

Supporting Information

Microwave-Facilitated Crystal Growth of Defect-Passivated Triple-Cation Metal Halide Perovskites toward Efficient Solar Cells

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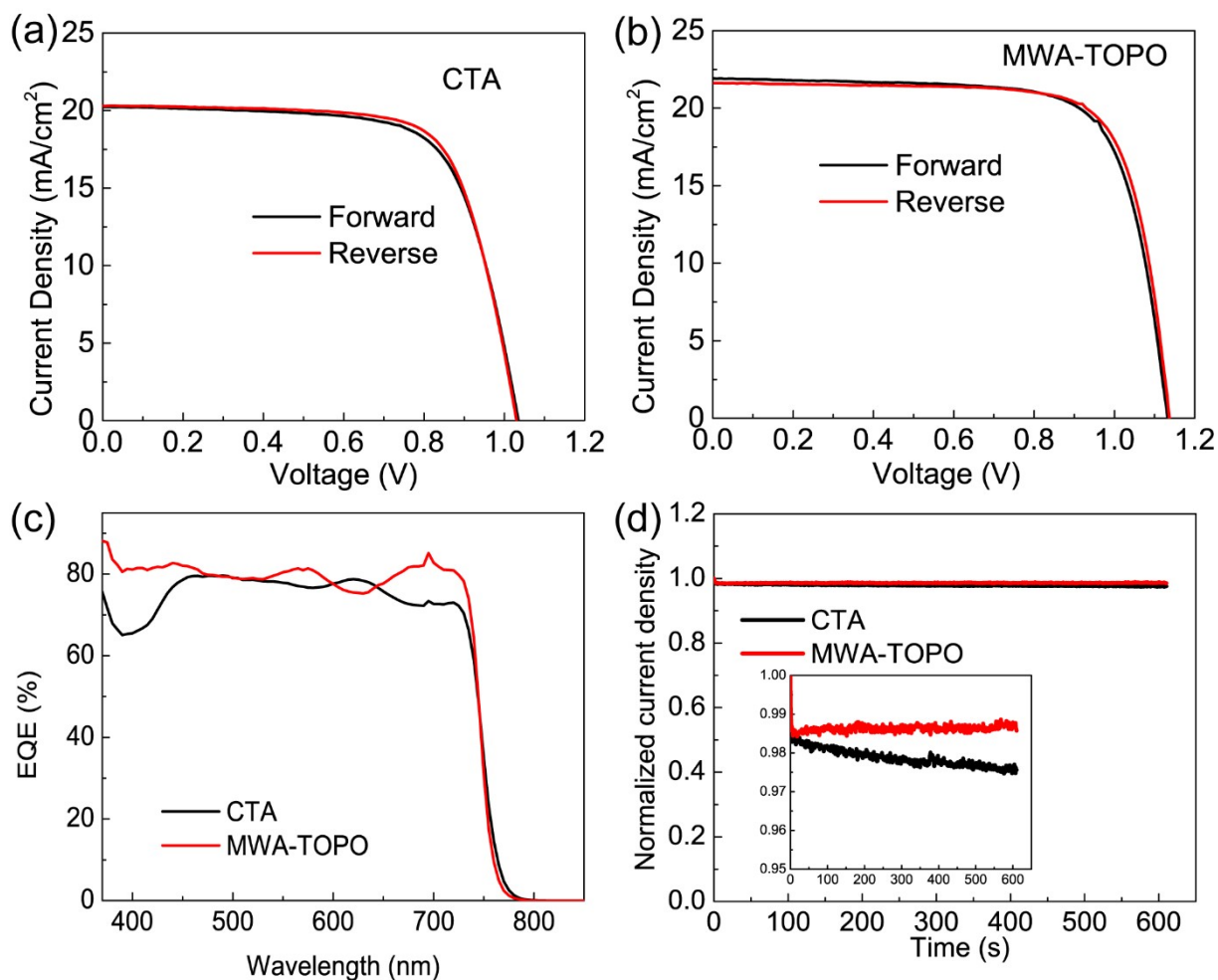


