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In-core Measurement Systems for Nuclear Materials Characterization

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Changing the World's Energy Future

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Idaho National Laboratory

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In-Core Measurement Systems for Nuclear Materials Characterization

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Project Description: Two instruments for in-reactor measurements of the critical physical properties of nuclear fuels and materials have been in development over the past fiscal year: fiber-based photothermal radiometry (fiber-PTR), and laser-based resonant ultrasound spectroscopy targeting the zero-group-velocity Lamb mode plate waves detection (RUS-ZGV). The fiber-PTR instrument monitors thermal wave propagation by collecting the local blackbody radiation in order to measure thermal conductivity. This instrument is ideal for high-temperature measurements. In addition, it requires little or no surface preparation and only one-side access to the sample. The RUS-ZGV instrument monitors the ZGV plate wave propagation and relates it to the microstructure evolution. ZGV plate waves are localized evanescent waves with a significantly higher signal-to-noise ratio than that of other wave modes. Therefore, the ZGV measurements are less sensitive to the boundary condition and the background noise.

Impact and Value to Nuclear Applications: Current modeling efforts for predicting the real-time, in-reactor behavior of nuclear materials can only be validated through post-irradiation examination (PIE). However, important information may not be correctly captured by PIE testing, due to the continuous microstructure evolution after the reactor shuts down. The instruments developed under this work package aim to fill this technical gap. Once finalized and deployed, these instruments are expected to greatly boost the development of advanced nuclear fuels and materials for end use by producing critical experimental data for validating and verifying advanced fuel performance codes.

Recent Results and Highlights: High-temperature in situ tests were conducted on reference materials on both instruments. As expected, ZGV plate waves show greater tolerance to the mounting approach, and the fiber-PTR measurement signal increases significantly at high temperatures. Meanwhile, a probehead with different spatial resolutions was fabricated for the fiber-PTR system to increase the measurement range.

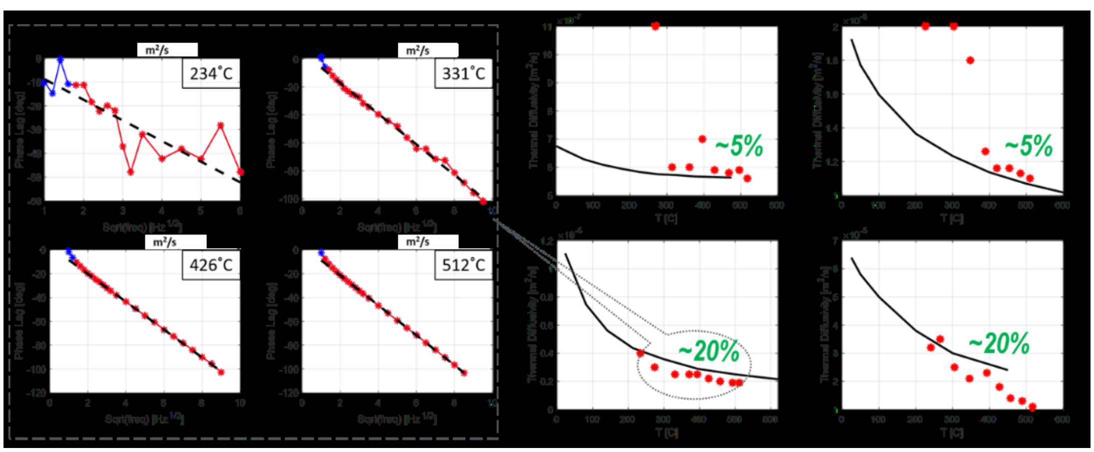

Figure 1. Right panel: Measured thermal diffusivity on the reference materials by fiber-PTR. The temperature range is 260–515°C. Experimental values (red stars) are 5–20% different than the values found in the literature (solid line). Left panel: The raw data on Al_2O_3 *at different temperatures were given to show the signal improvement with temperature.*