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Advancement of Neutron Imaging Techniques Towards the Highest Resolution and Development of Imaging Application with RANS Using Particle Tracking Detectors

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Neutron imaging (NI) is a nondestructive and noninvasive inspection technique with a wide range of potential applications. The fundamentals of this technique need to be improved, particularly in achieving micrometer-scale or finer resolution, which remains a challenging task. Recently, we developed a high-resolution NI device utilizing fine-grained nuclear emulsions (FGNE). The NI of gadolinium-based gratings were successfully performed. The calculated imaging resolution, based on grayscale optical images of a gadolinium-based grating with a periodic structure of 9 μm was, 0.945 $\pm$ 0.004 μm, the highest imaging resolution achieved so far. Although these detectors offer exceptionally high resolution, they are not reusable. To address this limitation, we investigated the potential of fluorescent nuclear track detectors (FNTDs) for high-resolution NI. We presented an approach to perform optical bleaching under the required conditions for the imaging applications. It was concluded that FNTDs can be reused for imaging applications at least seven times. The NI of a gadolinium-based grating with a periodic structure of 9 μm was performed, and the grating structure was successfully resolved first using the novel FNTD-based neutron imaging technique. The measured resolution with the FNTD-based neutron detector is 0.887 $\pm$ 0.009 μm. In the near future, these FNTDs will be further developed for use in compact neutron systems RIKEN Accelerator-driven compact neutron systems (RANS), where there is a high demand from industry for research and development in non-destructive observation. We aim to develop a high-resolution neutron computed tomography technique and realize neutron imaging applications with RANS, utilizing FNTDs and FGNEs.

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