Figure S1. $J-V$ characteristics scanned in forward and reverse directions of (a) CTA and (b) MWA-TOPO devices. (c) EQE under short circuit conditions and (d) current density at maximum power point under continuous one-sun light illumination

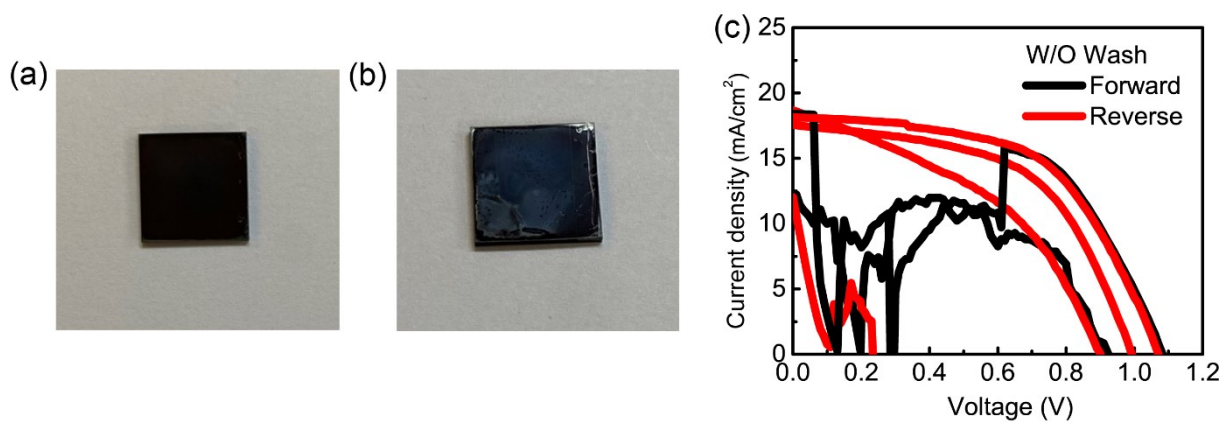


Figure S2. Photographs of (a) washed and (b) unwashed MWA-TOPO perovskite films. (c) $J-V$ curves of unwashed MWA-TOPO devices.

