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§1. Electrical Insulating Performances of MOD Er_2O_3 Ceramic Coating

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Development of ceramic coatings with high electrical insulating performances has been conducted for reduction of MHD pressure drop in li1uid metal cooled fusion blanket system.[1] As to a coating fabrication method, the metal organic decomposition (MOD) method has been selected as one of candidates in the development for applicability to large area coating fabrication on fusion blanket components and flexibility in coating techniques.[1] In fabrication of MOD coating, a thin layer of organic liquid containing metal such as Er is formed on a substrate by dip coating technique etc. The substrate is baked in the atmosphere containing oxygen to remove organic components of the liquid and obtain Er_2O_3. Oxide ceramic coating is obtained by baking at >550 °C and higher baking temperature improve the crystallinity. However, the maximum temperature in the baking process is limited to avoid property degradation of a substrate material, e.g. ~700 °C for low activation ferritic steel. Therefore, crystallinities of MOD ceramic coatings for a fusion blanket would be lower than those of sintered ceramic materials. Electrical insulating performances of MOD Er_2O_3 coatings have been examined in the present study.[2]

Schematic drawings of the electrical measurements on MOD Er_2O_3 coatings are shown in Fig. 1. Electrical conductivities of coating layers were measured by making Pt electrodes of 1.2 mm in diameter and ~200 nm in thickness on the surfaces (Fig. 1. (a)). Bias voltages were applied to metal substrate and conductivities were evaluated from magnitudes of currents through coating layers. The MOD coatings were fabricated on SiO_2 substrate covered with Pt layer and as-rolled stainless steel (SUS430) substrates. The thicknesses of the coating layers were 0.5 µm and 1.0 µm, respectively. Baking temperature was 600 °C for both the coatings. Breakdown voltages of a coating layer fabricated on a polished SUS430 plate were measured with W needle probe (Fig. 1. (b)). Thickness of the coating layer was 1.0 µm and baking temperature was 700 °C. To eliminate influence of pores observed in a coating layer, electrodes were not made on coating surfaces. Similar to the conductivity measurements, breakdown voltages were examined from the change in electrical currents through the coating layers.

Results of the conductivity measurements are shown in Fig. 2. Results of our previous measurements on Er_2O_3 sintered disc (20 mm dia. x 1 mm thick) and Er_2O_3 RF sputter coating (1.6 µm thick) on polished stainless steel are also plotted in the figure. The results indicate that the conductivity of the coating on a Pt covered SiO_2 substrate was larger than that of a sintered disc by two orders at room temperature. However, the magnitude of the conductivity is still significantly low. The reason for the higher conductivity compared with that of the sintered disc might be current paths through small pores and cracks in the coating layer. The conductivities of the coating on an as-rolled stainless steel were significantly higher compared with the sintered disc and other coatings. This is considered due to the rough coating surfaces formed on unpolished as-rolled substrate. Small openings might exist in the coating layer. While magnitudes of the conductivities were high at the low temperature region, the activation energy of the temperature dependence was small. Therefore, the presents results indicate that the MOD Er_2O_3 coatings would keep the conductivity of $<10^{-2}$ S/m at ~650 °C which is required for suppression of MHD pressure drop in Li/V-alloy blanket system.[3]

The result of the breakdown voltage measurement is shown in Fig. 3. Measured electrical currents increased for the bias voltages of 20-40V. Electric field strength in the coating layer is 20-40kV/mm. A breakdown voltage of > 25 V was also confirmed at 450 °C. According to a Li/V-alloy blanket design study, magnitude of potential difference applied to the insulating coating layer would be ~1V.[3] MOD Er_2O_3 coating layers could withstand the electrical environment in the blanket.

Results of two electrical measurements indicate that MOD Er_2O_3 coatings have preferable insulating properties for reduction of MHD pressure drop in the blanket, while the crystallinities were low due to the low baking temperatures. Studies on influence and suppression of cracks and pores in MOD coating layers are next essential issues to achieve required insulating performances in the blanket environment.

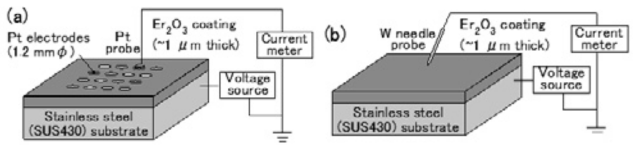

Fig. 1. Schematic drawings of (a) electrical conductivity measurement and (b) breakdown voltage measurement.

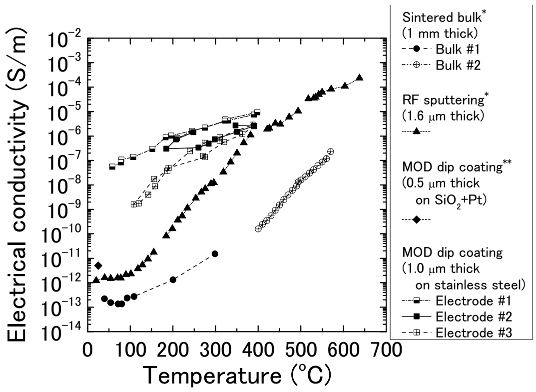

Fig. 2. Result of electrical conductivity measurement.

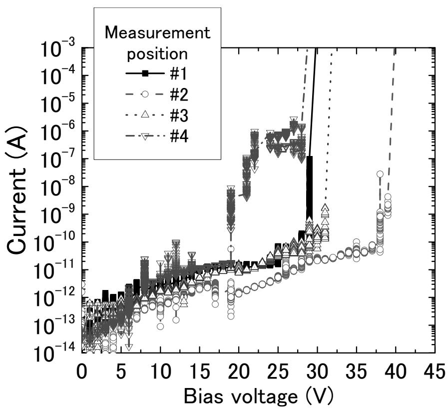

Fig. 3. Result of breakdown voltage measurement.

1) Zhang, D. et al.: J. Nucl. Mater. **417** (2011) 1249–1252.
2) Tanaka. T. et al. : Fusion Engineering and Design, in press.
3) Hashizume, H.: Fusion Engineering and Design 81 (2006) 1431-1438.