§12. Studies on Retention Behavior of Deuterium in Li_2TiO_3

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i) Introduction

In ITER, lithium titanate (Li_2TiO_3) is introduced into a blanket system as a tritium breeding material. The elucidation of tritium chemical behavior in Li_2TiO_3 is quite important for the estimation of tritium recycling and recovery. In our previous studies, it was revealed that the annihilation of E'-center, which was oxygen vacancy occupied by one electron, by diffusion of O^- triggered the tritium release[1]. In addition, our attention was also paid to tritium retention behavior to estimate for the estimation of tritium release in detail. Therefore, in this study, the retention behavior of deuterium implanted into Li_2TiO_3 was investigated by means of Thermal Desorption Spectroscopy (TDS) and X-ray Photoelectron Spectroscopy (XPS).

ii) Experimental

The disk of sintered Li_2TiO_3 was used as a sample. After preheating treatment at 1000 K for 10 min, deuterium ion (D_2^+) was implanted into the sample with an ion energy of 3.0 keV D_2^+. An ion flux of 2.0×10^{18} D^+ m^{-2} s^{-1}, an ion fluence of 1.0×10^{22} D^+ m^{-2} at various implantation temperature (R.T. - 673 K). Thereafter, TDS measurement was performed from room temperature to 1000 K with the heating rate of 5 K min^{-1} to understand deuterium desorption behavior. Before and after D_2^+ implantation, XPS measurements were also performed to estimate chemical states of the sample.

iii) Results and discussion

Figure 1 shows the D_2 TDS spectrum with the fitted curves analyzed by the Gaussian distribution function. In this figure, D_2 desorption process consists of four stages. Compared to the tritium TDS spectrum reported previously[1], the two desorption stages at higher temperature side were attributed to the desorption from E'-center (Peak 3) and decomposition of hydroxide (Peak 4). It was thought, on the other hand, that Peak 1 and Peak 2 in this figure would be derived from the desorption of deuterium trapped on the sample surface. Especially, the desorption from E'-center and the decomposition of hydroxide are quite important to evoke the tritium desorption behavior as the amount of tritium retained in the bulk is much larger than that on the sample surface. Therefore, our attention was focused on those trapping states. Figure 2 shows the comparison between deuterium retention and the ratio of Ti^{4+} XPS peak area versus Ti-$2p^{3/2}$ XPS peak area, which exhibit the amount of Ti^{4+}, as a function of D_2^+ implantation temperature. The Ti^{4+} XPS peak area was decreased with increasing Ti^{3+} peak area and O-1s XPS peak area was decreased. These results suggested that Ti^{4+} reduced into Ti^{3+} due to the formation of E'-center. On the other hand, above 423 K, Ti^{4+} XPS peak area increased again and the deuterium retention as Peak 3 decreased, indicating that E'-center was annihilated by diffusion of O^-, and deuterium trapped by E'-center would be detrapped from the trapping site. Above 423 K, the retention as Peak 4 was increased. It was thought that detrapped deuterium from E'-center might be re-trapped with forming O-D bond above 423 K.

Therefore, it is concluded that the formation of O-T bond would affect tritium inventory and might restrict tritium recovery.

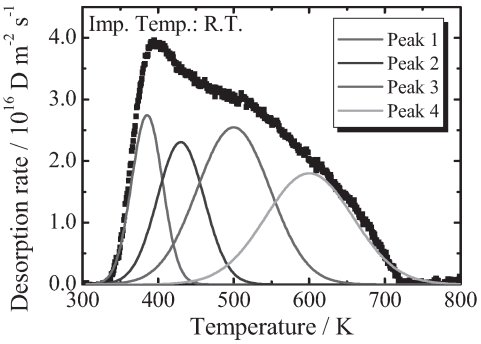

Fig. 1 D_2 TDS spectrum with fitted curve using Gaussian distribution function

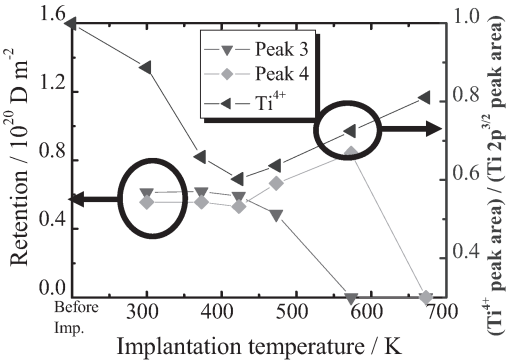

Fig. 2 D retention of Peak 3 and 4, and Ti^{4+} XPS peak area as a function of implantation temperature

1. M. Oyaidzu, et al., J. Nucl. Mater., **329** (2004) 1313.