§2. Study on Formation of Stainless Steel Re-deposition Layer and Hydrogen Trapping Behavior under Low-energy Plasma

Katayama, K., Fujiki, T., Fukada, S. (Kyushu Univ.), Ashikawa, N., Uda, T.

Investigation of hydrogen retention in deposition layers is important issue from viewpoints of fuel control and radiation safety of tritium. It has been reported by the present authors that tungsten deposition layers formed from hydrogen isotope plasma retain a large amount of hydrogen isotope.[1-3] Recently, it was found in collaboration study under National Institute for Fusion Science that a deposition layer formed from stainless steel can retain hydrogen as much as a tungsten deposition layer[4]. In the present study, a deposition layer was formed from stainless steel by deuterium plasma. Deuterium release behavior and retention were investigated.

A deposition layer was formed by a sputtering method using an RF plasma. The RF source was derived at a frequency of 13.56 MHz with a power of 100 W. A type 316 stainless steel tile (50 mm × 50 mm, thickness 1 mm) was mounted on an RF electrode as a target. Sputtered particles were deposited on tungsten substrates mounted on a ground electrode. Deposition conditions are summarized in Table I.

A sputtering rate of stainless steel was estimated from weight loss before and after plasma discharge. The sputtering rate by deuterium plasma was 1.4 times larger than that by hydrogen plasma. This value is equal to the root of the mass ratio.

Atomic ratio in the deposition layer was investigated by an energy dispersive X-ray equipment. Ratio of Fe, Cr, Ni and Mo in the deposition layer was almost same as that in 316 stainless steel. More than 30 % of oxygen was observed in a deposition layer formed near the chamber wall where temperature and ion flux are low, but no oxygen was detected in a layer formed at the center of the chamber. This oxygen is considered to originate from a residual water vapor in the chamber.

Hydrogen release behavior from the deposition layer was observed by thermal desorption method using a quadrupole mass spectrometer. Release curves of HD and D_2 are shown in Fig.1. Deuterium release began at 150 °C and a peak appeared at 400 °C. The observed release behavior is similar to that from a tungsten deposition layer. In Fig.2 the amount of deuterium released from the deposition layer are compared with hydrogen retention in stainless steel deposition layer, deuterium retention in a tungsten deposition layer and so on. The deuterium retention obtained in this work was more than two orders of magnitude smaller than results obtained so far. In this experiment, the amount of HDO and D_2O could not be evaluated because background levels of them were so high. A majority of deuterium trapped in the deposition layer was speculated to be released as water vapor. However, there is possibility that deuterium has been released to atmosphere at room temperature before the thermal desorption experiment.

Table I Deposition conditions.

Gas	D_2
RF power [W]	100
Substrate temperature [°C]	95
Gas pressure [Pa]	10
Gas flow rate [cm^3/min]	5
Discharge period [h]	168

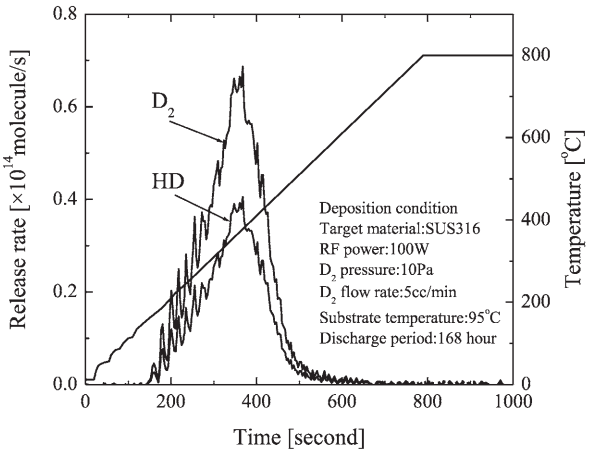

Fig.1 Release behavior of deuterium from SUS deposition layer.

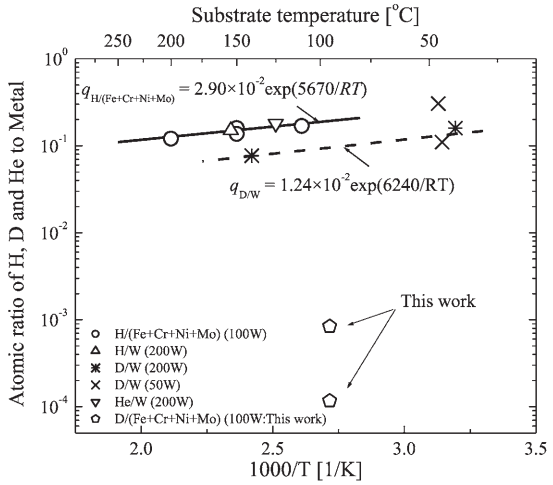

Fig.2 H, D and He retention in SUS and W deposition layers.

1) T. Kawasaki, Y. Manabe, K. Katayama, T. Takeishi, M. Nishikawa, Fusion Sci. Tech. 48 (2005) 581-584.
2) K. Katayama, K. Imaoka, T. Okamura, M. Nishikawa, Fusion Eng. Des. 82 (2007) 1645-1650.
3) K. Katayama, K. Imaoka, T. Tokitani, M. Miyamoto, M. Nishikawa, S. Fukada, N. Yoshida, Fusion Sci. Tech., 54 (2008) 549-552.
4) Y. Uchida, K. Katayama, T. Okamura, K. Imaoka, M. Nishikawa, Fusion Sci. Tech., 54 (2008) 545-548.