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Enhanced stability in perovskite solar cells via room-temperature processing†

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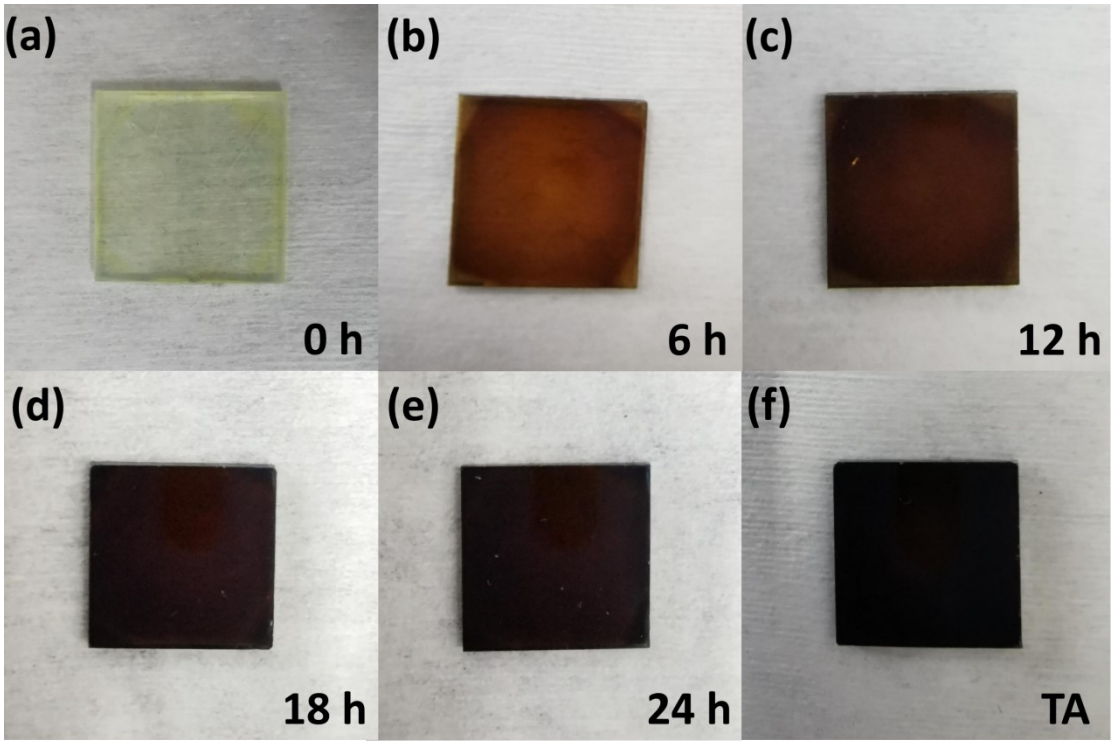

Figure S1. The colour difference between the TA and RT processed films. (a) - (d) The perovskite film crystallized for different times (0, 6, 12, 18 and 24 hours). (f) The control sample crystallized by thermal annealing.

