# Supporting Information for

## Hybrid Solar Cells with Outstanding Short-Circuit Currents Based on a Room Temperature Soft-Chemical Strategy: the Case of P3HT:$Ag_2S$

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**Experimental Details**

All of the reactants were commercial available. First, to avoid local short circuits, $15\Omega cm^{-2}$ ITO substrate was etched to form an insulate gap by photoengraving. Second, the ITO substrates with a insulate gap was cleaned in solution of detergent and water, mixed $NH_3 \cdot H_2O:H_2O_2:H_2O$ (volume ratio, 1:2:5) solution and distilled water, orderly. After that, the ITO substrate was dried at 120$^o$C for 2h. A 250 nm silver layer was coated on the ITO substrate by magnetron sputtering in the present of a mask. The pressure in the chamber was about $7.0\times 10^{-3}$ mbar.

The above silver film on the ITO substrate and 0.01g sulfur powders were put into a 20ml vessel, then 15ml N,N-dimethylformamide (DMF) was added. The container was maintained at 25 $^{o}C$ for 8h, after that a black thin film on the ITO substrate was obtained. This thin film was washed with ethanol for several times, and dried in the vacuum drying oven at 80$^{o}C$ for 24h.

The $Ag_2S$ thin film on the ITO substrate was spin-coated with P3HT (Aldrich: regioregular with an average molecular weight, MW=87000) in chloroform or chlorobenzene solution (10mgmL$^{-1}$), then dried at room temperature in glove-box for 24h. Top gold electrode was thermally evaporated on the film through a shadow mask at a pressure around $9.0\times10^{-5}$ mbar. Finally, a hybrid solar cell device with a ~0.15cm$^2$ active area was obtained.

**Characterization**

The obtained thin film was characterized by X-ray diffraction (XRD, Bruker D8 Advance diffractometer) with nickel-filtered CuKα radiation. Morphology of the film was investigated by scanning electron microscopy (SEM, Hitachi S-4800) and atomic force microscope (AFM, Veeco Digital Instruments, Nanoscope IIId). High-resolution transmission electron microscopy (HRTEM) data were obtained from a JEM-2100 transmission electron microscopy (TEM). The samples for TEM analysis were prepared by dispersing the powders scraped from the $Ag_2S$ film in ethanol. The photovoltaic performance of the hybrid solar cell device was measured under illumination of AM 1.5G 100mW/cm$^2$ by using a solar simulator (Newport Inc.). Quantum efficiency data were recorded from Newport QE system, and the Uv-Vis spectrum was obtained from Cary 5000 Uv-Vis-NIR.

