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

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i) Introduction

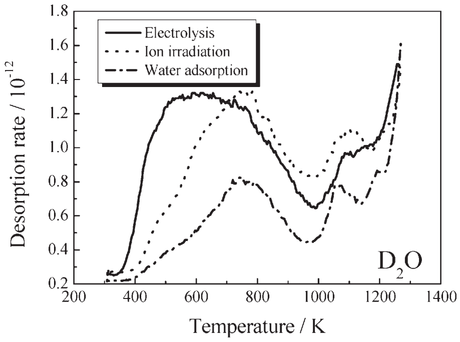
Stainless Steel (SS-304 [1],316 etc) is expected to be used in fusion reactors as various component materials like cooling pipe because of its good mechanical properties and corrosion resistance. The elucidation of tritium behavior in SS and its interaction are important issues for the safety evaluation of DD experiment in LHD. In especially, the tritium retention and desorption behaviors are largely influenced on the chemical states of tritium on the SS surface. 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-316, was chosen as specimen and tritium retention behavior in SS was evaluated.

ii) Experimental

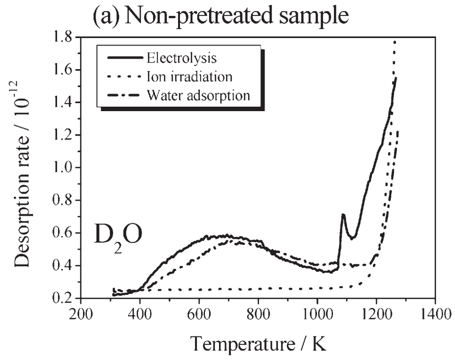
The SS-316 sample with size of 10×10×1mm^3 was used. Two kinds of sample with different surface finish, namely the non-pretreated sample and pretreated sample by mechanical polish and annealing at 1273 K in vacuum for 30minutes to remove surface oxide layers, have prepared. For these samples, D_2 or 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 5.1x10^{18} D^+ m^{-2}s^{-1} up to the fluence of 2.04x10^{22} D^+m^{-2}. The chemical states of iron, chromium, nickel, molybdenum, carbon and oxygen on the SS-316 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

According to the previous study[1], it was found that the oxyhydroxides, namely FeOOD or CrOOD, were formed on the surface of the sample after electrolysis according to the XPS results. The thickness of the oxide layer for the sample after electrolysis was thicker than that after water adsorption. Fig.1 shows the D_2O TDS spectra after various treatments. The reduction of D_2O was observed for the pretreated samples, which indicate that the surface oxide layer retains large amount of deuterium. The oxyhydroxide layer was almost removed by pretreatment. These facts show that the reduction of oxide layer formation and/or removal of oxyhdroxide layer after tritium exposure will be important to reduce tritium retention in SS. In future, the effective tritium removal technique will be developed.



(a) Non-pretreated sample



(b) Pretreated sample

Fig.1 The D_2O TDS spectra for SS-316 sample after various treatments

iv) Conclusion

The chemical forms of hydrogen isotopes on/in SS-316 were studied by XPS and their desorption behavior was evaluated by TDS. It was found that the deuterium desorption stages consisted of three stages. Most of deuterium would be retained in the oxide layer on the surface and it concluded that the reduction of oxide layer formation and/or removal of oxyhdroxide layer after tritium exposure will be important to reduce tritium retention in SS.

References

1) Oya, Y. et al., Fusion Sci. & Tech..,**44** (2003) 359.