§91. Effects of Plasma Exposure on Hydrogen Isotope Retention by Plasma-facing Materials

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It is of importance to clarify phenomena of implantation, retention, diffusion and permeation of tritium on surface of the armor materials of the first wall/blanket and the divertor from a viewpoint of precise control of fuel particles, reduction of tritium inventory and safe waste management of materials contaminated with tritium. In addition, it is well known that re-deposited layer, which includes the first wall components emitted by sputtering and residual gases such as oxygen, is formed. On the other hand, tungsten would be used as the armor material of the first wall and divetor in DEMO reactor. Therefore, clarification of behavior of tritium on surface exposed by plasma in all metallic first wall and divertor needs to be made. In the present work, tritium exposure experiments have been carried out for long term installed samples on first wall in spherical tokamak QUEST, which is an all metallic first wall device.

Samples have been installed on vacuum chamber of spherical tokamak QUEST at Kyushu University. The vacuum vessel, and an armor of divertor and center stack of QUEST are made of SUS316L and tungsten, respectively. After the plasma discharge experiments, the samples have been examined using XPS, RBS and ERD. In addition, tritium exposure experiments have been carried out using a tritium (T) exposure device at University of Toyama. Pressure of the T gas was 1.3 kPa and T exposure was kept for 4 h in all examinations. T concentration in the gas was about 5 %. After thermal exposure to T gas, T amount retained in surface layers of the sample was evaluated by β-ray-induced X-ray spectrometry (BIXS) and imaging plate (IP) measurements. In this fiscal year, T exposure experiments on sample which was exposed by 10th cycle (from 2013/5 to 2013/9) under the condition which temperatures of pre-heating and T exposures were both 100 ºC have been also performed.

XPS analyses showed that a thin re-deposited layer was formed on W substrate and main composition of the re-deposited layer was W, Fe, O. Spectra of $W4f_{7/2}$、 $W4f_{5/2}$ and $W5p_{3/2}$ from the re-deposited layer were different from normal W peaks. It is considered that oxidation of W in the re-deposited layer influences these spectra modification of W peaks. Figure 1 show the experimental results of RBS and ERD of SUS316L which was exposed to the plasma discharges. Less than one layer of W was detected on the surface of SUS316L. In addition, hydrogen is also detected on the surface of SUS316L and W, however, the amount of hydrogen was almost the same comparing with that of unexposed samples. Figure 2 shows the result of IP measurement of the SUS316L and W. The results of T exposure experiments so far indicated that the amount of T on samples after the plasma exposure increased because the re-deposited layer was formed on the samples surfaces due to the plasma exposure. On the other hand, this experiment shows that the amount of T on the surfaces of samples after the plasma exposure were lower than that of un-irradiated sample. It is considered that this thin re-deposited layer may suppress T retention and diffusion depending on properties of the re-deposited layer.

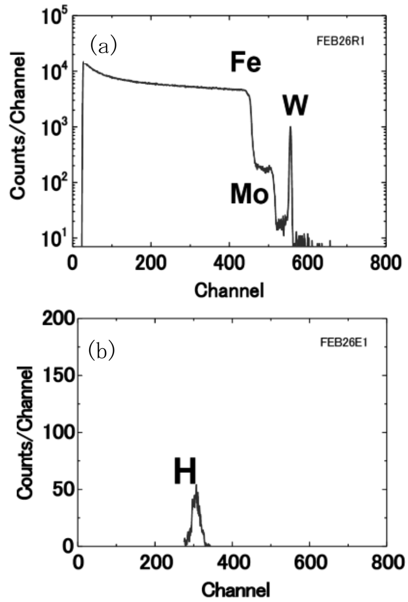

Fig.1 Result of RBS(a) and ERD(b) of SUS316L

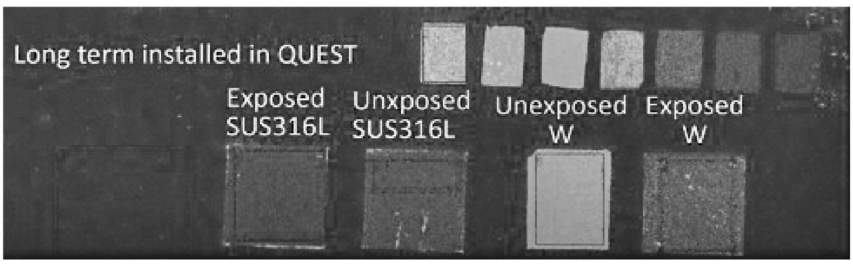

Fig.2 IP images of SUS316L and W which are unexposed and exposed by plasma discharges