Size distribution of nano-tendril bundles with various additional impurity gases

R. Zhang, D. Hwangbo, S. Kajita, H. Tanaka, N. Ohno

Graduate School of Engineering, Nagoya University, Furo-cho, Chikusaku, Nagoya, 464-8603, Japan

a Institute of Materials and Systems for Sustainability, Nagoya University, Furo-cho, Chikusaku, Nagoya, 464-8603, Japan

zhang.rongshi@i.mbox.nagoya-u.ac.jp

Tungsten (W) has been chosen as the most promising candidate material for divertor target due to its high melting point and low sputtering yield. For reducing the heat load from core, ITER attempts to use some neutral gases to cool down the plasma temperature. In recent years, a new morphology change with isolated island of bundles of nanostructure named nano-tendril bundles (NTBs) on W surface has been found [1].

Previous researches showed that NTBs could be formed on W surface under helium (He) plasma irradiation with additional impurity gases as nitrogen (N₂), neon (Ne), and argon (Ar) [2], in which similar conditions can be realized in actual fusion devices as well. Erosion and re-deposition effects would be important factors in the growth process of NTBs [3], indicating that the erosion yield will be a key parameter. Both incident ion energy and impurity gas ratio seemed to influence the erosion yield [3]. However, it is still unclear how the incident ion energy and impurity gas ratio influence the erosion yield and resultant growth of NTBs. In this paper, NTBs’ size distributions are analysed to clarify the effects of the incident ion energy and the impurity gas ratio on the growth of NTBs’.

Several W samples were irradiated with He plasmas with additional impurity gases, as Ar, Ne, or N₂ in the linear divertor plasma simulator NAGDIS-II. The incident ion energy was controlled in the range of 60–300 eV by adjusting the applied negative bias to the sample, and the impurity gas ratio was in the range of 3-20% by changing the flow rate of secondary impurity gases. After irradiation, scanning electron microscopy (SEM) and confocal laser scanning microscopy (CLSM) were used to analyze NTBs’ area and height distributions.

It was found that the average area of NTBs increased with incident ion energy. Further analysis using the CLSM technique revealed that the area distribution became wider while the incident ion energy increased: no significant difference could be seen by changing impurity gas ratio. The results indicated that the incident ion energy rather than impurity gas ratio could be one of the principal parameters for the growth process of NTBs.