§35. Studies on Permeation Behavior of Tritium in Cooling Piping Material

Oya, Y., Okuno, K., Kurata, R., Kobayashi, M.,
Osuo, J., Suzuki, M., Hamada, A., Matsuoka, K.
(Shizuoka Univ.),
Asakura, Y.

i) Introduction

Type 316 Stainless Steel (SS-316) is expected to be used as various component materials like cooling pipe in fusion reactors due to its good mechanical property and corrosion resistance, and is thought to be exposed to hydrogen isotopes including tritium. Elucidations of tritium behaviors in the SS-316, especially, the elucidation of tritium permeation behavior in SS-316 is important from the viewpoint of the tritium safety for D-D plasma experiment in the Large Helical Device (LHD). From our previous study, chemical states of oxide film on the surface affected tritium permeation behaviors. In this study, adsorption and retention of the hydrogen isotope on the surface of SS-316 were clarified.

ii) Experimental

The SS-316 powder (-100 mesh) was used as samples. The samples were heated in 673 K under oxygen gas diluted by argon gas with the oxygen partial pressure of 2 kPa for 1 hour to form the oxide layer without impurity. Thereafter, deuterium (D_2) gas was exposed to the oxidized sample at 573 K, and 0.2 MPa. Thereafter, fourier transform infrared spectroscopy (FT-IR) measurement was carried out in the temperature range of R.T.-873 K.

For the evaluation of deuterium retention in SS-316, the plate (10x10mm^2, 1mm^t) samples were used. Preheating, the oxygen exposure, and the D_2 exposure were performed in the same condition as the above experiment. Thermal desorption spectroscopy (TDS) measurement was carried out in the temperature range of R.T.-1173 K.

iii) Results and discussion

Figure 1 shows FT-IR spectra for SS-316 powder after D_2 exposure at 573 K. The peak attributed to stretching vibration of FeO-D bond was appeared at 2590 cm^{-1} .[1] This shows that deuterium was retained as O-D bond on the surface by D_2 exposure.

Figure 2 shows intensity of FeO-D bond for FT-IR spectra and ratio of deuterium desorption ratio to total deuterium retention estimated by TDS measurements in D_2 exposed SS-316. It was found that the peak of FeO-D bond was disappeared by heating at 523-723 K. Moreover, deuterium was desorbed as D_2O at the temperature range of 523-723 K, which was corresponded to the decomposition of FeO-D bond in FT-IR result. Deuterium was also desorbed as D_2 at 500-900 K, suggesting that the D_2 was released from bulk by removing oxide film on the SS-316 surface. It was thought that the oxide film was not decomposed in the cooling piping material due to low operation temperature, thus the tritium retained as O-T bond in stainless steel surface. Therefore, to remove tritium retained in the oxide film, it is necessary to decompose the oxide film on the stainless steel surface by the heating of the system.

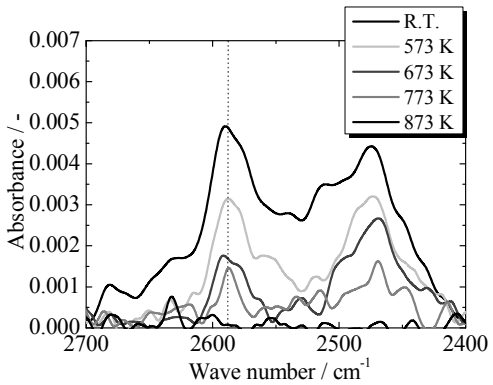

Fig.1 FT-IR spectra for SS-316 powder after D_2O exposure

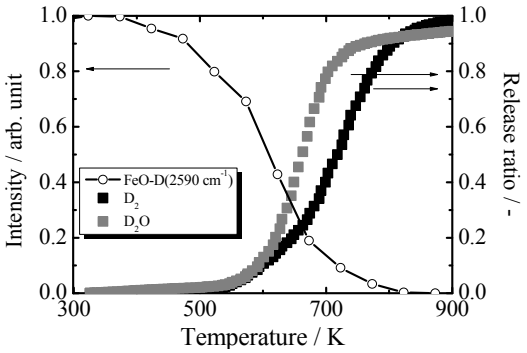

Fig.2 Intensity of FeO-D bond for FT-IR and deuterium release ratio for TDS in gaseous D_2O exposed SS-316.

1) Luo, T. et al. : J. Nucl. Mater. 382 (2008) 46-50.