27pB05

TFGR W中の水素同位体挙動
Deuterium Retention in Toughened, Fine-Grained Recrystallized Tungsten

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1. Introduction

Tungsten (W) will be used as a plasma-facing material (PFM) in future fusion reactor, and in the divertor of ITER. However, W suffers from poor mechanical properties such as high ductile to brittle temperature resulting in room temperature brittleness or neutron irradiation embrittlement.

To improve W mechanical properties, a variety of advanced W materials have been or are currently under development. One such material is TFGR W (Toughened, Fine-Grained Recrystallized W) developed by Kurishita at Tohoku University [1]. TFGR W has an average grain size of ~1 μm with a small amount of TiC or TaC dispersoids. Since TFGR W has enhanced toughness compared to other W materials, it is expected that it would improve poor irradiation brittleness of pure W. However, concerning plasma wall interaction issues such as tritium retention under plasma exposure, TFGR W has limited data so far.

In this study, we investigated deuterium (D) retention in TFGR W-1.1wt%TiC and TFGR W-3.3wt%TaC by ion beam implantation followed by thermal desorption in order to increase the D retention database of TFGR W and clarify D retention mechanisms.

2. Experiment

TFGR W-1.1wt%TiC and TFGR W-3.3wt%TaC specimens of 10 x 10 x 1 mm size were used. The D implantation into TFGR W specimens was conducted using High-Flux ion beam Irradiation Test device (HiFIT) in Osaka University [2], with an incident energy of 1keV, and flux density of ~1 x 10^{20} $m^{-2}s^{-1}$. Deuterium fluence of up to about 1 x 10^{24} m^{-2} was implanted at temperatures of 473 – 873 K. Following implantation, D retention was measured by thermal desorption spectroscopy (TDS) in a separate apparatus. For comparison, the experiments were also made with pure W specimens under the same conditions. In addition to pure D implantation, experiments with some impurity concentration in D ion beam were also conducted.

3. Results and Discussion

It was found that D retention in both TFGR W-1.1wt%TiC and TFGR W-3.3wt%TaC specimens was systematically higher than that of pure W specimens at all irradiation temperature. In addition, D retention in TFGR W decreases with temperature more slowly than pure W. This suggests that TFGR W has trapping sites with higher trapping energies than those in pure W. The trap sites could be TiC or TaC dispersoids, which has chemical affinity with D atoms.

It was also found that D retention in TFGR W-3.3wt%TaC was lower than that of TFGR W-1.1wt%TiC at high temperature of 773K, while no apparent difference between retention of these two specimens at 573 – 673 K. This could be originated from different types of dispersoids of TiC and TaC. One possible explanation is difference of chemical composition of hydrogen isotopes that Ti or Ta made chemical bonding with D atoms into TiD_2 or TaD.

In this presentation, we will discuss the role of dispersoids (TiC or TaC) and crystalline structure on D retention in the TFGR W materials.

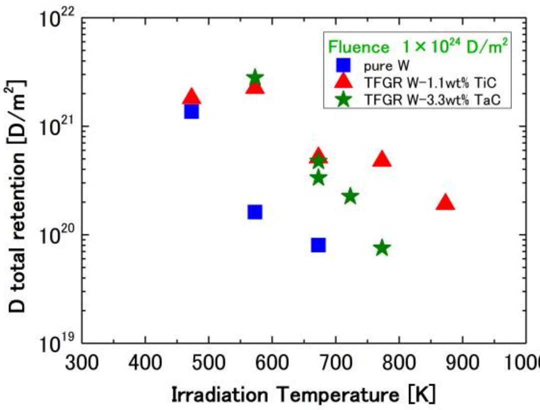

Figure.1 Temperature dependence on D retention in W materials (pure W, TFGR W-1.1wt%TiC and TFGR W-3.3wt%TaC)

Referance

[1] H. Kurishita et al., J. Nucl. Mater. **398** (2010) 87-92.
[2] Y. Ueda et al., Fusion Eng. Design **62** (2002) 255-261.