Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Electronic Supplementary Information

Highly Efficient, Transparent and Stable Semitransparent Colloidal Quantum Dot Solar Cells: A Combined Numerical Modeling and Experimental Approach

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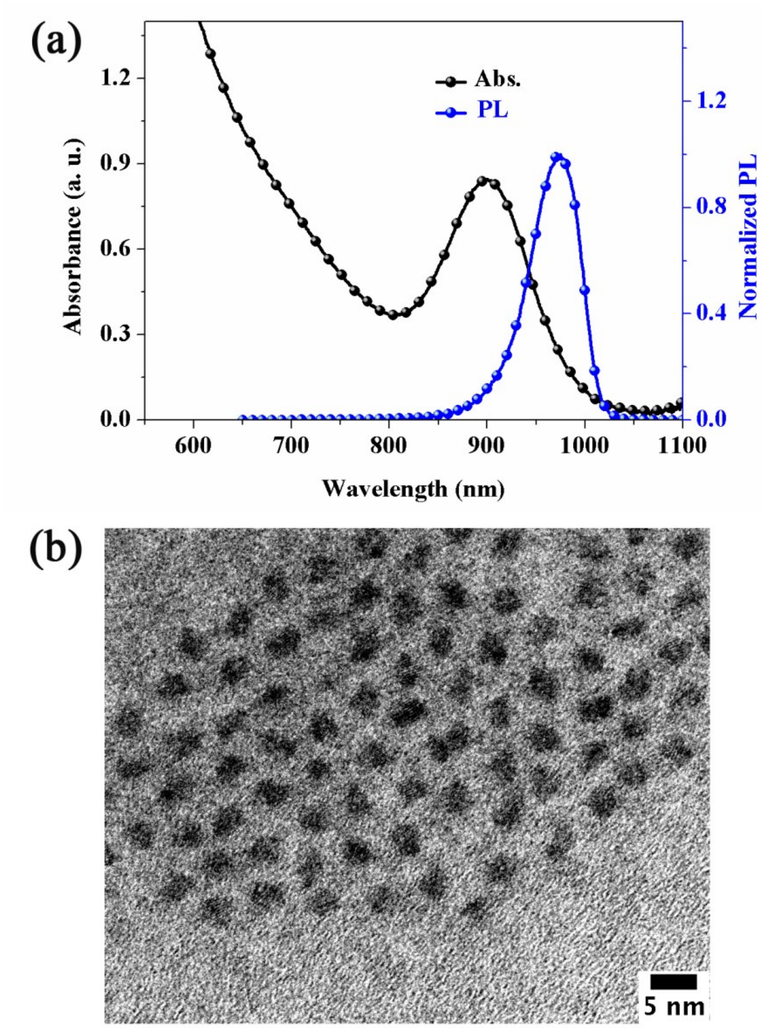

Figure S1. (a) Absorption and normalized photoluminescence spectra of PbS CQDs. (b) TEM image of PbS CQDs.

The high trap density of the CQD film working as light absorber in the solar cell significantly affects the charge carrier collection and therefore solar cell performance. To decrease the trap density of CQD film, PbS CQDs were synthesized according to a previously method,[1] where the CQDs are passivated with oleic acid and treated with molecular iodine to improve the passivation of traps in the CQDs. The results show that a two-fold decrease in trap density in the molecular iodine-treated CQD film, leading to improved charge carrier collection and device performance.[1] Figure S1a shows the light absorption and normalized photoluminescence spectra of the PbS CQDs, which show that the maximum of the absorbance and photoluminescence related to the first exciton transition are at ~899 nm and ~970 nm. Figure S1b shows the TEM image of PbS CQDs, which shows that the dot size is ~3 nm.

