strengths of the Bureau and IMSE, unimpeachable measurement techniques and high-quality preparation techniques and results that others can use with confidence.

A Suggestion

Industry is making rapid progress in the composites field and consideration should be given to forming an Institute-wide program, including the expertise in fracture and deformation, perhaps similar to the ONDE. Such would be a useful point of contact for industry, and for the assembly of standards-type information. It could be a focus for industry-originated techniques in composites to be evaluated for acceptance as prospective standards, a partnership possibility that could do much to help bring the entire Bureau back into regular contact with industry. The Panel suggests that this programmatic vehicle be planned and initiated promptly.

AN EVALUATIVE REPORT ON THE OFFICE OF NONDESTRUCTIVE EVALUATION

Panel Members

G. S. Kino, Stanford University, Chairman
Laszlo Adler, Ohio State University
John R. Barton, Southwest Research Institute (Retired)
Joseph A. Giordmaine, AT&T Bell Laboratories
Edmund G. Henneke, II, Virginia Polytechnic Institute and State University
Robert W. McClung, Oak Ridge National Laboratory

Unable to Attend

Peter Bridenbaugh, Aluminum Company of America

This report, submitted for the Panel by the Chairman, G. S. Kino, covers the activities of the Office of Nondestructive Evaluation during the 12 months preceding the Panel meeting on December 8-9, 1986.

Functions of the Office

The Office of Nondestructive Evaluation (ONDE), a part of the Institute for Materials Science and Engineering (IMSE), provides for enhanced reliability, productivity, and economy in the use of materials, structural components, and systems, both during their manufacture and in-service by conducting research leading to the development, stimulation, and dissemination of (1) more sensitive and reliable nondestructive evaluation (NDE) measurement methods; (2) improved NDE physical measurement standards, calibration services, and document standards; and (3) information to relate NDE measurement results to material and systems properties and performance.

During fiscal year 1987, the Office had a staff of about 6 and a total operating budget of approximately $2.4 million.

Organization

Nondestructive evaluation is an interdisciplinary field. It requires knowledge of such subjects as materials processing, signal processing, optics, acoustics, and a broad range of physics, as well as the techniques for applying the basic principles to field applications.

The organization of the ONDE, requiring a wide range of talents, has a permanent nucleus to manage the interdisciplinary programs and to recruit the necessary talent from the relevant parts of NBS. They typically use a core of people with a long and productive background in the field of nondestructive evaluation, along with others on a less-permanent basis, who are needed to address particular problems of interest.

The Panel believes that ONDE, by drawing upon the interdisciplinary resources available within NBS, has devised a very constructive approach for tackling the problems of nondestructive evaluation. Such efforts are often difficult to implement in university or, for that matter, industrial research settings. The Panel is most enthusiastic about the way this has been done at NBS and believes that the approach carried out by ONDE is working extremely well.

Strategic Plan and Goals

As stated earlier, during fiscal year 1986, the Office had a staff of about 6 and a total operating budget of approximately $2.4 million. Support for this program has been approximately constant during the last 3 to 4 years. This represents a net decrease in effective operating budget of the order of 15 to 20 percent during the same period.

There is a critical need to improve productivity and to make the manufacturing process more efficient in the United States. Research is needed on a number of critical problems associated with manufacturing. One important need is that of furthering research and applying NDE techniques to automated manufacturing with the aim of measuring critical material and structural parameters during the manufacturing process and to use these measurements in a feedback loop to control the process itself. The development of sensors and appropriate techniques of NDE are needed for this purpose.

Previous Panels urged the ONDE to develop a strategic plan. The nucleus of a strong contribution by ONDE to research on applications of NDE to the manufacturing process has been developing for a number of years, and is now guided by a worthwhile strategic plan. As proposed in this strategic plan, ONDE would focus on four primary activities: (1) NDE for metal and ceramic powder production and consolidation, (2) NDE for metal processing, (3) NDE for composites and interfaces, and (4) NDE standards and methods.

This has resulted in a reduction of the total number of programs from 52 in 1985 to 24 in 1986. In the opinion of the Panel, this concentration has led to a more efficient way to use the limited resources available to ONDE.

Some Outstanding Programs

Automated Materials Processing

The Panel believes that the program on automated materials processing is a major opportunity for NBS to exert leadership in research on automated materials processing. The initial program is a study of powdered metal production. It is planned to demonstrate the use of NDE to evaluate the condition of the materials being used during various stages of production in a metal powder atomization system. The basic idea is to measure droplet formation and particle size, and to modify the atomization system by process feedback control.

