§4. Development of Er₂O₃ Insulator Coating through a MOCVD Process

Hishinuma, Y., Tanaka, T., Nagasaka, T., Muroga, T., Tanaka, T., Tasaki, Y. (Toshima MFG, Co., Ltd)

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 the MHD pressure drop. Erbium oxide (Er₂O₃) 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 Er₂O₃ bulk and Physical Vapor Deposition (PVD) thin film. Furthermore, Er₂O₃ 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 Er₂O₃ 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°C 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°C 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 Er₂O₃ 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°C. In the case of the Er(IBPM)₃, Er deposition was confirmed at the substrate temperature of 400°C, suggesting that the process with Er(IBPM)₃ can form the Er₂O₃ 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°C. 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.