Development of a Rapid Chemical Assessment Capability for In-Situ TEM Ion Irradiations

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ABSTRACT:

Over the past several decades, it has been discovered that the inclusion of a high number of internal interfaces can increase a material system's radiation tolerance, strength, and creep tolerance. A common method to include these interfaces is through the addition of nanophases, such as nanometric oxide clusters. These highly tailored microstructures will evolve dynamically under irradiation, where they can remain stable or unstable depending on a range of irradiation and material property variables. In-situ transmission electron microscopy (TEM) ion irradiations are advantageous to observe these dynamic responses, but the low diffraction contrast of many of these features and interfaces means imaging such evolution is difficult, if not impossible using the current domestic in-situ TEM ion irradiation facilities. This work seeks equipment to overcome this issue with dynamic observations by establishing a rapid chemical assessment capability for in-situ TEM ion irradiations at University of Michigan's Michigan Ion Beam Laboratory. Specifically, a Gatan Imaging Filter (GIF) will be coupled to a ThermoFisher Tecnai TF30 capable of observing radiation damage events from a single or dual beam irradiation source. The GIF will enable completion of energy filtered TEM (EFTEM) imaging which provides chemical signature mapping capable of detecting and observing the complex nanofeatures in today's complex nuclear alloys. Additional workflows will also be enabled including the determination of the local distribution of transmutation gasses (e.g. helium and hydrogen) either during in-situ or ex-situ characterization efforts. The result is a capability that enables new insights into the microstructural evolution of complex material systems for advanced nuclear reactor applications. Establishment of this novel capability extends beyond users at the University of Michigan. The in-situ TEM ion irradiation facility is open to external user access via the Nuclear Science User Facilities (NSUF). The resulting increase in capability at MIBL will thus serve all nuclear energy supporting universities, national laboratories, and industry.