Electronic Supplementary Information

Combined Influence of Plasmonic Metal Nanoparticle and Dual Cathode Buffer Layer for Highly Efficient rrP3HT: PCBM Based Bulk Heterojunction Solar Cell

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Fig. S1. Graphical representation of resistive device of PEDOT:PSS layer at different concentration of (a) AuNPs and (b) AgNPs. Insert the graph, the schematic of the fabricated resistive device (AL/PEDOTPSS (with or without metal NPS at different concentration/Al) and UV-Vis Spectra of AuNPs and AgNPs are shown.



Fig. S2. UV-vis absorption spectra (in solution) and TEM image (in inset) of (a) AuNPs and (b) AgNPs.



Fig. S3. FESEM images of (a) AuNPs and (b) AgNPs respectively



Fig. S4. FESEM images of PEDOT:PSS doped with 20% (v/v) (a) AuNPs and (b) AgNPs respectively



Fig. S5. AFM topography images (scan size: $2 \ \mu m \times 2 \ \mu m$) of 40 nm thin (a) PEDOT: PSS + AuNPs (~40 nm) and (b) PEDOT: PSS + AgNPs (~50 nm) deposited on the top ITO coated glass substrate. The FESEM images of bare and lager in sized AuNPs and AgNPs are shown in the inset of (a) and (b) respectively.



Fig. S6. (a) GIWAXS images and (b) the corresponding integrated diffraction intensity plot of P3HT:PC₇₁BM active layers on PEDOT: PSS + AgNPs coated thin film.



Fig. S7. AFM topography images (2µm×2µm) of rrP3Ht:PC₆₁BM and rrP3HT:PC₇₁BM blend polymers on PEDOT:PSS+AgNPs and PEDOT:PSS+AuNPs layers respectively.



Fig. S8. GISAXS images of (a) P3HT:PC₆₁BM and (b) P3TH:PC₇₁BM active layers on PEDOT: PSS + AuNPs coated thin film. The corresponding horizontal cuts from the 2D GISAXS data plots are shown in (b) and (d). GISAXS images and its corresponding horizontal cuts from the 2D GISAXS data of P3TH:PC₇₁BM active layers on PEDOT: PSS + AgNPs are shown in (e) and (f) respectively.



Fig. S9. UV-Vis absorption spectra of (a) rrP3HT:PC₆₁BM and (b) rrP3HT:PC₇₁BM BHJ solar cells in presence of bare PEDOT: PSS, PEDOT: PSS + AgNPs and PEDOT: PSS + AuNPs respectively.



Fig. S10. Steady-state photoluminescence (PL) spectra of (a, b) rrP3HT:PC₆₁BM and (c, d) rrP3HT:PC₇₁BM in presence of different concentration of AgNPs and AuNPs respectively.



Fig. S11. Schematic representation of the combined effect of plasmonic metal NPs and BPhen/LiF/Al as the dual cathode buffer layers on rrP3HT: PCBM based bulk heterojunction solar cell with (a) bare PEDOT: PSS, (b) PEDOT:PSS + AgNPs and (c) PEDOT:PSS + AuNPs.



Fig. S12. AFM images of (a) BPhen and (b) BCP on rrP3HT:PC₆₁BM and (c) BPhen and (d) BCP on rrP3HT:PC₇₁BM blend polymer thin film.

Table S1. Summary of the series and shunt resistance value of all the fabricated BHJ devices obtained from J-V characteristics curves.

Blend polymer	Hole Injecting	Device Configuration	R _s	R _{sh}
	Layer (HIL)	with ITO/HIL/Blend	$(\Omega.cm^{-2})$	$(\Omega.cm^{-2})$
		Polymer/		
(i) rrP3HT:PC ₆₁ BM	(a)Bare PEDOT:PSS	(1) LiF/Al	119	4921
		(2) BPhen/LiF/Al	112	5181
		(3) BCP/LiF/Al	100	5257
	(b)PEDOT:PSS+A gNPs	(4) LiF/Al	114	5021
		(5) BPhen/LiF/Al	95	7368
		(6) BCP/LiF/Al	88	8051
	(c)PEDOT:PSS+A uNPs	(7) LiF/Al	103	5089
		(8) BPhen/LiF/Al	99	7442
		(9) BCP/LiF/Al	82	8510
(ii) rrP3HT:PC ₇₁ BM	(a)Bare PEDOT:PSS	(10) LiF/Al	114	5488
		(11) BPhen/LiF/Al	107	6349
		(12) BCP/LiF/Al	103	6435
	(b)PEDOT:PSS+A gNPs	(13) LiF/Al	106	6583
		(14) BPhen/LiF/Al	102	8347
		(15) BCP/LiF/Al	101	8130
	(c)PEDOT:PSS+A uNPs	(16) LiF/Al	104	6775
		(17) BPhen/LiF/Al	98	8944
		(18) BCP/LiF/Al	102	8665