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Development of event-type neutron imaging detectors at the energy-resolved neutron imaging system RADEN at J-PARC

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At the RADEN instrument [1], located at beam port 22 of the high-intensity, pulsed neutron source at the Materials and Life Science Experimental Facility at J-PARC in Japan, we take advantage of the accurate measurement of neutron energy by time-of-flight to perform *energy-resolved neutron imaging*. By analyzing the two-dimensionally resolved, energy-dependent neutron transmission, these techniques can image macroscopic distributions of microscopic properties for bulk materials *in situ*, including crystallographic structure (Bragg-edge transmission), nuclide-specific density and temperature distributions (resonance absorption), and internal/external magnetic fields (polarized neutron imaging). At RADEN, we use advanced neutron imaging detectors based on cutting-edge technologies, such as micropattern detectors and fast, all-digital data acquisition systems with Field Programmable Gate Arrays (FPGAs), to provide event-by-event timing information with sub-µs resolution.

To better perform these measurements at RADEN, we are continually working to improve our event-type neutron imaging detectors for better spatial resolution and shorter measurement times and, as a user facility, to improve the ease-of-use of their control and analysis software. In particular, we are actively developing a micropattern detector known as the Micropixel chamber based Neutron Imaging Detector (µNID) [2]. The µNID uses a gaseous time projection chamber (TPC) with a micropixel chamber (µPIC) micropattern readout. This 400-µm pitch, two-dimensional strip readout is coupled to an FPGA-based data acquisition system designed for high-rate operation. Absorption on 3He in the gas mixture facilitates neutron detection, and the detailed tracking and analysis of the reaction products in the TPC enables a fine spatial resolution. The µNID currently provides 100 µm spatial resolution with a 10 cm × 10 cm field of view, 0.25 µs time resolution, 26% detection efficiency for thermal neutrons, ultra low gamma sensitivity, and an effective peak count rate of 1 Mcps [3]. We have recently redesigned the µNID control software to allow full integration into the automated experiment control system at RADEN, and we are carrying out optimization of the analysis algorithms for improved image quality and rate performance. We are also developing a new 215-µm pitch µPIC readout for improved spatial resolution, and a µNID with boron-based converter for increased count rate via a much-reduced event size.

In this presentation, we will give an overview of our detector development activities at RADEN and discuss in detail the present status of the µNID system. Demonstration measurements for energy-resolved neutron imaging and preliminary results for the small-pitch µPIC and µNID with boron converter will also be shown.

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References

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