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高フラックス照射下でのTFGRタングステン中の水素同位体挙動

Deuterium Retention in TFGR W (Toughened, Fine-Grained Recrystallized W) under high-flux irradiation

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1. Introduction

Tungsten (W) is a leading candidate for use as a plasma-facing material (PFM) in a fusion reactor, and will be used in the divertor of ITER. To improve the mechanical properties of W (room temperature brittleness and neutron irradiation embrittlement), TFGR W (Toughened, Fine-Grained Recrystallized W) was 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 which enhances toughness and increases ductility. However, tritium retention properties of TFGR-W under fusion relevant plasma exposure conditions are not well known.

In our previous study using ion beams (~10^{20} D/m^{2}s), we observed increased deuterium (D) retention in TFGR W compared to pure W. In this study, we investigated D retention in TFGR W exposed to higher fluxes (10^{22} or 10^{24} D/m^{2}s) using linear plasma machines in order to increase the D retention database of TFGR W and examine flux dependency.

2. Experiment

TFGR W-1.1wt%TiC (W-TiC) and TFGR W-3.3wt%TaC (W-TaC) specimens of 10 x 10 x 1 mm size were used. These specimens were exposed to D plasma in two types linear plasma generators; at JAEA [2] and Pilot-PSI at DIFFER [3]. The specimen was biased at 50 V and the incident D flux was ~1 x 10^{22} m^{-2}s^{-1} and ~1 x 10^{24} m^{-2}s^{-1}, respectively. Deuterium fluence up to ~1 x 10^{26} m^{-2} was implanted at temperatures of 573 – 773 K. Following implantation, D retention was measured by Nuclear Reaction Analysis (NRA) and thermal desorption spectroscopy (TDS). For comparison, pure W specimens were also exposed at similar conditions. Surface morphology was observed by Scanning Electron Microscope (SEM).

3. Results and Discussion

D depth profiles measured by NRA are shown in Fig. 1 for W-TiC, W-TaC, and pure W specimens for the two different linear plasma devices. In both cases, the trapped D concentration in TFGR W was higher than pure W. Specifically, in the near surface layer (1 – 8 μm) D trapped in TFGR-W was 10 and 5 times higher than pure W following exposure at JAEA and Pilot-PSI, respectively. From TDS measurement, the total D retention in TFGR W (W-TiC and W-TaC) was approximately 7 times higher than compared to pure W, in the case of JAEA plasma exposure. Typically, a dominant peak at ~700 K with a smaller trailing shoulder up to 1100 K was observed. SEM revealed the presence of small blisters on TFGR W surface, following exposure at Pilot-PSI.

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

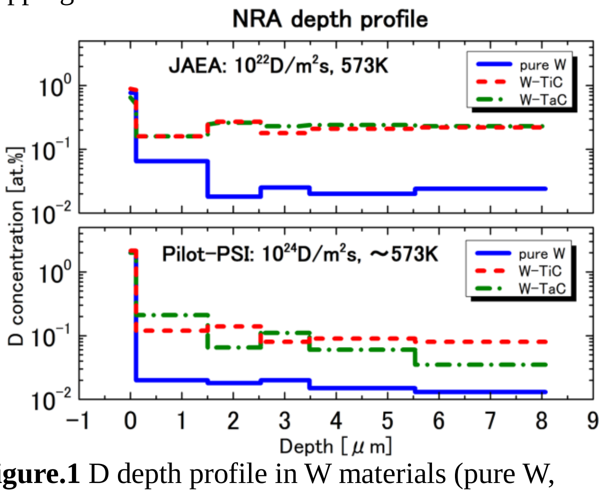

Figure.1 D depth profile in W materials (pure W, TFGR W-1.1wt%TiC and TFGR W-3.3wt%TaC), irradiated at JAEA (upper) and Pilot-PSI (lower)

Referance

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[2] G.-N. Luo et al., Rev. Sci. Instrum. **75** (2004) 4347.

[3] Van Rooij et al., Appl. Phys. Lett. **90** (2007) 121501