Supporting information

Organic/a-Si hybrid solar cells with complementary light absorption

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Experimental Section

a-Si solar cell fabrication

The a-Si (p-type/intrinsic/n-type stack) thin film was deposited on FTO glass (NSG Inc., Model name TEC-7, sheet resistance is lower than 10 Ω $sq.^{-1}$) using radio-frequency plasma enhanced chemical vapor deposition. The a-Si multilayers were deposited in separated chambers to prevent from inter-contamination. To obtain properties suitable for better performance of solar cells, each single layer of a-Si stack was optimized individually by tuning the deposition parameters. This inorganic solar cell was demonstrated as the top-cell.

Organic solar cell fabrication

The ITO layer was deposited on the a-Si top-cell using magnetron sputtering, afterward a ~ 40 nm thick PEDOT: PSS (Clevios 4083, purchased from H. C. Starck) layer was spin coated onto the ITO layer. The samples were then annealed on a hot plate at 150 °C for 15 minutes in air. Poly (diketopyrrolopyrrole-terthiophene) (PDPP3T) and [6,6]-phenyl-C_{61}-butyric acid methyl ester ($PC_{61}BM$), and [6,6]-phenyl-C_{71}-butyric acid methyl ester ($PC_{71}BM$) were bought from Solarmer and used as received. The PDPP3T:$PC_{71}BM$ (1:2, weight ratio) and PDPP3T:$PC_{61}BM$ (1:2, weight ratio) was dissolved in dichlorobenzene-chloroform-1,8-diiodooctane (ODCB-CF-DIO, purchased from Sigma-Aldrich Co. Ltd) ternary solvent with a total concentration of 15.0 mg ml^{-1}, respectively. The photoactive layers were spin-coated onto the PEDOT:PSS layer. The thickness of the PDPP3T: PCBM active layer was characterized by a Bruker Dektak-150 stylus profilometry.

Multi-junction device fabrication

The structure of organic/a-Si hybrid multi-junction solar cells was as follows: glass/ FTO/ a-Si/ ITO/ PEDOT: PSS/ PDPP3T: $PC_{61}BM$/ cathode interface layer/ Al (Figure 1a). ITO and PEDOT: PSS double layers were applied as intermediate layer. After spin-coating of PEDOT:PSS and PDPP3T:PCBM layers, devices with Ca/Al as the back-contact were then transferred to the vacuum chamber for metal contact evaporation. 10 nm Ca and 150 nm Al were successively deposited by thermal evaporation. For devices with $PF_{EO}SO_3Na$ CIL, $PF_{EO}SO_3Na$ solution of 0.25 mg ml^{-1} in CH_3OH was spin-coated on top of the active layer. Then the devices were transferred to vacuum chamber for evaporation of Al electrode.

Characterization

A computer-controlled Keithley 2400 source measure unit was used to characterize the J-V performance of solar cells along with an AM 1.5G oriel solar simulator at illumination intensity of 100 mW cm^{-2}. The corresponding external quantum efficiency was characterized on the Enli technology QE-R system. In order to test the EQE of the top and bottom component cells, bias-light with wavelength at 780 nm and 400 nm was applied, respectively. The ultraviolet–visible absorption spectra (UV-Vis) were measured on a Varian Cary 5000 spectrometer. SKPM test was carried out on Bruker Metrology Nanoscope III-D atomic force microscopy at ambient atmosphere. Conducting AFM tips used for this study had a typical spring constant of 2.8 N $m^{-1}$and a resonant frequency of 75 kHz.