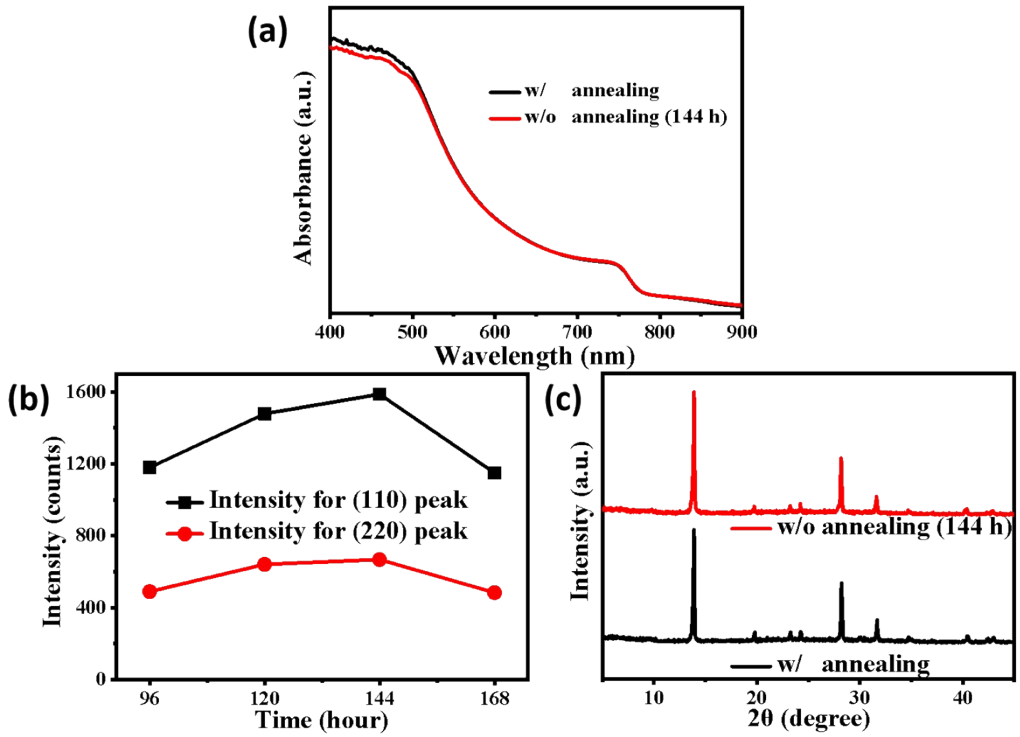

Figure S2. (a) UV-Vis spectra of perovskite films crystallized at room temperature for 144 hours and control sample crystallized by thermal annealing inside a N_2 filled glovebox. (b) Peak intensity of (110) and (220) planes of the perovskite film crystallized for different times (96, 120, 144 and 168 hours). (c) XRD of perovskite films crystallized at room temperature for 144 hours and control sample crystallized by thermal annealing inside a N_2 filled glovebox.

