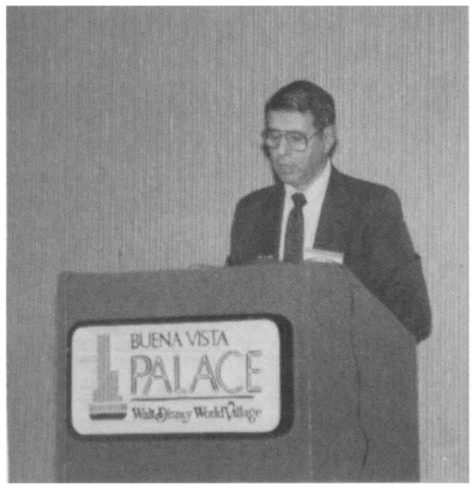
ASM Symposium Attendees Discuss Critical and Strategic Materials

The American Society for Metals (ASM) Materials Week '86 program (October 4-9, 1986 in Orlando, Florida) included a symposium on "Developments in Critical and Strategic Materials." Organized by D.M. Glancy (U.S. Department of Commerce) and sponsored by the ASM Government and Public Affairs Committee, the symposium featured the following presenters: Brian Benson (National Critical Materials Council) [read by D.M. Glancy]; Samuel Goldberg (INCO, USA; also a member of National Strategic Materials and Mineral Program Advisory Committee); Klaus Zwilsky (National Materials Advisory Board); James A. Ford (Aerojet Heavy Metals Co.; also president of Federation of Materials Societies) [read by Betsy Houston, executive director of Federation of Materials Societies]; Benjamin Wilcox (Defense Sciences Office, Defense Advanced Research Projects Agency); Robert J. Reynick (National Science Foundation); Lyle A. Schwartz (National Bureau of Standards); William L. Miller (U.S. Bureau of Mines); and Paul Maxwell (House Committee on Science and Technology who provided "A Congressional Perspective") [read by D.M. Glancy]. The symposium was chaired by John Durant of Vacuum Industries, Inc.

The National Critical Materials Act of 1984 (*See the BULLETIN, January/February 1985, p. 21-23; and May/June 1986, p. 33.*) was intended to provide a unified, informed governance of U.S. actions as applied to critical and strategic materials, their use, sources, stockpile, substitutes, and their definition. The law mandated the formation of a three-member Council in the President's Executive Office. After some delays and replacements, the Council has been formed. The Council members include Interior Secretary Donald P. Hodel, who is chairman of the Council; Thomas Moore, a member of the President's Council of Economic Advisors; and William Martin, Deputy Secretary of Energy. The Council's staff is headed by executive director Brian Benson.

Reading Benson's remarks, Glancy noted that "materials are invisible to the user" and that one of the Council's roles is to "increase public awareness." The Act assigns a broad charter to the Council, ranging from concern for "natural resources to how to apply research funds." The second part of the charter implies a new algorithm for prioritizing and ultimately supporting R&D, and this is why materials researchers will want to follow the progress of the newly constituted Council closely. The Council will begin a study of a "critical materials program" and "advanced materials R&D program." Considered on the critical list initially are "copper and aluminum (high-volume elements); cobalt, chromium, and ferrosilicates (steel alloying elements); and titanium and germanium (high growth potential elements)."



K. Zwilsky, National Materials Advisory Board.

The Council has not determined how to categorize R&D programs for the study. Possible schemes include organization by "materials type, by mission, by agency, by properties, by market/industry or by level of research (i.e., in terms of expected payback time frame analogous to DOD's scheme of 6.1, 6.2, 6.3...)." Other elements will be added to the Council's study of the implications of its charter, and Benson solicits input directly to him at (202) 634-1993.

