

## Supporting information

The amount of HCl, HI and H<sub>2</sub>O is 7 vol%, 5 vol% and 4 vol% (the stoichiometric HCl from 33 wt% hydrochloric and the stoichiometric HI from 47 wt% hydroiodic), respectively. The doped amount of H<sub>2</sub>O is equal to amount of H<sub>2</sub>O in HBr, the result also means excluding the influence of H<sub>2</sub>O, and the halogen ions played an more important role.

Table S1. Solar cell performance of MAPbI<sub>3-x</sub>Cl<sub>x</sub> films with different percentages of HBr (vol).

HBr	FF	$J_{sc}(\text{mA}/\text{cm}^2)$	$V_{oc}(\text{V})$	PCE(%)
0 vol%	0.72	19.12	0.87	12.13
5 vol%	0.73	20.81	0.90	13.67
7 vol%	0.77	21.71	0.94	15.76
9 vol%	0.71	19.97	0.89	12.61

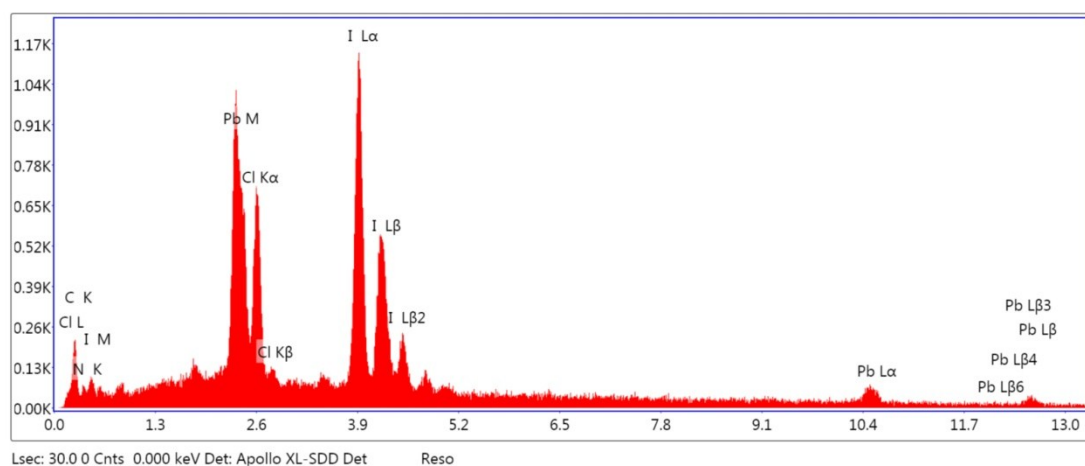


Fig. S1. EDS spectra of HBr-MAPbI<sub>3-x</sub>Cl<sub>x</sub> film on ITO/TiO<sub>2</sub>.

The added HBr is weaker thermostability and few amount, so the resulting perovskite film is MAPbI<sub>3-x</sub>Cl<sub>x</sub>. The blue shift of UV-Vis spectra is ascribed to added HBr, however, the red shift of EQE is ascribed to high quality perovskite films (crystallinity).

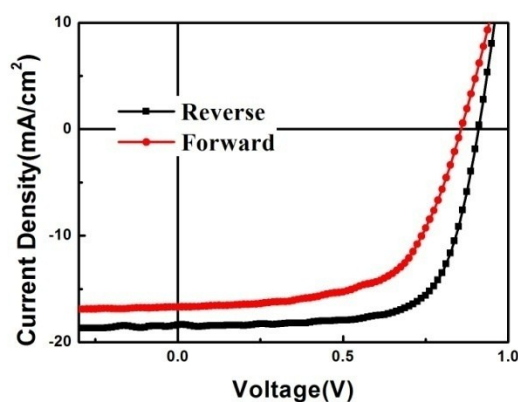


Fig S2. Representative without HBr-modified device scanned from different directions.

The hysteresis data of solar cell without HBr treatment is shown in Fig S2. The HBr treatment can reduced hysteresis effect.