Frontiers of Materials Research: A Decadal Survey

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In 2007, the National Academies in the United States published a comprehensive report outlining opportunities and challenges in condensed-matter and materials physics from 2010 to 2020, highlighting opportunities for materials research and recommending specific steps to realize the full potential of materials research. The report identified six areas—complex emergent phenomena, energy, processes far from equilibrium, biological phenomena, nanoscience, and information technology—as being especially critical. The predictions have been accurate, and progress in these six broad areas, especially through a materials lens, has been enormous.

Recently, the US Department of Energy (DOE) and the National Science Foundation (NSF) requested a new decadal survey of materials research. The National Academies will issue a report in 2018 that will offer guidance to federal agencies that support materials research, science policymakers, and researchers in materials research and other adjoining fields. The report will articulate the status of and promising future directions for materials research in the United States in the context of similar efforts worldwide. For this assessment, materials research will be considered broadly in terms of material type, forms/structure, property, and phenomenon, as well as the full breadth of approaches to materials research (e.g., experiment, theory, computation, modeling and simulation, instrument/technique development, synthesis, characterization).

This report will also evaluate recent trends in R&D investments by using case studies of representative areas of materials research that have either experienced recent growth or are anticipated to see significant near-term growth. Based on these trends, the report will recommend steps the NSF and DOE might take to secure progress and to enhance collaboration and coordination of such research support for identified subfields of materials research.

As part of this effort, the Academies are assessing the progress and achievements in materials research over the past decade. To accomplish this, they are seeking community input on the future of materials research. As one step in this input gathering process, a town hall meeting was held at the 2017 MRS Spring Meeting in Phoenix, Ariz., to obtain the perspectives of MRS and its members and to see where the Society envisions opportunities and gaps in materials research in the next decade. Erik Svedberg, study director from the National Materials and Manufacturing Board, and Laura Greene, professor of physics at Florida State University, discussed how the *Frontiers of Materials Research: A Decadal Survey* looks at defining the frontiers of materials research, ranging from traditional materials science and engineering to condensed-matter physics.

In this session, areas discussed included achievements and principal changes in the R&D landscape; identification of key materials research areas that have major scientific gaps or offer promising investment opportunities from 2020 to 2030; and challenges that materials research may face over the next decade and how these challenges might be addressed.

Materials topical areas discussed at this town hall as being very relevant in the coming decade included characterization (moving from *ex situ* to *in situ* to *in operando*); characterization over a broader range of length scales; biomedical applications of materials; quantum materials and quantum computing; traditional materials (cement, steel) made in different ways; post-Si transistors; and aerospace materials. There are many drivers for future materials research, two examples being the Internet-of-everything and next-generation computers. The role of computation and data analytics also continues to grow.

In the area of materials fabrication, the rise of 3D printing and additive manufacturing was discussed and identified as being especially crucial, along with manufacturing institutes coupling public and private R&D that could be a model for the future, and green products that are less energetically expensive and more sustainable and economical.

Today, science has become more of a global enterprise, with new, strong players relative to a decade ago. It was emphasized that interdisciplinarity demands the free flow of people across political borders. China has become a leading source of technical papers, and there are large efforts overseas (e.g., Graphene in Europe, Korea Institute of Basic Science, Japan Nanotube project) to establish flagship programs. The question was asked—can MRS and the National Academies promote new methods for (international) collaborations? The field of materials research has always been interdisciplinary, but understanding the need for systems-level thinking is becoming more pervasive in the field. A diverse (geographically, disciplinary training, gender) workforce is needed.

Several additional similar town hall-type sessions will be conducted by the Academies at various conferences before the new decadal study report is published. Visit **www.nas.edu/materials** to learn more about the study and to provide further input for the decadal report.

Considerations for technology and innovation

- What is the best method to accomplish tech transfer in a timely fashion?
- How can we best capture patentable ideas?
- How can we facilitate the development of prototypes in materials-based startups?
- Are the Fraunhofer Institutes in Germany a good model for technology innovation and transfer?
- Is the US FDA timeline too long for medical devices and applications?

https://doi.org/10.1557/mrs.2017.153 Published online by Cambridge University Press