Supporting Information

Bright and Efficient Light-emitting Diodes Based on MA/Cs Double Cation Perovskite Nanocrystals

Bing Xu, Weigao Wang, Xiaoli Zhang, Wanyu Cao, Dan Wu, Sheng Liu, Haitao Dai, Shuming Chen, Kai Wang*, Xiaowei Sun**

Dr. B. Xu, Mr. W. Wang, Dr. X. Zhang, Prof. S. Chen, Prof. K. Wang, Prof. X. W. Sun

Department of Electrical & Electronic Engineering, Sourthern University of Science and Technology, Shenzhen, 518055, China

*E-mail: chensm@sustc.edu.cn, wangk@sustc.edu.cn, sunxw@sustc.edu.cn

Ms. D. Wu

School of Electrical & Electronic Engineering, Nanyang Technological University, 50 Nanyang Avenue, 639798, Singapore

Ms. W. Cao, Prof. H. Dai

Tianjin Key Laboratory of Low Dimensional Materials Physics and Preparing Technology, School of Science, Tianjin University, Tianjin 300072, China

Dr. B. Xu, Dr. X. Zhang, Prof. S. Liu

School of Power and Mechanical Engineering, Wuhan University, Wuhan, 430072, China

Table S1 The summary of perovskite nanocrystals LED

Perovskite Emitting layer	EL peak (nm)	Von (V)	Max. L. (cd/m^2)	Max. EQE (%)	Max. CE (cd/A)	Ref.
$MACsPbBr_3$ NCs	523	3.0	24510	1.3	4.1	Our work
$CsPbBr_3$ QD	516	4.2	946	0.12	0.43	1
$CsPbBr_3$ QD	516	3.5	1377	0.06	0.19	2
$CsPbBr_3$ QD	523	2.6	2335	0.19	0.75	3
$CsPbBr_3$ QD	527	4.6	3853	2.21	8.98	4
$CsPbBr_3$ QD	527	3.0	407	0.008	0.035	5
$MAPbBr_3$ NPs	521	2.9	2503	1.1	4.5	6
$MAPbBr_3$ NCs	534	-	-	1.2	-	7
$MAPbBr_3$ amorphous NPs	505	2.8	11830	3.8	11.49	8

Reference

1. J. Song, J. Li, X. Li, L. Xu, Y. Dong, H. Zeng, *Adv. Mater.*, 2015, 27, 7162.
2. X. Zhang, H. Lin, H. Huang, C. Reckmeier, Y. Zhang, W. C. H. Choy, A. L. Rogach, *Nano Lett.*, 2016, 16, 1415.
3. G. Li, F. W. R. Rivarola, N. J. L. K. Davis, S. Bai, T. C. Jellicoe, F. de la Peña, S. Hou, C. Ducati, F. Gao, R. H. Friend, N. C. Greenham, Z.-K. Tan, *Adv. Mater.*, 2016, 28, 3528.
4. X. Zhang, B. Xu, J. Zhang, Y. Gao, Y. Zheng, K. Wang, X. W. Sun, *Adv. Funct. Mater.*, 2016, 26, 4595.
5. N. Yantara, S. Bhaumik, F. Yan, D. Sabba, H. A. Dewi, N. Mathews, P. P. Boix, H. V. Demir, S. Mhaisalkar, *J. Phys. Chem. Lett.*, 2015, 6, 4360.
6. H. Huang, F. Zhao, L. Liu, F. Zhang, X.-G. Wu, L. Shi, B. Zou, Q. Pei, H. Zhong, *ACS Appl. Mater. Interfaces*, 2015, 7, 28128.
7. S. G. R. Bade, J. Li, X. Shan, Y. Ling, Y. Tian, T. Dilbeck, T. Besara, T. Geske, H. Gao, B. Ma, K. Hanson, T. Siegrist, C. Xu, Z. Yu, *ACS Nano*, 2016, 10, 1795.

