§4. Synthesis of Er_2O_3/buffer Multilayered Ceramic Coating for an Advanced Breeding Blanket Systems

Hishinuma, Y., Tanaka, T., Watanabe, T., Sagara, A., Muroga, T.,
Shinkawa, T., Murakami, S., Matsuda, K. (Univ. Toyama),
Tanaka, T., Tasaki, Y. (Toshima MFG Co., Ltd.)

Erbium oxide (Er_2O_3) was shown to be the promising one of the candidate oxide coating materials to prevent magneto-hydrodynamic (MHD) pressure drop 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 to form large area oxide coating into duct tubing. We succeeded to make Er_2O_3 coating layer on metal substrate using MOCVD process. We found that the hydrogen permeation quantity was decreased compared with that of stainless steel (SUS 316) substrate without coating and it suggested that Er_2O_3 coating layer was also effectively able to become one of the candidate materials as the hydrogen permeation barrier.

In order to enhance these properties of Er_2O_3 as the electrical insulator for MHD and hydrogen permeation barrier coating, it is necessary to form thicker and higher crystanity of Er_2O_3 coating layer. However, the epitaxial growth like the chemical vapor deposition is difficult to form thicker coating layer. We approached and investigated to form the double stacking coating layer on the SUS substrate using intermediate layer (buffer layer) for the thicker and high crystanity of Er_2O_3 coating formation. Generally, it is well known that the crystanity and alignment of coating layer affected by the lattice constant of the substarate. It is possible to the high crystanity of Er_2O_3 coating by the buffer layer formation with similar Er_2O_3 lattice constant between Er_2O_3 and substarte. The relationship of lattice constant between coating and substrate is often discussed using mismatch factor. The mismatch factor is estimated by the following formula;

Mismatch factor $f = |(b-a)| / a$
a: lattice constant of substrate,
b: lattice constant of coating

Table.1 The comparisons of lattice mismatch factor between various multilayered coating case

Sample	Er_2O_3 Lattice parameter (Å)	Buffer Lattice parameter (Å)	SUS (γ-Fe) Lattice parameter (Å)	Lattice mismatch (f)
Non-Buffer	10.55		3.646	1.86
CeO_2		5.41		0.95/0.48
Y_2O_3		10.60		0.005/1.91

The consistence between coating layer and metal substrate intend to be better with similar to the mismatch factor. In this study, Y_2O_3 and CeO_2 having the similar lattice constant of Er_2O_3 and SUS materials were selected as the buffer layer. Table.1 indicates the summary of mismatch factor in this study.

Typical image and X-ray diffraction of the Er_2O_3/CeO_2 multilayered coating sample are shown in Fig.1. We found that the interference band was decreased compared with no buffer coating sample. It suggested that coating thickness uniformity was improved by the buffer layer on substrate. From the X-ray diffraction, main diffraction peaks of Er_2O_3 and CeO_2 phases were also observed sharply. We concluded that Er_2O_3 coating layer was easily formed on CeO_2 buffer layer by MOCVD, and buffer layer was effective to form homogeneous coating layer. TEM image of the cross-sectional area in on the Er_2O_3/CeO_2 multilayered ceramic coating on the stainless steel substrate is shown in Fig.2. Er_2O_3 crystal formed columnar-like structure and it formed densely compared with the sample without CeO_2 buffer layer. The origin of grain growth of Er_2O_3 crystal seemed to be CeO_2 crystals. In the future, the microstructure of Er_2O_3/Y_2O_3 multilayered coating samples will be also investigated.

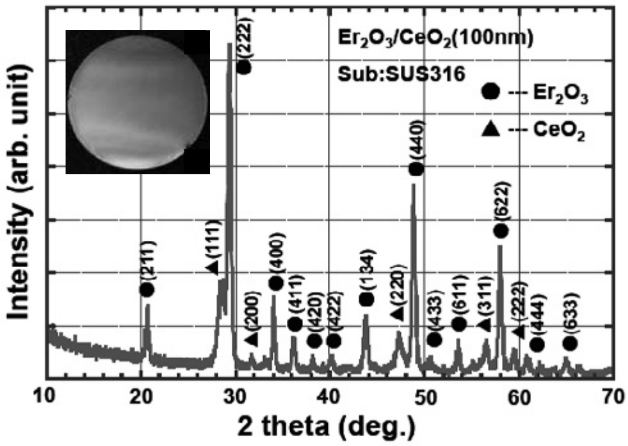

Fig.1 Typical X-Ray diffraction of the Er_2O_3/CeO_2 multilayered ceramic coating on the stainless steel (SUS 316) substrate.

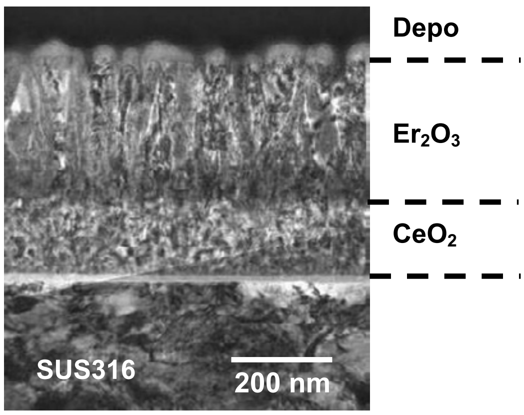

Fig.2 TEM image of cross-section area on the Er_2O_3/CeO_2 multilayered ceramic coating on the stainless steel (SUS 316) substrate.