Reduced interfacial recombination losses and lead leakage in lead-based perovskite solar cells using 2D/3D perovskite engineering

Huan Bi[a,b], *Yao Guo*[c], *Mengna Guo*[a], *Chao Ding*[b], *Shuzi Hayase*[b], *Hanjun Zou*[d], *Qing Shen*[b]*, *Gaoyi Han*[a]*, *and Wenjing Hou*[a]*

[a]Institute of Molecular Science, Key Laboratory of Materials for Energy Conversion and Storage of Shanxi Province, Shanxi University, Taiyuan 030006, P. R. China

[b]Faculty of Informatics and Engineering, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan.

[c]School of Materials Science and Engineering, Henan Joint International Research Laboratory of Nanocomposite Sensing Materials, Anyang Institute of Technology, Anyang 455000, P. R. China

[d]Analytical and Testing Center, Chongqing University, Chongqing 401331, P. R. China

Corresponding Author (Q. Shen, G.Y. Han, W.J. Hou)

E-mail: shen@pc.uec.ac.jp

E-mail: han_gaoyis@sxu.edu.cn

E-mail: houwenjing@sxu.edu.cn

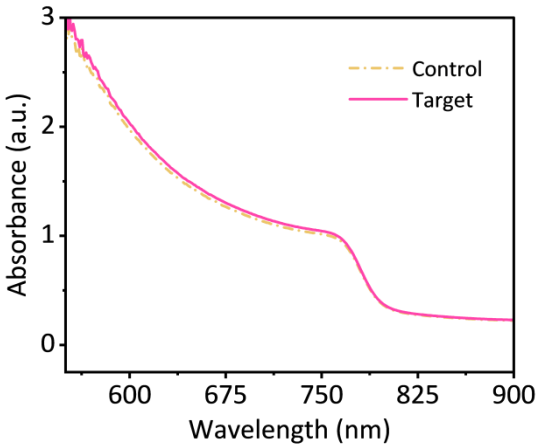

Fig. S1. UV-vis absorption spectra of the perovskite films without and with MEMI.

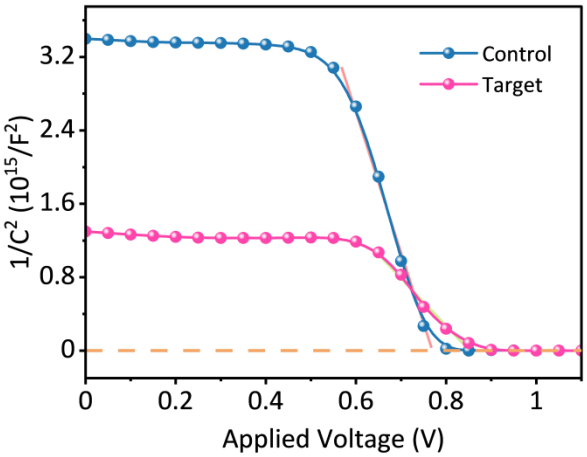

Fig. S2. Mott-Schottky plots for the control and target devices. V_{bi} is determined by the voltage intercept of $1/C^2$ curves.

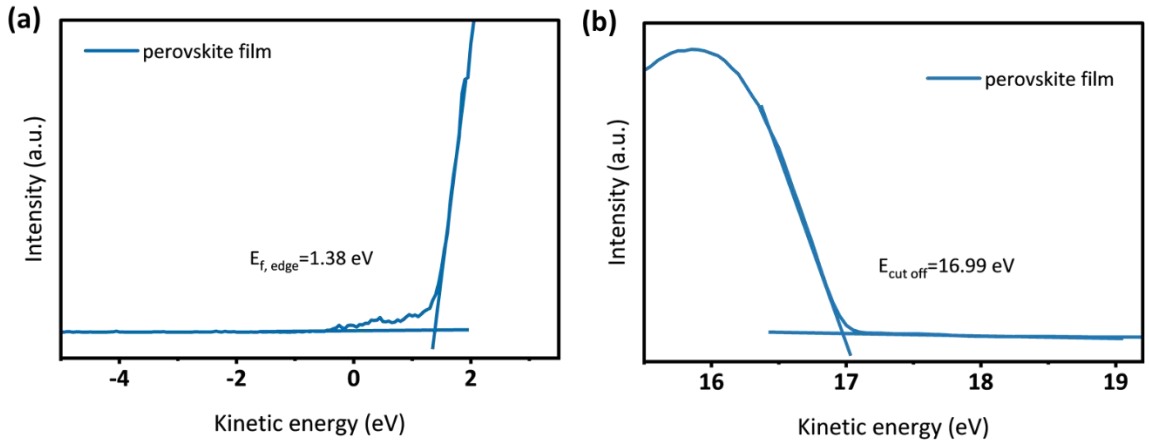

Fig. S3. UPS test, (a) $E_{F,edge}$ and (b) $E_{cut\text{-}off}$ of the control perovskite films.

