Deuterium retention in tungsten with and without helium fuzz after irradiation by a pulsed high-temperature plasma

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Tungsten (W) is the reference material for the divertor of ITER and DEMO reactors. In the fusion reactor, W will be exposed to energetic particles of hydrogen isotopes and helium, high heat flux, neutrons (14 MeV-peak neutron spectrum) and transmutation products. In this regard, a study of accumulation of hydrogen isotopes and helium in W under normal operation conditions and transit events is necessary for assessment of safety of fusion reactor due to the radioactivity of tritium and material performance and for the plasma fuel balance. In the present work, W samples were exposed to pulsed heat loads using deuterium (D) plasma in quasi-stationary high-current plasma gun QSPA-T. The pulse duration was 1 ms and number of pulses was varied from one to ten. The irradiation was performed below and above the melting threshold and sample temperature was kept during irradiation either 300 or 1273 K. We examined the impact of (i) ELMs-like events, (ii) sample temperature and (iii) formation of low-energy ion-induced helium (He) nano-structured 'fuzz' on the D retention in W. The He 'fuzz' on W was produced by exposure of W to low-energy He plasma at 1273 K prior to pulsed high-temperature D plasma exposure. The D and He retention in each irradiated sample was measured by a method of thermal desorption spectroscopy (TDS) up to 1700 K. We found that the total D retention was the highest for samples irradiated by plasma gun above the melting threshold. The D retention after 10 pulses of plasma gun exposure was much higher than that after stationary low-energy plasma exposure at sample temperature of either 600 or 700 K indicating the dominate influence of ELM's-like events on the D retention compared to normal operation regime. The D retention in W samples with the presence of ion-induced He 'fuzz' was lower than without. The pulsed plasma exposure at base sample temperature of 1273 K indicates a reduction in the density of He 'fuzz' and decrease of the D retention compared to the base sample temperature of 300 K. The results obtained give possibility to assess the hydrogen isotope and helium retention in divertor areas subjected to high thermal loads at different operation regimes.