Deuterium Retention and Surface Blistering in Non-Damaged and Damaged Tungsten after Repetitive Plasma Exposure and Outgassing

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As a promising candidate of plasma facing materials in future fusion reactor, tungsten (W) inevitably faces severe challenges to particles (hydrogen isotopes and helium) bombardment and high-energy neutron irradiation. Neutron irradiation tends to create numerous crystal defects in material, while hydrogen isotopes are easily trapped by these defects. Thus, effects of neutron irradiation on fuel hydrogen behaviour in W is one critical issue that needs to be investigated. In this work, iron ions were utilized to create neutron-like damage in W, then deuterium (D) retention and surface blistering were investigated after plasma exposure. After the first-round investigation, D plasma exposure was carried out again for the samples that had been exposed to D plasma and had experienced thermal desorption (heating up to 1273 K) to study the persisting effect of the irradiation damage. It is expected to offer a different insight into the effects of neutron irradiation on the fuel retention in W.

After the first-round exposure to low-energy (40 eV) and high-flux ($10^{22}$ D/m²s) D plasma at different temperatures (450/550/750 K), it is found that D retention is largely enhanced and surface blistering is aggravated by pre-damage introduction at all temperatures [1]. The most serious blistering and D retention are present at a temperature of 550 K. Observation of the blister-related cavities indicates that D aggregates at a depth that 4 times deeper than the undamaged one. Comparison of D increment in the near-surface layer and in the whole bulk reveals that D flux diffusing into the material is enhanced by the appearance of damage layer [1].

After the second-round exposure to D plasma at a temperature of 500 K, it is found that blisters are newly formed on the surfaces while an increased D retention is obtained in comparison with that with the first-round exposure. Notably, as compared to the non-damaged W a decreased amount of blisters appears on the damaged W while a similar amount of D retains. It is suggested that the damage introduced initially no more affects D retention in the sequential repetitive D plasma exposure, however, cavities pre-formed in the material affect the behaviour of D aggregation and blistering.