Tritium Areal Distribution on Graphite Tiles of JT-60U Divertor by Imaging Plate Technique

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Tritium areal distribution on graphite divertor tiles, dome units and baffle plates of JT-60U was successfully measured for the first time. Tritium distribution observed in JT-60U tiles can be well explained by homogeneous implantation of rather high energy tritium but influenced by redeposited layers and redistributed by the temperature increase due to the plasma heat load.

Keywords: tritium, retention, surface distribution, JT-60U, graphite tile, imaging plate technique

Tritium retention in plasma facing materials both for long term and sort term is one of the most important safety issues in fusion reactors [1-3]. Quite recently, we have successfully applied the Tritium Imaging Plate Technique (TIPT) to determine the tritium areal distribution on in-vessel components used as limiter tiles of TEXTOR-94.[4,5] We have found that TIPT not only gives very detailed tritium surface profiles, but can also be used as a new diagnostic technique to investigate plasma wall interaction through tritium behavior. Here we have applied TIPT for the determination of the tritium areal distribution on JT-60U divertor tiles and reported the first results.

The imaging plate (IP) is a photo-stimulated luminescence (PSL) based radiation image sensor and detects tritium distributed within the depth of ~3.5 µm from the surface of the graphite tiles (i.e. within the range of tritium β-rays in graphite). The IP used here was BAS-TR2025 for low energy β-ray emitter such as tritium, manufactured by Fuji Photo Film Co., Ltd. The surface of IP was exposed to the graphite tiles with a face-to-face contact for one hour in a dark shielded room. After the exposure, IP was processed by an imaging plate reader, Fuji BAS-2000 or BAS-2500 to obtain a digitized intensity mapping, or a tritium image. Measured graphite tiles were isotropic graphite (IG-340U) and CFC graphite (CX-2002U), used as divertor tiles and/or baffle plates just outside of the divertor of JT-60U. The details of the measurements have been given elsewhere [5,6]

Figure 1 shows the tritium images for divertor tiles, dome unit and baffle plates. In the figure, tritium level is higher for the red region and less in the blue region. One can note that the highest tritium level was recorded at the outer baffle plates and the top of the divertor dome unit, where plasma did not directly hit. In addition, the tritium areal distributions on those tiles appear rather homogeneous compared to other divertor tiles. In the previous work, we have shown that the tritium detected in limiter tiles in TEXTOR was those without fully losing its energy and homogeneously distributed to the plasma facing surface [5]. This also seems to be true for the tritium detected here. The tritium level at the top of the dome unit and baffle plate was estimated to be in the order of 10 kBq/cm²[6]. Supposing all plasma facing tiles contain this amount of tritium, the integrated tritium amount over all the PFM surface is calculated to be nearly the same to the totally produced tritium (18 GBq) in the period when those tiles were used. This is consistent with the observation that, in JT-60U, the long term tritium retention of vacuum vessel is about 50% of the total produced. Thus a fair amount of tritium produced by D-D reaction is not fully confined in the plasma. It may lost its initial energy of 1 MeV but escaped and injected homogeneously with some retaining energy to plasma facing surface. In addition to this general tendency, there is an appreciable tritium distribution...
along the toroidal and poloidal directions in other tiles. Particularly, the tritium level at the divertor foot point was the lowest owing to the temperature escalation during the plasma discharges. In addition redeposited layer could also influence the IP measurements giving somewhat different profiles from tile to tile. In conclusion, tritium areal distribution on graphite divertor tiles, dome units and baffle plates of JT-60U was successfully measured for the first time. Tritium distribution observed in JT-60U tiles can be well explained by homogeneous implantation of rather high energy tritium but influenced by redeposited layers and redistributed by the temperature increase due to the plasma heat load. Nevertheless, it should be mentioned that the present IP imaging missed some tritium adsorbed or absorbed in the near surface layer with low energy impinging after losing energy in the plasma. This is because such surface tritium was mostly removed by hydrogen discharges and air ventilation before and after torus opening, respectively. More detailed analysis is under progress.


Fig.1 Tritium image of graphite tiles used as divertor and baffle plates in JT-60U. Tritium level is higher for the red region and less in the blue region. In the center is a photograph of divertor region.