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Effect of Carbon Impurity on Molybdenum Nanostructure evolution under Helium Ion Irradiation in Extreme Conditions

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Abstract

The performance of plasma facing components (PFC) is of great important for the realization of prototype nuclear fusion. Tungsten has been considered as the leading high-Z PFC material for these reactors and tokamaks due to its superior thermophysical properties, high melting point, low sputtering yield, and low tritium inventory. However, its surface deteriorates significantly under helium ion irradiation in extreme (fusion) conditions and forms nanoscopic fiber like structures (fuzz) Recent studies show that the formation of fuzz nanostructure on tungsten can be suppressed by the presence of plasma impurities such as carbon and beryllium. In the present study, the effects of carbon impurity on molybdenum nanostructure evolution under extreme condition helium ion irradiation have been investigated. For mixing the carbon impurity on molybdenum surface, a mixture of helium and methane (CH_4) gas has been used. Separate experiments with 100% pure helium and with mixture gas have been performed. Ion energy (100eV), ion-flux (7.2×10^{20} ions m^{-2} s^{-1}), ion-fluence (2.6×10^{24} ions m^{-2}) and target temperatures (923K) were chosen from our previous studies and fixed constant during the whole study, for all the samples. The surface modification and compositional analysis, due to 100% pure helium ion and "helium+ carbon" ion irradiations, will be studied using scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), respectively. In addition, optical-reflectivity measurements will also be performed for monitoring the surface deterioration due to energetic pure helium ion and mixture "helium+carbon" ion irradiations. Our results indicate that 0.5 % carbon impurity (a mixture of 97.5 % helium and 2.5% methane gas) may prevent almost all the molybdenum fuzz formation and deposit a thin carbon layer on molybdenum surface.

Keywords: nuclear fusion, materials, nanostructure, plasma, impurity