§4. Construction of MOCVD Apparatus for the Large Area Er_2O_3 Insulator Coating

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Magneto-hydrodynamic (MHD) pressure drop is one of the key issues for advanced liquid metal breeding blanket systems. The electrical insulating coating on the blanket components such as duct and wall is an attractive concept for restraining of the MHD pressure drop. 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. However, PVD coating process was fixed to deposition direction, so this technology has limited capability in coating on complex surfaces expected in the blanket components. 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 of the advanced liquid metal breeder blanket application.

We have constructed MOCVD apparatus to demonstrate synthesis of Er_2O_3 oxide layer on the large surface area of metal and single Si substrate. The photograph of MOCVD apparatus is shown in fig. 1. The MOCVD apparatus consists of three main components; the metal organic supplying line with a vaporizer, a gold furnace type quartz tube reactor and an exhaust system. The metal organic complex was vaporized at 200 ºC in the vaporizer and introduced into the reactor by the argon carrier gas. All supplying lines were heated at 250 ºC by the ribbon heater to prevent the metal organic complex solidification. The vaporized complex reacted with oxygen gas via the other supplying line and the oxide coating layer was grown on the various substrates. In this study, the $Er(IBPM)_3$ (isobutyrylpivaloylmethane) complex, which is one of the β-diketone complexes was used as the Er source material. The features of this complex are to be wealthy in the oxidation and to vaporize at lower temperature compared with the other complex. The various plate-shaped metal substrates such as vanadium (V), Stainless steel (SUS) and Nickel (Ni) were placed into the reactor and Si single crystal substrate was also placed for comparison. We confirmed clearly that a green-colored coating layer was formed on the Si single crystal and metal substrates macroscopically.

Fig.1 The photograph of the MOCVD apparatus for the large area oxide coating in NIFS.

We tried to form the Er_2O_3 insulator coating on the large interior surface area of a commercial SUS pipe. However, Er_2O_3 coating was easy to remove from the interior surface of the SUS pipe. In order to improve the surface roughness, the honing SUS pipes of 600 mm long, whose interior surface was polished by the rotating hone grinding stone and the brush, was prepared. As the commercial SUS pipe, the average roughness (Ra) value of interior surface was obtained at about 2.0 μm. The Ra value of honing SUS pipe was about 0.62 μm. It was confirmed that the interior surface roughness of the commercial SUS pipe was higher than that of the honing pipe. The undulation of the interior surface was also improved by the honing deformation. In the case of the honing pipe, Er_2O_3 coating was not removed from the interior surface at all. This was caused by the reduced surface roughness by the honing deformation. The photograph of the interior surface of a part of the honing SUS pipe before and after coating process is shown in fig.2. We confirmed that the green-colored homogeneous thin coating was formed stably on the interior surface of the SUS pipe. These suggested that surface roughness was one of the effective factors to form oxide coating layer via MOCVD process. Using EDX analysis the coating was identified as Er-oxide, probably most Er_2O_3. The thickness of Er_2O_3 coating was about 800 nm and it was distributed homogeneously on the interior surface of SUS pipe.

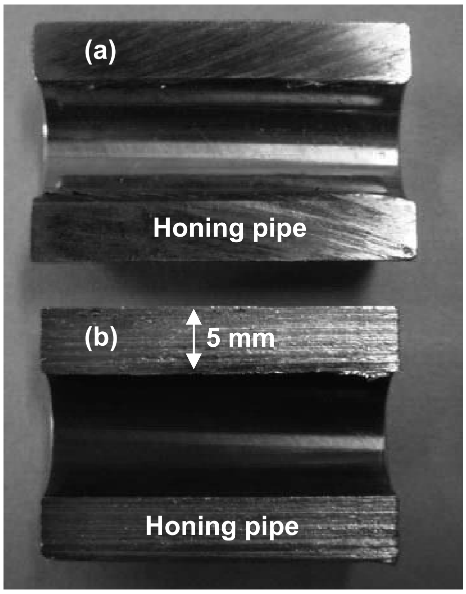

Fig.2 Typical photograph of the interior surface of the honing SUS pipe. (a) Before MOCVD coating, (b) After MOCVD coating