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タングステンにおける水素同位体透過に及ぼす核反応生成物Re添加効果
Role of nuclear transmuted Re on hydrogen isotope permeation through tungsten

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1.Introduction

Tungsten (W) is one of the candidates for plasma facing materials (PMFs) in the fusion reactors due to its high melting point and low sputtering yield. W will be exposed to high flux deuterium (D) and tritium (T) including helium (He) ash during the operation. In addition, 14MeV neutron, that produced by nuclear fusion reaction of D and T, will be irradiated into W, leading to the transmutation of Re in W. Therefore, the evaluation of hydrogen isotope permeation behavior for W-Re alloy are important.

2.Experiment

The W-10%Re alloy disk with the size of 6 mm diameter and 0.5mm thickness, were used. The disk was installed in the plasma driven permeation (PDP) device and D permeation behavior was studied at the temperature range between 673 K and 833 K. The results of D permeation behavior for W-10%Re alloy was compared with that for W. After the PDP experiment, these samples were exposed to tritium gas (T ratio of 7.2 %) at 773 K for 3 hours at University of Toyama. Tritium imaging plate (IP) technique and β-rays induced X-ray spectroscopy (BIXS) were applied to evaluate T distribution in plasma exposed W and W-10%Re samples.

3.Results and discussion

Fig. 1 shows the temperature dependence of D diffusion coefficients and D permeation flux for W and W-10%Re. D diffusion coefficients for W-10%Re were lower than that for W and D permeation flux for W-10%Re were higher than that for W. It was considered that the surface recombination coefficient decreased due to the addition of Re and the D concentration beneath the surface increased.

Fig. 2 shows that BIXS spectra for undamaged W and W-10%Re after exposure to the tritium gas. X-ray intensity for W-10%Re was higher than that for W. The existence of W (Lα) peak for W-10%Re indicated that T was diffused toward the bulk for W-10%Re. It was considered hydrogen isotope solubility of W-10%Re was higher than that of W. The surface recombination coefficient decreases with increasing hydrogen isotope solubility [2]. The results of permeation measurements and BIXS measurements are consistent with each other.

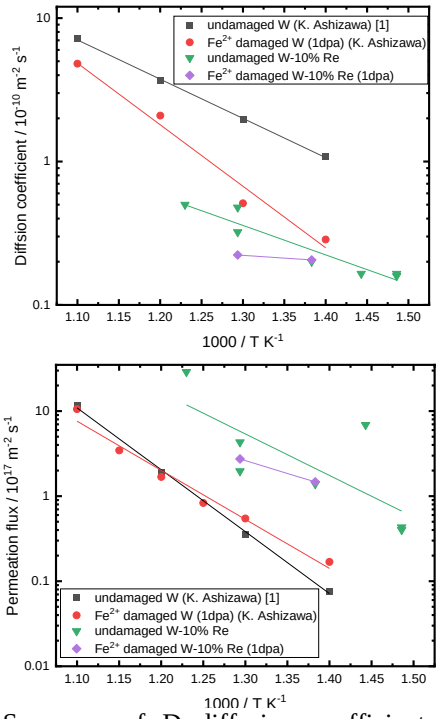

Fig. 1 Summary of D diffusion coefficients and D permeation fluxes for W and W-10%Re

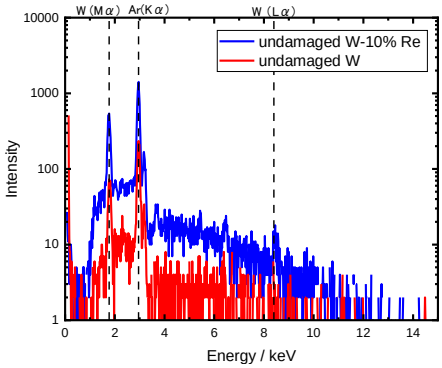

Fig. 2 Comparison of BIXS spectra for W and W-10%Re.

Reference
[1] K. Ashizawa et al., “Plasma driven permeation behavior of hydrogen isotope in tungsten under H-D-He mixed plasma exposure”, Atomic Energy Society of Japan (2021).
[2] M. A. Pick, K. Sonnenberg, J. Nucl. Mater. 131(1985)208-220.