Optical Fiber Based System for Multiple Thermophysical Properties for Glove Box, Hot Cell and In-Pile Applications

PI: Heng Ban- Utah State University

Collaborators: Dario Manara, Institute for Transuranium Elements

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ABSTRACT:

The proposed project will develop a robust technique for the measurement of multiple thermophysical properties at very high temperatures. This technique will lead to a system design that will be the first step toward the eventual measurement of irradiated ceramic or metal fuels in a glovebox and/or hot cell with all sensors and electronics outside the glovebox and/or hot cell. The measurement will be carried out in a very simple and small pressure vessel, which can be placed inside the glovebox or hot cell. Optical fiber based, continuous wave lasers will be used to heat a small disk sample of a few millimeters in diameter to very high temperatures, above 3000◦C, and another pulsed laser to generate a short temperature pulse for pyrometric measurements. Thermal properties to be determined by the technique include: thermal diffusivity, thermal conductivity, heat capacity, and melting point. The unique features of the technique offer several distinct advantages:

- A small stainless steel vessel is used inside the glovebox or hot cell, while measurements and sample heating are achieved by lasers through optical fibers (no need for a bulky furnace);
- Control, power, sensors and measurement electronics can be placed outside the glovebox or hot cell;
- Multiple thermal property measurements can be taken on the same sample in a single, non-contact measurement system;
- Measurements can be performed in vacuum, at the atmosphere pressure, or at very high pressures of inert gases; and
- Metal and especially ceramic fuels can be measured because the temperature range can reach above 3000◦C.

The ***specific objectives*** of the proposed project are to:
(1) Design, build, and tune the measurement technique;
(2) Develop theoretical models and computational codes for data processing;
(3) Demonstrate performance limits and quantify uncertainty levels; and
(4) Measure selected materials and nuclear fuel surrogates.

These objectives will be achieved by an extensive experimental program and some theoretical and computational efforts. The project team consists of a university and an international institution. Because the team members have been involved in major US and European programs in the development of thermal property characterization techniques for fuels and other nuclear materials, the team has extensive expertise and experience in laser based techniques for thermophysical property measurements. In addition, the national laboratory and the international institution have radioactive material handling and glove box and hot cell capability and experience that can guide the development effort. The collaborative partnership already established among team members through other research projects will ensure the successful execution of this project. The proposed technique will improve the existing technology at a national laboratory by providing metal and ceramic high temperature and multiple properties measurements beyond the current range of moderate temperatures for metal only and thermal diffusivity. The DOE FCR&D Advanced Fuels program focuses on innovative LWR and transmutation fuel systems. The program has significant activities in fuel characterization and measurement technique development for in-pile and out of pile testing capabilities.