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Multiscale Modeling and Experiments for Investigating High Burnup LWR Fuel Rod Behavior Under Normal and Transient Conditions

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Program: Phase II Continuation

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ABSTRACT:

The current project targets a mechanistic understanding of the Cr-doped UO_2 fuel performance at high burn-up (HBU) under both normal and accident-like conditions. We will employ multiscale models to conduct physics-based simulations of the performance of Cr-doped UO_2 at relevant operating and transient conditions via extending our existing models of undoped fuels [6, 15-20]. We will use rate theory/cluster dynamics models to evaluate irradiation-enhanced U and Xe diffusivities and their effect on creep and fission gas release rates [15-17]. We will utilize microstructure-informed finite-element simulations of heat conduction to relate the effective thermal conductivity of the doped fuels to their underlying microstructure [18, 19]. Similarly, microstructure-informed finite-element simulations of fracture [6, 20] will be conducted to study the effect of the microstructure on fuel micro-cracking and macro-cracking (fragmentation). All the models will be implemented in the open-source, state-of-the-art MOOSE framework. Selected recent experimental data sets of doped fuels [4, 11-14] along with novel sets to be generated in this project will be used to validate the models. The project will leverage the on-going irradiation campaign of doped MiniFuel in the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) [11] to obtain unique data of the doped fuels at HBU with accurate power history and fuel cycle management. The details of how data from experiments will be utilized to validate our models are discussed thoroughly. *The outcomes of this project will reduce the uncertainty and improve the predictions of existing fuel performance models of doped fuels. Hence, this study will be able to provide the nuclear industry with validated, physics-based criteria for the safety margin of this novel Accident Tolerant Fuel (ATF).*