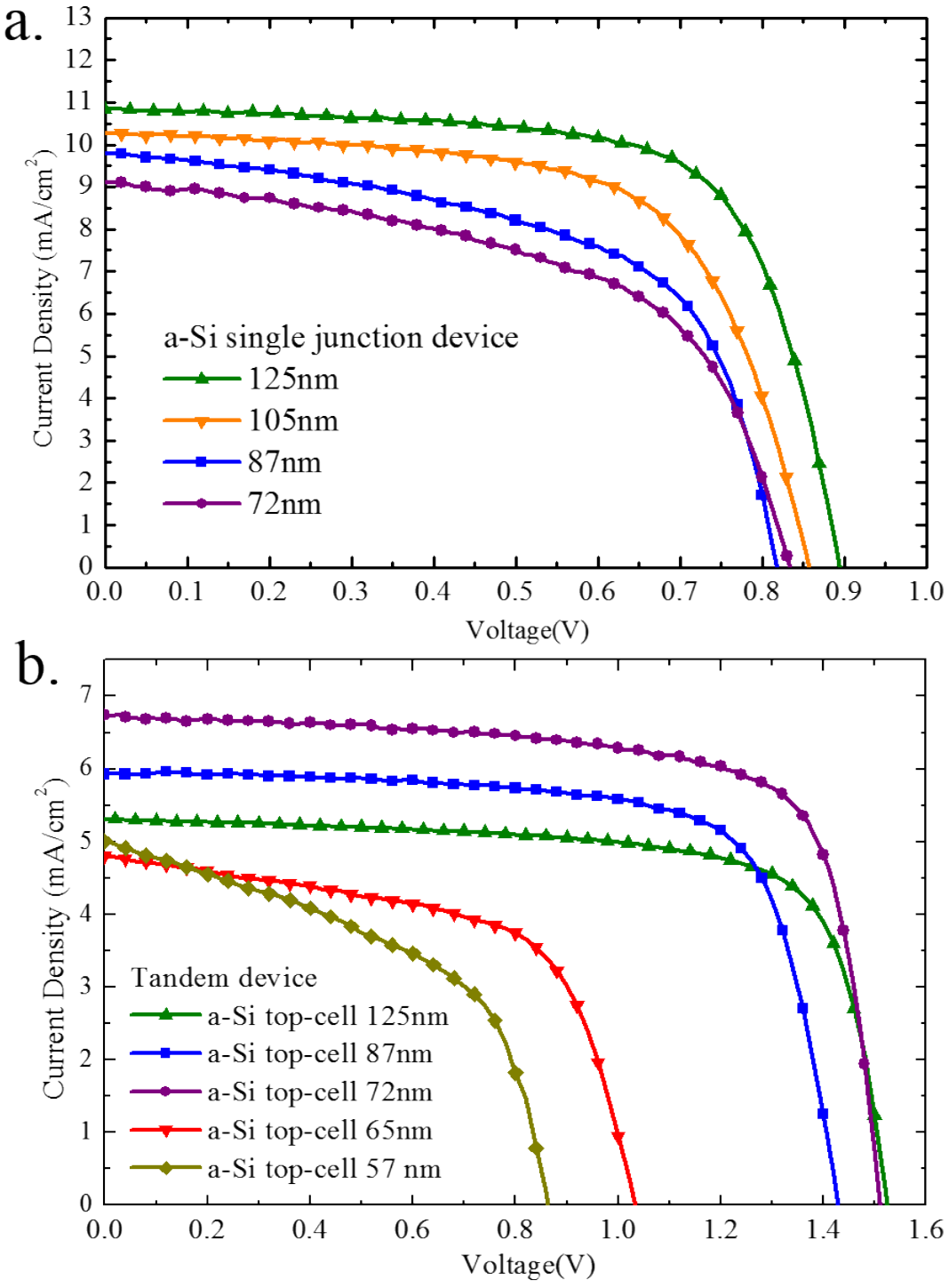

Figure S1 J-V characteristics of (a) single junction a-Si devices with various thickness, and (b) hybrid multi-junction solar cells with different thickness of a-Si top cell.

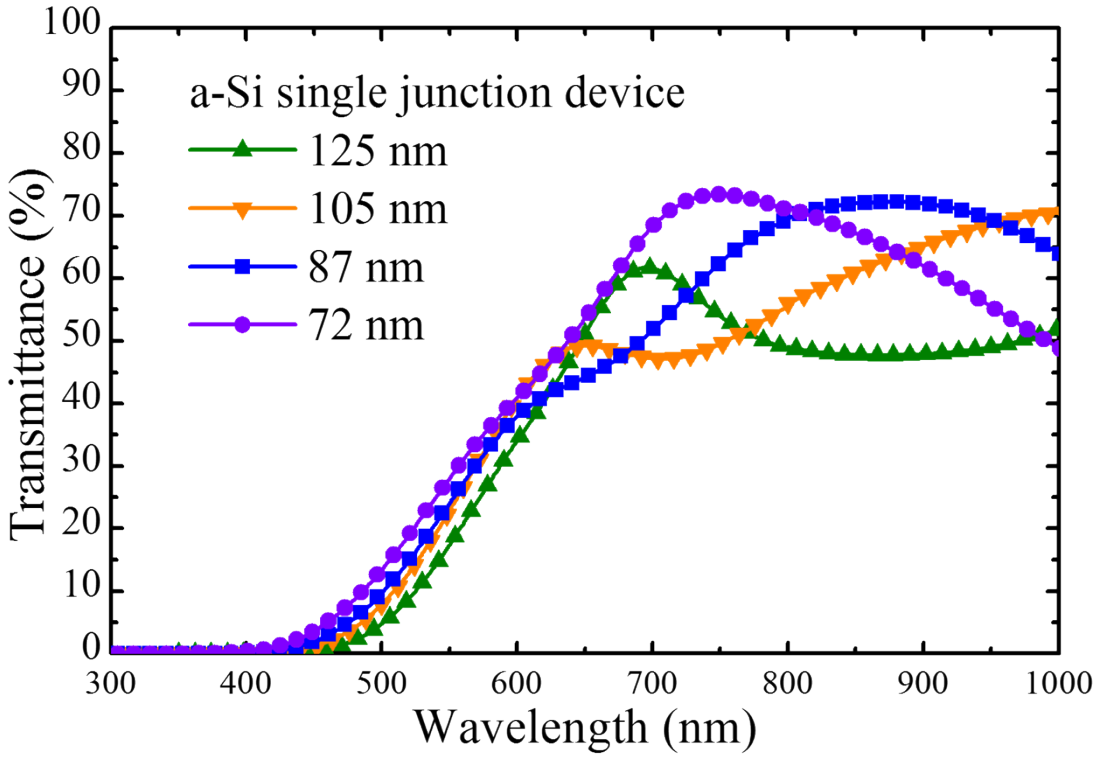

Figure S2 UV-Vis transmittance spectrum of single junction a-Si devices with various thickness.