Microstructure, Thermal, and Mechanical Properties Relationships in U and UZr Alloys

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ABSTRACT:

Uranium-zirconium (UZr) alloys are candidate fuel systems for transmutation based reactors that can be used to burn long-lived minor actinides and fission products in fast spectrum reactors. Metallic fuels have also been gaining more recent attention for applications as accident tolerant fuels, as well as for use in small modular reactors. These metallic fuels have a number of advantages such as a high melting point, high thermal conductivity, operation at lower temperatures, higher fuel density, and ease of fabrication and reprocessing. Albeit metallic fuels have been studied for over five decades, the majority of the historical research on these systems has focused on performance based parameters, typically resulting in high burn-up data. Moreover, there has been a lack of microstructural, thermal, and mechanical assessment of fuels prior to and following their irradiation. Consequently, the connection between the post-irradiated fuels and the pre-irradiated fuels seldom existed. As advanced experimental and modeling techniques have been recently developed, these new capabilities and tools can now be utilized to better understand the microstructure-properties connections more effectively than in the past. This research will focus on a **"science-based" approach to capture the connections between U and UZr alloys' 3D microstructure, thermal properties, and mechanical properties through closely coordinated experiments and modeling efforts from the unirradiated to the irradiated fuels**. This proposed research will use the state-of-the-art, three-dimensional (3D), synchrotron-based characterization techniques, novel techniques that couple thermal and mechanical properties, existing experimental facilities, and complementary multiscale modeling implemented within the MOOSE-BISON-MARMOT framework to evaluate microstructure-properties relationships (both thermal and mechanical). Ultimately, this research will dramatically improve the existing fuel performance codes by providing requisite links between 3D microstructure and properties, where little data currently exists.