§62. Studies on Improvement of Tritium Safe-Handling Techniques and Material Interactions with Tritium

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Accumulation of basic data on the interactions between high-level tritium and the plasma-facing materials is indispensable for establishment of a fusion reactor. In addition to this, the research and development on systematization and improvement of various elemental techniques related to the tritium safe-handling techniques is of a great important issue. Namely, it is required that construction of data base on the techniques for reduction of tritium inventory and tritium confinement in the reactor. For this purpose, it is necessary to scientifically systemize a wide technique region concerning to supply, recovery, purification-separation, and storage of tritium.

Evaluation of dynamic behavior of the trapping and release of tritium in/from materials is one of key issues from viewpoints of not only control of fuel particle balance but also tritium confinement in a fusion reactor. In this study, stainless steel exposed to plasmas of the 13th cycle in the Large Helical Device (LHD) was used as a model material, and the effects of plasma exposure for trapping and release of tritium have been examined.

Sample plates of stainless steel type 316 (SS316) were fixed at four location (1.5U, 5.5U, 6.5L and 9.5L) in the LHD before plasma experiments. After the 13th cycle, the plates are taken out and cut a size into 10x10 mm^2. At first, sample surfaces were observed by a digital microscope and a scanning electron microscope (SEM). Tritium exposure of four samples was carried out by using a conventional tritium exposure device. Exposure temperature was room temperature and 623 K, exposure time was 4 hours, and the total pressure of tritium gas was 1.3 kPa. After tritium exposure under the given conditions, the samples were analyzed by β-ray-induced X-ray spectrometry (BIXS).

Fig. 1 shows one of photographs of the 9.5L sample observed by SEM. Sample surface was covered by depositions, and flatness of them was within 1 μm. Many fine particles (*ca*. 0.3 μm) were observed on the surface, which struck the deposition layer of a sample surface from the same direction.

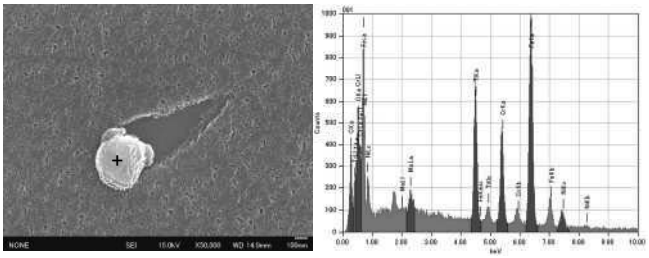

Fig. 1 Surface analysis of 9.5L sample by SEM. Mark "+" indicated in the photograph is the point analyzed by EDS.

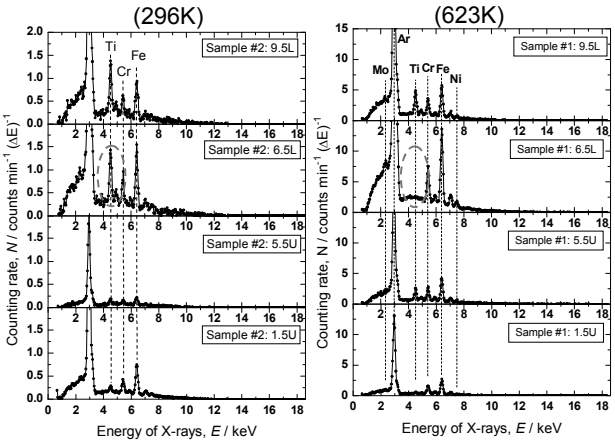

Fig. 2 X-ray spectra observed for 4 samples by BIXS. Tritium was exposed at 296 and 623 K.

The deposition layer consisted of carbon, boron, titanium and constituent element of stainless steel.

Fig. 2 shows the X-ray spectra observed by BIXS. X-ray spectra indicate that various elements such as Ti, Cr, Fe, Ni, and Mo exist on/in surface layers of the deposition. Boron observed in Fig. 1 was not able to detect by BIXS because X-ray energy emitted from boron atoms is lower than 1 keV. Titanium did not appear in all samples, and depended on heat treatment. Titanium appearance comes from usage of a Ti-sublimation pump in the vacuum system. It is well known that titanium easily ad-/absorbed hydrogen isotopes. Therefore, further examinations about the chemical states of titanium are required.

The amount of tritium trapped on the sample surface was the following order:

6.5L>9.5L>5.5U>1.5U for exposed at 623 K

6.5L>9.5L>1.5U>5.5U for exposed at 296 K

Namely, the adsorption and/or absorption amount of tritium for the 6.5L sample was highest. This is due to the deposited layers of a thin carbon film, and its formation was examined by laser Raman spectroscopy. Trapped tritium in the 6.5L sample was gradually released even at ambient temperature and in atmosphere, although release behavior could not be observed for other samples within 500 hours.