8. H. Huang, F. Zhao, L. Liu, F. Zhang, X. G. Wu, L. Shi, B. Zou, Q. Pei, H. Zhong, *ACS Appl. Mater. Interfaces*, 2015, 7, 28128.

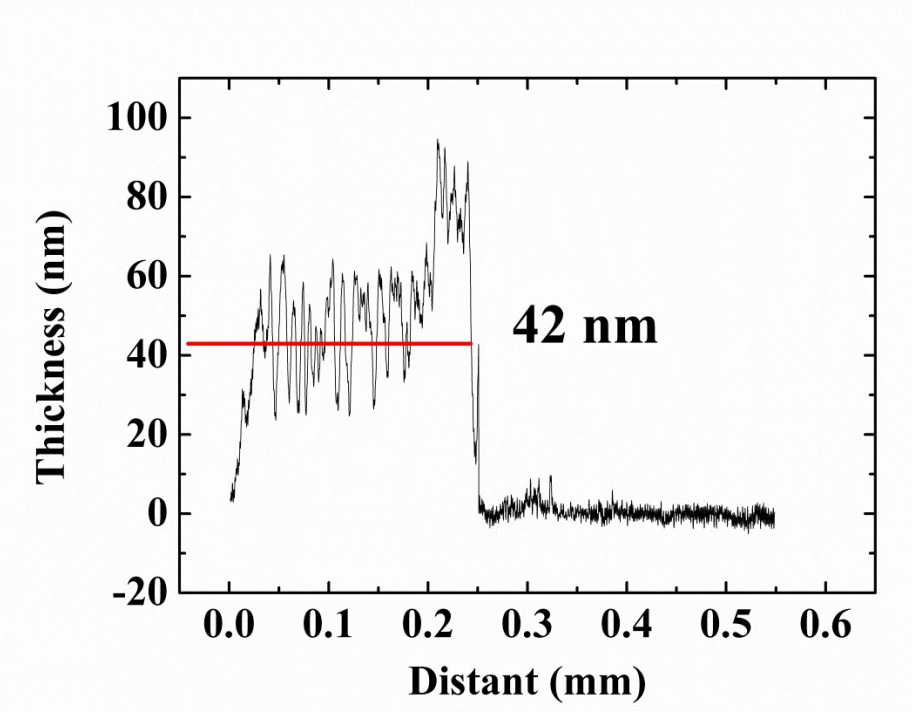

Figure S1 The thickness of $MA_{1-x}Cs_xPbBr_3$ layer

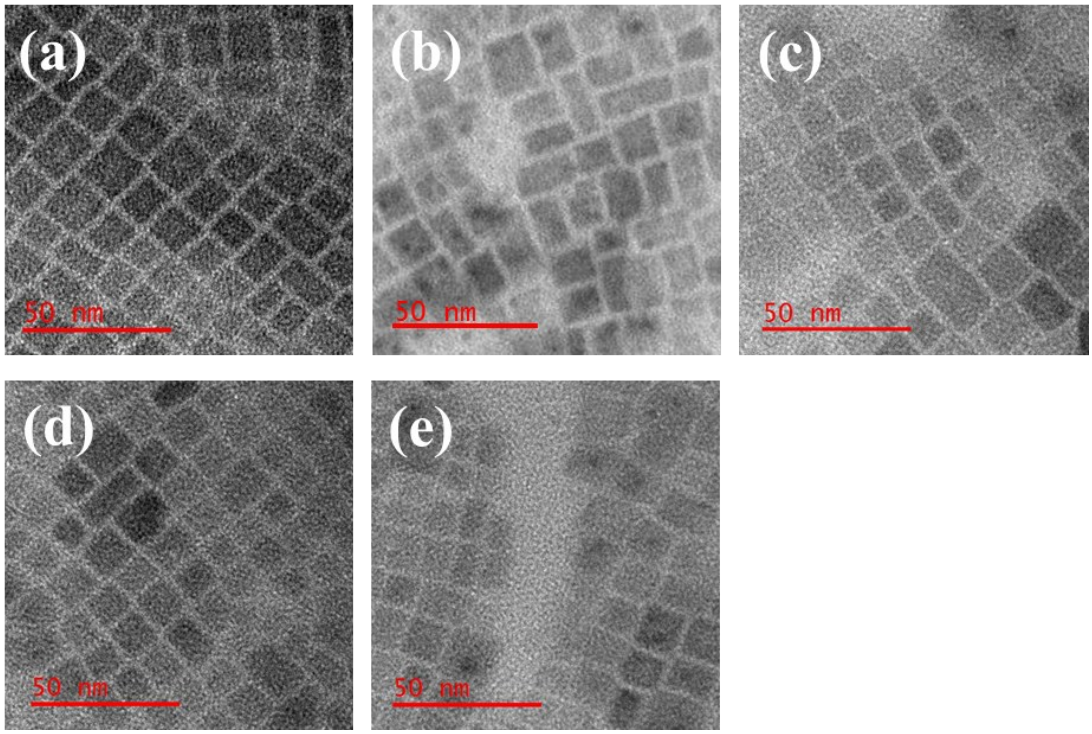

Figure S2 TEM image of $MA_{1-x}Cs_xPbBr_3$ nanocrystals (a) x=0, (b) x=0.1, (c) x=0.2, (d) x=0.3, (e) x=0.4

