§26. Retention Enhancement of Hydrogen Isotope in Tungsten Exposed to LHD Plasma

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i) Introduction

The understanding of Plasma-Wall Interaction (PWI) is important from a viewpoint of tritium retention control. Especially, when Plasma Facing Material (PFM) will be exposed to fusion plasma, tritium retention enhancement in PFM on the actual environment on a fusion reactor would be greatly different from the laboratory well-controlled environment. In 15th, 16th and 17th cycle campaign experiment, hydrogen isotope retention enhancement in tungsten (W) placed on the plasma facing wall in Large Helical Device (LHD) at National Institute for Fusion Science (NIFS) had been evaluated. As a result, the amount of carbon was increased in the vacuum chamber by introduction of closed diverter, and thicker deposition layer was formed on W surface, leading to enhancement of hydrogen isotope retention.

In this study, deposition layer formed on the W surface and hydrogen isotope retention enhancement in samples introduced in 18th cycle campaign, were estimated.

ii) Experimental

Polycrystalline W (10 mm$^{\varphi}$×0.5 mm^{t}) purchased from A.L.M.T. Corp. Ltd was used. For the pretreatment, the samples were heated at 1173 K for 30 minutes under ultrahigh vacuum (<10^{-6} Pa). Thereafter, the samples were placed into four typical positions, namely the higher plasma wall interaction area called as PI, the deposition area as DP, the higher heat load area as HL and the erosion dominated area as ER and exposed hydrogen plasma. Thereafter, the 1.0 keV deuterium (D_2) ions were additionally implanted into these samples up to the fluence of 5.0×10^{21} D^+ m^{-2} and the hydrogen isotope retention was estimated by Thermal Desorption Spectroscopy (TDS). In addition, surface chemical states and microstructure were observed by X-ray Photoelectron Spectroscopy (XPS) and Transmission Electron Microscopy (TEM) in Kyushu University.

iii) Results and discussion

Fig. 1 shows TEM images for PI, DP and ER samples. Based on XPS measurement and TEM observation, amorphous deposition layer mainly consisted by carbon and a little amount of metals, namely carbon dominated mixed material layer was formed on the surface of DP, PI and HL samples and their thicknesses were reached to >1600, 190 and 210 nm, respectively. For PI sample, metal impurities derived from plasma facing wall which made from stainless steel, were contaminated and condensed in carbon dominated mixed material layer. On the other hand, for ER sample, carbon deposition layer was not almost formed due to erosion, and damages, such as helium bubbles were formed.

Fig. 2 shows the D_2 TDS spectra for these samples. The D desorption was found at the temperature region of 300 – 600 K and 600 – 1100 K for ER sample and other samples, respectively. It was indicated that the D retention for ER sample was mainly trapped by W although D retention was enhanced compared from that for pure W because D was trapped by defects produced by helium plasma exposure. TDS spectra for other samples were consisted of three peaks located at 500, 700 and 800 K. Three peaks were attributed to the desorption of D trapped by the dangling bond induced by the irradiation defect, that trapped by C-Fe-C bond and that caused by graphitization for the carbon dominated mixed material layer at lower temperature by the catalytic effect of iron existence. It is indicated that metals including carbon would be complicated the hydrogen isotopes desorption behavior by metals and carbon interactions.

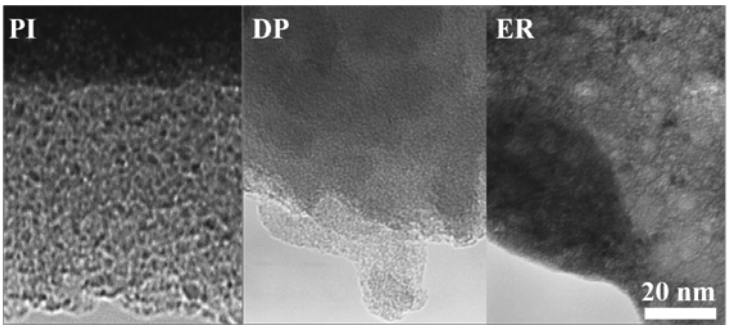

Fig. 1. TEM image for each sample

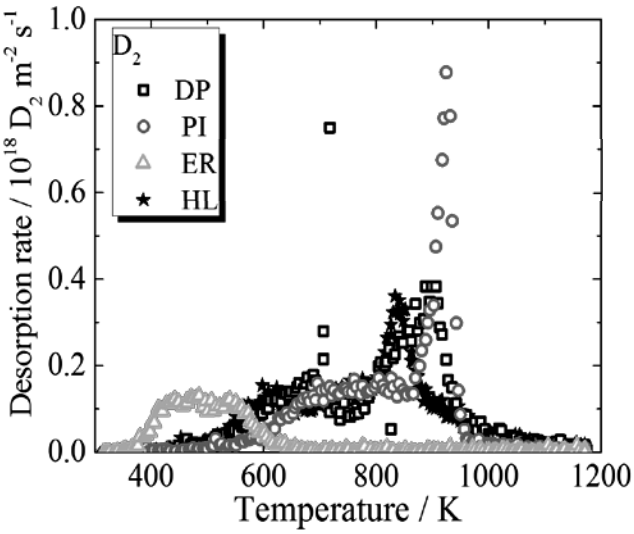

Fig.2 D_2 TDS spectrum of each sample