

Improving X-ray Detection Sensitivity Using Hybrid Active Layers of PBDB-T:ITIC and CdSe Core 2D Nanoplatelets

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In recent semiconductor scaling, encountering its physical limits, 2D materials are gaining attention. Among them, nanoplatelets represent quantum confinement effects in the z-axis direction, allowing bandgap tuning and achieving high efficiency, making them a highly researched 2D material. We used hybrid active layer composed of PBDB-T, ITIC organic materials and cadmium selenide nanoplatelets (CdSe NPLs) inorganic materials. Figure 1 show Emission and absorbance properties and TEM of CdSe NPLs. Figure 2 shows the energy levels of the proposed X-ray detector and the charge collection process. To conduct experiments on the mixing ratio of organic materials, PBDB-T:ITIC was prepared at different ratios of 1:1/1:2/1:3/2:1. Figure 3a shows J-V curve of the proposed X-ray detector, and Figure 3b shows radiation parameter of the proposed X-ray detector (CCD –DCD, sensitivity). A low series resistance (R_s) and high current density (J_{sc}) were achieved with a 1:1 ratio, enabling optimization, and a sensitivity of $1.37 \text{ mA/Gy}\cdot\text{cm}^2$ was achieved. Subsequently, CdSe NPLs were blended into the active layer along with the optimized organic material ratio to enhance performance. The CdSe NPLs were prepared in amounts of 0.5 mg, 1 mg, 1.5 mg, and 2 mg. Figure 4 shows Radiation parameters of PBDB-T:ITIC with different amount of CdSe NPLs. Using 1.5 mg of NPLs, PCE of 6.75%, J_{sc} of 18.61 mA/cm^2 , and R_s of 494.87Ω were achieved. The radiation parameters represent a trend similar to that of J_{sc} , with a sensitivity of $1.72 \text{ mA/Gy}\cdot\text{cm}^2$. It was 25.54% higher than the sensitivity of the PBDB-T:ITIC with pristine. By enhancing electrical carrier generation and transport characteristics through NPLs and adding physical and chemical stability, the detector demonstrated improved sensitivity and electron mobility compared to conventional detectors.

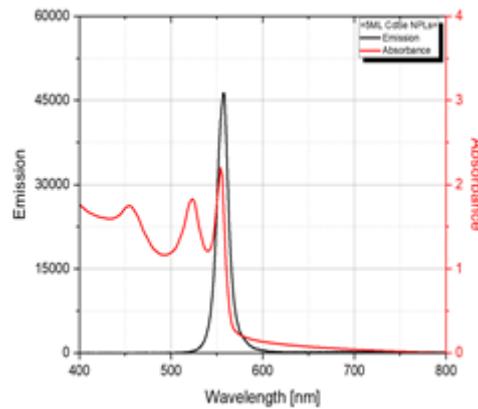


Figure 1: Figure 1a

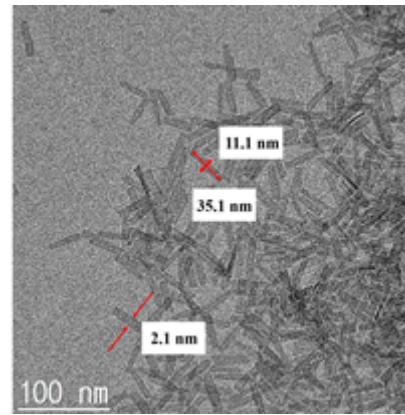


Figure 2: Figure 1b

Figure 1. (a) Emission and absorbance properties of 5ML CdSe Nanoplatelets, (b) the TEM image of 5ML CdSe Nanoplatelets