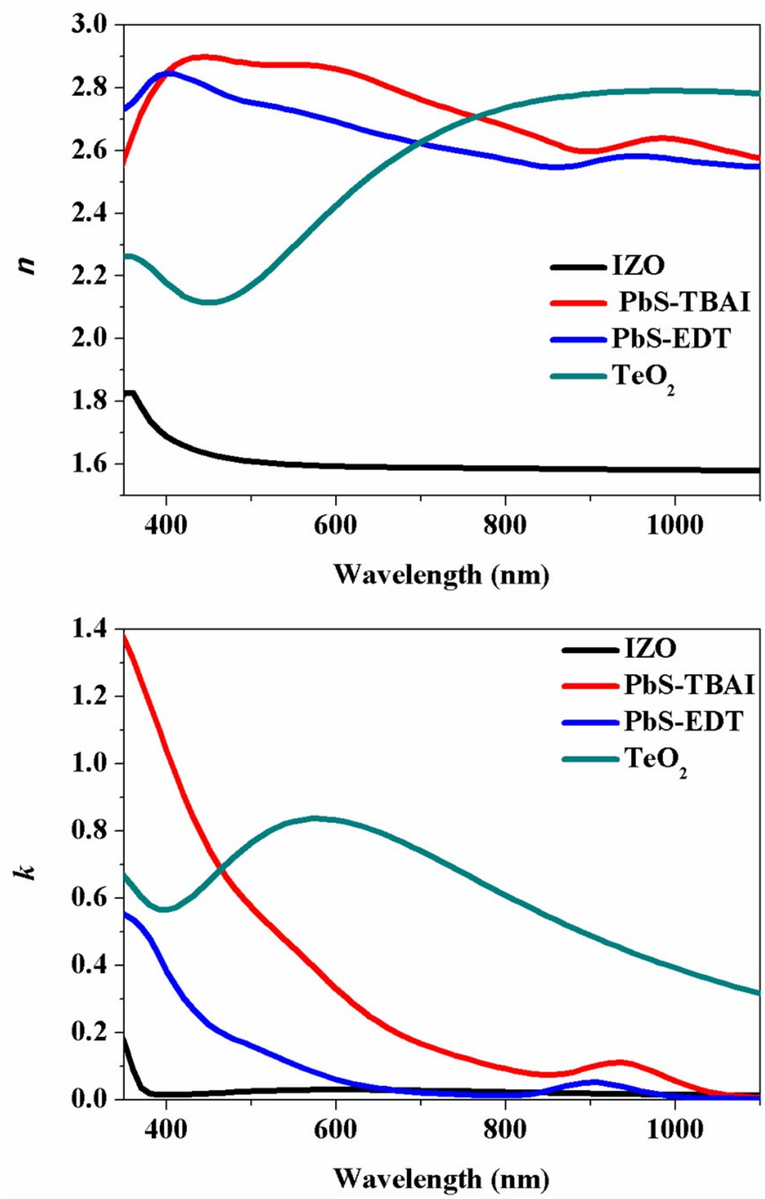

Figure S2. Complex refractive index ($\tilde{n}(\lambda) = n(\lambda) + ik(\lambda)$) of each layer in the SCQDSC.

