§6. Development of Large Area Ceramic Coating by Dip-coating Method

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Liquid blanket concepts are highly-promising in future fusion reactors because of the economical advantage of a high temperature operation, simple structure, no irradiation damage nor no exhaustion in a tritium breeder etc. One of the critical issues involved in the Li blanket system is a magneto-hydrodynamics (MHD) pressure drop, which is induced in a liquid metal coolant flowing across strong magnetic fields. For the Flibe blanket system, a critical issue is a reduction of tritium permeation through the structural materials. For reduction of the MHD pressure drop and tritium permeation, fabrication of ceramic coatings on structural materials has been proposed and studied. Among the ceramic materials recently investigated, Er_2O_3 ceramics showed a superior compatibility with liquid Li of up to 800 °C, high electrical resistivity, low hydrogen permeability and is regarded as a promising candidate material for coatings in liquid blanket systems.

Fundamental properties of the ceramic coatings have been studied for high quality but small samples fabricated by RF sputtering, arc source plasma deposition etc. However, the development of fabrication techniques of large area coating is indispensable for an application in the fusion blankets. The MOD (metal organic decomposition) process is a simple liquid phase technique widely used to form a thin coating with spin coating, dip coating, draining or spraying methods. In this study, the MOD process with dip coating method has been selected for fabrication of large area ceramic coatings on complex shaped reactor components. Coatings of Er_2O_3 have been fabricated by the dip coating method and the microstructure and crystallinity have been examined.

The substrate was a SS430 plate with dimensions of 20 x 25 x 0.5 mm^3. Before dipping to the organic solvent containing Er, one side of the substrate was polished to a mirror surface and cleaned with the ultrasonic bath of acetone and ethanol. A thin liquid film was obtained by dipping the substrate into the organic solvent and withdrawing at a constant speed of 112 mm/min (Fig.1). After the dipping, the substrate was dried at 120 °C for 15 minutes in air. The procedures of dipping and drying were repeated 12 times. The dried organic film was heated up with the rate of 5 °C/min in a furnace and baked at 600 °C for 120 minutes in air.

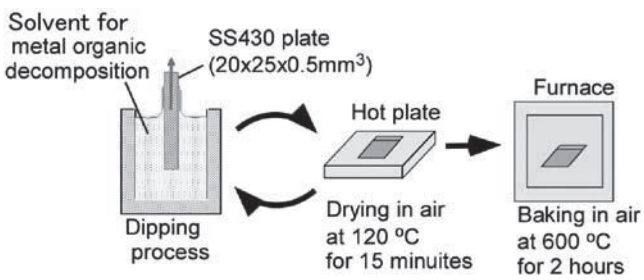

Fig.1 Fabrication Er_2O_3 coating by dip coating process

The cross section of the Er_2O_3 coating fabricated by the dip-coating method was observed with SEM (Fig. 2). A layer with the uniform thickness of about 0.6 μm was obtained on the substrate. The coating thickness is controllable by repeating the dipping process or adjusting withdrawal speed. Figure 3 shows the elemental depth profile of the Er_2O_3 coating obtained by XPS with Ar sputtering The atomic concentrations indicate that the organic solvent was completely removed by the heating process and compositions of erbium and oxygen are uniform in the surface layer. It was also found that the substrate was oxidized during baking in air and a oxidation layer lies below the Er_2O_3 coating. Figure 4 shows the XRD patterns of the Er_2O_3 coating. The peak positions, heights and widths were similar to those of Er_2O_3 sintered bulk and data on literature.

The present results indicate that the high quality large area Er_2O_3 coatings could be obtained by the present MOD process with dip coating method. Studies of the performances in electrical insulation and reduction of hydrogen permeation are in progress. A trial of coating fabrication on more complex shaped substrates, e.g. straight tubes, U-shaped tubes etc., are also planned in the future work.

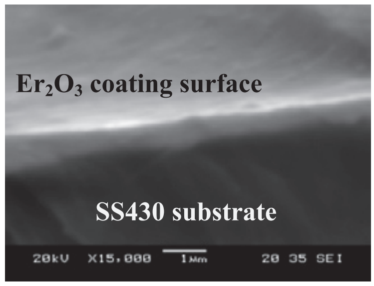

Fig.2 SEM image of coating cross section fabricated by dip-coating

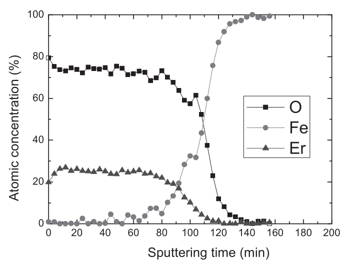

Fig. 3 Elemental depth profile of Er_2O_3 coating on SS430 substrate obtained by XPS with Ar sputtering

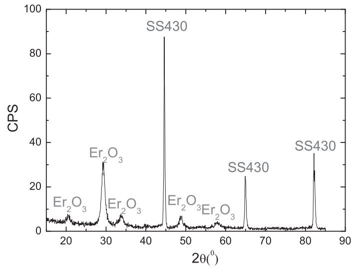

Fig.4 XRD pattern of Er_2O_3 coating on SS430 plate