Goldberg described the mission and activities of the National Strategic Materials and Minerals Program Advisory Committee (often called the "Mott Committee" after its chairman, Rear Admiral William C. Mott, USN, Ret.). This 25-member committee of private individuals advises, on a *pro bono* basis, the Secretary of the Interior on critical materials issues. Created in April 1984, the group made 15 recommendations in April 1986, including strong support for activating the Critical Materials Council. The committee's charter (originally two years) has been extended by 18 months, and the committee plans to be active in pushing for implementation of its recommendations. [Other than the recommendation to activate the Critical Materials Council, none of the 15 recommendations appears to impact materials research.] In Goldberg's view, the "Administration began by viewing the critical materials issue as hopeless but not serious—thus budget matters dominated policy." His committee, however, believes "the problems are serious, but not hopeless and will thus push for solutions."

Zwilsky recounted the history of the critical materials issue and identified three issue categories. First, the critical materials stockpile (now at about $11 billion) is managed by a bewildering combination of separate government offices including FEMA, GSA, multiple agencies, and finally Congress itself. A focus is needed, said Zwilsky, as would arise if a Presidential commission were appointed. Second is the issue of how to appropriately fund and direct materials science and engineering R&D. Can the post-World War II massive government funding continue as is? Should individual, entrepreneurial, multi-investigator diversity be encouraged with its preservation of creative serendipity, or should a Japan-style focus with central project planning be pursued? Congress and the National Critical Materials Council are studying this issue and public input is requested. The third issue concerns how regulatory vs. competitive environments affect materials science and engineering and what course can mitigate the worsening U.S. trade deficit.

Speaking for Ford, Houston pointed to a lack of coordination among agencies funding R&D and a lack of clearly defined goals, both of which can result in duplication and omission in R&D. The Federation of Materials Societies (FMS), which represents about a dozen scientific and engineering societies, believes the National Critical Materials Council should act as the focus and should coordinate across agencies and with other government concerns. FMS is promoting its own role as an interface between the materials community and the Council, and has recommended a list of 15 agenda items for the Council.

B. Houston, Federation of Materials Societies.

The agenda items enumerated by Houston suggested Council action in a subset of materials-relevant areas. Most, except for critical stockpile issues, are being explicitly

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addressed by the MSE Study of the National Research Council (NRC). [No proposal for coordination with the NRC study was made, however.]

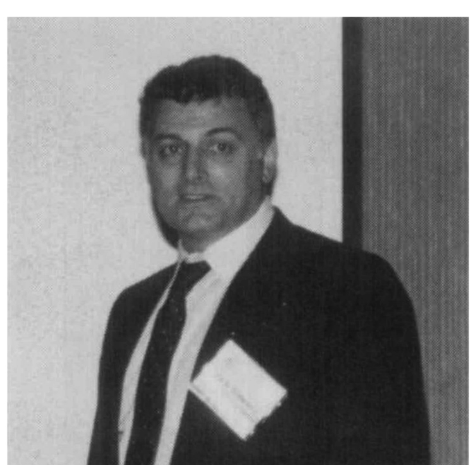
B. Wilcox, Defense Advanced Research Projects Agency.

Wilcox's remarks dealt primarily with advances in composites, linking them to critical materials issues because, in some instances, composites constitute substitutes. He alluded to specific advances in ceramic, metal-matrix, carbon-carbon and microcomposites (molecular-level reinforcement). The Defense Advanced Research Projects Agency (DARPA) supports R&D in these areas.

An inadvertently telling example was included in Wilcox's list. High-temperature, high-strength usage requires a strong, high-conductivity material, and niobium fiber-reinforced copper seems to be an excellent candidate. This material was fabricated and characterized ten years ago by Jose Bevk (now at AT&T Bell Laboratories, then a Harvard graduate student) under a National Science Foundation (NSF) grant supporting studies of superconductors. Whether a highly focused, project-oriented algorithm for supporting materials R&D could replicate this serendipity with a ten-year lead-time was a question that did not go unnoticed by the audience.

