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FTP/P1-33: An Advanced Plasma-material Test Station for R&D on Materials in a Fusion Environment

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A new era of fusion research has started with ITER under construction and DEMO for power demonstration on the horizon. However, the related fusion reactor material science requires further development before DEMO can be designed. One of the most crucial and most complex outstanding science issues to be solved is the plasma surface interaction (PSI) in the hostile environment of a nuclear reactor. Not only are materials exposed to unprecedented steady-state and transient power fluxes, but they are also exposed to unprecedented neutron fluxes. Both the ion fluxes and the neutron fluxes will change the properties and the micro-structure of the plasma-facing materials (PFM) significantly, even to the extent that their structural integrity is compromised.

A new PMTS (Plasma Material Test Station) is proposed to address these challenges, utilizing a new high-intensity plasma source concept. This device will be well suited to test toxic, as well as irradiated material samples. The advanced plasma source is based on an RF based plasma production and heating system. The source is electrode-less, so that impurity generation in the source region that could invalidate the interpretation of PSI processes will be minimized. This is especially important for high fluence experiments, accelerated lifetime studies and reduced maintenance in a radiological managed environment. B2-Eirene simulations demonstrate that ion fluxes in excess of 10^24 m^-2s^-1 should be achievable at the target delivering power fluxes of > 30 MW/m^2. Upstream temperatures at the exit of the source system should be high enough (T_e > 30 eV) to study also radiative dissipation of heat fluxes in this device. The RF source system consists of a helicon antenna for plasma production and additional electron as well as ion heating to increase electron and ion temperature separately. A pre-prototype helicon antenna has been tested at moderate magnetic fields. A maximum electron density of n_e = 4.0 x 10^19 m^-3 has been achieved in deuterium discharges. Electron heating has been investigated in a separate experiment. Electron temperatures in excess of 10 eV have been measured in the device.

The roadmap for the source development to provide the prototype plasma source for PMTS will be presented.

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