In-Pile Instrumentation Multi-Parameter System Utilizing Photonic Fibers and Nanovision

PI: Dr. Eric Burgett, Idaho State University

Collaborators: Dr. Mohamad Al-Sheikhly, University of Maryland

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ABSTRACT

To advance the state-of-the-art in fuel cycle research requires one to know, with extreme precision, the structure of the fuel pellet and its grain structure. An advanced in-pile grain level fuel pellet monitoring system is being proposed in this funding opportunity. The proposed effort brings cutting edge, high fidelity optical measurement systems into the reactor environment in an unprecedented fashion with unprecedented resolution. This data is used by modelers from the atomistic scale to the macroscopic scale. It is proposed to measure fuel behavior and study grain propagation and fuel pellet morphologies during irradiation, in real time, with nanometer resolutions with a system called "NanoVision". NanoVision is a unique solution to a grain level fuel monitoring need in core while being minimally intrusive in the reactor core. This project directly supports the development of and understanding of fuel performance through advanced instrumentation, predictive physics based fuels performance models at a micro-structured and nanostructured level. Detector designs proposed herein can monitor fuel compression and expansion in both the radial and axial dimensions as well as three dimensional deformations. To further complicate the delivery of these data, some of the most interesting measurements will need to be made in-pile during the first few hours of irradiation. These sensitive new measurements may require novel systems to collect, package and send data from in-pile sensors to remote data acquisition systems, which must be maintained well outside the neutron radiation field. Delivering this high precision, in-pile data is a daunting task and we propose to take the first necessary steps in developing a viable research and development effort to meet these challenges.

This novel technique that we refer to as "NanoVision", utilizes the photonic crystal structure in a completely new fashion in order to yield information in real time fuel changes on the scale of nanometers as opposed to millimeters. It becomes possible to measure nearly atomistic changes in real-time during irradiation. NanoVision provides a unique monitoring capability which can be applied to fuel materials, cladding materials, any material in which more precise information over grain swelling, grain compression, temperature, crack formation and propogation is desired in two or three dimensions. This system provides unprecedented accuracy (nm scale deformations) and can do it in a repeatable fashion using nanotechnology.