§44. Study on Surface Modification of Tungsten Plasma Facing Materials

Tokunaga, K., Araki, K., Fujiwara, T., Miyamoto, Y., Hasegawa, M., Nakamura, K. (RIAM, Kyushu Univ.),
Nagata, S. (IMR, Tohoku Univ.),
Tsuchiya, B. (Fac. Sci. & Tech., Meijo Univ.),
Tokitani, M.

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 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 in 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. Quantitative analyses of depth profiles of composition and the implanted He and H in the materials deposited on the glassy carbon plates were carried out by means of Rutherford back scattering (RBS) and elastic recoil detection (ERD). Depth profiles of H and D were measured by using an $4He^{2+}$ analyzing beam ERD technique with an energy of 2.8 MeV. The incident angle of the analyzing beam was 72^o from the surface normal to the specimen. The scattered ^{4}He atoms were detected with the RBS detector placed at an angle of 170^o to the incidence direction. The recoiled H and D atoms were detected by the ERD detector at an angle of 30o to the analyzing beam direction. An Al film 12 μm thick was placed in front of the ERD detector to absorb the He ions scattered from the specimen surface. The depth profile of he was also measured by using an $16O^{4+}$ analyzing beam ERD technique with an energy of 4.0 MeV. The geometry of the RBS & ERD system is same as that for the H and D measurements. In the first fiscal year, SUS316L has been investigated because the vacuum vessel is made by SUS316L. In addition, tritium exposure experiments have been carried out using a tritium (T) exposure device.

Figure 1 shows depth profiles from XPS analyses of SUS316L installed in the 3rd cycle (from 2009/11 to 2010/4). These results show that re-deposited layer was formed and main composition was C. BIXS measurement which temperatures of pre-heating and T exposures were 400 ^{o}C and 350 ^{o}C, respectively showed that Fe(Kα) etc. peaks originated from composition of SUS6316L in addition to Ar(Kα) peak, originated from β ray on T near surface of SUS316L, were detected. IP measurement indicated that amount of T on the re-deposited sample at RT and 350 ^{o}C exposure was 4.6 and 2.5 times higher than that of non-exposure sample in QUEST.

Figure 2 shows depth profiles from XPS analyses of SUS316L installed in the 7rd cycle (from 2011/10 to 2012/4). Re-deposited layer, which main composition was Fe, Cr, W and O, was formed on SUS316L sample which was installed in the 7 th cycle. Amount of T on the re-deposited sample which temperatures of pre-heating and T exposures were both 100 ^{o}C (same temperature of wall during plasma discharge experiment in QUEST) was 8.5 times higher than that of non-exposure sample in QUEST. These results indicate that formation on re-deposited layer enhances T retention, and amount of T must be evaluated taking into account the re-deposited layer. In addition, ERD analyses showed large amount of H was co-deposited on the re-deposited layer in 3rd cycle.

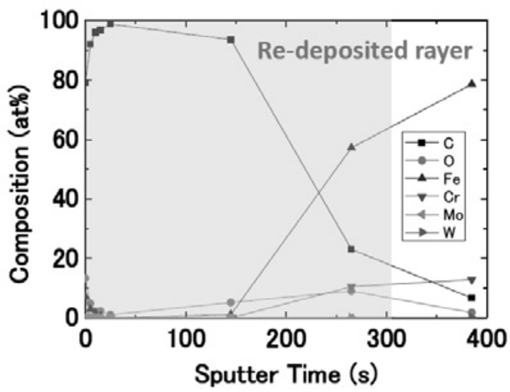

Fig. 1. Depth profiles of surface composition of SUS316L exposed to the 3rd cycle in QUEST.

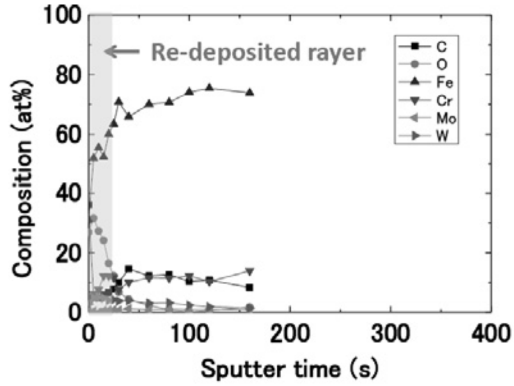

Fig. 2. Depth profiles of surface composition of SUS316L exposed to the 7th cycle in QUEST