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

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It is one of great important issues from viewpoints of not only controlling the fuel particle balance in the reactor core but also safety and economy of tritium to reduce tritium retention in the plasma-facing materials (PFM's) of a future fusion reactor as well as ITER, since a huge amount of tritium is used. However, the trapping and release behavior of tritium in/from the PFM's will be changed by exposure to fusion plasmas for a long operation, because PFM's are always bombarded by neutrons, fuel particles, and the impurity particles. In addition to this, the surface of PFM's is eroded by chemical and physical sputtering due to bombardments of various particles, and consequently results in formation of deposition layers on different surface of PFM's. Namely, it is important to study the effects of exposure to plasmas for tritium retention.

In this study, stainless steel exposed to plasmas of the 15th 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 studied. Sample plates of stainless steel type 316 (SS316: 10x10 mm^2) were preliminarily fixed at four locations (1.5U, 5.5U, 6.5L and 9.5L) in the LHD prior to experimental campaign of the 15th cycle. After being exposed to plasmas, sample plates were separated from each wall, and those were loaded in a conventional tritium exposure device. The samples were heated in vacuum at a temperature range from room temperature to 623 K in order to examine the effects of heat treatment, and subsequently they were exposed to tritium gas at room temperature after each heat treatment. Exposure time was 4 hours, and the total pressure of tritium gas was 2.66 kPa. After tritium exposure under the given conditions, the samples were analyzed by β-ray-induced X-ray spectrometry (BIXS) and an imaging plate (IP) technique.

Fig. 1 shows the result of surface tritium distribution for the sample of 1.5U observed by IP to examine the effects of heat treatment. As clearly seen from the IP images, tritium retention increased with increasing a temperature of heat treatment in vacuum, and non-uniform distribution of tritium

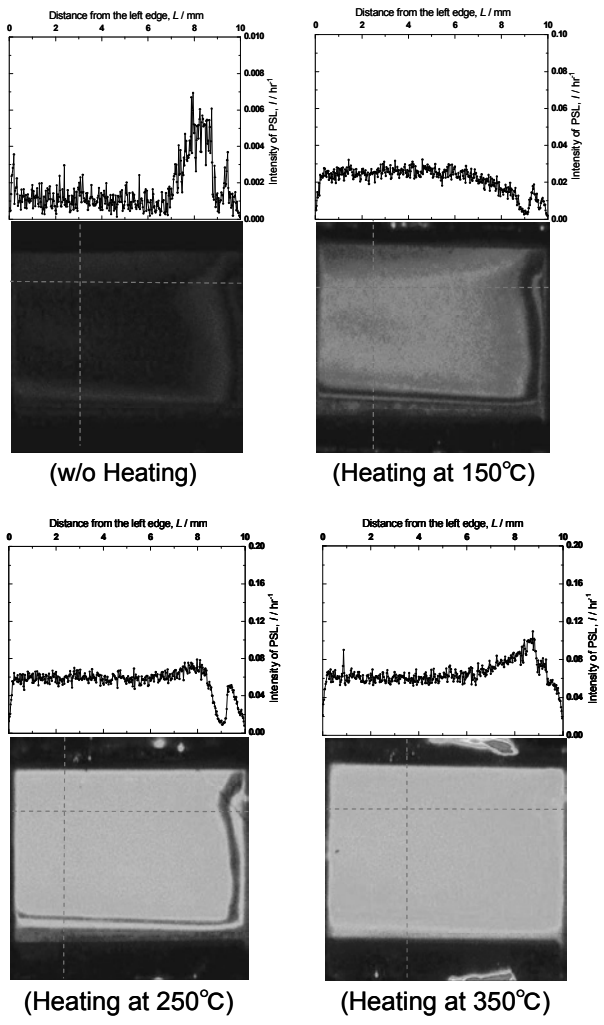

Fig. 1 IP images for 1.5U sample heated at various temperatures in vacuum.

was observed at peripheral part (especially, right and lower parts) of the sample. The retention amount on the surface increased about 20 times by heating at 423 K. It is considered that this is due to the effects of desorption of impurities on the surface. In addition, a different behavior appeared in central and peripheral parts after heat treatments. In particular, quite different image appeared after heating at 623 K in vacuum. Namely, the tritium retention at a peripheral part significantly increased. It is suggested that this is due to appearance of the new adsorption sites by heating at the high temperature.

Surface tritium distribution was again examined after 100 days since heating at 623 K. Tritium retention in central part largely decreased in comparison with the initial retention, suggesting that different adsorption sites were created at a peripheral part by the heat treatment. Spot analyses in a peripheral part by BIXS showed titanium deposition. Further investigations are required to make it clear.