# Cladding Development for Current and Advanced Reactor Applications: A Comparison of Thin-walled Tubes for Three Variants of Oxide Dispersion Strengthened Alloys

Caleb P. Massey[a], David T. Hoelzer[a], Sebastien N. Dryepondt[a], Philip D. Edmondson[a], Stuart A. Maloy[b], Maxim N. Gussev[a], Anoop Kini[c], Baptiste Gault[c], Kurt A. Terrani[a], Steven J. Zinkle[a,d]

[a] Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
[b] Los Alamos National Laboratory, Los Alamos, NM 87545
[c] Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, Germany
[d] University of Tennessee, Knoxville, TN 37996, USA

Oxide dispersion strengthened (ODS) alloys are under development as cladding concepts for current and advanced reactor concepts due to their beneficial high temperature mechanical properties and irradiation resistance in extreme environments. Although much research has focused on the evaluation of this alloy class in the as-consolidated form, a major obstacle to the implementation of ODS alloys as cladding is the difficulty associated with forming these alloys into thin-walled tubes due to their high strength and limited ductility. This work presents microstructural and mechanical property evaluations on three advanced Fe-based ODS alloys after fabrication into thin-walled tubes: (1) CrAZY (Fe-10Cr-6.1Al-0.3Zr+0.3$Y_2O_3$), (2) OFRAC (Fe-12Cr-0.3Ti-1.0Mo-0.3Nb+0.3$Y_2O_3$, and (3) 14YWT (Fe-14Cr-0.4Ti-3.0W+0.3$Y_2O_3$). Depending on the alloy thermomechanical processing route, alloy composition and thin wall tube fabrication conditions, vastly different nanoprecipitate dispersions were noted in all three alloys, measured using atom probe tomography. Precipitates in the ODS FeCr OFRAC tube exhibit the highest number density, while precipitates in the ODS FeCr 14YWT tube and the ODS FeCrAl CrAZY tube appear coarsened due to differences in fabricating thin wall tubes of these alloys. Scanning electron microscopy coupled with electron backscatter diffraction results also illustrate differences in grain size and texture between the three thin-walled tubes, which results in significant differences in orientation-dependent tensile properties between each alloy. Using calculated grain sizes and nanoprecipitate characteristics in all three alloys, the sink-strength of each alloy is calculated and evaluated in the context of projected irradiation resistance in advanced reactor temperature/dose operating regimes. The results presented in this work provide the framework for future thin-walled tube scale-up efforts currently underway for advanced ODS cladding initiatives.