Reynick detailed the history and current activities of NSF's Division of Materials Research, which was initiated when NSF took over DARPA's Interdisciplinary Laboratories in 1971. Funds are divided among single-investigator research proposals, block grants to the NSF Materials Research Centers and Groups, national user facilities, and instrumentation (including local group facilities). At present the 26-member (Presidential appointees) National Science Board governs NSF, and NSF participates in the Interagency Materials Group to coordinate with other agencies. The trend toward encouraging interdisciplinary research continues, said Reynick, and is enhanced by interdivisional cooperation within NSF itself. Reynick closed by noting the existence of a gap between the university research base (concerned with creating knowledge, developing new concepts and materials, and education) and the industrial base (concerned with productivity and profit, quality, etc.). Saying that "condensed matter theorists do esoteric things and it's not clear how to translate [that] into materials development," Reynick described the NSF thrust as an attempt to help close that gap.

Schwartz, director of the Institute for Materials Science and Engineering at the National Bureau of Standards, indicated that the Institute hosts a large number of guest researchers, finding that an efficient technology transfer algorithm. The Institute currently runs with $33 million of the $276 million NBS budget and operates the NBS-wide nondestructive evaluation office. A sizable fraction of NBS funding originates from other agencies. New activities include an expanding program in advanced ceramics (aimed at finding the best-suited characterization methods), a proposed program in high-performance composites initially focused on polymer types, and a pending program in cold-neutron scattering characterization (the fate of which is now being decided for fiscal year 1987 by Congress). Another major research interest is intelligent materials processing systems, consisting of a process model, an intelligent (computer-based) control, and newly developed sensors, which may be the rate-controlling item for progress in this area. Schwartz cautioned the audience about an additional materials issue [which presumably should be noted by the National Critical Materials Council]. That issue is whether new materials technologies invented in the United States will also result in new products produced in the United States or, as is often the case, new products produced abroad.



L. Schwartz, National Bureau of Standards.

Miller emphasized that critical materials issues are naturally central to U.S. Bureau of Mines research. He indicated that there are 14 identified groups of such materials in addition to the major ones (i.e., chromium, manganese, cobalt, and platinum-group metals). Research there aims at substitution and at improved performance with reduced loss to corrosion, wear, and so on. One structural material he lauded is sulfur concrete, which displays superior structural properties.

Because the entire issue of critical and strategic materials is so broad and complex, materials R&D may not be recognized as a vital component in the immediate sense. It is thus understandable that most speakers at this ASM event encouraged public input to the process at this formative stage.

E.N. KAUFMANN

Metals Societies Honor Morris Cohen

During their joint meeting in Orlando, Florida, the week of October 5, 1986, both the American Society for Metals (ASM) and The Metallurgical Society (TMS) sponsored separate programs in honor of Professor Morris Cohen, Institute Professor at the Massachusetts Institute of Technology (MIT). ASM's Materials Science Division, Phase Transformations Committee sponsored the "Morris Cohen Symposium on Martensite." Three half-day sessions were held in the Great Hall Center of the Buena Vista Palace Hotel, ASM meeting headquarters. The first session dealt with martensite structure, the second with mechanisms and kinetics, and the third with structure/property relations.

The TMS Governmental, Energy, and Minerals Committee sponsored a one-day symposium, the "Morris Cohen Symposium on Future Directions of Materials Science and Engineering," in the Grand Ballroom of Marriott's Orlando World Center, TMS meeting headquarters. Professor Cohen's opening address for this symposium provided his overview of the history and evolution of materials science and engineering. He has a unique perspective on this topic, partly because of his chairmanship of the National Academies' COSMAT study which was completed twelve years ago. Subsequent speakers included Chairmen of the five panels of the national Materials Science and Engineering Study (chartered by the National Academies) and the Study Chairs, Merton Flemings and Praveen Chaudhari. (*See "TMS Considers MSE Study at Symposium Honoring Morris Cohen" in this issue.*)

On Tuesday evening, October 7, ASM and TMS also hosted a dinner in honor of Prof. Cohen. Addressing several hundred

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M. Cohen, Institute Professor at MIT.

guests, a series of speakers looked back on many years of association with Prof. Cohen and enumerated highlights of his career, any one of which would be enough to honor him. The list was impressively long. This event also marked Morris Cohen's 75th birthday and 50 years on the MIT faculty. In recognition of these milestones and his immeasurable contributions to metallurgy and materials science, an endowed chair in his name was created at MIT in the Materials Science and Engineering Department. Professor Cohen is a member of the Materials Research Society and was instrumental in launching the first MRS symposium on "Frontiers in Materials Education" in 1985.

