

§1. Studies of Tritium Trapping States and their Desorption Behaviors from Cooling Pipe Materials

Oya, Y., Yoshikawa, A., Ishikawa, H., Kikuchi, Y., Suzuki, S., Kurata, R., Kobayashi, M. (Shizuoka Univ.), Tanaka, S., Oda, T. (Univ. Tokyo), Kawano, T., Asakura, Y., Uda, T.

i) Introduction

Stainless Steels (SS-304, 316 etc) are expected to be used in fusion reactors as various component materials like cooling pipe because of their good mechanical properties and corrosion resistance. Elucidations of tritium behaviors in SS, especially, the tritium trapping and desorption behaviors in SS bulk are one of important issues for the safety evaluation of DD discharge experiment in LHD. In our previous studies, it was reported that the existence of oxide layer has an important role for the tritium retention in SS^[1]. Therefore, the present study focused on the tritium trapping behavior in oxide layer formed on the SS surface by means of Thermal Desorption Spectroscopy (TDS) and X-ray Photoelectron Spectroscopy (XPS).

ii) Experimental

The SS-316 samples with the size of $10 \times 10 \times 1 \text{ mm}^3$ were used. The samples were heated at 1173 K under vacuum for 1 hour to remove the oxide layers on the sample surface. Following the heating treatment, the samples were exposed to air at 673 K for 1 hour. Thereafter, the 0.5 keV deuterium ion (D_2^+) was implanted into the samples, especially into the oxide layer, with the ion flux of $5.0 \times 10^{17} \text{ D}^+ \text{ m}^{-2} \text{ s}^{-1}$ and the ion fluence of $(0.5-5.0) \times 10^{21} \text{ D}^+ \text{ m}^{-2}$ at room temperature. After D_2^+ implantation, the samples were heated from room temperature to 1273 K with the heating rate of 0.5 K s^{-1} to evaluate the desorption behavior of hydrogen isotopes from the samples. The XPS measurements were also performed to elucidate the chemical behavior in the oxide layer with various implantations.

iii) Results and discussion

The Fe-2p^{3/2} XPS spectrum after air exposure at 673 K showed the formation of FeO and Fe₂O₃. In addition, the peak area of pure iron increased after D_2^+ implantations. For the O-1s XPS spectra, the peak area decreased as the ion fluence increased. The peak energies of O-1s after the implantations were shifted toward higher energy side compared to that before the implantation. These results indicate the sputtering of oxygen and the trapping of D as FeO-D by D_2^+ implantation.

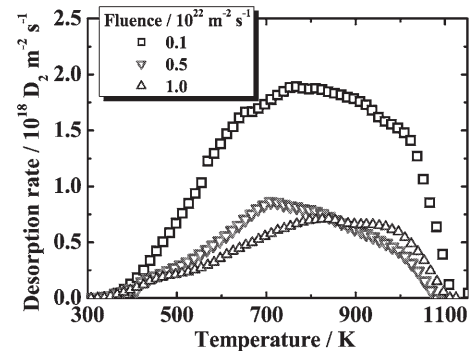


Fig. D_2 TDS spectra for the samples with various ion fluences

The figure shows the D_2 TDS spectra for various ion fluences. It was found that these TDS spectra consisted of two regimes. In the first regime less than $2.5 \times 10^{21} \text{ D}^+ \text{ m}^{-2}$, the D retention was increased, although it was decreased in the second regime above $2.5 \times 10^{21} \text{ D}^+ \text{ m}^{-2}$. These behaviors have a large correlation with the changes of peak area of FeO-D in O-1s XPS spectra. In addition, the mass spectra during the implantation showed the release of $M/e=20$, which corresponding to the desorption of the heavy water (D_2O), indicating that the implanted D was trapped by iron oxide with forming FeO-D and simultaneously, released with forming D_2O . It was expected, however, the trapping of D by iron oxide would be saturated around the fluence of $2.5 \times 10^{21} \text{ D}^+ \text{ m}^{-2}$ and the D retention could be decreased by the release of D_2O . These facts indicate that the oxide layer would control the retention behavior of hydrogen isotopes.

[1] K. Okuno *et al.*, *Fusion Sci. Technol.*, in press.