A production system of this kind, costing approximately $1 million, has been built for this purpose. Initial project funding by NBS is on the order of $250,000; a total funding on the order of $1 million per year is needed. ONDE is attempting to start an industrial consortium with each contributor giving $75,000 per year in money or equivalent compensation (this may include industrial scientists working at NBS). They will need on the order of 8 to 10 industrial firms with a minimum of 4 to provide the bare minimum of financing required.

It is the opinion of the Panel that the use of an industrial consortium is an excellent way to obtain funding in a tight funding situation. It also provides a good vehicle for transfer of technology. Because of the importance of this work to the country, and the leadership role being exerted by NBS, the Panel suggests that it would be of great value, both to the country and to NBS, to provide further up-front funding to get this program under way as soon as possible and to encourage industry to contribute matching funds.

It has been most difficult to start programs of this type in the United States. There are very few, if any, examples of such a coherent research program in automated materials processing. ONDE has taken all the right steps to begin such a program. They started with a workshop on the subject that was well attended and most interesting to the industrial, university, and government research participants. They were also involved with a National Materials Advisory Board panel, examining the same subject, whose participation and leadership in this work enabled them to start a program of their own. In the opinion of the Panel, this is a first-rate example of how NBS can provide a good bridge between fundamental research and industrial needs.

Sensors for Steel Process Control

A second program of cooperation with industry, which is being conducted with the steel industry, is the measurement of temperature profiles of steel billets. A demonstration system has been set up as a cooperative effort with participants from the steel industry. Members of the Panel who saw this work found it most impressive. The type of cooperative effort is an excellent way of transferring technology and for obtaining financing for this type of applied research.

There are several other programs related to the steel and aluminum industry. A very similar program on temperature sensing is being started with the aluminum industry. Other programs involve measurements of surface condition of metals while being machined. This makes it possible to evaluate the condition of the surface or the steel being machined, and tool wear in lathes and milling machines.

In the opinion of the Panel, such research is most important to production efficiency in this country. There are also several other programs of importance, such as the measurements of composites, evaluation of ceramics, measurements of temperatures, and so on, all of which again should be encouraged as ones of vital importance for manufacturing.

Standardization Programs

Along with these programs, there are some of the more conventional NBS standards, such as those for acoustic emission and leak standards, which have been done well and are vital functions of NBS, that should receive continued encouragement and support.

Management of ONDE

The Panel was impressed with the leadership being exerted by ONDE. The Panel believes that there has been great progress in the last few years. The focus on national needs and organizing the internal program has been well thought out and is following an excellent strategic plan.

ONDE has started a Gordon Conference on NDE and workshops on materials processing subjects of great importance to this country. Staff members have typically started research programs of their own based on the findings of these workshops. By the use of consortia and other cooperative efforts with industry, they are attempting to find sources of other funding and to improve the transfer of technology to industry.

Typically, staff members publish most of their scientific results in journals such as the Journal of Applied Physics, as indeed they should. However, the Panel would encourage them to publish some of the results related to manufacturing in more general magazines and trade journals, such as the Journal of Research Development, the American Society for Testing and Materials Standardization Journal, Semiconductor International, Sensors, Electronics, Laser Focus, and Robotics World. ONDE has already begun to do this; more publications of this type will be needed in order to communicate their findings to the relevant people in industry.

Electron Devices

Last year, the Panel recommended that ONDE pay attention to the NDE problems of electron devices. Very little progress has been made in this direction. There is, already, in the Semiconductor Electronics Division, a strong program in many aspects of NDE of electron devices. However, the problems of packaging semiconductor devices, which are of critical importance to the electronics industry, are to a large extent structural in nature, and lend themselves well to the types of acoustic and photoacoustic techniques familiar to ONDE. A cooperative effort between ONDE and the Semiconductor Electronics Division could be a very productive way to make progress in this field.

The Panel recommends that NBS facilitate cooperative programs of research between ONDE and the Semiconductor Electronics Division on certain aspects of NDE of electron devices. In certain cases, such as packaging, the expertise of both groups is needed.

Survey of NDE Applications in Japanese Manufacturing

The Panel discussed the role of NDE in Japanese industry, where many sectors have stressed the development and operation of highly automated factories. There appears to be little available information on the extent of Japanese NDE use in manufacture for materials measurements, process control, and product evaluations, or as features in the design of industrial and consumer products.

