7P58 Fabrication and characterization of zirconium oxide coating on stainless steel tube by metal organic decomposition

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1. Introduction

In fusion reactor blankets, multifunctional coatings have been investigated for tritium permeation reduction, corrosion protection, and electrical insulation. Aiming to realize the advanced fusion blanket, it is crucial to establish a ceramic coating technique on the inner wall of pipes in the liquid metal blanket. In this research, zirconium oxide (ZrO_2) coatings were fabricated on steel tubes by the metal organic decomposition method.

2. Experiment

316L stainless steel tubes of half an inch in outer diameter and up to 250 mm in length were used as the substrates, and the ZrO_2 coating was fabricated on both the outer and inner walls of the tubes. The coating procedure was followed in our previous study [1]. For a long tube, the pre-heat treatment process of dipping, drying, and pre-heating was repeated eight times to ensure a homogenous coating. After every four pre-heat treatments, one heat treatment was carried out at 700 °C for 30 min in an argon and hydrogen atmosphere. The coated samples were characterized by surface and cross-sectional observations, and EDX analysis. To estimate the electrical insulation, the electrical resistivity was measured at high temperatures up to 550 °C in the air. Accordingly, the compatibility of the coating with liquid metal was examined by liquid lithium-lead exposure at high temperatures for a prolonged time.

3. Results and discussion

The ZrO_2 coatings were homogeneously formed on the inner wall of the tube with a coating thickness of approximately 400 nm. The electrical resistivities of 10^4–10^7 Ω m were obtained at the temperature range of R.T–550 °C. These results revealed that the coating satisfied the electrical resistivity of $>10^2$ Ω m and dielectric strength of >1 kV/mm required for the MHD insulator coating in a liquid metal blanket [2].

After exposure tests at 600 °C for 100 h and 550 °C for 500 h and 1000 h, the ZrO_2 coating remained on the entire substrate without cracks and peelings. In comparison to the unexposed sample, the elemental concentration has not significantly changed by EDX analysis. The corrosion product was observed on the coating surface and detected through increasing carbon.

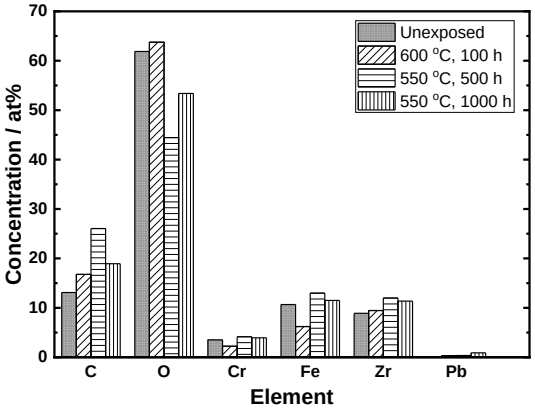

Figure. Elemental composition of ZrO_2-coated tubes with and without liquid Li-Pb exposure by EDX analysis

Reference

[1] M. Matusnaga et al., J. Nucl. Mater. 511 (2018) 534-543.
[2] T. Tanaka, et al., Fusion Eng. Des. 88 (2013) 2569–2572.