§17. 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]. 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 tritium are also required. In this study, tritium retentions by the molecular gasses into the deposition layers are analyzed, and the removal methods for these tritium from the deposition layers are investigated.

A target deposition layer, namely sample S2, was produced on stainless steel (SS) 316 target samples which was set near the graphite divertor targets during one experimental campaign in LHD. On the sample S2, the thickness of deposition layer was 382 nm and the atomic concentrations were 80 %C, and 15 % Fe. The retained hydrogen from the deposition layers were 1.03×10^{22} mol./m^2 on sample S2. 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 sample S2 was 0.23. The ratio of sp2/sp3 bonded carbon is 0.1-0.2 measured by X-ray photoelectron spectroscopy (XPS). Based on the ellipsometry analysis, single C-H bonds in the carbon deposited layers were observed. Four kinds of analytical parameters, H/C, sp2/sp3 ratio, Raman spectroscopy, and the ellipsometry show that these carbon deposited layers have characterizations of hydrogenated amorphous carbon with single C-H bonds [2].

The tritium imaging plate technique is one of the useful tools for tritium measurement. The LHD deposition layer on sample S2 was exposed to tritium gasses of 7% 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) and the detected tritium amount was 5.25×10^{17} molecular/m^2. Molecular tritium was confirmed to be trapped near the surface of deposition layers.

Long-term tritium desorption from the deposition layer after the tritium gas exposure measured by the tritium imaging plate technique. The specimens were kept at the room temperature in the air. The released tritium amount from the deposition layer was about 30% for 3 months as shown in Fig.1. After that time to one year, the released tritium is negligible. Specially, during two weeks after tritium gas exposure, effective tritium desorption was observed. Tritium has chemical bindings with oxygen and tritium water (T_2O) was produced and released. Molecular tritium trapped near the surface regions of the LHD deposition layers has a limitation to long-term tritium desorption, and the baking using an isochronal annealing is effective for the tritium decontamination from the deposition layer as future works.

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[1] T. Tanabe, et al., Journal of Nuclear Materials 313 (2003) 478.
[2] N. Ashikawa, et al., JPFR-SERIES 11 (2015) 015.

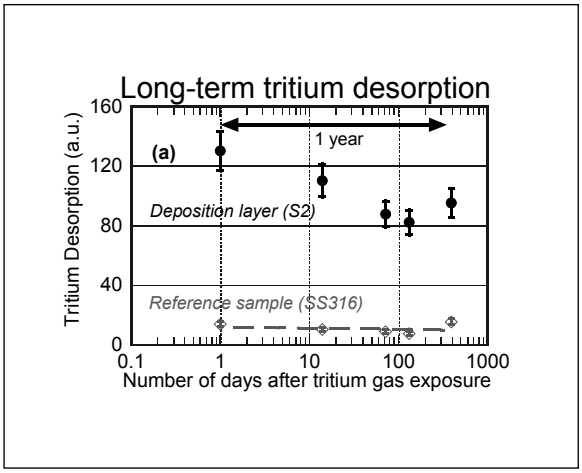

Fig.1. (a) Long term tritium desorption measured by the tritium imaging plate technique