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Advancing the technical readiness of FeCrAl alloys and ODS steels under extreme conditions for fast reactor fuel cladding

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ABSTRACT:

A key technology gap for advanced high-performance fuel applications is the current unavailability of materials that can withstand extremely high doses without significant degradation of cladding performance. Advanced alloys, such as FeCrAl and ODS steels, hold tremendous potential. But for these materials, irradiation data at very high doses (beyond 50 dpa and up to 400 dpa) and elevated temperatures (up to 700°C) are unavailable. This, combined with the limited understanding of the degradation of microstructure and mechanical properties, needs to be understood before engineering concerns are considered.

The proposed project aims at advancing the technical readiness of two candidate alloys – FeCrAl and ODS-14YWT – for fast reactor fuel cladding. The project team will perform several closely-knit tasks to probe the mechanical behavior of ion irradiated alloys at high temperatures and develop a correlation to the attendant microstructural changes. Ion irradiation experiments (up to 400 dpa) will generate a database on microstructure evolution and material degradation, with irradiation temperature and high dose as key variables. Separate gas implantation effects will be probed to investigate the effects of He concentration at high irradiation doses. We will use a custom-built in situ miniature test facility to assess the mechanical behavior of the irradiated alloys under different loading conditions. Detailed examination with electron microscopy will probe the relevant microstructural mechanisms that control the mechanical behavior of the ion irradiated samples. Finally, mesoscale simulations will quantify the dynamic evolution of the microstructure under different loading and thermodynamic conditions .