Advanced measurement techniques for highly radioactive fuels and materials*

J. Rory Kennedy, Matthew K. Fig, David Hurley, James I. Cole, Dawn E. Janney
Idaho National Laboratory
Idaho Falls, ID, United States

Abstract

In the realm of radioactive materials, a major challenge to the development of materials is the measurement of the properties for which the material is being developed. For example, the phenomenon of microstructure evolution of a nuclear fuel in reactor is well known but the details of the effects of the change on the behaviour of such important phenomena as thermal conductivity, mechanical properties and phase formation have not been quantified at high spatial resolution. There is a strong need to develop or adapt advanced instrumentation for measurements on radioactive materials. Idaho National Laboratory has an ongoing effort to develop or adapt a variety of measurement techniques to radioactive and highly radioactive materials. These efforts are also coupled with efforts to produce experimental results at spatial and temporal scales that are equivalent to those available to computational modelling and simulation. A laser-based device called the Scanning Thermal Diffusivity Microscope, conceived and developed over the past few years, has recently been installed in a hot cell where examinations of fresh and irradiated fuel samples have begun in order to profile the thermal diffusivity of fuels and materials down to 50 μm spatial resolution. Recent developmental strides in the area of laser-based resonance ultrasound spectroscopy have allowed real time monitoring of elastic property changes associated with microstructure evolution correlated to modelling and simulation that can predict the relationship between the polycrystalline elastic constants and the evolving microstructure. Further development effort includes the unique application of dual-beam focused ion beam (FIB) microscopy to highly radioactive materials, which will be an exceedingly useful tool to prepare samples for study by nano/micro indentation or compression testing (also under development), transmission electron microscopy, or even atom probe tomography. Finally, the application of micr--focus X-ray diffraction will allow crystal phase identification at spatial resolution of 10-100 μm. This contribution will present the current state of the implementation plan of these instruments to highly radioactive materials. Material study examples will be given and the challenges met to implementing these measurement techniques to highly radioactive materials will be discussed.

* The full paper being unavailable at the time of publication, only the abstract is included.