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#11-175 Perovskite Semiconductor X-ray and Gamma Detectors

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The application of perovskite materials for radiation sensors is a rapidly emerging field, with strong cross-over from perovskite research on photovoltaic devices. Perovskite materials offer new technologies for digital X-ray and gamma ray sensors with potential application areas in medical imaging systems, industrial X-ray inspection, and airport security systems. Perovskite materials, principally metal halide perovskites, offer several advantages over traditional silicon radiation sensors, primarily their high quantum efficiency due to the presence of high atomic number ("high Z") atoms, and the use of solution growth techniques to realise low cost, large area, sensors.

We present our work on the direct detection of X-rays and gamma rays using semiconductor lead halide perovskites. Single crystal lead halide perovskites are conveniently grown using simple solution-based methods, and we have studied the radiation sensitivity and detector performance of single crystal detectors based on FAPbBr3 (FA = the organic cation Formamidinium). These crystals show strong room temperature photoluminescence (PL) with a peak emission wavelength of ~550 nm, and absorption spectroscopy give a band gap energy of 2.16eV. Temperature dependent PL shows an unusual red shift in the emission wavelength as the temperature reduces, which is the opposite to that seen in conventional semiconductor materials. Time resolved PL shows long radiant lifetimes up to ~400 ns, which is consistent with high quality crystalline material. Charge transport studies show that the drift mobility in these materials is relatively low compared to other semiconductors, however the carrier lifetimes are long and the resulting mobility-lifetime products are reasonably high. Optimal contact preparation is important to limit dark currents in these materials, where the bulk resistivities are typically in the range 1E8–1E9 ohm-cm.

We have also studied the X-ray sensitivity of polycrystalline lead halide perovskites, which are particularly suitable for X-ray imaging and dosimetry applications. Fabrication of large area devices up to 20mm in diameter has been achieved using millimetre thick films of polycrystalline perovskite, and the dark current and X-ray sensitivity have been measured using a 50kV X-ray tube. Due to the high effective Z number of these materials containing lead atoms, a high detection efficiency can be achieved for relatively thin sensor layers. We will compare the X-ray sensitivity of polycrystalline perovskite films with other traditional imaging materials such as a-Si and selenium.

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