30aA04　　タングステン材料への炭素被覆膜による繊維状ナノ組織形成の阻止

Suppression of Fiber-Form Nanostructure Formation on the Tungsten Surface with Carbon Thin Film Coverage

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Tungsten (W) material is very important in terms of plasma-facing component not only in DEMO but also in ITER. But helium (He) defects are strong concerns when employing W for the divertor target and/or the first wall due to enormous heat load because He is one of fusion products. The fiber-form nanostructure, so called “fuzz”, has been investigated on a variety of W surface irradiated by He or He/D mixture plasmas since it was recently found [1].

One of the serious issues for the W with the fiber-form nanostructure is a dust formation. It seems that so called “fuzz” may easily be peeled off due to a mechanical or a thermal shock. In fact an adhesive carbon tape on the defected W sticks the nanostructure easily as shown. Instead these structures can be shaved with a cutting knife. On a shaved surface many holes can be seen over all the shaved area. The dust thus made is observed with FE-SEM. A kind of fragility has been demonstrated in these treatments.

The most effective way against the formation of nanostructure on the W surface is to suppress the formation process itself. Concerning the mitigation of such nanostructured W, we have identified a life time, in other words, thickness of carbon film to have a complete suppression on W surface by putting carbon thin film on the W surface where the carbon may be sputtered by He ions depending on their impinging energy.

First, a W sample of 10×10×0.1 mm^3 was covered with another thin W of 10×7×0.035 mm^3. This double W sample was exposed to He (70 sccm) and methane (0.5 sccm) mixed gas discharge plasma for one hour to have a carbon film coating on the whole surface. Then, the thin cover W is removed to have a fresh W area. The sample with two areas was exposed to pure He plasma with a biasing voltage of -40 V for two hours. The macroscopic view for the sample is shown in Fig.1 where the black area has a nanostructure while the gray one does not.

Figure 2 shows microscopic views for the above sample, where (a) and (c) show the cross-section, and (b) and (d) are grazing views for these areas. We found that the carbon thin layer protect against the formation of nanostructure. Such an inhibition of fuzz structure formation was originally reported by PISCES group [2]. Here a more concrete way has been clearly demonstrated.

[1] S. Takamura et al., Plasma Fusion Res. **1** (2006) 051.

[2] M.J. Baldwin et al., J. Nucl. Mater. **390-391** (2009) 886.

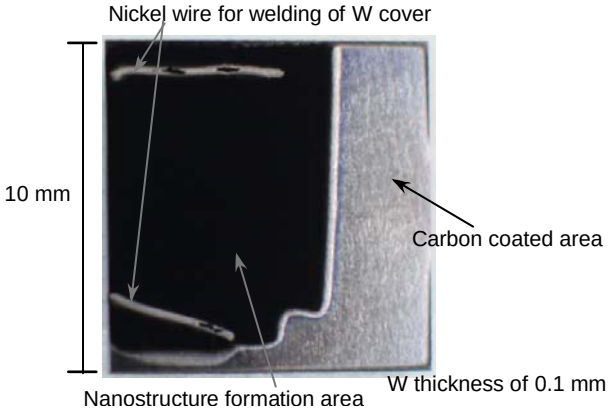

FIG. 1. Photo of W surface where two areas of fiber-form nanostructure developed black one and gray zone without nanostructure. The size of PM-W sample is 10×10×0.1 mm^3.

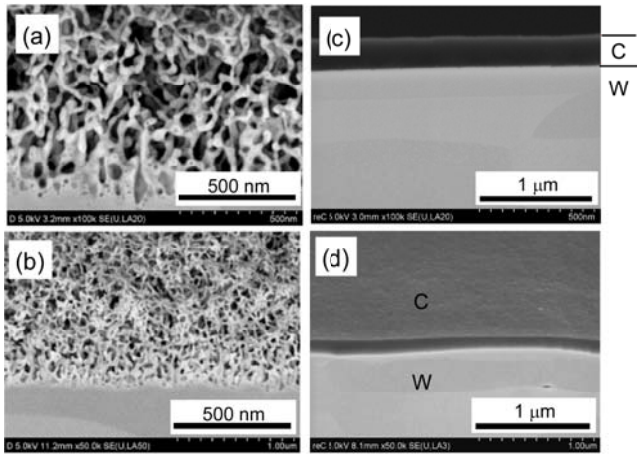

FIG. 2. SEM photos for two areas seen in Fig.1. Here (a) and (b) show the top and grazing views of black zone, while (c) and (d) do those at gray zone.