§3. Fabrication of MHD Coatings by RF Sputtering Method

Terai, T., Sawada, A. (Quantum Eng. and Systems Sci., Univ. of Tokyo),
Suzuki, A., Muroga, T.

For a D-T fusion reactor system, a blanket is a necessary component, where tritium is produced from lithium, heat is generated, and radiation is shielded. In fusion reactor designs, the liquid blanket concepts are the promising ones in order to realize a DEMO (demonstration) fusion reactor system of high power density, because it has advantages such as continuous replacement of breeders for reprocessing, no radiation damage for breeders, larger TBR (tritium breeding ratio) and better thermal transfer than solid blankets. Liquid lithium is considered to be one of the most attractive candidates as a liquid breeding material. In the self-cooled liquid lithium blanket system, the liquid lithium can be used not only as the tritium breeding material, but also a coolant for the blanket system. Moreover, sufficient TBR could be obtained without neutron multipliers, such as Be, due to high lithium density in the blanket. Thus, the liquid lithium blanket concept has a possibility to propose a blanket with the simplest structure.

A crucial issue for the self-cooled liquid lithium blanket concept, so-called magnetrohydrodynamics (MHD) pressure drop, however, had been pointed-out that a large pumping power may be required due to the pressure drop in the conductive coolant induced by MHD effect with the magnet field. In order to solve this issue, insulating ceramic coatings on the inner surface of the tubing for the liquid lithium had been proposed. The coating should have high electrical resistivity, high corrosion resistance, and high thermomechanical integrity. Aluminum nitride (AlN), yttrium oxide (Y_2O_3), erbium oxide (Er_2O_3) have been chosen for the coating candidate materials by the investigations on compatibility with liquid metals. Some studies on the application of these candidate materials to the MHD coating shows fabrication of the coating with sufficient abilities is an important investigation point.

In this study, the coatings of AlN, Y_2O_3 and Er_2O_3 were fabricated by the RF sputtering method. The RF sputtering method is one of PVD methods to realize a high density and high crystalline coating with a high deposition rate.

The preparation parameters of coatings by the RF sputtering method are shown bellow:

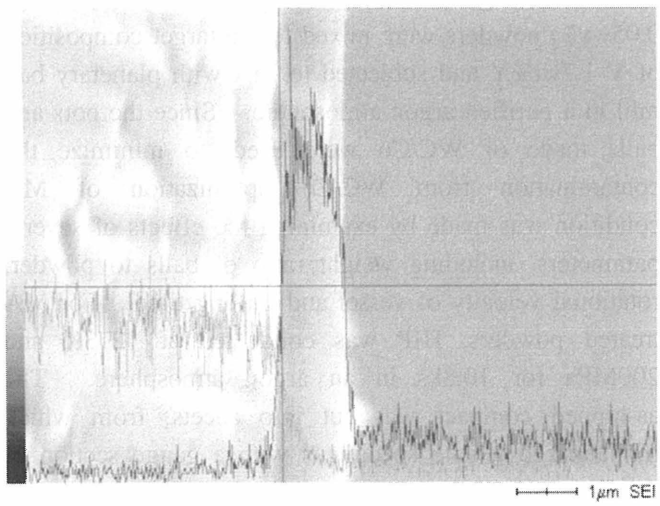
(1) target material (60mm in diameter and 5mm in thickness) : AlN (99 % in purity), Y_2O_3 (99.9 %), or Er_2O_3 (99.9 %)
(2) substrate material: SUS430.
(3) gas composition: Ar or N_2 for AlN, Ar for Y_2O_3 and Er_2O_3.
(4) gas pressure: 0.6-0.8Pa.
(5) Substrate temperature: 573K.
(6) Distance between Target and substrate: 40mm.
(7) Input RF power: 100-300W.
(8) Sputtering time: 150-180 min.

The properties of the coatings were investigated by (1) thickness, (2) XRD pattern, (3) SEM-EDS analysis of the cross section, and (4) electrical resistivity.

The AlN coatings fabricated by the RF sputtering method were transparent with interference fringe. Figure shows SEM-EDS analysis of the cross section of the coating. The existences of Al and Fe are indicated in a dark line and a grey line respectively, which shows the intensity of the main EDS peak of each atom along the horizontal line in the figure. The electrical resistivity of the AlN coatings were about $10^9\ \Omega m$ at room temperature. The thickness of the coatings was increased with increasing the input RF power. On the other hand, the resistivity of the coatings did not depend on the RF power.

The Y_2O_3 and Er_2O_3 coatings fabricated were also transparent with interference fringe. The electrical resistivity of Y_2O_3 and Er_2O_3 coatings were about $10^9\ \Omega m$ at room temperature. The thickness of the Y_2O_3 coatings was decreased with increasing the input RF power and the resistivity of the coatings did not depend on the RF power.

The electrical resistivity required for the MHD coating at the actual blanket is considered to be 10^2-$10^4\ \Omega m$ under fusion blanket conditions, such as high temperature, irradiation, and etc. The coatings fabricated by the RF sputtering method have relatively high electrical resistivity. However, the electrical resistivity of the coatings should be developed, because these are still 3-8 orders in magnitude smaller than those of the bulk specimens.



SEM-EDS analysis of a cross section of AlN coating