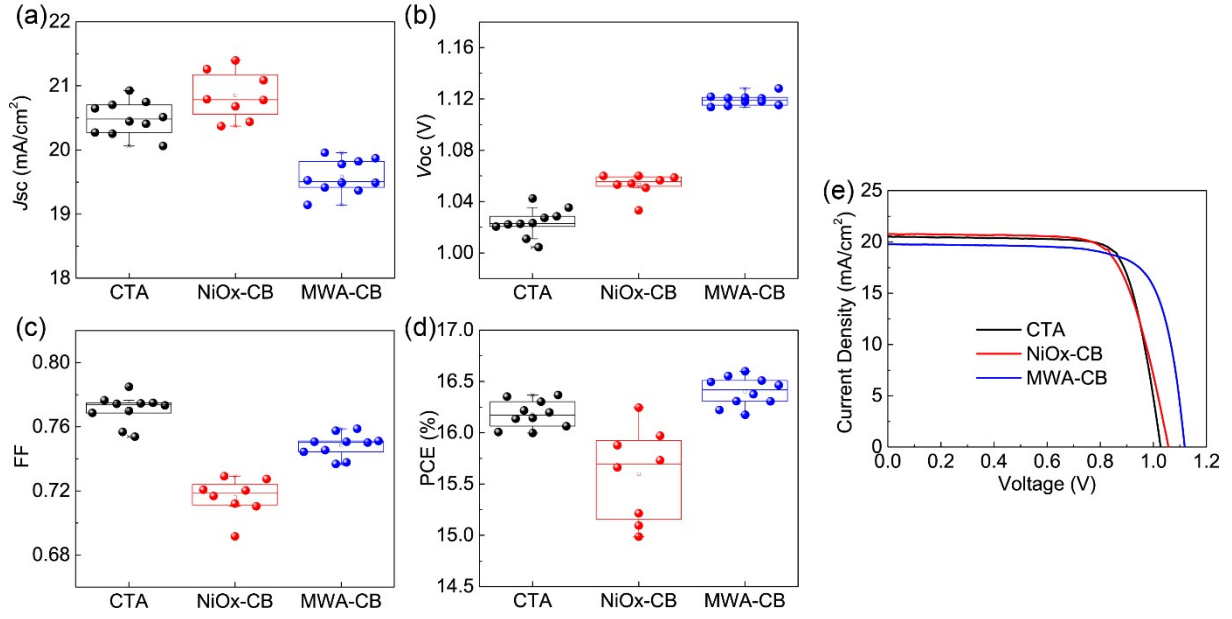


Figure S3. Statistics of (a) J_{sc} , (b) V_{oc} , (c) FF, (d) PCE for CTA, NiO_x-CB and MWA-CB. (e) $J-V$ characteristics of the best devices.

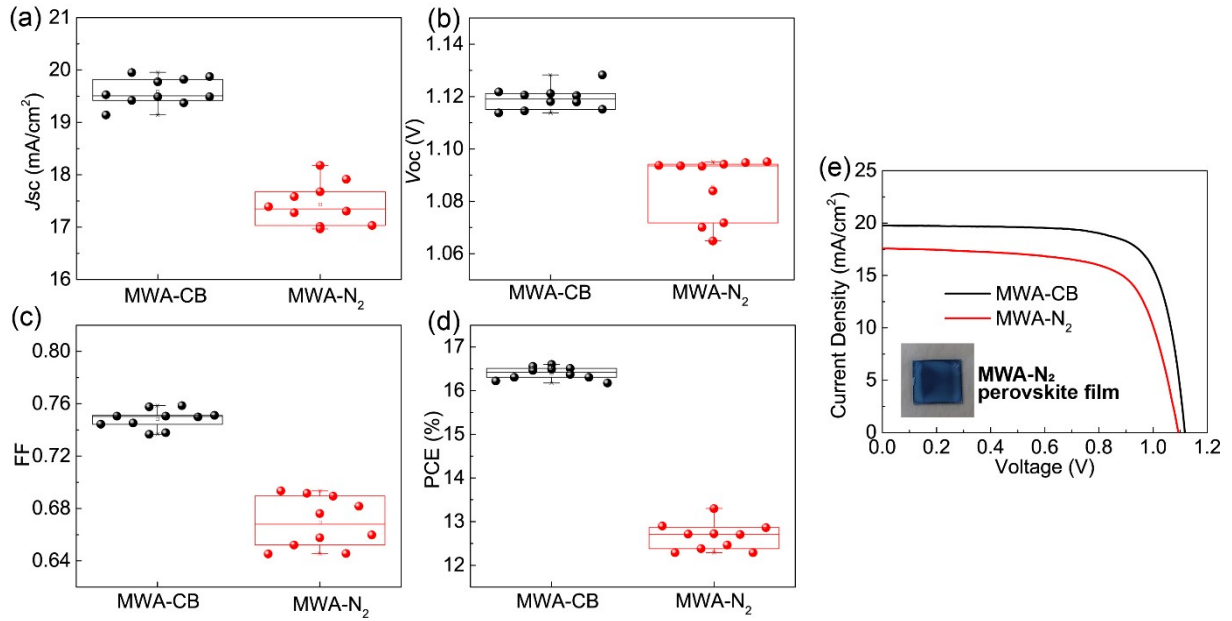


Figure S4. Comparison of the statistics (a) J_{sc} , (b) V_{oc} , (c) FF, (d) PCE for MWA-CB and MWA-N₂. (e) $J-V$ characteristics of the best devices.

