Impact of lithium-lead and gamma-ray irradiation on corrosion of ceramic-iron joint coatings

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The strategic vision focuses on the Li-Pb corrosion behaviors of ceramic coating and ceramic-iron joint coating on tubular specimens under gamma-ray irradiation.

Keywords: Coating, Li-Pb, Corrosion, Irradiation

1. Introduction

The development of the fusion blankets is directly proportional to the compatibility of blanket materials. The previous studies proved that ceramic-iron joint coatings meet the requirements for electrical insulation and resistance for liquid metal flow [1]. One of the remaining questions is whether the coating must endure irradiation and liquid metal exposure simultaneously. Therefore, the purpose is to investigate the cumulative effects of Li-Pb corrosion mechanisms and irradiation for the ceramic coating.

2. Experimental details

Polished 316L stainless steel tubes were used as a substrate. Two-layer ZrO_2-Fe_2O_3 and ZrO_2 coatings were fabricated by metal organic decomposition for ceramic-iron joint coating and single-layer coating, respectively. Then, the Fe tube jointed into the coated tube by a hot isostatic pressing (HIP) machine with 25 MPa at 550 ºC. The specimen was fixed with pure iron wire in the crucible which contained melted Li-Pb then enclosed in the insulated container. The tests were conducted at 550ºC for 100–200 h, an additional 300–400 h exposure with and without irradiation respectively. The estimated gamma-ray absorbed dose in the coating was approximately 27 kGy. The sample characterizations were conducted using a scanning electron microscope (SEM) with energy dispersive X-ray spectroscopy (EDX).

3. Results and discussion

Figure shows SEM images for the specimens after Li-Pb exposure test under gamma-ray irradiation. The HIP specimen exhibited improved resistance compared to the single layer coating one. Cracking, gaps, and grain boundary corrosion were observed in the single-layer coating. Depletion of Fe and Cr on the surface layer, may lead to Cr-depleted zone, which results in grain boundary corrosion. In HIP specimen, coating delamination was observed in some area, while remained intact in others. However, this delamination may happen during the sample preparation after the test as EDX mapping confirmed that there is no Li-Pb penetration through the coating. Detailed results of the corrosion mechanisms including coating recovery after 200-h irradiation during exposure will be discussed in the presentation.

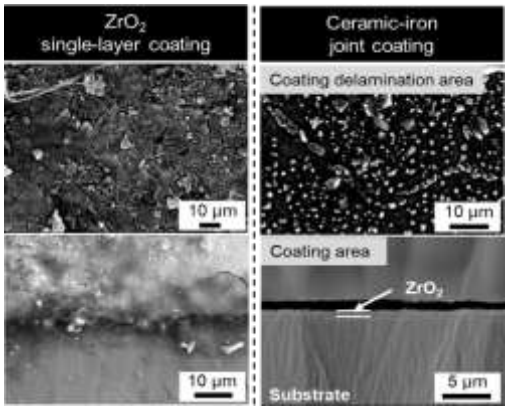

Fig. Surface and cross-sectional SEM images of ZrO_2 single-layer and ceramic-iron joint coating specimens after Li-Pb exposure under gamma-ray irradiation.

Reference

[1] R. Norizuki, T. Tanaka, E. Akahoshi, K. Kimura, K. Nakamura, T. Chikada, Fusion Eng. Des. 168 (2021) 112438.