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Plasma-wall interaction studies in the full-W ASDEX Upgrade during helium plasma discharges

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The possible start-up phase of ITER with helium plasmas has set the need to understand in detail the interaction between tungsten plasma-facing components (PFCs) and helium. In addition, a smooth start of He plasma operations requires cleaning the vessel wall from residual fuel species and other impurities. To this end, Ion Cyclotron Wall Conditioning (ICWC) is a promising method. We have investigated these plasma-wall interaction topics in ASDEX Upgrade (AUG) during its He campaign in 2015. First, the main-chamber components were cleaned from their D inventory by ICWC. The He content of the plasma increased from 30% to 80%, and bulk W samples exposed at the outer midplane of AUG were all measured to contain both He and D. Next, surface modifications and the formation of fuzz on virgin and pre-damaged (by He exposure) W surfaces as well as erosion and re-deposition of W were studied. Tungsten samples were exposed to ELMy H-mode plasma discharges in He at the outer strike point of AUG. The fluence and ion energy were sufficient for inducing nanoscale modifications on the surface. The D content of the plasma remained at a constant level of ˜10% during the experiment while the He content fluctuated around the average value of 80% due to H beams used for plasma heating. Surface analyses showed that all the samples had been covered with deposits, mainly containing W, C, O, and B. In addition, the coral-like surface structures on the pre-damaged samples were intact and no signs of melting could be observed. The thickest deposits were observed in the private flux region and the rougher and the more modified the surface was, the more noticeable deposition was measured throughout the strike point region. Only little erosion, if anything at all, could be seen for W. The observed strong net deposition at the divertor is attributed to an influx of material from the main chamber and is qualitatively different from the behaviour during D operations in AUG. This could also be the case in ITER: nanoscale modifications of different W surfaces compete with the surface being eroded by plasma and with the growth of co-deposited layers on PFCs by re-deposited W, seeded impurities, and beryllium from the main chamber. Dedicated lab experiments and modelling efforts in the presence of impurity mixes are needed to enlighten the issue further.

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