§1. Studies of Interaction between Cooling Pipe Materials and Tritium, and Their Chemical Behaviors

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i) Introduction

Stainless Steel (SS-304, 316 etc) is expected to be used in fusion reactors as various component materials like cooling pipe because of its good mechanical properties and corrosion resistance. The elucidations of tritium behavior in SS and its interaction, especially, the tritium trapping and desorption behaviors in SS bulk from the viewpoint of chemistry are important issues for the safety evaluation of DD discharge experiment in LHD. Our group had reported on this study[1-2]. In the present study, the typical material for components, SS-316, was chosen as specimen and tritium trapping and detrapping behaviors due to difference on the production process of oxide layer on the SS surface were evaluated by Thermal Desorption Spectroscopy (TDS) and X-ray Photoelectron Spectroscopy (XPS).

ii) Experimental

The SS-316 sample with the size of 10×10×1 mm^3 was used. The sample was heated at 1173 K under atmosphere of inert gas for 1 hour to remove the oxide layers of sample surface. Following heating treatment, the air exposure experiment was performed at 298, 473 and 673 K for 1 hour, respectively. The 0.5 keV deuterium ion (D_2^+) was implanted into the sample, especially into the oxide layer, with the ion flux of 5.0×10^{17} D^+ m^{-2} s^{-1} and the ion fluence of 5.0×10^{21} D^+ m^{-2} at room temperature. After D_2^+ implantation, the sample was heated from room temperature to 1273 K with the heating rate of 0.5 K s^{-1}, and these results were applied to the evaluation of the desorption behavior of hydrogen isotopes from the samples. The XPS measurement was also performed to elucidate the profile of oxide layer.

iii) Results and discussion

It was found that not only deuterium (m/e=4) but also heavy water (m/e=20) were desorbed from the D_2^+-implanted samples according to the TDS results. Figures (a) and (b) show the D_2 TDS spectra for the D_2^+-implanted SS-316 sample with and without the oxide layer. From the comparison of both spectra, it was revealed that additional peak was appeared at around 600 - 800 K in the sample with oxide layer and total D retention for (a) was more than that for (b). It was suggested that this peak associated to the oxide layer. Compared with these exposed samples, the D retention derived from the peak at 600 - 800 K was increased with increasing the exposure temperature. TDS results for heavy water were almost the same as those for deuterium. From the XPS results, the atomic concentration of oxygen for the D_2^+ implanted region was increased with increasing exposure temperature. In addition, from Fe 2p XPS spectra, it was revealed that FeO and Fe_2O_3 were formed by air exposure, and O-D bond was also formed by D_2^+ implantation. From those results, it was suggested that oxidized species of iron were increased as increasing exposure temperature with increasing D retention. These facts indicated that, in various components for fusion reactor using Stainless Steel, tritium would be trapped in oxide layer on the SS-316 surface and tritium retention would be increased by the formation of O-T bond. It can be said that control of thickness of the oxide layer would be quite important to keep the tritium retention.

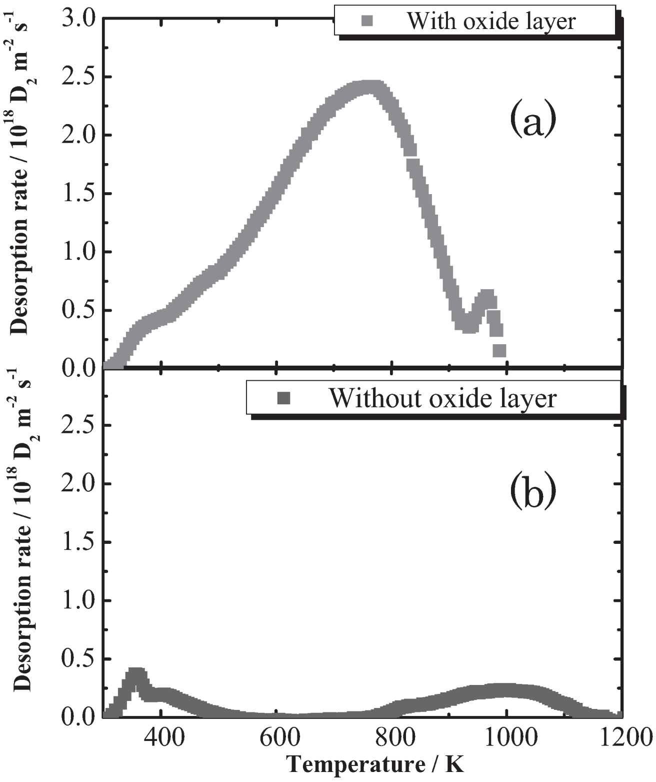

Fig. D_2 TDS spectra for (a) the sample with the oxide layer and (b) without the oxide layer.

1. Y. Oya, et al., Fusion Sci. Technol., **44** (2003) 359
2. Y. Oya, et al., Fusion Sci. Technol., **48** (2005) 598