27th IEEE Symposium on Fusion Engineering

Contribution ID: **265** Type: **Oral**

Design and Analysis of an Actively Cooled Window for a High Power Helicon Plasma Source

Thursday 8 June 2017 15:00 (20 minutes)

The development of the next generation of magnetically confined plasma fusion facilities on the path to commercial fusion power will depend on an increased understanding of plasma material interactions (PMI). Plasma facing components in future facilities such as a Fusion Nuclear Science Facility (FSNF) or DEMO will experience high heat fluxes, high energy neutron fluence, and helium and hydrogen isotope permeation. This combination of environmental effects is unique to the fusion environment, and research and development in the field of PMI will require integrated facilities that can provide prototypical conditions. Particularly, facilities are required that will simulate conditions in the first wall and divertor regions. One such proposed facility is the Materials Plasma Exposure eXperiment (MPEX). MPEX will use a helicon antenna as a plasma source, which is a non-contact source that will produce a high-density plasma and minimize impurities. The plasma will be heated by electron Bernstein wave (up to 200 kW) and ion cyclotron heating (up to 400 kW) systems, which will produce heat fluxes of up to 10 MW/m2 and ion fluxes of up to 1024/m2-s over a 75 cm2 area at a target where the plasma will terminate. In order to provide long-pulse conditions, the plasma will be confined with superconducting magnets with on-axis fields from 1 to 2.5 T. All plasma facing components will be actively cooled. To examine the plasma interactions with neutron damaged materials, MPEX will have the capability to handle low activation irradiated samples.

The helicon source is based upon a design that has been successfully demonstrated in a prototype experiment (proto-MPEX). Power is coupled into the plasma through the antenna at a frequency of 13.56 MHz. The antenna is located in air, and the power is coupled through a ceramic cylinder (or "window") forming the vacuum boundary in this region. The antenna is located outside the vacuum due to the fact that high neutral pressures in the range 0.1 to 3 Pa are required in the helicon section in order to produce the required plasma densities, and at this pressure and power level antenna sputtering would otherwise be likely to occur that could contaminate material samples being tested. However, a drawback is that up to 20% of the power launched by the antenna is deposited on the inner surface of the window due to RF-plasma sheath interactions and the production of hot neutrals. The window thus must be adequately cooled so that thermal stresses do not become excessive. Experimental results from the uncooled window are correlated with finite element results in order to confirm the heat flux profile. The design of the actively cooled window is presented with computational fluid dynamics and finite element analyses to confirm the design will function with a 200 kW antenna within performance limits.

Eligible for student paper award?

No

Authors: Dr LUMSDAINE, Arnold (Oak Ridge National Lab); Mr MEITNER, Steve (Oak Ridge National Lab); Dr GOULDING, Richard (Oak Ridge National Lab); Dr CANESES, Juan (Oak Ridge National Lab); Mr MCGINNIS, Dean (Oak Ridge National Lab); Dr RAPP, Juergen (Oak Ridge National Lab)

Presenter: Dr LUMSDAINE, Arnold (Oak Ridge National Lab)

Session Classification: R.OP5: Experimental Devices II

Track Classification: Plasma-material interactions, plasma edge physics