05aD17P

イオンビームその場分析によるW中の同位体交換研究
Deuterium-Hydrogen isotope exchange in self-damaged W studied by in-situ nuclear reaction analysis

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1. Introduction

Neutron damage results in increased T inventory in tungsten (W), which must be strictly controlled for safety reasons. Isotope exchange is proposed as one method for such control. However, the detailed kinetics of such process is not yet well understood but is important to clarify to estimate the efficiency of removal. Therefore, we have performed preliminarily in-situ experiments examining Deuterium-Hydrogen isotope exchange in self-damaged W to demonstrate the feasibility of studying the kinetics of isotope exchange.

2. Experiment

A single W sample manufactured by Plansee was polished to a mirror finish, and outgassed at 1223 K in vacuum. The sample was implanted by 20 MeV W ions up to 1.4×10^{14} cm^{-2} fluence at 300 K and then recrystallized at 2000 K for 10 minutes in vacuum. A dual-beam system [1] connected to a tandem accelerator for in-situ ion beam analysis was used to implant 9 keV D^{3+} with fluxes of 10^{18}–10^{19} D^+/m^2s up to a fluence of ~10^{24} D/m^2 at 300 and 450 K. The implanted D concentration was measured using nuclear reaction analysis (NRA) using the $D(^3He,p)^4He$ nuclear reaction at 0.69 to 4.0 MeV. D depth profiles were determined by SIMNRA [2] fitting of the spectra. Following D implantation, H was implanted in smaller fluence steps using the same source conditions. Between each H implantation step, NRA was performed to measure the change in trapped D concentration profile.

3. Results and Discussion

D depth profiles measured by NRA are shown in Fig. 1 at 300 K and 450 K. At 300 K, the D trapped within 100 nm is released or replaced following 310 s H implant corresponding to an implanted fluence of 8×10^{21} H/m^2 (not shown). However, as seen from Fig. 1, the absolute amount of D trapped at greater depths is hardly affected but there is a redistribution of the trapped profile even at 300 K. At 450 K, the isotope exchange process is enhanced but the process is still inefficient. In this presentation, we discuss the removal efficiency based on the data below as well as future plan for improving the experiments.

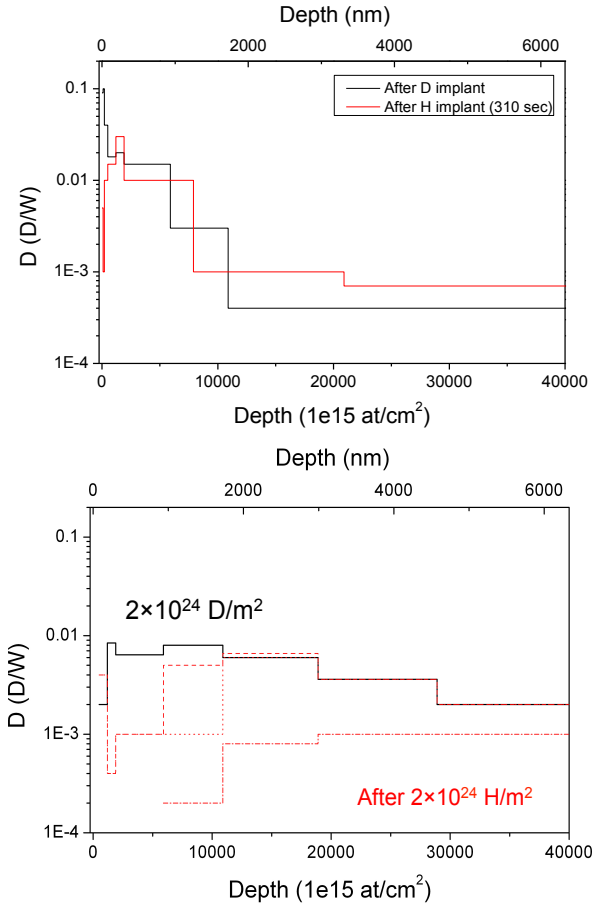

Figure.1 D depth profiles following H implantation steps at 300 K (upper) and 450 K (lower).

Reference

[1] I. Bizyukov, K. Krieger, Rev. Sci. Instrum. 77 (2006) 043501.
[2] M. MAYER, *SIMNRA User's Guide*, Report IPP 9/113, Max-Planck-Institut fuer Plasmaphysik, Garching, Germany (1997).