Interface reactions, irradiation response, and mechanical properties of FeCrAl-coated Zircaloy-4

Miltiadis Kennas[1], Hyosim Kim[1], Jonathan G. Gigax[1,2], Benjamin R. Maier[3], Hwasung Yeom[3], Greg O. Johnson[3], Kumar Sridharan[3], and Lin Shao[1]

[1] Department of Nuclear Engineering, Texas A&M University, College Station, Texas 77843
[2] Los Alamos National Lab, Los Alamos, New Mexico 87545
[3] Department of Materials Science and Engineering, University of Wisconsin, Madison, Wisconsin 53706

FeCrAl has been proposed as a coating layer to enhance the accident tolerance of Zircaloy-4 fuel cladding. In this study, we systematically study the diffusion kinetics and interface compound formation of the spray-coated FeCrAl and Zircaloy-4 substrate. After vacuum annealing at 923 K, 963 K and 998 K for various time periods, a mixture of Zr_2Fe/ZrC phase and Zr_3Fe phase form at the interface. The formation energies of these two phases are found to be 68 kJ/mol and 46 kJ/mol for Zr_2Fe and Zr_3Fe, respectively.

Bending tests of cantilevers prepared by a focused ion beam technique showed good interface bonding between the coating layer and the substrate. Nanoindentation and micropillar compression tests on site-selective regions of cross-sections of polished samples show different mechanical responses of each phase. The substrate exhibited the lowest hardness and most ductile deformation under compression, and interfacial Zr_2Fe and Zr_3Fe possessed the highest hardness and greatest brittle deformation. After cross-sectional polishing, the interface zones were exposed to 3.5 MeV Fe^{+2} irradiation. The study is important to evaluate performance limits of such coating structures under harsh environments. especially since some studies show that interface phases often can become amorphous under irradiation.

Presenting author: Miltiadas Kennas, mdk1@tamu.edu