# §5. Development of $Er_2O_3$ Insulator Coating through a MOCVD Process

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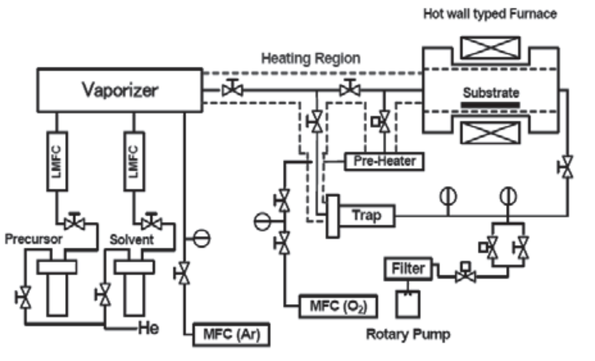
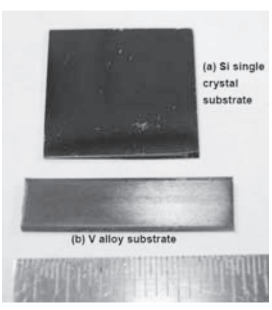
Magneto-hydrodynamic (MHD) pressure drop is one of the key issues for advanced liquid metal breeding blanket systems. The electrical insulating coating on the blanket components such as duct and wall is an attractive concept for restraining of the MHD pressure drop. Erbium oxide ($Er_2O_3$) was shown 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. MOCVD has a vapor phase epitaxy growth technique which is synthesized via vapor phase from metal organic complex.

At the first, 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. Two kinds of Er complex materials such as $Er(TMOD)_3$, $Er(DPM)_3$ and $Er(IBPM)_3$ were investigated and they used for the MOCVD process via solution vaporization and sublimation. The apparatus configuration and the typical photograph of $Er_2O_3$ coating on V and Si substrates are 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. It was clear that coating layers on the metal and Si substrate were almost homogeneous $Er_2O_3$ single phase. The typical SEM image of cross-sectional region in the coating layer/Si substrate is also shown in Fig.2. The flat and clean surface of coating layer was formed on the Si substrate and then coating layer will be grown for thickness direction by the epitaxial growth. And the thickness of coating layer was obtained to be about 600 nm. The differences in XRD patterns of coating layer via sublimation on the V alloy substrate in different substrate temperature are shown in Fig. 3. The diffraction peaks of $Er_2O_3$ phase was observed at the substrate temperature above 500℃ and these peaks were higher and sharper with elevated substrate temperature, and it suggested that the substrate temperature above 500℃ was necessary for the active epitaxial grain growth of $Er_2O_3$ phase.




| | Solution Vaporization | Sublimation |
|---|---|---|
| Substrate | V-4Cr-4Ti, Si single crystal (with Pt buffer) | |
| Flow rate (Complex) | 0.3 g/min | |
| Flow rate (Ar carrier gas) | 200 ml/min | |
| Flow rate ($O_2$ gas) | 200 ml/min | 300 ml/min |
| Vaporizer Temperature | 250 ℃ | |
| Substrate Temperature | 450 ℃ ~ 600 ℃ | |
| Reaction pressure | 20 Torr | 30 Torr |
| Reaction Time | 1 min ~ 180 min | |

Fig.1 The apparatus configuration and the typical photograph of $Er_2O_3$ coating on V and Si substrates

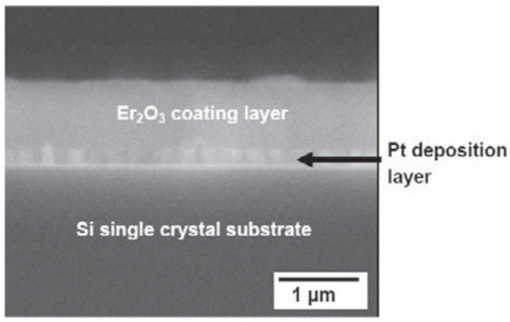



Fig.2 Typical SEM image of the cross-sectional region on the $Er_2O_3$ coating on Pt/Si substrates

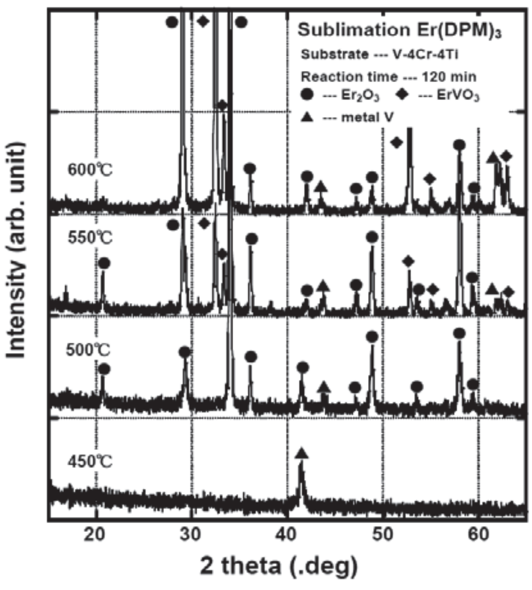



Fig.3 The comparisons between the XRD profiles on the V alloy substrate temperature condition of MOCVD process