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A perovskite-thermoplastic composite for 3D printing novel radiation detectors.

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The fabrication of perovskite-polymer composites offers improved stability in perovskite radiation detectors alongside properties such as flexibility or improved strength. The facile production of all-inorganic perovskite nanocrystals is a convenient and cost-effective source of radiation detecting material. Incorporating these nanocrystals into the thermoplastic filaments used for fused filament fabrication (FFF) would enable users to design and manufacture custom low-cost 3D printed radiation detectors.

In this work, the characterization of early perovskite-polymer objects made from CsPbBr3 and the thermoplastic polycaprolactone (PCL) are presented. Following the creation of the solid plastic composite material, custom disc-shaped pellets have been formed into test devices with metal contacts. Electrical measurements have been recorded alongside the direct radiation response when exposed to a tungsten target X-ray source. Compositional analysis of early samples has been carried out using microCT to examine the internal structure of samples to reveal defects such as air pockets or cracks. X-ray fluorescence imaging (XRF) and scanning electron microscopy (SEM) has been used to study the uniformity of nanocrystal dispersion throughout the composite and the relation to charge collection. The CsPbBr3/PCL devices presented are composed of ˜7% CsPbBr3 by weight. IV-characterization has been performed with bias sweeps and dark current measurements. Exposure to the X-ray source at 70 kV across a series of mA values demonstrates a clear photocurrent response of the device under bias. From these measurements, the photocurrent response as a function of dose-rate has been found, demonstrating a linear response at greater dose-rates. Sensitivity and conductivity measurements have been calculated using the known detector area of the metal contacts for these devices. MicroCT and SEM images have been used to demonstrate the improvements made between early and recent generations of samples.

This work lays the foundation for novel 3D printable perovskite-polymer composites for use in direct radiation detection by exploring the compositional makeup of these materials and characterizing their detective properties. Recent device sensitivity to radiation will be presented along with progress that has been made in production of high-quality composite devices for characterization.

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