Study on Surface Exfoliation of Tungsten Alloys by Helium-ion Bombardment

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Erosion of plasma facing material by helium (He) -ion bombardment is one of the important issues of fusion power reactors. The recent assessment of energetic particle bombardment to first wall in DEMO reactor reported that 3.5MeV alpha particles incident to the first wall was up to $10^{26}\text{He}/\text{m}^2$ for 2 years operation. In such high-energy alpha particle bombardment, erosion by surface exfoliation will be larger than that of sputtering. In our previous works, 3MeV He-ion irradiation experiments were performed to various Tungsten (W) alloys, such as recrystallized powder metallurgy W alloys and W-0.3TiC alloy fabricated by mechanical alloying method to investigate surface exfoliation behavior by high-energy He-ion. The results showed that critical fluence of exfoliation of W-0.3TiC alloy was more than ten times larger than that of powder metallurgy W alloys. The purpose of this study is to investigate irradiation temperature dependence of the surface exfoliation behavior of W alloys fabricated by mechanical alloying method.

Examined specimens were W-0.3, 0.5TiC alloys fabricated by mechanical alloying method and powder metallurgy W alloys. The grain size of W-TiC alloys were about 100nm. The irradiation temperature was controlled from RT to 1000C. Surface morphology observation, microstructure observation, thermal desorption experiment and electrical resistivity measurement were performed. Cross-sectional observation of the He implanted area with TEM was also carried out. In irradiation at 550C, surface exfoliation on W-0.5TiC alloy was not observed up to $10^{23}\text{He}/\text{m}^2$ as same as W-0.3TiC alloy. A few bumps were formed in W-0.3TiC alloy after the irradiation, but there were no surface morphology change in W-0.5TiC alloy. Swelling of He in irradiated area was detected by step-height measurement. Result of TDS showed that total amount of desorped He of W-0.3TiC alloy from RT to 1500C was one order larger than that of powder metallurgy W alloy. Cross-sectional observation of He implanted W-0.3TiC alloy by TEM showed that bubble formed from the implanted surface to projected range of 3MeV He. These results might be attributed to the enhanced diffusion of He in fine grain structure of W-0.3, 0.5TiC alloys. The effect of microstructure on the He bubble formation behavior will be discussed.