

the development of oxidation-resistant coatings to "enable the development of CMCs suitable for applications that demand longer component lifetimes" such as thermally loaded gas turbine engine components; and the development of a viable interface for oxide CMCs, focusing on "weakly bonded, thermally stable oxide coatings (e.g., rare-earth phosphates of the general formula  $M^{3+}PO_4$ ) [and] the development of oxide composites that do not require fiber coatings (e.g., porous

matrices)." To enhance creep resistance, the committee recommends studies on "mechanism(s) by which SiC nanoparticle dispersions inhibit creep in bulk oxide ceramics," the mechanism by which "certain solutes lower the creep rate of bulk polycrystalline oxides (e.g., yttria in alumina)," and the use of "multiphase microstructures to promote increased high temperature microstructural stability (e.g., resistance to grain growth)." Of a lower priority, the committee recommends con-

tinued studies on Si-B-N-C amorphous fibers in the area of non-oxide fibers; according to the report, "for many applications, adequate properties have already been attained" in this area.

To obtain a copy of the report, *Ceramic Fibers and Coatings: Advanced Materials for the Twenty-First Century*, contact National Academy Press, Box 285, 2101 Constitution Ave., N.W., Washington DC 20055; 800-624-6242; website <http://www.nap.edu>. □

## PUBLIC AFFAIRS FORUM

*An analysis of public policy issues and how they affect MRS members and the materials community...*

### FMS Meeting Addresses Materials R&D Role in the U.S. Scientific Innovation Process

The 15th Biennial Conference on National Materials Policy, held in Georgetown on May 17-19, 1998, addressed the topic, "Maximizing Return on U.S. Research and Development," with a focus on case studies in materials. The conference was sponsored by the Federation of Materials Societies (FMS), an umbrella organization whose members and affiliates represent the professional societies, universities, and National Research Council organizations which are involved with materials science, engineering, and technology.

The topic was chosen for its importance and timeliness. The end of the cold war and the globalization of science, technology, and the marketplace have placed new importance on federal sponsorship of research and development. These global currents have raised new questions about what R&D should be done and who should pay for it. They have already had a profound impact on materials R&D in the United States. They will continue to affect what materials researchers do, how they go about it, and how effective they can be in serving the national interest.

The conference began with overviews from Senator Jeff Bingaman (D-NM); Ray Kammer, Director, National Institute of Standards and Technology; and Joseph Bordogna, Acting Deputy Director, National Science Foundation. These talks stressed the importance of the innovation process and the special role of materials R&D in this process.

Bingaman spoke of his efforts to strengthen R&D overall, providing S. 1305 as an example, which is his co-sponsored bill that would double R&D expenditures over a period of years. He indicated his

concern that although overall R&D spending would increase in the President's budget for the next fiscal year, much of that increase would go to the National Institute of Health, with other nondefense spending actually decreasing. He said that half of the U.S. productivity improvement is due to innovation and that the country needs to develop a stewardship model for innovation. He said that the federal government might best help innovation by doing so indirectly, by supporting institutions that foster innovation.

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Some of Bordogna's key points were that major advances in understanding, controlling, designing, and fabricating materials have been made in this century. Materials science and engineering (MSE) has led to exponential improvements in performance of machines and devices and is a basic engine for technologies creating new wealth. Nonetheless, society understands little of what goes into development of new materials and processes, and tends to take materials for granted. New and improved materials and processes will play a central role in improving the future well-being of the United States and the planet.

Arden L. Bement, Jr. (Purdue University) reported on the international MSE

benchmarking study he chaired recently ("International Benchmarking of U.S. Materials Science and Engineering Research," National Academy Press, 1988). His study showed that the United States leads in some areas, although not all. He emphasized that the U.S. lead is threatened in several areas. The U.S. innovation process is a major determinant in the country's overall world pre-eminence. Kammer outlined the numerous NIST programs aimed at enhancing innovation in materials and other industries.

Following these introductory addresses, industrial speakers talked about present and projected economic impacts of materials R&D. Praveen Chaudhari (IBM) summarized the incredible and continuing advances in information technology through advances in materials and materials processing. Roger Heimbuch (General Motors) described the important impact of materials technologies on automotive performance and competitiveness of the industry, and discussed the problems encountered in the vital task of introducing new materials and processes into automobile manufacture.

The theme of the difficulty of introducing new materials and processes into the marketplace was echoed by Azusa Tomiura, who headed Nippon Steel's venture into the new materials area. It was further echoed by David Ragone (Ampersand Ventures) who spoke from a venture capitalist's point of view. New materials (and new processes) often take 20 years to successfully reach significant production levels. A simple "present value" calculation shows that a new business based solely on a new material or process is totally uninteresting to a ven-

ture capitalist. Yet those new materials and processes are vital to the long-term survival of present industries and the development of new industries. Thus, with a national interest but not a local commercial interest in materials R&D in the early stages, this area clearly requires government support.

