Supporting information

Cracked polymer templated metal network as transparent conducting electrode for ITO-free organic solar cells

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Experimental section:

Preparation of Ag network derived TCE: Glass substrates were cleaned with soap water, DI water and ethanol, dried with N_2 gas. A commercially available acrylic resin dispersion (Ming Ni Cosmetics Co., Guangzhou, China) is used for the preparation of crack forming dispersion. The dispersion is ultrasonicated for 30 min and left over night in an airtight bottle. The suspended solution is filtered with Whatman filter (1 μm GF/B w/GMF) and further diluted with the diluter (Ming Ni Cosmetics Co., Guangzhou, China), to adjust the concentration of 0.6 g/mL. The final dispersion is spin coating on glass substrate at 3000 rpm for 120 s, followed by thermal evaporation of Ag metal in a vacuum chamber. In the final stage, the acrylic resin template was removed with chloroform. The Ag network is cleaned with chloroform for 2-3 times to remove any residual acrylic resin nanoparticles and heated at 80 °C for 30 min. These Ag network derived TCEs were used for the fabrication of organic solar cell.

Fabrication of polymer solar cell: The Ag network derived TCE and ITO were cleaned with ethanol and dried with N_2 gas. A Zinc acetate solution (109.75 mg zinc acetate dihydrate, 30.5 μL ethanol amine and

1ml methoxyethanole) is mixed, stirred for at least two hours and filtered with 0.2 µm hydrophilic filter. To obtain a 45 nm thick ZnO layer, 100 µL of zinc acetate solution is spin coated on TCE at 4000 rpm for 50 s, followed by heating at 150 °C for 5 min to convert zinc acetate to zinc oxide.[31] Different thicknesses for ZnO layers were obtained by repeating the above procedure. A 2.7 wt% of PCBM:P3HT (0.8:1) in chlorobenzene solution is stirred for 2 hours and filtered with 0.2 µm hydrophobic filter. A 80 µL PCBM:P3HT solution is spin coated on the ZnO coated TCE at 700 rpm for 60 s, followed by annealing at 130 °C for 15 min inside glove box. HTL – Solar PEDOT:PSS (Heraeus-Clevios) is ultrasonicated for 10 minutes and filtered with 0.2 µm hydrophilic filter. A 100 µL of the solution is spin coating on the active layer at 4000 rpm for 90 s and followed by annealing at 130 °C for 15 min in air. In the final step, 60 nm Au is evaporated on PEDOT layer using a thermal evaporator (BOC Edwards, Auto 306, FL 400). Four cells with different ZnO thicknesses (45, 95, 135 and 230 nm) were fabricated, each consisting of five cells (area of each cell: 0.09 -0.13 cm^2).

Measurements: Metal fill factors are estimated from imageJ software analysis SEM was carried out using a Nova NanoSEM 600 instrument (FEI Co., The Netherlands). Wyko NT9100 Optical Profiling System (Bruker, USA) was used for height and depth measurements and Dektak profiler for thickness measurements. Current-voltage characteristics were measured under standard AM 1.5 G spectral conditions at an intensity of 100 mW/cm^2 using a solar simulator (Newport-Oriel, 92250A-1000) and an electrometer (Keithley, Model 6517). Light source was regularly calibrated using a silicon solar cell (WPVS cell, ISE Call lab, Freiburg). External quantum efficiencies were measured with a PVE300 photovoltaic device characterization system (Bentham).

SEM images of Ag network:

