Non Destructive Thermal Analysis and In Situ Investigation of Creep Mechanism of Graphite and Ceramic Composites using Phase-sensitive THz Imaging & Nonlinear Resonant Ultrasonic Spectroscopy

PI: Zhang, Xi-Cheng - Rensselaer Polytechnic Institute

Collaborators:
Han, Pengyu - Rensselaer Polytechnic Institute
Hurley, David H. - Idaho National Laboratory

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Abstract

This project will study the evolution of microstructure-mediated creep properties of nuclear-grade graphite using phase-sensitive terahertz (THz) imaging and nonlinear laser-based resonant ultrasound techniques. These non-destructive evaluation techniques will be used to monitor the mechanical properties of graphite, including the size, distribution, shape and orientation of both pores and grains. Initially, the team will measure surrogate samples subjected to weight loss due to oxidation, later considering the potential to conduct post-irradiation examination on neutron-irradiated samples. *Ex-situ* examinations will be conducted to monitor pore distribution and size as well as crack distribution and size. Ultimately, these baseline measurements will be used to design and implement *in-situ* experiments to monitor pore and crack evolution as well as crystal texture evolution. The results of this study will be used to support new multi-scale model development, which will contribute to the fundamental understanding of irradiation creep. This project has five tasks:

1. Calibration of system performance of both THz imaging and laser-based nonlinear resonant ultrasound imaging using pyrolytic graphite, and investigation of THz and NLRUS responses as a function of microstructure orientation.
2. Characterization of oxidized graphite porosity and texture using optical microscopy and electron backscatter diffraction, considering different conditions of temperature, stress and processing time.
3. Establishment of theoretical and empirical relationships between THz and NLRUS responses and microstructures, comparing measurements of microstructural evolution to current models (e.g., Kelly and Burchell).
4. Demonstration of *in-situ* monitoring using both THz and nonlinear resonant ultrasound techniques to monitor the property change of graphite, employing both furnace and micro-tensile equipment to study thermal creep and fracture under various temperatures and stresses.
5. Identification of a path forward for conducting *in-situ* measurements of neutron irradiated graphite samples.