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Overview of recent plasma-material interaction studies in the linear plasma device PSI-2

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The fuel retention and the lifetime of plasma-facing components are critical plasma-material interaction factors potentially limiting the availability of a magnetic fusion reactor. Linear plasma devices are excellent test beds for investigating specific questions of plasma-material interaction. This contribution summarizes the recent plasma-material interaction studies on the linear plasma device PSI-2 focusing 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 either to pure deuterium or noble gas or mixed species plasma. The fraction of impurities such as helium, argon or nitrogen added to deuterium plasma was controlled by optical emission spectroscopy and in-situ mass analyzer. Exposure parameters were an electron density of ˜10ˆ17-10ˆ19 mˆ-3, an electron temperature of 3-20 eV, an ion flux to the target of ˜10ˆ21-10ˆ23 mˆ-2sˆ-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 400-1400 K, covering the values for different first wall regions in a reactor. The incident ion fluence can be varied in a range between ˜10ˆ23-10ˆ27 mˆ-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. Optical emission spectroscopy (OES), target mass-loss technique and recently installed in-situ quartz microbalance (QMB) were employed to quantify the amount of eroded material. The deuterium retention was investigated by thermal desorption spectrometry (TDS) and nuclear reaction analysis (NRA). Scanning electron microscopy (SEM) including focused ion beam (FIB) cross-sectioning and transmission electron microscopy (TEM) was used to observe the evolution of the surface morphology. The results and conclusions from the recent investigations on PSI-2 will be presented.

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