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# Deuterium retention in self-ion irradiated tungsten: influence of irradiation temperature, damage dose, and alloying elements

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Tungsten (W) is considered as a promising plasma-facing material for future fusion reactors. W components will be subjected to an intense flux of 14 MeV neutrons. This will result in creation of radiation defects, production of H and He, and transmutation of W to Rhenium (Re). Radiation defects can trap tritium fuel, posing a stringent limitation to tritium self-sufficiency.

MeV self-ion irradiation is widely used for simulating the displacement damage created by 14 MeV neutrons because it induces dense collision cascades and does not alter the material composition. This approach is being used at IPP over a decade. Several aspects were addressed in the past, such as the evolution of trap sites with annealing temperature or the influence of the presence of hydrogen isotopes. Here we focus on the influence of irradiation temperature, damage dose, and alloying elements. In all cases the irradiated samples are exposed to a low-flux of low-energy deuterium (D) ions extracted from an ECR plasma at low temperature (370 K). This allows to decorate the irradiation-induced defects with D without introducing additional damage and deduce trap densities. Trapped D concentration profiles are measured using D(3He,p)4He nuclear reaction analysis. The D binding states in the defects are analysed using thermal desorption spectroscopy (TDS).

The dependence of the trapped D concentration on the damage dose (0.0001-2.3 dpa) and irradiation temperature (290, 800, 1350 K) was investigated. In the case of irradiation at 290 K, a linear increase of the D concentration with the damage dose is observed up to 0.001 dpa. At higher doses the D concentration starts to level off and eventually (> 0.1 dpa) reaches a saturation value of 1.8 at.%. The same trend is observed in the case of irradiation at 800 K, but the D concentrations are a factor of four lower, indicating a reduced defect density due to defect annealing. Irradiation at 1350 K exhibits a completely different behaviour. At damage doses below 0.1 dpa the D concentrations are lower than in the 800 K case, indicating further defect annealing. At higher dpa levels the D concentration exceeds the 800 K values and reaches 1.8 at.% at 2.3 dpa, showing no tendency for saturation yet. TDS indicates that the nature of D trapping sites is different for irradiation at 1350 K as compared with 290 K and 800 K. Transmission electron microscopy revealed the formation of nm-sized voids in the samples irradiated at 1350 K, which is not the case after irradiation at 290 K and 800 K.

To study the effect of Re transmutation products, W samples containing 0, 1, 3, and 5 % Re were irradiated to 0.5 dpa at 295 K and 1350 K. In the case of irradiation at 295 K, Re addition has little effect on trapped D concentration and the nature of trapping sites. In the case of irradiation at 1350 K, the trapped D concentration decreases compared with pure W: 5 times for W-1 % Re, 36 times for W-3 % Re, and 43 times for W-5 % Re. This can be attributed to the reduction of void growth caused by the presence of Re.

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