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Development of CsPbBr3-Polymer Composite Materials for Direct Detection of Radiation

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Interest surrounding the development of perovskite-based radiation detectors has largely emerged due to promising applications as an alternative or complementary candidate to silicon in solar cells. Such detectors can detect ionising radiation via both indirect scintillation and direct charge production mechanisms. The perovskite family encompasses a range of molecular combinations to make up the ABX3 chemical structure, known for impressive charge-transport and photoluminescence. Chemical compositions can be chosen to optimise properties such as band gap and stability, whilst maintaining favourable performance. This work explores the direct radiation detection mechanisms and viability of 3D-printable perovskite-polymer composites, in contrast to recent studies that showcase indirect detection using similar composite scintillators. Such materials, formed from the combination of an inorganic perovskite and a suitable thermoplastic, could see applications in medicine and nuclear security, where there might be a need to construct context specific devices. Users could take advantage of rapid production methods using 3D printable composites, and basic manufacturing approaches to create custom radiation detectors as an alternative to expensive commercial products.

In this work, perovskite-polymer composites have been prepared from either caesium lead bromide (CsPbBr3) perovskite nanocrystals (NCs) or crushed-powder crystalline CsPbBr3 (PP). Polycaprolactone (PCL) thermoplastic was loaded with perovskite ranging from 10% to 30% by weight, (continuing from a previous investigation of the 1% to 9% range). For characterisation, composites were melted and pressed into 1 mm pellets, and gold contacts were deposited on opposite faces to facilitate charge collection. Compositional analysis has been performed using SEM imaging with EDS analysis to assess perovskite dispersion, and microCT imaging to check for defects and evaluate sample uniformity. IV-characterisation and photocurrent response tests have been performed under bias, using X-ray illumination across a range of exposure conditions to examine response linearity with dose-rate. Measurements including dark current, photocurrent and sensitivity are used in comparisons to perovskite-based materials in recent literature.

Promising results and challenges encountered during this work are shared, with the intent of contributing to discussions around perovskite-based direct detection devices.

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