§99. Investigation of Tritium Inventory and Removal on Deposition Layer in LHD

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Investigations on hydrogen isotope inventories in plasma facing walls are important with the view of controls of fuel recycling and in-vessel tritium inventories in fusion devices. But, removal processes of hydrogen isotopes have not been optimized yet and still serious problems in ITER and DEMO. In particular, retained hydrogen isotopes in deposition layers are higher than that in bulk materials. Depth profiles in target materials are different between the retained hydrogen isotopes originating from energetic hydrogen isotopes during plasma discharges and the molecular hydrogen isotopes [1-2]. In tokamaks, high-level tritium retentions were observed under the dome regions and this phenomenon is the trappings of molecular hydrogen isotopes into deposition layers. Thus, investigations of the trapped molecular hydrogen isotopes are also required. In this study, the hydrogen isotope retentions by the energetic particles and the molecular gasses into the deposition layers are analyzed, and the removal methods for these hydrogen isotopes from the deposition layers are investigated.

Two kinds of deposition layers, namely samples S2 and S3, were produced on stainless steel (SS) 316 target samples, which were set near the graphite divertor targets during one experimental campaign in LHD [3]. On the sample S2, the thickness of deposition layer was 382 nm and the atomic concentrations were 80 %C, and 15 % Fe. On the sample S3, the thickness of deposition layer was 22 nm and the atomic concentrations were 60 %C, 25 %Fe and 5 %B. The retained hydrogen from the deposition layers were 1.03×10^{22} mol./m^2 on sample S2 and 1.10×10^{21} mol./m^2 on sample S3, respectively. The hydrogen was mainly trapped into the deposition layers through the main plasma discharges and the glow discharges in LHD. The hydrogen-carbon (H/C) ratio for the samples 2 and 3 were 0.23 and 0.55, respectively. The ratio of sp2/sp3 bonded carbon is 0.1-0.2 measured by X-ray photoelectron spectroscopy (XPS). Three kinds of analytical parameters, H/C, sp2/sp3 ratio and Raman spectroscopy [4], show that these carbon deposited layers have characterizations of hydrogenated amorphous carbon.

An advantage to use tritium gas is high-sensitivity detection. The tritium imaging plate technique is one of the useful tools for tritium measurement. The LHD deposition layer on sample S2 was exposed to 7% of tritium gasses at 423K for 3 hours. After the tritium gas exposure, the amount of retained tritium into the deposition layer was evaluated by β-ray-induced X-ray spectrometry (BIXS). The detected tritium amount was 5.25×10^{17} mol./m^2, and the molecular tritium was confirmed to be trapped near the surface of deposition layers. Figure 1 (a) shows the long-term tritium desorption from the deposition layer after the tritium gas exposure measured by the tritium imaging plate technique. The target was kept at the room temperature in the air. The released tritium amount from the deposition layer was about 30% for 3 months. After that time to one year, the released tritium is negligible. After the observation of long-term tritium desorption, the baking experiments were done at 368K, 423K, 573K and 773K. As shown in Fig.1 (b), the effective temperature for the tritium removal is from 425 K to 573 K, and the amounts of tritium desorption reached a background level at 773K[5] .

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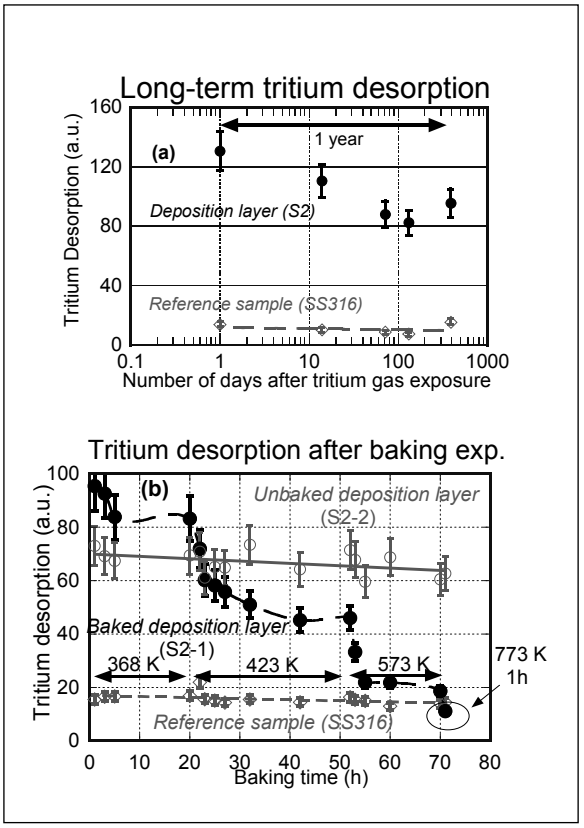

Fig.1. (a) Long term tritium desorption measured by the tritium imaging plate technique. (b) Tritium desorption after baking experiments. Four kinds of baking experiments were done at 368K, 423K, 573K and 773K after long-term exposure as shown in (a).