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QUEST 2020S/Sキャンペーンにてプラズマ曝露した タングステン試料における水素同位体滞留挙動

Evaluation of hydrogen isotope retention behavior for plasma exposed tungsten samples in QUEST 2020 S/S campaign

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1. Introduction

W (tungsten) is one of candidate PFMs (plasma facing materials) for future fusion reactors due to its higher melting point, lower sputtering yield and so on. In the fusion conditions, energetic ions including impurities will be irradiated into W. In addition, irradiation damages will be introduced into W accompanied with impurity deposition. Consequently, the hydrogen isotope retention behavior will be affected by the irradiation damages and impurity layers.

2. Experiment

In this study, Fe ion (Fe^{2+}) damaged W samples and undamaged W samples were exposed to H (hydrogen) plasma during the 2020S/S campaign of QUEST. Irradiation damages were introduced by 6 MeV Fe ion irradiation with the damage level of 0.3 dpa (displacement per atom). The unique features of QUEST 2020S/S plasma campaign are as follows: long term discharge about 6 hours, positive toroidal magnetic field and the wall temperature of 473 K. After the plasma exposure, the chemical states and the depth profile of atomic concentration were analyzed by XPS (X-ray photoelectron spectroscopy) at Shizuoka University. In addition, TEM (transmission electron microscopy) observation was also performed at Kyushu University and NIFS. SEM (scanning transmission electron microscopy) and FIB (Focused Ion Beam) was performed at NIFS. TDS (Thermal desorption spectroscopy) was applied from room temperature up to 1173 K with the heating rate of 30 K min^{-1} to evaluate the hydrogen isotopes retention behavior. Furthermore, additional 1 keV deuterium ion (D^{2+}) was implanted with the ion flux of 1.0×10^{18} D^{+} m^{-2} s^{-1} up to the ion fluence of 1.0×10^{22} D^{+} m^{-2} at room temperature to evaluate the deuterium trapping efficiency and trapping states. The correlation between discharge conditions and hydrogen isotopes retention were studied.

3. Results and discussion

Fig. 1 shows atomic concentration of W samples placed at top, equator, and bottom walls. The thickest deposited layer was found at equator wall. Top and bottom walls were almost the same thicknesses. It was clear that carbon is the major deposit on the QUEST plasma facing wall.

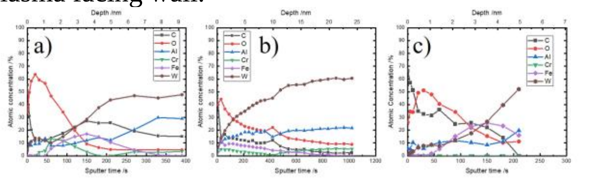

Fig. 1 Atomic concentration of W samples placed at top (a), equator (b) and (c) bottom walls during QUEST 2020S/S plasma campaign.

However, XPS spectra in Fig. 2 showed that W near the surface existed as oxides.

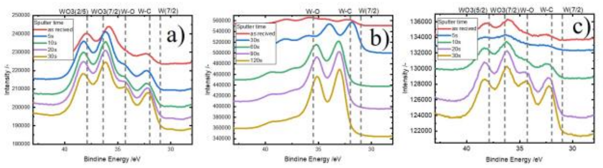

Fig. 2 W 4f XPS spectra for W samples placed at (top (a), equator (b) and (c) bottom walls during QUEST 2020S/S plasma campaign.

Fig. 3 shows FIB result for W sample placed at top wall. The amorphous metal oxide was formed at the surface. At the beneath the surface, the carbon containing layer was accumulated, which was almost the consistent with the XPS results.

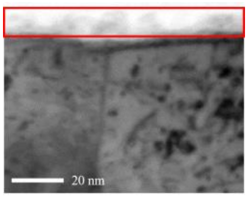

Fig. 3 FIB result for W samples placed at top wall during QUEST 2020S/S plasma campaign.

The details of how these factors affect the hydrogen retention behavior will be presented in a poster.