§73. Behavior of Tritium Retention on Metallic Surfaces Exposed to Plasmas in QUEST

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Reduction of tritium retention in the plasma-facing materials (PFMs) of a fusion reactor as well as ITER is of a great importance from viewpoints of not only controlling the fuel particle balance in the reactor core but also safety and economy of tritium. The surface of PFMs is eroded by chemical and physical sputtering due to bombardments by high energy particles, and consequently results in formation of deposition layers on different surface of PFMs. For this reason, trapping and release behavior of tritium in/from the PFMs should be varied with operation. Namely, it is important to study the effects of a long exposure to plasmas for tritium retention.

In order to clarify such effects, many investigations have been carried out so far by using deuterium and/or tritium. However, most of these studies have been done using samples exposed to atmosphere after exposing to plasmas. Exposure to atmosphere makes unclear interesting properties of plasma-exposed surface owing to adsorption of oxygen, water vapor, carbon dioxide and so on. Therefore, it is need to expose to tritium without air exposure after plasma exposure experiments. So, we have constructed a specially designed apparatus connected with QUEST.

Samples exposed to plasmas in the QUEST were made of type 316 stainless steel (SS316) of which size was 15x15x0.5 mm^3. After exposure to plasmas, the sample was transferred without air exposure by using a vacuum container to Hydrogen Isotope Research Center, University of Toyama, and they were exposed to tritium gas under the given conditions. Tritium retention was measured by β-ray induced X-ray spectrometry (BIXS) and an imaging plate technique.

At first, the sample was exposed to tritium gas at ambient temperature after evacuation at room temperature. Figure 1 shows an X-ray spectrum observed by BIXS, where argon was used as a working gas. When a given amount of tritium is adsorbed on the surface, one can find an X-ray peak (2.96 keV) of argon. However, we could not find the X-ray peak. This indicates that no adsorption of tritium can be taken place under the present conditions. This is very important information to understand tritium retention behavior.

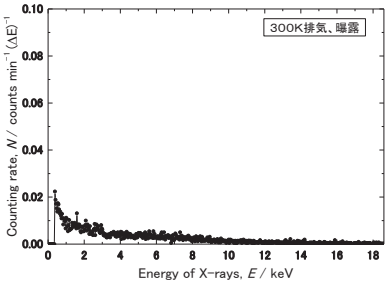

Fig. 1 X-ray spectrum observed without additional heat treatment.

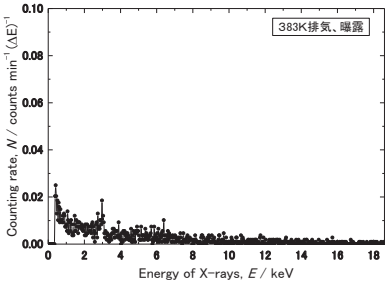

Fig. 2 X-ray spectrum observed by heat treatment at 383 K in vacuum.

Subsequently, the sample was again set in the tritium exposure device, and exposure to tritium gas was carried out after evacuation at 383 K. Small peak appeared in the energy region of 3 keV as shown in Fig. 2, which was not observed in Fig. 1. Namely, this indicates that the sample surface was activated for adsorption of tritium by heat treatment at low temperature. However, there are no large differences in chemical state of the surface described in Fig. 1.

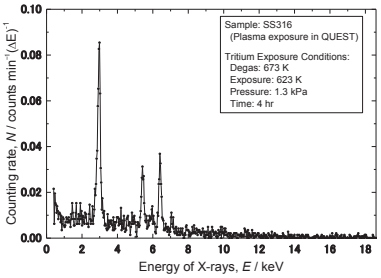

Fig. 3 X-ray spectrum observed by heat treatment at 673 K in vacuum and exposure at 623 K.

The third exposure to tritium gas was carried out under higher temperature condition: that is, evacuation at 673 K, and exposure at 623 K. The observed X-ray spectrum is shown in Fig. 3. Quite different spectrum appeared: namely, plural characteristic X-ray peaks were observed. Peak intensity of Ar(Kα) was about ten times greater than that observed in Fig. 2. It is suggested that the sample surface was fully activated by heat treatment in vacuum. Bremsstrahlung X-ray peak can be also seen in the spectrum. Maximum intensity appears in an energy region around 6 keV. In addition to this, characteristic X-ray peaks of Cr and Fe were observed. These phenomena indicate that tritium diffuses into the bulk of SS316 by heat treatment and exposure at high temperatures.

Similar behavior has been observed for the samples exposed plasmas in the Large Helical Device, although changes in the surface properties by heat treatment at higher temperatures after plasma exposure do not make clear.