Recent developments and experiments at DIFFER's PSI facilities

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This contribution gives an overview of the recent technological developments of the Plasma Surface Interaction (PSI) facilities at DIFFER. These new capabilities will be illustrated with some recent research examples.

The linear plasma generator Magnum-PSI is able to produce the expected steady-state and dynamic conditions in the divertor region of a fusion reactor. Re-attachment events may unwantedly occur in the divertor due to control errors in future fusion reactors such as EU-DEMO, leading to a strong increase in the heat load up to 60-70 MW m^{-2} for several seconds [1]. A way to protect the wall is to sweep the strike-point position up and down to spread the power. This mitigation method reduces surface temperatures, but will also impose cyclic thermal loads, which may result in the low-cycle thermal fatigue cracking of plasma-facing surfaces. This effect can now be mimicked in Magnum-PSI by modulating the current through the plasma source, and the influence of hydrogen plasma surface modification on the fatigue process has been investigated.

We will also report on the development of various novel diagnostics. A new camera system for coherent imaging spectroscopy has been installed on Magnum-PSI. This system captures the velocity of the plasma particles from the Doppler effect, providing a 2D image of the plasma and impurity flows in the near-surface plasma region for attached and detached plasmas. Furthermore Two-photon Absorption Laser-Induced Fluorescence (TALIF) and Coherent Anti-Stokes Raman Scattering (CARS) diagnostics are under development for measuring the atomic and molecular hydrogen densities in the electronic ground states, which play an important role in the plasma dynamics near the divertor.

Upgraded Pilot-PSI (UPP) is a second, smaller, linear plasma device, with lower magnetic fields and plasma fluxes. It has the unique capability of in-situ and operando ion beam exposure. This allows us to study the synergistic effects of plasma exposure and simulated neutron irradiation, and to perform operando ion beam analysis to study dynamic changes in material composition under plasma exposure.

These unique capabilities of UPP have been utilized to study the dynamic retention, outgassing and isotope exchange of deuterium in liquid lithium under plasma exposure.

[1] M. Siccinio, et al., Nucl. Fusion 59, 106026 (2019)

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