

Electronic Supplementary Information

One-Step Integration of a Multiple-Morphology Gold Nanoparticle Array on a TiO₂ Film via a Facile Sonochemical Method for Highly Efficient Organic Photovoltaics

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Following are the characterizations of multiple-morphology Au NPs and the inverted organic solar cells with and without Au NPs arrays. A comparison table of non exhaustive survey of Au plasmonic enhanced OPVs with P3HT:PC₆₁BM and PTB7:PC71BM blend systems is also presented in following.

Table S1. Non exhaustive survey of Au plasmonic enhanced OPVs with P3HT:PC₆₁BM and PTB7:PC71BM blend systems. The average photovoltaic parameters are compared to those measured for a reference cell without the Au plasmonic nanostructures. The ΔPCE, represents the PCE increase compared to that of the reference cell, are highlighted in bold.

Device architecture	J_{sc} [mA cm ⁻²]	V_{oc} [V]	FF [%]	PCE [%]	ΔPCE [%]	Ref.
PTB7:PC ₇₁ BM/ZnO	16.40	0.738	64.1	7.76	18.3	1
PTB7:PC ₇₁ BM/ZnO-Au NRs	17.73	0.742	69.8	9.18		
PTB7:PCBM	15.94	0.747	68.6	8.17	6.7	2
PTB7:PCBM-Au NSs	16.29	0.752	71.3	8.72		
PEDOT:PSS/PTB7:PC ₇₁ BM	14.74	0.724	55.5	5.92	11.5	3
PEDOT:PSS-Au/PTB7:PC ₇₁ BM	15.43	0.727	58.8	6.60		
PEDOT:PSS/P3HT:PC ₆₁ BM	9.25	0.602	66.2	3.67	15	3
PEDOT:PSS-Au/P3HT:PC ₆₁ BM	9.63	0.621	70.4	4.22		
PEDOT:PSS/P3HT:PC ₆₁ BM	9.47	0.58	65.3	3.42	14	4
PEDOT:PSS-Au/P3HT:PC ₆₁ BM	10.74	0.58	66.1	3.90		
PTB7:PC ₇₁ BM	16.27	0.76	60.1	7.43	8	5
PTB7:PC ₇₁ BM-Au	17.17	0.76	61.4	8.01		
ZnO/P3HT:PC ₆₁ BM	8.98	0.59	51	2.70	20.37	6
ZnO-Au/P3HT:PC ₆₁ BM	10.05	0.60	54	3.25		
ZnO/PTB7:PC ₇₁ BM	17.77	0.73	60.9	7.94	12	7
ZnO-Au/PTB7:PC ₇₁ BM	18.53	0.76	63.4	8.89		
PTB7:PC ₇₁ BM	15.87	0.75	64	7.35	23.7	8
PTB7:PC ₇₁ BM-Au:SR	17.24	0.76	70	9.09		
PTB7:PC ₇₀ BM	14.85	0.74	70.4	7.72	22.8	9
PTB7:PC ₇₀ BM-Au@Ag	18.10	0.74	70.7	9.48		
PTB7:PC ₇₀ BM	13.06	0.746	68.6	6.69	11.4	10
PTB7:PC ₇₀ BM-Au&SiO ₂	14.70	0.751	67.3	7.54		
PTB7:PC ₇₁ BM/MoS ₂	13.36	0.73	63.4	6.18	17.3	11
PTB7:PC ₇₁ BM/MoS ₂ @Au	15.44	0.72	65.2	7.25		
P3HT:PC ₆₁ BM	10.28	0.54	0.62	3.44	16.8	12
P3HT:PC ₆₁ BM-Au&SiO ₂ -OT	11.42	0.55	0.63	4.02		
TiO ₂ /P3HT:PC ₆₁ BM	9.03	0.640	62.9	3.64	17	13
TiO ₂ -Au/P3HT:PC ₆₁ BM	10.35	0.633	65.1	4.26		
TiO ₂ /PTB7:PC ₇₀ BM	15.58	0.71	56	6.23	12.6	14
TiO ₂ /Au/PTB7:PC ₇₀ BM	16.44	0.71	60	7.02		
P3HT:PC61BM	8.98	0.61	68.0	3.67	7.1	15
P3HT:PC61BM-Au&SiO ₂	9.80	0.60	66.9	3.93		
P3HT:PC ₆₁ BM	10.0	0.61	54	3.29	16	16
P3HT:PC ₆₁ BM-Au&SiO ₂	10.6	0.62	57	3.80		
TiO ₂ /P3HT:PC ₆₁ BM	9.38	0.65	61.5	3.73	12.6	17
TiO ₂ -Au/P3HT:PC ₆₁ BM	10.15	0.64	64.8	4.20		
TiO ₂ /PTB7:PC ₇₁ BM	17.23	0.71	65.5	8.02	9	17
TiO ₂ -Au PTB7:PC ₇₁ BM	18.07	0.71	68.1	8.74		
TiO ₂ /P3HT:PC ₆₁ BM	10.29	0.59	57.4	3.42	20.5	This work
TiO ₂ /Au array/P3HT:PC ₆₁ BM	11.47	0.59	60.3	4.12		
TiO ₂ /PTB7:PC ₇₁ BM	16.30	0.76	60.0	7.46	14.5	This work
TiO ₂ /Au array/PTB7:PC ₇₁ BM	17.73	0.76	63.3	8.54		

