

## Electronic Supplementary Information

### Efficiency Improvement of Semi-transparent Perovskite Solar Cells via Crystallinity Enhancement

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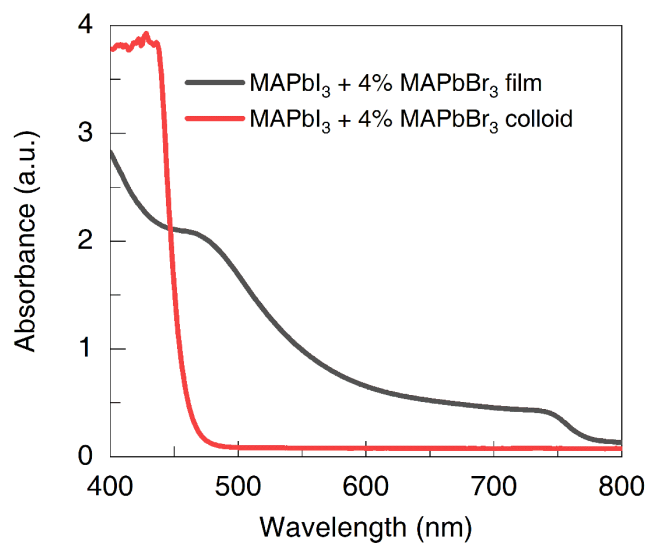
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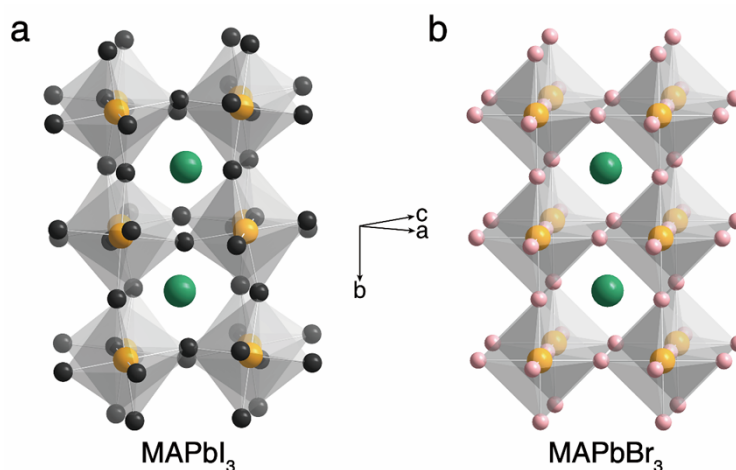
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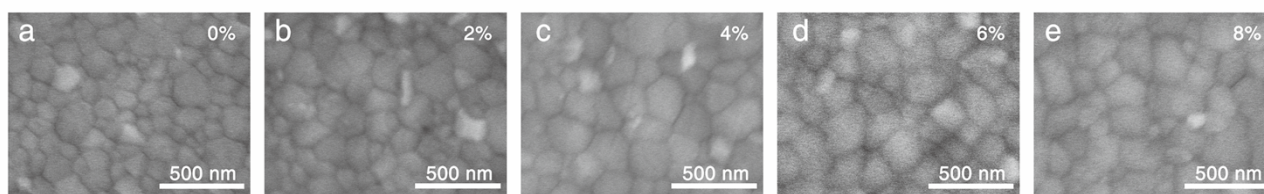
\* Corresponding author.



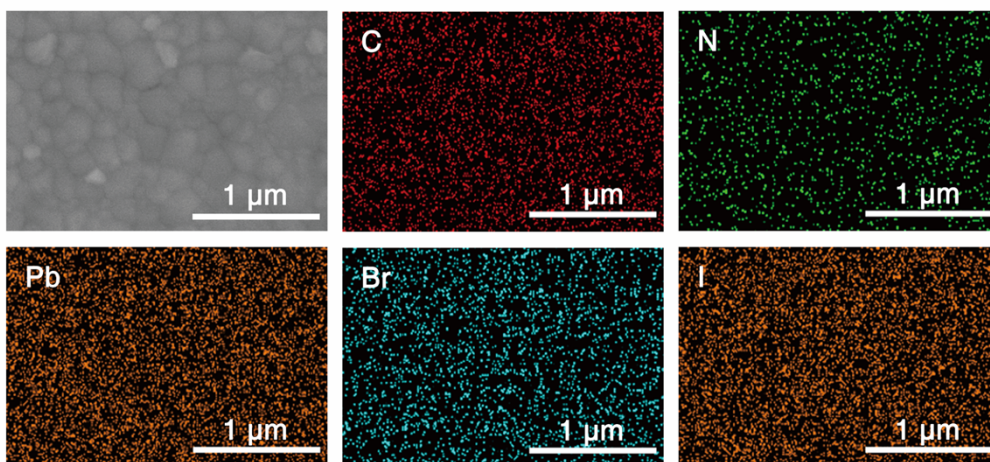
**Fig. S1** UV-vis spectra of colloids (red) and films (black) for  $\text{MAPbI}_3 + 4\% \text{MAPbBr}_3$ .



