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欠陥導入タングステン中の重水素滞留挙動に及ぼす炭素照射影響

Effect of carbon implantation on deuterium retention behavior for damaged tungsten

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Carbon (C^+) implantation effects on deuterium (D) retention for Fe^{2+} damaged tungsten (W) with the damage concentration of 0.001, 0.01, 0.1 and 1.0 dpa were studied. It was found that the amount of D trapped by voids was increased as the damage concentration was increased from 0.1 dpa. On the other hand, D desorption rate derived from vacancies did not change in spite of increased damage concentration. These results suggested that C was trapped by vacancies, which suppressed D trapping by vacancies.

1. Introduction

Tungsten (W) is planned to be used as plasma facing materials of fusion reactors like ITER due to its good physical characteristics such as higher melting point and lower sputtering yield. During the plasma operation, W will be exposed to energetic particles, including hydrogen isotopes, neutron and impurities like carbon (C). It is well known that hydrogen isotope is trapped in the defects produced by energetic particle irradiation. In addition, a C-W mixed layer was formed by C^+ implantation for W, which suppressed the deuterium (D) diffusion [1–2]. Therefore, it is important to elucidate C^+ implantation effect on D retention behavior for damaged W to comprehend hydrogen isotope dynamics in actual reactor conditions.

2. Experimental

The polycrystalline W (A.L.M.T. Corp., Japan) with the size of 10 mm diameter and 0.5 mm thickness was used as a sample. To remove impurities, these samples were preheated at 1173 K for 30 minutes under ultrahigh vacuum (< 10^{-6} Pa). To simulate neutron implantation, 6 MeV Fe^{2+} was implanted at room temperature with the damage concentration of 0.001, 0.01, 0.1, and 1.0 dpa (displacement per atom) by 3 MV tandem accelerator, TIARA (Takasaki Ions Accelerators for Advanced Radiation Application). Then, 10 keV C^+ implantation for these samples were performed with the ion flux of 1.0 × 10^{17} C^+ m^{-2} s^{-1} up to the ion fluence of 1.0 × 10^{21} C^+ m^{-2} at room temperature. Thereafter, 3 keV 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. Finally, thermal desorption spectroscopy (TDS) measurements were performed from room temperature to 1173 K to evaluate the D desorption behavior.

3. Results and discussion

D_2 TDS spectra for the sequential Fe^{2+} and C^+ implanted W with various damage concentrations (0.001 – 1.0 dpa) are shown in Fig 1. These spectra were consisted of three desorption peaks located at 400, 600, and 790 K. It is known that Peak 1 is desorption of D adsorbed on the surface and/or trapped by dislocation loops [3,4]. Peak 2 and Peak 3 were considered to be derived from desorption of D trapped by vacancies and voids, respectively [5]. Our previous experiment on the sequential Fe^{2+} and D^+ implantation showed that D desorption rate at Peak 2 and Peak 3 increased as the damage concentration increased [6]. In this experiment, D desorption rate at Peak 3 increased as the damage concentration increased. However, no remarkable change of D desorption at Peak 2 was found by the sequential Fe^{2+} and C^+ implanted W in spite of increased damage concentration, indicating that the vacancies formed by Fe^{2+} implantation would trap C, which refrained D trapping by vacancies. The voids can sufficiently trap D, because the size of voids is larger than vacancies.

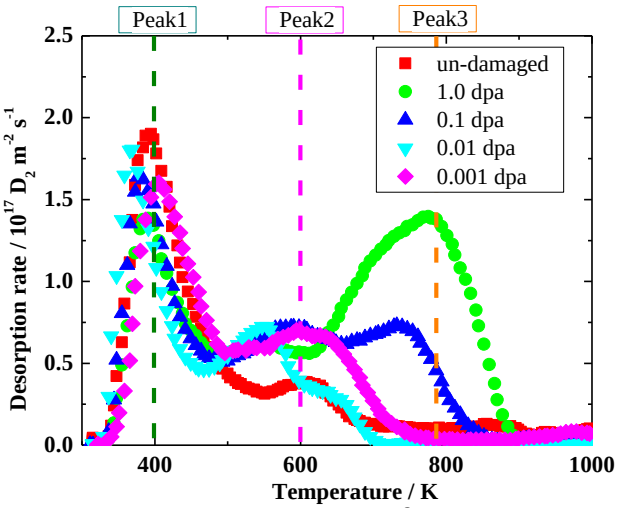

Fig.1 D_2 TDS spectra for the sequential Fe^{2+} and C^+ implanted W with various damage concentration and only C^+ implanted W

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