§2. Study on Hydrogen Permeation Barrier Performance of Er_2O_3 MOD Coating

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The development of Er_2O_3 ceramic coatings has been conducted for suppression of the MHD pressure drop in the Li/V-alloy blanket system. The material of the Er_2O_3 was selected for the chemical stability and the superior performances as an electrical insulator have been shown in the precious studies. Recently, it has been reported that an Er_2O_3 coating fabricated by the arc-source plasma deposition had the potential as a permeation barrier for hydrogen isotopes[1]. The hydrogen permeation barrier is becoming one of key issues to be developed especially in the blanket systems adopting a coolant with low tritium solubility, e.g. Flibe, Li-Pb. In the present study, Er_2O_3 coatings were fabricated by the metal organic decomposition (MOD) method with the dip-coating technique[2], which is considered suitable for large area coatings on blanket components, and their permeation barrier performances have been examined.

Coatings of Er_2O_3 were fabricated on substrates of the industrial ferritic steel SUS430 (18Cr) and fusion candidate low activation ferritic steel JLF-1 (9Cr-2W). The dimensions of the substrates were 20 mmϕ x 1 mm. The substrates were dipped into MOD liquid and withdrawn with the speed of 200 mm/min to make thin and uniform liquid layers on the substrate surfaces. The withdrawn substrates were dried at 120 °C in air for 10 minutes. After repeating the dipping and drying processes 10 times, the specimens were baked in air at 600 °C for 2 hours. The coatings were made on both side of the substrates and each thickness was ~1.0 μm.

The performances as hydrogen permeation barriers were examined by the measurement method shown in Fig. 1. The specimens were set between the high pressure and low pressure chambers. Hydrogen gas of 4k–40k Pa was introduced in the high pressure chamber and permeation to the low pressure chamber was evaluated from the magnitude of the response of the quadrupole mass spectrometer (QMS). The measurement was performed at 400-700 °C.

The evaluated permeabilities of the specimens with and without the Er_2O_3 coatings are shown in Fig. 2. The results indicate that the permeation reduction factors of the coatings on the SUS430 and JLF-1 substrates were ~1/35 and ~1/15, respectively. It was found by XPS analyses that a thick oxidation layer consisted mainly of Fe_2O_3 was produced between the Er_2O_3 coating and the JLF-1 substrate during the baking process in air. The oxidation layer between the Er_2O_3 coating and the SUS430 substrate was thinner and consisted of Cr_2O_3. The Figs. 3 (a) and (b) show SEM images of the Er_2O_3 coating surfaces. From the images, it is considered that the severe oxidation of the JLF-1 substrate surface made the Er_2O_3 coating surface rough and degraded the performance as a hydrogen permeation barrier.

Control of the baking atmosphere is under study for suppression of oxidation layer on the JLF-1 substrate and improvement of the hydrogen permeation reduction factors.

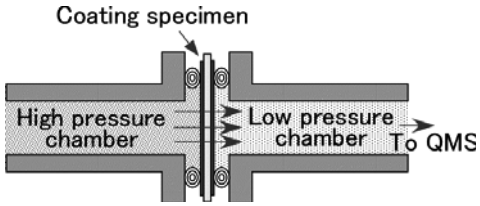

Fig. 1 Schematic drawing of hydrogen permeability measurements on Er_2O_3 coated SUS430 and JLF-1 specimens.

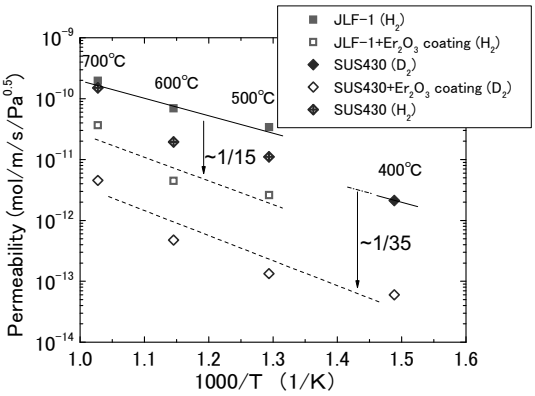

Fig. 2 Hydrogen permeabilities of SUS430 and JLF-1 substrates with and without Er_2O_3 coatings. The results using D_2 gas have been obtained in Osaka Univ.

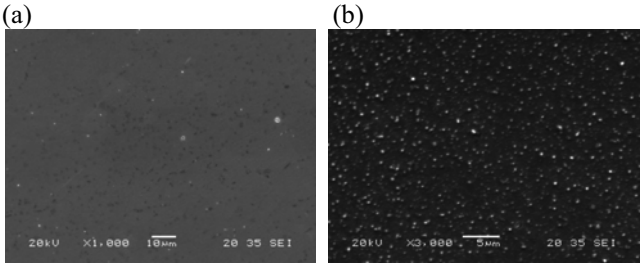

Fig. 3 SEM images of Er_2O_3 coating surfaces (a) on a SUS430 substrate and (b) on a JLF-1 substrate.

1) Chikada, T. et al.: Fusion Engineering and Design **84** (2009) 590–592.
2) Zhang, D. et al.: Annual report of National Institute for Fusion Science, April 2008-March2009, 440.