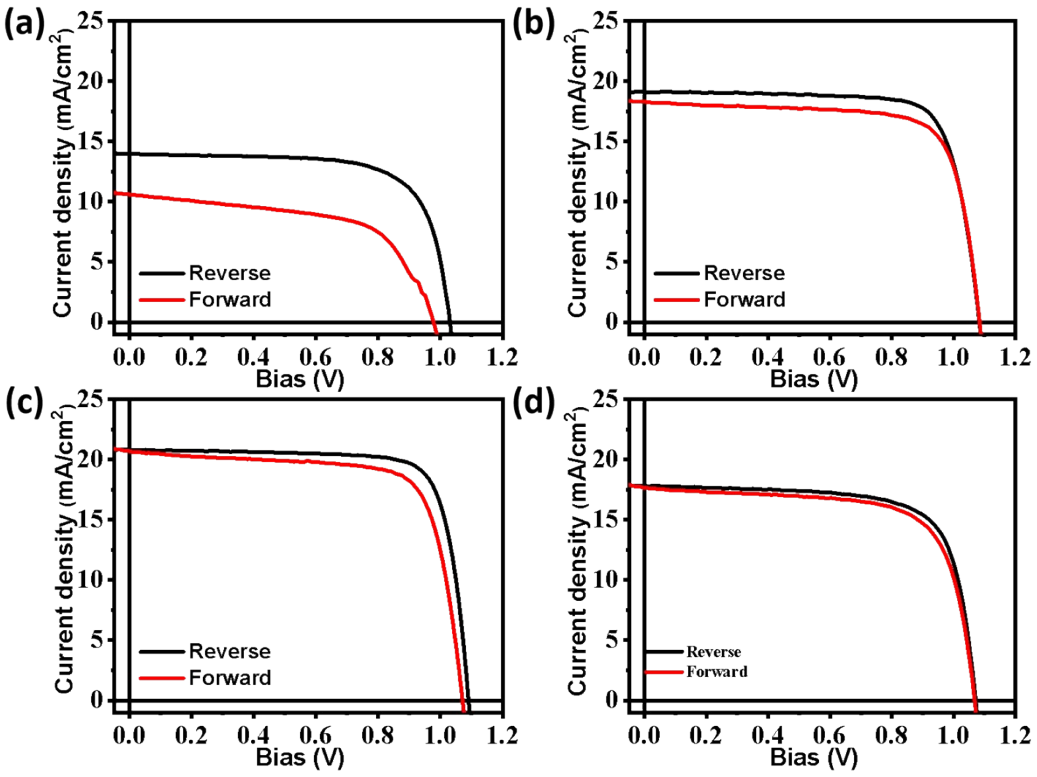

Figure S3. Comparison of the hysteresis effect in J-V characteristics of $MAPbI_3$ solar cells under 1 sun irradiation in the forward (F) and reverse (R) scan directions that made from perovskite films crystallized for (a) 96, (b)120, (c)144 and (d) 168 hours without thermal annealing.

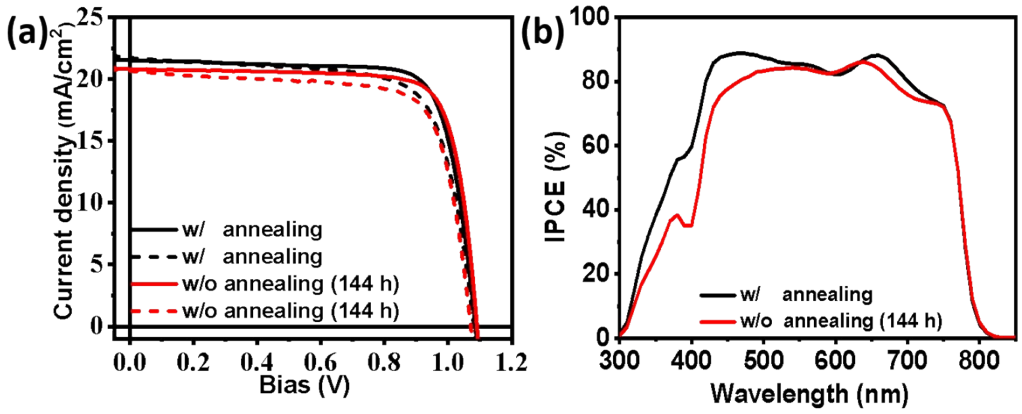

Figure S4. (a) Comparison of the hysteresis effect in J-V characteristics of $MAPbI_3$ solar cells under 1 sun irradiation in the forward (F) and reverse (R) scan directions and (b) EQE spectra that made from perovskite films crystallized for 144 hours without and with thermal annealing.

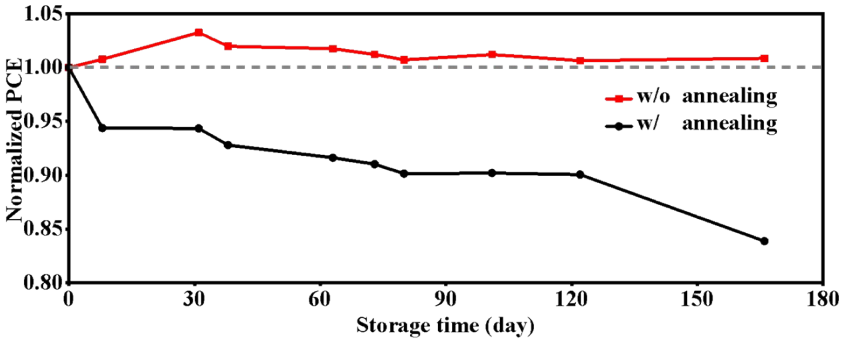

Figure S5. Shelf time of the solar cells obtained from 144 hours crystallized perovskite films and thermal annealing samples.