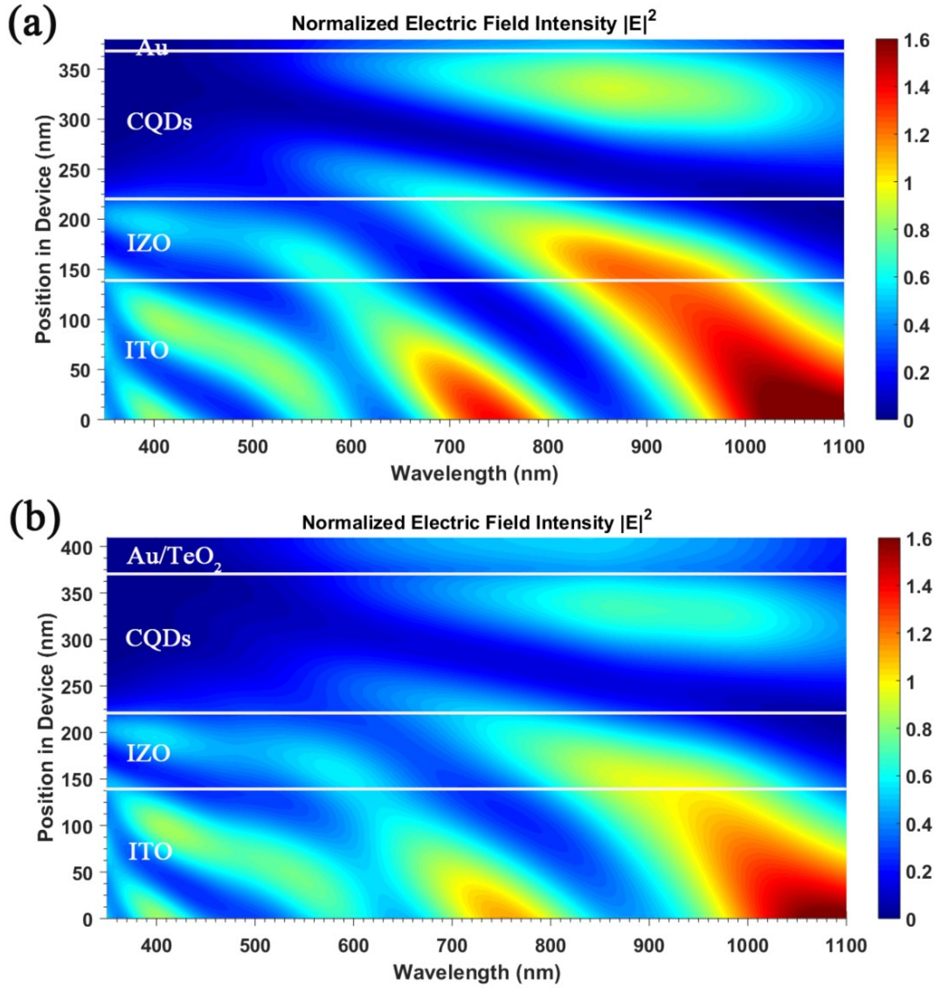

Figure S3. Optical electric field intensity distribution within the SCQDSC (a) without any capping layer and (b) with TeO_2 capping layer.

