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重水素・窒素/ネオン同時照射が タングステン中の重水素透過挙動へ与える影響

Effects of deuterium and nitrogen/neon simultaneous irradiation on deuterium permeation in tungsten

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1. Introduction

To reduce the heat load onto tungsten (W) plasma facing materials and protect it from melting, impurity seeding in the divertor will be mandatory. Nitrogen (N) and neon (Ne) are both candidate impurity species. The seeded impurities and hydrogen isotopes will irradiate the W surface simultaneously. The resulting interaction will modify the surface state of tungsten, affecting both hydrogen release and transport in tungsten. This would have significant impact on fuel recycling or safety aspects due to changes in tritium retention and permeation in a fusion device. Such changes in transport behavior of hydrogen isotopes in tungsten can be studied by ion driven permeation experiments. In our previous study, we examined the effects of helium [1] and carbon [2] impurities. However, permeation experiments with N or Ne impurity species has not been carried out yet. Therefore, we have performed mixed deuterium (D) ion driven permeation experiments with N or Ne impurities to determine the effect of such impurities on the transport of hydrogen isotopes.

2. Experiment

Permeation experiments were performed using a high flux ion beam test device (HiFIT) coupled with a permeation device at Osaka University [1]. The used W specimens were thickness of 30 μm, with purity of 99.99%. The D permeation flux was measured using a quadrupole mass spectrometer. The incident D flux was ~10^{20} $m^{-2}s^{-1}$, and the ion energy was 1 keV. The specimen temperature range was 500 – 1000 K, and the N and Ne fraction in the incident flux was ~ 3%.

3. Results

The steady state D permeation flux as function of temperature is plotted in Figure 1. For D+N irradiation case, measured D permeation flux at T < 900 K was larger than D-only case and at T = 650 K, the permeation flux is about 20 times larger. From XPS measurements, the formation of W and N mixed layer was observed on the specimen surface under D+N simultaneous irradiation. The tungsten nitrides were observed to be stable up to 773 K.

In contrast, for D+Ne irradiation case, D permeation flux was smaller than D-only case. However, the decrease follows similar temperature dependence to D-only case.

In this presentation, we discuss the change in near surface properties caused by N or Ne impurities and correlate it to the measured permeation fluxes. We also discuss the implications of using N or Ne as impurity species for radiative cooling in a full W-divertor.

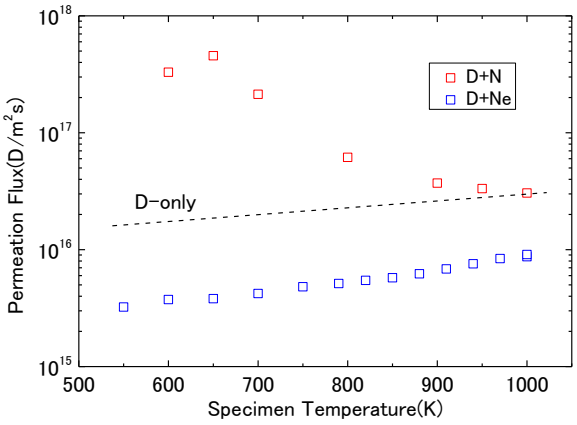

Fig. 1 Steady state D permeation flux for the case of D-only [2], D+N and D+Ne irradiation as function of temperature.

References

[1] H.T. Lee et al., J. Nucl. Mater. **415** (2011) S696.
[2] H.Y. Peng et al., Phys. Scr. **T145** (2011) 014046.