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Fast Neutron Imaging with Semiconductor Nanocrystal Scintillators

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Fast neutrons offer high penetration capabilities for both light and dense materials due to their comparatively low interaction cross-sections, making them ideal for the imaging of large-scale objects such as as-built plane turbines, for which X-rays or thermal neutrons do not provide sufficient penetration. However, inefficient fast neutron detection limits the widespread application of this technique. Traditional phosphors such as ZnS:Cu embedded in plastics are utilized as scintillators in recoil proton detectors for fast neutron imaging. However, these scintillation plates exhibit significant light scattering due to the plastic-phosphor interface along with long-lived afterglow (on the order of minutes), and therefore alternative solutions are needed to increase the availability of this technique. Here, we utilize colloidal nanocrystals (NCs) in hydrogen-dense solvents for fast neutron imaging. The light yield, spatial resolution, and neutron-vs-gamma sensitivity of several chalcogenide (CdSe and CuInS₂)-based and perovskite halide-based NCs are determined, with only a short-lived afterglow (below the order of seconds) observed for all of these NCs. FAPbBr₃ NCs exhibit the brightest total light output at 19.3% of the commercial ZnS:Cu(PP) standard, while CsPbBrCl₂:Mn NCs offer the best spatial resolution at ~2.6 mm.

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