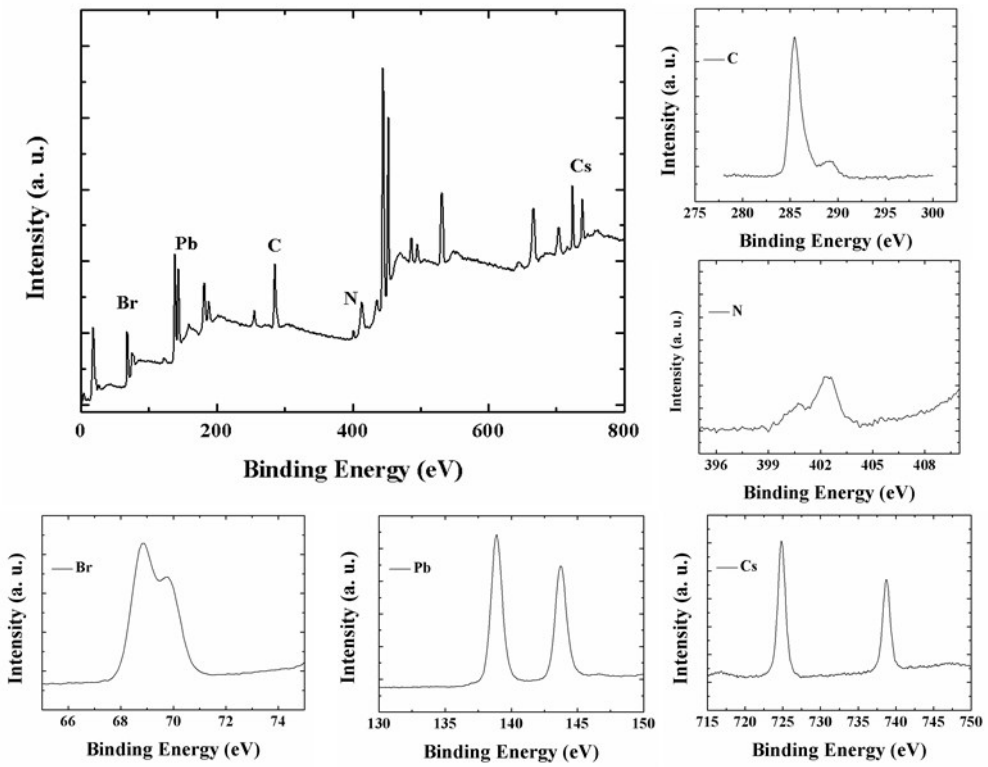

Figure S3 The total XPS spectrum of $MA_{0.7}Cs_{0.3}PbBr_3$

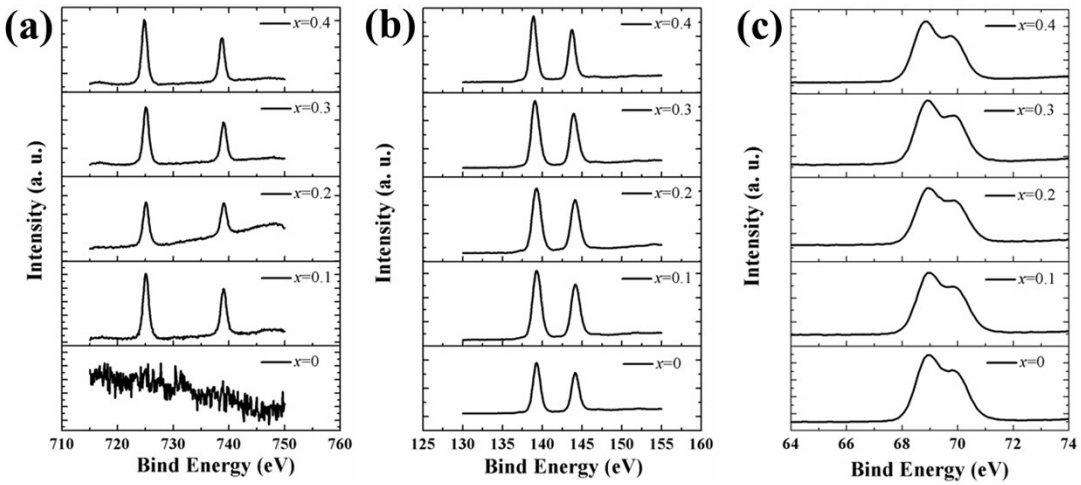

Figure S4 XPS spectra of (a) Cs 3d, (b) Pb 4f, (c) Br 3d of $MA_{1-x}Cs_xPbBr_3$ film spin coated on ITO glass

