NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

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

TECHNICAL PROGRESS REPORT & CONTINUATION PROPOSAL
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, 1992 to May 31, 1993.

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, 1992 to May 31, 1993. 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 recently-published 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. During July 1992, the PLSC sponsored a workshop on nonneutral plasmas in traps. Although no written report on the workshop results was prepared for public distribution, a summary of highlights was provided to the OPST Subpanel on Nonneutral Plasmas.

The PLSC also continued its follow-up briefings and discussions on the results of the report *Plasma Processing of Materials: Scientific and Technological Opportunities*. 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

DE-FG05-88ER53279

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 & BRIEFINGS

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 brief agency representatives, the scientific community, or other groups on matters of importance to the plasma science community-at-large. The highlights of regular meetings and special briefings during the performance period of this contract are presented below.

Regular PLSC Meetings

May 29-30, 1992 (Washington, DC). The spring 1992 meeting of the PLSC focused on several areas. The results of the PPPM report, including a recommended connection to the Federal AMPP Initiative, were presented to representatives of the DOE, NSF, NIST, ONR, AFOSR, and DARPA. The agency representatives offered suggestions on additional follow-up action. 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 research briefing, 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.

November 15, 1992 (Seattle, WA). At the fall 1992 meeting of the PLSC, the agenda included the following: a status report on follow-up activities to the plasma processing report, including the conduct of a workshop on database needs; a status report on the OPST study; a review of plasma science-related recommendations in a recent FEAC report; a review of meetings between representatives of the American Physical Society (APS) Division of Plasma Physics (DPP) and of DOE and NSF; a discussion on how to respond to a request for information from the NSF; and finally, detailed reports on potential areas of importance to plasma science and technology during the next decade.

PLSC Briefings and Representation at Other Meetings

July 20 -24, 1992 (Irvine, CA). The PLSC held a workshop on nonneutral plasmas in traps (discussed further below).

August 18-19, 1992 (Washington, DC). The PLSC Chair attended the initial meeting of the Panel on Opportunities in Plasma Science and Technology (OPST) (discussed further below).

November 17, 1992 (Seattle, WA). The PLSC Chair attended the Annual Meeting of the American Physical Society Division of Plasma Physics and at a special session described the recent activities of the PLSC

December 3, 1992 (Washington, DC). PLSC members, and former members of the Panel on Plasma Processing, briefed representatives of the Office of Naval Research—Bobby Junker, Michael Schlesinger, and Charles Roberson—on the results of report *Plasma Processing of Materials: Scientific and Technological Opportunities* and the status of subsequent follow-up efforts.

January 30-31, 1993 (Washington, DC). The PLSC Chair attended the initial meeting of the Panel on Opportunities in Plasma Science and Technology (OPST) (discussed further below).

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)
- Workshop on Nonneutral Plasma Physics
- 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.

During the course of the activity the PPPM met four times. The last meeting, in conjunction with members of the PLSC, was a workshop that was held in February 1991. At the February workshop, the Panel presented its findings to members of the community-at-large for evaluation and discussion. The subsequent input was incorporated into the final report that was completed and released in November 1991. The findings, conclusions, and recommendations of the panel were presented to members of the plasma science community in a special session at the November 1991 APS meeting of the Division of Plasma Physics. Following that presentation, briefings were held at the Office of Science and Technology Policy (OSTP) on November 8, 1991; at the Interagency Meeting of the Plasma Program Managers on February 27, 1992; at the spring 1992 PLSC meeting where the report was discussed in an open forum before DOE, NSF, NIST, ONR, AFOSR, and DARPA representatives; and, more recently, at ONR on December 3, 1992. Although the study was supported entirely by independent funding from NSF, ONR, AFOSR, and DARPA, 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

Currently, the PLSC is developing plans to sponsor, 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.

Nonneutral Plasma Physics

In March 1988, a symposium on nonneutral plasma physics was held at the National Academy of Sciences in Washington, DC. Members of the PLSC were instrumental in providing support and advice to the Office of Naval Research in organizing and conducting this symposium. The proceedings of the workshop were subsequently published as AIP Conference Proceedings 175, Nonneutral Plasma Physics (American Institute of Physics, New York, 1988). In addition, through the process of developing the assessment described below, the PLSC identified nonneutral plasmas as one of the major subdiscipline areas to be highlighted in the study. The PLSC perspective on this area is described in detail in the *Research Briefing on Contemporary Problems in Plasma Science*.

As a follow-up activity, the PLSC conducted a 5-day symposium/workshop on nonneutral plasmas in traps. The symposium was held at the Beckman Center in Irvine, CA on July 20-24, 1992. Plasma scientists with expertise in nonneutral plasmas met with atomic and molecular scientists with expertise in atomic traps and cooling techniques. The purpose of the meeting was to discuss common problems and identify scientific and technological opportunities. No report will be published, however the summary records of the meeting have become part of the internal working papers of the PLSC. A summary of the meeting is scheduled for publication in the next issue (spring/summer 1993) of the BPA Newsletter. Also, a summary of the workshop results was presented by the OPST Subpanel on Nonneutral Plasmas on January 30-31, 1993.

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 OPST Panel held its inaugural meeting on August 18-19, 1992 and developed an action plan to address the formal charge to the panel. Following that meeting, members of the Panel actively solicited input from the community-at-large on a broad range of issues. Letters were sent to key members of the plasma science community and officers of representative professional societies. General announcements and calls for input were published in the Newsletters of the APS, AGU, and IEEE. Town meetings were held at the APS DPP Annual Meeting (November 17, 1992) and at the Gaseous Electronics Conference (October 28, 1992). The Panel assembled a series of subpanel reports which were later reviewed at its second meeting on January 30-31, 1993. A revised action plan for producing the report was developed. 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

END

DATE
FILMED
8/26/93