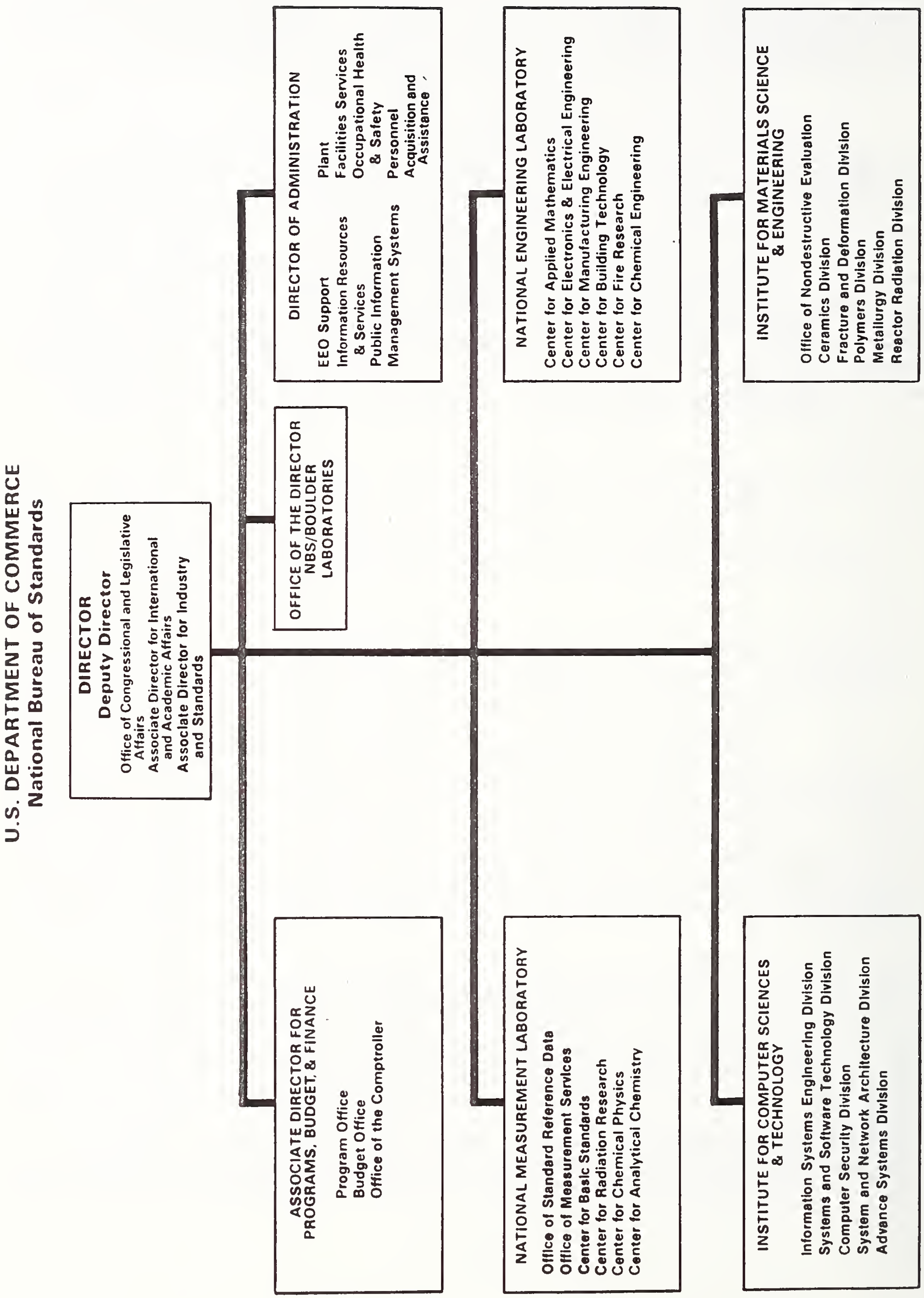
A strong indicator of NDE penetration into Japanese industry is the growth in research and development of sensors. Beginning around 1975, sensor research and development has had the sponsorship of a number of government research institutes, e.g., the Electrotechnical Laboratory, the National Research Laboratory of Metrology, and the Mechanical Engineering Laboratory. The work has also been coordinated by industry and professional organizations, e.g., the Japan Electronics Industry Promotion Association. Recent large-scale programs with important sensor technology components include the R&D Project of Basic Technology in Future Industries (begun in 1981) and the Research and Development Program for Advanced Robotic Technology (begun in 1983).

