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Influence of Plasma Impurities on the Fuel Retention in Tungsten

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The first wall in ITER will be subjected to mixed species fluxes containing hydrogenic isotopes, helium produced in D-T reactions and radiator gases such as argon, neon or nitrogen. It is necessary to test how plasma-facing materials perform with respect to hydrogen retention under the mixed species plasma conditions. In this study, the influence of helium, argon, neon and nitrogen as plasma impurities on the deuterium retention in tungsten was investigated in the linear plasma devices PSI-2 and PISCES-A. Tungsten samples were mechanically polished then recrystallized at 2070 K for 1 h before the exposure. Following mixed plasmas were produced: pure D, D+0.03He, D+0.07Ar, D+0.1Ne, D+0.05N and D+0.03He+0.07Ar. The exposure conditions were as follows: incident ion flux of ~10^21 to 10^22 m^-2s^-1, incident ion fluence of 1x10^25 to 1x10^26 m^-2, sample temperatures of 500 and 770 K. The incident ion energy was 70 eV, above the W sputtering threshold for Ar and N, but below it for D and He. For Ne, in addition, it was varied between 20 and 70 eV, below and above the W sputtering threshold, respectively. After exposures, samples were analysed by SEM, TEM, NRA and TDS. The admixture of He reduced the D retention by one order of magnitude, while Ar increased it by about 50%. In the D+He+Ar case the effect was similar as for D+Ar. Ar probably sputtered the near-surface layer and thus overrode the effect of He. The effect of Ne appeared to be sensitive on the incident ion energy. Ne had an effect similar to Ar increasing the D retention for the ion energies above the sputtering threshold, while for lower energies its effect was less pronounced. Addition of nitrogen increased the D retention by a factor of ~10 and ~100 for 500 K and 770 K, respectively. In general, the effect of impurities on the D retention appears to be sensitive to the properties of the damaged near-surface layer of tungsten. Admixed species, i.e. He, can form a near-surface damaged layer with open porosity, which serves as an escaping channel for D thus decreasing the D retention. However, if the process is dominated by sputtering, as for Ar, such a layer cannot be formed. The N enriched layer, in contrast, serves as a desorption barrier for D increasing its retention.

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