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Blistering and deuterium trapping in tungsten exposed to high-fluence plasmas

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Long-pulse high-power operation is the core requirement for future commercial fusion power plants, which poses a major challenge to the performance of wall materials. In this work, we focus on the irradiation effect of tungsten-based wall materials caused by high-flux and high-fluence plasma exposure. Based on two linear plasma devices STEP from Beihang University and Magnum-PSI from DIFFER, we systematically carried out a study on the effect of deuterium plasma irradiation in tungsten at two different fluxes with the highest fluence of 1E28-1E29 m-2 at a sample temperature of ~500 K. Grain orientation dependence of blistering was observed is STEP samples, but vanished in the highest fluence case in Magnum-PSI. Deuterium trapping was measured by thermal desorption spectroscopy and nuclear reaction analysis. A maximum defect depth of ~8 um was found in both rate theory calculation and transmission electron microscope observation in one Magnum-PSI sample. The effect of plasma flux and tungsten grade on blistering and deuterium retention will be discussed. Furthermore, a preliminary deuterium plasma-driven permeation measurement in STEP under a high flux of ~1E22 m-2s-1 is presented. This works helps understand the hydrogen isotopes diffusion and trapping in plasma facing materials in first wall and divertor for ITER and future fusion devices.

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