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トリチウム透過低減用多層被覆のリチウム鉛中腐食挙動
Corrosion behavior of multi-layer coating for tritium permeation reduction in Li-Pb

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1. Introduction

Tritium permeation through structural materials in fusion reactor blanket systems is a critical issue from the perspectives of radiological safety and fuel loss. In the previous studies, ceramic coatings have been investigated as a tritium permeation barrier and showed sufficient permeation reduction factors. On the other hand, corrosion of the coatings by liquid tritium breeders such as lithium-lead (Li-Pb) is an unavoidable concern. Recently it has been suggested that corrosion resistance was improved by multi-layer coatings [1]. In this study, up to four-layer ceramic coatings using erbium oxide (Er_2O_3) and zirconium oxide (ZrO_2) were fabricated and exposed to static Li-Pb to investigate the effect of layer structure on Li-Pb compatibility.

2. Experimental

Reduced activation ferritic/martensitic steel F82H (Fe-8Cr-2W, F82H-BA07 heat) substrates were used as substrates. The coating procedure including formation of chromium oxide on the substrate, dip-coating of the coating precursors, drying, pre-heat treatment, and heat treatment is described in detail in Ref. [1]. The layer structures of multi-layer coatings are summarized in Fig. 1. The heat treatment was performed every time after fabrication of each layer.

Li-Pb immersion tests were performed using an electric furnace at 600 °C for 500 h. The samples and Li-Pb were put into an iron crucible encapsulating in a stainless steel container. Surface and cross-sectional observations of the immersed samples were conducted by scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDX). Cross-sectional SEM observation and EDX analysis for the selected area was conducted using a focused ion beam system.

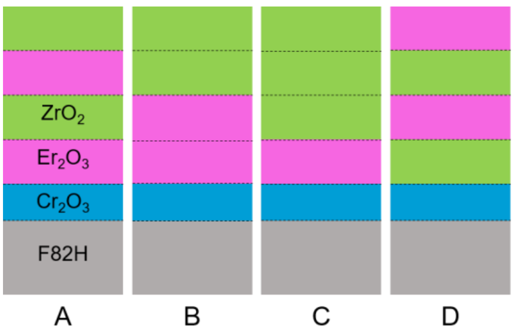

Fig. 1 Layer structure of coating samples.

3. Results and discussion

After immersion test, peeling of the first ZrO_2 layer was observed in Sample A. In Sample D, peeling between the second layer and the third layer was observed as shown in Fig. 2. A carbon-based interlayer product, which might contain Li undetectable by EDX, were observed in all sample surfaces. On the other hand, no reduction of the coating thickness was confirmed in Samples B and C. Samples A and D had the structure that Er_2O_3 layer was sandwiched between the two ZrO_2 layers, while Samples B and C did not. From these results, it is suggested that the carbon-based product invaded through cracks caused by difference in coefficient of thermal expansion between ZrO_2 and Er_2O_3, inducing the peeling at the ZrO_2-Er_2O_3 interface.

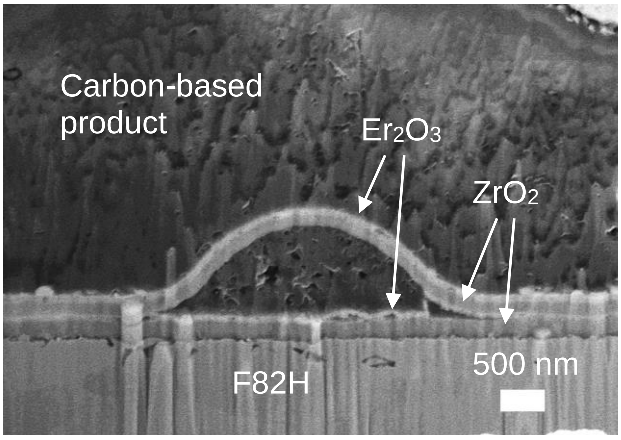

Fig. 2 Cross-sectional SEM image of Sample D after Li-Pb immersion test at 600 °C for 500 h.

Reference

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