Formation condition of fiberform nanostructured tungsten by helium plasma irradiation

W. Sakaguchi, S. Kajita, N. Ohno, M. Takagi, H. Kurishita[a],

Department of Energy Eng. and Sci., Graduate School of Eng., Nagoya University, Nagoya 464-8608, Japan

[a] *International Research Center for Nuclear Materials Science, Institute for Materials Research (IMR), Tohoku University, Oarai, Ibaraki 311-1313, Japan*

w-sakaguchi@ees.nagoya-u.ac.jp

Tungsten (W) is the candidate material in the divertor region in ITER where armors will be subjected to high-flux deuterium-tritium and helium plasmas, because of its high melting point, low sputtering yield and low tritium retention capability. Moreover, tungsten is considered as the candidate for the in-vessel mirror material for optical diagnostic system in ITER. Under certain conditions, it has been reported that fiberform nanostructured tungsten is formed on the surface by helium ion irradiation [1]. This damage may cause the degradation of the thermophysical properties and optical reflectivity. In this paper, we investigate the necessary conditions for the formation of the fiberform nanostructured tungsten by helium plasma irradiation. By measuring the optical reflectivity, the change of the surface nature under helium plasma exposure is evaluated. The surface is analyzed by scanning electron microscope (SEM) after helium plasma exposure.

Experiments are performed in the divertor plasma simulator NAGDIS-II (NAGoya university DIvertor Simulator-II), in which high-density (~10^{19} m^{-3}) and low energy (~7 eV) helium plasma is produced in steady state with the TP-D type discharge. The specimen, which is powder metallurgy tungsten provided by Nilaco Co. with 99.95% purity, is polished by sandpapers. The surface temperature of the tungsten is measured by a pyrometer and the ion flux is derived by the ion current.

By irradiating the helium plasma with the incident ion energy of above 30 eV at the surface temperature of ~1800 K, the surface is covered with fiberform tungsten. However, when the incident ion energy is lower than 30 eV, micro-sized bubbles and holes are formed on the surface. It can be said that the incident helium ion energy is a key factor to form the fiberform nanostructured tungsten [2]. When changing surface temperature at fixed incident ion energy of 50eV, the optical reflectivity becomes zero for the ion flux of 3.3 x 10^{25} m^{-2}, whereas it decreases by less than half at ~900 K for the ion flux of 4.6 x 10^{25} m^{-2}. The surface is covered with fiberform tungsten at the surface temperature of ~1100 K. It is indicated that a threshold of surface temperature may exist approximately 1000 K when the incident ion energy is ~50 eV. In addition, tungsten samples manufactured by different methods are exposed to the helium plasma. One is the ultra fine grained W-0.5 wt.% TiC consolidate which is fabricated utilizing mechanical alloying in purified Ar and hot isostatic pressing [3]. Another is the ITER-reference tungsten grade. Fiberform nanostructure is formed on the both samples; clear differences on the formation of fiberform structure were not observed at the surface temperature of ~1800 K even when the manufacturing method is different.

[1] S. Takamura, N. Ohno, D. Nishijima, S. Kajita, Plasma Fusion Res. **1** (2006) 051.
[2] W. Sakaguchi, S. Kajita, N. Ohno, M. Takagi, submitted J. Nucl. Mater.
[3] H. Kurishita, S. Matsuo, H. Arakawa, et al., Mater. Sci. Eng. A **477** (2008) 162-167.