Testing of Sapphire Optical Fiber and Sensors in Intense Radiation Fields, when Subjected to Very High Temperatures

PI: Thomas Blue – Ohio State University

Collaborators: Wolfgang Windl – Ohio State University
David Hawn – Ohio State University
Robert Fielder – TechOpp Consulting, Inc.
Jon Greene – Lambda Instruments, Inc.

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ABSTRACT

Due to the high melting point of optical fiber materials (sapphire melts at ~2050°C), fiber optic sensors are promising candidates for in-pile instrumentation to support fuel cycle research and development, provided they can survive continuous irradiation at very high temperatures. The objective of this project is to characterize, by comparison of measured and modeled results, the performance of sapphire optical fibers and sensors in intense radiation fields, while subjected to very high temperatures. Specifically, the goals of the proposed project are to 1) develop validated multiscale models for radiation damage from neutrons and gammas in sapphire fibers at high temperatures (~1600°C), 2) determine the optimum wavelength region for sapphire fiber-based sensors based on broadband (300-2400 nm) transmission measurements in a high temperature, high radiation environment and 3) evaluate the performance of sapphire fiber-based Fabry-Perot interferometric temperature and strain sensors subjected to intense neutron and gamma radiation at high temperatures (~1600°C). The multiscale models will predict the resulting damage and structure evolution as a function of temperature, time, and radiation absorbed dose for short and extended time scales. The modeling work will be performed in close collaboration with the experimental work. The irradiation experiments will begin with experiments in the OSU Gamma Irradiation Facility (OSUGIF) and will progress to experiments in the OSU Research Reactor (OSURR). The irradiations will be accompanied (in-situ) by broadband optical loss measurements that will validate the transport modeling and determine the optimum wavelengths at which sapphire fiber-based sensors could operate. Finally, temperature and strain measurements will be made in the OSUGIF and the OSURR using Fabry-Perot interferometric sensors developed by Lambda. With the inclusion of Lambda and its subcontractor, TechOpp Consulting, the research team has considerable previous experience in all of the proposed experimental and computational techniques.