

## Supporting Information

### Effect of substrate temperature on the crystallization process and properties of mixed-ions perovskite layers

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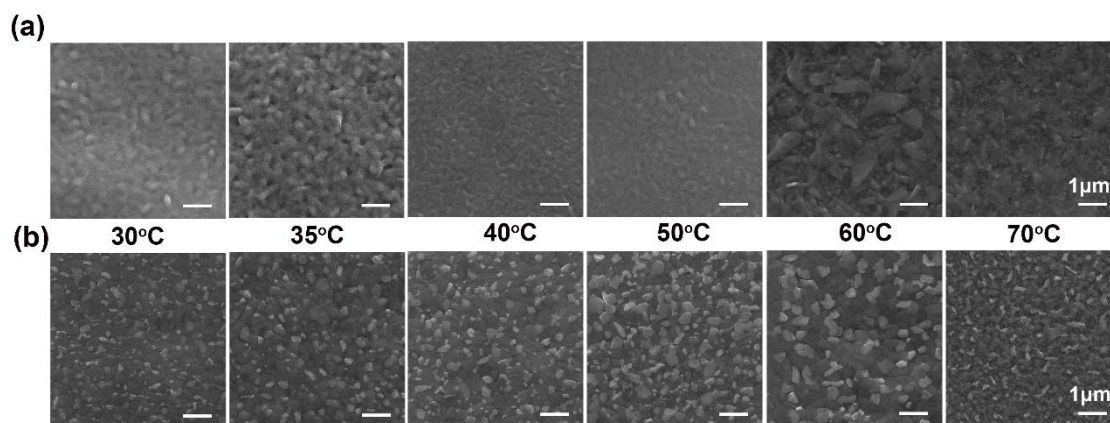


Fig. S1 SEM images of fresh perovskite thin films (a) and annealed perovskite films (b) spin-coated onto substrates with different temperatures.

Table S1 The surface thickness and roughness of the perovskite films spin-coated on the substrates with different temperatures.

	Thickness(nm)	Roughness(nm)
30 °C	418	16.1
35 °C	503	18.2
40 °C	592	33.9
50 °C	918	428.9
60 °C	150-4000	1766.1
70 °C	0-5000	2294.7

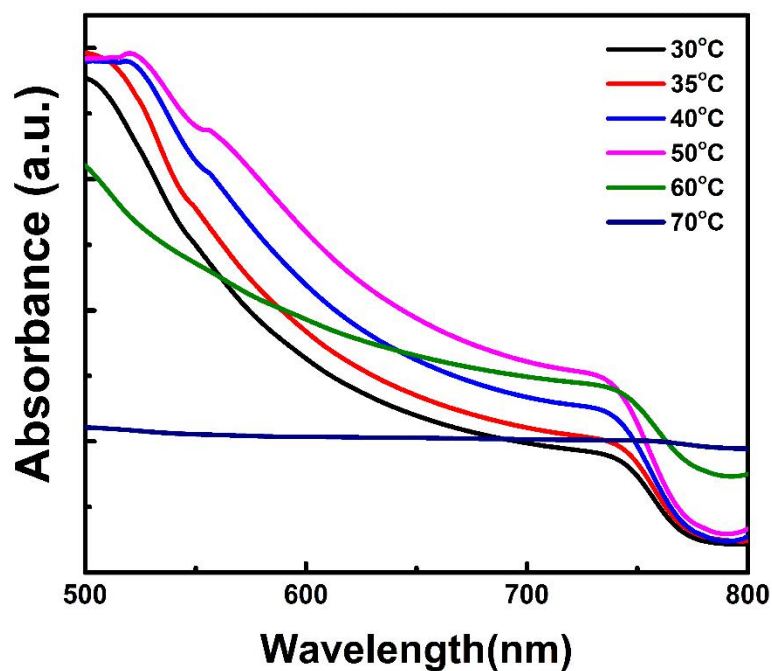


Fig. S2 The UV-Vis absorption spectra of the annealed perovskite films spin-coated on substrates with different temperatures.

