Fabrication and Characterization of Zirconium Oxide Coating on Tubular Steel Substrate by Metal Organic Decomposition

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To reduce tritium permeation through structural materials on blanket components in an actual fusion reactor, zirconium oxide (ZrO_2) coatings on 316L type stainless steel tubes were fabricated by the metal organic decomposition method.

Keywords: tritium, permeation, coating, corrosion, zirconium oxide, tube

1. Introduction

Multifunctional ceramic coatings in fusion reactor blankets have been investigated for tritium permeation reduction, electrical insulation, and corrosion protection [1,2]. Practically, the fabrication of homogeneous ceramic coatings on the fusion blanket components such as ducts and complex-shaped surfaces is challenging. In terms of sustainable development, it is critical to establish a ceramic coating technique on the inner surface of complicated-shape ducts for the liquid metal breeder in the blanket. Therefore, in this study, we applied the metal organic decomposition (MOD) method to fabricate the ceramic coating on tubular steel.

2. Experiment

316L stainless steel (SS316L) 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 surfaces of the tubes by the MOD method. To form a homogenous coating on the long tube, the dipping, drying, and the pre-heat process was repeated eight times, and the heat treatment was processed two times. The inner coated surface was observed by field emission scanning electron microscopy (FE-SEM), and the coating thickness was determined at the middle and both head tubes by cross-sectional observation.

3. Results and discussion

Figure shows the images of uncoated and ZrO_2-coated tubes and the SEM images of the inner surface of the uncoated and ZrO_2-coated tube. The SEM observation indicated a homogeneous formation on the inner surface of the coated tube, and the coating thickness is approximately 400 nm for each tubing-coated position. To evaluate the characterizations and compatibility of the coating with liquid breeding materials, we are proceeding with the deuterium permeation measurements, electrical measurements, and corrosion tests by liquid lithium-lead exposure. The detailed results will be released and discussed in the presentation.

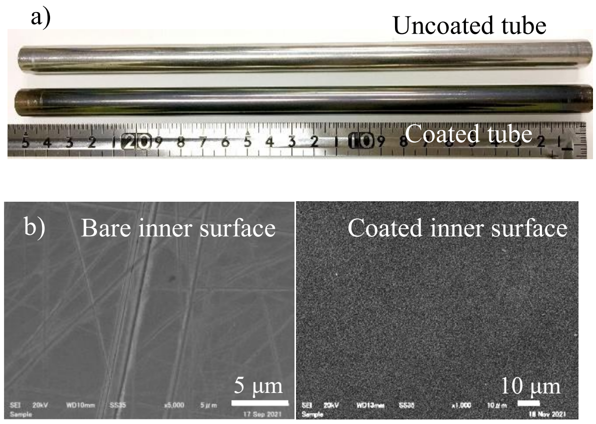

Figure. a) Images of uncoated and ZrO_2-coated SS316L tubes, and b) inner surface SEM images of uncoated and ZrO_2-coated SS316L tubes

References

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