§4. Development of Er_2O_3 Insulator Coating through a MOCVD Process

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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 inner surface of complicated shaped duct tubing of the advanced liquid metal breeder blanket application.

We tried to demonstrate synthesis of Er_2O_3 oxide layer on the surface of V-4Cr-4Ti (NIFS-HEAT-II) substrate through the MOCVD process as the newly technology for the inner surface coating. The apparatus configuration is shown in Fig. 1. We confirmed clearly that a green-colored coating layer was formed on the Si single crystal and metal V alloy substrates macroscopically through the MOCVD process. The thermo analysis results of the two kinds of Er complex materials such as $Er(DPM)_3$ and $Er(IBPM)_3$ are shown in Fig.2. Tg-DTA measurement was carried out under flowing dry air. The melting point of the $Er(IBPM)_3$ complex was estimated to be about 150℃ from the endothermic peak of DTA curve. This value was lower than that of the $Er(DPM)_3$ complex. The crystallization temperature of $Er(IBPM)_3$ was also lower than that of the $Er(DPM)_3$ according to the exothermic peak. On the other hand, the remaining mass of the $Er(IBPM)_3$ complex above 300℃ was smaller than that for $Er(DPM)_3$ from the result of the Tg curve. The remaining materials after the Tg-DTA measurement were mostly Er_2O_3 powder, indicating that $Er(IBPM)_3$ complex is easy to be oxidized. These suggested that $Er(IBPM)_3$ was preferable material of the MOCVD process in the view points of the thermal pyrolysis and oxidation. The deposition temperature can be reduced with the use of the $Er(IBPM)_3$ as Er source material for the MOCVD process.

The Er deposition rate which was estimated from the ICP mass analysis is shown in fig.3. In the case of the $Er(DPM)_3$, Er deposition was confirmed at the substrate temperature above 500℃. In the case of the $Er(IBPM)_3$, Er deposition was confirmed at the substrate temperature of 400℃, suggesting that the process with $Er(IBPM)_3$ can form the Er_2O_3 coating layer at lower temperature than that with $Er(DPM)_3$ complex. Furthermore, the Er deposition rate of the $Er(IBPM)_3$ was increased four times compared with $Er(DPM)_3$ at 550℃. We found that the deposition quantity of was able to be increased by using the $Er(IBPM)_3$ at lower temperature.

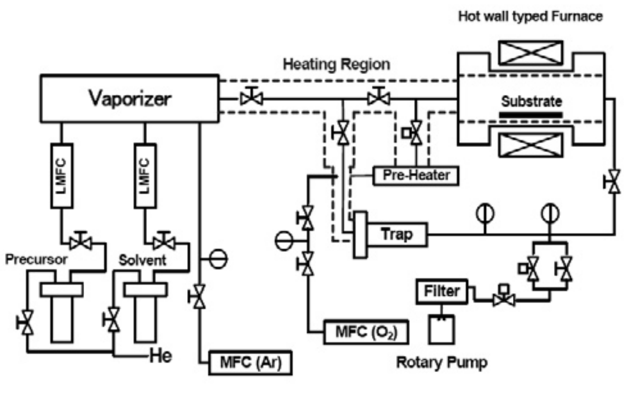

Fig.1 The apparatus configuration of the MOCVD process

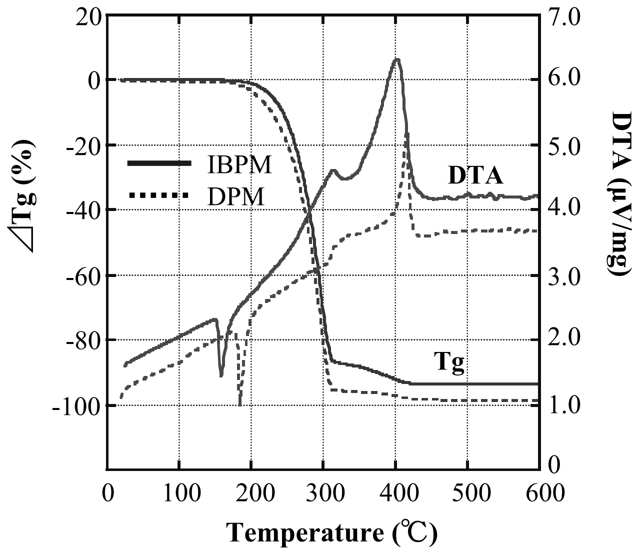

Fig.2 Thermo analysis of the Er complex materials in dry air using Tg-DTA

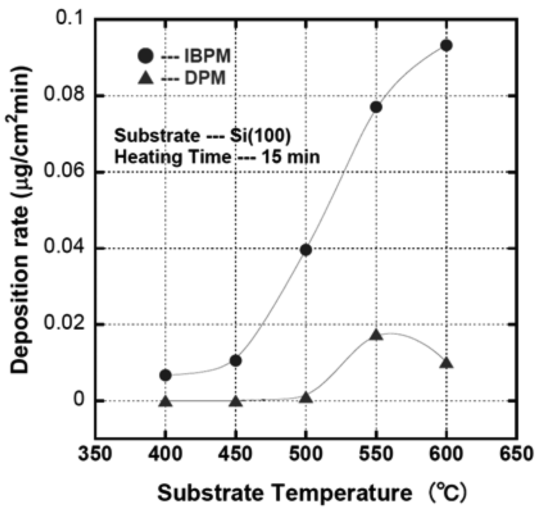

Fig.3 The relationship between deposition temperature and Er deposition rate. The deposition time is fixed at 15 min.