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A High-Sensitivity Near-Infrared Phototransistor Based on Organic Bulk Heterojunction

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Support Information

1. Experimental Section

1.1 Materials:

The DPP-DTT polymer was synthesized as reported Ref. 23. The molecular weight of DPP-DTT was determined by gel-permeation chromatography against polystyrene standards and the average molecular weight (M_n) was 106, 000. 1-octanethiol, octyltrichlorosilane (OTS-8) and PCBM were purchased from Sigma-Aldrich Co. LLC.

1.2 Device Fabrication:

The substrate is a heavily n-doped silicon wafer (used as the gate electrode) deposited with a 300 nm thickness SiO_2 film, which is used as a dielectric layer (capacitance: 10.5 $nFcm^2$). The substrate was firstly cleaned ultrasonically in acetone and isopropyl alcohol (IPA) for 10 minutes, respectively, then immersed in solution of H_2SO_4/H_2O_2 (1:1) for 5 minutes at room temperature. Gold source-drain electrodes with a thickness of 30 nm were defined by photolithography to get a channel length of L=10 μm and channel width of W=15 mm on the substrate. The substrate with gold electrodes was firstly immersed in 0.1 M solution of OTS-8 in toluene at 60 °C for 30 min, then immediately immersed in 10 mM solution of 1-octanethiol in IPA for 2 minutes at room temperature. A photosensitive thin film was then deposited by spin-coating the solution of DPP-DTT: PCBM (mass ratio 1:1) blend (concentration: 10 mg/mL) and annealed at 135 ^{o}C for 30 minutes in a nitrogen atmosphere.

2. Results of the photodiode based on DPP-DTT/PCBM blends

A photodiode (Fig. S1a) based on DPP-DTT/PCBM blend is prepared for a comparative study. The film processing and measurement conditions for the photodiode were kept the same as the phototransistor. The J-V curves and the EQE spectra of the photodiode are shown below.

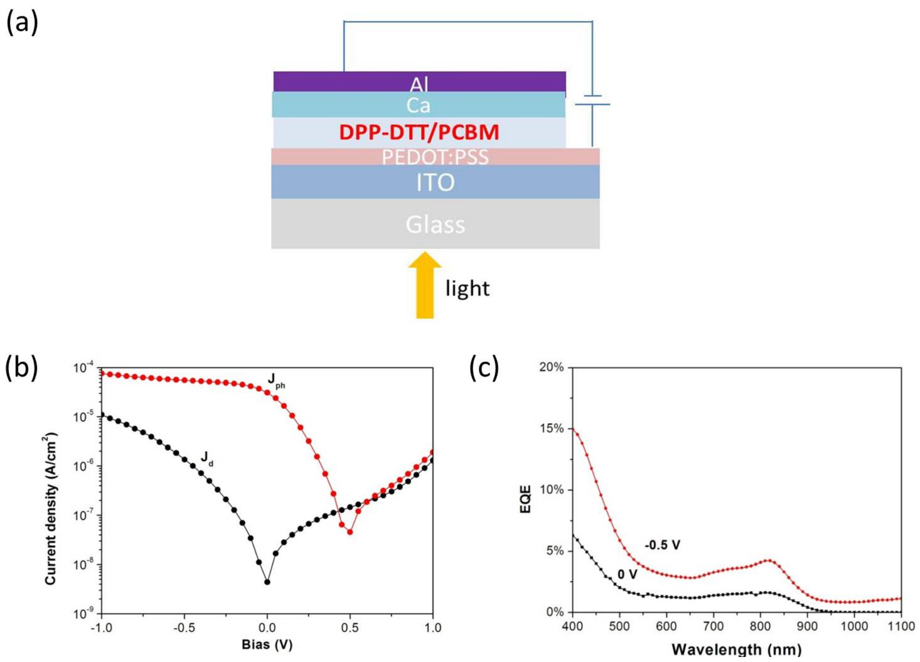

Fig. S1. (a) The schematic of photodiode based on DPP-DTT: PCBM (1:1) bulk heterojunction; (b) current-density versus voltage (J-V) of the photodiode measured in the dark (J_d) and light conditions (J_{ph}) (λ=808 nm, P=3 mW/cm^2); (c) External quantum efficiency (EQE) at different bias voltages.

3. External quantum efficiency (EQE) of the phototransistor under different gate bias.

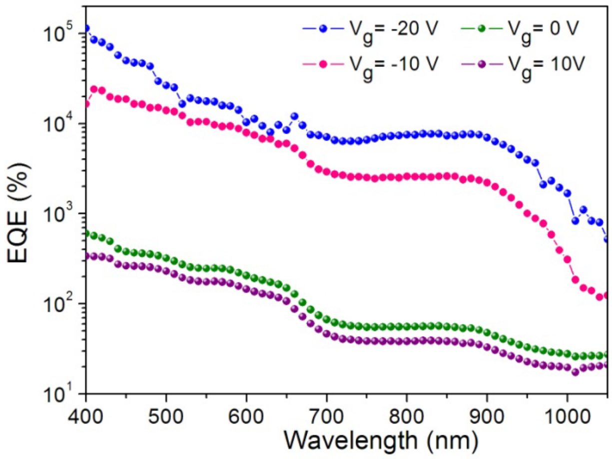

Fig. S2 External quantum efficiency (EQE) versus gate voltage (V_d=-5 V), the power intensity of the light source is 5 μW cm^{-2}.

4 . Calculation of detectivity

The detectivity D^* of the photodetector is given by the following equation:

$$D^* = (A\cdot\Delta f)^{1/2}\cdot R\cdot i_n^{-1}$$

where A is the active area of the photodetector, Δf is the electrical bandwidth, R is the responsivity of the photodetector, i_n is the noise current which is determined by three components: [1, 2] shot noise, Johnson noise, and thermal fluctuation noise. In general, the noise current is dominated by the shot noise originated from dark current, thus, the D^* can be approximated as: [3]

$$D^* = R \cdot (2 \cdot q \cdot J_d)^{-1/2}$$

where q is the value of elementary charge (1.6×10^{-19} Coulomb), J_d is the dark current.

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