Deuterium permeation behavior in rolled W foil and forged W rod studied by gas-driven permeation method

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Abstract: The deuterium permeation behavior in W foil and W rod were studied by Gas-Driven Permeation (GDP) method, in which the gas loading surface were parallel and perpendicular to the grain elongated direction respectively. The results show that the deuterium permeability and effective diffusivity in W foil were lower than that of W rod.

Keywords: Hydrogen isotopes permeation, Gas driven permeation, Tungsten foil, Tungsten rod

1. Introduction

Well understanding of tritium (T) permeation and retention behavior requires the knowledge of hydrogen isotopes transport parameters in tungsten (W). It has been known that the mechanical properties of W are closely associated with the grain orientation and manufacture process. However, the manufacture process and grain orientation dependence of hydrogen isotope permeation behavior in W has not been sufficient studied yet. In the present study, the deuterium (D) permeation behavior in rolled W foil and forged W rod are studied comparatively.

2. Experiment

The materials used in this study are W wafer with the diameter of 6 mm cut from rolled W foil and forged W rod supplied by Allied Material (A.L.M.T.) Corp. Ltd. The thickness of sample from W foil and W rod are 0.025 mm and 0.5 mm respectively. To release the internal stress, heating treatment up to the temperature of 1173 K for 30 min is performed for the experimental W samples under high vacuum. Thereafter, the D permeation behavior in W is studied by Gas-Driven Permeation (GDP) method with the temperature range from 627 to 994 K. For W foil sample, the gas loading surface is parallel to the grain elongated direction. In the case of W rod sample, the gas loading surface is perpendicular to the grain elongated direction

3. Results and discussion

For both of the W foil and W rod sample, the steady state permeation flux is proportional to the square root of the loading pressure of D_2 gas meaning that the permeation process is diffusion limited. Then, the permeation parameters, effective diffusivity (D_{eff}) and permeability (Φ) are calculated by the pre-steady state and steady state permeation data. The effective diffusivity and permeability as a function of reciprocal of temperature are shown Fig. 1. in which the literature data are also plotted as comparison. The effective diffusivity and permeability in W foil are lower than that of W rod which should be attributed to the difference in grain orientation and manufacture process. It has been reported that diffusion barrier energy of hydrogen (H) in grain boundary (GB) is lower than in W bulk. Meanwhile H can easily jump into the GB and it will be difficult to jump out of GB [1]. For the application of W in fusion reactor, the recommended-grain orientation is parallel to the direction of the heat flow. In this case, the-possible enhancement in hydrogen isotopes transport should be considered.

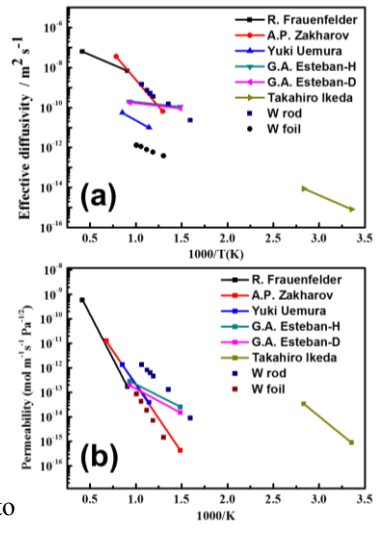

Fig. 1. Permeation parameters, (a) effective diffusivity, (b) permeability.

References

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