Topic number

Fuzzy nanostructure growth on precious metals by He plasma irradiation

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By helium plasma irradiation to precious metals including rhodium (Rh) and ruthenium (Ru), it was found that fiberform nanostructures were formed on the surface. By scanning electron microscopy and transmission electron microscopy analysis, helium bubble growth inside the fuzzy structures were observed. It was likely that the fuzzy structures were easily formed by He plasma irradiation on Rh and Ru because the shear modulus was high similar to tungsten.

1. Introduction

It was found in plasma material interaction in fusion devices that helium (He) plasma irradiation leads to the formation of fiberform fuzzy nanostructures on tungsten surface [1]. The incident ion energy and surface temperature are important parameters to control the surface morphology changes. Furthermore, the He plasma irradiation leads to the nanostructure formation on various metals including titanium, nickel, molybdenum and so on [2]. Because the nano-structurization of metallic material are important for industrial application including for catalysis and photocatalysis, it would be of interest to further investigate the He plasma irradiation effects on other metals as well which were not used for irradiation experiments. In this study, we conducted He plasma irradiation on precious metals including rhodium (Rh) and ruthenium (Ru).

2. Experiments

He plasma irradiation was conducted in the linear plasma device NAGDIS-II, in which high density (~10^{19} m^{-3}) He plasmas can be produced in steady state. Rh and Ru samples were prepared by a magnetron sputtering device. The sample was negatively biased, and the surface temperature was increased by the bombardment of He ions. The surface temperature was measured by a radiation thermometer. Figure 1 shows a typical scanning electron microscope (SEM) micrograph of the He plasma irradiated Rh surface. The incident ion energy was ~45 eV, the surface temperature during the irradiation was ~700 K, and the He ion fluence was 1.1x10^{26} m^{-2}. It was found that fiberform nanostructures were formed on the surface. By transmission electron microscope (TEM) observation, elongated bubbles were observed in the fiberform structures. We also conducted He plasma irradiation on Ru sample. Fiberform structures were also observed on Ru sample which was exposed to the He plasma at the surface temperature of 920 K, the incident ion energy of ~45 eV, and the fluence of 2.4 x10^{26} m^{-2}. The shear modulus of Rh and Ru at the room temperature was 150 and 173 GPa, respectively, and the values were comparable to that of W (161 GPa). It is likely that nanostructure formation tends to take place when the shear modulus is high [3] such as Rh and Ru.

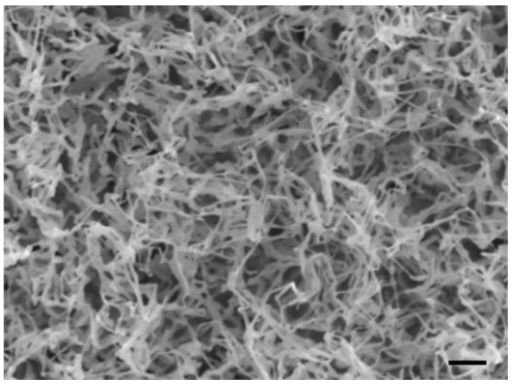

Figure 1: SEM micrographs of He plasma irradiated Rh surface. The length of the bar is 200 nm.

3. References

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