§2. Study on Formation of Metal-carbon Mixed Deposition Layer and Hydrogen Isotope Behavior

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Understanding of hydrogen isotope behavior between plasma and wall is an important issue from viewpoints of fuel control and radiation safety of tritium. Stainless steel and graphite are used as wall materials in Large Helical Device (LHD). Therefore metal - carbon mixed deposition layer will be formed in the vacuum vessel. Many studies about hydrogen retention in carbon deposition layers have been performed. However, hydrogen sorption/desorption behavior in metallic deposition layer and metal-carbon mixed layer have not been studies sufficiently so far[1, 2]. In this study, deposition layers were formed from type 316 stainless steel by a sputtering method using hydrogen isotope plasma. The release behavior of hydrogen isotope from the deposition layer was investigated by a thermal desorption method. An experimental apparatus for formation of metal-carbon mixed deposition layer was constructed and operated on a trial basis.

i) Release behavior of hydrogen isotope from a deposition layer of stainless steel

Deposition layers were formed by a sputtering method using 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. In this experiment, a mixed gas of hydrogen and deuterium was used. Deposition conditions are summarized in Table I.

The release behavior of hydrogen isotope from the deposition layer was observed by thermal desorption method using quadruple mass spectrometer. Release curves of H_2, HD and D_2 are shown in Fig.1. Even though an atomic ratio of H_2 and D_2 in the input gas was 1:1, a majority of constituent released from the deposition layer was hydrogen. This reason is not clarified yet. Currently, it is considered by the present authors that deuterium trapped on the surface of a deposition layer was exchanged to hydrogen by the isotope exchanger reaction with residual water vapor in the plasma chamber. A sharp peak was observed at the beginning of heating. This means that some amounts of hydrogen isotope are trapped at a weak energy. The hydrogen release continued steadily after it showed a peak at 400 °C. This means that it is necessary to heat the deposition layer at high temperature for a long time in order to remove the trapped hydrogen.

ii) Experimental apparatus for formation of mixed deposition layer

Fig.2 shows a schematic diagram of the experimental apparatus constructed for formation of metal-carbon mixed deposition layer. A preliminary operation was conducted using a methane/hydrogen mixed gas. Stainless steel inserted into plasma as a target metal was successfully sputtered and mixed deposition layers were formed.

Table I Deposition conditions.

Gas	$H_2 : D_2 = 1 : 1$
RF power [W]	100
Substrate temperature [°C]	95
Gas pressure [Pa]	10
Gas flow rate [cm³/min]	5
Discharge period [h]	241

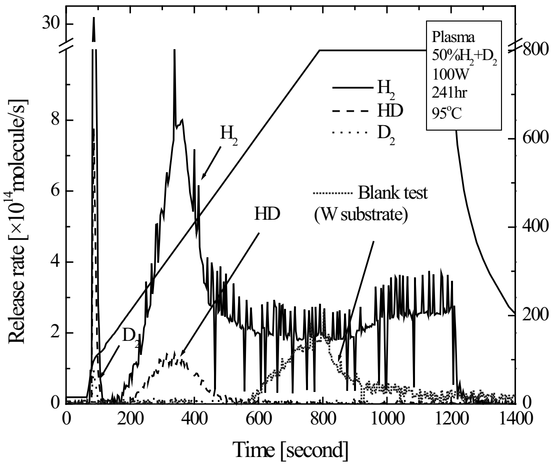

Fig.1 Release curves of hydrogen isotope from SUS deposition layer.

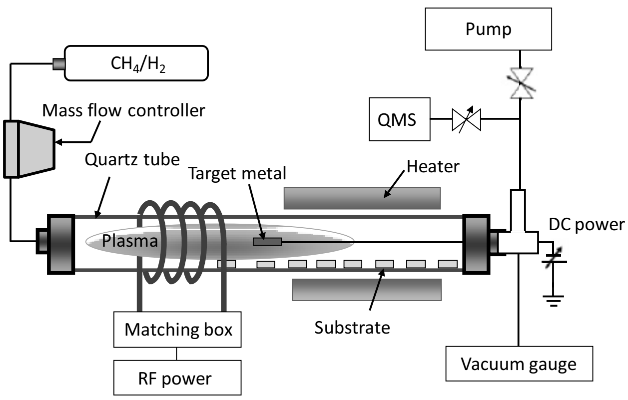

Fig.2 A schematic diagram of the experimental apparatus for formation of metal-carbon mixed deposition layer.

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2) Y.Uchida, K. Katayama, T. Okamura. K. Imaoka. M. Nishikawa, S. Fukada, Fusion Sci. and Technol. 54 (2008) 545-548.