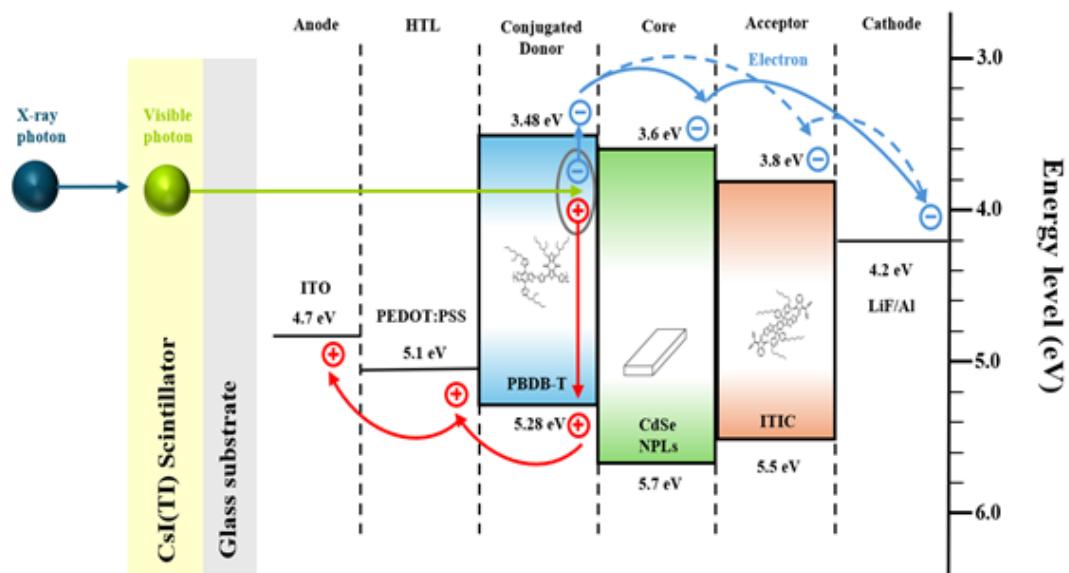


Figure 3: Figure 2

Figure 2. The energy band diagram of the indirect X-ray detector

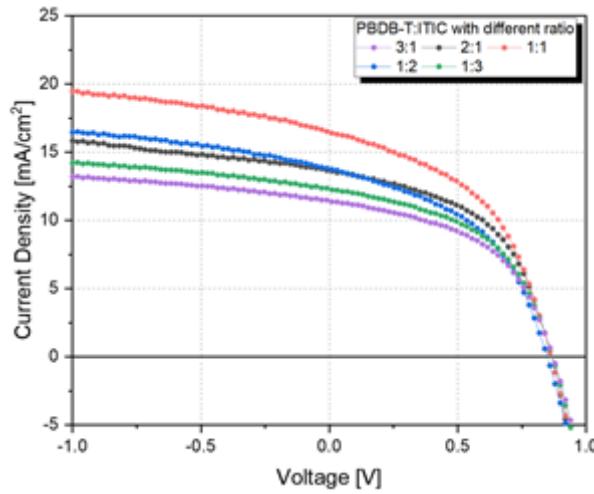


Figure 4: Figure 3a

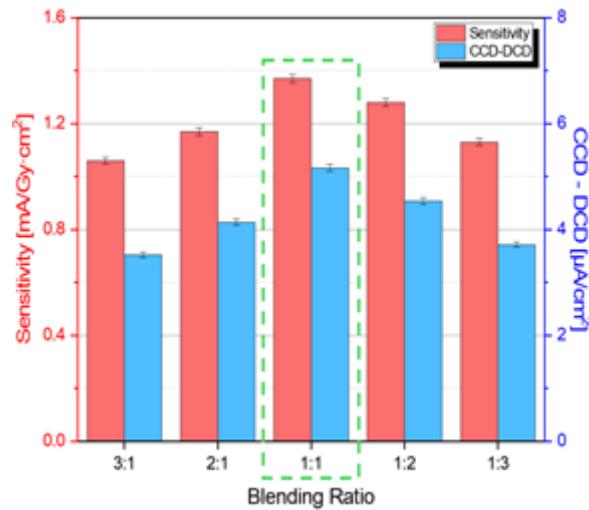


Figure 5: Figure 3b

Figure 3. (a) J-V curve of PBDB-T:ITIC detector with different ratio, (b) radiation parameters of PBDB-T:ITIC detector with different ratio

Table1. Photovoltaic parameters with different CdSe NPLs Concentration

	Pristine	0.5 mg	1 mg	1.5 mg	2 mg
PCE [%]	5.74	5.71	6.19	6.75	6.68
Rs [Ω]	502.16	533.12	519.71	494.87	500.40
J _{sc} [mA/cm ²]	15.97	17.07	17.44	18.61	18.04

Figure 6: Table 1

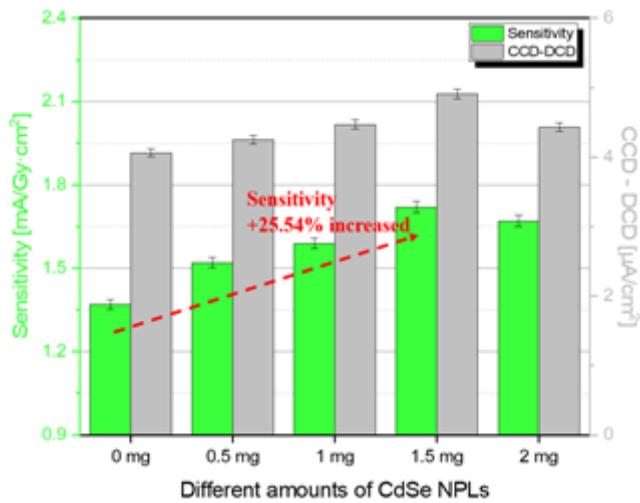


Figure 7: Figure4

Figure 4. Radiation parameters of PBDB-T:ITIC detector with different amount of CdSe NPLs

Workshop topics

Detector systems

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