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Supporting Information

Multiple-cation wide-bandgap perovskite solar cells grown via using cesium formate as Cs precursor with high efficiency under sunlight and indoor illumination

Qiang Guo[a], Yuanjia Ding[a,b], Zheng Dai[a,b], Zongwei Chen[a], Mengzhen Du[a,b], Zongtao Wang[a,b], Lei Gao[a], Chen Duan[a], Qing Guo[a], Erjun Zhou[b*]

[a] Henan Institute of Advanced Technology, Zhengzhou University, Zhengzhou 450003, China.

[b] CAS Key Laboratory of Nanosystem and Hierarchical Fabrication, CAS Center for Excellence in Nanoscience, National Center for Nanoscience and Technology, Beijing 100190, China.

E-mail: zhouej@nanoctr.cn

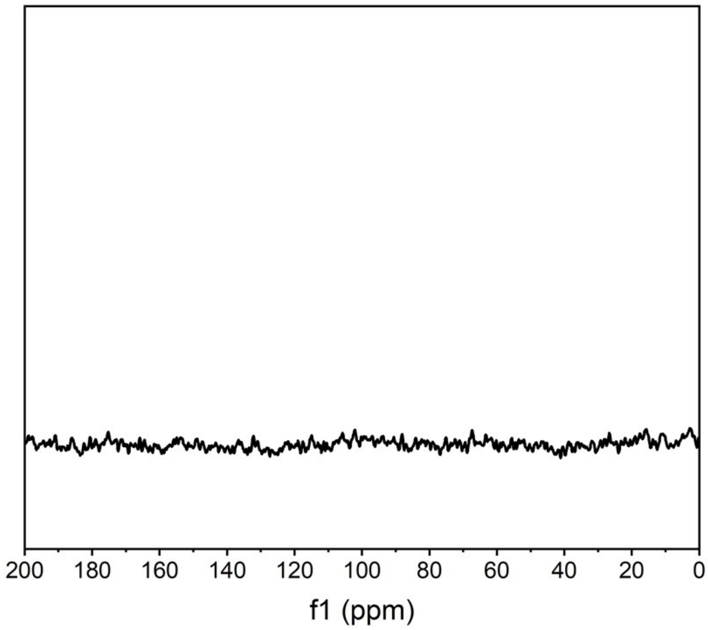

Figure S1. ^{13}C MAS NMR spectrum of the first-step precursor film with CsFa.

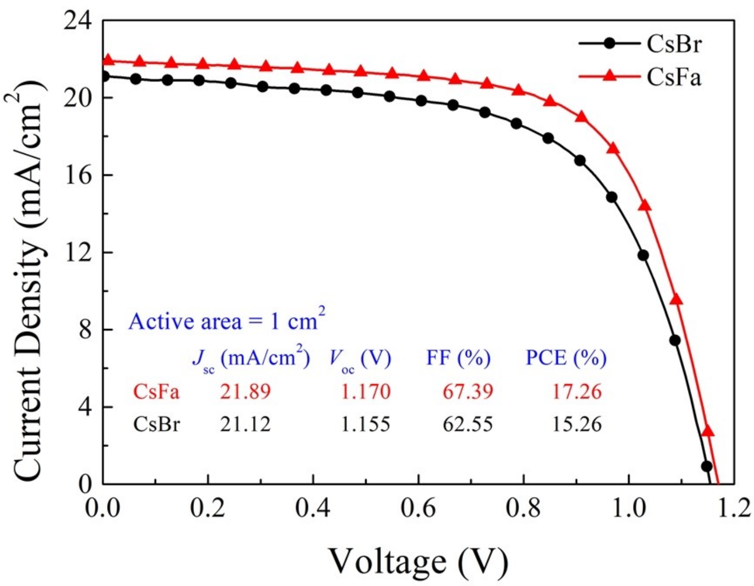

Figure S2. *J-V* curves of 1.63 eV PSCs with large active area of 1 cm^2.