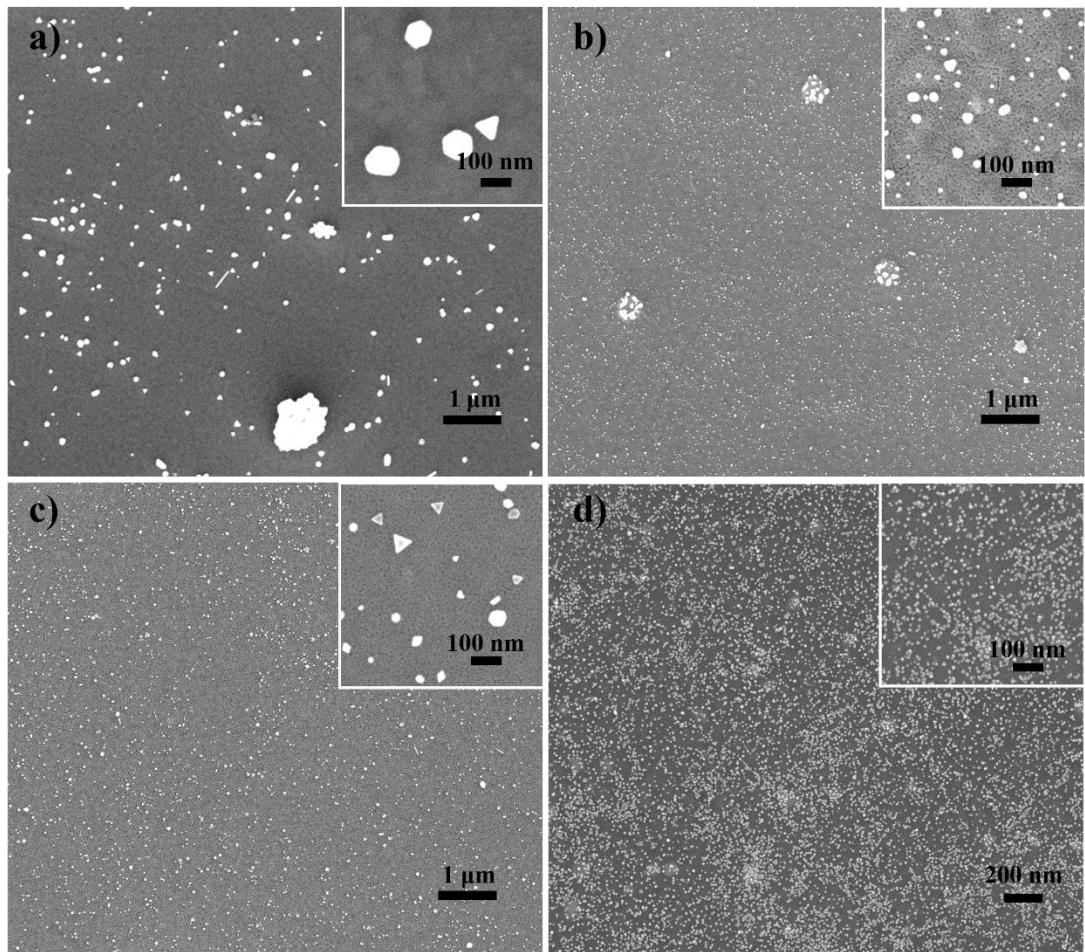


Figure S1. SEM images of Au NPs on TiO_2 films after ultrasonic irradiation for 1 hour in the growth solution with HAuCl_4 concentrations of a) 2, b) 1, c) 0.5, d) 0.25 mmol L^{-1} , respectively.