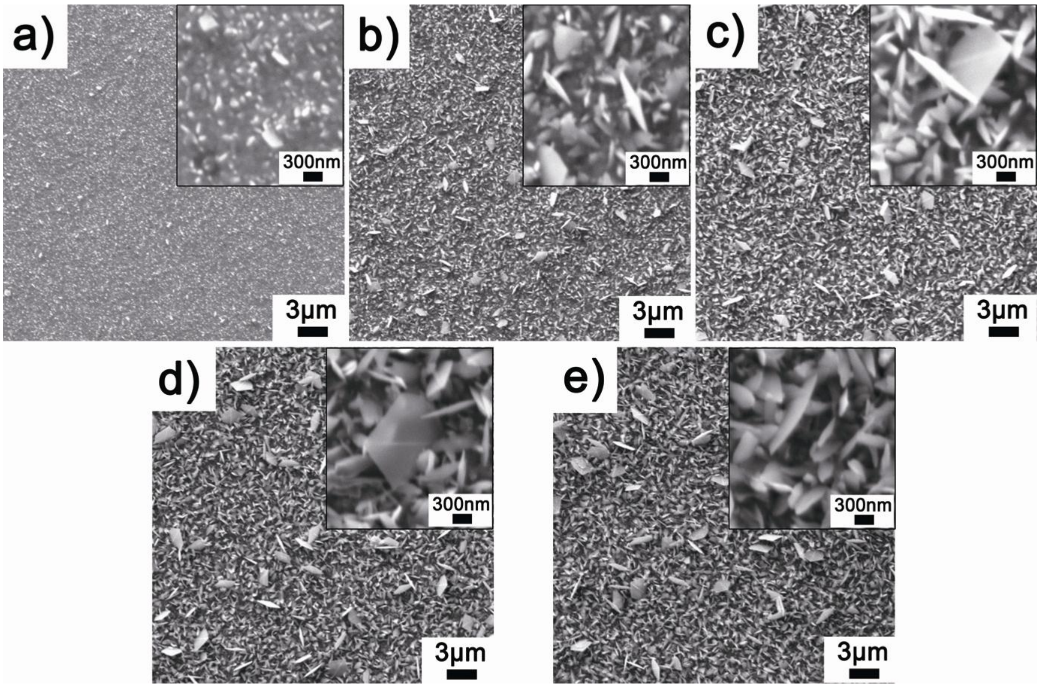


**Figure S1.** Growth process of the $Ag_2S$ nanocrystal on ITO substrate at 25$^{o}$C. a) 2h; b) 4h; c) 6h; d) 8h; e) 10h.

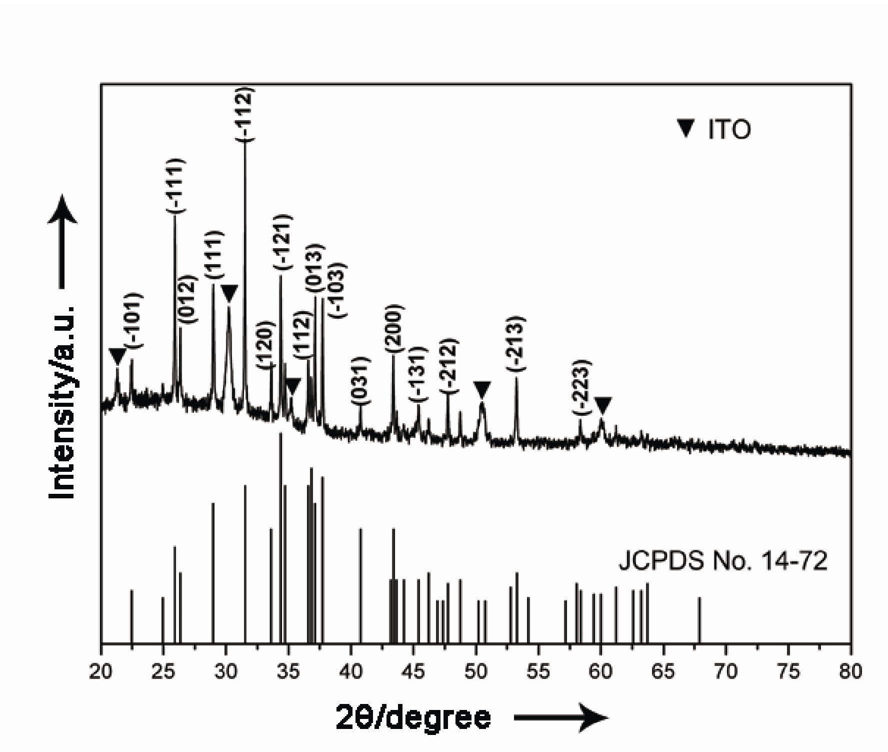


**Figure S2.** XRD patterns of $Ag_2S$ nanosheet film and the standard data.

Figure S2 shows the X-ray diffraction (XRD) pattern of the resulting $Ag_2S$ thin film on the ITO substrate, the diffraction peaks can be well indexed with standard data of the $Ag_2S$ ( JCPDS File No. 14-72, monoclinic), all other diffraction peaks come from the ITO substrate.

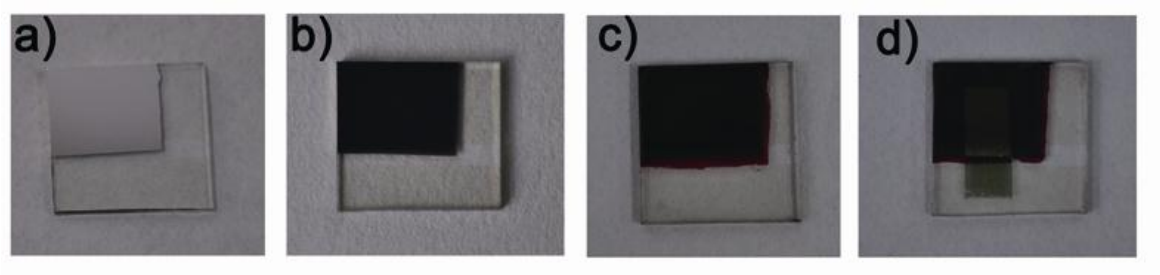


**Figure S3.** Photographs of a) Ag thin film; b) $Ag_2S$ thin film; c) P3HT:$Ag_2S$ composite thin film on patterned ITO substrate; d) hybrid solar cell model based on P3HT:$Ag_2S$.

