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A Dual Ion Beam Interface to a TEM for *In Situ* Study of Microstructure Evolution under Irradiation and Implantation

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ABSTRACT:

Radiation damage of core component reactor materials is a very important issue for the safe operation of nuclear power reactors as well as for the long-term isolation of radionuclides in nuclear waste management. Due to the high cost, long experimental turn over time, and the radioactivity of the neutron irradiated samples for the in-reactor irradiation, ion beam irradiation has been extensively used at several major laboratories in the world, including the Michigan Ion Beam Laboratory (MIBL*) at the University of Michigan to emulate the radiation damage induced by neutrons in the core components of nuclear power reactors. In addition, ion beams have also been used to simulate the alpha decay damage suffered by materials used in nuclear waste storage due to self-decay of the constituent radionuclides.

University of Michigan has one of the leading nuclear engineering departments in the nation that has been supporting the mission of DOE NS&E programs for a long period of time. By virtue of the 2013 IRP award on “High Fidelity Ion Beam Simulation of High Dose Neutron Irradiation” to the University of Michigan and its partners, MIBL was expanded to include the capability to conduct dual and triple beam irradiations. This capability is unique in the U.S. and is only achievable in two other facilities in the world. What is needed to complete the full range of capabilities is in-situ irradiation with dual ion beams in a transmission electron microscope (TEM) for conducting *in situ* observation of microstructure evolution. *In situ* observation of radiation damage in the TEM provides the capability to capture the temporal evolution of damage and at very low doses that are difficult to achieve in bulk irradiations to low doses. These data are critical in exposing the early evolution of defect clusters and for benchmarking microstructural evolution models in the early stages of damage development. A new 300kV TEM has just been ordered with support from university funds and alumni donation, and all that remains is the coupling of the TEM to the accelerators via two beam lines. Completion of this task will provide unprecedented capability to greatly accelerate the development of materials for reactor systems.

The objective of this project is to assemble and interface two ion beam lines to the new 300kV TEM to provide unprecedented capability for conducting *in-situ* analysis of microstructural evolution of materials under simultaneous irradiation and implantation.

*MIBL is a charter partner NSUF laboratory and hosts several NSUF projects each year. As of 2014, MIBL was the most utilized of all NSUF partner laboratories.