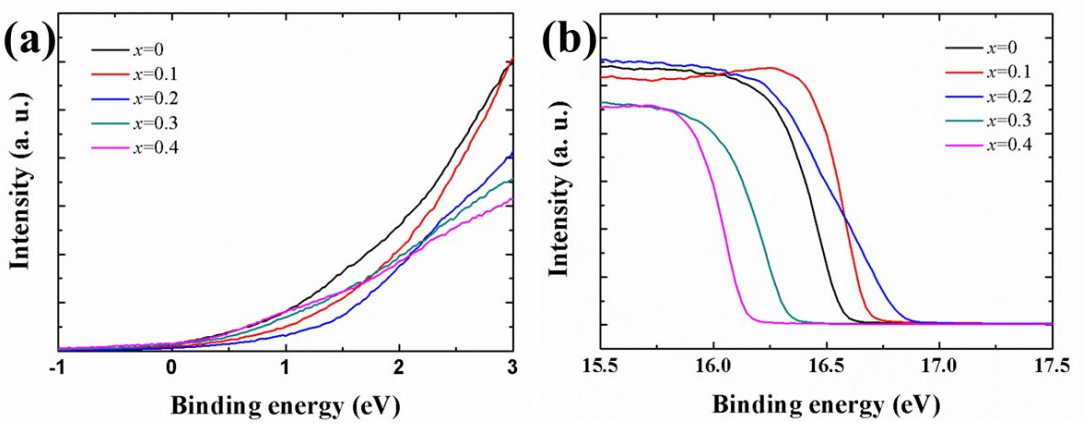

Figure S5 UPS spectra of $MA_{1-x}Cs_xPbBr_3$ film deposited on ITO glass substrates. a) VB-edge region of perovskite NCs. b) High-binding energy secondary-electron cutoff regions of perovskite NCs.