

Condensed-Matter and Materials Physics: The Science of the World Around Us

An Interim Report

CMMP 2010: An Assessment of and Outlook for Condensed-Matter and Materials Physics
Chaired by Millie Dresselhaus (MIT) and Bill Spencer (SEMATECH, retired)

CMMP 2010 Committee

Mildred Dresselhaus, Co-chair, Massachusetts Institute of Technology

William Spencer, Co-chair, SEMATECH

Gabriel Aeppli, University College London

Samuel Bader, Argonne National Laboratory

William Bialek, Princeton University

David Bishop, Bell Labs/Lucent Technologies

Anthony Cheetham, University of California at Santa Barbara

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Steven Kivelson, Stanford University

Andrea Liu, University of Pennsylvania

Paul McEuen, Cornell University

Karin Rabe, State University of New Jersey, Rutgers

Thomas Theis, IBM T.J. Watson Research Center

Task of the Committee

1. Review recent accomplishments and new opportunities in the field.
2. Identify the potential future impact of CMMP on other scientific fields.
3. Consider how CMMP has contributed and will likely contribute to meeting national societal needs.
4. Identify, discuss, and suggest priorities for construction, purchase, and operation of tools and facilities.
5. Make recommendations on how to realize the full potential of CMMP research.
6. Examine the structure and level of the current research effort in CMMP. Gather information on the performing institutions, different levels of aggregation of researchers, the role of the research community and performing institutions in initiating research, the relationship between research opportunities and the current structure of the research effort.

Sketch of Workplan

- In-person meetings held to gather data, involve the community, generate ideas, hold discussions, and build consensus
 - Town Hall meetings, Focus group sessions, Four CMMP 2010 committee meetings
- Interim Report was released September 14, 2006
- Target release of approved prepublication draft of final report is April, 2007
 - Final editing, design, layout, illustration, and publication by the National Academies Press will occur afterward

CMMP 2010 Community Input

- Eight focus groups held to date at universities and national laboratories
- Town Hall meetings:
 - APS March meeting (March 12, 2006)
 - ACS spring meeting (March 28, 2006)
 - MRS spring meeting (April 18, 2006)
 - AVS meeting (November 15, 2006)
 - MRS fall meeting (November 30, 2006)
- Public E-mail Box: cmmp2010-input@nas.edu
(all input received posted on committee website)
- Committee website:
<http://www7.nationalacademies.org/bpa/CMMP2010.html>

