照射分布を持つW中の重水素滞留に及ぼすバルク欠陥分布影響評価

Evaluation of bulk defect distribution influence on deuterium retention in damaged tungsten.

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1. Introduction

In the fusion reactor, tungsten (W) is a candidate material for plasma facing materials (PFMs). During the operation of devices, W would be exposed to intense fluxes of energetic hydrogen isotopes, helium and neutron. The irradiation damage would be the potential hydrogen isotopes trapping sites, leading to an increase of their retention. In neutron irradiation experiments, high operational costs, setup time and unsafety measures would be invoked. In previous study, although high energy Fe^{2+} was used to simulate the defect caused by neutron, the range was less than 1 μm, which is much smaller than that of neutron. Since high energy H^+ has long range and same mass number, H^+ was irradiated to W to introduce defects deeply into the bulk in the present work. Thereafter, the Deuterium(D) retention behavior was evaluated by thermal desorption spectroscopy (TDS).

2. Experimental

The polycrystalline W (A.L.M.T. Corp., Japan) with the size of 6 mm diameter and 0.5 mm thick was used. To remove impurities, these samples were preheated at 1173K for 30 minutes under ultrahigh vacuum (< 10^{-6} Pa). 0.8, 3 MeV H^+ was implanted at room temperature with the damage concentration of 3.0×10^{-4} dpa (displacement per atom) by 3 MV tandem accelerator, TIARA (Takasaki Ions Accelerators for Advanced Radiation Application). After that, 3 keV D_2^+ implantation was performed 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 performed from room temperature to 1173 K to evaluate the D desorption behavior.

3. Result and discussion

TDS spectra of D_2 desorption for H^+ implanted W with the damage concentration of 3.0×10^{-4} dpa are shown in Fig 1. These spectra were divided into 3 desorption peaks to be located near 400, 600 and 800 K. It is known as the desorption of D absorbed on the surface and trapped in dislocation loops, vacancies and voids, respectively. Although the desorption of D trapped by vacancies was increased, that by surface and dislocation loops was reduced in the case of 0.8 MeV H^+ irradiation, indicating that D was trapped by trapping sites with higher trapping energy because the Bragg peak of 0.8 MeV H^+ irradiation is located near the surface (Fig. 2) compared with that of 3 MeV H^+ irradiation. Thus, D would be quickly desorbed before trapping by vacancies or voids.

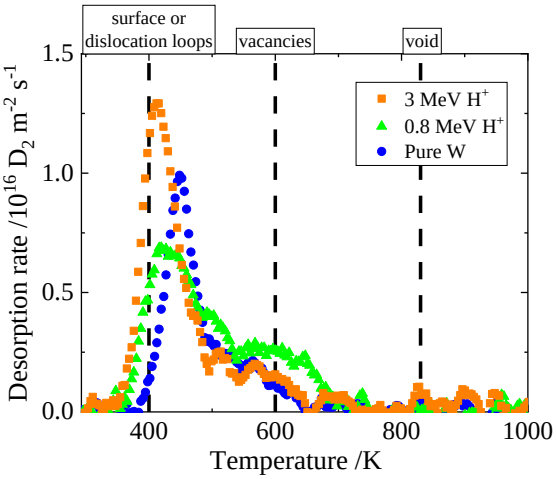

Fig.1 D_2 TDS spectra for H^+ implanted W and un-damaged W

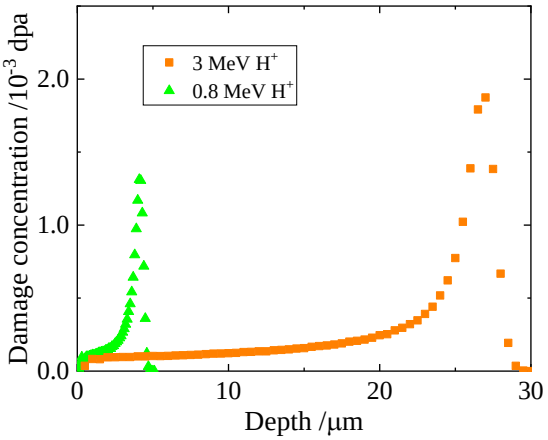

Fig. 2 Distribution of damage concentration in W calculated by SRIM.