Development of a Self-Biased High-Efficiency Solid-State Neutron Detector for MPACT Applications

PI: Yaron Danon – Rensselaer Polytechnic Institute

Collaborators: Ishwara Bhat and James Lu – Rensselaer Polytechnic Institute

Program: FCR&D

ABSTRACT

Neutron detection is an important aspect of materials protection, accounting, and control for transmutation (MPACT). Currently He-3 filled thermal neutron detectors are utilized in many applications; these detectors require high-voltage bias for operation, which complicates the system when multiple detectors are used. In addition, due to recent increase in homeland security activity and the nuclear renaissance, there is a shortage of He-3, and these detectors become more expensive. Instead, cheap solid-state detectors that can be mass produced like any other computer chips will be developed. The new detector does not require a bias for operation, has low gamma sensitivity, and a fast response. The detection system is based on a honeycomb-like silicon device, which is filled with B-10 as the neutron converter; while a silicon p-n diode (i.e., solar cell type device) formed on the thin silicon wall of the honeycomb structure detects the energetic charged particles emitted from the B-10 conversion layer. Such a detector has ~40% calculated thermal neutron detection efficiency with an overall detector thickness of about 200 µm. Stacking of these devices allows over 90% thermal neutron detection efficiency.

The goal of the proposed research is to develop a high-efficiency, low-noise, self-powered solid-state neutron detector system based on the promising results of the existing research program. A prototype of this solid-state neutron detector system with sufficient detector size (up to 8-inch diam., but still portable and inexpensive) and integrated with interface electronics (e.g., preamplifier) will be designed, fabricated, and tested as a coincidence counter for MPACT applications. All fabrications proposed are based on silicon-compatible processing; thus, an extremely cheap detector system could be massively produced like any other silicon chips.

Such detectors will revolutionize current neutron detection systems by providing a solid-state alternative to traditional gas-based neutron detectors.