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Tritium accumulation in plasma facing walls
プラズマ曝露した核融合炉材料へのトリチウムの蓄積

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Accumulation of tritium on the surface and in the bulk (at depths up to 1 mm) in poloidal divertor tiles exposed to D-T plasma shots in JET was measured by β-ray-induced X-ray spectroscopy (BIXS). Additionally, tritium accumulation in tungsten preliminary exposed to TEXTOR core plasmas and subsequently loaded with tritium was determined by IP method. Tritium distributions were highly non-uniform over the plasma-facing wall surface.

1. Introduction

During an operation of fusion machines with D-T plasma, tritium (T) is accumulated in plasma-facing components (PFCs). To improve the understanding of tritium behavior in PFCs under plasma exposure, various techniques were used to measure a tritium accumulation and distribution in those components.

In this study, a complete set of 10 poloidal divertor tiles (Mark IIA configuration) retrieved from JET after the first Deuterium-Tritium Experiment campaign (DTE1) was analyzed by β-ray-induced X-ray spectroscopy (BIXS) [1]. Additionally, the tritium accumulation in tungsten preliminary exposed to the TEXTOR plasmas and subsequently loaded with tritium was examined by using IP technique.

2. Experimental

2.1 Measurement of tritium distribution in JET divertor tiles by BIXS

A complete set of 10 poloidal divertor tiles numbered from IN1 to ON10 was investigated by BIXS. X-ray spectra from the tiles were measured at Tritium Laboratory of Karlsruhe Institute of Technology (KIT) by using a portable germanium X-ray detector.

2.2 Measurement of tritium accumulation tungsten preliminary exposed to the TEXTOR plasma

Tungsten samples were prepared from W rods provided by Dr. Philipps (FZ Jülich) by mechanical cutting. The samples were cleaned and placed into a tritium exposed apparatus. First, the samples were pre-evacuated up to 10^{-6} Pa at 573 K for 3 h, and then were loaded at 573 K with tritium from the D-T mixed gas at 1.2 kPa for 3 h. Tritium concentration distribution over the samples surface was measured by the Imaging Plate technique (IP).

3. Results

3.1 Tritium distribution in JET divertor tiles

Figure 1 shows a map of tritium distribution over the surfaces for 10 JET tiles. One can see that the tritium concentrations on the surface are highly non-uniform both in the toroidal and poloidal directions. The maximum Ar(Kα) intensity are about 120 times higher than the minimum intensity.

Analysing X-ray spectra with the use of computer simulation, tritium depth profiles were determined. Four types of the depth profile were obtained by BIXS analysis over the divertor surface (Figure 2).

There are many factors which influence on tritium depth profile and the amount of tritium. Tritium can be retained in the co-deposition layers on the surface, and the tritium content depends on the rate of co-deposition, rate of erosion, flux of tritium particles, power loads and etc. Tritium can be implanted from plasma into the co-deposition, and in this case the tritium amount depends on the plasma flux, tritium ion energy, tile temperature, and properties of the tile in the near surface region. Tritium can desorb from the surface and can migrate into the bulk. The competition between these two processes determines the T accumulation and the depth profile.

3.2 Tritium accumulation in tungsten preliminary exposed to TEXTOR plasmas

Figure 3 shows tungsten specimens mounted on the TEXTOR limiter (a), the specimens and IP images after tritium loading both for specimen set exposed to the TEXTOR plasmas (b) and for specimen set without plasma exposure (c). High content of tritium was observed on the specimen placed on the central part of the limiter. The tritium accumulation in the central specimen can be explained by carbon deposition. It is well know that carbon impurities deposited on the surface act as tritium trapping sites.

4. Conclusions

Tritium accumulations in a complete set of 10 poloidal divertor tiles retrieved JET after DTE 1 and in tungsten rods exposed TEXTOR core plasma were investigated. Tritium distributions were highly non-uniform and very complicated on the plasma-facing wall.

References

[1] M. Matsuyama et. al., J. Nucl. Mater. 290-293, (2001) 437.