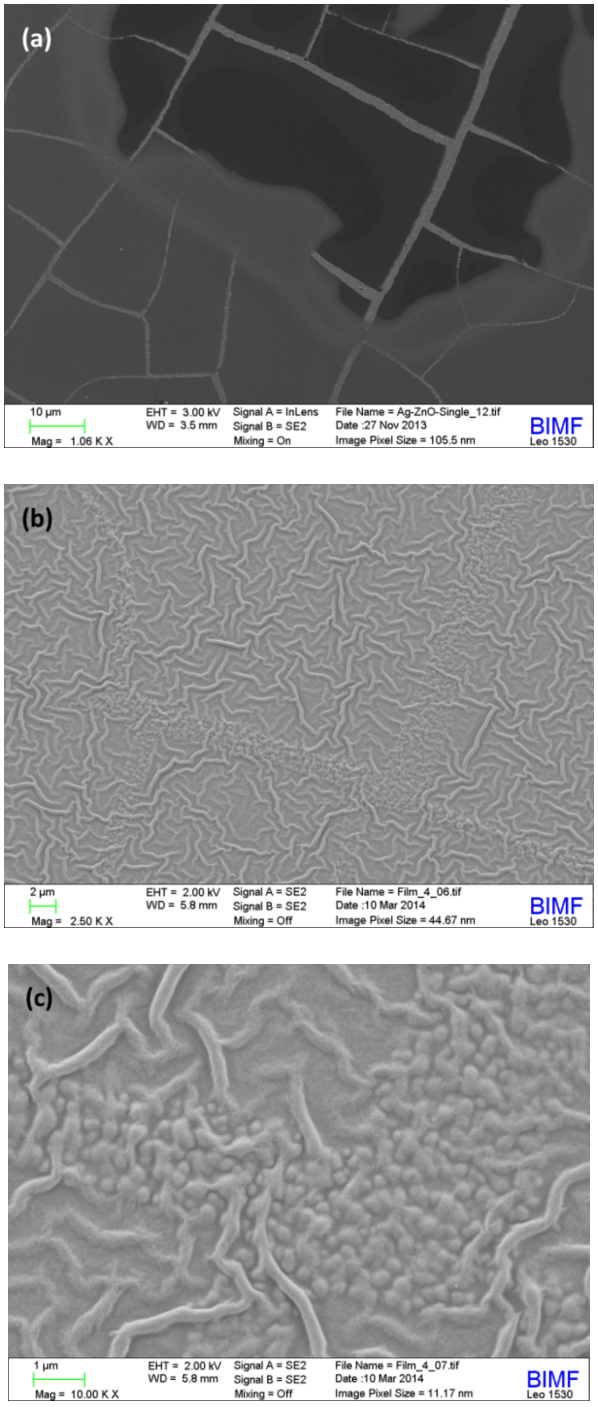

Fig S1 SEM images for Ag network TCEs in different magnifications with (a) 45 nm ZnO magnified by 1.06K, (b) 135 nm ZnO magnified by 2.50K and (c) 135 nm ZnO magnified by 10.00K. In (c) the underlying Ag network is clearly discernible. The substructures in (b) and (c) are observed at high magnification.

Current Voltage Characteristics:

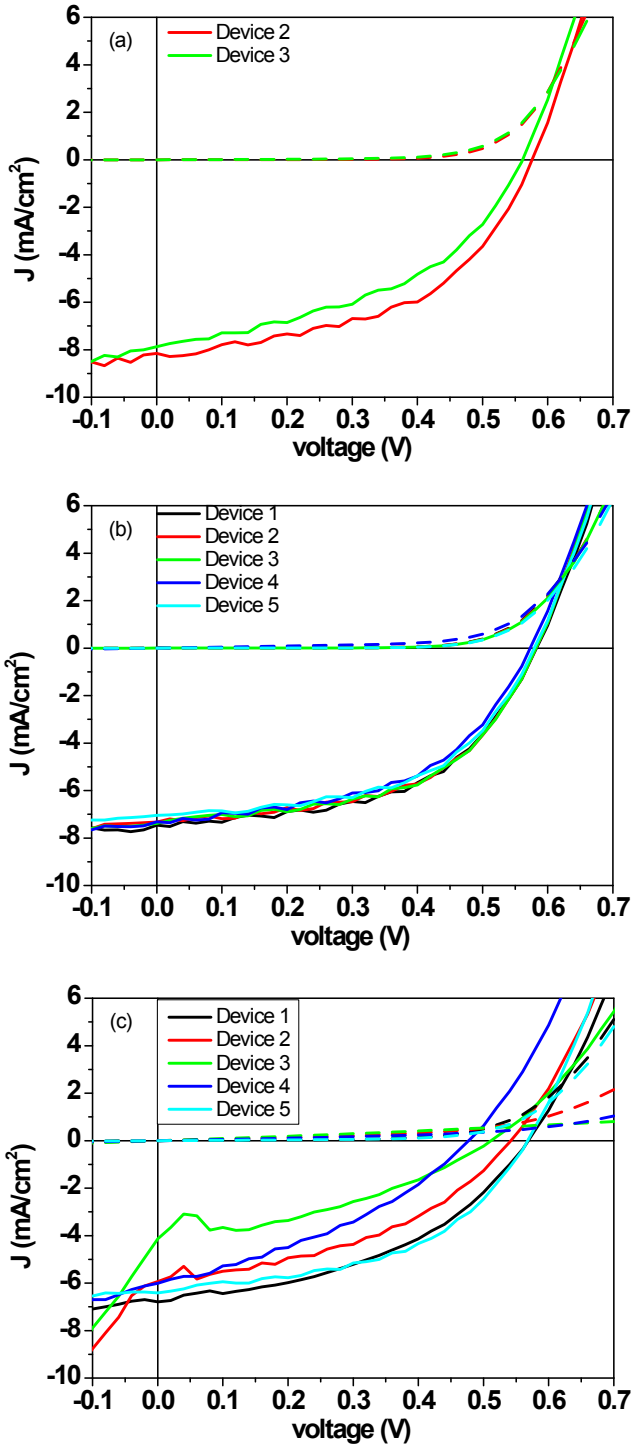

Fig. S2 J-V characteristics of all working Ag wire TCE derived polymer solar cell with (a) 95 nm, (b) 135 nm and (c) 230 nm ZnO layer thicknesses.

Absorption of devices:

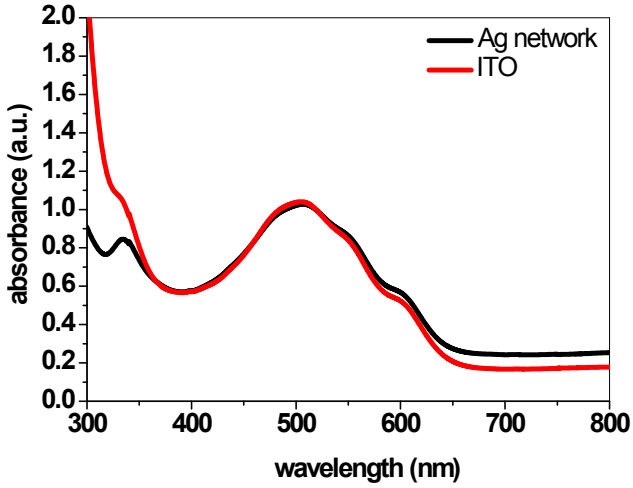

Fig. S3 Absorbance of devices having Ag wire network and ITO TCEs.

The total absorbance of the (P3HT: PCBM) active layer together with ZnO layer, PEDOT:PSS and TCEs, (Ag network or ITO) is measured. As shown in Fig. S3 the absorbance of the organic layer in both devices is very similar. The only difference corresponds to the difference in the absorption of ITO and Ag network in the UV region.