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

Workshop Identifies Opportunities for Materials Researchers

A workshop on accomplishments and opportunities in condensed matter and materials physics was held in Washington, DC on June 1–2. Sponsored by the Solid State Sciences Committee and two American Physical Society Divisions, the workshop provided input to a newly formed National Research Council Committee on Condensed Matter and Materials Physics, chaired by Venky Narayanamurti (University of California—Santa Barbara) that has been charged with preparing a scholarly assessment of the field. The last assessment occurred a decade ago, *Physics through the 1990s: Condensed Matter Physics* (National Academy Press, Washington, DC, 1986).

The meeting began with a session on "Federal Perspectives on Science and Materials," featuring presentations by William C. Harris, Assistant Director for Mathematical and Physical Sciences at the National Science Foundation, and Pat Dehmer, Associate Director of Energy Research for the Office of Basic Energy Sciences. Both speakers described a future of constrained resources for science in which it will be impossible both to respond to exciting new opportunities and to continue all activities in the current portfolio. All aspects of the science enterprise must be questioned as to what systemic changes would be necessary to ensure that American science will still be world class in 2010. The quality of science education needs to be re-examined at all levels. Dehmer urged the workshop to search for connectivity in interdisciplinarity, in connections across spatial and temporal scales, in the increasing complexity of interlinked phenomena, and between fundamental science and technological advances.

The second session focused on the "Future of Condensed Matter and Materials Physics." Looking at opportunities in theory, David Nelson (Harvard University) said physics needs to branch out into new areas and be defined by its methods and outlook rather than the details of the subject matter. Areas particularly ripe for such an approach include polymer science and biophysics. Marc Kastner (MIT) described the interrelationship between scientific breakthroughs and technological progress in the area of artificial nanostructures. Major advances over the past decade such as the fractional quantized Hall effect, universal conductance fluctuations, and single electron phenomena have been enabled by advances in materials that were motivated by technological needs. While Moore's Law, predicting the exponential increase in semiconductor technology will eventually fail, most likely due to economic rather than scientific circumstances, the demand will continue for increasingly powerful computers. This presents a period of opportunity for condensed matter and materials scientists, but only if they act quickly and consider the economic as well as scientific and technological implications of their work. Most of the work in Kastner's talk came from AT&T Bell Laboratories and IBM, two research giants that have undergone tremendous change. He asked what sort of institution might provide a similarly fertile ground in the coming decade, pointing out the importance of a critical mass of activity and the value of institutions with missions. He contrasted such an institution with universities which are missing a research-driven mission and lack the interdisciplinarity that made many of the advances of the past decade possible. Zachary Fisk (Florida State University) described some of the major advances in new materials in the last decade, including most notably high temperature superconductivity. These compounds differ from their predecessors in their complexity, which Fisk views as a key to the future. Like Kastner, he emphasized the importance of research institutions with a long history, critical mass, and a staff knowledgeable about a wide range of phenomena.

The third session focused on "Accomplishments and Opportunities in Condensed Matter and Materials Physics," with presentations on the role of computation; surfaces, interfaces, and thin films; optical materials and phenomena; measuring single biomolecules; electronic and magnetic materials and phenomena; macromolecular materials; and nonequilibrium phenomena. A theme reinforced by these presentations is the increasing complexity of phenomena along with the expectation that this will be a key for future progress. Studies spanning several orders of magnitude in time, energy, and/or length scales are providing insights. High performance computing has made the theoretical treatment of such problems tractable in some cases, and computing power is expected to increase according to Moore's Law for the next decade. Within a single material, complexity is increasing as increasing numbers of elements are combined in true compounds, such as the high-temperature superconducting quaternaries. Artificially structured materials allow ever more complicated structures unavailable in nature. Increasingly complex processing of "traditional" materials also leads to structures with previously unachievable properties. Gaps between materials classes are also fruitful areas for both scientific and technological progress, for example, organic-inorganic or crystal-glass-polymer materials systems.

The second day of the workshop began by considering infrastructure and policy issues. Kumar Patel (UCLA) described the research university as an "ivory tower under siege." Historically, research in universities has been a curiosity-driven one-person affair, with connections between the research and its end users left to others. The role of academics in society is changing, and the federal government is looking for scientific *leaders*. The reward structure must be changed, and undergraduate education needs to be better connected to research.

Al Narath (Lockheed Martin) and Lyle Schwartz (National Institute of Science and Technology) see government-university-industry partnerships as increasingly necessary, due in part to the withdrawal of industry from long-range work needed to ensure future economic success. Rather than the competition and tension that have characterized interactions among disciplines and institutions in the past, greater emphasis is needed on collaboration and cooperation. Condensed matter and materials physics is particularly amenable to inter-institutional partnerships. An interactive *system* of research and development institutions with broad-based support is needed in the political as well as public arena. Lack of a sustained public policy with regard to such partnerships as well as intellectual property matters currently hinder inter-institutional partnerships.

In addition to the talks, breakout sessions focused on various technical subareas of condensed matter and materials physics and other issues, from facilities (large and small) to demographics and the roles of research universities and partnerships. The Committee on Condensed Matter and Materials Physics will shortly issue a research briefing on the workshop. The Committee has a website at www.nas.edu/bpa/cmmp.html and encourages input about accomplishments of the past decade and future opportunities and issues facing the field.

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https://doi.org/10.1557/S0883769400035648 Published online by Cambridge University Press

MRS Internet Journal of Nitride Semiconductor Research

(MIJ-NSR)

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