§2. Studies of Interaction between Cooling Pipe Materials and Tritium, and Their Chemical Behavior

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1) Introduction

Stainless steels (SS) are expected to be used in fusion reactors as various component materials like cooling pipe, vacuum vessel and so on, because of its good mechanical properties and corrosion resistance. The behavior of tritium in SS is one of the most important issues for the assessment of fusion safety. However, the chemical behaviors of hydrogen isotopes with various adsorption/absorption have not been well studied. These backgrounds motivate us to study the detailed analysis of hydrogen isotopes behavior in SS. In the present study, the typical material for components, 316-SS, was chosen as specimen and deuterium was charged with various absorption/adsorption methods like water adsorption or electrolysis. The chemical states of iron, chromium, nickel and oxygen on SS-316 were observed by the XPS. Depth profiles of chemical states of elements were also evaluated by using Ar^+ sputtering technique. The TDS was also applied to the analyses of the thermal desorption behaviors of D_2 and D_2O from 316-SS for comparison.

2) Experimental

The 316-SS sample with size of $10\times10\times1mm^3$ 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/and D_2O was sorbed on/in the sample by various methods, such as water adsorption 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. The chemical states of iron, chromium, nickel, molybdenum, carbon and oxygen on the 316-SS sample 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.

3) Results and discussion

In our previous studies [1,2], it was found that the oxyhydroxide was mainly formed on the surface of SS after electrolysis. For the sample after water adsorption, hydroxide was the major chemical form of the surface. To elucidate the chemical behavior of 316-SS as a function of depth, XPS analysis and the depth profiling by Ar^+ sputtering was conducted for the non-pretreated 316-SS sample. Fig.1 shows the chemical compositions of 316-SS as a function of depth. It was found that the thickness of the oxide layer for the non-pretreated sample after electrolysis was the largest compared to the as received sample and the sample with water adsorption. This fact indicates that the oxyhydroxide layer made the oxide layer thicker and a large amount of hydrogen isotopes would be trapped in this thin layer.

It can be concluded that the oxyhydroxide layer would have a large influence on hydrogen isotope retention including tritium, and the surface finish would be an effective method for decreasing its retention on/in 316-SS.

4) Conclusions

The chemical states of 316-SS after various hydrogen adsorption/absorption treatments were evaluated by XPS. These results were compared to the hydrogen isotope desorption behavior by TDS. A large amount of hydrogen isotope was trapped in the oxyhydroxide layer for the non-pretreated sample after electrolysis. The hydrogen isotope trapping by this layer would be a major influence on hydrogen retention. The surface finish would be one of the effective improvements for decreasing tritium retention in 316-SS.

References

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

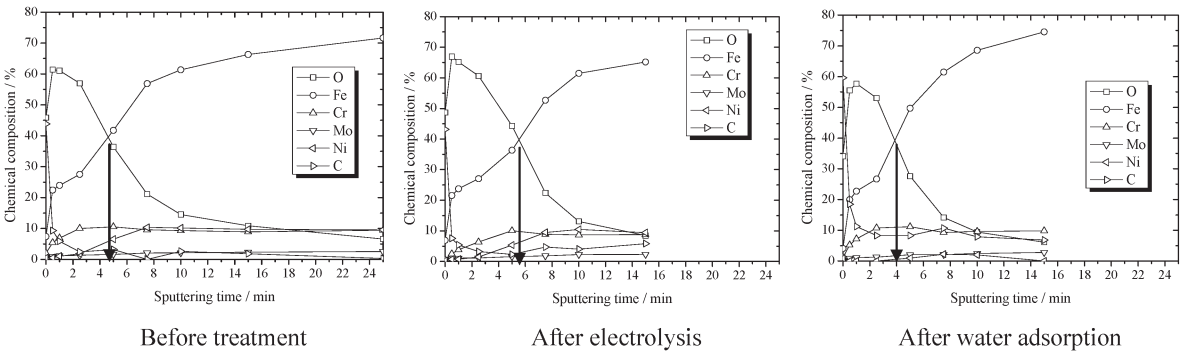

Fig.1 Depth profiles of the sample with various treatment estimated by XPS with Ar^+ sputtering.