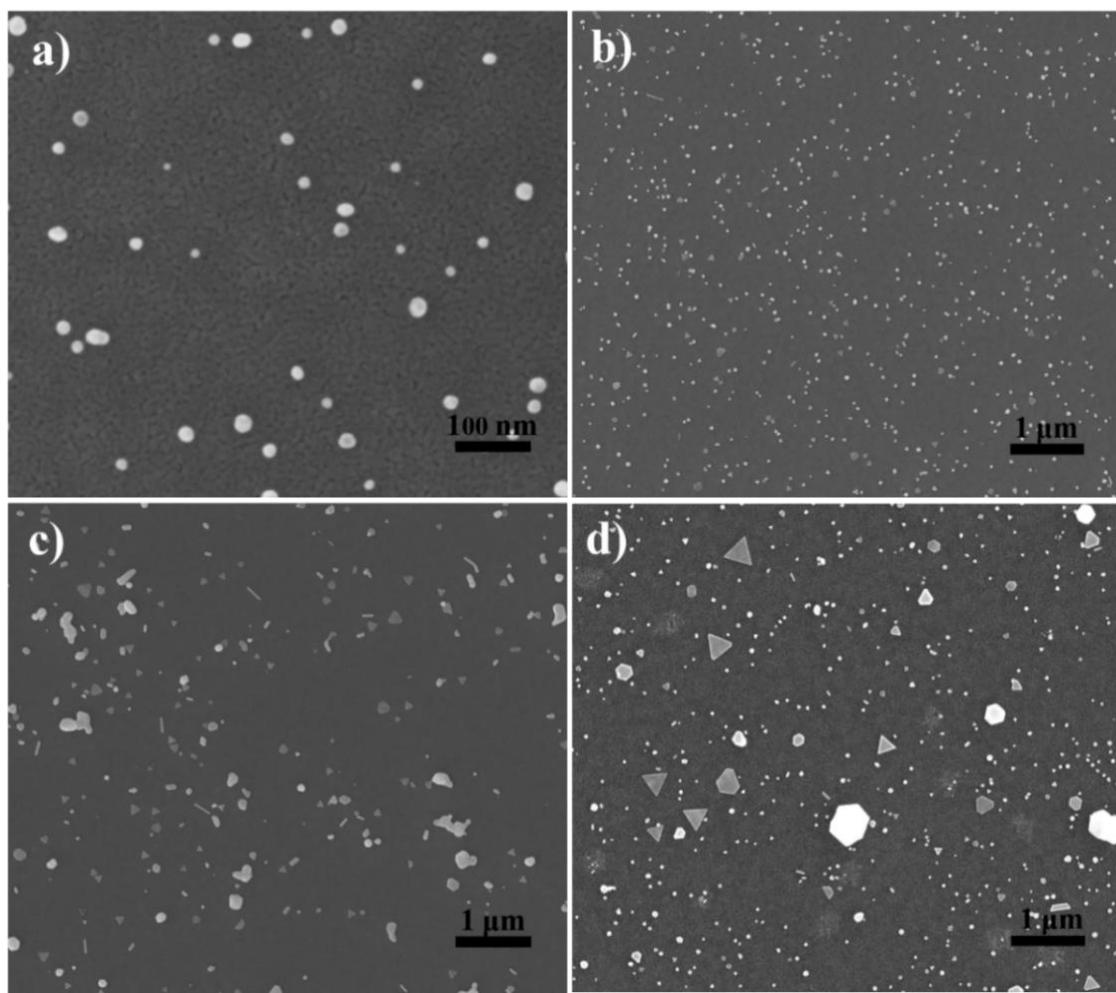


Figure S2. SEM images of Au NPs on TiO_2 films obtained by ultrasonic irradiating for a) 0.5, b) 1, c) 1.5 and d) 2 h in the reaction solution with HAuCl_4 concentrations of 0.5 mmol L^{-1} , and consist of H_2O and $\text{C}_2\text{H}_5\text{OH}$ (1:1 by volume).

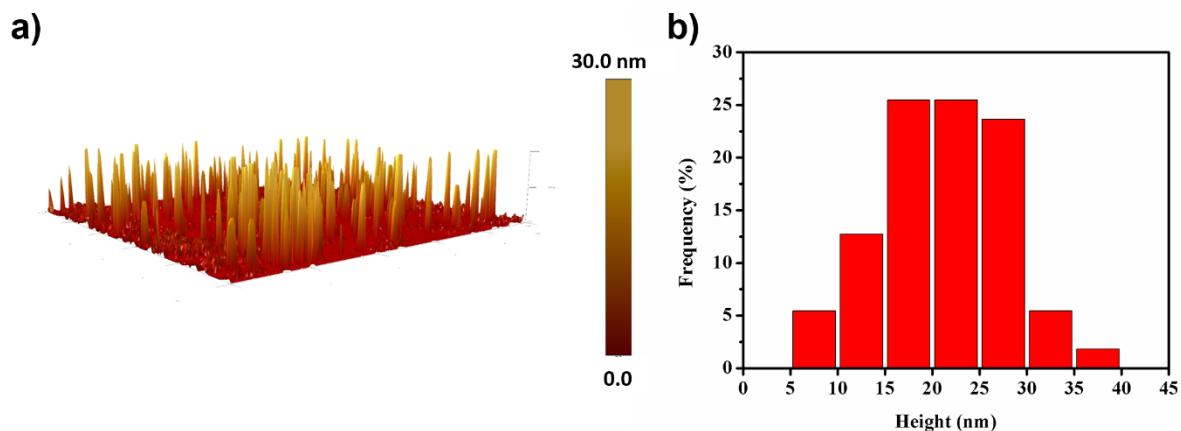


