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NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS
Board on Physics and Astronomy
Plasma Science Committee

FINAL TECHNICAL PROGRESS REPORT
to the
Department of Energy
on the

Plasma Science Committee (PLSC)
and the Panel on Opportunities in Plasma Science and Technology (OPST)

Grant No. DE-FG05-88ER53279

This progress report covers activities of the Plasma Science Committee for the period June 1, 1993 to May 31, 1994.

SUMMARY

The Plasma Science Committee (PLSC) of the National Research Council (NRC) is charged with monitoring the health of the field of plasma science in the United States. Accordingly, the Committee identifies and examines both broad and specific issues affecting the field. Regular meetings, teleconferences, briefings from agencies and the scientific community, the formation of study panels to prepare reports, and special symposia are among the mechanisms used by the PLSC to meet its charge. This progress report presents a review of PLSC activities from June 1, 1993 to May 31, 1994. The details of prior activities are discussed in earlier reports. This report also includes the status of activities associated with the PLSC study on opportunities in plasma science and technology.

During the above period, the PLSC continued to track and participate in, when requested, discussions on the health of the field. Much of the perspective of the PLSC has been presented in its report *Research Briefing on Contemporary Problems in Plasma Science*. That report not only has served as the basis for briefings to representatives of the federal government and the community-at-large, but also served as the starting point for the Panel on Opportunities in Plasma Science and Technology (OPST) as it began an assessment of the field.

The PLSC also continued its follow-up briefings and discussions on the results of the report *Plasma Processing of Materials: Scientific and Technological Opportunities* (PPPM). As a result of these activities, the Committee is now working with the NRC Committee on Atomic, Molecular, and Optical Sciences (CAMOS) to organize a symposium on database needs in plasma processing of materials.

THE COMMITTEE

The Plasma Science Committee is a standing committee under the auspices of the Board on Physics and Astronomy (BPA), Commission on Physical Sciences, Mathematics, and Applications (CPSMA) of the National Academy of Sciences (NAS)--National Research Council. The PLSC is a multidisciplinary committee with membership drawn from universities, industry, government, and national laboratories. Areas of expertise on the committee include accelerators, beams, and radiation sources; nonneutral plasmas; space plasma physics; astrophysics; computational physics and applied mathematics; fusion plasmas; fundamental experiments and theory; and, low-temperature plasmas, including plasma-surface interactions. It is broadly representative of the community, providing perspective on various issues that affect the progress and vitality of plasma science. A special effort has been made to ensure that the committee takes into account the roles of both the science and engineering communities in the field. [A roster is attached.]

Ronald Taylor

DISCLAIMER

The Committee identifies and makes recommendations on the needs of the plasma science community, particularly in connection with research opportunities and support, and provides guidance to federal agencies regarding their plasma science research programs. The operating guidelines of the PLSC, organized in 1988 to monitor the continuing development and assess the general health of the field, include the following: (1) to provide a continuing forum for the discussion of problems in the field of plasma science, while simultaneously developing, initiating, and overseeing the conduct of special studies focused on high-priority topics; (2) to maintain a broad and unified definition of plasma science as a field; (3) to maintain a clear and comprehensive formulation of current plasma science policy issues and give guidance to decision makers in universities, non-profit research centers, and government agencies; (4) to promote coordination among institutions involved in plasma science and make recommendations aimed at education of sufficient personnel in the field; (5) to monitor the industrial technological base; and (6) to sponsor workshops and symposia as a means of communication among different branches of the field. Several mechanisms have been developed to achieve these objectives and to develop and undertake new projects. In particular, the PLSC organizes and conducts special technical studies, surveys, workshops, and other meetings. The PLSC also functions as an oversight committee for *ad hoc* panels charged with the task of preparing reports on specific issues or topics. Symposia held at the National Academy of Sciences or at research centers have been used to focus attention on particular issues connected with facilities, programs, or other matters of concern to the community.

The PLSC recognizes that issues that affect plasma science are periodically addressed by other advisory bodies, such as the Department of Energy (DOE) Fusion Energy Advisory Committee (FEAC) and the National Aeronautics and Space Administration (NASA) Space Science and Applications Advisory Committee (SSAAC) and its subcommittees. However, the PLSC has a broader mandate and as a consequence provides a focus for the plasma science community as a whole that is unique and essential.

The PLSC is well prepared to respond to requests for studies on a broad array of topics and issues. Specific report-generating projects under the aegis of the PLSC are separately proposed and funded as the committee identifies key issues itself or accepts requests from agencies of the government and develops corresponding activities.

HIGHLIGHTS OF COMMITTEE MEETINGS

Regular meetings of the Committee and special meetings with federal agency representatives and the scientific community are essential to maintaining continuous contact with both groups. Committee members are often requested to make presentations to agency representatives, the scientific community, or other groups on matters of importance to the plasma science community-at-large. The highlights of regular meetings during the performance period of this contract are presented below.

Regular PLSC Meetings

November 1-5, 1993 (St. Louis, MO). The committee discussed the results of the PPPM report, including a recommended connection to the Federal AMPP. The Committee also met with the Co-Chairs of the assessment panel, reviewed the background to the study, including the PLSC perspectives presented in the sumary document, and discussed ways that the PLSC might assist the study panel. Finally, the PLSC discussed near-term and long-range plans—a workshop on nonneutral plasmas and another on laboratory experiments related to space plasmas.

