§34. Tritium Accumulation and Decontamination of Deposition Layer

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From a safety point of view, the tritium inventory in plasma-facing materials is one of the key issues due to the restrictions posed on the tritium inventory inside of fusion machines. Based on results on the deuterium retention in fusion materials exposed to low-energy, high flux D plasmas, the tritium inventory in future fusion reactors was assessed by thermal desorption spectroscopy (TDS). TDS is an excellent method for the determination of hydrogen isotope trapping and trapping strength. By TDS, specimens can be heated quickly up to 1073 K or even higher temperature. In actual fusion machines, like LHD, ITER or DEMO, structure materials and the existence of plasma determine temperatures. The maximum baking temperature of LHD is only 95ºC, and of ITER 150 to 350ºC. Therefore, TDS cannot determine the tritium trapping amount and release behavior under conditions prevailing in a fusion reactor.

In this study, an investigation on the trapping of tritium in plasma irradiated and deposited fusion reactor materials was commenced in order to evaluate the tritium inventory of fusion machine under real conditions. Additionally, results on the decontamination of W from tritium by thermal release and glow discharge methods are provided.

Figure 1 shows a new TDS apparatus for tritium release and baking studies. The apparatus comprises a specimen heat treatment section and an analysis section. Both sections have independent vacuum systems of different evacuation speeds. While that of the heat treatment section is very fast that of the analytic section is comparatively slow. The analysis section is equipped with one normal quadrupole mass spectrometer (QMS) and one of high resolution capable of separating He and D_2. The apparatus which is installed in a control area, permits handling of tritium contaminated specimens and the determination of tritium release by TDS or baking.

Figure 2 shows the example of tritium release by baking. Tungsten was irradiated by D_2 ions comprising 0.4% T_2 with an irradiation energy of 0.5 or 1 keV. After irradiation, the amounts of tritium on the surface was measured by the imaging plate technique (IP). The specimens were then evacuated to a vacuum of less than 10^{-6} Pa. After evacuation, the specimens were heated at 423K for 1hour and then surface tritium was determined again by IP. Under these conditions, 60 to 70 % of the surface tritium is liberated by baking. Thereafter, the specimens were re-introduced into the release apparatus and heated at 573 K. This treatment caused release of about another 20%. In spite of heating the specimen at 573 K, it was not possible to achieve full decontamination of the surface from tritium. Tritium remaining in the tungsten specimen is probably in traps firmly retained.

Figure 3 shows the tritium decontamination of carbon deposited on SS316L by D glow discharge. Left photo shows the carbon deposit on SS316L specimen. The specimen was loaded with tritium gas. Figure 3 1) shows the IP image taken from a tritium-loaded specimen, 2) shows the IP image after irradiated with a D glow discharge for 30 min and 3) shows the IP image after irradiated by a D glow discharge for additional 60min. After completion of the glow discharge, all surface tritium disappeared together with the deposited carbon layer on the surface. Additionally, all surface tritium trapped on SS316L was removed via D glow discharge. Hence, glow discharge decontamination is a good method to remove surface tritium on plasma facing wall.

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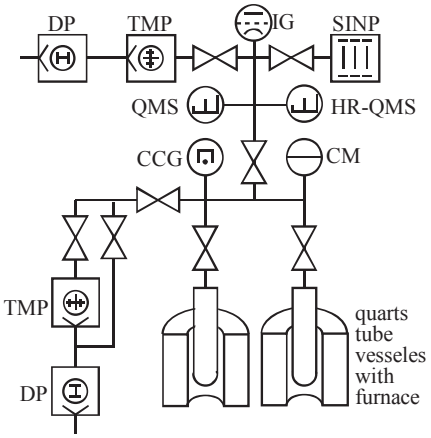

Fig.1 Tritium release apparatus for TDS and baking experiment. It consists of two turbo molecular pump (TMP), two dry pump (DP), a quadrupole mass spectrometer (QMS) and a high-resolution QMS(HR-QMS), a sputter ion noble pump (SINP), a capacitance manometer (CM), a cold cathode gauge (CCG), an ion gauge (IG) and two quartz tube vessels with furnaces.

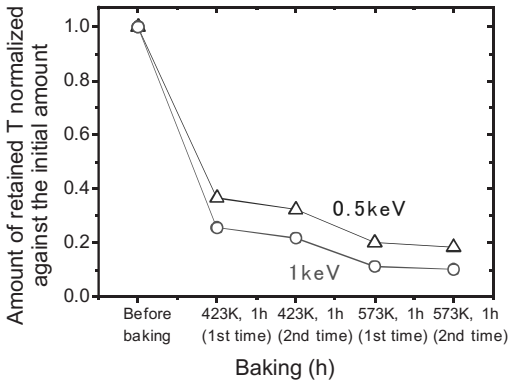

Fig.2 Tritium decontamination by thermal baking at under vacuum condition.

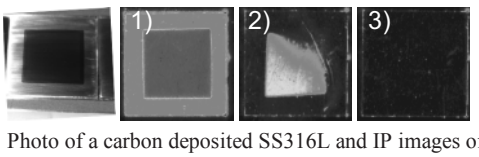

Fig.3 Photo of a carbon deposited SS316L and IP images of the tritium contaminated SS316L. 1) : before irradiated to D plasma, 2) : after irradiated to D plasma for 30 min, 3) : after irradiated to D plasma for 90 min.