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

Katayama, K., Uchida, U. (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 trap a large amount of hydrogen isotope.[1-3) Hydrogen trapping in a deposition layer formed from stainless steel has not been studied sufficiently so far. In the present study, deposition layers were formed from type 316 stainless steel by a sputtering method using hydrogen RF plasma and hydrogen retention was quantified by a thermal desorption method.

A schematic diagram of RF plasma device is shown in Fig. 1. 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.

Atomic ratio on the deposition layer was obtained 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 the deposition layers formed at 150 °C and 200 °C. It is considered that a part of metal element was oxidized with the oxygen that originates in a small amount of water vapor that remains in the plasma chamber. No oxygen was observed in the deposition layer formed at 110 °C.

Hydrogen release behavior from the deposition layer was observed by thermal desorption experiment at an argon atmosphere. The deposition layer with substrate was packed into a quartz reaction tube. The reaction tube was filled with argon gas and heated from 200 °C to 1000 °C in 100 °C step every 3 hours by an electric furnace. Argon gas was introduced into the reaction tube every 30 minute in order to transport the desorbed hydrogen into a gas chromatograph. It was previously confirmed that hydrogen release from the deposition layer is negligible below 200 °C. The amount of hydrogen released at each temperature was different in each sample. For instance, a large peak at 700 °C was observed from only the deposition layer formed at 110 °C. The atomic ratio represented as H/(Fe+Cr+Ni+Mo) was estimated from the weight of deposition, the ratio of metal atoms, and total amount of released hydrogen. The estimated values are shown in Fig.2. For comparison, the values of H/W and He/W in tungsten deposition layers previously obtained are also shown in this figure.[2,3) Hydrogen atomic ratio in the deposition layers formed from stainless steel is in agreement with the values of H/W and He/W in tungsten deposition layers. Hydrogen atomic ratio to metal atoms in a metallic deposition layer seems not to depend on the kind of the metal constituting it.

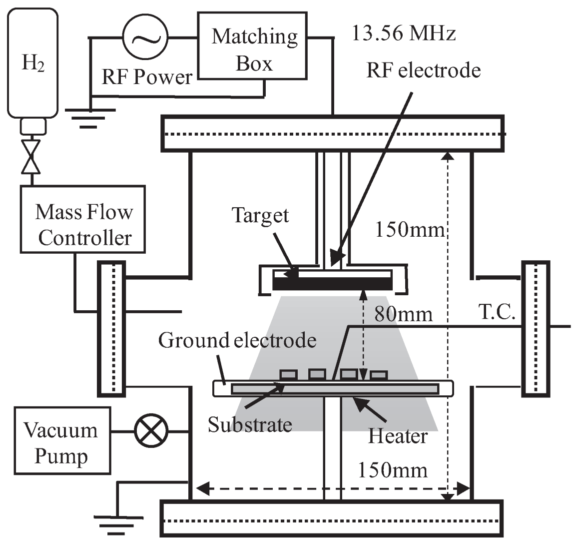

Fig.1 A schematic diagram of RF plasma device.

Table I Deposition conditions.

Gas	H_2		
RF power [W]	100		
Substrate temperature [°C]	110	150	200
Gas pressure [Pa]	10		
Gas flow rate [cm^3/min]	1.2		
Discharge period [h]	240		

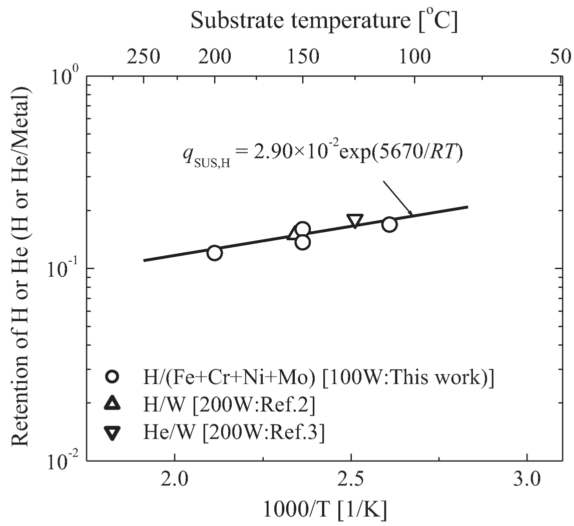

Fig.2 The comparison of H/(Fe+Cr+Ni+Mo) in deposition layers formed from 316 stainless steel with H/W and He/W in tungsten deposition layers.

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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. (2008) in press.