



Preface

This special issue is devoted to articles summarizing research results from the APEX Study. APEX was initiated in 1998 as part of the US Fusion Energy Sciences Program initiative to encourage innovation and scientific understanding. The primary objective of APEX was to identify and explore novel, possibly revolutionary, concepts for the plasma chamber technology that could substantially improve the attractiveness of fusion energy systems. A particular focus was to provide the capability to extract heat at high neutron and surface heat loads. The chamber technology includes the components in the immediate exterior of the plasma (i.e. first wall, blanket, divertor, and vacuum vessel) and has a tremendous impact on the economic, safety and environmental attractiveness of fusion energy systems. The underlying strategy of the study was to improve the fundamental understanding and advance the underlying engineering sciences, integrate the physics and engineering requirements, and enhance innovation for the chamber technology.

The APEX study was carried out by a multi-disciplinary, multi-institution integrated team in two phases. The first phase was a broader effort to look at many innovative concepts and techniques in chamber technology. The results of this first phase were described in detail in the APEX Interim Report [1], and summarized by Abdou et al. [2]. The second phase of APEX followed, where specific concepts that showed the most promise, and their underlying scientific phenomena, were analyzed in much greater detail. In this Special Issue, twelve papers report on the technical results from the second phase of the APEX study. Three other papers, included in this issue, summarize key results from the ALPS Study, which was carried out in-

teractively with APEX and had a special emphasis on the divertor region and plasma-surface interactions.

A number of promising ideas for new innovative concepts have emerged from APEX. While these ideas need additional extensive research before they can be formulated into mature design concepts, some of them offer great promise for fundamental improvements in the vision for an attractive fusion energy system. These ideas fall into two categories. The first category seeks to totally eliminate the solid bare first wall. The most promising idea in this category is a flowing liquid wall. The liquid wall idea is “concept-rich”. These concepts vary from liquid first walls, where a thin layer of liquid (<2 cm) flows on the plasma-side of the first wall, to thick liquid walls, where a flowing thick liquid (>40 cm) serves as both the liquid wall and blanket. Other variations in the liquid wall concepts include the type of restraining force utilized to control the movement and geometry of the liquid. Candidate liquids range from high conductivity, low Prandtl number liquid metals to low conductivity, high Prandtl number liquids such as the molten salt Flibe. While all concepts in the liquid wall category share some common advantages and issues, each concept has its own unique set of incentives and issues.

The second category of ideas focuses on extending the capabilities, particularly the power density and temperature limits, of solid first walls. A promising example is the use of high temperature refractory alloys (e.g. tungsten) in the first wall together with an innovative heat transfer and heat transport scheme based on vaporization of lithium [1,2]. Another attractive concept considered in the study is based on using an advanced nano-composited ferritic steel struc-

ture with Flibe in an innovative re-circulating cooling scheme.

The papers in this issue cover a wide range of the technical aspects of these concepts: fluid mechanics, magnetohydrodynamics, heat transfer, plasma-material interactions, plasma edge physics, structural mechanics, materials, tritium and neutron transport, safety, as well as mechanical and engineering designs.

The APEX Study motivated plasma physicists and fusion scientists and engineers around the world to initiate new experimental and modeling research to investigate in more detail the new physics and engineering aspects embodied in the proposed novel concepts.

It has been a privilege for me to serve as the APEX Team Leader and also as Editor of this Special FED Issue. I wish to thank all the members of the APEX Team

for their dedicated efforts. It has been intellectually rewarding to work with so many talented physicists and engineers. Special thanks are due to my co-editors for this issue, Professors N. Morley and M. Sawan.

Mohamed Abdou

References

- [1] M.A. Abdou, A. Ying, N.B. Morley, et al., On the exploration of innovative concepts for fusion chamber technology, APEX Interim Report, UCLA-ENG-99-206, UCLA-FNT-107, November 1999.
- [2] M.A. Abdou, A. Ying, N. Morley, et al., On the exploration of innovative concepts for fusion chamber technology, APEX Interim Report Overview, Fusion Eng. Des. 54 (2001) 181–247.