§32. Study of Tritium Trapping on Plasma Exposed Materials

Torikai, Y. (Hydrogen Isotope Research Center, Univ. Toyama),
Ashikawa, N., Nishimura, K.

Thermal trapping of tritium is possible in the carbon layer depositing on stainless steel SS316L during exposure of this material to LHD plasmas. The amount of trapped tritium in the deposited layer is about 40 times larger than that in the base metal SS316L. When the release rate of tritium from carbon deposited on SS316L is measured, the results comprise the release from SS316L and from the carbon deposit. Long-term release measurements provide the information needed to calculate the release rate from the carbon deposit. Measurements of the kind presented here may thus constitute in the future an indirect procedure to estimate carbon deposition buildup during operation of a fusion machine.

With the objective of gaining more information on the retention properties of plasma-generated layers, an investigation on the release rate of tritium from carbon deposited on Ni was commenced in this work. Ni was chosen because a number of researchers has reported reliable data on the diffusivity and solubility of hydrogen isotopes in nickel. While the solubility of tritium in Ni is almost the same as that in SS316L, the diffusivity of tritium across Ni is ten time faster.

Nickel specimens having dimensions of $10\times5\times0.1$ mm^3 and a purity of 99 % were purchased from Nilaco, Co. Ltd., Japan and cleaned in an ultrasonic bath first three times in ion-exchanged water and then three times in acetone. Cleaned specimens introduced into the LHD at section 6.5 near of the graphite divertor were subjected to 5,131 H-H shots (numbers #112111 - # 117242). Exposure to LHD plasmas caused coverage of Ni specimens by a carbon layer.

For a description of the experimental equipment and procedures used for sample loading and thermal release studies, several previous publications are available[1]. Briefly, single specimens inside of a quartz reactor are subjected to 670 K for 3 hours under a vacuum better than 10^{-6} Pa. After completion of heating a deuterium-tritium mixture containing 7.2%-T is fed into the quartz reactor. Loading takes place at a temperature of 523 K and a pressure of 1.2 kPa.

Figure 1 shows a schematic diagram of the experimental setup used to investigate the release of tritium. The apparatus comprises a gas supply, a specimen tube, two water bubblers and a copper oxide reactor. All tubing and their connections are of stainless steel. During each run, they are trace heated at 400 K to minimize condensation and adsorption. The temperature of the specimen was controlled at (298 ± 2) K. With argon as carrier gas the released tritium was first passed through a bubbler in which HTO was retained, then through a copper oxide bed maintained at 800 K to oxidize molecular tritium and hydrocarbons into HTO and carbon oxides and finally through a second bubbler. By this procedure, it was possible to distinguish between released tritiated water and elemental tritium. The technique used to determine the amount of tritium retained in each bubbler is liquid scintillation counting.

A comparison between the tritium content of the first bubbler with that retained downstream of the CuO bed in the second bubbler consistently showed that more than 99 % of the liberated tritium as of water, i.e. HTO. Surface reactions between tritium diffused to the surface and traces of moisture present in the carrier gas explain the formation of HTO[1]. Figure 2 compares the release rate of tritium at ambient temperature from pure Ni (solid line) with that from Ni (•) covered by a thin layer of deposited carbon as function of time after tritium loading. As further noticeable from Fig. 2 the release rate of tritium from clean Ni drops sharply from initially 2×10^5 Bq/h down to 10^3 Bq/h after an ageing period of 24 hours and down to less than 1 kBq/h after elapsing of 40 hours. A one-dimensional diffusion model[2] simulates this behavior rather well. The release of tritium from nickel having a deposited carbon layer, on the other hand, was quite different. In this case, the release rate became less 10 Bq/h after an ageing period of more than 1,000 hours and slowly decreased to 4 Bq/h after an ageing period of 8,350 hours. Evidently, the release of tritium from the carbon deposit on the surface is much slower than that from the Ni metal bulk.

This work is supported by NIFS budget NIFS14KEMF056.

1) Torikai Y. et al., Fusion Sci. and Technol., **48**, (2005) 177-181.
2) Saito M. et al., Fusion Sci. and Technol., **60,** (2011) 1459-1462.

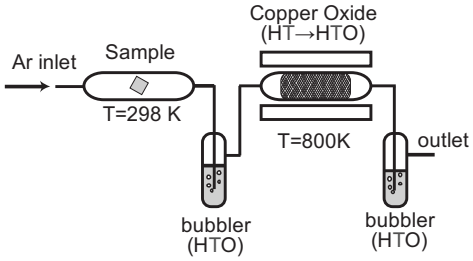

Fig.1. Experimental arrangement for the chronic release studies.

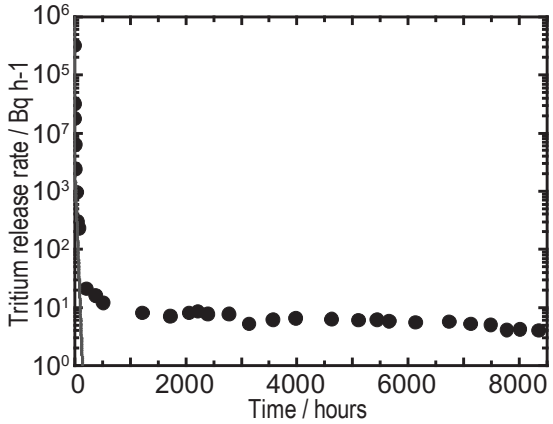

Fig. 2. Tritium release from carbon deposited Ni and simulation result of tritium release from pure Ni.