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欠陥導入 W における水素同位体同時照射が及ぼす重水素滞留挙動

The influence of hydrogen isotopes simultaneous irradiation on D retention in damaged tungsten

齋藤 巧[1]、小池彩華[2]、和田拓郎[2]、山﨑翔太[2]、芦沢京祐[2]、孫 飛[1]、大矢恭久[1,2]
SAITO Takumi[1], KOIKE Ayaka[2], WADA Takuro[2], YAMAZAKI Shota[2], ASHIZAWA Kyosuke[2], SUN Fei[1], OYA Yasuhisa[1,2]

[1]静岡大理、[2]静岡大学院総合科学技術
[1]Fac. of Sci., Shizuoka Univ., [2]Grad. Sch. of Integrated Sci. and Tech., Shizuoka Univ.

1. Introduction

Plasma-facing-materials (PFMs) for fusion reactor must withstand high energy particles. Tungsten (W), which has high melting point and low sputtering rate, is suitable as a candidate. It is important to study the hydrogen isotopes retention behavior in the materials from the viewpoint of tritium recycling. Additionally, high-flux particles introduce various defects in W during the operation. At the plasma operation, hydrogen isotopes namely deuterium and tritium will be co-existed and implanted simultaneously into plasma facing wall. The hydrogen isotope retention under coexistence of the other hydrogen isotope was not well understood and the isotope effect on hydrogen isotope in W have to studied to establish the fuel cycle in fusion reactor. In the present study, the influence of the H/D ratio on the D retention behavior in undamaged W and damaged W was investigated by the simultaneous irradiation of hydrogen isotopes and thermal desorption spectroscopy (TDS).

2. Experiment

6 MeV Fe^{2+} was irradiated into the polycrystalline W samples (A.L.M.T. Co. Ltd) at room temperature (R.T.) with damage level of 1 dpa by TIARA (Takasaki Ion Accelerators for Advanced Radiation Application). Thereafter, 3.0 keV D_2^+ and H_2^+ simultaneous irradiation was performed with the ion total flux of 2.0×10^{18} m^{-2} s^{-1} up to the ion total fluence of 2.0×10^{22} m^{-2} for both undamaged W and damaged W at R.T.. The ratios of D to H were set to be 2 : 0, 1.5 : 0.5, 1 : 1 and 0.5 : 1.5, respectively. Finally, TDS measurement was performed from R.T. to 1173 K with the heating rate of 0.5 K s^{-1}.

3. Results and Discussion

Fig. 1 shows the D_2 TDS spectra for undamaged W with various H/D ratios. the dislocation loops and vacancies than D [1]. Focusing on the ratio of 1 : 1 and 0.5 : 1.5, D_2 desorption at around 600K was appeared. According to Ref. [1], the energy of H trapped in W was more stable in the defects than that of D. As a result, D was not trapped in shallow region and diffused into deeper region in W. Hence, D was trapped by defects deep in W and the desorption was shifted to higher temperature side. Fig. 2 shows the D_2 spectra for 1 dpa damaged W with various H/D ratios. Compared to the TDS for undamaged W, the D desorption temperature was not shifted toward higher temperature side even if the D/H ratio was decreased. This was because there were still enough defects in 1 dpa damaged W that D would still be trapped. Therefore, the diffusion of D into the bulk was less likely to occur than in 1dpa damaged W. In conclusion, simultaneous irradiation of hydrogen isotopes changed the desorption behavior of D.

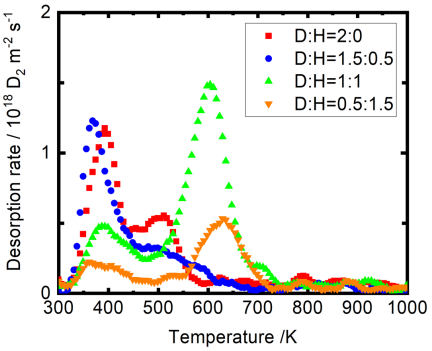

Fig. 1. D_2 TDS spectra for undamaged W

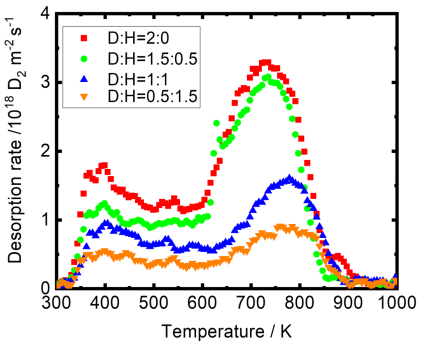

Fig. 2. D_2 TDS spectra for 1.0 dpaW

4.Reference

[1] Donald F. Johnson et al., J. Mater. Res., *25*(2), 315-327. (2010)