

Supporting information

Universal Strategy To Reduce Noise Current for Sensitive Organic Photodetectors

Sixing Xiong,[†] Lingliang Li,[‡] Fei Qin,[†] Lin Mao,[†] Bangwu Luo,[†] Youyu Jiang,[†] Zaifang Li,[†] Jinsong Huang^{,‡} and Yinhua Zhou^{*,†}*

[†] Wuhan National Laboratory for Optoelectronics, School of Optical and Electronic Information, Huazhong University of Science and Technology, Wuhan 430074, China

[‡] Department of Mechanical and Materials Engineering, Nebraska Center for Materials and Nanoscience, University of Nebraska, Lincoln, Nebraska 68588-0656, United States

*E-mail: yh_zhou@hust.edu.cn; jhuang2@unl.edu

EXPERIMENTAL SECTION

Materials: P3HT, PC₇₁BM and ICBA were purchased from Luminescence Technology Corp. PBDTTT-EFT was purchased from 1-Material and PDPP3T was purchased from Solarmer Materials Inc. PEIE was purchased from Sigma-Aldrich. Silver and molybdenum oxide (MoO₃) were purchased from Alfa Aesar. All the materials were used as received without further purification.

Device fabrication: Indium tin oxide (ITO) glass substrates (CSG Holding Co. Shenzhen) were cleaned in sequential ultrasonic baths of detergent in deionized water, deionized water, acetone and 2-propanol for 20 min. The cleaned glass substrates were blown dry by nitrogen flow and further dried in an oven at a temperature 70 °C. After that, the substrates were transferred to N₂-filled glovebox. Polyethylenimine ethoxylated (PEIE) in 2-propanol solution (IPA) with a concentration of 0.1 wt.% was spin-coated onto ITO substrates at 5000 rpm for 1 min. Then the substrates were thermal annealed at 100 °C for 5 min in glovebox. Cooling for 10 min in glovebox to room temperature, the active layer solution was spin-coated onto glass/ITO/PEIE substrates from the following solutions: P3HT: ICBA (1:1, weight ratio, total 40 mg/ml) in chlorobenzene, PBDTTT-EFT: PC₇₁BM (1:1.5, weight ratio, total 25 mg/ml) in chlorobenzene, PDPP3T:PC₇₁BM (1:2, weight ratio, total 18 mg/ml) in a mixed solvent of chloroform and o-dichlorobenzene (o-DCB) (1:4, volume ratio), respectively.

The P3HT electron-blocking layer was prepared on top of the active layers by transfer-printing method. The details of the process include: a clean silicon wafer was treated by air plasma for 10 min to tune surface hydrophilicity. P3HT was dissolved in chlorobenzene with a concentration of 20 mg/ml. The P3HT solution was

spin-coated at 1000 rpm for 2 min onto the silicon wafer. And then, a piece of polydimethylsioxane (PDMS) was put onto the P3HT layer on the silicon wafer. The PDMS/P3HT on wafer was dipped into deionized water for 10 s. After that, the PDMS was peeled from the silicon wafer and P3HT film was adhered on the PDMS. Subsequently, the OPD samples of ITO/PEIE/active layer/ were taken out of the glovebox. Immediately, the PDMS with P3HT film was put onto the active layer. Next, the sample was transferred to glovebox and thermal annealed at 100 °C for 10 s. PDMS was peeled from the sample and the P3HT blocking layer was retained on the active layer.

Device characterization: The J - V characteristics were measured inside a N₂-filled glovebox by using a Keithley 2400 source meter controlled by a LabVIEW program in the dark and under illumination (AM 1.5, 100 mW cm⁻²). All the data of the dark noise current was measured in dark under -0.1 V. The noise signal was amplified by a current pre-amplifier, and then the frequency dependent noise amplitude was directly read-out by a Fast Fourier Transformation (FFT) analyzer. For noise equivalent power measurement, the device was measured under illumination of light emitting diode (LED) modulated at 35 Hz, and the light intensity was controlled by the neutral density filters. For linear dynamic range measurement, the amplitude photo-current signal, which was modulated at 35 Hz, was measured by a lock-in amplifier.

