

§18. Deuterium Retention of Plasma Facing Walls under DD Discharge in LHD

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In the DD discharge scheduled in LHD, in-vessel tritium inventory has to be minimized from a view point of safety, and the fuel hydrogen (deuterium and tritium) retention in the plasma facing walls has to be controlled to suppress the hydrogen recycling. Thus, the fuel hydrogen retention of the plasma facing materials has to be clarified, and also the method to reduce the fuel hydrogen retention has to be developed. In this study, first, the fuel hydrogen retention of candidate plasma facing materials (stainless steel, graphite and tungsten) is investigated using a glow discharge apparatus at Hokkaido University. Secondary, for reduction of the fuel hydrogen retention, the performance of the inert gas (He, Ne, Ar) glow discharge was investigated. In addition, the reduced amount of fuel hydrogen retention was evaluated based upon the numerical calculation using SRIM code.

The deuterium retention of stainless steel (SS) wall was determined using a residual gas analysis (RGA) in the deuterium glow discharge with the SS liner wall. The amount of retained deuterium was $2\sim3 \times 10^{16}$ D/cm². The amount of retained hydrogen was similarly obtained, and the value was same as the deuterium retention. Thus, the tritium retention and desorption can be regarded same as that of the deuterium or hydrogen.

Similar experiments were conducted for the graphite (C) and tungsten (W) walls. As the example, Fig. 1 shows the partial pressure change during the deuterium discharge for the graphite (IG-430U) wall. The net reduction of deuterium partial pressure corresponds to the deuterium retention. The amounts of retained deuterium in W and C walls were twice and one order larger compared with SS, respectively. Therefore, the use of graphite has to be minimized from the view point of tritium inventory.

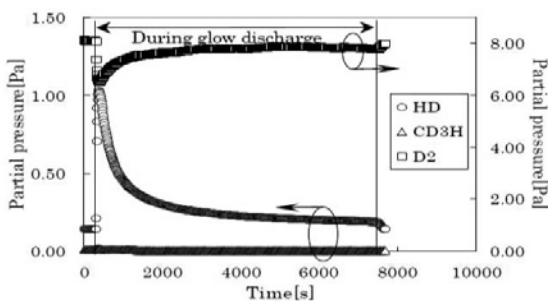


Fig.1 Change of partial pressure during D₂GD

In order to reduce the deuterium retention, He, Ne and Ar glow discharges were conducted after the deuterium discharge. As the example, Fig. 2 shows the partial pressure change during the He glow discharge for the graphite wall.

The retained deuterium desorbed in forms of HD, CD₃H and D₂. The ratio of desorbed amount to deuterium retention, the removal ratio, was about 50%, 15% and 15% for He, Ne and Ar discharges, respectively. It is seen that the use of He discharge is most effective for reduction of fuel hydrogen retention. This reason is due to the long implantation depth of helium ion. For the SS wall, the performance of the inert gas glow discharge was comparable with that for the graphite wall. However, for the W wall, the performance was one order lower compared with the case of C or SS. The tungsten employed was polycrystalline tungsten consisting of submicron grain particles. Many holes or dips with submicron order were produced by the ion bombardments, and thus the ion impact desorption little removed the implanted deuterium.

The reduced ratio experimentally obtained well

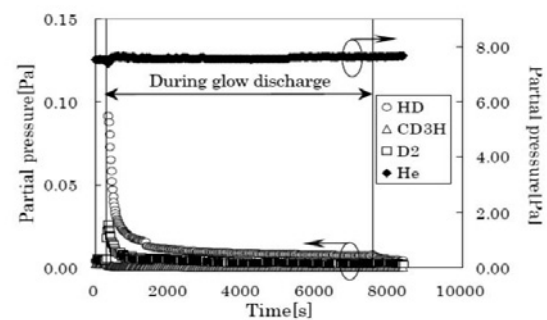


Fig.2 Change of partial pressure during HeGD

corresponded to the values obtained by the numerical calculation using the SRIM code. Namely, the removal ratio can be expressed by the summation of removals due to etching and ion impact desorption.

The present results are quite useful to evaluate the fuel hydrogen retention in the LHD walls, and to reduce the fuel hydrogen retention and in-vessel tritium inventory.

Publications on this study

- 1) Y. Kimura, T. Hino, Y. Yamauchi, K. Nishimura, Journal of Nuclear Materials **417**, 896–899, 2011.
- 2) T. Hino, Y. Yamauchi, K. Nishimura, Y. Ueda, Retention of fuel hydrogen retention of tungsten plasma facing wall in fusion reactor, To appear in Material Science Forum, 2012.
- 3) T. Hino, Y. Yamauchi, Y. Kimura, K. Nishimura, Y. Ueda, Fuel hydrogen retention of tungsten and the reduction by inert gas glow discharges, To appear in Fusion Engineering and Design, 2012.