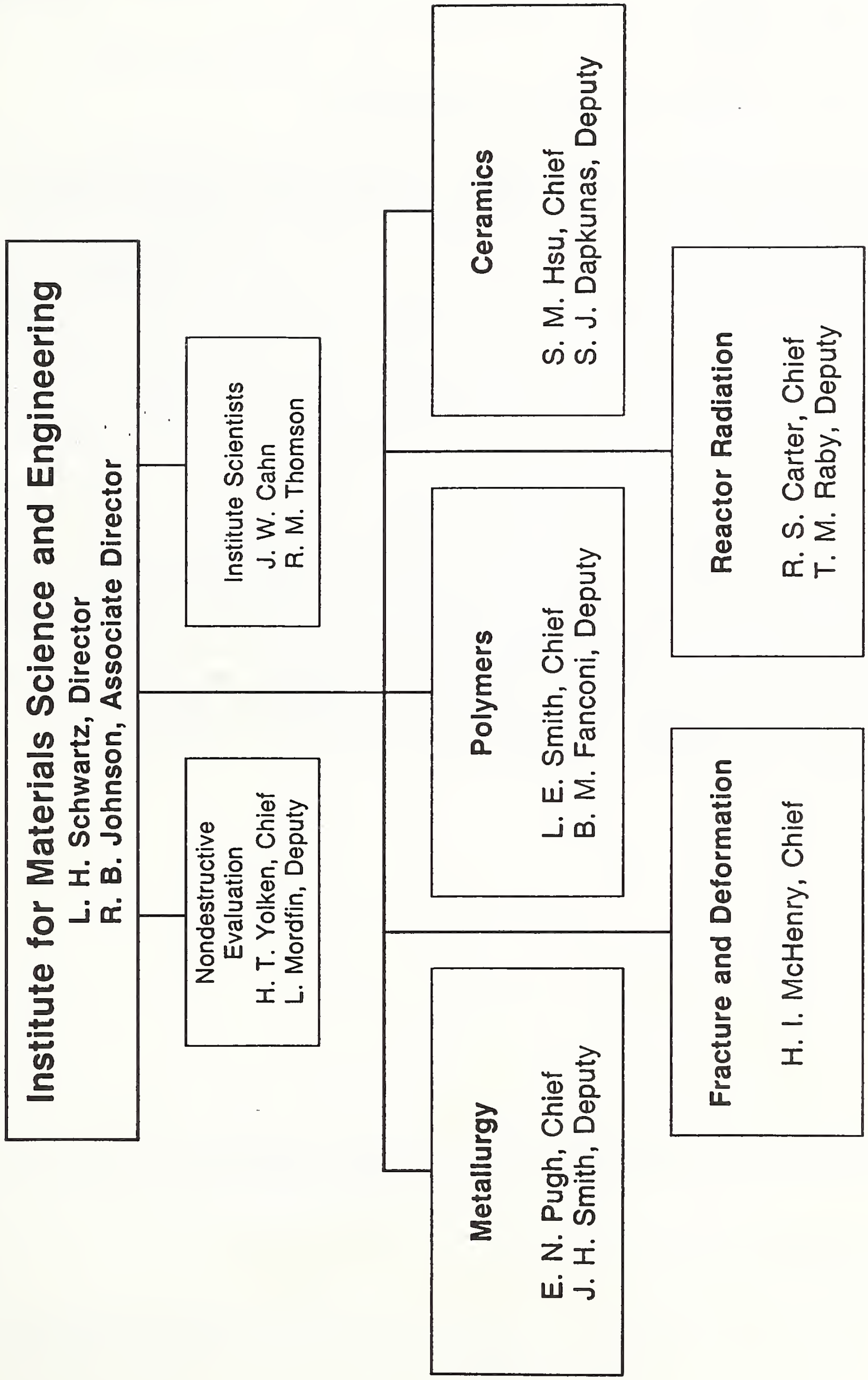
There is little applications literature on the introduction of NDE and sensors into materials and product development/manufacture in Japan. However, it is difficult to imagine that the advances that the Japanese have reported in factory automation and enhanced product features could have occurred without extensive NDE applications.