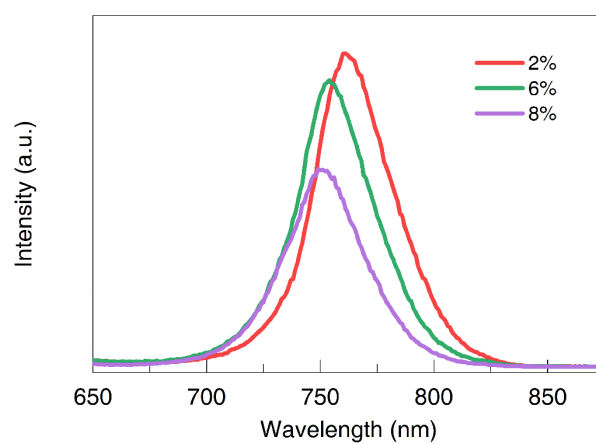
**Fig. S2** (a) Distorted tetragonal perovskite structure of  $\text{MAPbI}_3$  at room temperature. (b) Cubic perovskite structure of  $\text{MAPbBr}_3$  at room temperature.



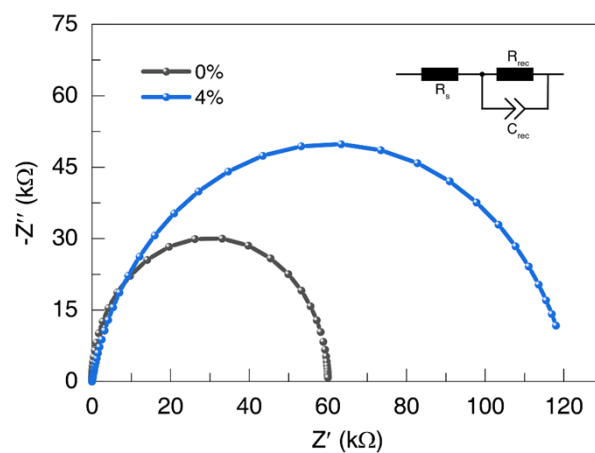
**Fig. S3** Top-view SEM images of  $\text{MAPbI}_3 + x\% \text{MAPbBr}_3$  ( $x = 0, 2, 4, 6, 8$ ) perovskite film deposited in FTO-glass.



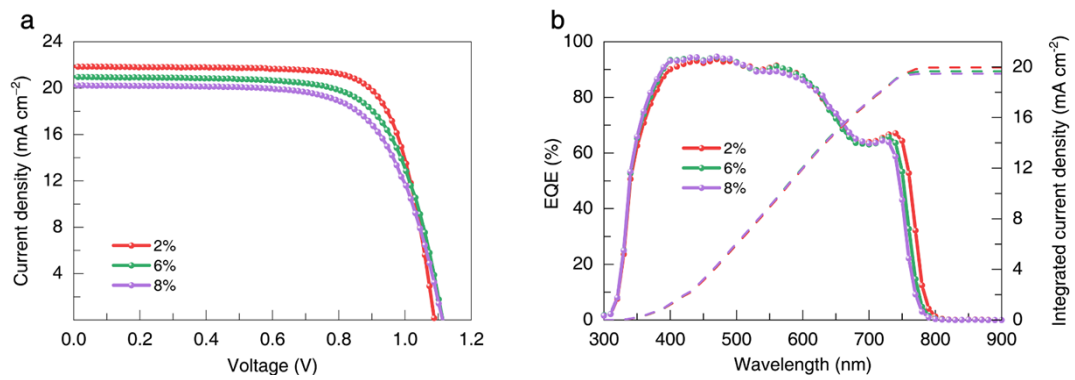
**Fig. S4** EDS mapping of MAPbI<sub>3</sub> + 4% MAPbBr<sub>3</sub> perovskite film.