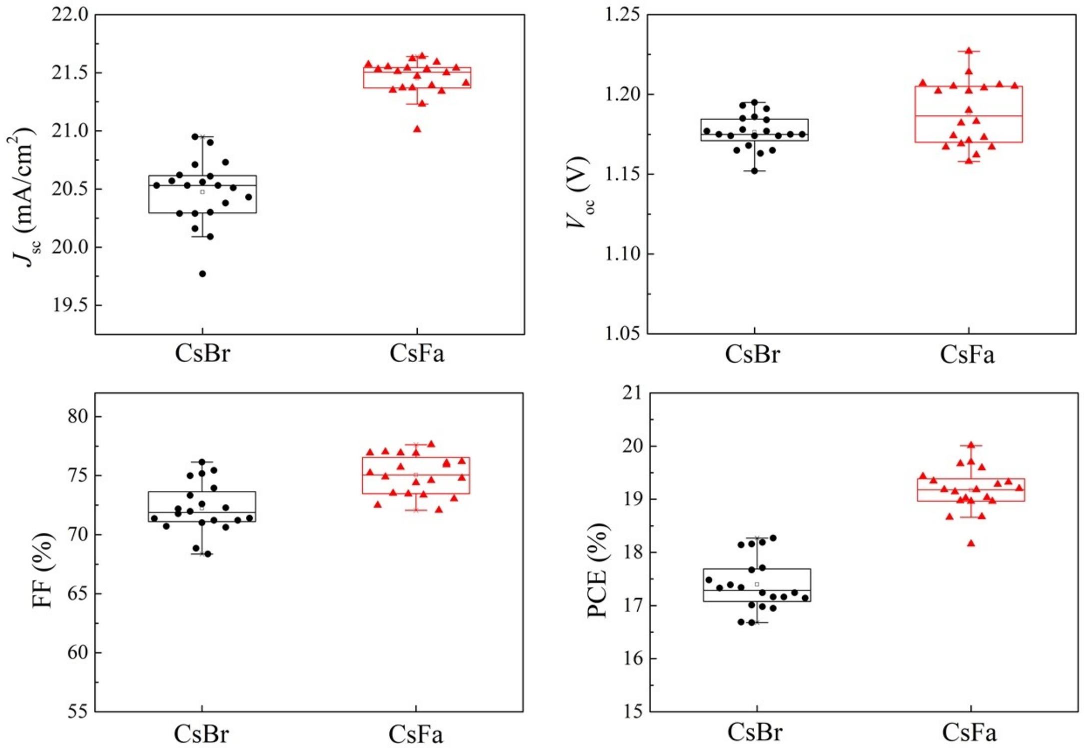

Figure S3. Photovoltaic parameters (reverse scan) distribution of 20 individual 1.63 eV WBG PSCs based on CsBr-perovskite and CsFa-perovskite.

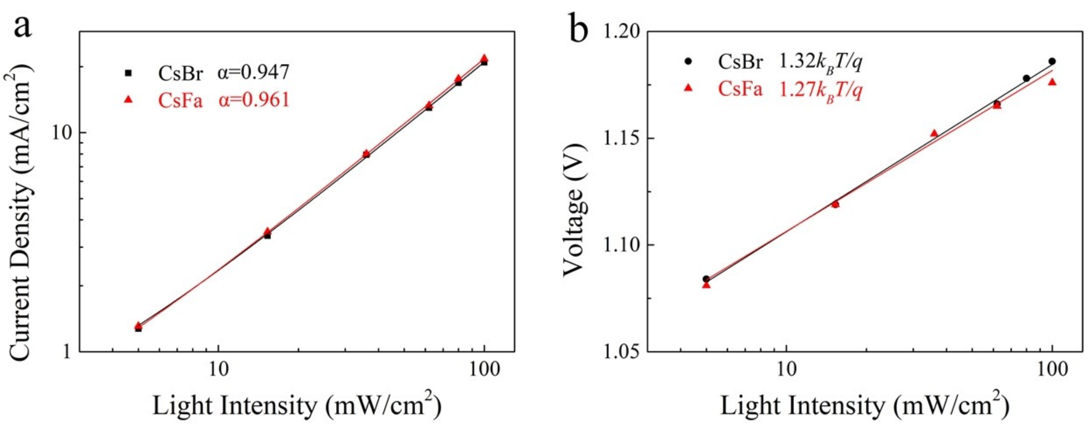

Figure S4. (a) J_{sc} and **(b)** V_{oc} versus light intensity of the 1.63 eV WBG PSCs.