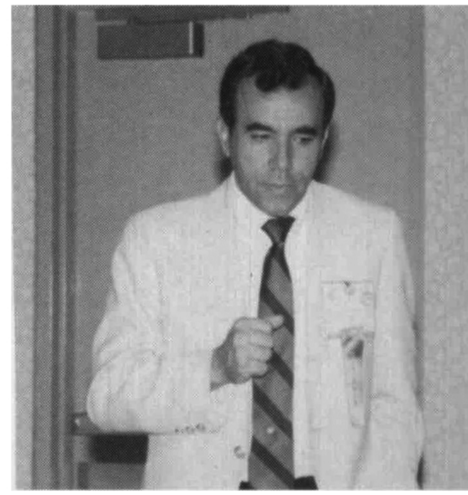
MRS and TMS Sponsor Surface Modification Symposium

The Materials Research Society and The Metallurgical Society (TMS) hosted a jointly sponsored symposium, "Surface Modification: Review, Update, and Tutorial," during the TSM Fall Meeting October 5-9, 1986 in Orlando, Florida. The one-day symposium, the first to be jointly sponsored by MRS and TMS, was organized by Anthony Giamei (United Technologies) from TMS and Paul Peercy (Sandia National Laboratories) from MRS. Chaired by Ram Kossowsky (Pennsylvania State University), the symposium's twelve invited speakers covered an impressively broad spectrum of topics relating to surfaces.

G.A. Somorjai (University of California-Berkeley and Lawrence Berkeley Laboratory) spoke on "Chemistry and Structure in Two Dimensions." He emphasized the vastly increased ability of today's characterization tools to reveal surface structure at the atomic level and how this is leading to the recognition of a great and diverse potential in engineering surfaces for use in catalysis, lubrication, etc. The point made most strongly was that the first few monolayers of a surface are not merely composed of structure and properties readily predicted from knowledge of the bulk. D.M. Mattox (Sandia National Laboratories) followed with a description of "Adhesion: A Basic Property Controlling Film Viability," which ranged from the practical aspects of the effect of desirable and undesirable surface contaminants and of surface roughness on film adhesion to the detailed interface chemistry affecting this field.

M.H. Jacobs (Ipsen Industries International) discussed surface-protective layer formation via plasma carburizing and plasma nitriding, with examples of industrial uses, in a talk entitled "Plasma Assisted Diffusive Processes." Two presentations concerning beam-related surface processing were given by E.N. Kaufmann (Lawrence Livermore National Laboratory) and C.J. McHargue, (Oak Ridge National Laboratory). In "Rapid Beam-Melting of Alloy Surfaces: Nucleation, Growth and Metastability," Kaufmann illustrated the use of electron and laser beams for producing rapidly solidified layers on metallic alloys. These layers are often found to consist of metastable crystalline or glassy phases. In "Ion Implantation and Ion-Beam Mixing," McHargue reviewed the use of ion beams to create surface alloys in both metals and ceramics and alluded to consequent property enhancement and industrial uses.

The morning session closed with a talk by J. Narayan (North Carolina State University) on "Transient Thermal Processing of Semiconductors." Narayan described how levels of electrically active dopants far beyond equilibrium solubilities can be



TMS program organizer A. Giamei (United Technologies).

retained in semiconductors through pulsed surface melting regimes and how subsequent transient annealing programs can remove crystal defects. Application to such processes as silicide formation and gate oxidation were presented along with detailed microscopic characterization of surface layer structure and morphology.

