NUCLEAR ENERGY UNIVERSITY PROGRAMS

Testing of Performance of Optical Fibers Under Irradiation in Intense Radiation Fields, When Subjected to Very High Temperatures

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Abstract

The primary objective of this project is to measure and model the performance of optical fibers in intense radiation fields when subjected to very high temperatures. This research will pave the way for fiber optic and optically based sensors under conditions expected in future high-temperature gas-cooled reactors.

Sensor life and signal-to-noise ratios are susceptible to attenuation of the light signal due to scattering and absorbance in the fibers. This project will provide an experimental and theoretical study of the darkening of optical fibers in high-radiation and high-temperature environments. Although optical fibers have been studied for moderate radiation fluence and flux levels, the results of irradiation at very high temperatures have not been published for extended in-core exposures.

Several previous multi-scale modeling efforts have studied irradiation effects on the mechanical properties of materials. However, model-based prediction of irradiation-induced changes in silica's optical transport properties has only recently started to receive attention due to possible applications as optical transmission components in fusion reactors. Nearly all damage-modeling studies have been performed in the molecular-dynamics domain, limited to very short times and small systems.

Extended-time modeling, however, is crucial to predicting the long-term effects of irradiation at high temperatures, since the experimental testing may not encompass the displacement rate that the fibers will encounter if they are deployed in the VHTR. The project team will pursue such extended-time modeling, including the effects of the ambient and recrystallization. The process will be based on kinetic MC modeling using the concept of amorphous material consisting of building blocks of defect-pairs or clusters, which has been successfully applied to kinetic modeling in amorphized and recrystallized silicon. Using this procedure, the team will model compensation for rate effects, and the interplay of rate effects with the effects of annealing, to accurately predict the fibers' reliability and expected lifetime.