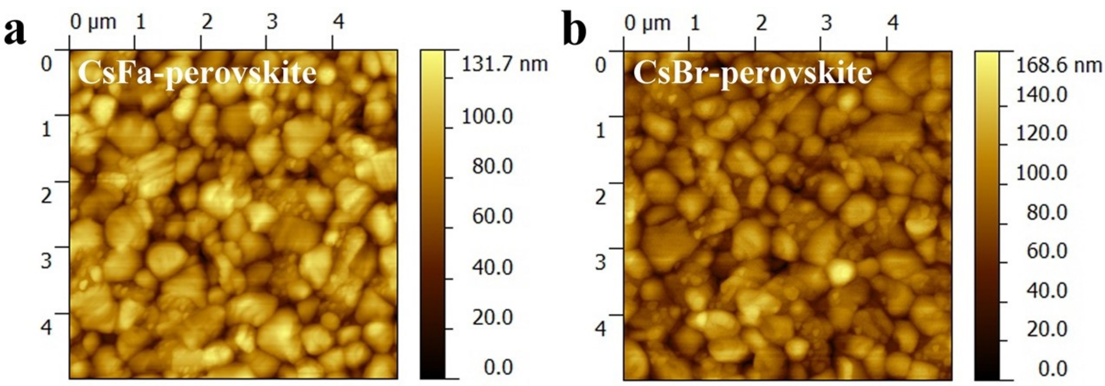

Figure S5. AFM topography images of **(a)** CsFa-perovskite and **(b)** CsBr-perovskite after continuous illumination under AM 1.5G sunlight for 7 hours.

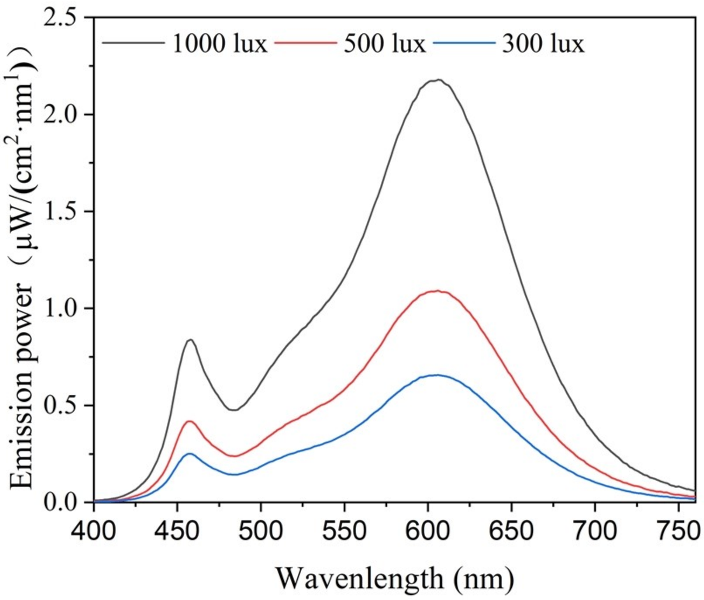

Figure S6. Emission power spectrum of the LED bulb.