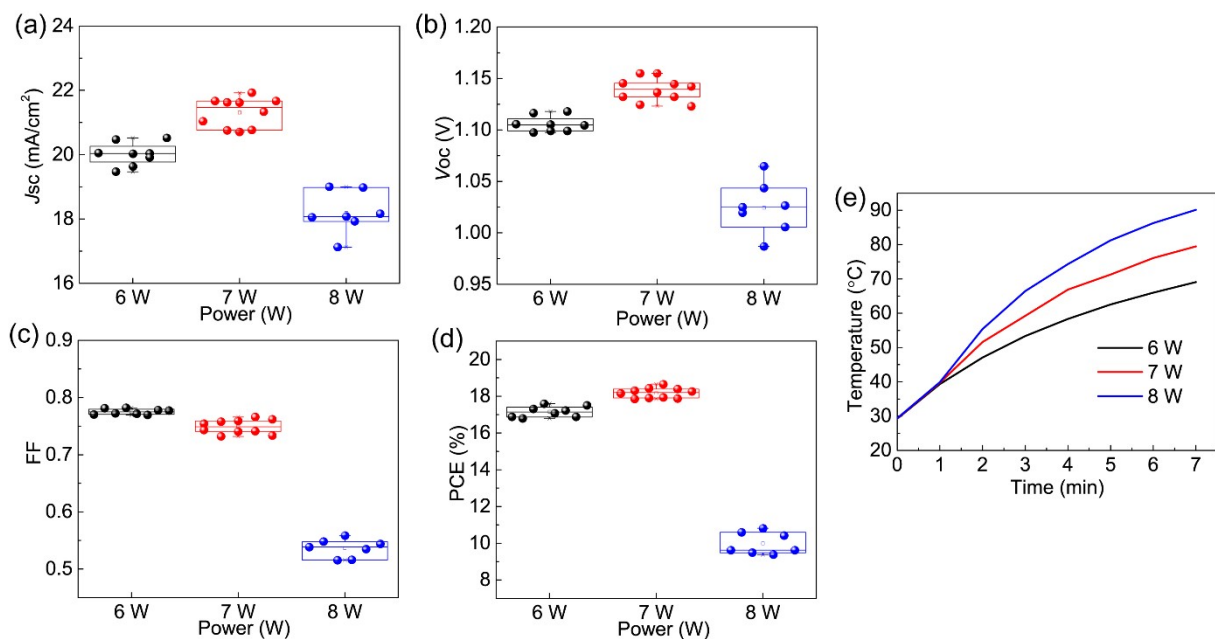


Figure S5. Microwave power dependence of the MWA-TOPO devices. Statistics of a) J_{sc} b) V_{oc} c) FF, and d) PCE of perovskite devices with different microwave powers. e) Comparison of sample temperature for 6, 7, and 8 W with increasing microwave irradiation time.

