§22. Basic Studies for Reduction of Tritium Retention, and for Recovering and Recycling of H, D and T under LHD-DD Operations

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Tritium (T) produced by D-D reactions is a safety concern in deuterium discharges planned in LHD. We have been investigating; (1) where and how much tritium is retained at particular locations in plasma facing surfaces and remote areas, (2) reduction and/or removal of the retained tritium in the vacuum vessel, and (3) recovery and separation of hydrogen isotopes from evacuated gases.

Because of the limited space, this report focus two results (i) Thermal release of hydrogen retention in carbon materials, (ii) cryogenic recovery of hydrogen isotopes from evacuated gases and (iii) behavior of hydrogen on the surface and in the bulk of stainless steels in order to control surface contamination and de-contamination. Some of other results are given in published papers[1-7].

(i) Thermal release of hydrogen retention in carbon materials,

From extensive studies of hydrogen retention in plasma facing tiles of JT-60U, the retained amount and their release behavior during heating were successfully summarized in Fig. 1, where temperature dependence of hydrogen concentration and desorption rates for retained hydrogen at various temperatures by plasma exposure are superposed. With increasing the plasma exposure temperature, the desorption peak shits to higher temperature but desorption rates at higher temperature do not change significantly. Such desorption behavior is typical for carbon materials in which hydrogen diffusion is negligibly small and most of hydrogen is bound to carbon atoms. Hence the higher temperature operation with carbon plasma facing tiles is promising to reduce tritium retention.

(ii) Cryogenic recovery of hydrogen isotopes from evacuated gases.

Since the evacuation system of LHD is consisted of cryogenic pumps, hydrogen isotopes could be separated from other impurity gases, like He, hydro-carbons and water vapors, by temperature controlled heating of the cryo-panels. To do this, basic data for gas release characteristics during the heating are required. Separation of H_2 from He was already confirmed. In this year, gas mixture of H_2 and CH_4 were examined and it was found that CH_4 was desorbed much higher temperature than H_2, as shown in Fig. 2, where the relative adsorption amount of H_2/CH_4 in the cryo-panel during temperature increase together with a model calculation. One can see the model calculation fits well. Thus cryogenic separation is very much promising and could be applied to a real system. .

(iii) Behavior of hydrogen in stainless steels

Hydrogen behavior at surface and bulk for stainless steels exposed to hydrogen gas and plasma were studied applying tritium tracer techniques, i.e., surface profiling and depth profiling by Imaging Plate and observation of release rate by a scintillation counter. Although significant amounts of hydrogen were trapped near surface regions, they did not influence the release hydrogen from the bulk. Most probably, the surface tritium was trapped with rather high energy trapping. Therefore apparent release behavior is controlled by relative amounts of surface trapping and of dissolved in bulk, i.e. larger the former, the release would be slower. In other words, even if surface T was once removed by decontamination, T from the bulk could diffuse out to re-contaminate the surface again.

Published papers
1) M. Yoshida, T.Tanabe, Y.Nobuta, et al. J. Nucl. Mater. **390-391**(2009) pp.635-638.
2) T. Tanabe, et al. J. Nucl. Mater. **390-391**(2009) pp.705-708.
3). M. Yoshida, T. Tanabe, Y. Nobuta, et al. J. Plasma and Fusion Research, SERIES **8**(2009) pp.1253-1255
4). T. Tanabe, K. Masaki and K. Sugiyama, Physica Scripta, **T138** (2009) 014006 (9p)
5) T. Otsuka, T. Hoshihira and T. Tanabe, Physica Scripta, **T138** (2009)014052 (4p)
6) S. Fukada, et al. Fus. Sci. Technol., **57** (2010) 112-119.
7) M. Nishikawa, Fus. Sci. Technol., **57** (2010) 120-128

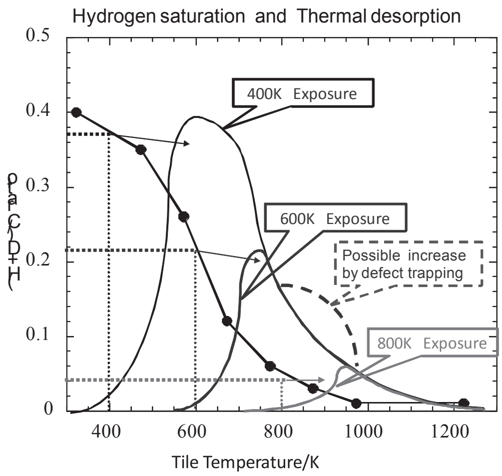

Fig. 1 Temperature dependence of saturated hydrogen concentration (H/C) in carbon materials and schematics of thermal desorption rate.

Relative adsorption amounts in H_2-CH_4 System

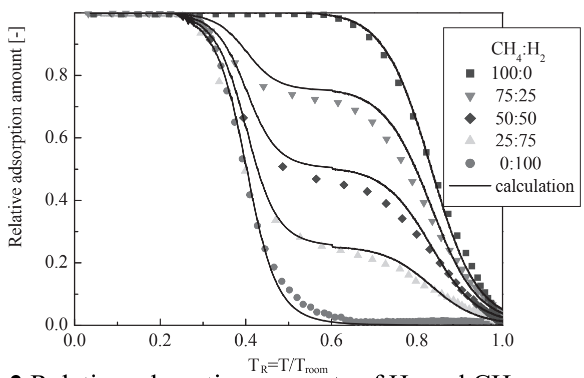

Fig. 2 Relative adsorption amounts of H_2 and CH_4 during cryogenic recovery process.