§71. Study of Hydrogen Accumulation in Tungsten Exposed to D Plasma

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Since tungsten (W) is one of the candidate materials for plasma facing components of fusion reactor, many investigations related the interaction of plasma-W have been carried out. From a view point of safety, the tritium inventory of materials which will be used as plasma facing components is one of key issues, due to the limitation of tritium inventory in the vacuum vessel. Therefore, the hydrogen isotope behaviour in W is an important issue. We have studied the surface morphology and the hydrogen inventory of W exposed with low energy (38 eV), high flux D plasma (10^{22} $D^+/m^2/s$).[1, 2] Deuterium inventory of W increased by plasma exposure and was found to depend on the exposure temperature. And there is a possibility that the amount of hydrogen isotope which could be solved or trapped in W surface is also increased after D plasma exposure. To understand the increase of hydrogen that could exist in W after plasma exposure, tritium was introduced into W exposed to D plasma and the distribution of tritium on W surface was examined by the technique of autoradiography.

The W specimen exposed to plasma was the recrystallized W (A.L.M.T. Corp., Japan) with 99.99 wt% purity. D plasma exposure to recrystallized W was carried out at around 495 K of specimen to the fluence of 10^{26} D/m^2. Tritium was introduced into the specimens thermally by exposure to hydrogen gas containing tritium. The exposure of tritium gas, in which the pressure of gas was 1 kPa, was carried out at 473 K in 5 hours. Tritium in the source was diluted with deuterium and the tritium concentration was 7.8 %. As received W was also exposed together with W exposed to plasma. Tritium autoradiography technique was carried out to above two specimens. At first, the thin collodion film was placed on the surface by dipping the specimen in collodion diluted by ethanol. The role of this collodion film is to avoid direct contact of the specimens with the AgBr grains in the radiographic emulsion. The monolayer of the radiographic emulsion (ILFORD L4) was placed on the collodion film by a wire-loop method. The specimens were kept in a light-tight box at around 273 K for 12 days to expose the emulsion to the β-ray from tritium. After that, specimens were dipped in a developer solution and then in a fixer solution. The AgBr grains exposed by the β-ray were turned by the development into Ag grains. The distribution of Ag grains was observed by the scanning electron microscope.

The results of autoradiography are shown in Fig. 1, in which white spots correspond to Ag grains. Fig. 1 (a) is the radiograph of W exposed to D plasma and Fig. 1 (b) is that of as received W. Ag grains were observed as white lines along with grain boundary in Fig. 1 (a). And White points accumulated Ag grains were also observed in the inner of grains in Fig. 1 (a). Ag grains were also observed in as received W as shown in Fig. 1 (b), however, the accumulation of Ag grains could not be observed. The result of Fig. 1 indicated that D plasma exposure produced accumulation points of hydrogen. In other words, D plasma exposure caused the trapping site of hydrogen. In the inner grain, hydrogen was accumulated on the blister. These blisters are considered to be created by the bubble that exists in more deep depth from the surface than the β-ray escape depth to the surface. Therefore, Ag grains observed on the blister would not indicate that tritium in the babble. On the other hand, the density of defect in the area around the blister will be higher than that in other inner grain. Therefore, defects created by the presence of bubble in W would play as trapping sites of hydrogen and as hydrogen accumulated points on the blister.

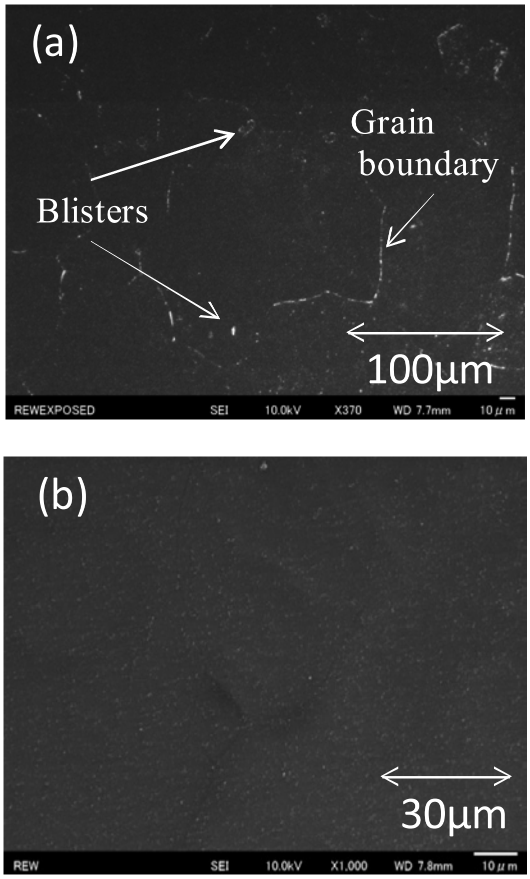

Fig. 1. (a) Autoradiograph of W exposed to D plasma
(b) Autoradiograph of as received W

1) Shu W.M. et al.: Nucl. Fusion 47 (2007) 201.
2) Alimov V. Kh. et al.: Physica Scripta T138 (2009)014048.