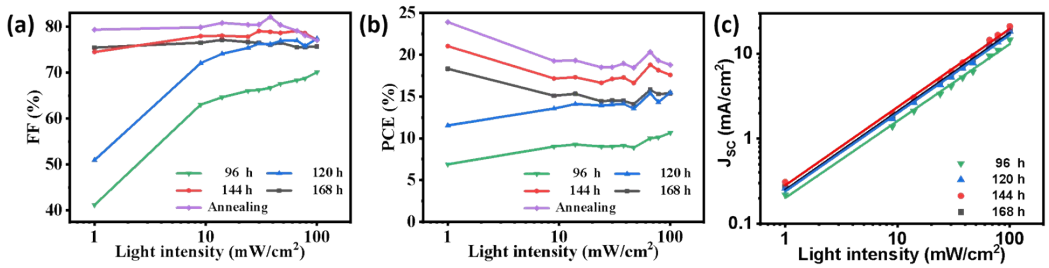

Figure S6. Irradiation dependent of (a) fill factor (FF), (b) PCE and (c) short-circuit current J_{sc} of $MAPbI_3$ solar cells that made from perovskite films crystallized for 96, 120, 144 and 168 h with room-temperature processing and theamal annealing.

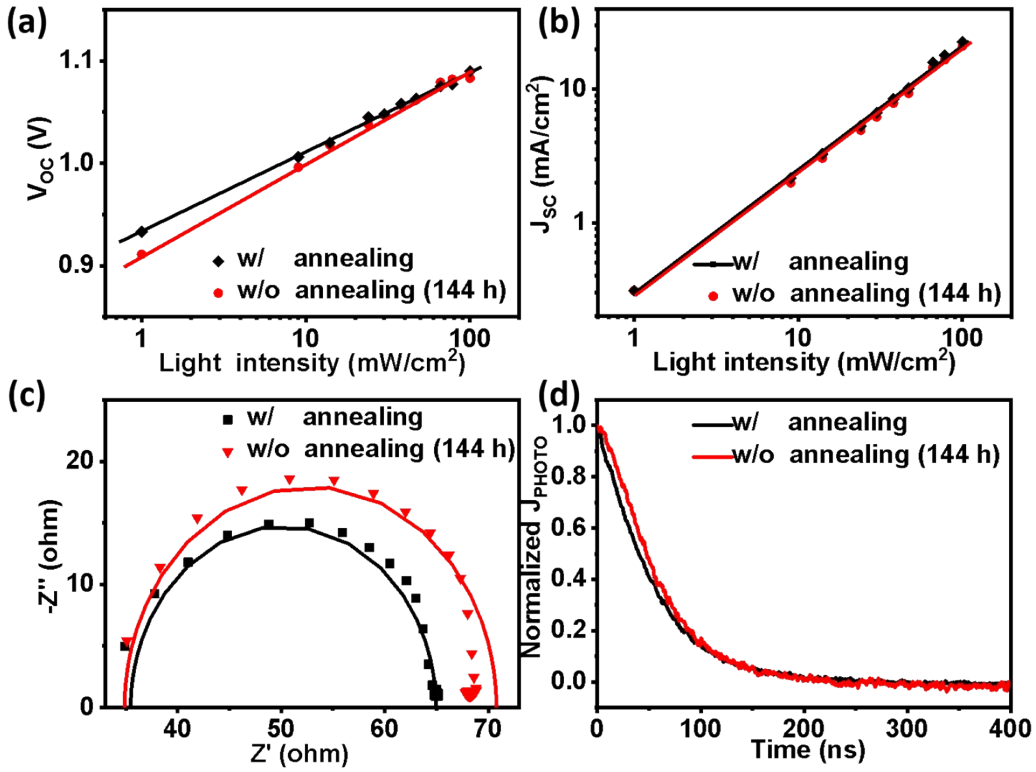

Figure S7. Irradiation dependent (a) open-circuit voltage and (b) short-circuit current J_{sc} of $MAPbI_3$ solar cells that made from perovskite films crystallized for 144 h without thermal annealing and with annealing. (c) Nyquist plot of the impedance measured on the same solar

cells under 1 sun irradiation (bias at V_{oc}). Lines are the results of equivalent circuit modelling. (d) TPC of perovskite solar cells with crystallized for 144 h without thermal annealing and with annealing.

