23Da

低放射化フェライト鋼およびセラミックス被覆の固体増殖材ペブルとの共存性と重水素透過挙動に与える影響

Compatibility of reduced activation ferritic steel and ceramic coating with ceramic breeder pebbles and its effect on deuterium permeation behavior

松浦 航[1], 鈴木 亮権[1], Leys M Julia[2], 中野 優[3], 金 宰煥[3],
星野 毅[3], 中道 勝[3], Regina Knitter[2], 近田 拓未[1]
Wataru Matsuura[1], Akiyoshi Suzuki[1], Julia M Leys[2], Suguru Nakano[3], Jaehwan Kim[3], et al.

[1]静岡大, [2]カールスルーエ工科大, [3]量研
[1]Shizuoka University, [2]KIT, [3]QST

1. Introduction

Strict control of tritium permeation is a critical issue in the development of a fusion blanket in terms of fuel efficiency and radiological safety. Tritium permeation barrier (TPB) coatings have been investigated for several decades to solve the problem, and ceramic coatings showed high permeation reduction performance. However, there are a limited number of researches to investigate compatibility of the coatings with solid tritium breeder pebbles and the corrosion effect on hydrogen isotope permeation. In this study, deuterium permeation behavior of a structural material with and without a TPB coating under exposure to solid tritium breeder pebbles was investigated to establish a database of tritium permeation in solid breeder blankets.

2. Experimental

Reduced activation ferritic/martensitic (RAFM) steel F82H (Fe-8Cr-2W) plate was used as substrates. The ZrO_2-coated sample was fabricated by metal organic decomposition described in our previous study [1]. Deuterium permeation measurements were conducted using a gas-driven permeation apparatus for the F82H and ZrO_2-coated samples in contact with lithium metatitanate (Li_2TiO_3) pebbles produced by an emulsion method [2]. The deuterium driving pressure was 10–100 Pa, and the test temperature was 250–550 ºC.

Surface and cross-sectional observation of the samples before and after the measurements was conducted by scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy.

3. Results and discussion

Fig. 1 shows the Arrhenius plots of deuterium permeation flux for the F82H and the ZrO_2-coated samples under exposure to ceramic pebbles. In the measurements at 100 Pa, the F82H showed three orders of magnitude lower permeation fluxes in comparison with that without pebbles at 80 kPa. The permeation reduction factor was much larger than that in the case assuming diffusion limited regime. This result indicates surface reactions made a large contribution to the permeation at lower driving pressures. The ZrO_2-coated sample showed two orders of magnitude lower permeation fluxes in comparison with F82H under the same condition. Besides, the ZrO_2-coated sample kept a stable permeation flux over 200 hours without significant degradation confirmed by SEM observation after the measurements, indicating the ZrO_2 coating worked as a TPB under solid blanket conditions.

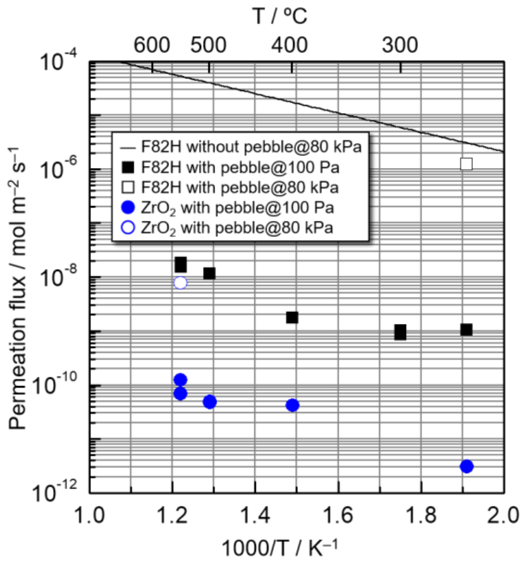

Fig. 1. Arrhenius plots of deuterium permeation flux for the F82H and the ZrO_2-coated samples under exposure to ceramic pebbles.

Reference

[1] J. Mochizuki et al., Fusion Eng. Des. 136 (2018) 219–222.

[2] T. Hoshino, Fusion Eng. Des. 98–99 (2015) 1788–1791.