Advanced post-irradiation examination of accelerated burnup Cr-doped UO_2

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ABSTRACT:

This project aims to uncover several outstanding questions in mechanistic understanding of oxide fuel behavior by performing advanced microscopy characterization of fuels irradiated under accelerated burnup conditions. The first goal is to *characterize intragranular fission gas bubbles and dislocation*s to uncover mechanisms of fission gas retention in chromium-doped uranium dioxide (Cr-UO_2). The second goal is to investigate the impact of *accelerated irradiation on microstructure evolution* in UO_2, specifically on the early stages of grain restructuring leading to formation of the high burnup structure (HBS). Experimental data collected under this program containing high resolution electron microscopy images will enable a more direct validation of mechanistic models for fission gas behavior and grain restructuring.

Fuel vendors are actively seeking ways to extend the burnup of nuclear fuel. Understanding fission gas retention and restructuring in the fuel at high burnup are critical steps in achieving this goal. The advantage of chromium (Cr) dopants to uranium dioxide (UO_2) has been recognized by the nuclear community, however the interplay between enhanced diffusion of fission products and enlarged grain size is not yet well understood. On one hand, larger grain size offers an improved fission gas retention under a steady state operation, on the other hand, it is not clear if the enhanced atomic diffusion leads to a larger fractional fission gas release under transient conditions. Independently, the mechanical integrity of the fuel specifically in the high-burnup rim structure formed at the periphery of the fuel has been a source for a concern as this may lead to fuel dispersal in case of cladding failure. The role of restructuring in the central dark region and over-pressurized intragranular fission gas bubbles on fuel integrity are emerging areas in fuel performance and have been a subject of a recent studies. Impact of Cr-doping on fuel restructuring is unknown.

Over the past years, DOE Advanced Fuel campaign (AFC) has supported post irradiation of commercial fuels as well accelerated irradiation tests using MiniFuel vehicles with different fuel materials, including UN kernels and enhanced UO_2 (Cr-doped, RB targets). This NSUF proposal will perform additional electron microscopy characterization of the recent Cr-doped UO_2 samples irradiated using MiniFuel vehicles in High Flux Isotope Reactor at Oak Ridge National Laboratory.