

Supporting Information

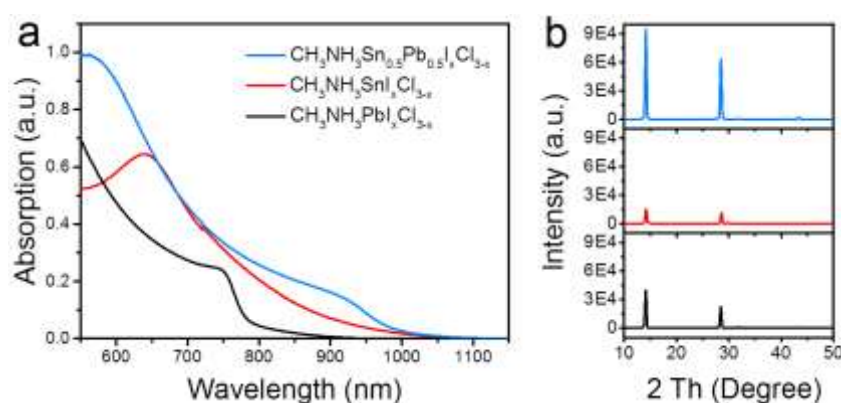


Figure S1. (a) Absorption and (b) XRD patterns of $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_x\text{Cl}_{3-x}$, $\text{CH}_3\text{NH}_3\text{SnI}_x\text{Cl}_{3-x}$ and $\text{CH}_3\text{NH}_3\text{PbI}_x\text{Cl}_{3-x}$ thin films.

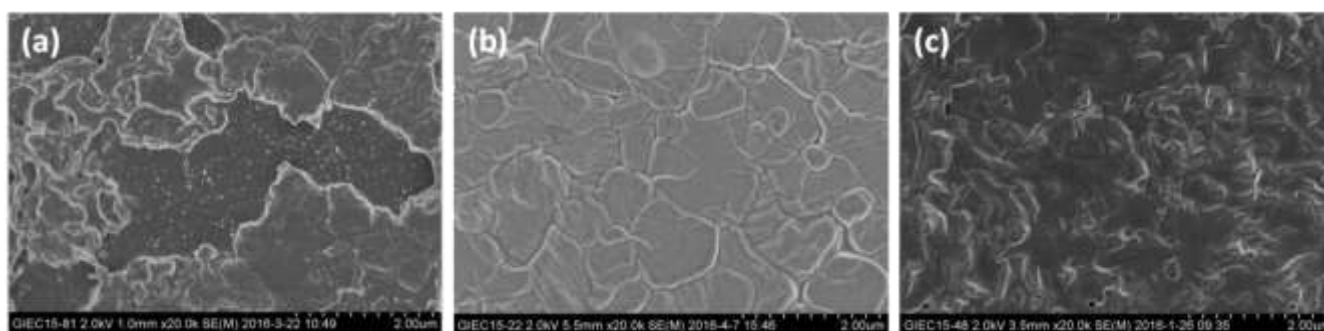


Figure S2. Top-view SEM images of (a) $\text{CH}_3\text{NH}_3\text{SnI}_x\text{Cl}_{3-x}$, (b) $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_x\text{Cl}_{3-x}$ and (c) $\text{CH}_3\text{NH}_3\text{PbI}_x\text{Cl}_{3-x}$ thin films annealed in a nitrogen environment.

Table S1. Energy-dispersive spectrometric measurement of elements contained in $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_x\text{Cl}_{3-x}$ thin film annealed in various environments.

Annealing Time	Condition	Pb	Sn	I	Cl
0.5h	Vacuum	13.09	14.33	72.56	--
	Nitrogen	14.09	13.96	61.59	9.34
1h	Vacuum	13.62	12.54	73.81	--
	Nitrogen	13.02	12.04	71.19	3.71
1.5h	Vacuum	14.49	13.88	71.61	--
	Nitrogen	12.72	11.88	75.34	--