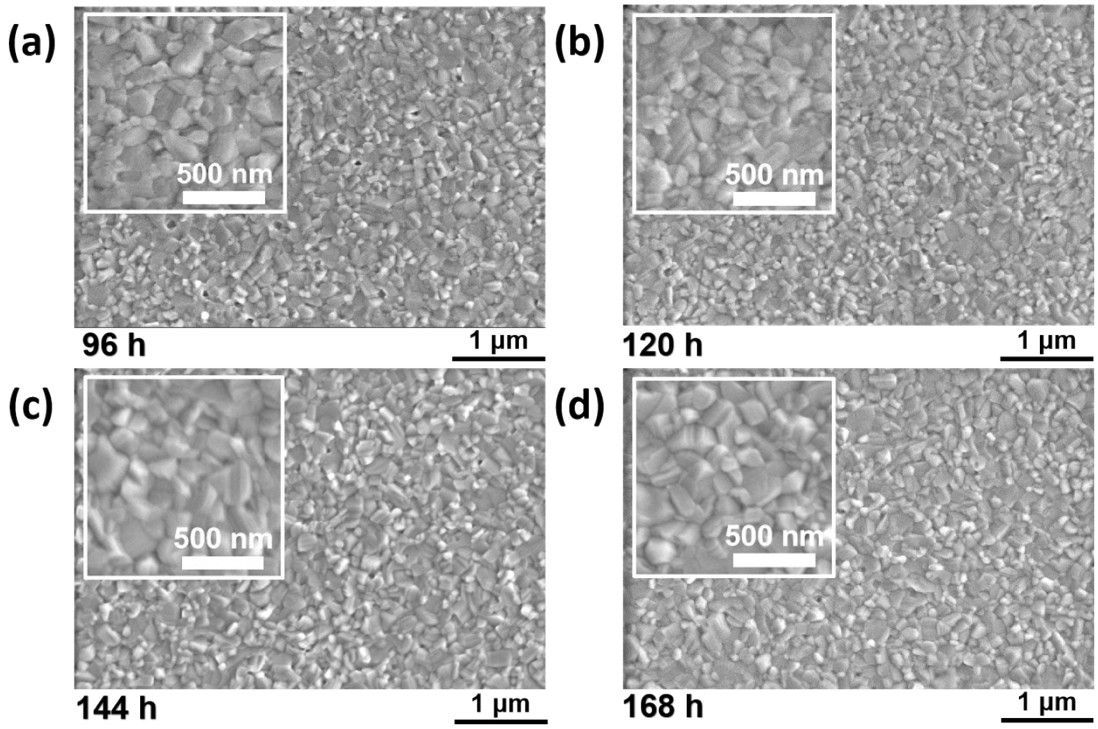

Figure S8. SEM images (a - d) of the perovskite films crystallized for 96, 120, 144 and 168 hours without thermal annealing.

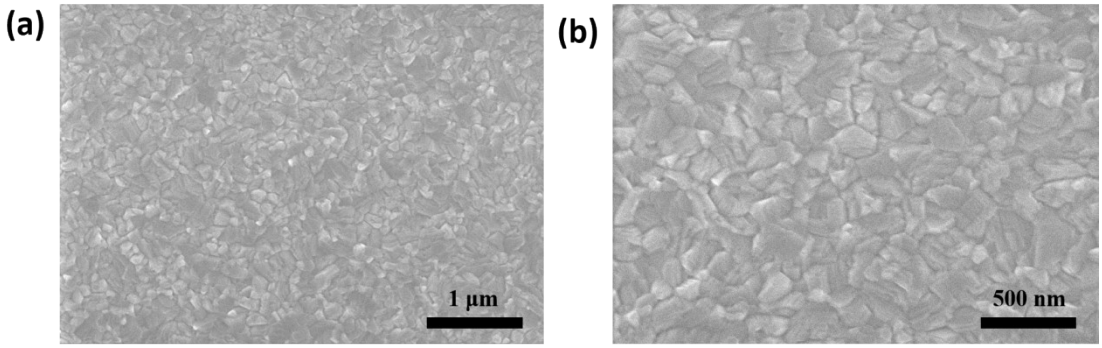

Figure S9. SEM image of the perovskite films by thermal annealing.

