Challenges and opportunities of high density nuclear fuel use in light water reactors

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High uranium density fuels are currently being considered for drop in replacement in the nuclear reactor fleet. This class of fuels, such as UN and U_3Si_2, provides higher thermal conductivity and improved plant economics relative to native UO_2, while also overcoming the neutronic penalties of accident tolerant based alloys. Recent investigations have shown pulverization of high uranium density fuels under leaker or high temperature oxidative scenarios, which unless mitigated, will challenge integration of these fuels in light water reactors. Many of the fundamental mechanisms underlying the oxidation behavior of these unique class of fuels has not been properly investigated in the literature to date and has been a focus of research to understand in order to mitigate or delay oxidation under leaker scenarios. To this end, this work investigates the fundamental corrosion mechanisms in both steam and pressurized high temperature water to elucidate the governing mechanisms in simulated PWR environments. Application of inert coatings on U_3Si_2 using both plasma spray deposition as well as electroless depositions will be discussed as a potential method to mitigate washout in these fuels with steam oxidation and microstructural evaluations. Coatings that are roughly 15 to 100 μm thick are evaluated with high temperature steam oxidation experiments. Stability of the films on the pellets is also examined in inert atmospheres to elevated temperatures to anticipated operating reactor conditions for U_3Si_2. Discussion will assess the practical application of coatings in a commercial setting as well as evaluating this as a method to minimizing or preventing oxidation in this class of nuclear fuels.