§4. Fabrication and Properties of Ceramic Coatings for CTR Liquid Blanket

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In fusion reactor designs, liquid blanket concept is a promising one to realize a DEMO reactor of high power density, because it has advantages such as continuous replacement of breeders for reprocessing, no radiation damage for breeders, larger TBR, simpler blanket structure and better thermal transfer than solid blanket concept. On the other hand, it has several critical issues; (1) a large MHD pressure drop requires large pump power, in particular in self-cooled designs, (2) liquid breeders have low compatibility with structural materials, and (3) a large amount of tritium may leak to environment due to permeation through tubing walls, particularly in case of Li17-Pb83 blanket concepts.

In order to solve these critical issues, a ceramic coating on the surface of tubing materials is proposed. The coating should have high electrical resistivity, high corrosion resistance, low tritium permeability and high thermomechanical integrity: Of course, all these properties are not necessarily required at the same time, and they depend on blanket concept. Obviously, fabrication of the coatings is also a very important point. Alumina (Al_2O_3) and aluminum nitride (AlN) have been already proposed as coating materials for self-cooled Li17-Pb83 and Li blankets, respectively, and some studies have been carried out on preparation, tritium permeability and compatibility with liquid metals.

In this study, Al_2O_3 and AlN coatings were newly prepared by sputtering method. The dependence of some basic properties such as structure and electrical resistance on several experimental parameters was investigated.

The parameters in the procedure are the followings:

1) Material of target: Al_2O_3 (purity 99.99%) and AlN (purity 99%),
2) Material of substrate: SUS430 (ferritic steel; Fe-82%, Cr-16%, Mn-1% and others- 1%),
3) Composition of environmental gas: pure Ar, Ar + 5% N_2 and pure N_2,
4) Working gas pressure: 0.17-0.55 Pa,
5) Substrate temperature: 723 K,
6) Target-substrate distance: 40 mm,
7) Input electric power: 100-370 W, and
8) Sputtering time: 1-5 hr.

In case of Al_2O_3 coating, the thickness change of prepared coatings was investigated with the following three parameters being changed; 1) input electric power, 2) sputtering time, and 3) working gas pressure of pure Ar. In addition, the prepared coating was investigated on the properties such as 1) average thickness calculated from the weight change of the thin plate, 2) thickness distribution with a thickness meter, 3) crystallographic structure by XRD and 4) electrical resistance by conventional two-probe method.

In case of AlN coating, on the other hand, the change of the average thickness of the prepared coating was investigated with input power being changed. The properties of the prepared coating with different composition of the working gas (100% Ar, 95% Ar + 5% N_2 and 100% N_2) were investigated as well.

Several micrometers thick Al_2O_3 and AlN coatings were successfully prepared in several hours. The Al_2O_3 coating prepared was amorphous, but it had high density comparable with the theoretical value with high electrical resistance at room temperature (more than $10^{11}\ \Omega$). On the other hand, the resistance of the AlN coating was dependent on the concentration of N_2 in the working gas. In case of 100% N_2 gas used, AlN coating of very high electrical resistance was successfully prepared.

As for liquid blanket ceramic coating, more data are required on the properties including mechanical properties, compatibility with liquid breeders, tritium permeability, etc. In the next stage of our study, some of them are planed for investigation using the coating specimens prepared in this study.