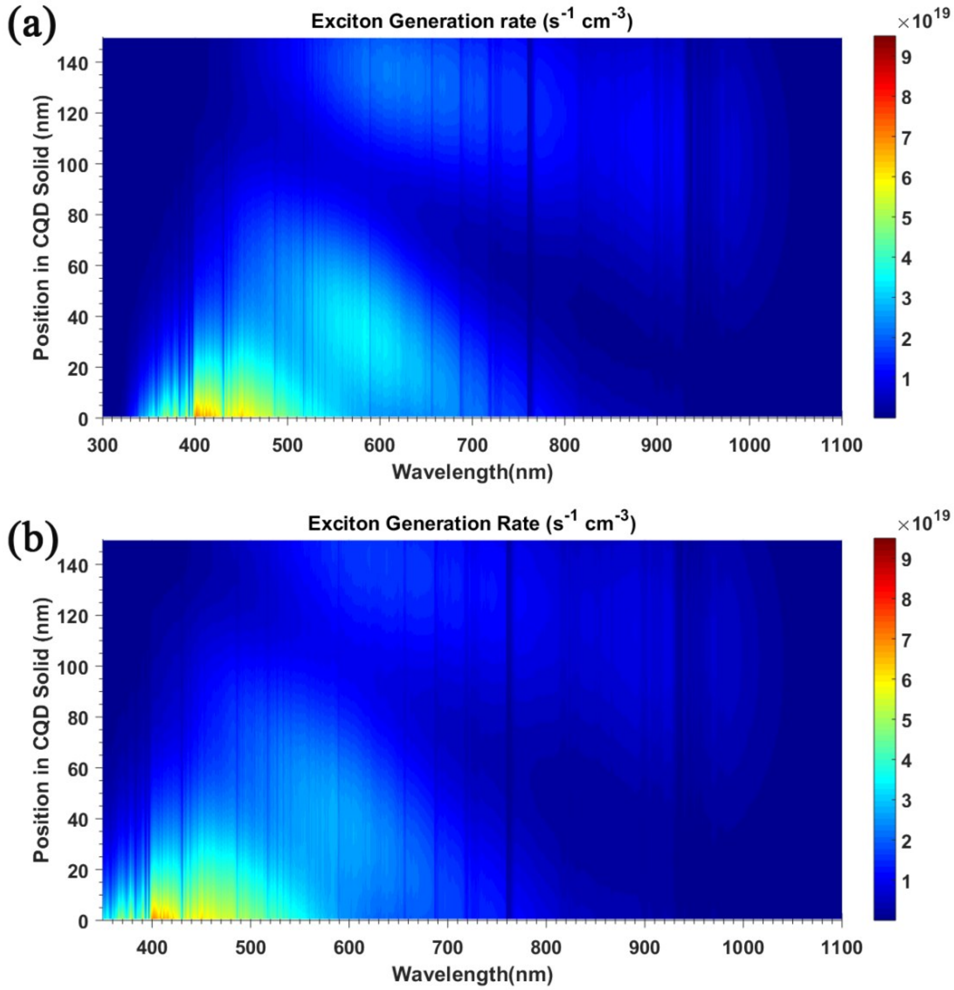

Figure S4. Exciton generation rate within the CQD solid of the SCQDSC (a) without any capping layer and (b) with TeO_2 capping layer.

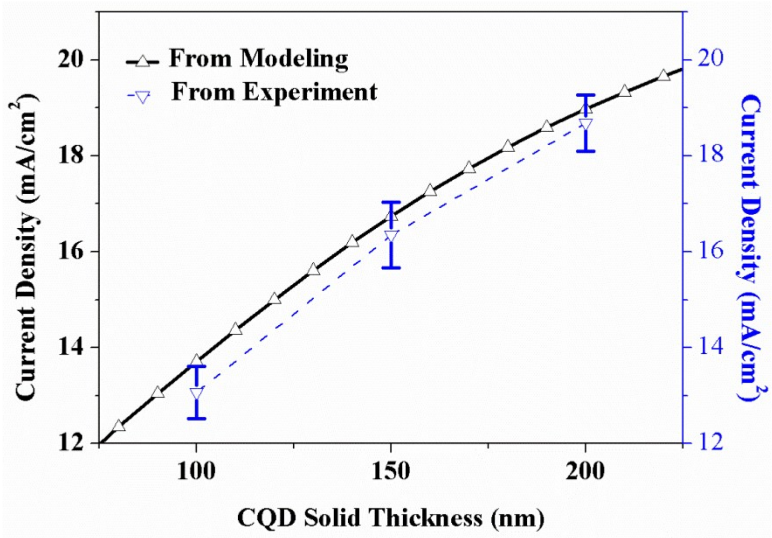

Figure S5. Photocurrent density of SCQDSCs obtained from the modeling and experimental results.

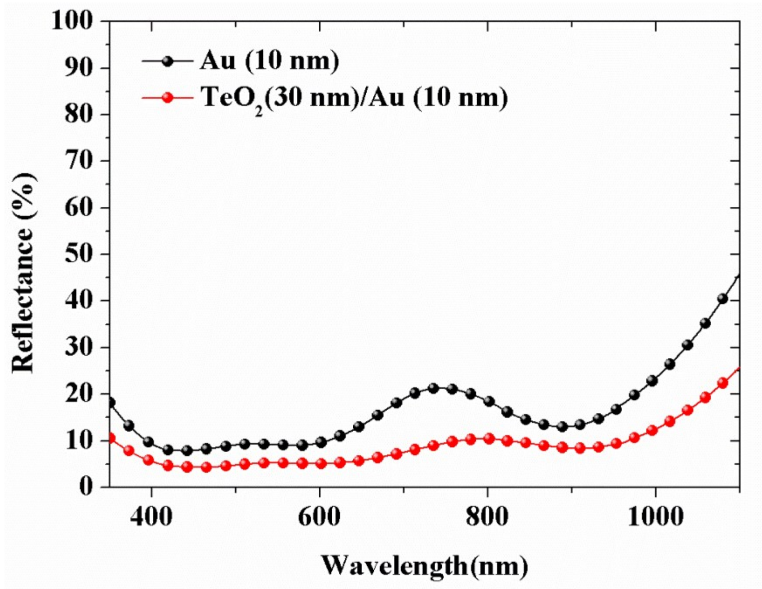

Figure S6. Reflectance spectra of SCQDSC with Au (10 nm) and Au(10 nm)/TeO_2(30 nm), respectively.

