§3. Deuterium Retention Enhancement for LHD Plasma Exposed W

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i) Introduction

The understanding of Plasma-Wall Interaction (PWI) was important from a viewpoint of tritium retention control. Especially, when Plasma Facing Material (PFM) was exposed to fusion plasma, tritium retention enhancement in PFM on the actual environment on a fusion reactor was greatly different from the laboratory well-controlled environment. In 15th and 16th 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 17th cycle campaign, were estimated.

ii) Experimental

Polycrystalline W (6 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) 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 was formed on the surface of DP, PI and HL samples and their thicknesses were reached to 1600, 170 and 105 nm, respectively. For PI sample, metal impurities derived from plasma facing wall which made from stainless steel, were contaminated and condensed in carbon deposition 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 and the other samples, by carbon deposition layer, respectively.

Fig. 3 shows hydrogen desorption spectra on DP, PI and HL normalized by deposition layer thickness formed on the samples. It was found that the hydrogen retention behaviors were good agreement among the samples. Therefore, it was can be said that the thickness of carbon deposition layer would control the hydrogen isotope retention enhancement. Therefore, it was concluded that carbon deposition layer of uniform structure was formed on W and most of hydrogen isotopes would be trapped by the deposited layer.

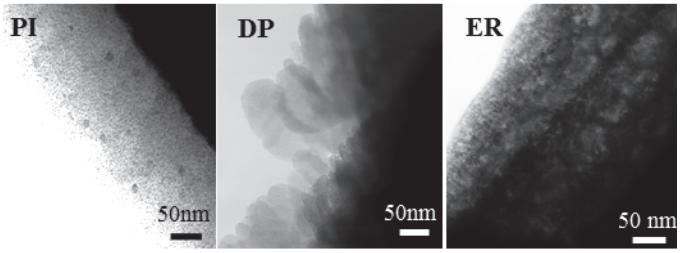

Fig. 1. TEM image for each sample

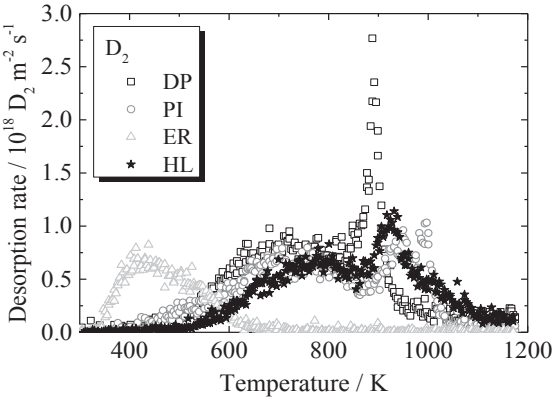

Fig.2 D_2 TDS spectrum of each sample

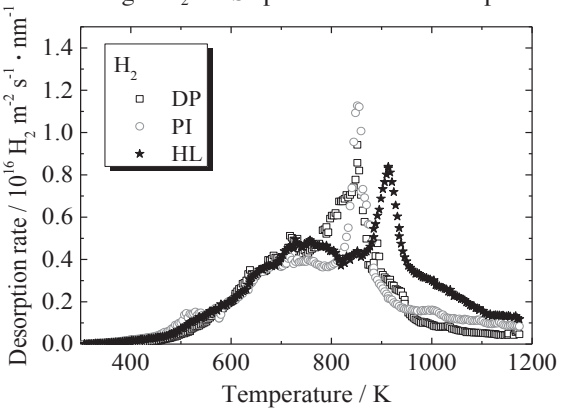

Fig.3 H_2 TDS spectrum on DP, PI and HL normalized by deposition layer thickness