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The Effect of Mixed Plasma Irradiation on the Surface Structure of Tungsten
混合プラズマ照射がタングステン表面構造に与える影響

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The effects of argon or neon plasma which works as radiative cooling gas to tungsten surface structure should be investigated. In this study, pure plasma irradiations or mixture plasma irradiation with He, Ne, and Ar to tungsten are performed in an ECR plasma device. The surface modification by He plasmas and the effects of Ar and Ne on He induced morphology (nano-structure) observed by a scanning electron microscope (SEM) or a transmission electron microscope (TEM).

1. Introduction

Tungsten is one of the candidates for diverter materials in ITER because tungsten has high melting point and low sputtering yield. However, there is a concern such that helium plasma generated by D-T reaction makes surface damage on tungsten. Therefore, the influence of helium plasma on tungsten has been investigated. In particular, at high temperature and high ion energy, helium exposure on tungsten forms nanostructure-sized fibrous structure which contains the helium bubble [1].

In addition to the effects of helium, argon or neon plasma possibly affects surface morphologies of tungsten. Argon and neon have an important role in nuclear fusion reactors such that they are expected to work as radiative cooling gas in diverter plasmas. In this study, the effects of argon and neon ion irradiation on the tungsten nanostructure induced by helium plasma irradiation are studied.

2. Experiments

The experimental device is called LaPlex (Laser and Plasma exposure device). Steady state high density plasmas are produced by electron cyclotron resonance (ECR) discharge by 2.45 GHz microwave. Tungsten samples size is 10mm square and 1mm thickness, and their surface are polished to a mirror finish. The sample holder is electrically isolated from the vacuum chamber and can be biased (~150V) to control the incident ion energy to the tungsten surface. The surface temperature of tungsten is measured by a radiation thermometer, and the surface morphology and microstructure are observed by SEM or TEM.

3. Analysis method

At high temperatures (>1200K) and high ion energies (>100eV), the surface color of sample exposed to helium was totally black visually after the exposure. The exposure time, ion energy, and temperature were 3600s, 150eV, and 1300K respectively, The SEM micrograph of the samples showed the fibrous structure about 500 nm in thickness.

The mixed plasma irradiation is expected to change the tungsten surface because argon and neon have higher sputtering yield than that of helium. Among several parameters, ion energy is a more important parameter because the sputtering yield of tungsten is increased rapidly with increasing the incident ion energy. This parameter is expected to change the morphology of tungsten surface. Similarly, there is possibility for ion density and exposure time to change the tungsten surface. We investigate the dependency of these parameters on tungsten surface and formation process of tungsten nanostructure.

References

[1] W. Sakaguchi, S. Kajita, N. Ohno, and M. Takagi: Journal of Nuclear Materials 390–391 (2009) 1149–1152.