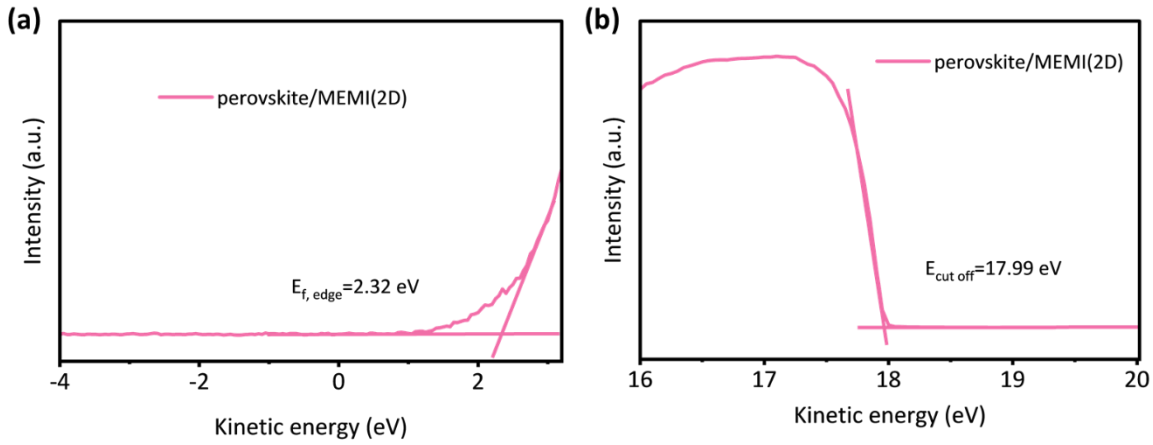

Fig. S4. UPS test, (a) $E_{F,edge}$ and (b) $E_{cut\text{-}off}$ of the target perovskite films.

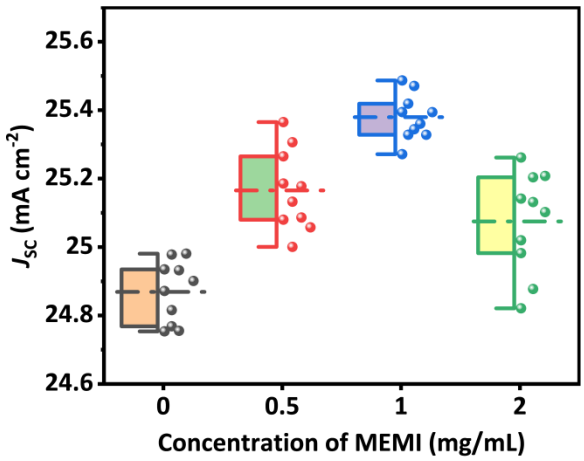

Fig. S5. *J*SC statistical diagrams of the devices modified by different concentrations of MEMI.

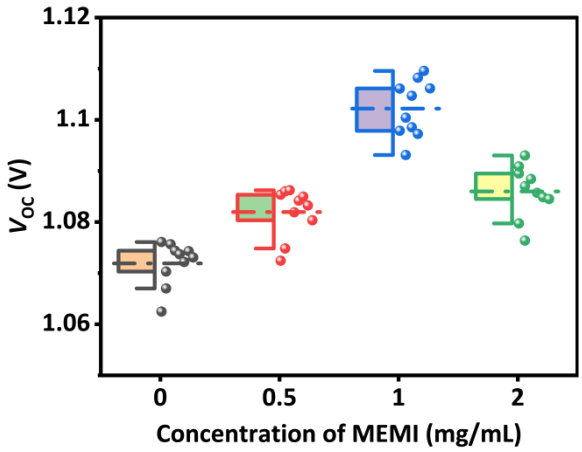

Fig. S6. V_{OC} statistical diagrams of the devices modified by different concentrations of MEMI

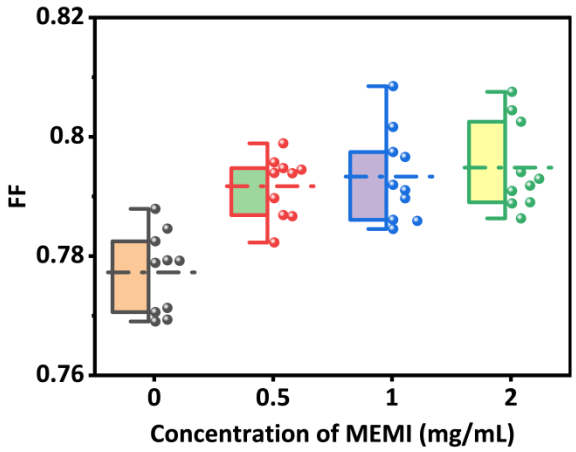

Fig. S7. FF statistical diagrams of the devices modified by different concentrations of MEMI

