Recent results from PSI-2 and status of the JULE-PSI project

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Plasma-material interaction (PMI) studies on the linear plasma device PSI-2 are focused on the topics of fuel retention, erosion and evolution of surface morphology of metallic materials. The aim of these studies is the qualification of plasma-facing materials proposed for future fusion reactors: tungsten and reduced activation ferritic martensitic (RAFM) steels. Depending on individual tasks, material samples were exposed to either pure deuterium or a noble gas or mixed species plasma. Exposure parameters were an electron density of ~10^{17}-10^{19} m^{-3}, an electron temperature of 3-20 eV, an ion flux to the target of ~10^{21}-10^{23} $m^{-2}s^{-1}$ and an incident ion energy of 20-300 eV, controlled by the target biasing. The sample temperature can be controlled in a range between 400-1500 K, covering the values for different first wall regions in a reactor. The incident ion fluence can be varied in a range between ~10^{23}-10^{27} m^{-2} by extending the duration of exposure. A Nd:YAG laser (lambda = 1064 nm) with a maximal energy per pulse of 32 J and a duration of 1 ms was used to apply repetitive heat loads for the ELM simulation on material samples. Results and conclusions from the recent PMI investigations on PSI-2 will be presented.
The deterioration of the first-wall materials by neutron irradiation is one of the critical issues on the way to a fusion reactor. To address this, the linear plasma device JULE-PSI is dedicated to plasma-material interaction studies focusing on the response of neutron damaged materials (including toxic materials such as beryllium) to steady-state plasma loads and transient heat loads provided by laser irradiation. JULE-PSI will be located in a Hot Cell environment for handling of activated material samples and will be equipped with a target exchange and analysis chamber for in-vacuo characterisation of the sample surface.
JULE-PSI has a reflex arc plasma source with a heatable LaB_6 cathode and a grounded anode made of stainless steel with a Mo heat shield. Unlike the predecessor device PSI-2, which incorporates a cylindrically shaped cathode, the cathode of JULE-PSI has a disk-shaped geometry. The steady-state magnetic field is generated by water cooled copper coils arranged in the linear geometry. The design value of the magnetic field in the sample exposure region is 200 mT. The differential pumping system consists of several turbomolecular pumps and roughing pumps, thus providing a partial decoupling of the pressures in the plasma source and sample exposure regions. Presently, JULE-PSI is set up on a test stand outside the Hot Cell for the purpose of commissioning. Here, plasma flows from the source along the stainless-steel vacuum vessel to a segmented plasma dump. Post initial plasma characterisation, the device will be extended by separate (i) sample exposure and (ii) target exchange and analysis chambers.
After the first argon plasma was generated in December 2022, a broad range of magnetic field configurations with argon, neon and helium plasmas with a discharge power of up to ~10 kW was explored in the linear plasma device JULE-PSI. Steady-state operation was achieved after the optimization of the in-vessel components and the cooling system.

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