Photomultiplication type polymer photodetectors with broad spectral response range from UV light to NIR

Polymer photodetectors (PPDs) have attracted more and more attention due to the low cost, flexible and environment friendly and lighter weight compared to their inorganic counterpart. Up to now, most of the reported PPDs are photodiode type photodetectors with external quantum efficiency (EQE) values less than unit. Very recently, we successfully reported photomultiplication (PM) type PPDs with rather high EQE and broad response range based on P3HT:PCBM as the active layers which are commonly used in polymer solar cells. The working mechanism of PM type PPDs is attributed to interfacial trap-assisted hole tunneling injection and efficient hole transport in the active layers.

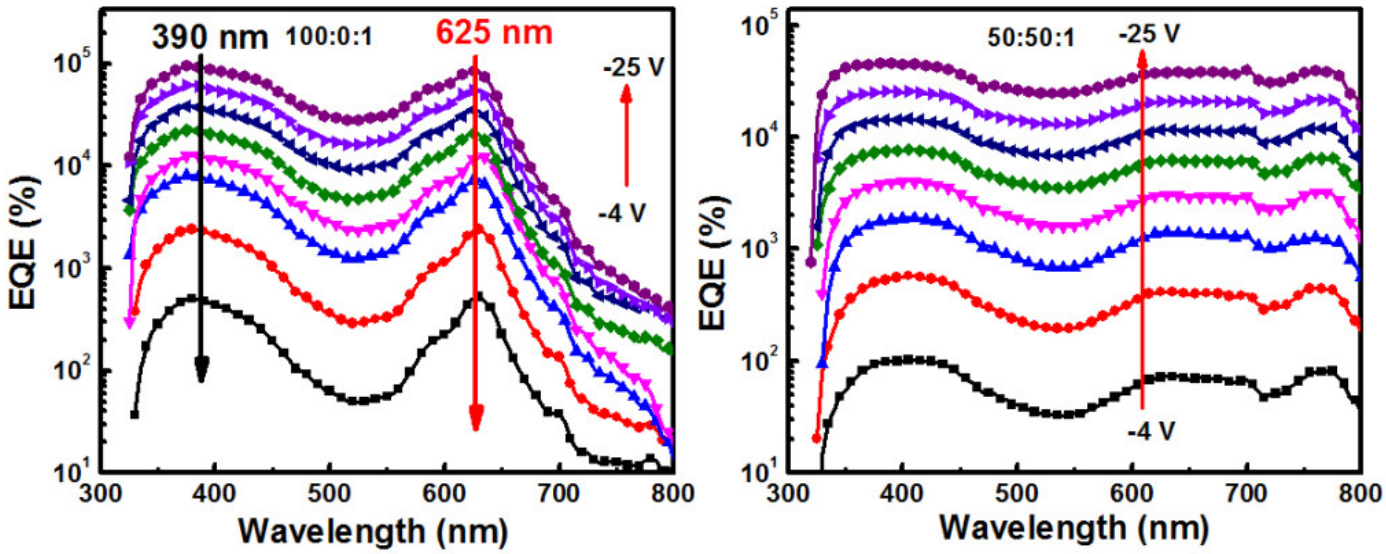

Fig. 1. EQE spectra of the PPDs under different bias from –4 V to –25 V with an interval of 3 V, (a) P3HT100:PCBM1; (b) P3HT50:PTB7-Th50:PCBM1 as the active layer.

The work mechanism of PM type PPDs has been adequately demonstrated by adjusting P3HT molecular arrangement and interfacial barrier width. The spectral response range of PM type PPDs is extended to 800 nm by doping narrow band gap materials in the active layers. The highest EQE values of PM type ternary PPDs are 97000% at 390 nm, 84100% at 610 nm and 38000% at 750 nm under ?25 V bias. . Very recently, Prof. Xiong Gong and Alan J. Heeger also highlighted the work in their review article that this approach could be an important study direction for overcoming the low photoresponsivity and high dark current densities in NIR PPDs.

The working mechanism of this PM type PPDs should be clearly revealed: i) photon harvesting by

P3HT; ii) rather small part exciton (close to PCBM) dissociated into charge carriers, electrons trapped in PCBM and hole transport along P3HT channels; iii) electrons accumulated in PCBM near Al electrode, resulting in interfacial band bending for the better hole tunneling injection; iv) the injected holes transport in the active layers under the reverse bias; v) injected holes collected by ITO electrode. As long as the photogenerated electrons can be trapped in PCBM near Al electrode, holes can be continuously injected from external circuit and transported to ITO electrode. This is why the EQE of PM type PPDs can be much larger than unit, which provides a great potential application because a pre-amplifier circuit is not necessary for the PM type PPDs. It means that our reported PM type PPDs may provide a new platform to obtain broad or adjusted spectral response range polymer photodetectors.

Publication

Revealing the working mechanism of polymer photodetectors with ultra-high external quantum efficiency.
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