

Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A
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Supporting Information

Performance Improvement of Perovskite Solar Cell by Employing CdSe Quantum Dot/PCBM Composite as Electron Transport Layer

Xiaofeng Zeng,^{†a} Tingwei Zhou,^{†a} Chongqian Leng,^b Zhigang Zang,^{*a} Ming Wang,^a Wei Hu,^a
Xiaosheng Tang,^a Shirong Lu,^b Liang Fang^c and Miao Zhou^{*a}

^a Key Laboratory of Optoelectronic Technology & Systems (Ministry of Education), College of Optoelectronic Engineering, Chongqing University, Chongqing 400044, China. [†]These authors contribute equally to the paper.

* Email: zangzg@cqu.edu.cn, mzhou@cqu.edu.cn.

^b Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences, Chongqing 401122, China.

^c Department of Applied Physics, College of Physics, Chongqing University, Chongqing 401331, China.

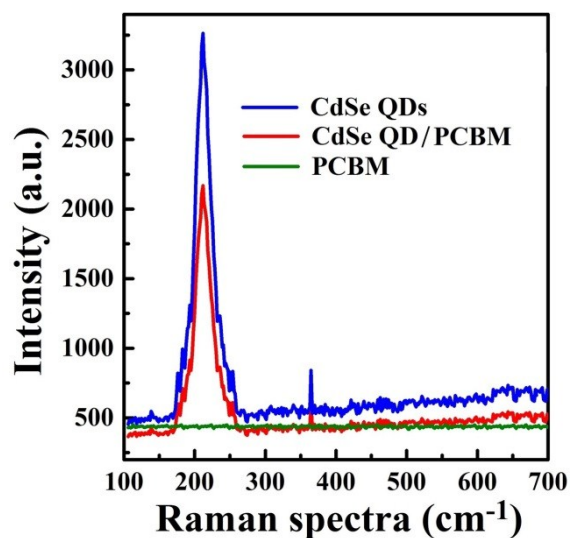


Figure S1. Raman spectra of CdSe QDs, CdSe QD/PCBM composite and PCBM.

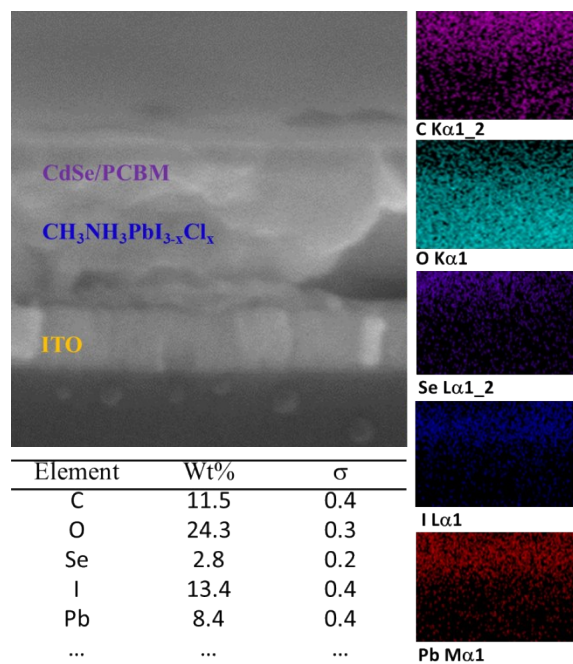


Figure S2. Cross-sectional SEM image, EDS elemental mapping and compositional analysis of CdSe/PCBM composites on $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$ perovskite.

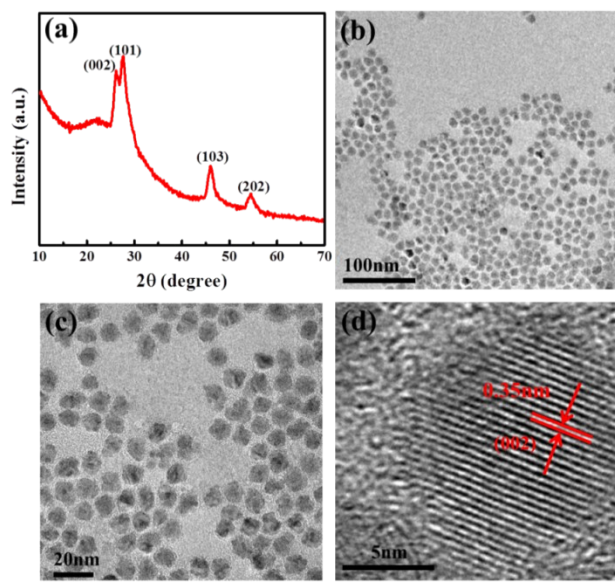


Figure S3. (a) XRD pattern, (b-c) TEM and (d) HRTEM of pure CdSe QDs.

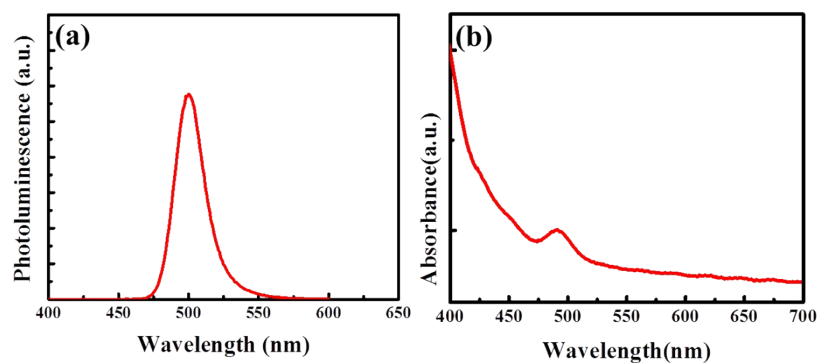


Figure S4. (a) PL spectra and (b) UV-vis spectra of pure CdSe QDs.