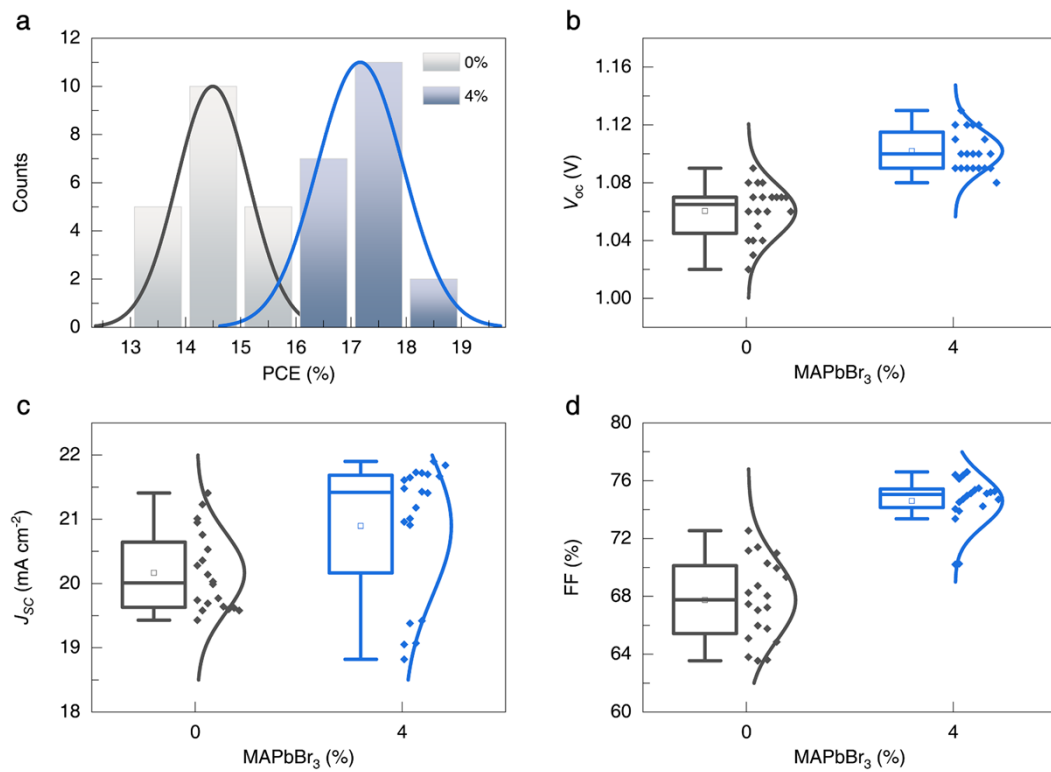
**Fig. S5** PL spectra of MAPbI<sub>3</sub> + x% MAPbBr<sub>3</sub> (x = 2, 6, 8) perovskite film deposited in FTO-glass.



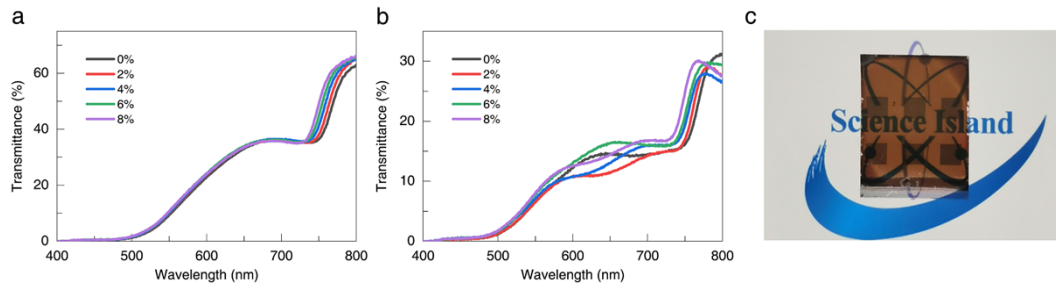
**Fig. S6** Nyquist plots fitted from EIS measurement of MAPbI<sub>3</sub>-based PSCs with and without 4% MAPbBr<sub>3</sub> using equivalent circuits shown in the inset.



**Fig.S7** (a)  $J$ - $V$  curves for MAPbI<sub>3</sub>-based devices with 2, 6, 8% MAPbBr<sub>3</sub> under reverse scan and corresponding (b) EQE curves and integrated  $J_{sc}$ .



**Fig. S8** (a) PCE histogram fitted with a Gaussian distribution and (b-d) the statistical distribution of corresponding photovoltaic parameters for MAPbI<sub>3</sub>-based PSCs with and without 4% MAPbBr<sub>3</sub> among 20 measured devices.