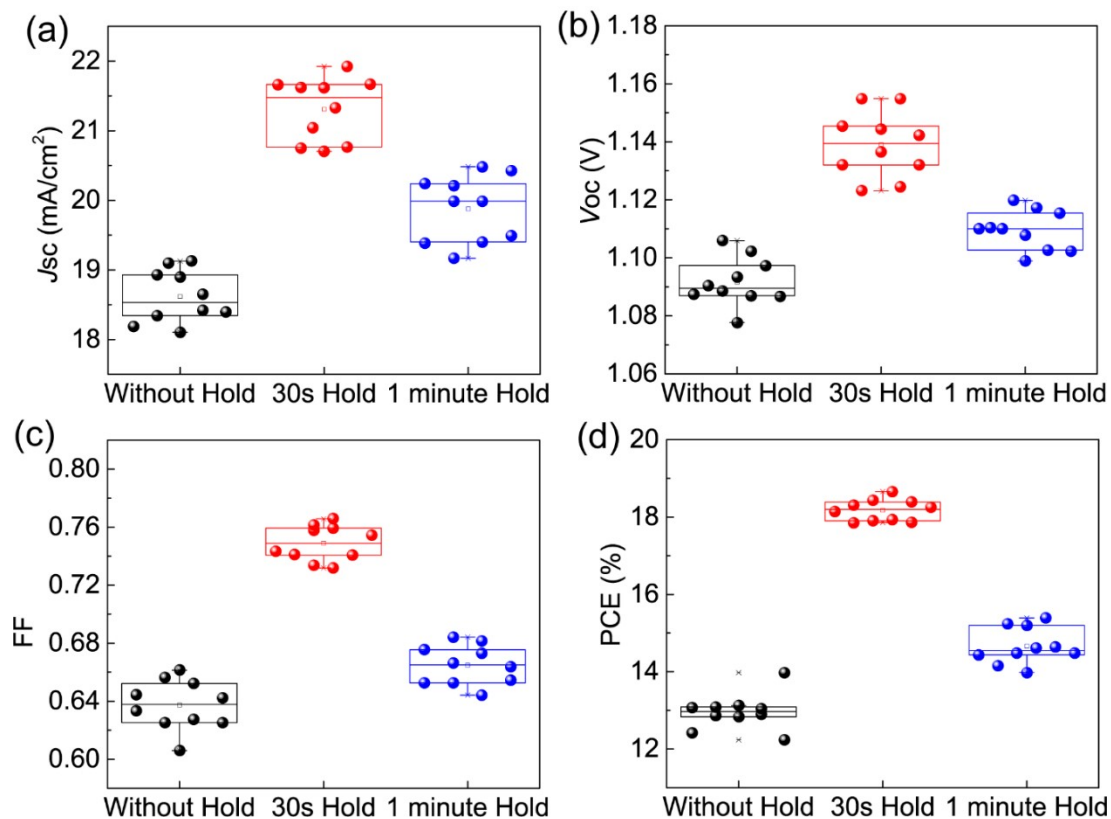


Figure S6. Holding time dependence of the MWA-TOPO devices. Statistics of (a) J_{sc} , (b) V_{oc} , (c) FF, and (d) PCE for the MWA-TOPO perovskite devices with different holding times at 7 W power for 7 min microwave condition.

