Advanced 3D Characterization and Reconstruction of Reactor Materials

PI: Melissa Teague- Idaho National Laboratory

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Collaborators: Michael Tonks- Idaho National Laboratory
Bradley Fromm, David Field- Washington State University
Kumar Sridharan, Wendy Crone- University of Wisconsin, Madison

ABSTRACT:

A coordinated effort to link advanced materials characterization methods and computational modeling approaches is critical to future success for understanding and predicting the behavior of reactor materials that operate at extreme conditions. The difficulty and expense of working with nuclear materials have inhibited the use of modern characterization techniques on this class of materials. Likewise, mesoscale simulation efforts have been impeded due to insufficient experimental data necessary for initialization and validation of the computer models. The objective of this proposed research is to develop a critical line of inquiry that integrates advanced materials characterization techniques developed for reactor materials with state-of-the-art mesoscale modeling and simulation tools.

For this project, we propose realistic steps to address current characterization limitations and to enhance the advanced characterization and reconstruction capabilities recently developed by the Lead PI in order to allow for efficient characterization of reactor microstructures and their reconstruction within MARMOT. This 3-year project will consist of three key objectives that will push the limits of present technology, including:

1) Explore new sample preparation techniques for reactor materials using broad beam ion-etching methods to decrease sample preparation time, improve scan quality, increase scan size, and reduce radiation exposure/waste (Please note that the ion-etching system is already in place at the Laboratory and approved for radiological work).

2) Implement an advanced characterization technique known as high-resolution EBSD (HR-EBSD) to enable estimation of critical material properties like dislocation density and residual strain from reactor materials.

3) Develop necessary post-processing tools and procedures to utilize the HR-EBSD data obtained in Objective 2 for microstructure reconstruction into MARMOT and perform model validation based on the HR-EBSD data.