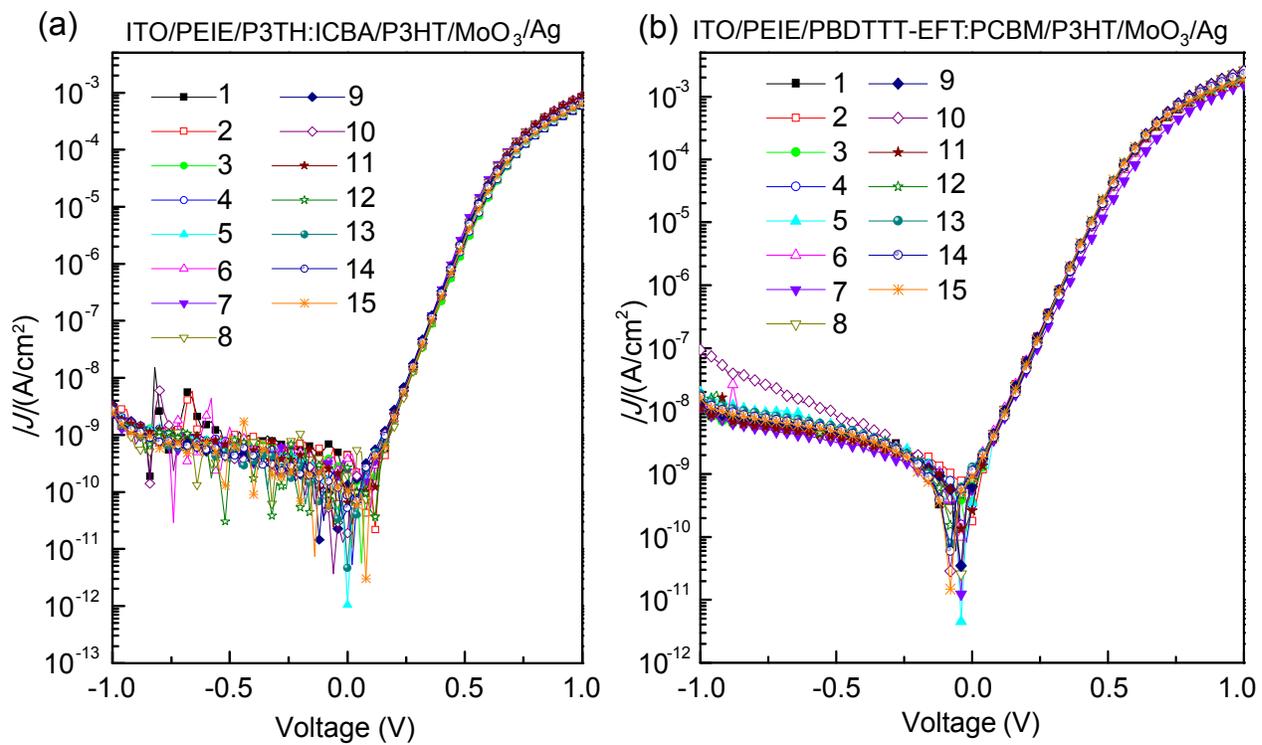


Figure S1 J - V characteristics of 15 devices for each active layer to check the reproducibility. The active layers are: (a) P3HT:ICBA; (b) PBDTTT-EFT:PCBM

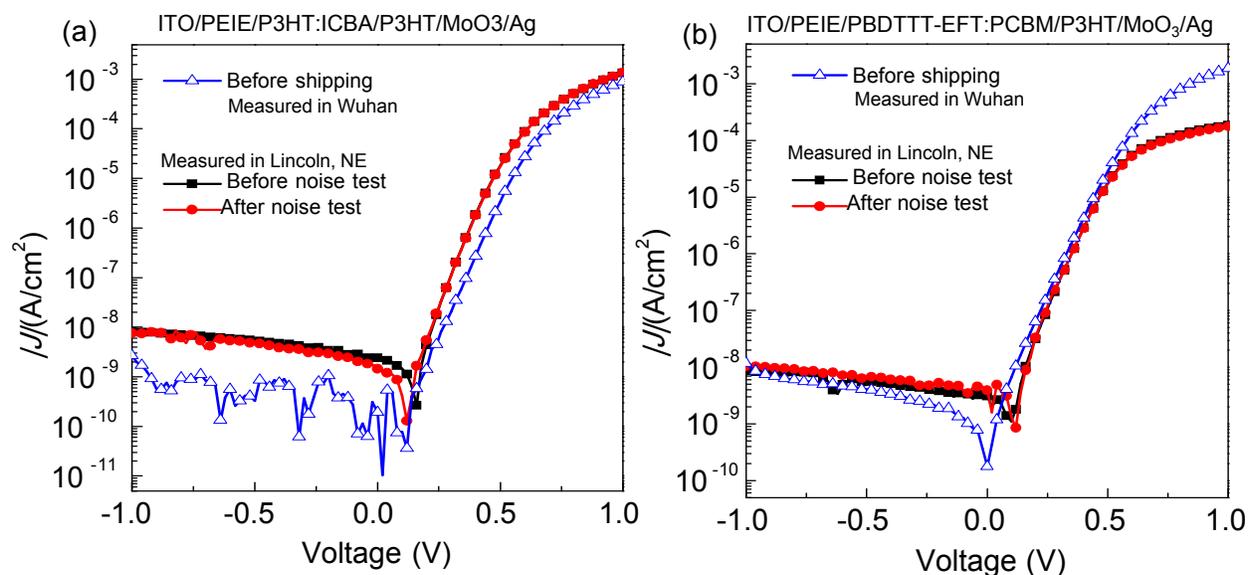


Figure S2 J - V curves of the samples before and after shipping to Lincoln, Nebraska. J - V curves of the devices before and after noise test measured in Lincoln were also included. The devices were shipped at 08/04/2016 and received at 08/09/2016. (a) P3HT:ICBA-based OPD; (b) PBDTTT-EFT:PCBM-based OPD.

Table S1 Thickness of the P3HT EBL changed with different spin-coating speed from a 20mg/ml P3HT chlorobenzene solution.

Spin speed	Thickness (nm)
1000 rpm	130 ± 10
1500 rpm	100 ± 5
2000 rpm	70 ± 5
2500 rpm	55 ± 3
3000 rpm	53 ± 3