STATUS OF PLSC PROJECTS

Summary

Over the past several years, the PLSC initiated or completed several projects. Under the auspices of the PLSC, the Panel on Plasma Processing of Materials completed a study on low temperature plasma science and its

relationship to the industrial base of plasma science. Also under PLSC auspices, the Panel on Opportunities in Plasma Science and Technology began an assessment of the field that will both assess the state of knowledge in basic plasma science and also lay out the priorities of the community in pursuing its research agenda over the next several years. In addition, the Committee has undertaken several other projects, including the following:

- Follow-up to the Study on Plasma Processing
- Workshop on Database Needs for Plasma Processing of Materials (in cooperation with the CAMOS)
- Study on Opportunities in Plasma Science and Technology

The current status of these projects bears directly on the activities of the PLSC during the performance of this contract.

Plasma Processing of Materials

As one of its first projects, the PLSC initiated a study on plasma processing of materials. In 1991, the Panel on Plasma Processing of Materials, chaired by Joseph Proud (GTE Laboratories, Inc.), completed a study which focused on several aspects of plasma processing of materials—its relationship to low-energy plasma science, its application to the electronics industry, the scientific foundations, and educational issues. The study not only pointed out the contribution that plasma processing science makes to the national well being, but also identified the technological significance of this area and its role in international competitiveness. More specifically, the study did the following: (1) evaluated the advances in low-temperature plasma science on surface processing technology with an emphasis on microelectronic applications; (2) identified key research problems in plasma physics and chemistry and the interaction of plasmas and surfaces; and (3) identified ways to bring to bear the strength of the plasma science community on the scientific, technological, and educational needs of the plasma processing community.

Additional follow-up activity has been and continues to be promoted and conducted by the PLSC.

Workshop on Database Needs for Plasma Processing of Materials

The PLSC is co-sponsoring, jointly with the Committee on Atomic, Molecular, and Optical Sciences of the NRC, a workshop on database needs for plasma processing of materials. The need for improved database was explicitly identified in the report *Plasma Processing of Materials: Scientific opportunities and Technological Challenge*. The workshop would bring a small group of experts together so that they may develop a specific, prioritized list of needs, appropriate action items, and an assessment of the potential impact on technology. Workshop participants would be expected to create a matrix that relates processes to the most important data base and diagnostic needs. Topics would include the following: electron and ion impact ionization, dissociation, and excitation cross sections; ion transport cross sections, particularly in the energy range from 1 eV to 100 eV; ion molecule reaction cross sections for ion energies in the same energy range; database generation and dissemination; theoretical capability; experimental capability; surface reaction probabilities and surface kinetics for free radicals, ions, and electrons; state-of-the-art plasma process simulation and plasma reactor design; and state-of-the-art plasma diagnostic capabilities. The workshop is being planned for April, 1995.

New Opportunities in Plasma Science and Technology

Plasma physics is not only a field which is rich in intellectual content, it is also the source of many new opportunities for scientific and technological advances. The development of its scientific forefronts and the exploitation of these new opportunities have implications for broader contemporary issues, such as education, industrial competitiveness, national defense, and interdisciplinary research. The PLSC is concerned that emphasis on application-oriented goals for most of the funding for plasma physics is neglecting the science foundation on which all such applications depend. This is undermining the development of the field, interfering with its role in science education, and ultimately weakening its ability to support plasma applications. Issues needing immediate attention include research in basic plasma physics, the impact of program priorities on education in plasma physics,

and the role of plasma physics in science education. A detailed perspective on these problems is presented in *Research Briefing on Contemporary Problems in Plasma Science.*

The PLSC devoted much of its effort in the past three years in planning for and organizing a broad assessment of the scientific and technological opportunities in plasma science. Through this process the PLSC developed the perspective presented in the research briefing discussed above. The OPST Panel, consisting of members with expertise and experience in a wide range of scientific activities, has been appointed to conduct the study. [A roster is attached.] The Panel consists of 13 members—7 chosen for their expertise and experience in a wide range of scientific activities and 6 chosen for their expertise in specific areas of plasma physics which span the bulk of the field. These areas are: (1) beams, accelerators, and coherent radiation sources; (2) nonneutral plasmas; (3) basic plasma science in magnetically-confined and inertial fusion plasmas; (4) space plasma physics; (5) astrophysics; (6) theory and computational plasma physics; (7) other fundamental plasma experiments; and, (8) low temperature plasmas. The assessment has been planned to reflect the views of the plasma community on the following topics: the health of plasma science in the United States; selected new opportunities for research and application to technological advances; the plasma science community's short-term and long-range goals; an evaluation of these goals in the context of national needs and the broader issues referred to above; and recommendations to federal agencies on optimum strategies for achieving these goals. The findings of the panel will be prepared as an NRC report and distributed to the appropriate federal agencies, Congressional committees, educational institutions, and research facilities.

The Panel is scheduled to meet next in late spring/early summer 1993. Following that meeting, the final draft of the report will be assembled and submitted to the NRC for review. After approval, the Panel Co-Chairs will begin a series of briefings of the sponsoring agencies, members of the community at professional society meetings, and Washington policymakers.

Funding for this project has been obtained from DOE, NSF, and ONR. As the oversight committee for the panel, the PLSC continues to assist the panel, as necessary, in addressing the charge and will assist the panel in its dissemination and followup activities.

Attachments

(1) Roster of the Plasma Science Committee

(2) Roster of the Panel on Opportunities in Plasma Science and Technology

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