§71. Effects of Plasma Exposure on Hydrogen Isotope Retention by Plasma-Facing Materials

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From viewpoints of not only recycling in the reactor core but also safety and economy of tritium, reduction of tritium retention in the plasma-facing materials (PFMs) is one of great important issues. The surface of PFMs is eroded by chemical and physical sputtering due to bombardments by high energy fuel particles, and consequently results in formation of deposition layers on different surface of PFMs. For this reason, surface properties of the PFMs have been changed, and the trapping/release behavior of tritium in/from the PFMs should be varied with a long operation. Namely, it is important to study the effects of a long exposure to plasmas for tritium retention.

Stainless steel type 316L (SS316L) was used as a model sample, which was exposed to the plasmas in QUEST. After plasma exposure, the sample was transferred to the University of Toyama by using a special sample container to expose to tritium gas. Color change of the sample surface has been observed after exposing to plasmas. This may be due to the deposition of inner materials in the device and surface oxidation by impurities in the plasmas.

Figure 1 shows the X-ray spectrum observed after exposure to tritium gas at 393 K for 4 hours in the tritium exposure device which has been operated in the tritium laboratory of the University of Toyama. Very weak characteristic X-ray peak of $Ar(K_{\alpha})$ was only observed in the spectrum. $Ar(K_{\alpha})$ peak is responsible for usage of argon gas as a working gas of β -ray-induced X-ray spectrometry (BIXS) to evaluate of tritium retention on the surface and near surface layers. This X-ray spectrum indicates that very small amount of tritium is retained on surface of the sample because $Ar(K_{\alpha})$ peak is basically induced by β -rays emitted from tritium nuclei on the surface.

Figure 2 shows a similar X-ray spectrum observed for the second experiment of tritium exposure for the same sample. The enlargement of Fig. 2 is shown in Fig. 3. The sample was heated at 673 K in the vacuum device after the first experiment, and it was again exposed to tritium gas at 623 K for 4 hours. About 10 times higher concentration of tritium gas was applied in this experiment. As clearly seen, plural characteristic X-ray peaks were observed: one is $Ar(K_{\alpha})$ and the others are due to the components of SS316L. The intusity of $Ar(K_{\alpha})$ peak was about 100 times in comparison with the result of Fig. 1. In addition to this, broad X-ray peak appeared in the region of higher than energy of 3.5 keV. This indicates that a part of tritium gas exposed is dissolved into bulk of the SS316L sample. It is considered that such a change in the X-ray spectrum is due to the cleaning of surface by heating at high tempearture in vacuum. It is suggested, therefore, that tritium retention is strongly dependent of chemical state of surface of the PFMs, and non-uniform distribution of tritiuim retention shall be formed in the plasama-faced surface of QUEST.

To investigate the desorption behavior of tritium dissolved into the bulk, the sample was heated stepwise after the second experiment, and the remaining tritium was measured by BIXS after heating at each temperature. As a result, linear decrease of the intensity of $Ar(K_{\alpha})$ was observed, which was similar to the desorption behavior for the sample of tritium ion irradiation. Other characteristic X-ray peaks also decreased about 1/3 by heating at 673 K. However, this is not sufficient from view point of decontamination. Further investigations are required for the detailed discussion of trapping and release behavior of tritium.



Fig. 1 X-ray spectrum observed by BIXS after the first experiment of tritium exposure.



Fig. 2 X-ray spectrum observed by BIXS after second experiment.

Fig. 3 Enlargement of Fig. 2.