The second session continued the broad topical coverage. H.K. Yasuda (University of Missouri-Rolla) spoke on "Plasma Polymerization and Its Significance in Materials Science," emphasizing the unique properties of surface film and bulk polymers formed via the plasma method. J.A. Thornton (University of Illinois-Urbana) spoke on "Thin Film Deposition by Sputtering" and summarized the various alternative sputtering procedures, their pros and cons,

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MRS program organizer P. Peercy (Sandia National Laboratories) (left), and symposium chair R. Kossowsky (Pennsylvania State University).

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and effect on resultant film properties. A. W. Mullendore (Sandia National Laboratories) presented an overview of the history, current methodologies, and applications of the CVD process in "Science and Technology of Chemical Vapor Deposition."

Three materials-specific presentations rounded out this session: "Effect of Film Composition on the Corrosion Behavior of Ion-Plated TiC" by H. Yoon and W.B. Carter (Georgia Institute of Technology); "Influence of Surface Preparation on Tritium Permeation into 304L Stainless Steel" by D. A. Hardwick (Los Alamos National Laboratory); and the use of "Refractory Metal Ions in Arc Vapor Ion Deposition" for formation of refractory nitride coatings, by C. Bergman (Multi-Arc). Each of these presentations exemplified state-of-the-art surface modification applications while collectively confirming the wide variety of processes, properties and phenomena that fall within the surface modification field.

Researchers Discuss Advances in Hyperfine Interactions

During the week of September 8, 1986 more than 250 researchers, including over 100 from abroad, gathered in Bangalore, India, for the 7th International Conference on Hyperfine Interactions. Hyperfine interactions methods have advanced considerably since the last international conference on this topic three years ago, and many presentations were devoted to details of new techniques with greater resolution in the time and energy domain and greater use of advanced apparatus such as new lasers, on-line isotope separators at heavy ion accelerators, and so forth.

Hyperfine interactions as a class of techniques can often be a valuable adjunct to the more conventional approach to materials research. Many contributions to the Bangalore conference dealt with such applications. These techniques comprise experiments such as the Mössbauer effect, perturbed angular correlations and distributions of gamma radiation, nuclear magnetic and/or quadrupole resonance, muon spin rotation (*see "μSR-86: Report on the 4th International Conference at Uppsala" by K. Crowe and A.M. Portis in this issue*), and nuclear orientation at cryogenic temperatures. The hyperfine interaction itself is the interaction between the electromagnetic moments of the nucleus and the surrounding atomic and band electrons in the environment of the nucleus. Thus, the technique samples the material environment from the microscopic point of view of the nuclear site.

The Bangalore conference was organized by Drs. S.H. Devare, H.G. Devare, and

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Hyperfine Interactions: Lost in America

Hyperfine interactions is an excellent example of a field which suffers a lack of identity by virtue of being interdisciplinary. Most students of science will recognize the phrase "hyperfine interactions" as a phenomenon associated with atomic physics. It probably first came to their attention when they were studying the emission or absorption spectra of atoms where the concept of hyperfine structure in optical spectra caused by the interaction of the nuclear spin with the atomic electrons was introduced.

Hyperfine interactions, of course, derives its name from that phenomenon; but as the accompanying conference report illustrates, it is now a technique applied far more broadly than merely in optical spectroscopy. In addition to the materials-related topics described in the conference report, the technique is invaluable in the study of nuclear moments for nuclear physics purposes and in the fundamental study of the electronic structure and magnetic structure of materials.

Examining the demographics of the attendance from outside India at the Bangalore conference reveals that Europe was by far the best represented. From within Europe, West Germany was most evident. This is no accident. In West Germany a funding category within the ministry governing scientific research is labeled Nuclear Solid State Physics or Nuclear Solid State Chemistry. These terms include explicitly the interdisciplinary area covered by hyperfine interactions. In contrast, U.S. government funding agencies are strictly compartmentalized as atomic, nuclear, condensed matter, or materials areas and have no explicit category to support the border region work represented by hyperfine interactions. The work carried on in the United States is primarily funded, if it is accelerator-related, through nuclear physics funding. Similarly, some fraction of the work is related to chemistry departments on university campuses and could be funded through a chemical sciences budget, but this catch-as-catch-can way of deriving funds for a truly interdisciplinary field has been inadequate. Over the past ten years the practitioners in this field have slowly diffused to fields where greater support may be garnered.

