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Gas retention in Tungsten exposed to Noble gas plasmas
希ガスプラズマ照射を受けたタングステンのガス吸蔵特性

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Tungsten specimens were exposed to pure Ar or Ne plasmas at 1000-2000 K and several incident ion energies. Even under the irradiation condition under which the tungsten nanostructures were formed by He plasma irradiation, holes/bubbles and fiberform nanostructure were not formed on the surface by exposing to Ar or Ne plasmas. In addition, EDX results supported the results that Ar and Ne did not remain in the sample.

1. Introduction

Tungsten (W) has a high melting point, low neutron activation cross-sections and low tritium retention, so that it is a candidate of plasma-facing materials. In spite of these advantages, it is known that helium holes/bubbles [1,2] and fibreform nanostructure [3,4] are formed on tungsten surface by exposing to He plasma. In addition to He, Ne and Ar are introduced to fusion plasma for radiative cooling. Those noble gases have potential to form irradiation damages like bubbles and nanostructures. However, those irradiation effects have not been fully understood yet. Thus, this study aims to investigate the interaction between noble gas plasmas and tungsten.

2. Experimental

Specimens were powder metallurgy W disks (Nilaco.Co.) 5 mm in diameter. The polished specimens were irradiated by noble gas plasmas in the linear divertor plasma simulator (NAGDIS-II [5]). Irradiation condition is 1000-2000 K in the surface temperature and higher than 20 eV in incident ion energy. Those conditions are the one in which the tungsten nanostructure is easily formed by He plasma irradiation [6]. After the irradiation, the irradiated surface was analyzed by scanning electron microscopy (SEM), transmission electron microscopy (TEM), and energy dispersive X-ray analysis (EDX).

3. Results and discussion

3.1 Analysis of irradiation area and cross-sectional

Figure 1(a) shows a cross-sectional TEM image of the Ar irradiated surface. The incident ion energy, surface temperature, and ion fluence were 100 eV, 1650 K and 2.8×10^{25} m^{-2}, respectively. Those irradiation conditions are the one in which the tungsten nanostructure is easily formed by He plasma irradiation. For example, figure 1(b) shows a cross-sectional TEM image of the He irradiated surface [6]. The incident ion energy, surface temperature and ion fluence were 50 eV, 1400 K and 5.5×10^{25} m^{-2}, respectively. Figure 2(b) shows a dramatic change in the surface morphology. However, on the sample irradiated with Ar plasma (Figure 1(a)), holes/bubbles and fibreform nanostructure were not observed on the surface. Also, for the case of Ne ion irradiation, holes/bubbles and fibreform nanostructure were not observed.

3.2 Analysis of EDX

Figure 2 shows the cross-sectional SEM micrograph of specimen, which were exposed to pure Ar plasma at 1650 K and 100 eV with the Ar fluence of 2.8 $\times$ 10^{25} m^{-2}. Figure 3 shows the compositional analysis of the cross-section in figure 2. EDX spectra taken from the rine area regions of marked 'A' and 'B' in figure 2. Near the plasma irradiated surface is 'A'. Meanwhile, 'B' is the bulk tungsten.

EDX spectra shows Ar, Mo, C, and W peak. The presence of Mo is likely due to the sample holder of EDX, which is made of Mo. O are likely due to surface oxide passivation and C adhered to tungsten surface on contact with atomosphere when targets are removed from NAGDIS-II after cooling to ambient temperature. The Ar peak of 'A' and 'B' is small compared with W peak. The Ar peak level is about noise level. Therefore, EDX result shows that sufficient amounts of Ar did not remain in the sample. Also, for the case of Ne ion irradiation, recognizable Ne peak was not observed. EDX results supported the results that sufficient amounts of Ar and Ne did not remain in the sample.

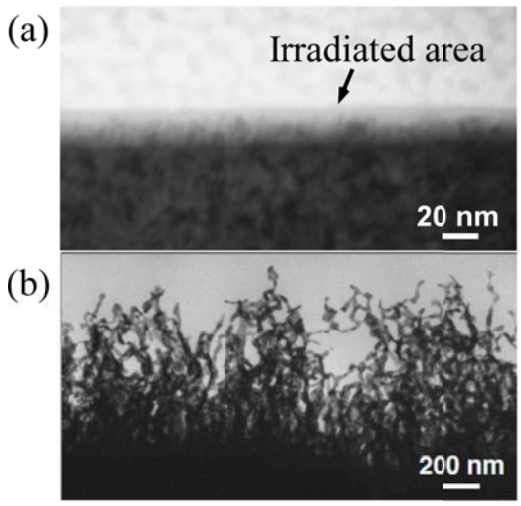

Figure 1. TEM images are Ar (a) and He (b [6]).

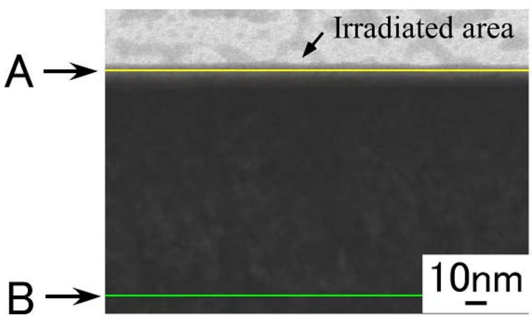

Figure 2. Cross-sectional SEM micrograph of W target that was exposed at exposed to pure Ar plasma.

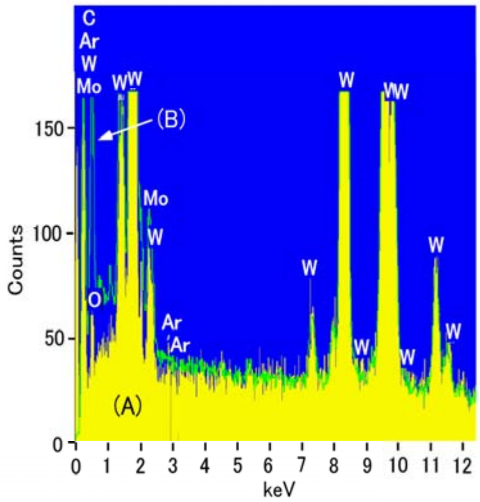

Figure 3. EDX spectra taken from the rine area regions of marked 'A' and 'B' in figure 2.

4. Conclusion

In the present work, Tungsten exposed to pure Ar or Ne plasma at 1000-2000 K and several incident ion energy, even under the irradiation condition that the tungsten nanostructure is formed by He plasma irradiation. However, holes/bubbles and fiberform nanostructure were not formed on tungsten surface by exposing to Ar or Ne plasmas. In addition, EDX results supported the results that sufficient amounts of Ar and Ne did not remain in the sample. It is likely that holes/bubbles and fiberform nanostructure cannot be easily formed on tungsten surface by the exposure to Ar or Ne plasmas, even under the irradiation condition under when the tungsten nanostructure is formed by He plasma irradiation.

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