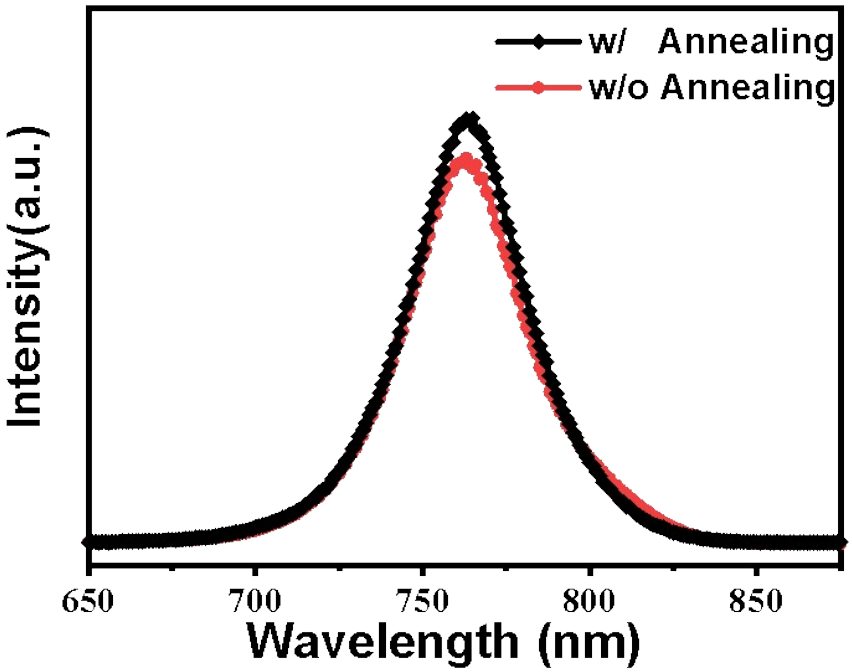

Figure S10. Photoluminescence (PL) spectroscopy of the perovskite films with crystallized for 144 h without thermal annealing and with annealing.

Table S1. Comparison of the hysteresis effect in J-V characteristics of $MAPbI_3$ solar cells under 1 sun irradiation in the forward (F) and reverse (R) scan directions that made from perovskite films crystallized for (a) 96, (b)120, (c)144 and (d) 168 hours without thermal annealing.

Time		V_{oc} (V)	J_{sc}/ (mA·cm^{-2})	FF (%)	PCE (%)
96 h	R	1.03	13.95	71.56	10.28
	F	0.97	10.56	59.28	6.07
120 h	R	1.08	19.09	77.59	16.00
	F	1.08	18.27	75.26	14.85
144 h	R	1.09	20.76	79.75	18.05
	F	1.07	20.64	74.28	16.40
168 h	R	1.07	17.79	72.86	13.87
	F	1.06	17.64	70.84	13.25
Annealing	R	1.08	21.66	79.71	18.65
	F	1.08	21.52	74.97	17.42

Table S2. Device parameters of impedance spectroscopy and TPC of $MAPbI_3$ solar cells measured.

	R_1 (Ω)	C_1 (C)	R_2 (Ω)	τ (ns)
96 h	32.11	9.251E-9	69.72	94.02 ± 0.57
120 h	33.69	9.417E-9	47.87	70.83 ± 0.38
144 h	34.88	1.420E-8	35.89	55.72 ± 0.24
168 h	33.41	9.046E-9	57.52	76.33 ± 0.49
Annealing	35.47	1.636E-8	29.46	53.36 ± 0.12