Evaluation of the Lithium Compatibility of New Ceramic Candidates for Insulating Coatings

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Electrically insulating coatings on the first wall of magnetic confinement reactors are essential to reduce the magnetohydrodynamic (MHD) force that would otherwise inhibit or distort the flow of the lithium coolant and result in severe pumping losses. In some liquid-metal fusion concepts, MHD coatings would be exposed to temperatures in excess of 700°C. Because molten lithium will dissolve most oxides even at much lower temperatures, there are only a limited number of compositions that can be considered for use as such coatings. In order to evaluate lithium compatibility in this context, specimens of bulk ceramics representing candidate MHD coatings were used for preliminary capsule-test evaluations of lithium compatibility from 500 – 800°C. Those compositions showing the most promising results under these conditions will then be developed as coatings and further evaluation, including testing in flowing lithium and a temperature gradient would be pursued.

Bulk ceramic specimens were submerged in molten lithium held in sealed vanadium or molybdenum capsules for 1000 h. After exposure, distillation was used to remove residual lithium from the specimen. The amount of dissolution was evaluated by mass changes and microstructural analysis, and any reaction products were characterized. Such capsule testing of single-crystal CaO and high-purity AlN (0.9wt%O, 0.04%Y) indicated very high dissolution rates after 1000h at 700°C and higher temperatures. The dissolution rates were equivalent to specimen surface recession of more than 10μm. These experimental findings for AlN and CaO were consistent with results from thermodynamic modeling which considered the solvation enthalpies of these components in lithium as a function of temperature. Thus, it is unlikely that these materials could be used at such high temperatures. Subsequently, capsule tests are being used to evaluate compositions based on Y_2O_3, Sc_2O_3, Er_2O_3, $YScO_3$ and a higher purity AlN for application as MHD coatings in molten lithium. All of these are good electrical insulators and are more thermodynamically stable than Li_2O. Results will be presented in terms of the amount of dissolution observed at 600°, 700°, and 800°C and reaction product analyses (where applicable). As before, comparison to predictions from equilibrium solubility calculations will be made when appropriate thermodynamic data are available.
Add – Ca, O, N doping

Research sponsored by the Fusion Materials Program, Office of Science, U. S. Department of Energy (DOE), under contract DE-AC05-00OR22725 with UT-Battelle, LLC.