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有機金属分解法で作製したイットリア安定化ジルコニア被覆の作製と特性評価

Preparation and characterization of yttria-stabilized zirconia coating by metal organic decomposition

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1. Introduction

For the realization of a sufficient fuel cycle in a fusion reactor, functional coatings have been investigated mainly using ceramics to suppress tritium leakage through structural materials and corrosion by liquid tritium breeders. In particular, yttria-stabilized zirconia (YSZ) produced by the addition of yttrium oxide (Y_2O_3) in zirconia oxide (ZrO_2) has higher thermal stability and fracture toughness than typical ceramics. Therefore, there are possibilities that the YSZ coating has thermal cycle resistance and a self-repairing function that suppresses crack propagation in the coating. In this study, the YSZ coatings were prepared by a liquid-phase method, which has a potential for plant-scale fabrication, and the characteristics of the coatings were investigated.

2. Experiments

Before the coating preparation, a reduced activation ferritic/martensitic steel F82H (Fe-8Cr-2W) plate substrate was heat-treated to form a chromium oxide layer on the surface to improve the coating performance [1]. ZrO_2 coatings doped with 4 mol% Y_2O_3 (4Y-YSZ) were prepared by metal organic decomposition with a dip-coating technique. The coating procedure including dipping, drying, pre-heating, and heat treatment is described in detail in Ref. [2]. In this study, the sample was dipped into the coating precursor and then dried under argon atmosphere in a glove box. The whole coating process was repeated twice.

Four-point bending tests were performed to give the coating damage with 1–3 % elastic bend strains of F82H.

Deuterium permeation tests were conducted for the samples before and after the bending tests using a gas-driven permeation apparatus. The deuterium driving pressure was 10–80 kPa, and the test temperature was 300–600 ºC. After the permeation tests, thermal cycle tests were performed for the sample before the bending tests. The change in deuterium permeation flux was monitored during ten thermal cycles by changing the sample temperature from 300 to 600 ºC. The rates of temperature increase and decrease were approximately 5 ºC/min.

3. Results and discussion

Fig. 1 shows the temperature dependence of deuterium permeation flux for the 4Y-YSZ coating sample before the bending tests. The permeation flux decreased at 500 ºC due to crystallization and/or grain growth, and the permeation barrier performance was maintained at up to 600 ºC. In the last measurement at 300 ºC, the permeation flux decreased by a factor of 1700 in comparison with that of the substrate. No significant increase in the permeation flux observed during the thermal cycle test. From these results, the coating might have thermal cycle resistance. In the presentation, the permeation behavior after the bending tests will be also discussed.

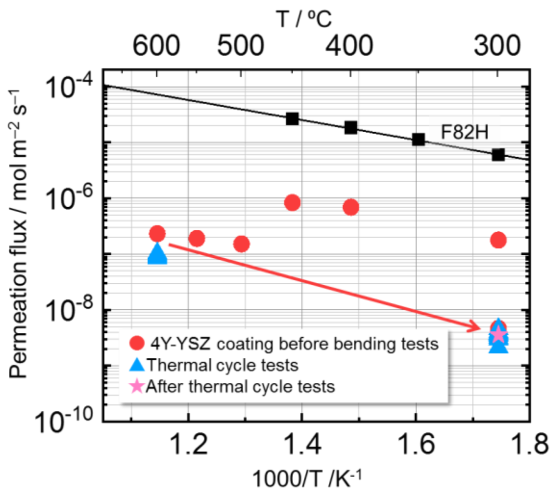

Fig. 1. Arrhenius plots of deuterium permeation flux of 4Y-YSZ coating sample before bending tests.

Reference

[1] T. Tanaka et al., J. Nucl. Mater. 455 (2014) 630–634
[2] J. Mochizuki et al., Fusion Eng. Des. 136 (2018) 219–222