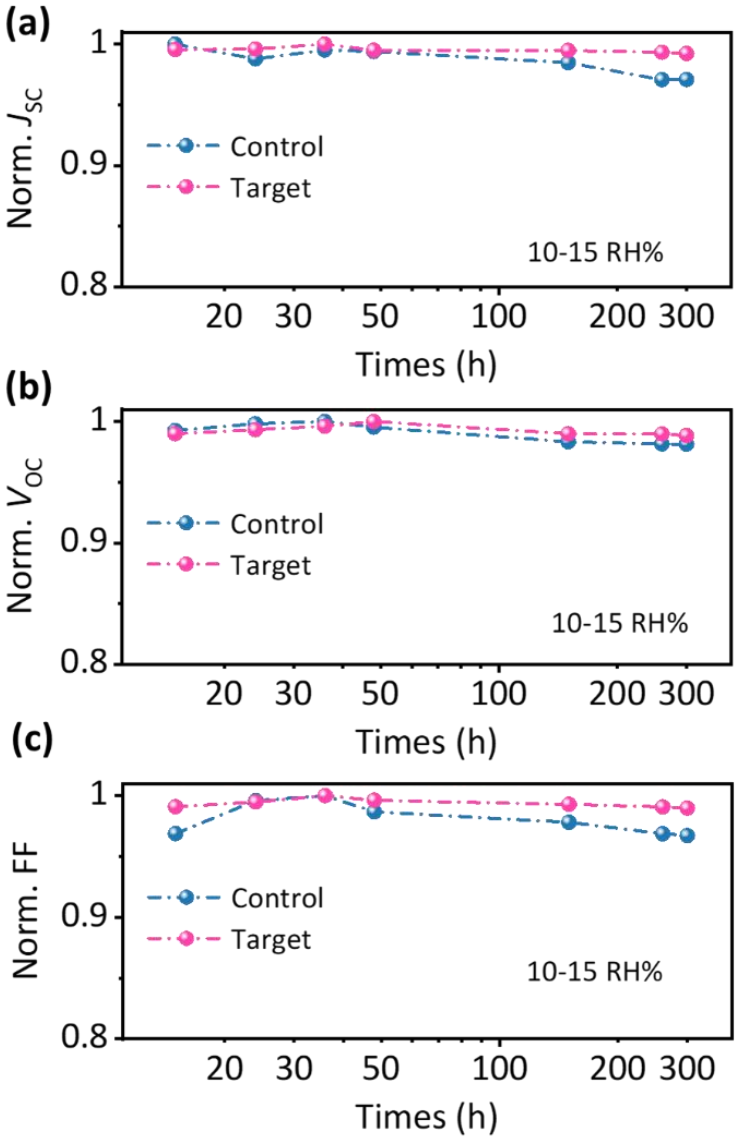

Fig. S8. (a) J_{SC}, (b) V_{OC}, and (c) FF as a function of time for the unencapsulated control and target devices aged under a relative humidity of 10-15% at room temperature in the dark.

Table S1. Fitted TRPL results of the devices with the structure of glass/perovskite and glass/perovskite/MEMI.

	Glass/PVSK	Glass/PVSK/MEMI
τ_1 (ns)	11.96	14.56
%	47.03	55.61
τ_2 (ns)	61.44	85.24
%	52.97	44.39
τ_{ave} (ns)	54.15	72.78

Table S2. Fitted TRPL results of the devices with the structure of glass/perovskite/HTL and glass/perovskite/MEMI/HTL.

	Glass/PVSK/HTL	Glass/PVSK/MEMI/HTL
τ_1 (ns)	4.44	4.13
%	66.32	78.36
τ_2 (ns)	20.71	17.57
%	33.68	21.64
τ_{ave} (ns)	15.88	11.38

Table S3. Photovoltaic parameters of the devices modified with different concentrations of MEMI from 0 to 2 mg/mL.

MEMI (mg/mL)		J_{SC} (mA/cm^2)	V_{OC} (V)	FF	PCE (%)
0	**Champion**	24.76	1.074	0.785	20.85
	Average	24.87±0.111	1.072±0.004	0.777±0.011	20.72±0.135
0.5	**Champion**	25.26	1.080	0.795	21.67
	Average	25.16±0.199	1.082±0.004	0.792±0.007	21.56±0.129
1	**Champion**	25.27	1.106	0.802	22.41
	Average	25.37±0.106	1.102±0.007	0.793±0.015	22.19±0.218
2	**Champion**	24.98	1.078	0.807	21.78
	Average	25.07±0.186	1.085±0.007	0.793±0.012	21.64±0.139