# §90. Hydrogen Elements Adsorption Properties on Helium Irradiated Tungsten

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Tungsten (W) has a high melting point, low neutron activation cross-sections, and low tritium (T) solubility, so that it is a candidate of plasma-facing materials. In spite of these advantages, it is known that He bubbles and fiber-form nanostructures are formed on tungsten surface by exposing to He plasma [1]. In this paper, fractal analysis was applied for the W nanostructures formed by the He plasma irradiation. Using the SEM micrographs, fractal dimension $D$ and a parameter $d_{\min}$ were inferred, and the obtained $D$ is compared with the one obtained from the gas desorption property.

The samples were prepared in the linear plasma device NAGDIS-II by the exposure to the He plasmas. The temperature during the irradiation was 1700K and the He fluence was ~$2 \times 10^{26}$ m$^{-2}$. Fig. 1(a) shows the cross sectional SEM micrograph of a He irradiated tungsten sample. The irradiation condition satisfied the necessary condition for the nanostructure growth, and the nanostructures are sufficiently grown on the surface. Fig. 1(b) shows the variance of the brightness level $z(l)$ as a function of the distance from reference point, $l$, for the SEM micrograph shown in Fig. 1(a). The depth of the reference position was 400 nm from the top of the image, as shown in Fig. 1(a). Clear knee can be identified in Fig. 1(b); interestingly, in the scale larger than $d_{\min}$, that the slope became flatter but still it also satisfied the power law. From both of the slopes, the fractal dimension can be deduced; here, we define the fractal dimension obtained in the scales below and above $d_{\min}$ as $D_1$ and $D_2$, respectively. It was obtained that $D_1$=2.38±0.20, $D_2$=2.84±0.03.

In Fig. 1(c), fitting was conducted using the data in the range 0.1 <$P/P_0$<0.3, where the linear relationship can be well identified and the above condition is satisfied. From the fitting, $D$ was obtained to be 2.68 ±0.02, which is in between $D_1$ and $D_2$ obtained from the cross sectional SEM micrographs.

Concerning the two fractal dimension values $D_1$ and $D_2$ obtained from the cross sectional image, it is likely that $D_1$ reflects the information of surface morphology of the structure itself, since $d_{\min}$ was 10–50nm, which corresponds almost to the width of the nanostructure. In the same manner, it is likely that the $D$ from the top SEM images also reflects the information of the morphology of the nanostructure fibers. Since the SEM micrograph only reflects the surface morphology and does not contain the information of the inner porous structure, the fractal dimension in the scale less than the fiber width could be close to two. If images that contain inner porous structure were used for the analysis, the fractal dimension can alter.

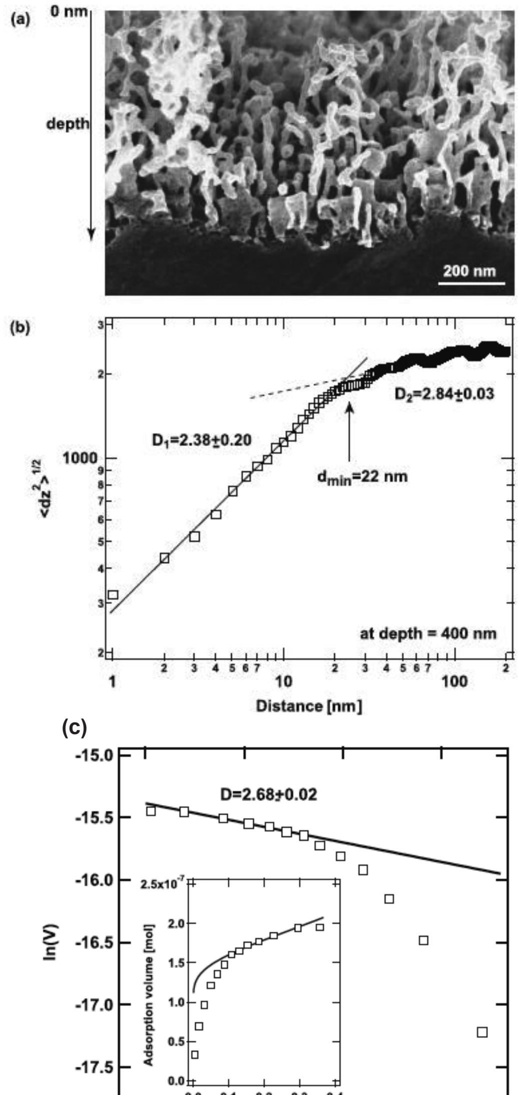


Figure 1: (a) A cross sectional SEM micrograph of the He irradiated tungsten sample, (b) the variance of the brightness level as a function of the distance, and (c) surface fractal analysis of the adsorption isotherms obtained for the He irradiated sample.

1) S. Takamura, N. Ohno, Dai Nishijima, and S. Kajita, Plasma Fusion Res. **1**, 51 (2006).