Two subdisciplines of hyperfine interactions, the Mössbauer effect and nuclear magnetic resonance, have somewhat escaped this fate. They existed before the advent of the catchall terminology, "hyperfine interactions," and have developed their own identities within the condensed matter physics and chemistry communities. The Mössbauer effect has demonstrated applications for steels, and magnetic resonance has been extended into biological and medical applications with substantial impact. In spite of this, other less visible areas of hyperfine interactions have found it difficult to sustain research programs. The dearth of support in this area has gone on so long that students have not been produced in the field, and it is unlikely that a healthy hyperfine interactions program in the United States can be regained.

Perhaps for the hyperfine interactions field (especially in view of the excellent progress being made in Europe and also in Japan), this is no great loss for the scientific community as a whole. But the hyperfine interactions field in the United States may well represent the fate of any crossdisciplinary thrust which does not benefit from explicit recognition at the potential sources of support. There is clearly a continuing need to advise research supporters about the value of a variety of techniques—as obscure as they may appear—and it is incumbent upon not only the practitioners of the techniques, but also those in allied fields to bring this to the attention of those who determine funding directions.

In materials research and development—by nature interdisciplinary—the analogous problem does not exist as a global one. Funding categories labeled "materials" are present in most funding agencies now. In addition, categories with applications-oriented titles such as electronic materials can also be found. However, the danger is that at the most fundamental level the less popular research directions will be overlooked because they do not fit neatly into an appropriate funding category. Researchers should be encouraged to remain aware that important areas could be overlooked and work to see that the fate of those areas is not that of hyperfine interactions in the United States.

E.N. KAUFMANN

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Chairs of the Seventh International Conference on Hyperfine Interactions (left to right): H.G. Devare, S.H. Devare, and P.N. Tandon, all of the Tata Institute of Fundamental Research, Bombay.

P.N. Tandon, all of the Tata Institute for Fundamental Research in Bombay. With the help of an international advisory committee, they prepared a program that included materials related advances of the following types.

Talks were presented on the application of hyperfine interactions to amorphous metals for both structural and magnetic studies and to the microscopic processes involved in eutectic solidification. Also, muon spin rotation was described in applications to metals, to polyacetylenes, to solids under high pressure, and to heavy-fermion superconductors. The heavy-fermion systems were also studied using other gamma-ray and nuclear spectroscopic techniques. The description of the implantation into alkali metals of magnetic impurities was a highlight of the conference. This method provides an artificial environment for the magnetic ion where local moment effects under effective negative pressures can be studied. From a materials point of view, the implications of local moments implanted into metals such as the alkalis have yet to be recognized.

The topic of spin glasses as studied by various techniques occupied the bulk of one session. In addition, actinide metals under high pressures as well as metals containing gases such as helium and/or hydrogen have been studied by a variety of hyperfine techniques. Finally, the application of hyperfine techniques to a variety of semiconductor-related problems was described, including such systems as indium vacancy complexes in laser-annealed silicon and other impurities in silicon and germanium.

The general utility of hyperfine interactions techniques in studying condensed matter phenomena has been recognized for some time. In fact in 1980, the Materials Research Society held the first symposium on the applications of such techniques to materials science (*Nuclear and Electron Resonance Spectroscopies Applied to Materials Science*, Vol. III, MRS Symposia Proceedings, 1981). The practitioners of hyperfine interactions originate in many disciplines, including metallurgy, chemistry, biology, and atomic, nuclear and solid-state physics. The field, therefore, epitomizes an interdisciplinary field in which the expertise of a variety of specialties is required to pursue successful investigations. The next conference in this triennial series is scheduled for 1989 in Prague, Czechoslovakia.

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