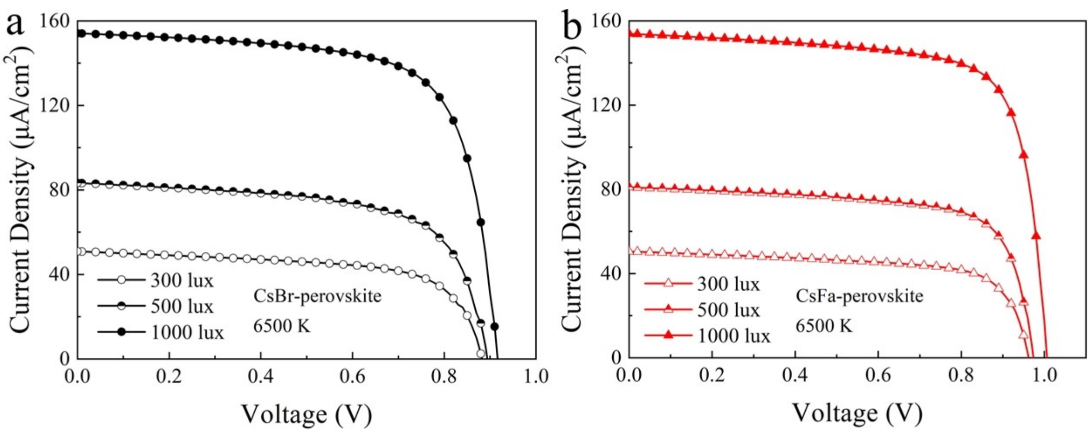

Figure S7. *J-V* curves of **(a)** CsBr-perovskite and **(b)** CsFa-perovskite based 1.63 eV PSCs under a 6500K LED light illumination condition.

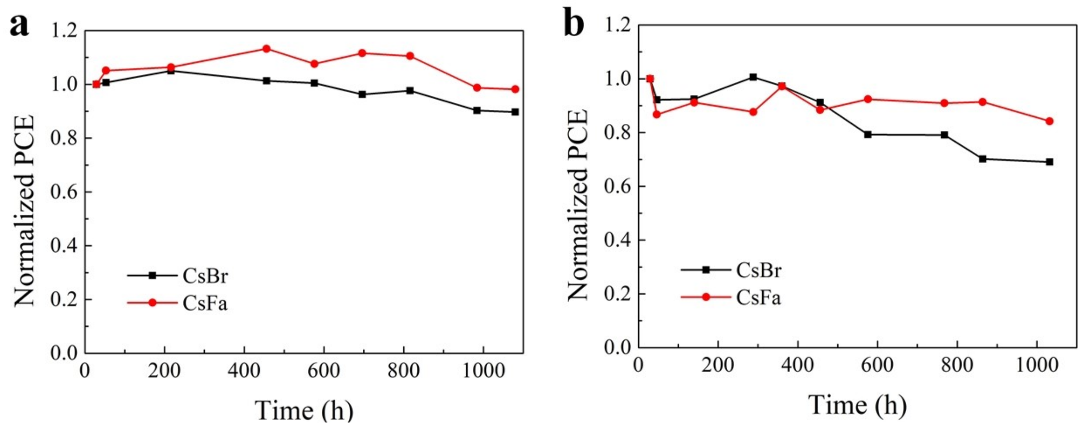

Figure S8. Normalized PCEs of unencapsulated 1.63 eV WBG PSCs based on CsBr-perovskite and CsFa-perovskite after aging **(a)** in an N_2-filled glovebox for 1080 hours and **(b)** in an ambient environment (relative humidity<10%) for 1032 hours.

Table S1. Kinetic Fit Parameters for CsBr-perovskite and CsFa-perovskite.

	λ_{probe} (nm)	τ_1 (ps)	A_1	τ_2 (ps)	A_2
CsBr	742	7.1±0.4	53.6%	700.7±25.6	46.4%
CsBr	750	7.1±0.5	50.7%	833.9±31.7	49.3%
CsFa	742	46.9±5.0	70.3%	998.9±46.3	29.7%

Table S2. Photovoltaic parameters of 1.63 eV PSCs based on CsBr-perovskite and CsFa-perovskite under 6500K LED light illumination.