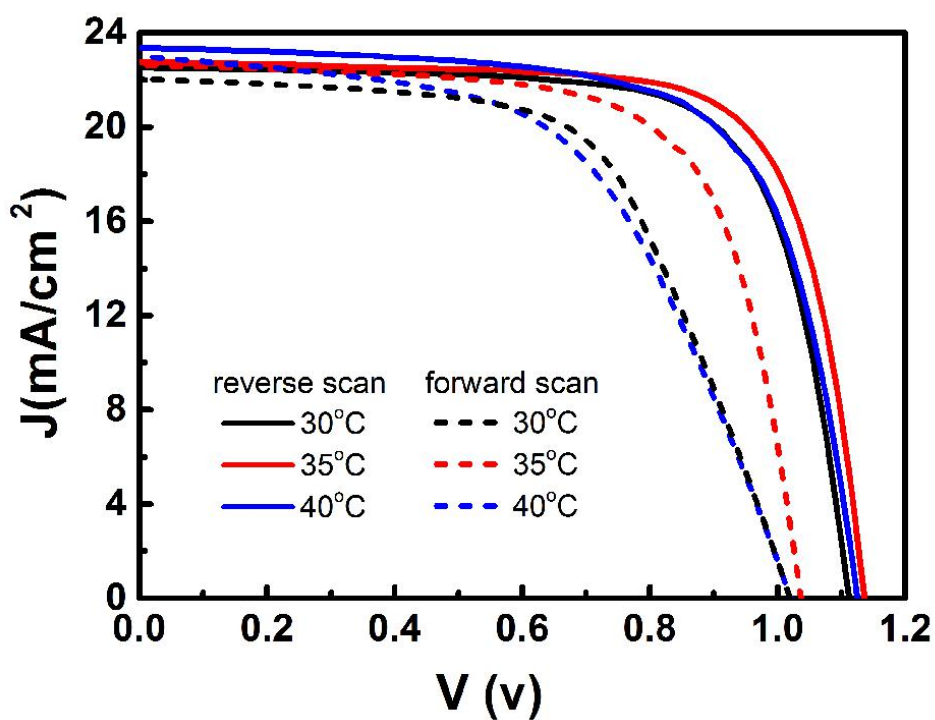


Fig. S3 Typical current density–voltage (J–V) reverse and forward scans of devices prepared on substrates with temperatures of 30 °C, 35 °C, and 40 °C.

Table S2 Photovoltaic parameters of the forward and reverse scans of the best PSCs fabricated at different substrate temperatures.

		Voc (v)	Jsc (mA/cm <sup>2</sup> )	FF (%)	PCE (%)
30 °C	Reverse scan	1.092	22.92	71.36	17.87
	Forward scan	1.023	22.06	57.43	12.96
35 °C	Reverse scan	1.135	22.75	73.72	19.03
	Forward scan	1.036	22.61	68.71	16.11
40 °C	Reverse scan	1.125	23.35	70.29	18.05
	Forward scan	1.029	23.07	54.93	13.04
50 °C	Reverse scan	0.935	22.35	62.46	13.06
	Forward scan	0.886	22.11	43.08	8.43
60 °C	Reverse scan	0.845	17.56	44.06	6.54
	Forward scan	0.623	16.51	32.68	3.36
70 °C	Reverse scan	0.657	16.22	40.33	4.31
	Forward scan	0.572	16.19	32.51	3.01

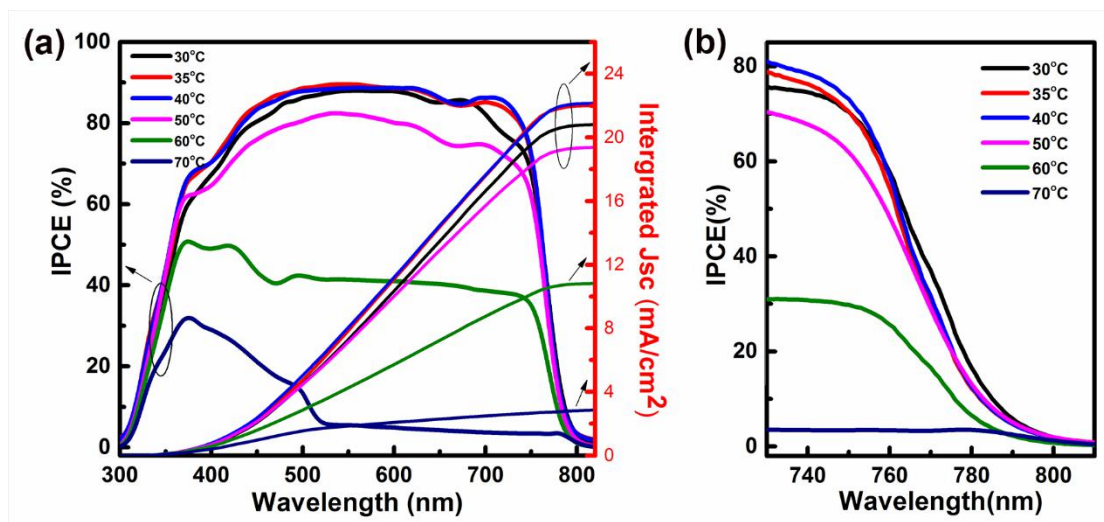


Fig. S4 (a) The incident photon-to-current conversion efficiency (IPCE), IPCE data-based integrated current density and (b) the absorption edge of the IPCE of the PSCs prepared at different substrate temperatures.

