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

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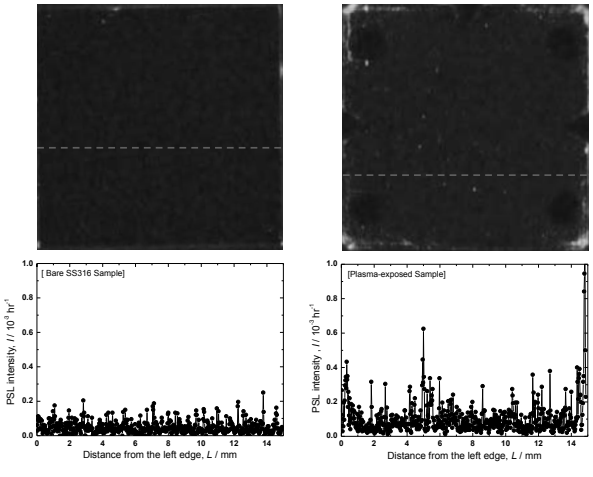
It is of a great importance to reduce tritium retention in the plasma-facing materials (PFMs) of a future fusion reactor as well as ITER from viewpoints of not only controlling the fuel particle balance in the reactor core but also safety and economy of tritium. The surface of PFMs is eroded by chemical and physical sputtering due to bombardments of various 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 by exposure to fusion plasmas. Namely, it is important to study the effects of exposure to plasmas for tritium retention.

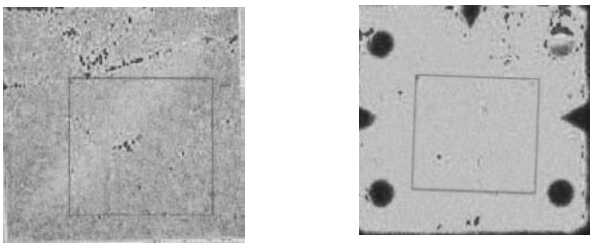
In order to clarify such effects, many investigations have been carried out so far by using deuterium and/or tritium. However, most of these studies have been done using samples exposed to atmosphere after exposing to plasmas. Exposure to atmosphere makes unclear interesting properties of plasma-exposed 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 used in this study were made of type 316 stainless steel (SS316) plate, and the size was 15x15x0.5 mm.



(w/o plasma exposure) (plasma exposure)

Fig. 1 Comparison of tritium distribution.



(w/o plasma exposure) (plasma exposure)

Fig. 2 IP images after heat treatment at 623 K in vacuum and exposure to tritium gas at 300 K.

After plasma exposure in QUEST, the sample was transferred to Toyama University without air exposure and it was set in a tritium exposure device along with a non-exposed SS316 sample. After vacuum pumping at room temperature, the evacuation was additionally continued at 373 K. Evacuation at a low temperature is to lower annealing effect of plasma exposure as possible. After heating in vacuum, tritium gas of 1.3 kPa was exposed to the samples for 4 hours at 300 K. The amount of tritium in surface layers and distribution of tritium on the surface were measured by β-ray-induced X-ray spectrometry (BIXS) and an imaging plate (IP) technique, respectively.

Figure 1 shows the tritium distribution of plasma-exposed and non-exposed sample as a reference one. Red dotted lines in the IP figures show the position analyzed tritium concentration and the results are described below the IP figures. Line analysis indicates that the tritium concentration for plasma-exposed sample becomes higher than that for non-exposed sample. Increase in the tritium retention was also confirmed by BIXS measurements.

After the experiment of tritium exposure at 300 K, the samples were again set in the tritium exposure device. They were again exposed to tritium gas at 300 K after heating at 623 K in vacuum. Clear increase in the tritium retention was observed for both samples as shown in Fig. 2. Additional heat treatment in vacuum gave rise to the increase. These results are shown in Table 1. As clearly seen form the table, increase in the heating temperature in vacuum brings about the increase in tritium retention, but it was seen that the difference in tritium retention between plasma exposed sample and w/o plasma exposed one became smaller.

Table 1 Summary of BIXS and IP measurements.

	vacuum heating at 373 K exposed to tritium at 300 K			vacuum heating at 373 K exposed to tritium at 373 K			vacuum heating at 623 K exposed to tritium at 300 K		
	BIXS		IP/PSL	BIXS		IP/PSL	BIXS		IP/PSL
	Ar(Kα)	Fe(Kα)		Ar(Kα)	Fe(Kα)		Ar(Kα)	Fe(Kα)	
Bare SS	2.3×10^{-2}	---	0.93	2.6×10^{-1}	6.0×10^{-2}	13.4	5.9×10^{-1}	6.1×10^{-2}	24.3
Plasma-exposed	4.1×10^{-2}	---	2.28	4.1×10^{-1}	5.8×10^{-2}	19.8	4.1×10^{-1}	6.1×10^{-2}	34.7
Ratio	1.8	---	2.5	1.6	1	1.5	0.7	1	1.4