§4. Hydrogen Permeation Property of Er_2O_3 Coating Layer via MOCVD Process

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Development of coating layer to prevent magneto-hydrodynamic (MHD) pressure drop is one of the key issues for advanced liquid metal breeding blanket systems. Erbium oxide (Er_2O_3) was shown to be the promising one of the candidate oxide coating materials because of its high stability in liquid lithium and high electrical resistivity from the results of Er_2O_3 bulk and Physical Vapor Deposition (PVD) thin film. Furthermore, Er_2O_3 is also known to be a candidate for the tritium barrier coating. We have been applied Metal Organic Chemical Vapor Deposition (MOCVD) process for the aim of the oxide coating to the large inner surface area of complicated shaped duct tubing. We made Er_2O_3 coating layer on SUS 316 disk substrate using MOCVD apparatus in NIFS to investigate the hydrogen permeation property. The thickness of MOCVD processed Er_2O_3 coating layer was shown to about 800 nm.

Hydrogen permeation measurement was carried out using MOCVD processed Er_2O_3 coating. The principle of this measurement is to measure the penetrated hydrogen from high to low pressure side chamber. The specimen was set between the high pressure and low pressure chambers. In order to enhance leakage efficiency of the sample attachment, nickel C-rings with inconel coil spring inside (U-tight seal) was used. Hydrogen gas of 4 - 40 kPa 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 ºC. Microstructure observation of Er_2O_3 coating layer via MOCVD process before and after hydrogen permeability measurement was also carried out using scanning electron microscope (SEM) and transmission electron microscope (TEM). It is well known that the permeability is estimated by the following equation (I);

$$J = P\frac{p^n}{d} \qquad (1)$$

where *J* is permeation flux, *P* is permeability, *p* is driving pressure and *d* is thickness of the sample. Especially, *P* is so called hydrogen permeation coefficient. The exponent *n* represents permeation regime. The first result of the hydrogen permeability on the Er_2O_3 coating via MOCVD process was shown in Fig.1. The Er_2O_3 coating layer was formed at 500 °C of coating temperature. In the case of 400 °C of sample temperature, the hydrogen-permeation quantity of the SUS 316 plate-shaped substrate without Er_2O_3 coating is estimated to be 2.8×10^{-12} mol/m/s/Pa$^{-1/2}$. As well as, the hydrogen permeation quantity of the SUS 316 with Er_2O_3 coating was also obtained to be 1.2×10^{-13} mol/m/s/Pa$^{-1/2}$. We found that the hydrogen permeation quantity was decreased by 1/20 compared with that of SUS 316 substrate. The hydrogen permeability of the sample with Er_2O_3 coating was lower than that of under the all temperatures and it suggested that Er_2O_3 coating layer was effectively able to act as the hydrogen permeation barrier material. TEM and selected area diffraction (SAD) images of the Er_2O_3 coating layer before and after permeability measurement are shown in fig.2. As dark field images shown in figs.2 a) and c), no macro defect such as crack and adhesion was observed around the boundary of Er_2O_3 and SUS 316 substrate. We confirmed that no damage of Er_2O_3 coating layer after the hydrogen permeation measurement. In the SAD patterns shown in figs. 2 b) and d), it was clear that Er_2O_3 coating layer was crystallized uniformly because the diffraction fleck which shows a crystallization was arranged like a ring shaped. We found that Er_2O_3 coating is one of the promising candidate materials for the hydrogen permeation barrier in an advanced breeding blanket system

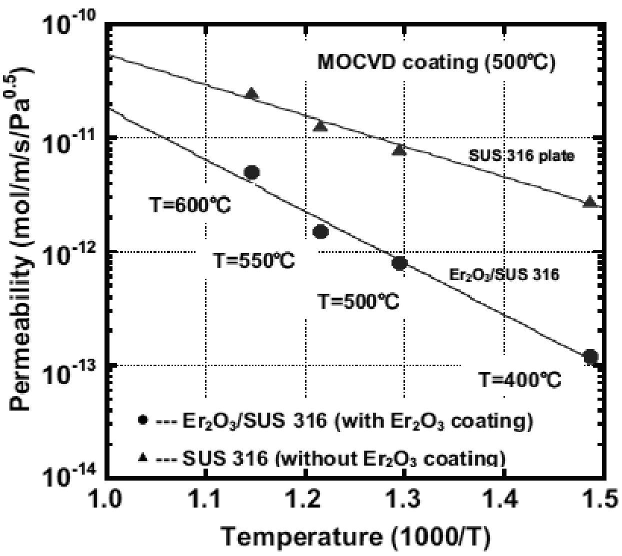

Fig.1 Temperature dependence of the hydrogen permeability on Er_2O_3 coating via MOCVD process.

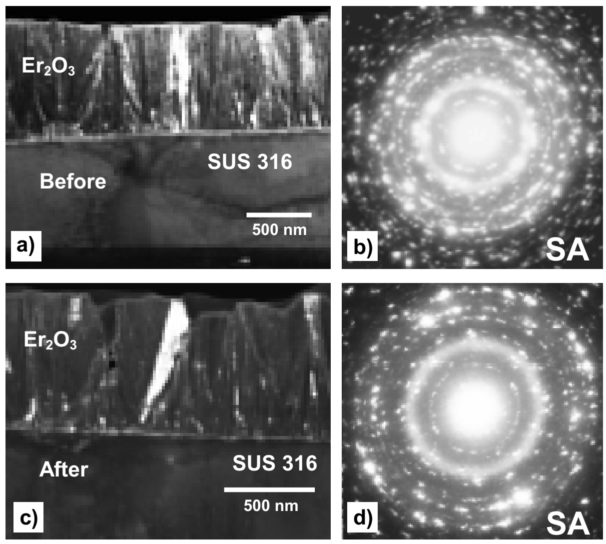

Fig.2 TEM and SAD images of the Er_2O_3 coating layer via MOCVD process before and after hydrogen permeability measurement. Fig.s a) and c) are dark field images of cross-section. Fig.s b) and d) are selected area diffraction patterns.