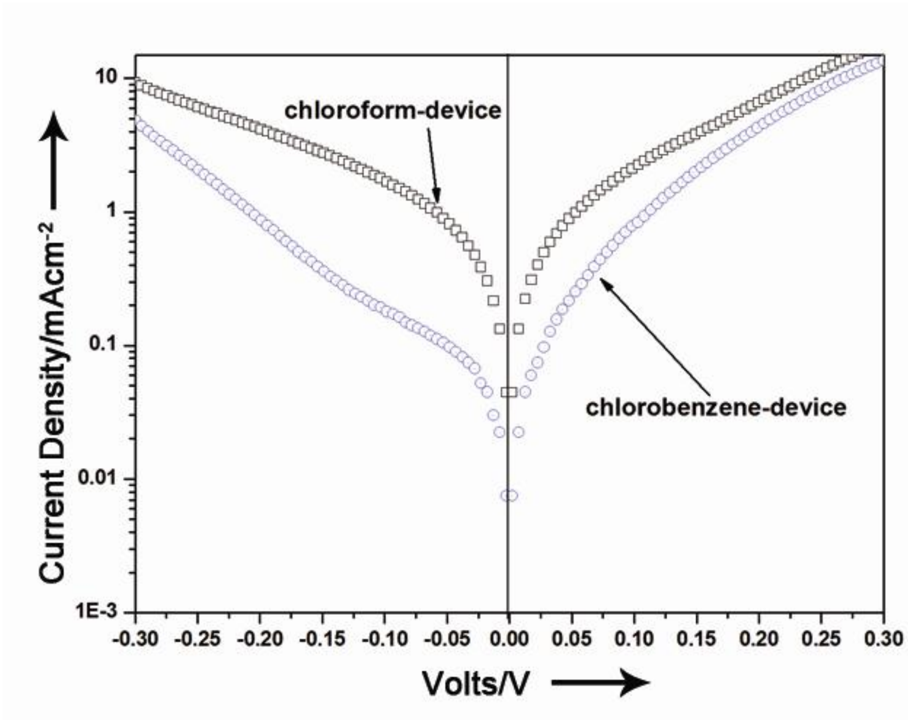


**Figure S4.** Dark current density of P3HT:$Ag_2S$ hybrid solar cell.

Figure S4 reveals that the dark current of the chloroform-device was higher than chlorobenzene-device, according to eqn (1), the chlorobenzene-device will bring out a higher open voltage.

$$\mathrm{Voc} = \frac{nKT}{q}\ln\left(\frac{J_{sc}}{J_{0}}\right) \tag{1}$$

where, $n$ is the ideality factor, $k$ is the Boltzmann constant, $T$ is the temperature, $q$ is the charge of an electron, $J_{sc}$ is the short-circuit current density and $J_o$ is the saturation current density of the device.

