# § 2. Studies of Tritium Behavior in LHD Cooling Pipe

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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 behavior of tritium in SS is one of the most important issues for assessment of fusion safety. However, the chemical behaviors of hydrogen isotopes with various adsorption/absorption have not been well studied. In the present study, the typical material for components, SS-304, was chosen as specimen and deuterium was charged either by water adsorption, ion irradiation or electrolysis. The chemical states of iron, chromium, nickel and oxygen on SS-304 were observed by the XPS. The TDS was also applied to the analyses of the thermal desorption behaviors of $D_2$ and $D_2O$ from SS-304 [1].

ii) Experimental

The SS-304 specimen with size of 10×10×1mm$^3$ was used. As a pretreatment, the samples were polished mechanically and annealed at 1273 K in vacuum for 30 minutes to remove the surface oxide layer. $D_2$ or $D_2O$ was sorbed on/in the sample by various methods, such as water adsorption, ion irradiation and electrolysis. In the water adsorption, the sample was immersed in heavy water for 30 min. In the electrolysis experiment, the sample was used as a cathode for 60 min with the current of 0.1A. For deuterium ion irradiation, the 4.0 keV $D_2^+$ ion was implanted into the sample with the flux of $5.1\times10^{18}$ $D^+$ $m^{-2}s^{-1}$ up to the fluence of $2.04\times10^{22}$ $D^+m^{-2}$. The chemical states of iron, chromium, nickel and oxygen on the SS-304 specimen were evaluated by X-ray photoelectron spectroscopy (XPS). The thermal desorption spectroscopy (TDS) was also applied to the evaluation of the desorption behavior of hydrogen isotopes from the stainless steel. The heating rate was set to 30 K/min from room temperature to 1273K.

iii) Results and discussion

Figures 1 and 2 show the photoelectron spectra of O 1s and Cr 2p of SS-304 with various implantation methods by XPS. After the pretreatment, oxygen was not observed on the SS-304 surface. Metal oxide was found to be formed mainly on the surface after water adsorption. However, in the case of electrolysis, the

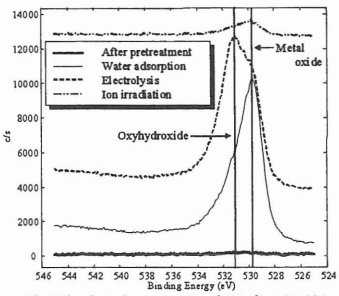


Fig.1 The photoelectron spectra of O 1s from SS-304 with various adsorption / absorption methods.

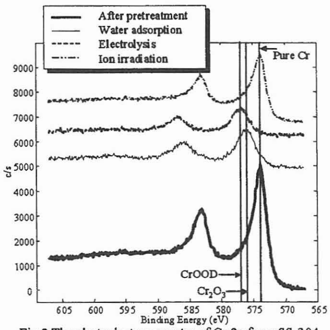


Fig.2 The photoelectron spectra of Cr 2p from SS-304 with various adsorption / absorption methods.

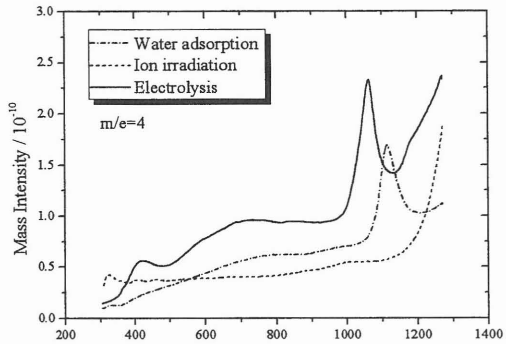


Fig.3 Thermal desorption spectra of $D_2$ from SS-304 with heating rate of 30 K/min.

oxyhydroxide was major component on the SS-304. There was not much oxygen observed after ion irradiation.

To investigate the hydrogen isotope desorption behavior from SS-304, TDS experiments were performed. Fig.3 shows the TDS spectra of deuterium released from SS-304.Three stages were found for the desorption of deuterium. In the first stage at around 420K, the deuterium trapped as the OD form was desorbed. At the temperature of 740K (second stage), the broad peak was observed which suggests that the deuterium retained as hydroxide or aquo-iron complex, was desorbed. In the third peak at around 1060-1120K, large amount of deuterium was desorbed. This temperature corresponds to the desorption of the superficial hydroxyl groups resulting from a dissociative absorption of water [2]. However, no deuterium was desorbed in the case of sample charged with ion irradiation.

iv) Conclusion

The chemical behaviors of SS-304 with hydrogen isotopes were studied by means of XPS and TDS techniques. It was found that the existence and chemical form of oxygen would influence the retention of deuterium on/in SS-304.

References

1) Oya, Y. et al., Fusion Sci. & Tech.., in press.
2) Joly, J.P. et al., Vacuum, **59** (2000) 854.