Figure S3. a) Three-dimensional AFM image and b) the statistical distribution of the Au particles obtained by ultrasonic irradiating for 1 h in the reaction solution with HAuCl_4 concentrations of 0.5 mmol L^{-1} , and consist of H_2O and $\text{C}_2\text{H}_5\text{OH}$ (1:1 by volume).

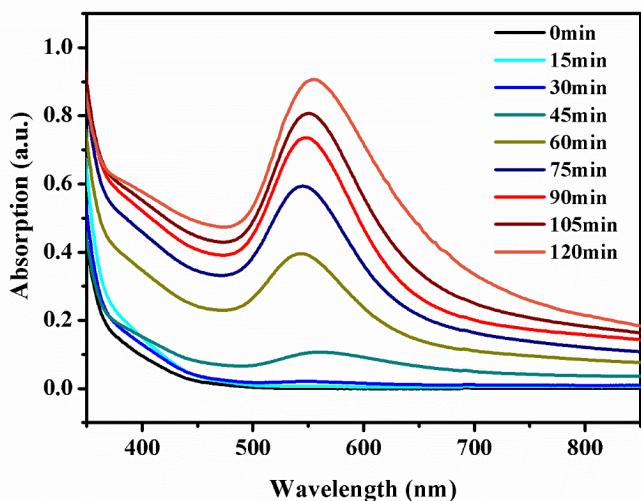


Figure S4.UV-vis spectra of the reaction solutions proceeded different ultrasonic treatment time.