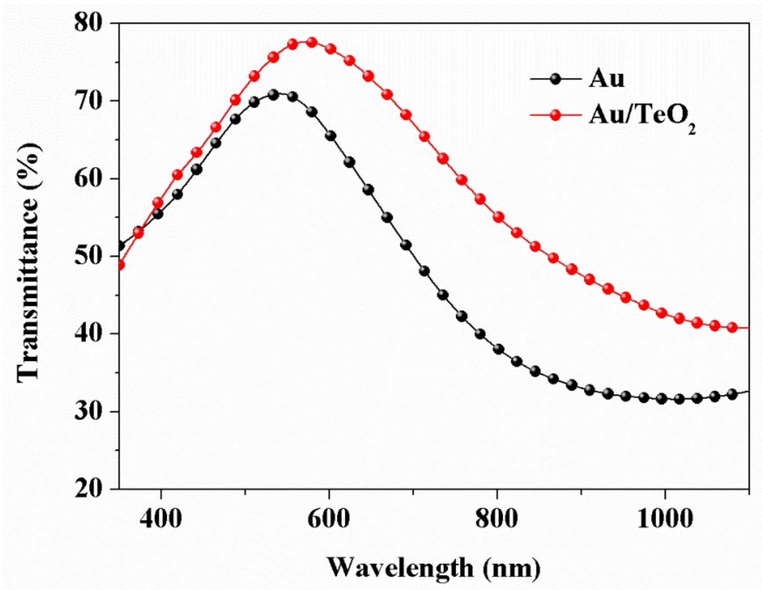

Figure S7. Transmission spectra of Au (10 nm) and Au(10 nm)/TeO_2(30 nm).

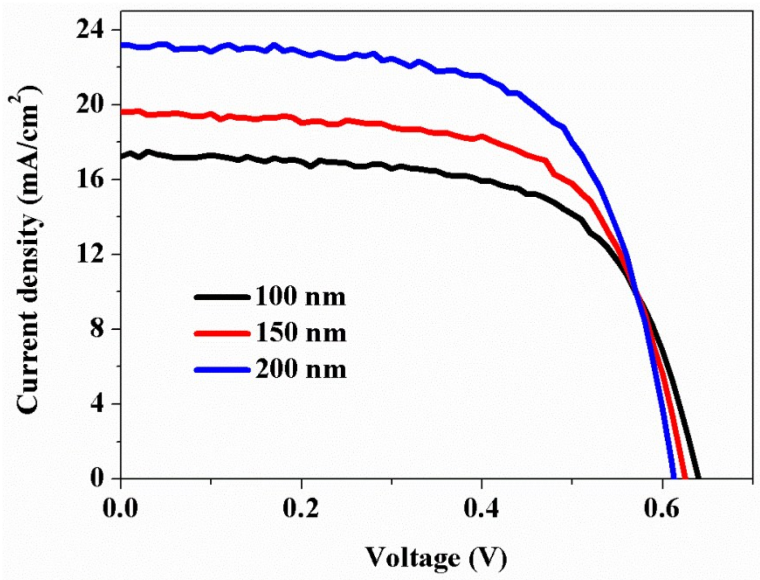

Figure S8. *J-V* curves of the opaque CQD solar cells with different thicknesses of CQD solid and 80 nm thickness of Au electrode.