The Panel recommends that ONDE consider a survey of NDE applications in Japanese materials-intensive manufacturing to be implemented in part by visits to representative processing, electronic, and other factories. The survey, with ONDE initiative, might be organized under auspices of the National Research Council, the National Materials Advisory Board, or other appropriate agencies. The results of such a survey would be of substantial value in planning and resource allocation for NBS and other U.S. research and development in this area.

Funding Level

The Panel applauds the new initiative in direction and the research in the field of NDE at NBS. The Panel believes that the work is of great importance to the country, and that it is underfunded at the current time. The country would be served well by a considerably increased funding level for ONDE along with the provision of more people to enhance this effort. The current funding level is of the order of $2,400,000. The country would be well served by a 20 percent increase in funding level per year for the next 5 years. This would reinforce ONDE's initiatives in the transfer of technology to industry and would encourage private-sector involvement with their research.


U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
DIRECTOR
Deputy Director
Office of Congressional and Legislative Affairs
Associate Director for International and Academic Affairs
Associate Director for Industry and Standards
OFFICE OF THE DIRECTOR NBS/BOULDER LABORATORIES
ASSOCIATE DIRECTOR FOR PROGRAMS, BUDGET, & FINANCE
Program Office
Budget Office
Office of the Comptroller
DIRECTOR OF ADMINISTRATION
EEO Support
Information Resources & Services
Public Information
Management Systems
Plant
Facilities Services
Occupational Health & Safety
Personnel
Acquisition and Assistance
NATIONAL MEASUREMENT LABORATORY
Office of Standard Reference Data
Office of Measurement Services
Center for Basic Standards
Center for Radiation Research
Center for Chemical Physics
Center for Analytical Chemistry
NATIONAL ENGINEERING LABORATORY
Center for Applied Mathematics
Center for Electronics & Electrical Engineering
Center for Manufacturing Engineering
Center for Building Technology
Center for Fire Research
Center for Chemical Engineering
INSTITUTE FOR COMPUTER SCIENCES & TECHNOLOGY
Information Systems Engineering Division
Systems and Software Technology Division
Computer Security Division
System and Network Architecture Division
Advance Systems Division
INSTITUTE FOR MATERIALS SCIENCE & ENGINEERING
Office of Nondestructive Evaluation
Ceramics Division
Fracture and Deformation Division
Polymers Division
Metallurgy Division
Reactor Radiation Division


Institute for Materials Science and Engineering
L. H. Schwartz, Director
R. B. Johnson, Associate Director
Institute Scientists
J. W. Cahn
R. M. Thomson
Nondestructive Evaluation
H. T. Yolken, Chief
L. Mordfin, Deputy
Ceramics
S. M. Hsu, Chief
S. J. Dapkunas, Deputy
Polymers
L. E. Smith, Chief
B. M. Fanconi, Deputy
Metallurgy
E. N. Pugh, Chief
J. H. Smith, Deputy
Reactor Radiation
R. S. Carter, Chief
T. M. Raby, Deputy
Fracture and Deformation
H. I. McHenry, Chief

FUNCTIONAL STATEMENT

INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

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, and glasses; characterizes the structure of materials, chemical reactions, and physical properties which lead to the safest, most efficient uses of materials; improves materials technologies, provides the bases for advanced material technologies, in basic and high-technology industries, and encourages recycling; 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 NBS reactor facilities to develop neutron measurement methodology, develop sophisticated structure characterization techniques, reference data, and standards; participates in collaborative efforts with other NBS 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.

NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. 87-3610	2. Performing Organ. Report No.	3. Publication Date December 1987

4. TITLE AND SUBTITLE

IMSE Annual Report, 1987

5. AUTHOR(S)

Lyle H. Schwartz

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)	7. Contract/Grant No.
NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234	8. Type of Report & Period Covered 10/1/86 to 09/30/87

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

National Bureau of Standards
Institute for Materials Science and Engineering
Gaithersburg, MD 20899

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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 1987 Annual Report was prepared for the NAS-NRC Board of Assessment of the Institute for Materials Science and Engineering. This volume contains background information on resources, activities, and representative highlights of the Institute.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

National Bureau of Standards; Institute for Materials Science and Engineering; Review; resources; activities; highlights.

13. AVAILABILITY	14. NO. OF PRINTED PAGES
☐ Unlimited ☒ For Official Distribution. Do Not Release to NTIS ☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. ☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161	15. Price

USCOMM-DC 6043-P80