**Fig. S9** Transmittance spectra of  $\text{MAPbI}_3 + x\% \text{MAPbBr}_3$  ( $x = 0, 2, 4, 6, 8$ ) ST-PSCs (a) without and (b) with 10 nm gold as top electrode. (c) Photograph of  $\text{MAPbI}_3 + 4\% \text{MAPbBr}_3$  ST-PSC with 10 nm gold as top electrode.

**Table S1.** Crystal plane spacing (d), lattice constant (a) and FWHM of (110) plane for  $\text{MAPbI}_3 + x\% \text{MAPbBr}_3$  ( $x = 0, 2, 4, 6, 8$ ) films.

x	d (nm)	a (Å)	FWHM
0	0.6289	8.8945	0.17014
2	0.6281	8.8820	0.16562
4	0.6267	8.8632	0.14939
6	0.6267	8.8632	0.13656
8	0.6254	8.8445	0.12862

**Table S2.** AVT values of films and PSCs based on  $\text{MAPbI}_3 + x\% \text{MAPbBr}_3$  ( $x = 0, 2, 4, 6, 8$ ) with and without top electrode.

x	AVT (%)		
	Film	Device without TE	Device
0	25.53	21.61	9.76
2	26.01	22.26	10.26
4	26.23	22.78	10.30
6	27.25	23.22	10.44
8	27.93	23.41	11.55

**Table S3.** The TRPL fitting results of  $\text{MAPbI}_3$  perovskite films with and without 4%  $\text{MAPbBr}_3$  coated

on FTO/glass.

<b>x</b>	<b><math>\tau_1</math> (ns)</b>	<b><math>\tau_2</math> (ns)</b>	<b><math>\tau_{avg}</math> (ns)</b>
0	9.94	38.50	23.99
4	14.63	50.43	38.44

**Table S4.** Photovoltaic performance parameters of PSCs based on MAPbI<sub>3</sub> + x% MAPbBr<sub>3</sub> (x = 0, 2, 4, 6, 8).

<b>x</b>	<b><math>V_{oc}</math> (V)</b>	<b><math>J_{sc}</math> (mA cm<sup>-2</sup>)</b>	<b>Integrated <math>J_{sc}</math> (mA cm<sup>-2</sup>)</b>	<b>FF (%)</b>	<b>PCE (%)</b>
0	1.06	21.25	19.84	69.68	15.69
2	1.09	21.85	19.96	75.20	17.89
4	1.10	21.88	20.19	75.79	18.27
6	1.11	20.96	19.66	70.21	16.39
8	1.11	20.23	19.47	68.47	15.42

**Table S5.** Photovoltaic performance parameters of PSCs based on MAPbI<sub>3</sub> with and without 4% MAPbBr<sub>3</sub>.

<b>x</b>		<b><math>V_{oc}</math> (V)</b>	<b><math>J_{sc}</math> (mA cm<sup>-2</sup>)</b>	<b>FF (%)</b>	<b>PCE (%)</b>
0	Average	1.06 ± 0.02	20.17 ± 0.62	67.75 ± 2.79	14.49 ± 0.65
	Champion	<b>1.06</b>	<b>21.25</b>	<b>69.68</b>	<b>15.69</b>
4	Average	1.10 ± 0.01	20.90 ± 1.08	74.60 ± 1.72	17.17 ± 0.78
	Champion	<b>1.10</b>	<b>21.88</b>	<b>75.79</b>	<b>18.27</b>

**Note:** (1) The active area of each device is 0.09 cm<sup>2</sup>; (2) the average parameters are calculated from 20 devices.

**Table S6.** Summary of PCE, AVT, LUE of ST-PSCs with different top electrodes in previous work.

<b>Top electrode</b>	<b>PCE (%)</b>	<b>AVT (%)</b>	<b>LUE (%)</b>	<b>Year</b>
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ITO	15.80	6.30	1.00	2015
Carbon grids	8.21	24.00	1.97	2017
Au	7.20	17.00	1.22	2018
MoO <sub>3</sub> /Au/MoO <sub>3</sub>	14.15	9.00	1.27	2018
AZO/Ag/AZO	11.65	12.76	1.49	2019
MoO <sub>3</sub> /Au/MoO <sub>3</sub>	12.50	5.00	0.63	2020
MoO <sub>x</sub> /Au/MoO <sub>x</sub>	13.70	11.70	1.60	2021
Au	11.60	22.00	2.55	2021
ITO	12.60	20.30	2.56	2021
IGTO	15.60	10.50	1.64	2021
Au	14.50	14.25	2.07	2022
Polyimide-integrated graphene	15.10	18.00	2.72	2022
<b>Au</b>	<b>18.27</b>	<b>10.3</b>	<b>1.88</b>	<b>This work</b>