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Progress In Developing Laser Based Post Irradiation Examination Infrastructure

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Abstract. To be able to understand the performance of reactor fuels and materials, irradiated materials must be characterized effectively and efficiently in a high rad environment. The characterization work must be performed remotely and in an environment hostile to instrumentation. Laser based characterization techniques provide the ability to be remote and robust in a hot-cell environment. Laser based instrumentation also can provide high spatial resolution suitable for scanning and imaging large areas. The INL is currently developing three laser based Post Irradiation Examination (PIE) stations for the Hot Fuel Examination Facility at the INL. These laser based systems will characterize irradiated materials and fuels. The characterization systems are the following:

Laser Shock
Laser based ultrasonic C-scan system
Gas Assay, Sample, and Recharge system (GASR, up-grade to an existing system).

The laser shock technique will characterize material properties and failure loads/mechanisms in various materials such as LWR fuel, plate fuel, and next generation fuel forms, for PIE in high radiation areas. The laser shock-technique induces large amplitude shock waves to mechanically characterize interfaces such as the fuel-clad bond. The shock wave travels as a compression wave through the material to the free (unconfined) back surface and reflects back through the material under test as a rarefaction (tensile) wave. This rarefaction wave is the physical mechanism that produces internal de-lamination failure.
As part of the laser shock system, a laser-based ultrasonic C-scan system will be used to detect and characterize debonding caused by the laser shock technique. The laser ultrasonic system will be fully capable of performing classical non-destructive evaluation testing and imaging functions such as microstructure characterization, flaw detection and dimensional metrology in complex components.

The purpose of the GASR is to measure the pressure/volume of the plenum of an irradiated fuel element and obtain fission gas samples for analysis. The study of pressure and volume in the plenum of an irradiated fuel element and the analysis of fission gases released from the fuel is important to understanding the performance of reactor fuels and materials. This system may also be used to measure the pressure/volume of other components (such as control blades) and obtain gas samples from these components for analysis. The main function of the laser in this application is to puncture the fuel element to allow the fission gas to escape and if necessary to weld the spot close. The GASR station will have the inherent capability to perform cutting welding and joining functions within a hot-cell.

Keywords: laser; laser shock, ultrasonic NDE; sensor, fission gas.