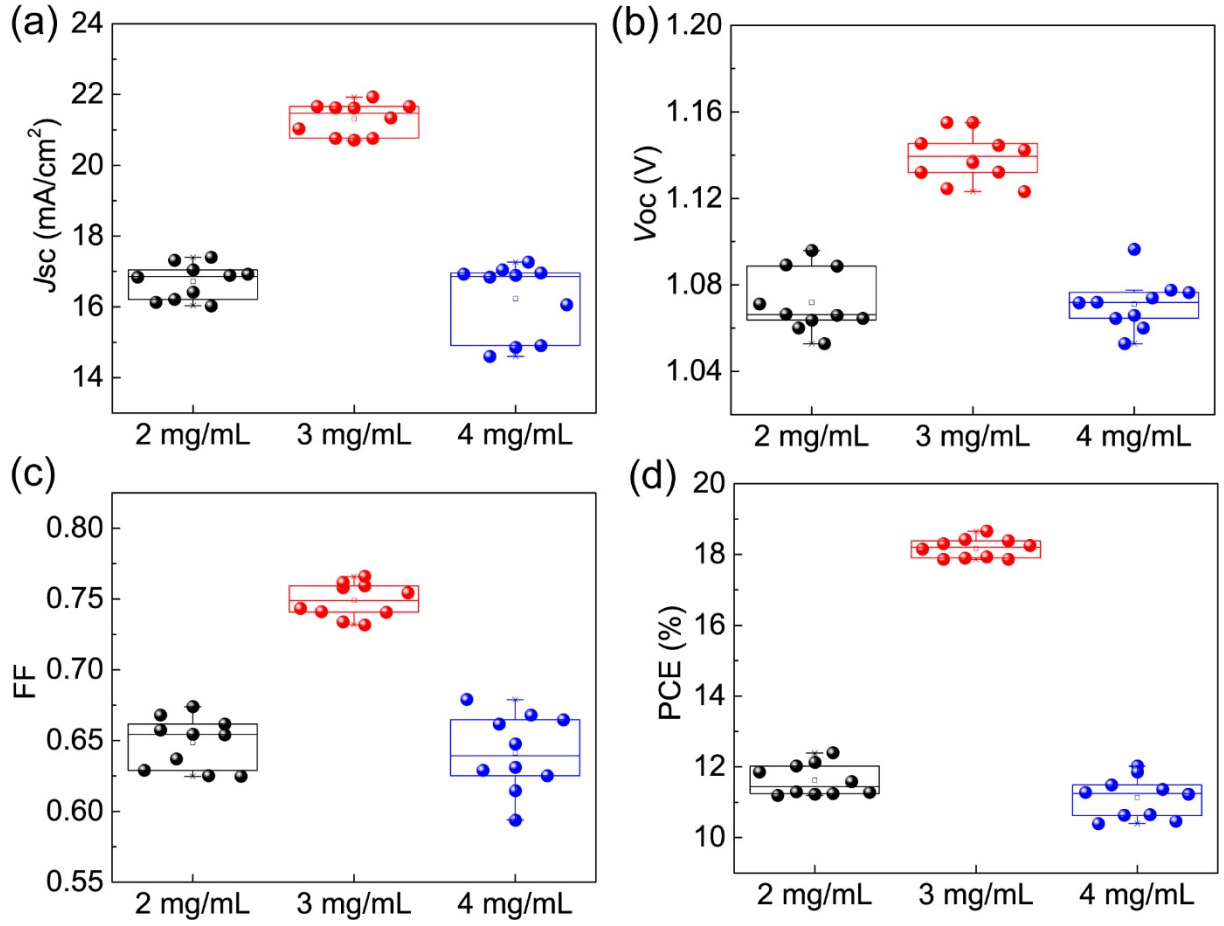


Figure S7. TOPO solution concentration dependence for MWA-TOPO. Statistics of (a) J_{sc} , (b) V_{oc} , (c) FF, and (d) PCE of the perovskite devices at 7 W power for 7 min annealing and 30 s holding time.

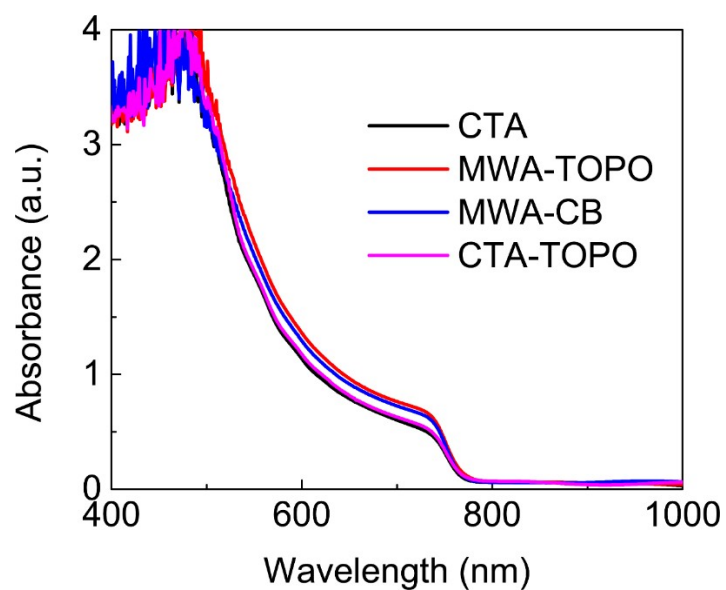


Figure S8. Absorption spectra of the CTA, MWA-TOPO, MWA-CB, and CTA-TOPO perovskite films.