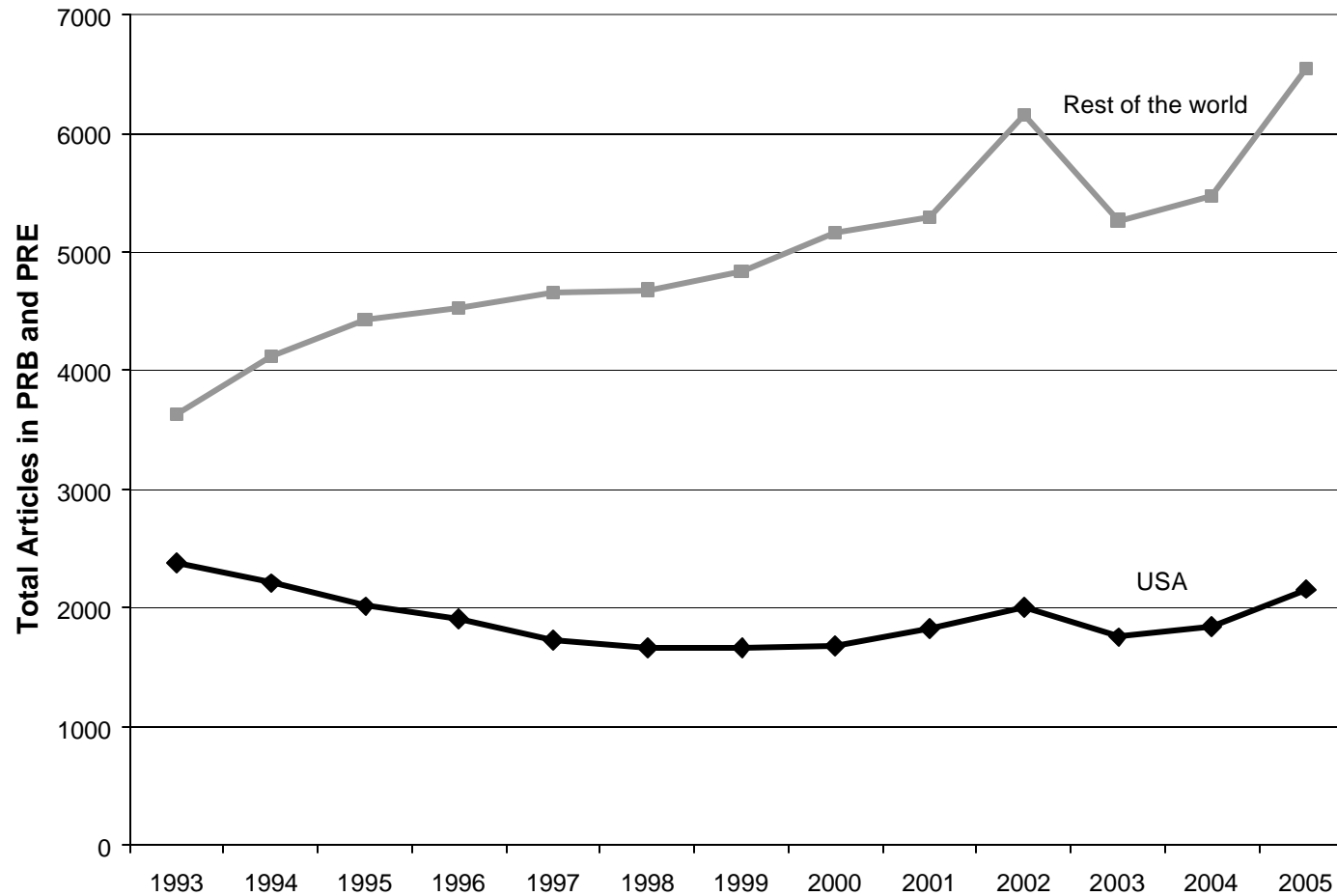
Interim Report: Introduction

- CMMP: the discovery, understanding, and exploitation of new materials and phenomena
- Fundamental and applied research in CMMP are inherently intertwined
- Research in CMMP is supported through federal sources and private investment
- Industrial and national laboratories have “evolved”
- Community consensus (reached through town meetings, focus groups, and committee members) to focus on challenges for the field

Eight Challenges for CMMP

1. How do complex phenomena emerge from simple ingredients?
2. How will we generate power in the future?
3. What is the physics of life?
4. What happens far from equilibrium and why?
5. What new discoveries await us in the nanoworld?
6. How can we extend the frontiers of measurement and prediction?
7. How do we revolutionize the information age?
8. How can we inspire and teach others?

Publication Trends



U.S. leadership in CMMP articles published in leading journals, *Physical Review B* (PRB) and *Physical Review E* (PRE), is eroding.

Warning Signs

- With the changing focus of industrial research laboratories and increasing investments abroad, US leadership in CMMP is uncertain
- Flat funding of CMMP over the last decade
- US is not participating well in the world growth of the field
- Recent advances and discoveries in CMMP occurring elsewhere

Some difficulties encountered with the interim report

- The core intellectual issues of our field are hard to explain in single punchy sentences.
- A report written by a committee tends towards the bland.
- It is difficult to go beyond anecdotal evidence concerning the many serious (even critical) issues that many of us feel face our field.

The fundamental issues in CMMP tend to be hard to explain in a single “punchy” sentence

Excerpts from Elihu Abrahams CMMP2010 Community Input

- “This report is seriously deficient and misdirected. Instead of focusing on the true frontiers of our science, it devotes itself to the same sort of peripheral issues that have constantly plagued such reports in the past.”
 - Response: This is an *interim* report from the committee and is focused on communicating to policy makers. The interim report also allows feedback from the community on the science topics.
- “If CMMP2010 is not going to mention, let alone strongly emphasize, fundamental issues in our science, who will?”
 - Response: We agree.
- “Where are the spectacular natural phenomena whose explanations are at the frontiers of research? ... Where is one of the greatest challenges of all – that of the strong correlation many-body problem? Where is high-temperature superconductivity? Where is quantum criticality? Where is magnetism? Where is the metal-insulator transition? Where are new methods for electronic structure? Where is low-dimensional physics? Where are non-Fermi liquid metals? Where are heavy electrons? ...”
 - Response: These topics belong in the final report. We cannot do them justice in a short document like the interim report. Our challenge is to include these topics in the final report, which is not yet written.

We have little more than anecdotal evidence on many important issues

- E.g. strong feeling that the individual investigator is in trouble, and increasingly inadequately funded (especially in experiment).
- We would like more input from the community concerning priorities for future facilities.

Proposed workshop on facilities for CMMP research

- Proposal to convene a government and scientific stakeholders workshop to evaluate future facility needs for the CMMP community
- “Facilities” range from the large government laboratories supported by NSF and DOE, to mid-scale facilities at Universities.
- Purpose is to generate ideas and consensus for recommendations concerning the facilities priorities of the CMMP community.

Final Report

- Will be released in spring 2007
- Will address questions such as:
 - How should CMMP research by single investigators be supported to keep it focused on addressing the challenges we have just discussed?
 - How can we promote and reward high-risk, high-creativity research?
 - How can we tackle larger-scale, longer-term problems that require the coordinated work of large teams?
 - What are the future instrumentation and facility needs for CMMP?
 - How can we develop, attract and retain the best scientific talent to ensure the continued health of the field, learning both from our own experience and from that of other countries?
 - Could we be spending the research funding we have more effectively? If resources are limited, what are the most critical research problems that should be given highest priority?