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Halide Perovskite Composites for High Stability X-ray Detection

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Halide perovskites one of the most promising materials for next-generation, highly sensitive, low-noise, direct high energy X-ray detectors due to their excellent optoelectronic properties including bandgap tunability, high photoluminescence quantum yields (PLQY), defect tolerance and chemical versatility. However, challenges for the successful commercialization of halide perovskites X-ray detectors remain. For example, processing halide perovskites into thick devices for optimal X-ray attenuation, without introducing defects via pressing, or mixing with polymer membranes represents one set of challenges. Further, to realize highly sensitive, low-noise detectors requires novel material choices to reduce dark currents, minimize current drift and enhance stability.

In this work, we present halide perovskite composites with functionality as direct X-ray detector and scintillators. Our scalable processing techniques can be tailored to the required X-ray energies for applications in radiography, CT, and PET scanning. By mixing halide perovskite with intrinsically more resistive scaffolds, we developed composites with high resistivity and significant reduction in dark current. In addition, our composite maintained high current densities and sensitivity resulting from charge carriers generated upon X-ray excitation of perovskite nanocrystals within the composite. Moreover, reproducible medical imaging requires device resistance to current drift. In this regard, halide perovskites often see large dark current drifts due to strong ion migration effects, thus requiring long pre-biasing before optimally functioning. However, our halide perovskite composite shows a significant reduction in dark current drift compared to the equivalent standalone perovskite detector, which we attribute to the rigid scaffold structure limiting ion migration effects. We further present a full direct X-ray detector material characterisation framework using our perovskite composite, demonstrating the full range of device performances which can be achieved by varying incident properties. The methodology of this work will lay the foundations for further device performance characterisation, removing ambiguity from current performance metrics and significantly advancing the application and commercialisation of halide perovskite X-ray detectors.

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