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Single-Step Synthesis of Cs3Bi2I9 Nanocrystals for Scalable Direct X-Ray Detectors

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Lead-free perovskite-inspired materials have emerged as promising candidates for direct X-ray detection. Herein, we report a scalable, single-step synthesis of Cs3Bi2I9 nanocrystals (NCs) with a high effective atomic number (Z value) directly from their precursor powders through an ultrasonication approach. By precisely controlling the precursor ratio and ligands, we achieve uniform and highly crystalline hexagonal NCs, as confirmed from high-angle annular darkfield scanning transmission electron microscopy (HAADF-STEM). The large-scale synthesis of the NCs allowed for the production of 0.78 cm^2 pellets used in the fabrication of X-ray detection devices, which exhibit a high bulk resistivity of 1×10^{11} Ω cm and a low dark current density of 3.3 nA cm^{-2} under an applied bias of 50 V (357 Vcm^{-1} electric field). These polycrystalline devices achieve a limit detection of 108 nGyair s-1, an order of magnitude improved over the commercial standard for medical imaging, along with stable current during 25 min of continuous X-ray exposure when tested with an X-ray source with a peak energy of 35 keVp. Finally, we demonstrate the scale-up of these detectors by producing thick films 9 cm2 in area, achieving comparable performance to the detectors based on pellets.

Author: GHOSH, Joydip (Inorganic Chemistry Laboratory, University of Oxford, Oxford OX1 3QR, U. K.)

Co-authors: BRADDOCK, Isabel H. B. (UKRI Science & Technology Facilities Council, Rutherford Appleton Laboratory); REDDY DUDIPALA, Kavya (Inorganic Chemistry Laboratory, University of Oxford, Oxford OX1 3QR, U. K.); POLAVARAPU, Lakshminarayana (Inorganic Chemistry Laboratory, University of Oxford, Oxford OX1 3QR, U. K); VEALE, Matthew. C. (UKRI Science & Technology Facilities Council, Rutherford Appleton Laboratory); WILSON, Matthew. D. (UKRI Science & Technology Facilities Council, Rutherford Appleton Laboratory); BABO, Ramavath (CINBIO, Universidade de Vigo, Department of Physical Chemistry, Campus Universitario Lagoas Marcosende, 36310 Vigo, Spain); HOYE, Robert L. Z. (Inorganic Chemistry Laboratory, University of Oxford, Oxford OX1 3QR, U. K)

Presenter: GHOSH, Joydip (Inorganic Chemistry Laboratory, University of Oxford, Oxford OX1 3QR, U. K.)

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