§15. Surface Property Evaluation of Tungsten Possessing Nano-structure

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It has well-known that tungsten material, which has high Z number with regard to sputtering and erosion, has been widely used for representative one of first wall in nuclear fusion devices. Especially, understanding of divertor region irradiated by high-heat and high-particle flux is very important for not only control of the contamination but also stabilization of the high temperature plasma.

By the way, transition temperature of the tungsten from normal to superconductivity is around 0.01 K, it was reported the temperature of the tungsten film was dramatically increased to several K when the impurity including the hydrogen atoms was mixed into the film.[1] We have noticed the point to investigate surface properties of the tungsten material using this phenomenon.

Last year, we have tried to study the surface condition of the bulk tungsten material; however, it was difficult to observe apparent variation of the physical property like resistivity because the all part of the current was passing into the bulk part under the resistance measurement. Therefore, tungsten thin films deposited on the quartz and alumina that are one of the isolator were prepared by sputtering method. The high-flux He plasma was irradiated on the surface directly, the resistance measurement was done from 4.2 to 300 K. Figure 1 shows the temperature dependence of the resistance for the tungsten thin film irradiated by the plasma for each substrate. The measured resistivity was decreased with decreasing the temperature, which is similar to that of typical metal. It shows the apparent variation between quartz and alumina substrate was not observed and the obtained signal was fluctuated. On the film on alumina substrate, the difference of the resistance was detected because thermal expansion and/or shrink between the film and substrate would be there. Both temperature resistances were saturated below 20 K, which is same temperature dependence of the poly-crystalline metal. The temperature coefficient was calculated as order of 10^{-3}[1/K] which is much smaller than that of the reported value for bulk tungsten (5×10^{-3}[1/K]). This is shown that the crystalline in the fuzz structure would be one of the poly-crystalline or amorphous, and it guessed the electrical property in the fuzz structure could be realized by poly-crystalline model. In low temperature region, the resistance was not changed, and it showed that the conventional metallic model represented the temperature dependence.

Currently, the understanding of electrical property for fuzz structure has not realized completely because plenty number of the fuzz structure was there. Therefore, we change a strategy to understand the property by whole fuzz structure, and plan to use single fuzz for the measurement using MEMS technique.

1) Sadki et al., Appl. Phys. Let. (2004)

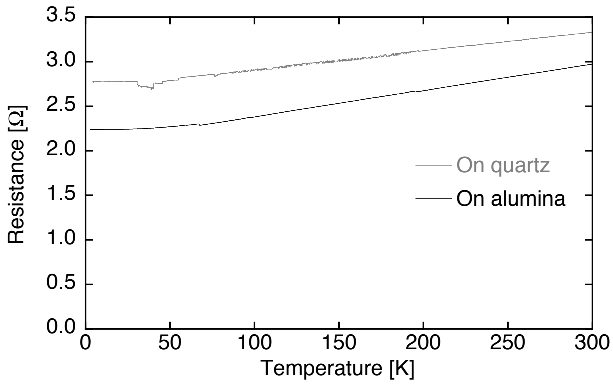

Fig. 1: Temperature dependence of resistance for tungsten film irradiated by He plasma on quartz and alumina substrates.