§88. Studies on Removal/Recovery Techniques for Residual Tritium in Materials

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Precise control of fuel particles in the reactor core is indispensable to make a steady operation for a long term. A part of energetic particles of deuterium and tritium is implanted into the plasma-facing materials (PFMs) and simultaneously released from them during the operation. Therefore, from viewpoint of stable fuel balance, it is of a great important issue to make clear absorption/desorption behavior of hydrogen isotopes. From these viewpoints, a new irradiation device of tritium ions was established.

Basic performance of the newly established ion irradiation device is shown in Table 1. An air-lock system is also connected with the irradiation device to shorten evacuation time. Three kinds of a sample size are applicable to the tritium irradiation, and two or three samples can be simultaneously irradiated under the similar conditions.

Behavior of tritium retention in stainless steel plates irradiated with tritium ions under given conditions was examined using the present tritium irradiation device. Prior to the irradiation, samples in each run were heated at 673 K in vacuum. After irradiation of tritium ions, examination of tritium retention was evaluated by β-ray induced X-ray spectrometry (BIXS) and imaging plate technique.

At first, dependence of ion energy for retention was examined, and the result is shown in Fig. 1. As clearly seen from the figure, tritium retention was changed in a concave shape with ion energy. This indicates that two kinds of irradiation and trapping behavior participate in the process.

Table 1. Basic performance of the tritium ion irradiation device.

Ion species	H_2^+, D_2^+, DT^+, He^+
Ion flux	～1x10^{17} m^{-2}s^{-1}(DT^+)
Ion energy	0.5～3.0 keV
Ion current	0.3～1 μA
Tritium pressure	1.3x10^{-4} Pa
Irradiation time	～60 min (Max.)
Sample size	6x6x0.5 mm (3 samples)
	10x10x0.5 mm (2 samples)
	15x15x0.5 mm (2 samples)
Irradiation spot size	5 mmϕ in diameter
Pre-heating in vacuo	～800 K (Max.)
Vacuum pressure	<1x10^{-6} Pa

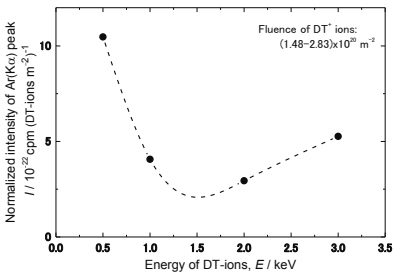

Fig. 1 Energy dependence of tritium retention.

Effects of radiation damage by pre-irradiation of helium ions on tritium retention were examined. Helium ions were pre-irradiated for 30 min, which was the same in each run. Energies of both helium and tritium ions were 1.0 keV. The result is shown in Fig. 2, and the dependence of helium ion fluence showed a concave shape. Tritium retention initially decreased with increasing in irradiation fluence of tritium ions, but the increase tendency appeared above the fluence of 7x10^{20} ions/m^2.

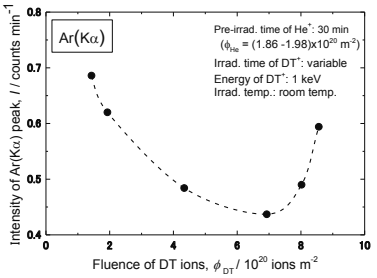

Fig. 2 Effects of radiation damage by pre-irradiation of helium ions on tritium retention.

Similar radiation effects were examined by changing helium fluence. Tritium ion irradiation was carried out for 30 min. The result is shown in Fig. 3. Tritium retention was proportionally increased with increasing in the fluence of helium ions. The linear relation was described as follows: $I = 0.830\times10^{-20}\phi_{He} + 0.424$.

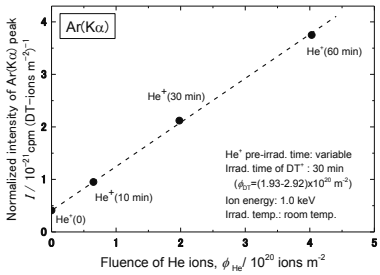

Fig. 3 Effects of pre-irradiation of helium ions.

Tritium irradiation samples described in Fig. 1 was heated stepwise in vacuum, and change in the tritium retention was tracked by BIXS. It decreased about 1/4-1/5 of initial retention by heating. Final heating temperature was 523 K. This was largely different from the samples exposed to gaseous tritium.

In addition to the preparation of ion irradiation device, a glow discharge cleaning device was also established for removal tests of tritium adsorbed on the surface/absorbed in the bulk of materials, and the performance tests are going now.