Table S1. Photovoltaic parameters measured from a batch of 30 devices with CdSe/PCBM composite as ETL for solar cells.

PCE (%)	J_{sc} (mA/cm ²)	V_{oc} (V)	FF (%)
10.46	17.61	0.92	64.74
13.73	20.95	0.90	73.16
12.81	20.92	0.88	69.25
11.32	18.98	0.90	66.62
10.61	19.42	0.87	62.62
12.96	20.16	0.93	69.17
11.85	17.35	0.98	70.03
10.61	17.51	0.94	64.40
12.74	17.75	0.95	75.37
11.59	17.23	0.95	70.63
12.77	18.97	0.93	72.41
12.69	18.24	0.98	71.36
11.42	17.27	0.94	70.29
12.41	18.61	0.93	71.76
12.73	18.73	0.93	73.10
12.50	18.65	0.92	73.00
11.97	18.22	0.93	70.70
9.78	16.46	0.93	63.91
11.97	17.80	0.91	74.18
12.49	19.38	0.91	71.13
11.85	18.80	0.91	69.55
12.51	19.86	0.90	70.33
11.58	19.13	0.90	67.60
12.90	19.07	0.96	70.20
12.56	19.34	0.94	69.01
11.62	19.66	0.87	67.75
11.19	19.36	0.87	66.28

12.35	18.72	0.94	70.11
12.30	19.49	0.90	70.48
12.04	18.63	0.91	71.28

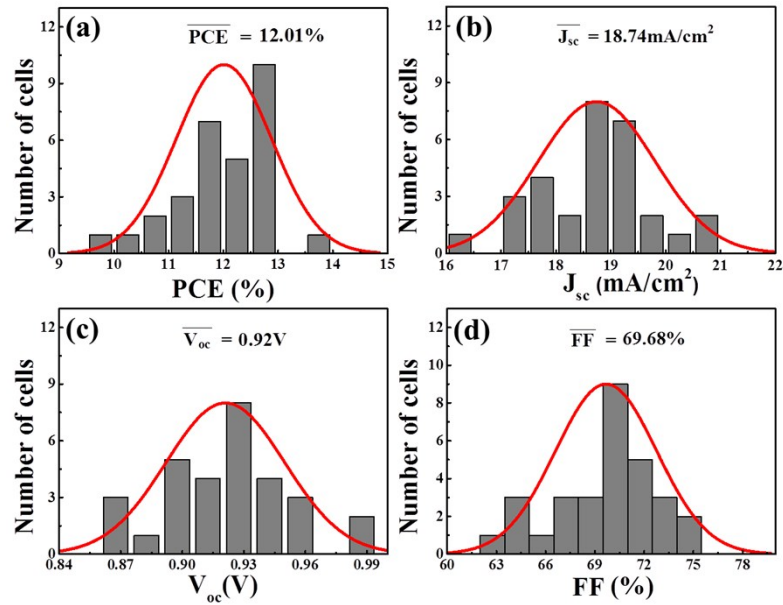


Figure S5. Histogram of PCE, V_{oc} , FF and J_{sc} measured from 30 solar cells with CdSe/PCBM composite as ETL. The averaged value for each parameter is also shown.

Table S2. Series resistance (R_s) and shunt resistance (R_{sh}) of devices with pure PCBM and CdSe/PCBM composite with 1%, 5% and 10% ratio of CdSe as ETL.

ETL	R_s (ohm)	R_{sh} (ohm)
PCBM	65.76	5151.07
1%	56.62	5421.21
5%	48.88	6023.12
10%	53.57	4679.68

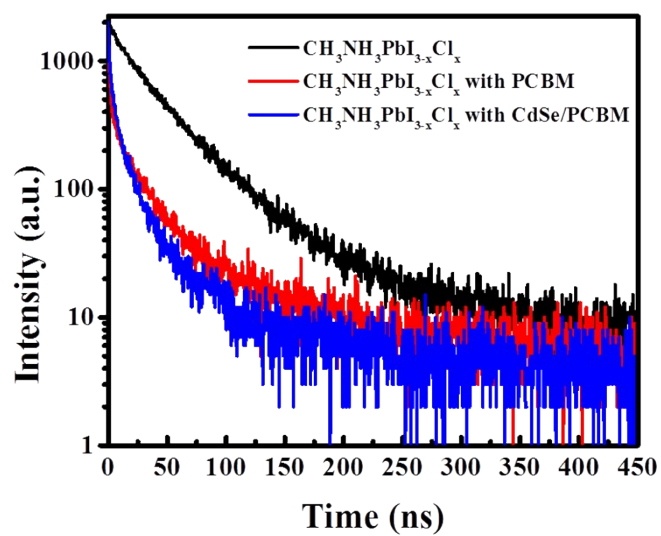


Figure S6. PL lifetime of pure $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$ layer, $\text{CH}_3\text{NH}_3\text{PbI}_{3-x}\text{Cl}_x$ layer with PCBM and CdSe/PCBM composite as ETL at 365 nm.

Table S3. Photovoltaic parameters of solar cell by using CdSe QDs as ETL.

PCE (%)	J_{sc} (mA/cm ²)	V_{oc} (V)	FF (%)
0.96	2.24	0.74	58.50