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

Supporting Information

Improved conductivity of $CH_3NH_3PbI_3$ via mixing LiCl for hole-conductor-free fully printable perovskite solar cells

Yusong Sheng†, Yue Hu†, Anyi Mei, Pei Jiang, Xiaomeng Hou, Miao Duan, Li Hong, Yanjun Guan, Yaoguang Rong, Yuli Xiong, Hongwei Han*

Michael Grätzel Center for Mesoscopic Solar Cells, Wuhan National Laboratory for Optoelectronics, School of Optical and Electronic Information, Huazhong University of Science and Technology, Wuhan 430074, Hubei, P. R. China

* Correspondence to Hongwei Han, E-mail: hongwei.han@mail.hust.edu.cn

Table S1. Performance of the studied solar cells under AM 1.5G illumination

Sample		V_{oc} (mV)	J_{sc} (mA cm^{-2})	*FF*	PCE (%)
Control	average	874±10	17.15±0.81	0.66±0.024	9.81±0.45
	champion	884	17.11	0.71	10.70
15%	average	895±12	18.05±0.36	0.72±0.017	11.56±0.38
	champion	915	18.08	0.74	12.24
30%	average	935±14	18.98±0.60	0.78±0.020	13.65±0.39
	champion	927	20.20	0.77	14.46
50%	average	871±13	12.37±0.62	0.80±0.013	8.62±0.53
	champion	888	12.64	0.82	9.15

Table S2. The XPS ultimate analysis of I, Cl and Pb. The mixing perovskite was prepared by spin-coating method on FTO and annealed at 100 °C for 10 min.

Peak	Position BE (eV)	FWHM (eV)	Raw Area (cps eV)	Atomic Mass	Atomic Conc %	Mass Conc %
I 3d	618.896	1.159	714282.2	126.904	30.04	56.24
Cl 2p	198.846	0.909	1160.1	35.460	0.62	0.33
Pb 4f	137.946	0.920	183062.8	207.206	10.74	32.84

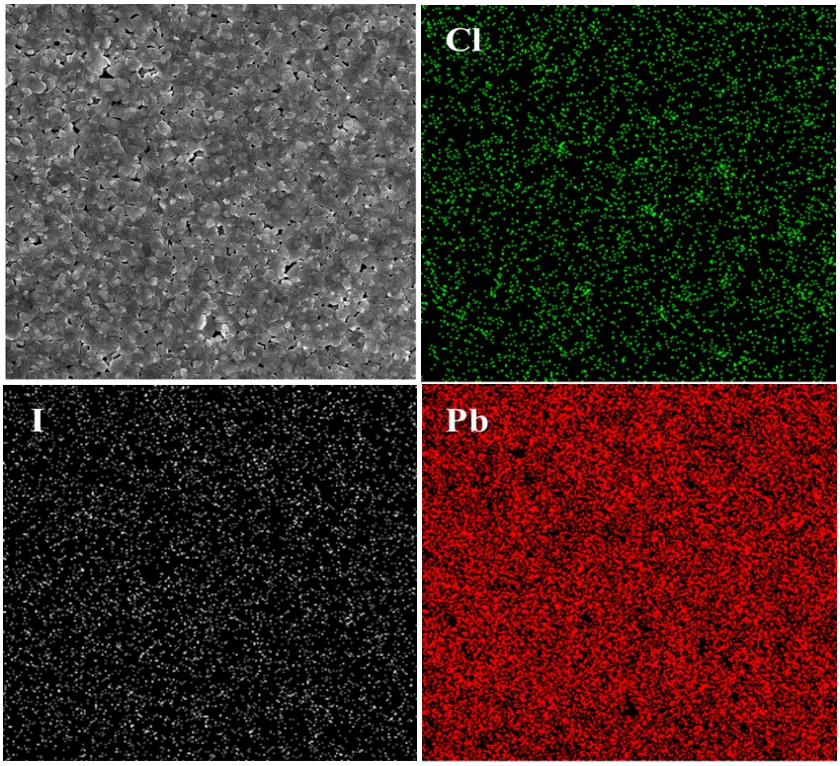

Fig. S1 The surface SEM image of 30% perovskite/LiCl film (on FTO) and its EDS elemental mapping of Cl, I and Pb.

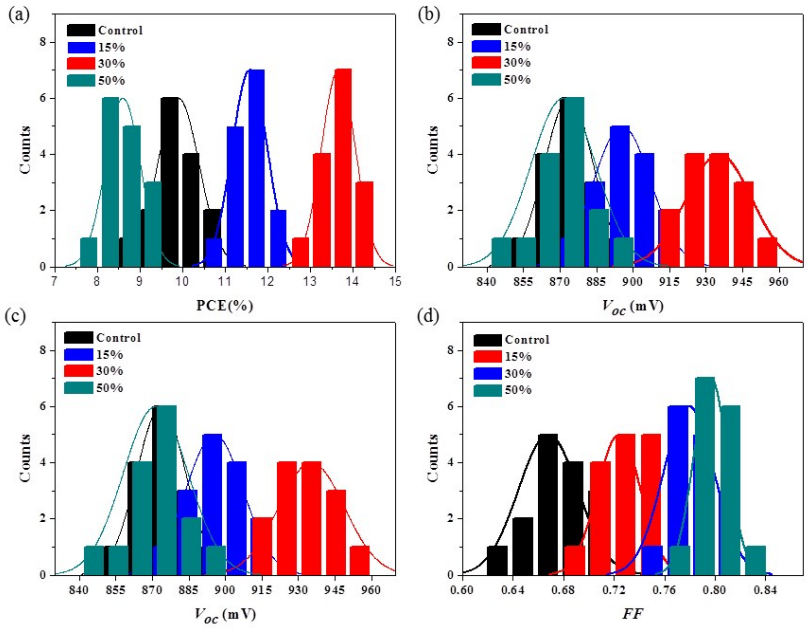

Fig. S2 Histograms of (a) PCE, (b) *Voc*, (c) J_{SC}, and (d) *FF* of all the devices.

