Mechanical Properties & Dislocation Dynamics in Irradiated FeCrAl using *In Situ* TEM Tensile Tests

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Iron chromium aluminum (FeCrAl) alloys are proposed to replace existing Zr alloy nuclear fuel claddings currently used in light water reactors, as part of an accident tolerant fuel (ATF) cladding concept. In order to commercially deploy FeCrAl ATF claddings, these materials must be tested to ensure that they can maintain their structural and mechanical integrity in the environments to which they are subjected. Conventional (i.e. ASTM standard) mechanical testing on neutron irradiated materials is expensive, time consuming, and requires unreasonable test reactor volumes. Ion irradiation is an attractive alternative to neutron irradiation due to its lower cost and higher throughput. But ions only penetrate a shallow surface layer on the order of a few hundred nanometers to a few micrometers, precluding standard mechanical testing. But recent advancements in *in situ* transmission electron microscopy (TEM) mechanical testing enable this shallow surface layer to be tested using micro-sized “dog bone” tensile specimens extracted from the irradiation damage region.

In this work, we utilize a coupled experimental-modeling effort to understand deformation mechanisms in FeCrAl alloys. Work focuses on two model FeCrAl alloys, C35M (nominally Fe-13Cr-5Al-2Mo) and C37M (nominally Fe-13Cr-7Al-2Mo), irradiated with Fe^{2+} ions to 7 displacements per atom (dpa) at 350°C. TEM *in situ* tensile bars are tested over a range of grain orientations. Electron backscatter diffraction (EBSD) is used to identify specific grains for site-specific tensile bar extraction using dual-beam scanning electron microscopy (SEM) with focused ion beam (FIB). Extracted tensile bars are attached to a push-to-pull fixture, then shaped to final dimensions. TEM *in situ* tensile testing allows the observation of dislocation slip mechanisms and dislocation-microstructure interactions in real time, while simultaneously collecting quantitative stress-strain data. Results are used to validate dislocation dynamics models in the FeCrAl system.