§43. Establishment of Active Control of Hydrogen Recycling in QUEST

Tokunaga, K., Miyamoto, Y., Araki, K., Fujiwara, T., Yoshida, N. (Res. Inst. Appl. Mech., Kyushu Univ.),
Iida, Y. (Grad. Sch. of Eng. Sci., Kyushu Univ.)

Recycling and wall pumping properties are critical issues for density control of a steady state plasma operation in thermonuclear fusion devices. In the case of the steady state operation in the QUEST, it is necessary that hydrogen recycling on the plasma facing materials and the divertor is actively controlled. Therefore, the understanding of hydrogen behavior on the plasma facing materials is the most critical issues as well as the plasma control, and then, absorption and desorption of hydrogen during the plasma discharge on the first wall are controlled from the basis for them. The purpose of the present work is established of active control of hydrogen recycling of tungsten (W) wall in the QUEST.

In the present work of this fiscal year, the influence of the substrate temperature on the crystal structure and deuterium retention of the W deposition has been investigated by transmission electron microscopy (TEM) and thermal desorption spectroscopy (TDS). In addition, specimens have been placed on the vacuum wall in the QUEST in order to investigate surface composition and structure change by plasma wall interactions. The surface probe transfer system has been moved and connected to the QUEST and a high temperature probe head has been fabricated.

W depositions were prepared by physical vapor deposition in a high vacuum with/without deuterium or oxygen atmosphere. Pre-thinned or bulk W was used as substrates. The substrate temperature during vacuum deposition was controlled from room temperature (RT) to 773 K. The deposition thickness was measured by a thickness monitor during the vacuum deposition and was 40 nm for all specimens. The depositions formed at various substrate temperatures were implanted with 1 keV-D_2^+ at RT to a fluence of $1x10^{21}$ D/m^2. TDS measurements were carried out for the quantitative analysis of deuterium retention in the W depositions.

Figure 1 shows dark field images and corresponding electron diffraction patterns of the W depositions formed in high vacuum (<1.0 x 10^{-4} Pa) at various substrate temperatures. The images were obtained from a part of the first broad diffraction ring. Under this image condition, only the grains satisfying the Bragg condition are designated as a white contrast. Microstructures of the depositions showed a strong dependence on the substrate temperature. The depositions formed consisted of fine bcc crystal grains around a few to a few ten nm in diameter depended on the substrate temperature.

Figure 2 shows thermal desorption spectra of D_2 (m/e=4) obtained from the deuterium ion irradiated W depositions, which were formed in high vacuum (<1.0 x 10^{-4} Pa) . Deuterium retention was below 1% of that of implanted deuterium. On the other hands, in the case of the W deposition, which were formed in oxygen atmosphere (～3.0 x 10^{-3} Pa), deuterium retention was 8.5 % of that of implanted deuterium. The depositions formed consisted of fine bcc crystal grains around 1nm in diameter. Large amount of deuterium absorbed crystal grains, deuterium cavities and oxygen in the depositions. These results indicate that microstructure and hydrogen isotope retention properties largely depend on the wall temperature and atmosphere.

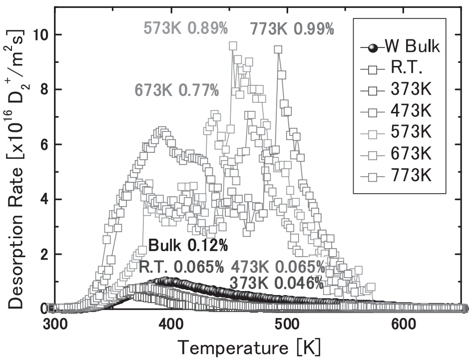

Fig.2 Thermal desorption spectra of D_2(m/e=4) obtained from W depositions implanted with 1keV D_2^+ at a fluence of 1.0 x $10^{21} D_2/m^2$ at room temperature

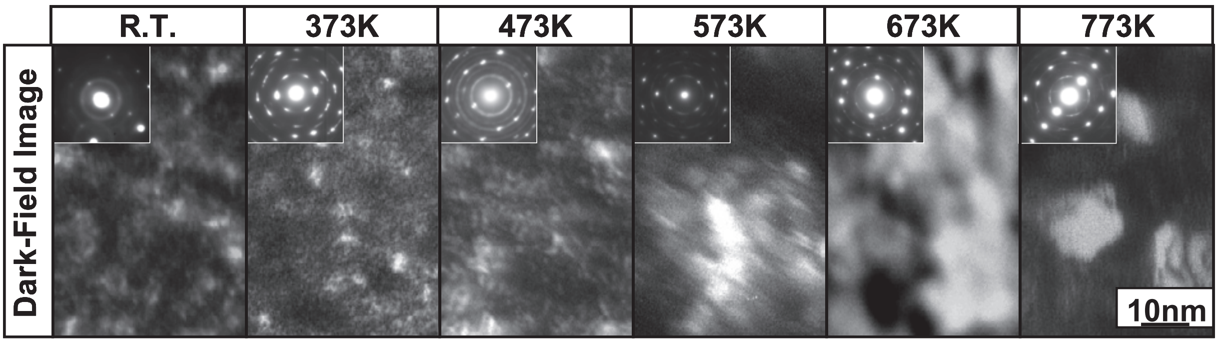

Fig.1 Electron diffraction and microstructures of W depositions at various substrate temperatures