3Da02

クエスト2017秋冬キャンペーンにてプラズマに曝された高温タングステン壁における水素同位体滞留挙動評価

Evaluation of hydrogen isotope retention behavior for plasma exposed tungsten placed on high temperature wall in QUEST 2017 Autumn / Winter Campaign

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1.Introduction

Tungsten (W) is a major candidate for plasma facing materials (PFMs) in future fusion reactors due to its higher melting point and lower sputtering yield. During plasma operation, irradiation damages will be introduced into W accompanied with impurity deposition. Consequently, hydrogen isotopes will be trapped by their introduced damages and impurity layers. From the viewpoint of fuel recycling evaluation and control of wall pumping effect, it is essential to study the hydrogen isotope retention behavior in plasma exposed W. In this study, W samples were exposed to hydrogen plasma at Q-shu University Experiment with Steady-State Spherical Tokamak (QUEST). Thereafter, the chemical states of elements on/in the sample surface were analyzed by X-ray photoelectron spectroscopy (XPS). Moreover, their hydrogen isotope retention behaviors were evaluated by thermal desorption spectroscopy (TDS).

2.Experiment

Polycrystalline W samples (10 mm$^{\phi}$, 0.5 mm^{t}) purchased from A.L.M.T. Co., Ltd. were used. Firstly, the samples were heat-treated at 1173 K to remove impurities and damages introduced by polishing process. Thereafter, the samples were placed on the top wall, the equatorial wall, and the bottom wall of QUEST and exposed to hydrogen plasma during 2017A/W (Autumn / Winter) campaign. After picking up these samples from QUEST, XPS measurements with 3 keV Ar^+ sputterings were repeatedly performed to examine their depth profiles. In addition, 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. Thereafter, TDS measurement was applied from room temperature up to 1173 K with the heating rate of 0.5 K s^{-1} to evaluate the hydrogen isotope retention. In order to observe the state of defects, TEM observation was carried out for samples which were annealed at various temperatures up to 1173 K.

3.Results and Discussion

Typical results for depth profiles of constituent elements are summarized in Fig. 1. It can be seen that the sample placed on the bottom wall has the thinnest deposited layer, namely erosion dominated. In 2016A/W, erosion dominated area was located at the top wall, which is likely to suffer ion impact due to large deviation from confinement region. This reverses in 2017A/W due to toroidal magnetic field reversal.

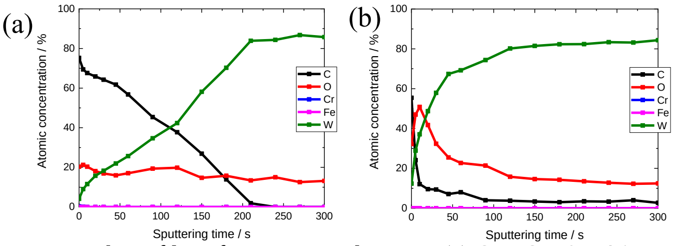

Fig. 1 Depth profiles of constituent elements; (a) QUEST2017A/W top wall and (b) QUEST2017A/W bottom wall.

The D_2 TDS spectra are shown in Fig. 2. The TDS spectra for all the samples had two major desorption stages located at 400 K and 650 K. It was considered that the peak at 400 K corresponded to the desorption of D absorbed on the sample surface or trapped by dislocation loops [1]. That at 650 K was considered to be derived from the desorption of D trapped by vacancies [2]. Compared with the results derived in the previous experimental campaign (2016A/W) in Fig. 2(a), It was thought that damages in the bottom wall was accumulated.

Fig. 3 shows TEM image of the bottom wall sample at room temperature. It was found that the bottom wall was heavily damaged and density of dislocation loops was increased. These results were due to the changes of plasma discharge condition in QUEST.

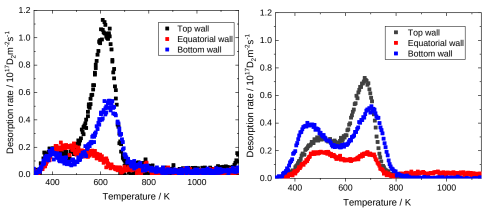

Fig. 2 D_2 TDS spectra; (a) QUEST2016A/W, (b)QUEST2017A/W

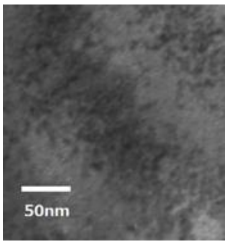

Fig. 3 TEM image for damage of QUEST2017A/W bottom wall

References

[1] M. Kobayashi, M. Shimada, Y. Hatano. T. Oda, B. Merrill, Y. Oya, K. Okuno: *Fusion Eng. Des.* **88**.1749 (2013).

[2] G. N. Luo, W.M. Shu, M. Nishi: *Fusion Eng. Des.* **81**.957 (2006).