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High-Fluence Active Irradiation and Combined Effects Testing of Sapphire Optical Fiber Distributed Temperature Sensors - ASI Project Summary

November 2021

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Idaho National Laboratory

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High Fluence Active Irradiation and Combined Effects Testing of Sapphire Optical Fiber Distributed Temperature Sensors

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Project Description: The goal of this work is to investigate the performance of sapphire optical fiber temperature sensors and develop clad sapphire optical fibers for in-pile instrumentation. This work tests the distributed sensing performance of sapphire sensors by using optical backscatter reflectometry methods under combined radiation/temperature effects and high fluence. A series of irradiations will be completed to evaluate the effect of irradiation on sapphire optical fiber temperature sensors and to determine an operational limit for the sensors.

Impact and Value to Nuclear Applications: Sapphire (α-Al2O3) fibers have the potential to be a high-temperature alternative to amorphous silica, due to the high melting temperature (about 2054°C), outstanding chemical resistance, and mechanical strength of their crystalline network. This research will deliver modern optical fiber sensing techniques usable in multiple extreme environment applications. In the area of nuclear fuel/material testing, these fibers will enable access to operational data with excellent time and space resolution during irradiation testing. Accurate online monitoring of test parameters (e.g., temperature and strain) will greatly reduce the time and cost associated with developing, demonstrating, and licensing new nuclear technologies.

Recent Results and Highlights: A high temperature irradiation experiment was completed at the Ohio State University Research Reactor in FY21. The irradiation experiment tested Rayleigh backscatter sensing in sapphire optical fibers for temperatures ranging from ambient to 1600°C.

Figure 1: Heated irradiation furnace rig.

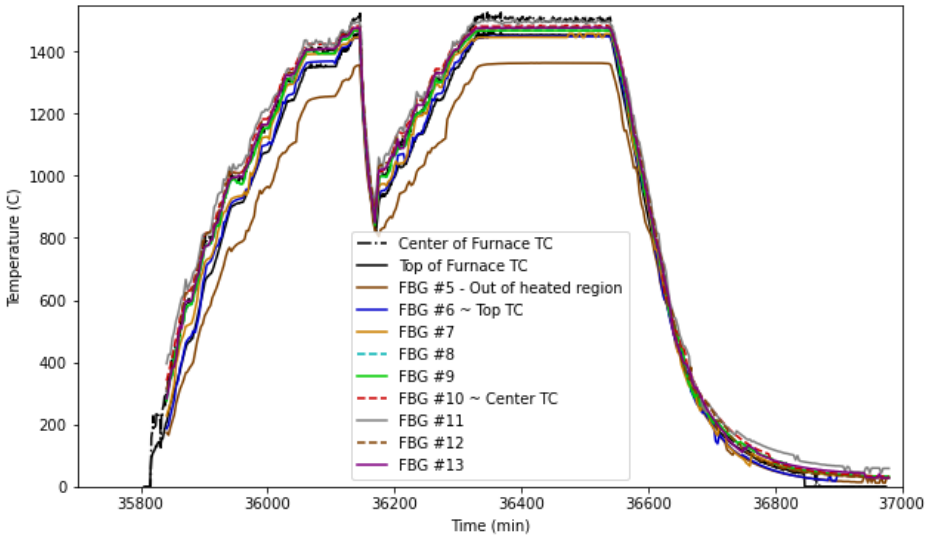

Figure 2:Rayleigh backscatter response at the locations of fiber Bragg gratings in a sapphire optical fiber under irradiation.