§28. Tritium Accumulation and its 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 important key issues due to the limitation of tritium inventory inside of fusion machines. Based on results on the deuterium retention in fusion materials irradiated to low-energy, high flux D plasmas, tritium inventory in future fusion reactors was assessed by thermal desorption spectroscopy (TDS). TSD is one of the excellent method to determine hydrogen isotope trapping amount and its trapping conditions. At the TDS, specimens are heated quickly up to 1073 K or more high temperature. But actual fusion machines, like LHD, ITER and DEMO, could control only few conditions of temperature and existence of plasma. The maximum backing temperature of the LHD is only at 95ºC, which of ITER is at 150 to 350ºC. So TDS cannot determine the tritium trapping amount and release behavior under real condition of the fusion reactor.

In this study the tritium trapping on the plasma irradiated and deposited fusion reactor materials were investigated in order to assume the tritium inventory of fusion machine under real conditions. During fusion plasma irradiation, the W surface will be modified due to sputtering and re-deposition. W deposited layer formed by hydrogen plasma sputtering was exposed to gaseous tritium-deuterium (T-D) gaseous mixture. The T retention in the deposition layer after T exposure and after heating in vacuum was monitored by the imaging plate (IP) technique.

Samples of W deposition layer(W/W) were formed on W substrates by hydrogen RF plasma sputtering. Prepared samples were separately put in a reaction tube of the T exposure apparatus installed in University of Toyama, and heated at the present temperature for 3 hours under the vacuum condition in order to remove adsorbed water on the sample surface. Then, the samples were exposed to the T/D mixture (7.2% T/D) for 3 hours. After the T exposure process, the closed reaction tube in which the samples were contained was transported into a glove box filled with argon. Then, T level of the samples were investigated by IP without air exposure. After that, the samples were put in the reaction tube again and heated under the vacuum condition. IP measurement and heating process were performed repeatedly. For comparison, W substrates without W deposition layer were exposed to T-D mixture at the same conditions.

As an example, IP image from the W deposition layer and W substrate exposed to the T-D mixture at 573K are shown in Fig. 1. The initial intensities of photo-stimulated luminescence (PSL) were 1,029 PSL/mm^2/h for the W/W and 81 PSL/mm^2/h for the W substrate. The T level on the W/W was 10 times larger than that on the W substrate. Deposited tungsten acts a tritium trapping site.

Figure 2 shows surface tritium amount after heated at given temperature and given time. Tritium on surface did not decrease at room temperature under vacuum condition. A part of retained T was released at a low temperature of 368 K. This result suggests that the formation of the W/W increase the T inventory in the vessel and a certain amount of T can be removed at about 373 K by in-vessel baking. On the other hand, surface tritium on W was not decontaminated by heating at 368 K. Tritium decontamination behavior was difference between W/W and W. After heating the specimens at 573 K for 5 hours under vacuum, a 10 % of surface tritium on W/W was additionally decontaminated. A 97.5 % of surface tritium on W/W was decontaminated by the heating at 773 K for 2hours. Finally, a 99.8 % of tritium on W/W was decontaminated by heating at 973 K for 1 hour and a 0.2 % of tritium was left in W/W even by heating at 973 K. Tritium trapping states on W/W are various kinds. In order to decontaminate the tritium trapped on W/W, it is necessary to heat the plasma facing wall at least about 773 K.

It is impossible to decontaminate efficiently the tritium on plasma facing wall at actual fusion machines by backing method. We have to develop the more efficient tritium decontaminating method for actual fusion machine. As one method, it is proposed for efficient tritium decontaminating method which combined a glow discharge and isotope exchange methods.

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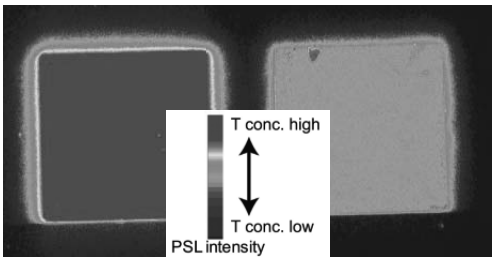

Fig. 1 IP image of the W deposition layer (left) and W substrate (right) exposed to T-D gaseous mixture at 573 K for 3 h.

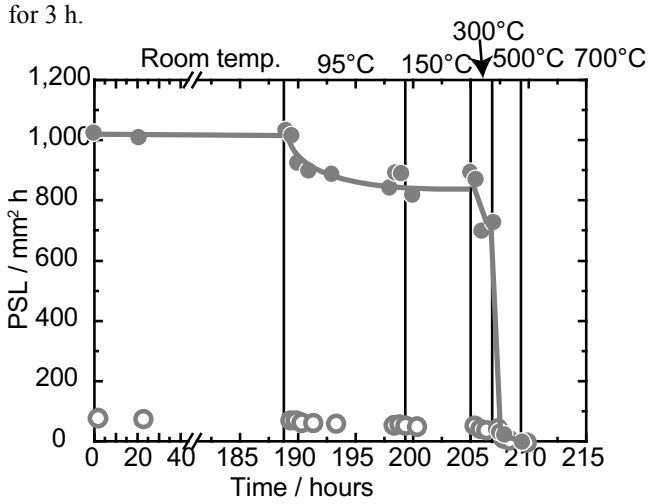

Fig. 2 Tritium amount on W(○) and W/W(●) surface, after heated from 368K to 978K for given temperature.