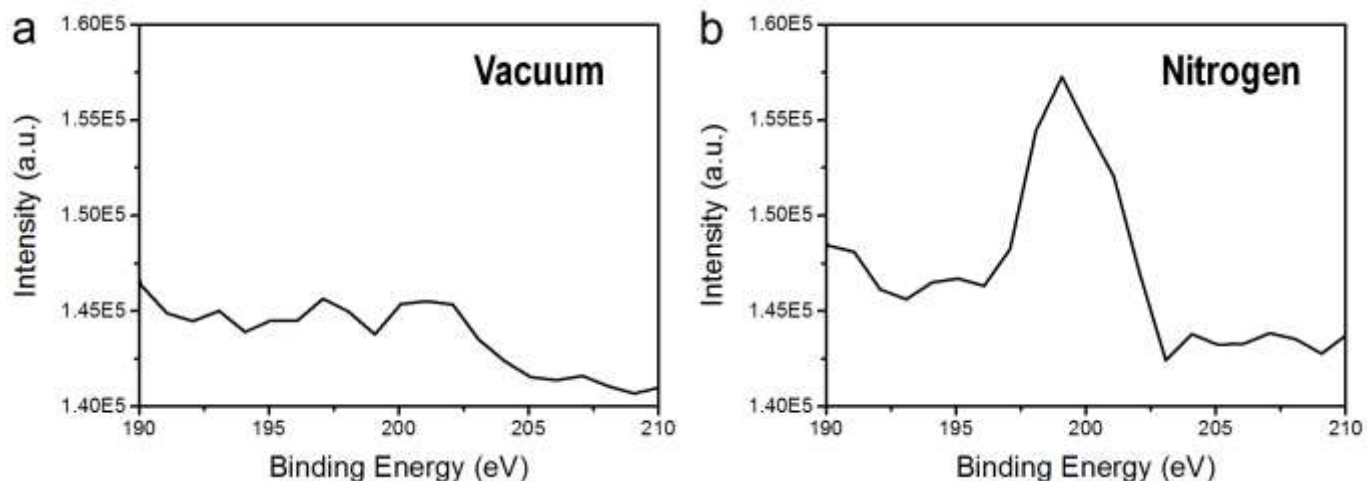


Figure S3. X-ray photoelectron spectroscopy measurement of Cl2p signal in $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_x\text{Cl}_{3-x}$ films annealed in (a) a vacuum environment and (b) a nitrogen environment for 1 hour.

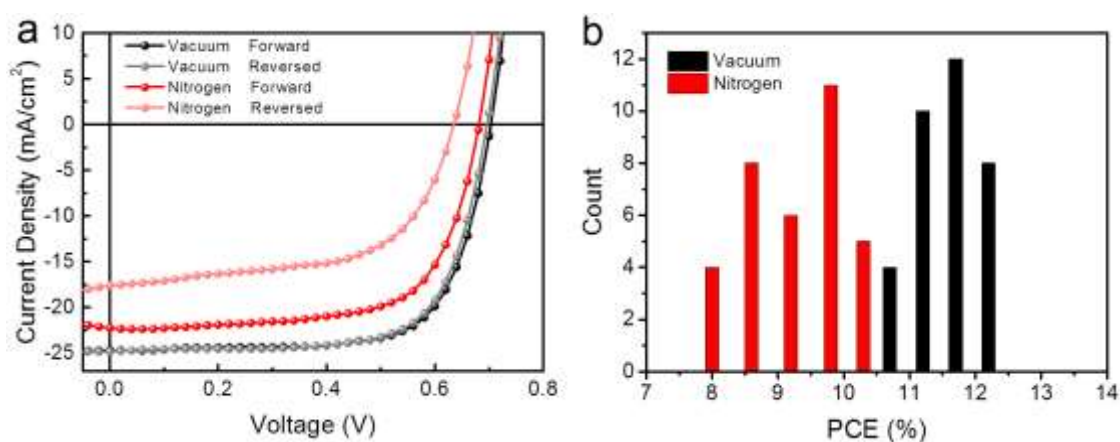


Figure S4. (a) Hysteresis properties of PVSCs fabricated in various annealing environments. (b) Statistical performances of 34 PVSCs fabricated in various annealing environments.

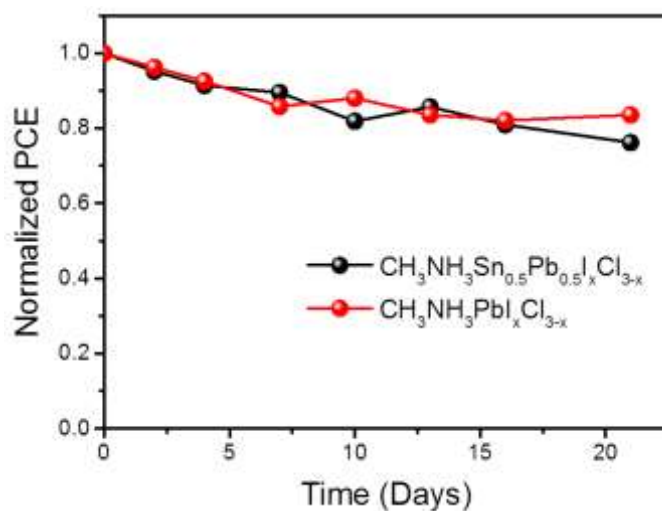


Figure S5. Long-term stabilities of $\text{CH}_3\text{NH}_3\text{Sn}_{0.5}\text{Pb}_{0.5}\text{I}_x\text{Cl}_{3-x}$ and $\text{CH}_3\text{NH}_3\text{PbI}_x\text{Cl}_{3-x}$ solar cells. All the devices were stored in an N_2 -filled glovebox.