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§39. Study on Hydrogen Isotope Exchange in Deposition Layer of Plasma Facing Material

Katayama, K., Ohnishi, Y., Fukada, S. (Kyushu Univ.),
Ding, F., Luo, G.N. (ASIPP),
Ashikawa, N.

Understanding of tritium behavior in plasma facing wall of a fusion reactor is an important issue from viewpoints of fuel particle control, tritium safety administration and design of fuel cycle system. Although studies on plasma wall interaction (PWI) have been performed widely, hydrogen isotope behavior in deposition layers formed by PWI has not been understood sufficiently. This study focuses on hydrogen isotope exchange reaction in deposition layer. When high energy hydrogen particles are implanted into a deposition layer, the isotope exchanger reaction will occur between hydrogen isotopes implanted and hydrogen isotopes retained in the deposition layer. Understanding of isotope exchange reaction in a deposition layer will be useful for discussing about tritium removal method and analysis method in used wall tiles.

Tungsten deposition layer was formed on tungsten substrates or quartz substrate, 10mm×5mm in size, 1mm in thickness, by the sputtering method using hydrogen plasma. It has been found that the tungsten deposition layer formed by hydrogen isotope plasma sputtering contains a large amount of hydrogen isotope [1,2]. A cross section SEM image for one of prepared tungsten deposition layers is shown in Fig.1. From weight and volume of deposition layer, the density was estimated to be 16.6 g/cm^3. This suggests that the porosity of the deposition layer is 0.14. Tungsten substrates with (Wd) and without (Ws) tungsten deposition layer were installed in EAST and exposed to deuterium plasma by the cooperation of the JSPS-NRF-NSFC A3 Foresight Program in the field of Plasma Physics (NSFC, No.11261140328) and the NIFS Collaboration Research program (NIFS12KEMF039).

The exposed samples were brought back Kyushu University, and TDS measurements were carried out. Release behaviors of deuterium from tungsten substrates with and without tungsten deposition layer are compared in Fig.2 and Fig.3, respectively. From sample Wd, obvious peaks were observed for mass3 (HD) and mass4 (D_2). From sample Ws, a peak of mass3 was observed at 900K but this peak corresponded with background. Therefore it was concluded that deuterium release from Ws is small below detection limit. From this result, it was revealed W deposition layer can retain a larger amount of deuterium than W bulk when they are exposed to deuterium plasma in almost same condition. Hydrogen isotope retention in Wd was evaluated 0.037 in H/W and 0.002 in D/W. It was found that tungsten deposition layer prepared for this experiment contains hydrogen of 0.032 in H/W originally. Because deuterium plasma exposure in EAST was performed at around room temperature, the implanted deuterium is considered to exist in shallow region from the plasma facing surface. In order to discuss about isotope exchange phenomena, an investigation of depth profile of hydrogen isotope will be done.

1) Katayama, K., et al., J. Nucl. Mater. (2013) in press, http://dx.doi.org/10.1016/j.jnucmat.2013.01.220.
2) Katayama, K., et al., Fusion Eng. Des., 86, 9-11 (2011) 1702-1705.

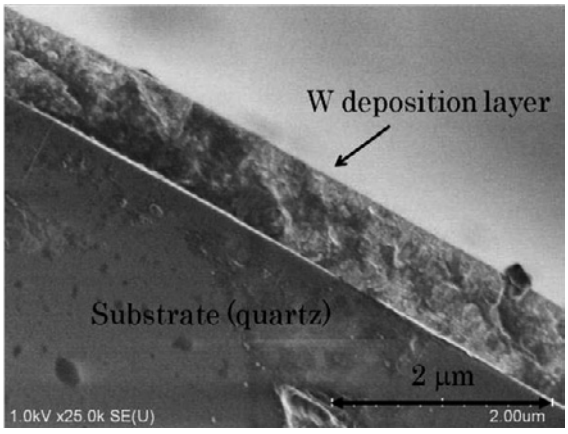

Fig.1 Cross-section SEM image of W deposition layer.

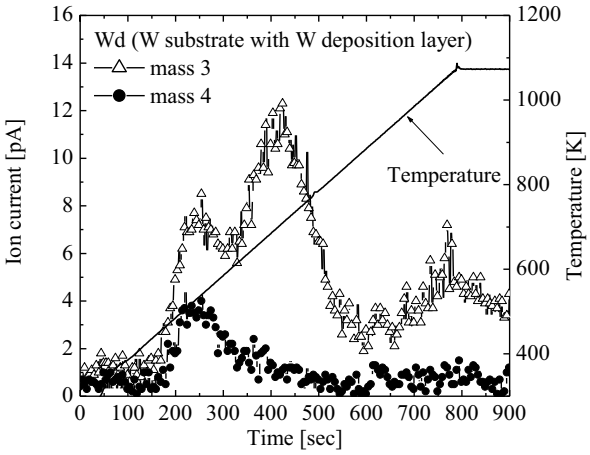

Fig.2 Deuterium release behavior from sample Wd.

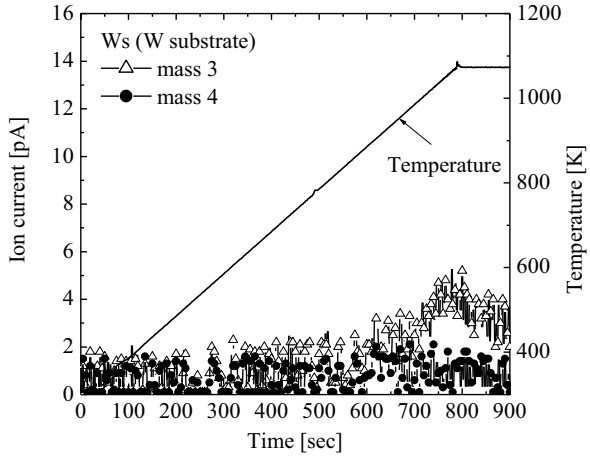

Fig.3 Deuterium release behavior from sample Ws.