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Evaluation of tritium accumulation in castellated structure of JET-ILW Be limiter tiles

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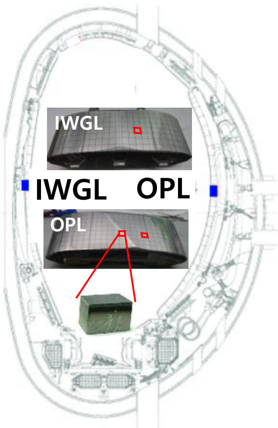

Fig. 1. Cross-section of JET and positions of IWGL and OPL.

An accurate tritium (T) retention analysis in plasma-facing components (PFCs) is important for safety assessment of fusion reactors. JET ITER-like wall (ILW) project has been carried out since 2011 as a test-bed of ITER and deuterium (D) plasma was discharged for the first three campaigns in 2011-12 (ILW1), 2013-14 (ILW2) and 2015-16 (ILW3). Main chamber limiter tiles were composed of beryllium (Be) and divertor tiles were made of tungsten (W). Tritium (T) is produced by DD fusion reactions (^{2}D + ^{2}D -> ^{3}T (1.01 MeV) + p (3.02 MeV)) and part of generated T was retained in PFCs of the JET tokamak. Be limiter tiles were castellated to protect tiles from thermo-mechanical and electromagnetic loads of the plasma. T was accumulated not only on plasma-facing surfaces (PFSs) but also in the castellation grooves [1].

In this study, T inventory in the castellation grooves of inner wall guard limiter (IWGL) and outer poloidal limiter (OPL) used in ILW1 or ILW3 was investigated. The positions and photos of limiter tiles are given in Fig. 1. Specimens for the measurements were cut from the limiter tiles along castellation grooves, as shown in Fig. 1. Imaging plate (IP) technique was applied to analyze 2-dimensional T distributions on specimen surfaces. Plastic reference samples labelled with known amounts of T were used for quantification.

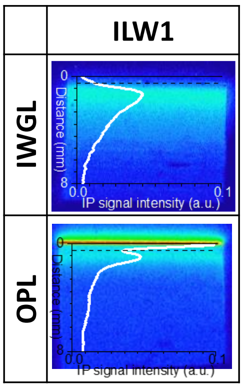

Fig. 2. IP images of castellation sides of ILW1 samples.

Typical IP images of the surfaces originally in the castellation grooves (castellation sides) are shown in Fig. 2, together with profiles of T concentration evaluated from the signal intensity from IP. In the case of OPL, the accurate evaluation of T profile near the entrance of the grooves was difficult due to the interference by β-rays emitted from PFS and scattered by air. Hence, the only T in the deeper region in the groove (the distance from the entrance ≥ 0.5 mm) was considered in the following evaluation. There were T enriched regions near the groove entrances. The analysis using X-ray photoelectron spectroscopy showed that T enriched region was covered by BeO layer whose thickness was ~50 nm. This observation suggests that T was co-deposited with sputtered Be and O.

Fig. 3 shows T retention on castellation sides with that on PFSs examined in our previous study [1]. Castellation sides showed smaller T retention than PFSs by an order of magnitude or more. T retention on castellation sides were comparable with each other after each campaign regardless to tile location. Contrary, T accumulation on PFS was highly dependent on limiter position; i.e., more T was retained in OPL than IWGL [1]. This difference was due to different retention mechanisms; the implantation of high energy triton for PFSs and co-deposition with Be and O for castellation sides. In conclusion, not the castellation sides but the PFS of OPL was primary T reservoir in the main chamber of JET.

References

[1] S. E. Lee et al., Fusion Eng. Des. 160 (2020) 111959.

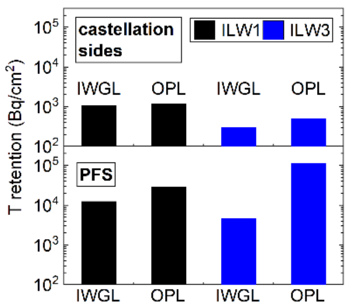

Fig. 3. T retention on castellation sides and PFS of Be limiter tiles.