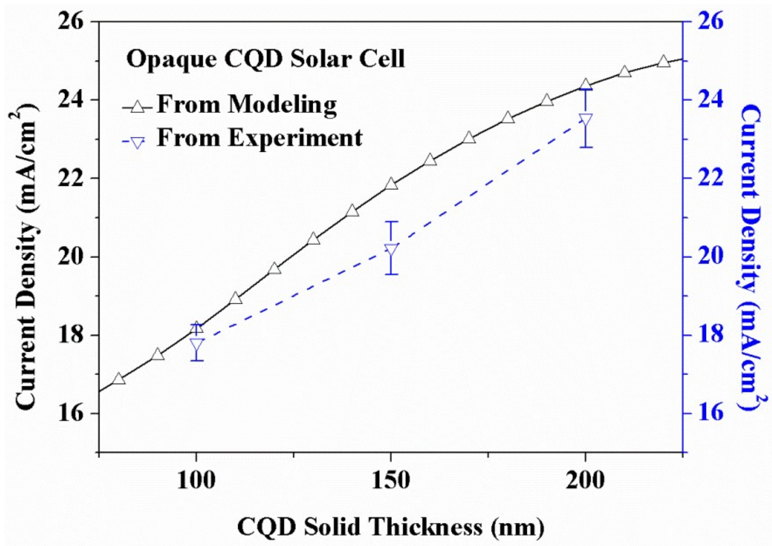

Figure S9. Photocurrent density of opaque CQD solar cells obtained from the modeling and experimental results.

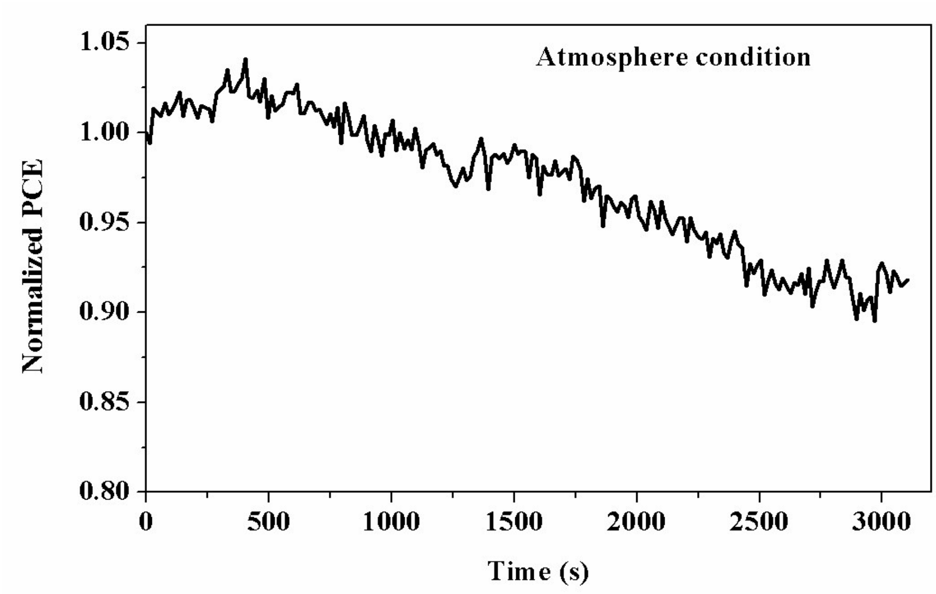

Figure S10. Steady-state normalized PCE of the SCQDSC at the MPP under ambient condition with continuous illumination of AM1.5G 100 mW/cm^2.

Table S1. Summarized photovoltaic performance and transparency of single-junction semitransparent organic solar cells (SOSCs) and SCQDSCs.

Device	V_{oc} (V)	J_{sc} (mA/cm^2)	*FF*	*PCE* (%)	Transparency (%)	Ref.
SOSCs	0.76	13.01	0.63	6.22	21.3 (AVT)	2
	0.73	13.0	0.58	5.50	48 (AVT)	3
	0.77	9.3	0.56	4.02	66 (at 550 nm)	4
SCQDSCs	0.58	12.83	0.52	3.88	22.74 (AVT)	5
	0.56	18.2	0.53	5.40	24.1 (AVT)	6
	0.61	18.4	0.65	7.30	20.4 (AVT)	This work

AVT: average visible transmittance

Table S2. Photovoltaic parameters of the opaque CQD solar cells with different thicknesses of CQD solid layer and 80 nm thickness of Au electrode.

Thickness (nm)	V_{oc} **(V)**	J_{sc} **(mA/cm^2)**	***FF***	***PCE*** **(%)**
100	**0.63**	**17.23**	**0.66**	**7.1**
150	**0.62**	**19.63**	**0.65**	**7.9**
200	**0.61**	**23.24**	**0.65**	**9.2**

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