Blistering and deuterium retention in Nb-doped W exposed to low-energy deuterium plasma

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Tungsten and tungsten-niobium alloy with niobium concentration of 5 wt% were exposed to deuterium plasma at ~470 – 506 K, with flux of ~1.8×10^{21} D/m^2/s, an ion energy of 100 eV and fluence of 1.3×10^{25} D/m^2 – 5.2×10^{25} D/m^2. Before exposure, the hardness and Young’s modulus as well as lattice parameter of W are obviously improved due to Nb doping. After exposure, the TDS spectra can be deconvoluted into two major Gaussian peaks located at ~700–800 K and ~900–1000 K for all samples. At low fluence (1.3×10^{25} D/m^2) and low temperature (470 K), only sparse and small blisters are formed on the pure W surface, while the strip-like surface structures are observed on the W-5Nb surface. The total D retention is significantly reduced due to the Nb doping, where the D retention in W-5Nb is 1.34 times lower than that of in pure W. With increasing fluence up to 2.6×10^{25} D/m^2, both the blister size of pure W and W-5Nb alloy continue to increase. The blister size of W-5Nb alloy is slightly bigger than that of pure W, but the opposite trend is observed in blister density. The total D retention in W-5Nb alloy is also observed to be 1.38 times higher than that of pure W. Further increase of irradiation fluence (5.2×10^{25} D/m^2) and temperature (506 K) at the same time lead to the significant increase of blister size and D retention for the pure W. However, whether the blister size or D retention are greatly suppressed in W-5Nb alloy. Moreover, the deuterium retention in W-5Nb is about 3 times less than that in pure W, implying that niobium alloying suppress the surface blistering and reduce the deuterium retention in tungsten exposed to D plasma with a fluence of 5.2×10^{25} D/m^2 at 506 K.