§1. Fabrication of Erbium Oxide Coating by Sol-gel Method

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For the concepts of Pb-Li/steel or Flibe/steel fusion blanket, one of critical issues is tritium permeation, as tritium solubility in breeders is quite low and tritium permeability through steel is high. One of promising solutions is to use coating as tritium permeation barrier (TPB) on the wall of metal duct.

Er_2O_3 coating has been studied as insulator for blanket. Also Er_2O_3 coating formed by arc-source PVD method was found to have low hydrogen permeability [1]. Therefore Er_2O_3 coating has potential to be both TPB and insulator for blanket. Sol-gel is a candidate method to form Er_2O_3 coating, which has advantages of high homogeneity and single composition for coating, controllable procedure and simple device for process. Especially sol-gel method has possibility to produce coating on the wall of component with complex shape. Here, the progress of Er_2O_3 coating fabricated by sol-gel method as potential TPB is reported.

Fig. 1 shows the elemental depth profile (by XPS with Ar-sputtering) of 316ss with sol-gel coating. The coating was produce by spin-coater in air at room temperature (RT), dried in air at 393K and baked in vacuum of ~1Pa by rotary pump at 973K. The sputtering rate was calibrated as ~14nm/min, thus the thickness of coating (enriched with erbium and oxygen) was ~0.3 μm.

Fig. 2 shows the phases of 316ss with sol-gel coating by XRD. The coatings were produce by spin-coater in air at RT, dried in air at 393K and baked in vacuum of ~1Pa or Ar-flow of 50ml/min at 973K. It showed that just an amorphous Er_2O_3 was formed during baking in vacuum of ~1Pa (a), however the good crystallization with Er_2O_3 (222) and (440) was achieved by baking in Ar-flow of 50ml/min (b). The other peaks were contributed from 316ss substrate. It indicated that a little of oxygen in baking atmosphere was beneficial to form crystalline coating.

Fig. 3 shows deuterium permeability measured by gas-driven permeation method of 316ss with Er_2O_3 sol-gel coating. To compare, the hydrogen permeability data of vanadium with Er_2O_3 arc-source PVD coating and that of some bare metals were referred [1]. Because hydrogen permeability through ceramic is much lower than that through metal, the apparent hydrogen (deuterium) permeability of ceramic coated metal is decided by that of coating. It showed that Er_2O_3 sol-gel coating had a comparable hydrogen permeability comparing with thicker crystalline Er_2O_3 coating (arc-source PVD) but higher. Presently, only the limited deuterium permeability data was achieved which was from a thinner amorphous Er_2O_3 coating (fig. 1 and fig. 2 (a)). It is expected that the lower deuterium permeability could be achieved from a thicker crystalline Er_2O_3 sol-gel coating (fig. 2(b)) in future.

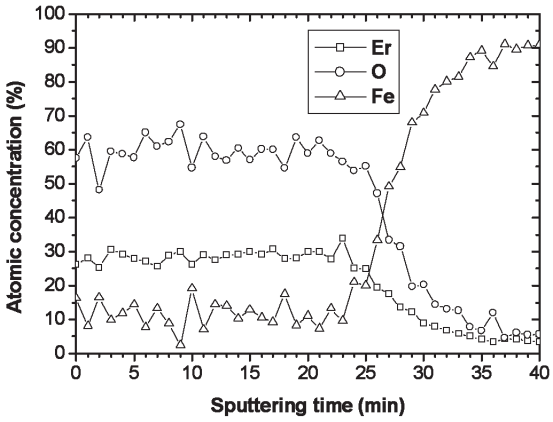

Fig.1 Elemental depth profile of coated 316ss by XPS with Ar-sputtering.

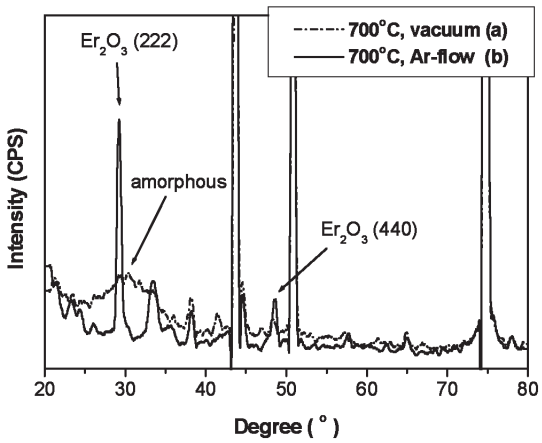

Fig.2 Phase of 316ss with sol-gel coating by XRD.

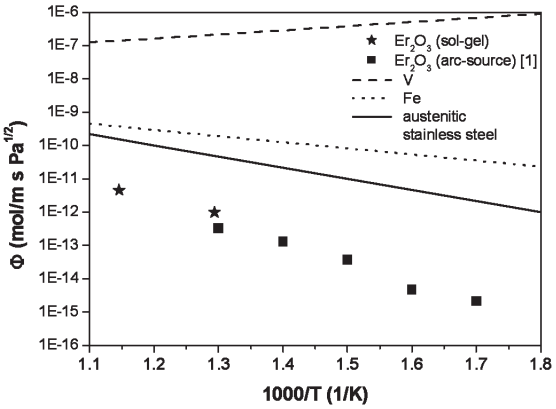

Fig.3 Deuterium (hydrogen) permeability through coated metal and bare metal.

Reference

1) Handa, T., Master Thesis, Univ. Tokyo, 2005.