Comparing deuterium retention in heavy ion damaged tungsten measured by GD-OES, NRA and TDS

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Tungsten (W) is considered to be the most potential plasma-facing materials (PFMs) in the future due to its high melting point, outstanding thermal conductivity, low hydrogen permeability and high threshold for sputtering. Low accumulation of hydrogen isotopes in the PFMs is required for the safety and cost concern. Thus, understanding the fuel retention behaviors of W in fusion environment is important.

In this work, the polycrystalline hot-rolled W samples were irradiated by 5 MeV Au^{3+} with different damage levels from 0 to 1.7 dpa at room temperature. After that, samples were exposed to deuterium (D) plasma with the flux of around 1×10^{21} D/m^2s and the energy of 38 eV/D at around 390 K to a fluence of about 1×10^{25} D/m^2 on the linear experimental plasma system (LEPS). Glow-discharge optical emission spectroscopy (GD-OES) and nuclear reaction analysis (NRA) were used to obatin the D retention depth profile, thermal desorption spectroscopy (TDS) was used to measure the total D retention. The calibration of GD-OES was reported in our provious study [1].

The results show that D accumulates mainly in the damaged area, and the depth of the maximum concentration of D is consistent with the simulation results of TRIM code. D concentration increases with the degree of damage until the degree of damage is 0.2-0.4 dpa, and higher dpa values do not increase the D accumulation in damaged region further. In addition, the depth profiles obtained by GD-OES and NRA show excellent agreement in the depth range of 0-3 μm.

The total D inventory increases rapidly with dpa values at low damage level (0-0.2 dpa), and increases by a factor of ~2.5 times at 0.2 dpa compared to the result of un-damaged sample, then shows a saturation trend. Moreover, D inventory measured by GD-OES of damaged samples are basically consistent with the results obtained by NRA and TDS, in other words, GD-OES is a reliable method to measure the D retention behaviour in damaged W.

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