The need for government involvement in R&D support has long been recognized with respect to technologies needed by the government to maintain national security. When these technologies are dual use, as is often the case for materials, government support has been key to commercial needs as well. At issue is whether other issues of national imperative (such as global competitiveness and environment) will be seen as justifying similar government support at and beyond the invention stage.

The next formal session dealt with specific case studies on economic and social impact of new materials and processes. Paul Percy (Sematech) further expanded on the impact of semiconductors on the economy. These are the heart of an electronics industry that is approaching one trillion dollars in annual revenue, and making a major contribution to the growth of the U.S. economy. Jim Williams (General Electric) emphasized that the competitiveness of the U.S. aircraft industry is due in significant measure to government support, largely in connection with military procurement. That support is now much reduced. Moreover, support where it exists is not always directed to critically important issues, such as improved metallic alloys and processes for engine components. He spoke of the great difficulty of introducing "other" materials into aircraft. Reza Abbaschian (University of Florida) described two successful materials-based companies which grew out of federally sponsored research programs. These companies, like those described by Ragone, became of interest to venture capitalists only after a decade or more of supported R&D.

In a final talk, Rep. Vernon Ehlers (R-Mich.) summarized the status of the National Science Policy Study he chairs. He said that with the end of the cold war, and the globalization of science, technology, and the marketplace, a new paradigm of science support is needed in the United States. Following the reports of workshop chairs, Allan Bromley (Yale University) acted as respondent and in the course of his remarks again emphasized the importance of materials R&D to the overall innovation process and to the economy as a whole. He urged practitioners in the materials field to relate to members of Con-

gress, not just when a specific issue arises, but on a frequent basis to help them stay aware of the importance of materials specifically and of R&D generally to the future well-being of the country.

Following the formal presentations, the participants broke into three workshops to formulate recommendations for policymakers. Based on the formal presentations and discussions immediately following, the participants agreed that the workshops would begin with five "givens":

1. Technology developments are critical to productivity gains (and productivity gains are essential to enhanced standard of living).

2. Materials developments are critical to technology developments in most other fields.

3. The nature and purpose of government support of R&D is changing because of the end of the cold war, global competitiveness, and global science and technology.

4. Because of inadequate investment from the private sector, government has a crucial role to play in development of basic materials technologies, and of young people to carry them forward.

5. Because of inadequate investment by the private sector, it is also in the national interest for government to play a role in enhancement of materials innovation in the private sector.

Workshops were chaired by Williams, Abbaschian, and Lyle Schwartz (Associated Universities, Inc.). The following summaries and recommendations resulted from the workshops:

■ **Issue:**

The long time required for commercialization of new materials and processes means that, without adequate federal support, needed materials technologies will not be available in a timely fashion to address the public's desire for sustainable development.

**Recommendations:**

The federal role in materials R&D must include and go beyond the "invention" stage to comprise much of the early innovation process.

The materials community needs to find better ways to help the public and policymakers understand the value of new materials technologies.

The materials community should play a stronger role in the political process. Materials arguments can and should be made in the context of jobs, productivity, and sustainable economic growth.

■ **Issue:**

The primary role of materials technolo-

gies in solutions to environmental problems is not recognized or on the agenda at high levels in government, or adequately on the agenda of the public or educators. Economic and environmentally sustainability issues critically depend on the introduction of new materials and on processing, including recycling.

**Recommendations:**

The materials community should request government agencies' responses in environmental initiatives to include materials issues.

The materials community should educate senior government officials.

The materials community should support ABET initiatives to incorporate environmental issues in college level curricula of materials and other departments.

The materials community should do a better job of engaging the public and of educating them as to the importance of materials in their daily lives.

The government, industry, and universities should expand international collaborations and agreements with regard to materials and the environment. It is no "solution" if smaller materials industries are simply driven off shore by environmental regulations.

The government should support synthesis and processing R&D with the goal of reaching zero emissions in manufacturing processes.

■ **Issue:**

The federal government does not have a coherent or coordinated materials policy.

**Recommendations:**

The federal government should re-establish a Subcommittee for Materials in the National Critical Technologies Council.

The federal government should carry out a follow-up study to the Bement benchmarking study in order to study the status of small-scale materials R&D, and of synthesis and processing facilities.

The federal government should continue to survey government agencies to determine and evaluate the current "investment portfolio," taking into account new national needs as they become evident. Surveys were made in 1993 and 1995 but, for example, how much is invested in sustainable development is unknown because few agencies list such work under this mission description.

MERTON C. FLEMINGS

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