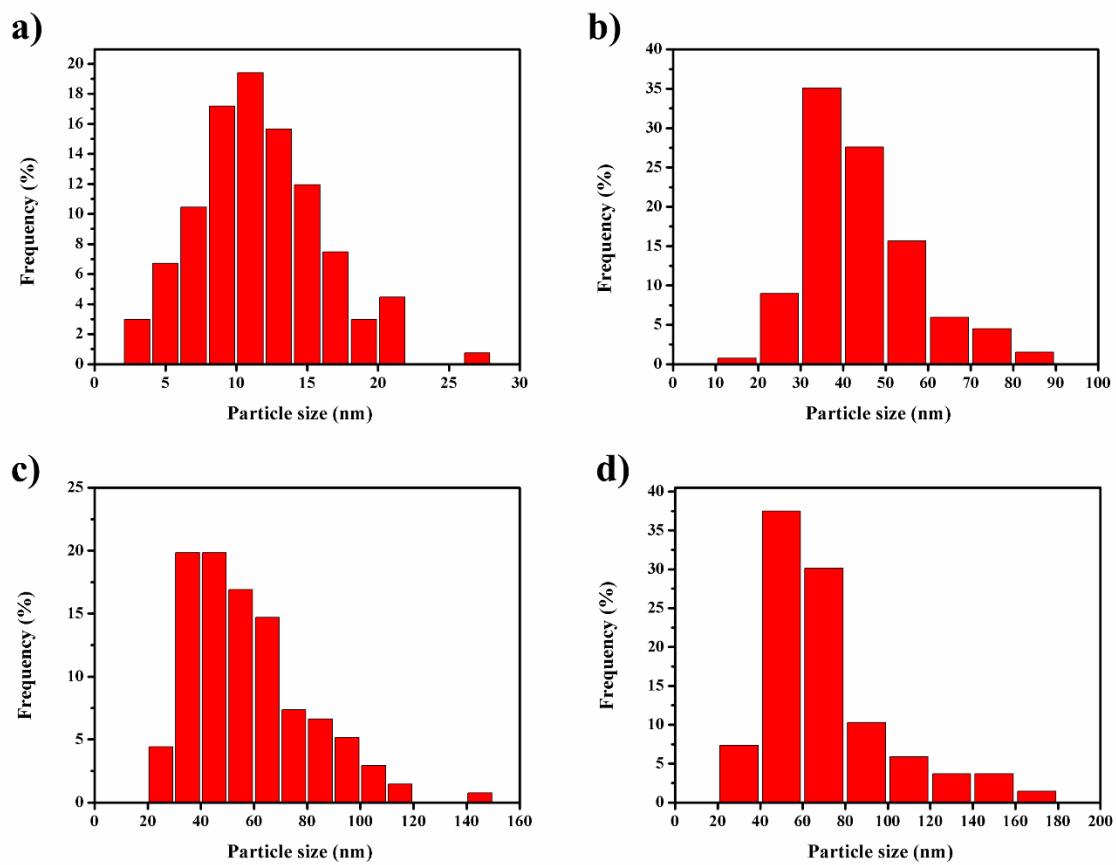


Figure S5. The statistical distribution of the Au particles obtained by ultrasonic irradiating for a) 0.5, b) 1, c) 1.5 and d) 2 h in the reaction solution with HAuCl_4 concentrations of 0.5 mmol L⁻¹, and consist of H_2O and $\text{C}_2\text{H}_5\text{OH}$ (1:1 by volume).