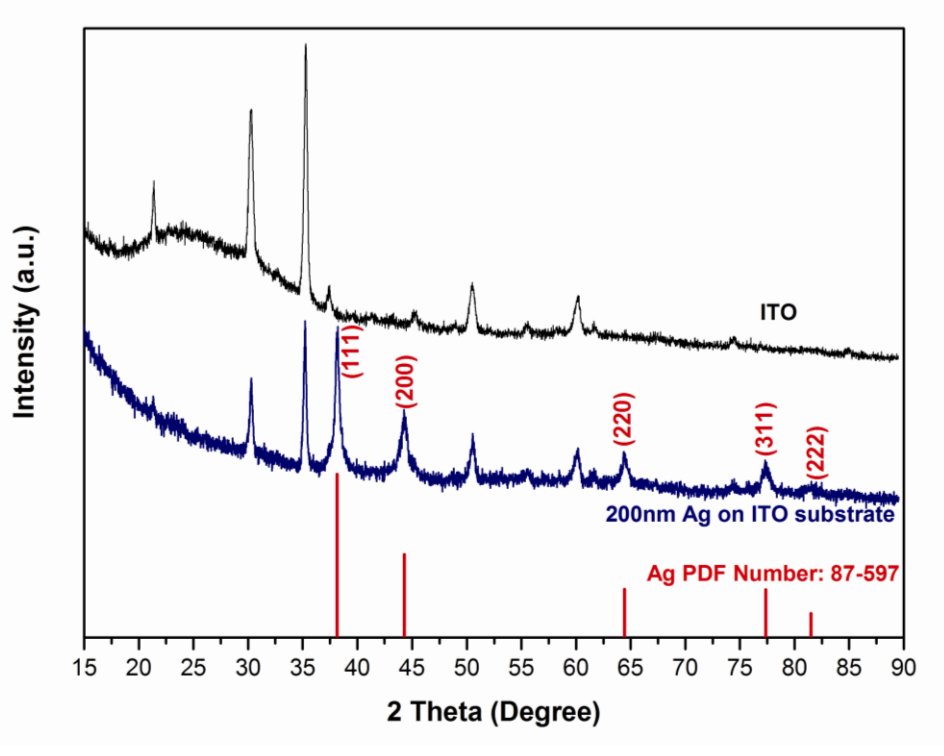


**Figure S5.** XRD pattern of elemental Ag film on ITO substrate after two weeks storage.

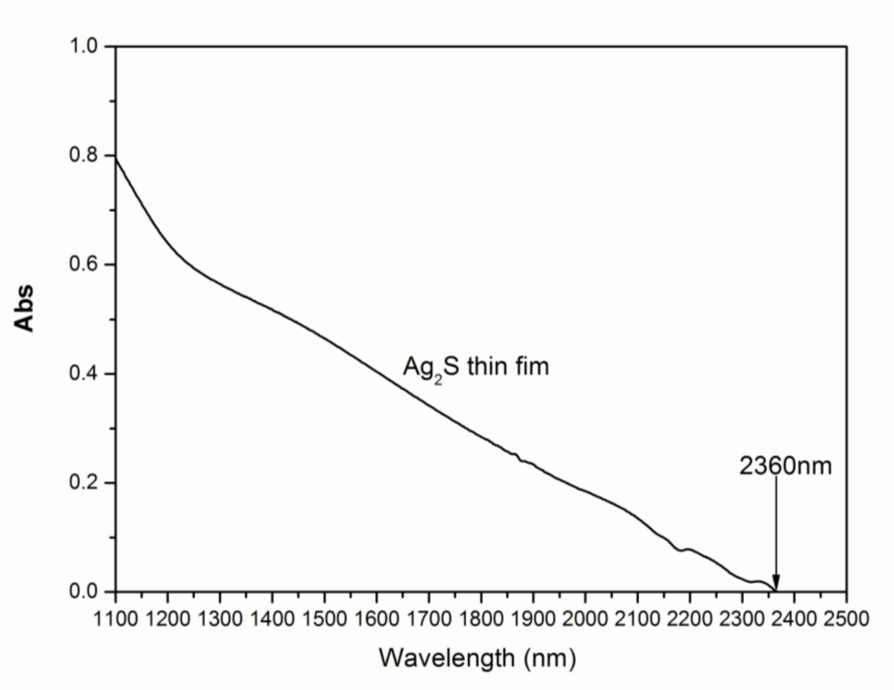


**Figure S6.** The absorption spectrum of $Ag_2S$ thin film in the near-IR region.

**Table S1** Testing data of P3HT:$Ag_2S$ hybrid solar cells

| Solvent | P3HT Concentration (mg/mL) | $V_{oc}$ (V) | $J_{sc}$ (mA/cm$^2$) | FF (%) | PCE (%) |
|---|---|---|---|---|---|
| Chlorobenzene | 15 | 0.21 | 9.15 | 45.37 | 0.89 |
| Chlorobenzene | 5 | Short Circuit | | | |
| Chloroform | 15 | 0.13 | 6.19 | 27.49 | 0.22 |
| Chloroform | 5 | Short Circuit | | | |

In order to demonstrate the feasility of our stretergy for hybrid thin film solar cell devices, we also added a video file as supporting information, in which we demonstrated that our solar cell model could drive a LED even after 8 months storage in a general desiccator without encapsulation. Please download from the following adress: http://www.gmail.com

Account: videomail0000
Password: videomail1111