Fluence dependence of surface topography and deuterium retention in nanocrystalline tungsten films exposed to D plasma

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The dependence of deuterium plasma fluence on surface morphology and deuterium retention in nanocrystalline W films was investigated. The morphology changes and deuterium retention behaviours of magnetron sputtering W films were significantly different from that of bulk W. In this work, the surface morphology and deuterium retention of nanocrystalline tungsten films were studied after exposure to a low-energy (100 eV/D), high-flux ($1.8 \times 10^{21}$ ions m$^{-2}$s$^{-1}$) deuterium plasma. The nanocrystalline tungsten films of 6 μm thickness were deposited on tungsten bulk and exposed to deuterium plasma for various fluences ranging from $1.30 \times 10^{25}$ to $5.18 \times 10^{25}$ ions m$^{-2}$. Surface modifications before and after irradiation were studied with scanning electron microscopy (SEM). It seems that the size of the blisters is associated with the deuterium ion fluences in our experiment. The sample exposed to low-fluence plasma ($1.30 \times 10^{25}$ ions m$^{-2}$) shows blisters about 2 μm in diameter. The blisters on samples irradiated to higher fluence plasma are much larger (~ 4 μm). Deuterium atoms prefer to be trapped by defects like dislocations and grain boundaries, and the formation of deuterium-vacancy clusters is considered as generation of blisters [1], which would diffuse to the surface and agglomerate, resulting in the formation of blisters. The increasing of the ion fluence not only causes the mutation of the surface morphology but also increases the amount of trapped deuterium. The deuterium retention is studied using thermal desorption spectroscopy (TDS). The retention of deuterium in W films increases with the increase of the deuterium plasma fluence when irradiated at 500K. There is no trend of saturation at the highest fluence in our experiment. Both deuterium retention and blistering behaviour show a dependence upon the exposure fluence.