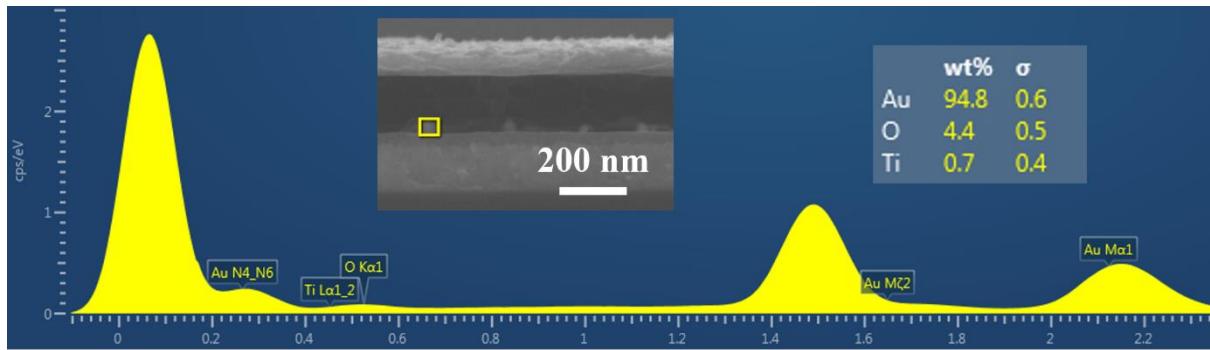


Figure S6. BSE image and EDX spectrum of an Au particle with the composition of Au, O and Ti on the cross-sectional SEM image of P3HT:PC₆₁BM device.

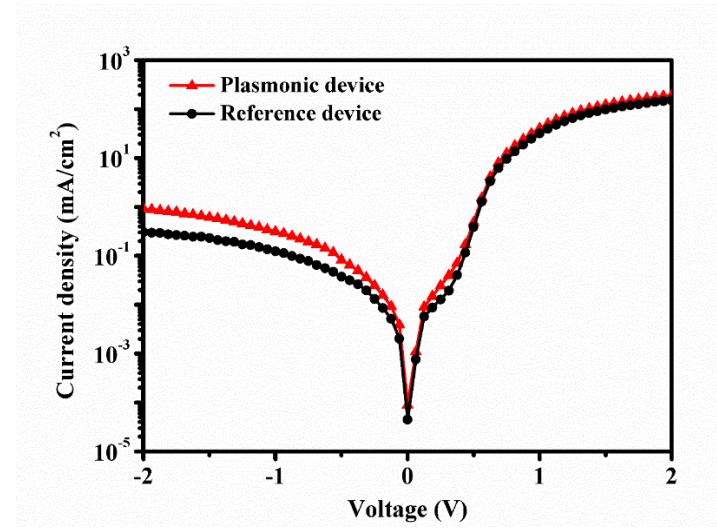


Figure S7. Logarithmic plot of dark J-V characteristics of P3HT:PC₆₁BM devices with and without multiple-morphology Au NPs array.

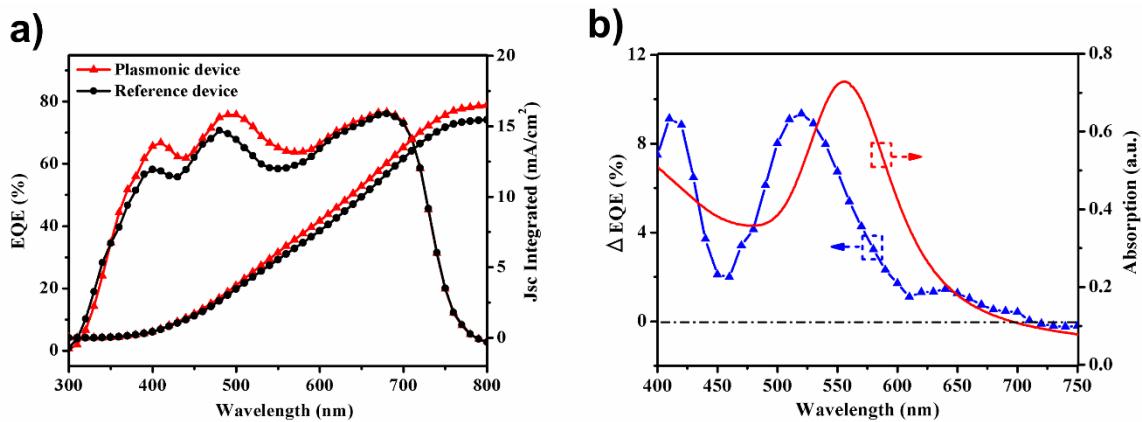


Figure S8. a) EQE spectra of representative reference device and Au NPs array enhanced device with PTB7:PC₇₁BM active layers. b) Δ EQE caused by Au NPs and the absorption spectrum of multiple-morphology Au NPs.

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