Effect of Irradiation Temperature and Alloy Composition on Microstructural Evolution of Wrought FeCrAl Alloys after Low-Dose Neutron Irradiation

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FeCrAl alloys have emerged as prime candidate materials for accident tolerant fuel (ATF) cladding in light water reactors (LWRs) due to their beneficial mechanical properties and oxidation resistance in comparison to conventional Zr-based cladding. As such, much research has recently focused on evaluating the irradiation response of this class of alloys in LWR-relevant temperature and irradiation dose regimes. Previous research has focused on the effects of Cr composition on dislocation loop and Cr-rich α'-precipitation in this class of alloys, and it has been previously found, as in FeCr binary alloys, the Cr content in FeCrAl heavily influences α'-precipitate characteristics in these alloys. Consequently, newly fabricated FeCrAl alloys have been developed that limit alloy Cr concentrations to those in the range of 10-13 wt.% Cr. However, questions still remain as to the influence of Al content on radiation-enhanced precipitation phenomena and dislocation loop formation in these low-Cr FeCrAl alloys. To assist in qualifying these alloys for use as ATF cladding, a comprehensive investigation was undertaken to evaluate the effect of both irradiation temperature and Al-content on the irradiation response of newly developed FeCrAl alloys after low-dose neutron irradiation. FeCrAl alloys with composition Fe-(10-13)Cr-(5-7)Al in wt.% were irradiated at temperatures ranging from 215-557°C to ~1.8 dpa at the High Flux Isotope Reactor at Oak Ridge National Laboratory. Using scanning/transmission electron microscopy methods, dislocation loops with Burgers vector of a/2<111> and a<100> were detected and quantified for each specimen. Using atom probe tomography, Cr-rich α'-precipitate dispersions and compositions were investigated as a function of temperature and alloy composition. Consistent with previous research on α'-precipitation in FeCrAl alloys, the Cr concentration in these precipitates is lower than that expected in binary FeCr alloys. In addition, as Al-content is increased, both the composition and the dispersion characteristics of α'-precipitates shifts due to the destabilization of the α'-phase due to Al partitioning to the Cr-rich precipitates.