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Tritium Retention to the First Wall of JT-60U

JT-60U第一壁炭素材タイルへのトリチウム蓄積

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Tritium inventory in some of the graphite tiles used as the first wall of JT-60U was measured by a full combustion method. The result showed that the amount of retained T increased with increasing the exposed discharge period of the tiles. Tritium retention rate was determined to be ~13 % of the total tritium production rate determined by the neutron production rate. It was confirmed that these retained tritium were part of the energetic tritium produced by DD reaction without being replaced by H during HH discharges.

1. Introduction

Selecting materials for vacuum vessel component is one of the key issues in the development of fusion energy. Because of its excellent performance under high heat load, carbon is one of the candidates for plasma-facing wall, and it has been widely used in most of the major tokamak fusion reactor. However recent studies have shown that carbon tends to retain and store tritium. Understanding of the process of tritium accumulation in carbon tiles is urgently required for the management of tritium fueling and safety. In this study, the tritium inventory in graphite tiles used as the first wall of JT-60U was measured by the full combustion method and the tritium retention rate to the first wall in respect of the total T production rate by DD reactions during discharges was evaluated.

2. Experimental

2.1 Sample tiles

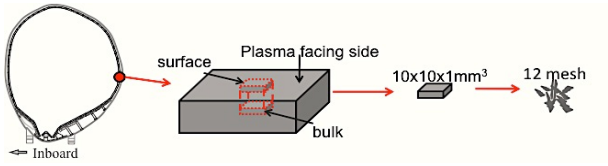

Fig.1 Samples from JT-60U

Sample plates of 10x10x1 mm were cut from a first wall tile including its surface (surface plates) or from inside around 2 mm and 20 mm in depth (bulk plates). The plates were crushed into 12 mesh fragments to make it easier to combust and put into quartz tube.

Analyzed tiles were located at the equatorial position of the first wall in JT-60U indicated in Fig.1. The tiles were exposed to DD discharges with different times as shown in Table 1 during operation years of 1991 to 2003.

Table 1 Sample's position & DD discharge time

Sample	Surface or bulk	DD discharge time[s]
1	Surface	1700
2	Surface	5000
3-1	Surface	21000
3-2	Surface	21000
4	Surface	40000
5	Surface	53000
A	Bulk (2mm depth)	35000
B	Bulk(20mm depth)	35000

Surface tiles were numbered in order of DD discharge time length. In JT-60U, HH discharges were performed after DD discharge campaign for tritium removal.

2.2 Experimental apparatus and operation

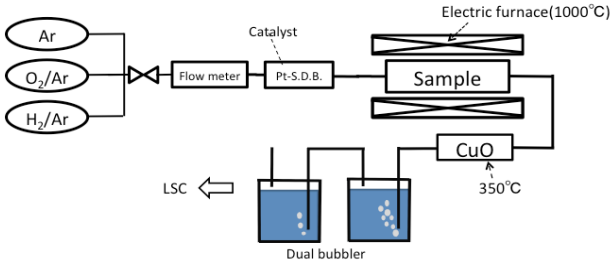

Fig. 2 Experimental apparatus

Fig.2 is a schematic diagram of experimental apparatus used in the full combustion experiment. All of the tritium contained in crushed samples was released by heating them up to 1273 K with an electric furnace. Humid argon gas with additional oxygen (10000 ppmH_2 + 50000 ppmO_2) was used as a purging gas and its flow rate was fixed to 0.2 L/min. Released tritium were transferred to a copper oxide bed at 623 K to convert HT to the tritiated water HTO, and collected in dual pure water bubblers. The amount of tritium collected in the bubblers was measured with a liquid scintillation counter. In all cases, the tritium concentration in the second bubbler was less than 1 % of the first bubbler.

3. Results and Discussion

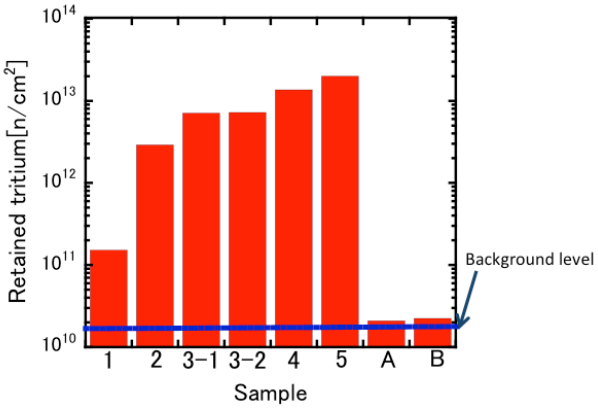

Fig.3 Tritium inventory of each examined sample

Fig.3 shows the tritium inventory of each examined sample plate. The tritium inventory varied from ~10^{11} to ~10^{13} T atoms/cm^2 for the surface plates and ~10^{10} T atoms/cm^2 for the bulk plates. The horizontal line in Fig.3 shows the background level, which is the tritium activity of pure water in the bubbler. Since bulk plates retained no more than background level of tritium, only the T retained in the surface plates were taken into account for the estimation of T inventory. From the results of the surface plates, it is clear that retained tritium increased with increasing the exposed DD discharge time of the tiles.

Under the assumption of toroidal and poloidal symmetry, the overall tritium inventory for whole first wall of JT-60U (50 m^2) was estimated for different discharge times. In Fig.4, the overall tritium inventories for whole first wall of JT-60U are plotted against the amount of tritium produced by DD reactions during the respective discharge times.

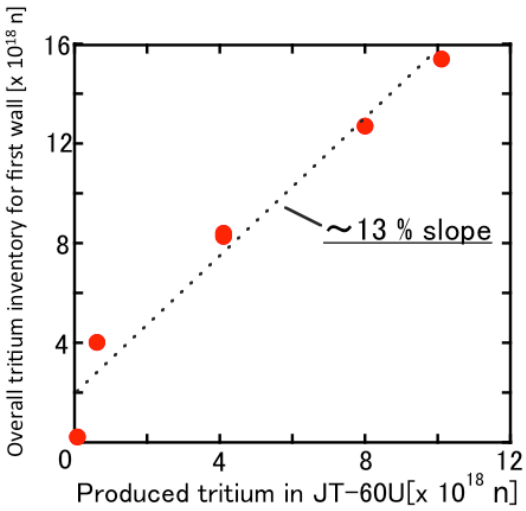

Fig.4 Comparison of the estimated overall tritium in inventory for whole first wall with the amount of tritium produced during the respective discharge times of the analyzed tiles

The gradient of the line in the figure shows about 13% of T produced by DD reactions in plasma was retained in the first wall. This value agrees with the previous evaluation given by a tritium imaging plate technique [1]. All these confirms that the part of energetic tritium produced by DD reaction were directly implanted within a few μm from the eroded plasma facing surface and retained there without being replaced by H during HH discharges performed after each DD discharge campaign.

4. Conclusion

Tritium retention in first wall graphite tiles exposed to different discharge times was measured by the full combustion method. Integrating the tritium retention of each tile with the total surface area of first wall, the tritium inventory for whole first wall was evaluated. Comparing the tritium inventory estimated from each tile with the amount of tritium produced during respective discharge time of each tile, it was found that about 13 % of the total tritium produced was retained in the first wall. The present results confirm that the part of energetic tritium produced by DD reaction were implanted into plasma facing surface and retained there without being replaced by H during HH discharges.

References

[1] M. Yoshida, et al. Fusion Science and Technology, in press