Radiation Effects on Optical Fiber Sensor Fused Smart Alloy Parts with Graded Alloy Composition Manufactured by Additive Manufacturing Processes

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ABSTRACT:

A nuclear reactor core is arguably the most challenging artificial environment. Situations inside nuclear reactors are critical to safe and efficient operations of nuclear power systems. However, most of existing sensors cannot survive extreme harsh environments of reactor cores. As platforms well-suited for harsh environments, optical fibers and fiber devices have been studied for nuclear energy applications since late 1990s to improve monitoring, control, and communication in nuclear energy systems. Although performance and survivability of various fiber optical point sensors have been studied under gamma and x-ray radiation, their viabilities for in-core environments has not been fully explored.

The objective of this NSUF program is to establish the foundation for converging disciplines of multi-functional fiber optic sensors and additive manufacturing to develop both robust fiber optical sensors and their package for in-core measurements. Through this NSUF project, we will study an important question: can optical fiber sensors survive and function in reactor core environments? Using advanced laser fabrication techniques, this project seeks to develop both high-temperature stable point sensors and distributed fiber sensors for high spatial resolution measurements in radiation-harden silica and sapphire fibers. Using additive manufacturing as a versatile fabrication approach, we will explore innovative materials and geometric shapes amendable via 3D printing to produce robust and durable fiber sensor package for in-core applications. Working with scientists at NSUF facilities including MIT reactors and Westinghouse's Material Center of Excellence, we will perform rigorous and systematic in-core fiber lead-out tests for both point and distributed sensors. This combined with post-irradiation examination for radiation damage studies will produce new knowledge and sensing technology for high spatial resolution in-core measurements.