Energy Resolved Neutron Imaging at LANSCE: A Non-Destructive Tool for Interrogating Materials in Next Generation Nuclear Reactor Designs

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Given the nature through which neutrons interact with the nucleus, the use of neutrons for radiography and imaging can offer complementary Non-Destructive Testing and Evaluation (NDTE) techniques to more conventional radiography probes, such as x-ray radiography. With neutron radiography, very complex attenuation functions emerge that depend both on the energy of the incoming neutrons and the isotopic composition of the object being imaged. These complex dependences can result in contrast mechanisms and material penetrabilities that are fundamentally different from X-rays, ranging from cold and thermal neutrons being highly attenuated by light elements (such as hydrogen, boron, or lithium) to fast neutrons being almost transparent to heavy and dense materials (such as tantalum, lead, or uranium). Furthermore, given the variation of nuclear structure across isotopic chains, resonance absorptions in neutron radiography can create highly selective and unique contrast mechanisms through which specific isotopes can be identified. This later technique, known as Energy Resolved Neutron Imaging (ERNI), is a powerful tool in which specific isotopes can be non-destructively mapped out in both 2D radiographs and 3D CT reconstructions.

Given their intricate nature of interactions with materials, neutrons are the ideal probe for integrating potential nuclear fuel and moderator materials for next generation nuclear reactors. In recent years, the Los Alamos Neutron Science Center (LANSCE) has developed ERNI capabilities on Flight Path 5 (FP05) specifically for characterizing nuclear fuels and moderator materials. Here, we will present some of the recent work performed on FP05 in characterizing nuclear fuel and moderator materials using neutron radiography and ERNI techniques. These measurements range from density and viscosity measurements in actinide-based molten salts, to hydrogen diffusion mapping in YHx moderators, to post irradiation examination (PIE) with isotope mapping in fresh and irradiated fuels. LA-UR-20-22377