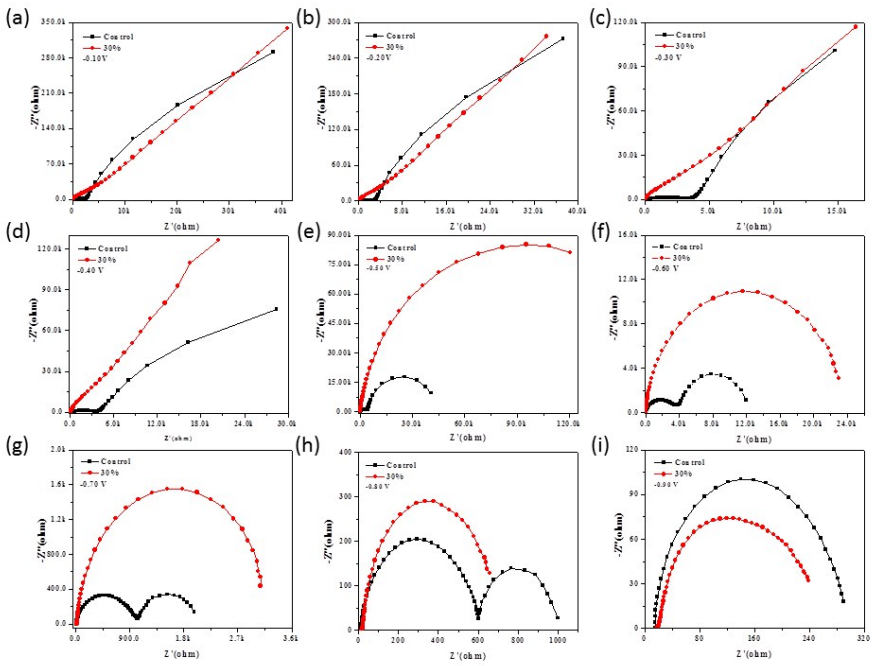

Fig. S3 Nyquist plots of the control and 30% LiCl-based devices under dark at various bias.

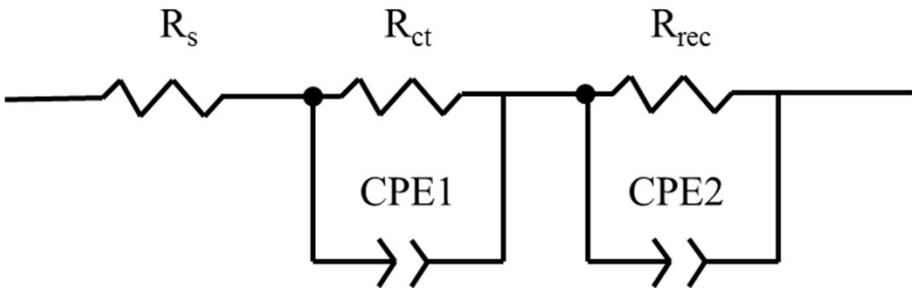

Fig. S4 Equivalent circuit was used to fit the Nyquist curves.

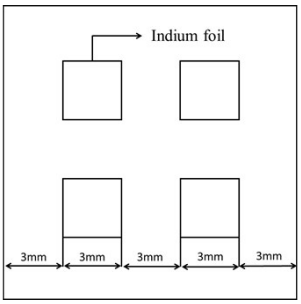

Fig. S5 Sample schematic diagram for Hall-effect measurements.

Hall-effect measurement

The sample used for Hall-effect measurement was prepared by spin coating process on the glass (15×15 mm). The thicknesses of perovskite about 1mm. Firstly, we prepared the perovskite layer on the glass. Then we pasted four indium foils (3×3 mm) on the surface of perovskite layer. Finally, the sample was used for Hall-effect measurement. Hall-effect measurements were performed at room temperature on a 4-probe sample holder placed between the plates of an electromagnet, where the magnetic field of 0.55 T and current of 40 nA were applied.

Table S3. The Hall-effect measurement parameters of the 30% LiCl-based film.

NO.	I (nA)	Bulk concentration (/cm^3)	Resistivity (ohm cm)	Conductivity (1/ohm cm)	Mobility (cm^2/Vs)	Average Hall coefficient (cm^3/C)
1	5.00E-09	-6.80E+14	1.40E+02	7.16E-03	6.57E+01	-9.18E+03
2	1.00E-08	-4.29E+15	1.21E+02	8.28E-03	1.21E+01	-1.45E+03
3	1.50E-08	-1.06E+15	1.34E+02	7.44E-03	4.36E+01	-5.86E+03
4	2.00E-08	-2.18E+15	1.23E+02	8.12E-03	2.32E+01	-2.86E+03
5	2.50E-08	2.74E+17	9.87E+01	1.01E-02	2.31E-01	2.28E+01
6	3.00E-08	-7.92E+15	7.31E+01	1.37E-02	1.08E+01	-7.88E+02
7	4.00E-08	-1.74E+15	5.71E+01	1.75E-02	6.27E+01	-3.58E+03
8	5.00E-08	-5.67E+15	1.02E+02	9.81E-03	1.08E+01	-1.10E+03