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欠陥導入したWにおける重水素滞留挙動の入射フルエンス依存性

Study of Deuterium retention behavior dependence on implantation fluence for damaged W

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1. Introduction

Tungsten (W) is considered as one of the candidate for plasma facing materials (PFM) in the future fusion reactors. During the operation, 14 MeV neutron will be irradiated into W and irradiation defects will be introduced uniformly [1]. In contrast, damages by ions or charge-exchanged particles will be accumulated near the surface. Therefore, the distribution of damages in W is ununiform. In this study, both of neutron and Fe ion were irradiated into W. Thereafter, D ion was irradiated by ion beam irradiation or plasma exposure and their D retention behavior was studied by thermal desorption spectroscopy (TDS).

2. Experimental

A disk-type polycrystalline W (6 $mm^{\varphi} \times 0.5\ mm^{t}$) purchased from A.L.M.T. Co. Ltd. was used. Heat treatments were performed at 1173 K for 30 minutes. 14 MeV fast neutron irradiation was performed with Fusion Neutronics Source (FNS) at damage level of 2.4×10^{-7} - 6.3×10^{-4} dpa. Afterwards, Fe^{2+} was irradiated into these samples at damage level of 0.1 dpa by Takasaki Ion Accelerators for Advanced Radiation Application (TIARA). Thereafter, 1.0 keV D ion implantation (flux: 1.0×10^{18} D^+ m^{-2} s^{-1}, fluence: 1.0×10^{22} D^+ m^{-2}, R.T.) was carried out for a part of the samples at Shizuoka University. D desorption behavior was evaluated by TDS from room temperature up to 1173 K with the heating rate of 0.5 K s^{-1}. The experimental details were summarized in Table I.

Table I. Experimental detail for ion implanted samples

Sample No.	neutron	Fe^{2+}	Retention ($D\ m^{-2}$)
(1)	6.3×10^{-4} dpa	0.1 dpa	5.6×10^{19}
(2)	2.5×10^{-7} dpa	None	5.0×10^{19}
(3)	None	0.1 dpa	1.3×10^{20}
(4)	None	None	1.1×10^{19}

3. Results and Discussion

Fig. 1 shows the D_2 TDS spectra for D ion implanted damaged W samples.

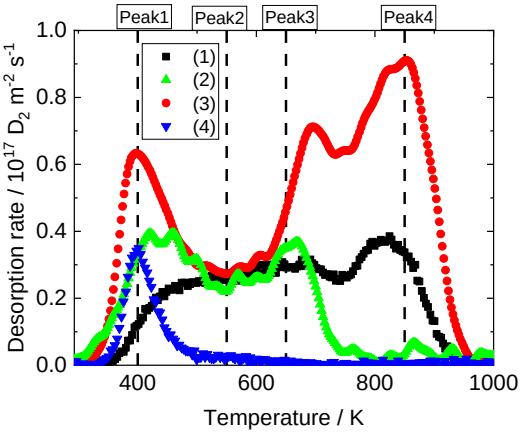

Fig. 1. D_2 TDS spectra for D ion implanted tungsten samples

It was found that the introduction of irradiation damages enhanced D retention in W. Large D desorption at higher desorption temperature which corresponds to the desorption of D trapped by vacancy clusters and voids, was found for 0.1 dpa Fe^{2+} damaged W. By the combination of neutron and Fe^{2+} irradiation, the D retention was clearly reduced even though the amount of total damage level is higher than that of single Fe^{2+} irradiated sample. These results indicate that 14 MeV neutron introduce the damages throughout the sample, which may enhance the D dynamic reemission from the surface. Despite the lower neutron damage level of 6.3×10^{-4} dpa compared to Fe^{2+} damage level of 0.1 dpa, the effect of damage throughout the sample by neutron may have a large impact on D retention.

References

[1] M. Shimada, Y. Hatano, Y. Oya, et al.: Fusion Eng. Des. **87,** 1166 (2012).