	Light intensity (lux)	Power density (μW cm^{-2})	J_{sc} (μA cm^{-2})	V_{oc} (V)	FF (%)	PCE (%)
CsBr-perovskite	300	98.00	50.89	0.883	65.27	29.93
	500	161.42	83.34	0.894	64.80	29.91
	1000	323.97	154.11	0.916	70.41	30.68
CsFa-perovskite	300	98.00	50.48	0.962	68.78	34.08
	500	161.42	81.08	0.974	70.41	34.45
	1000	323.97	153.89	1.006	74.10	35.41

Table S3. Summary of photovoltaic parameters for WBG PSCs with perovskite bandgap of around ~1.63 eV.

Bandgap of perovskite (E_g) (eV)	J_{sc} (mA/cm^2)	V_{oc} (V)	FF (%)	PCE (%)	Reference
1.61	22.98	1.184	77.34	21.04	*Adv. Energy Mater.*, 2020, **10**, 2000197.
1.62	23.79	1.17	79.05	22.06	*Adv. Mater.*, 2021, **33**, 2100791.
1.63	22.8	1.18	81	21.8	*Science*, 2016, **354**, 206-209.
1.63	21.8	1.14	74.0	18.4	*Energy Environ. Sci.*, 2018, **11**, 394-406
1.63	20.8	1.124	79.3	18.5	*Science*, 2019, **364**, 475-479.
1.63	22.11	1.13	81.35	20.35	*Nano Energy*, 2021, **86**, 106114.
1.63	22.3	1.12	77.7	19.4	*Nat. Commun.*, 2020, **11**, 1257.
1.63	22.37	1.24	77.65	21.54	*Nat. Photon.*, 2021, **55**, 681-689.
1.63	**21.58**	**1.204**	**77.01**	**20.01**	**This Work**
1.64	20.4	1.15	80.4	19.3	*Joule*, 2019, **3**, 177-190.
1.65	21.2	1.22	80.5	20.8	*Nat. Commun.*, 2018, **9**, 3100.
1.65	21.6	1.18	75.3	19.2	*Adv. Funct. Mater.*, 2020, **30**, 1909919.
1.65	21.69	1.127	82	20.04	*ACS Energy Lett.*, 2021, **6**, 2735-2741.

Table S4. Summary of some recently reported efficient PSCs' photovoltaic parameters under artificial indoor light.

Perovskite	Artificial light	Light intensity (lux)	Power density (μW cm^{-2})	J_{sc} (mA/cm^2)	V_{oc} (V)	FF (%)	PCE (%)	Reference
$CH_3NH_3PbI_3$	Fluorescent 2700K	1000	278.7	150.1	0.87	75.2	35.2	*Adv. Energy Mater.*, 2018, **8**, 1801509.
$CH_3NH_3PbI_{2-x}BrCl_x$	Fluorescent 2700K	1000	275.4	126.2	1.028	76.8	36.2	*Adv. Energy Mater.*, 2019, **9**, 1901980.
$CsPbI_2Br$	Fluorescent 6500K	1000	312.5	139.0	0.99	77	33.9	*Adv. Funct. Mater.*, 2019, **29**, 1905163
$MAPb(I_{0.9}Br_{0.1})_3$	LED 3000K	1000	280	170.8	0.821	68.8	34.5	*Nano Energy*, 2020, **75**, 104984.
$(FA_{0.6}MA_{0.4})_{0.9}Cs_{0.1}Pb(I_{0.6}Br_{0.4})_3$	LED 3000K	1000	279.6	111.0	1.08	83	35.6	*Nano Energy*, 2020, **78**, 105377.
$(FAPbI_3)_{0.92}(MAPbBr_3)_{0.08}$	LED 2700 K	824.5	301.6	152.10	1.001	79.52	40.1	*Adv. Mater.*, 2021, **33**, 2100770.
$CsPbI_3$	LED 2700 K	1000	365	177	0.988	77.8	37.24	*Adv. Mater.*, 2022, **34**, 2106750.
$Cs_{0.05}(FA_xMA_{1-x})_{0.95}Pb(I_yBr_{1-y})_3$	**LED 2700 K**	**1000**	**307.3**	**152.79**	**1.028**	**75.37**	**38.52**	**This work**