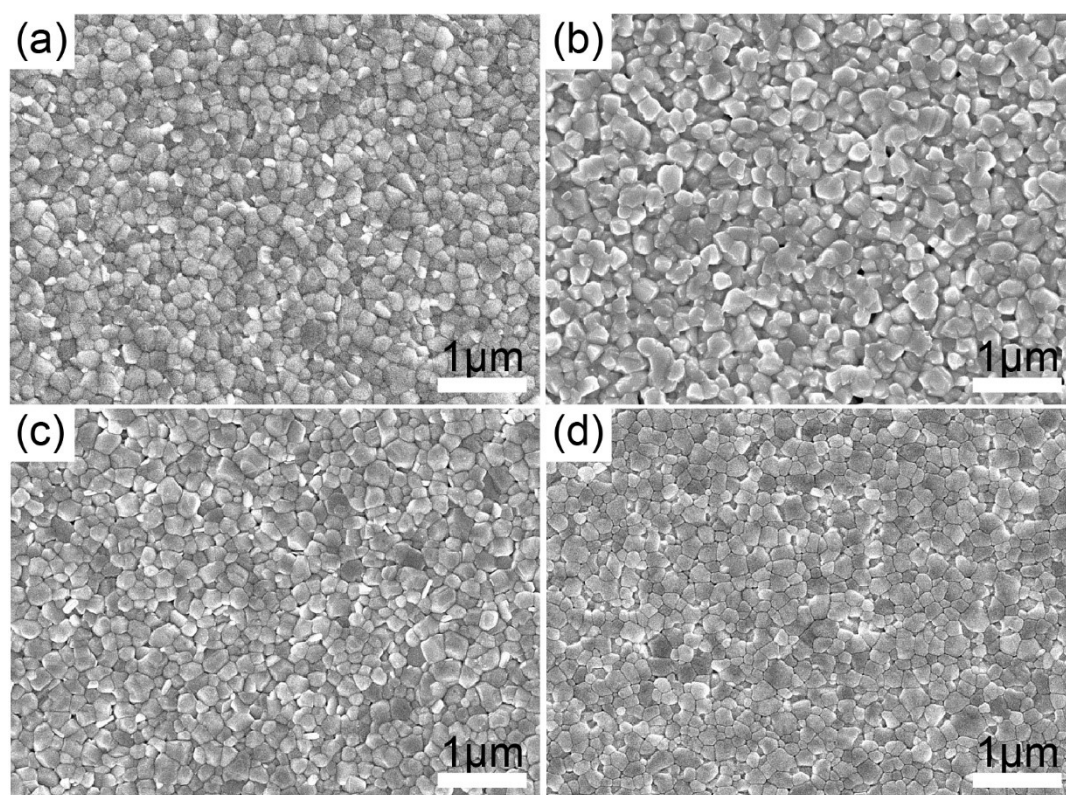


Figure S9. Top-view SEM images of perovskite films for (a) CTA, (b) MWA-TOPO, (c) MWA-CB, and (d) CTA-TOPO. The scale bar is 1 μm .

Table S1. Summary of photovoltaic parameters of the best CTA, MWA-TOPO, MWA-CB, CTA-TOPO devices. The average values for 10 devices are shown in the parentheses.

	J_{SC} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
CTA	20.515 (20.499)	1.027 (1.024)	0.777 (0.771)	16.367 (16.178)
MWA-TOPO	21.618 (21.309)	1.137 (1.139)	0.759 (0.749)	18.657 (18.174)
MWA-CB	19.777 (19.585)	1.118 (1.119)	0.751 (0.748)	16.598 (16.401)
CTA-TOPO	19.711 (19.696)	1.080 (1.076)	0.772 (0.768)	16.435 (16.263)

Table S2. Fitting parameters of time-resolved PL curves and the average PL lifetimes (τ_{avg}) for CTA, MWA-TOPO, MWA-CB and CTA-TOPO.

	A_1	τ_1 (ns)	A_2	τ_2 (ns)	A_3	τ_3 (ns)	τ_{avg} (ns)
CTA	0.61	2.18	0.15	44.19	0.23	240.60	63.30
MWA-TOPO	0.23	2.63	0.17	13.30	0.61	365.88	226.05
MWA-CB	0.46	2.72	0.09	30.04	0.42	299.05	129.56
CTA_TOPO	0.55	2.38	0.09	34.10	0.35	217.67	80.56

Table S3. Quantified crystal quality of perovskite films.

	CTA	MWA-TOPO	MWA-CB	CTA-TOPO
Crystal quality	2.85	11.70	7.23	4.65