§1. Investigation of Tritium Behavior and Tracability in Invessed Systems of LHD during D-D Burning

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In D-D discharge plasma apparatus, one can distinguish four different tritium sources; (i) the "edge plasma tritium" directly impinging from the boundary plasma, with an energy of a few eV to several tenth of eV, (ii) the residual "gaseous tritium" evacuated through pump ducts, (iii) the "high energy tritium" produced directly from D-D reaction in the plasma and (iv) tritium produced in materials by nuclear transmutation. The edge plasma tritium is, of course, the main source of tritium retention in plasma facing walls in future burning plasmas. The high energy tritium is the main tritium source in present D-D discharge devices. It is important to note that tritium produced by D-D reaction has the initial energy of 1 MeV and is likely to impinge into the plasma facing surface before complete thermalization to the plasma temperature.

Recent simulation shows around 30% of produced tritium could be implanted without fully loosing its initial energy through ripple–loss mechanism even in a DT reactor.[1] Actually, toroidal tritium distribution in JT-60U clearly shows the ripple loss due to toroidal filed inhomogenuity.[2] Although the cross section for D-D reaction is below 1/10 of that for D-T reaction, tritium produced by the D-D reaction (around 1/200-1/500 of the produced neutron amount in a D-T reactor) might be a serious concern because it can reach deeper regions in the plasma facing materials and is difficult to remove compared to the tritium absorbed or codeposited on the surface or near surface layers. In fact, tritium retention in deeper regions than hydrogen and deuterium was confirmed in graphite tiles used in TEXTOR[3] and JT-60U.[4] The retention of the gaseous tritium was clearly observed in JET tiles, as will be shown in later sections. The contribution of the gaseous tritium retention in one graphite tile was very small, but the integrated amount from back sides of all PFM tiles could contribute significantly to the total tritium retention.

According to those knowledge, most of tritium produced by D-D reaction in LHD is likely implanted directly to the plasma facing materials and only small amount of tritium is thermalized and evacuated pumps. Therefore, we have to think about two points.

1) How to remove tritium implanted rather deep (more than 1 μm) in the plasma facing wall.

This is very important for the ventilation of the LHD torous to keep people going into the vacuum vessel safe.

2) How to completely remove tritium quite diluted by deuterium gas.

In order to discuss above points, discussion meeting held at September 4-5, 2003 in NIFS with more than participants.

The results of the meeting are summarized as follows. Among the above mentioned 4 different component of tritium, the high energy tritons are likely implanted into all plasma facing surfaces homogeneously and relatively deeply with a maximum implanted depth of several micrometer. (see Fig.1) The edge plasma tritium is mostly co-deposited onto shadowed areas with lower surface temperature. This is the main tritium retention mechanism in D-T machines like JET. The gaseous tritium is adsorbed and absorbed everywhere, even in surface of the inner pores of graphite bulk owing to its porous nature.

The amounts of the retained tritium by these three components are modified by temperature somewhat differently, because they are retained at different depths with different concentrations. The high energy tritium is implanted deeply and dispersive compared to the highly concentrated co-depositions; the former is likely trapped strongly and hard to remove. Although the edge plasma tritium dominates the dynamic inventory, spontaneous release could reduce the long term inventory if the surface temperature is higher. If we could keep the temperature of the deposited area above 800 K, tritium inventory may be reduced significantly.

In the present tokamaks, contribution of the gaseous tritium is far less compared with the other two, although the inventory caused by the gaseous tritium may remain as the hardest inventory to be removed.

Reference

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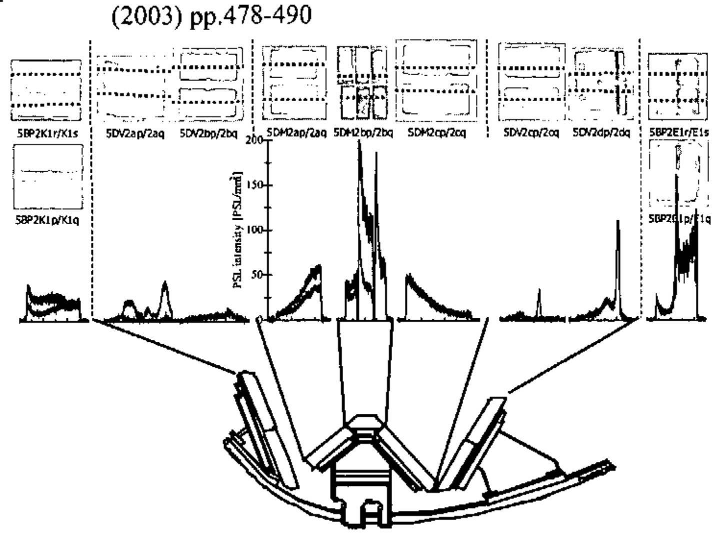

Fig.1 Tritium distribution on divertor tiles of JT-60U. Because of high energy implantation tritium retention is high at dome and baffle plates area.