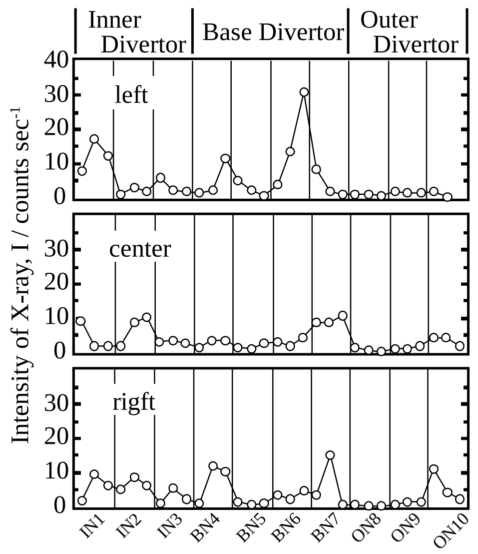

Fig. 1. Intensities of Ar(Kα) measured by BIXS.

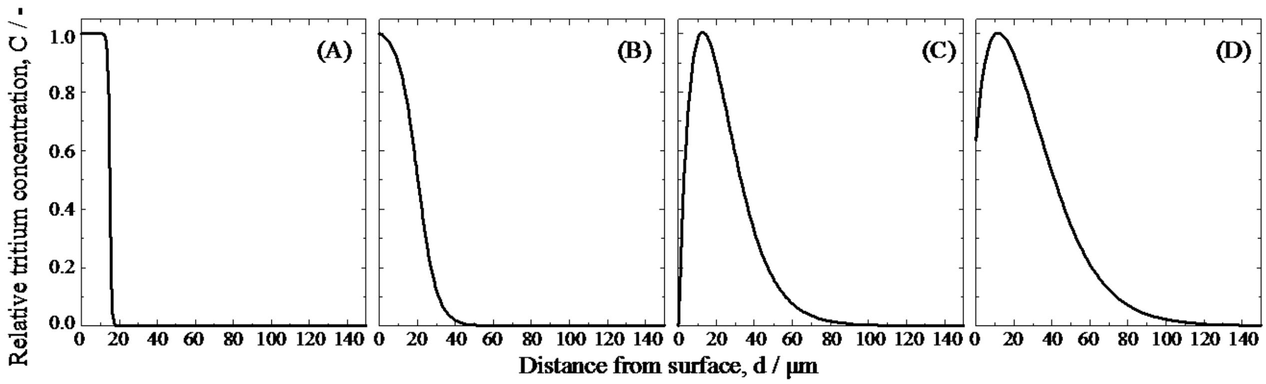

Fig.2. Tritium depth profiles determined by computer simulation

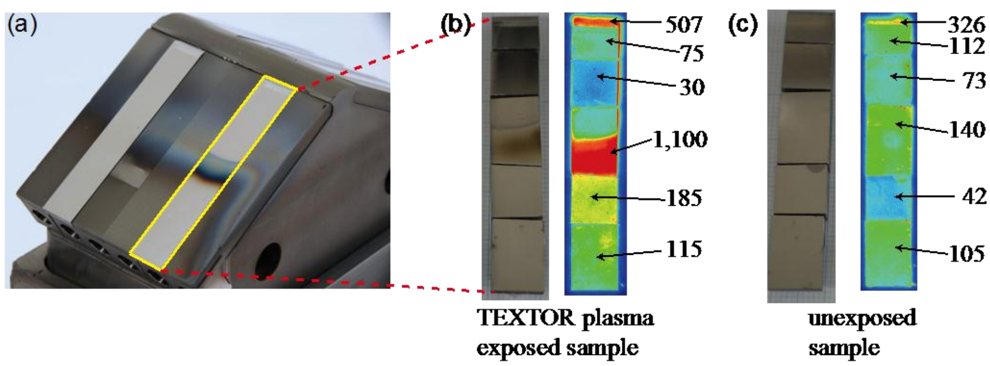

Fig. 3. Tungsten samples mounted on TEXTOR limiter (W sample set) (a), and the samples and corresponding IP images after tritium loading for sample set preliminary exposed to the TEXTOR plasmas (b) and for the sample set without the plasma exposure (c).