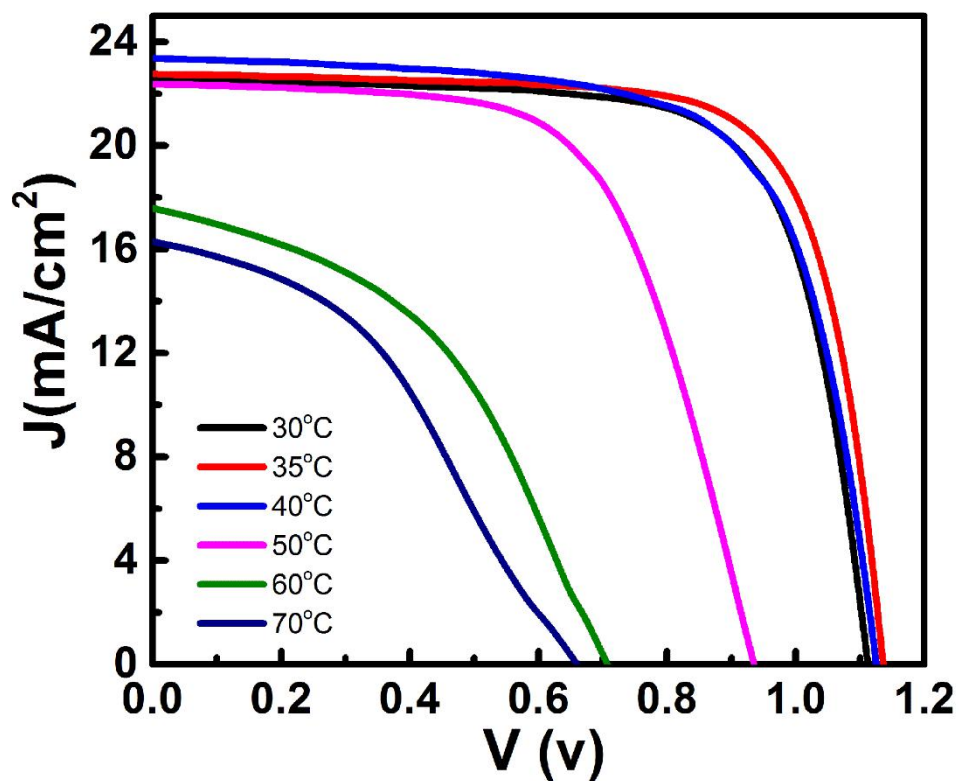


Fig.S5 Typical J-V reverse scan of PSCs prepared at different substrate temperatures from 30 °C to 70 °C.

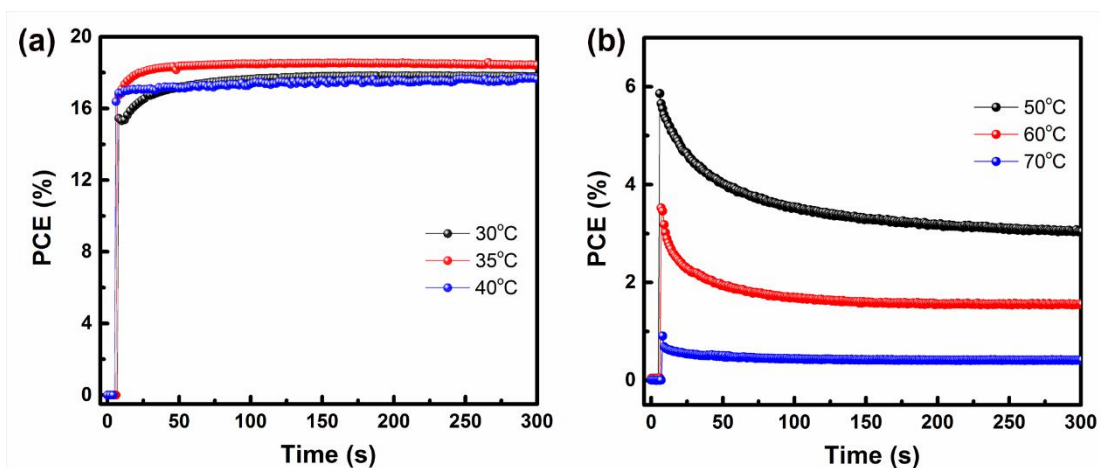


Fig. S6 Steady-state PCEs at Max Power Point conditions measured as a function of time; for PSCs fabricated at different substrate temperatures (30°C, 35°C, 40°C, 50°C, 60°C and 70°C) biased at 0.94V, 0.95V, 0.9V, 0.72V, 0.48V and 0.26V, respectively.

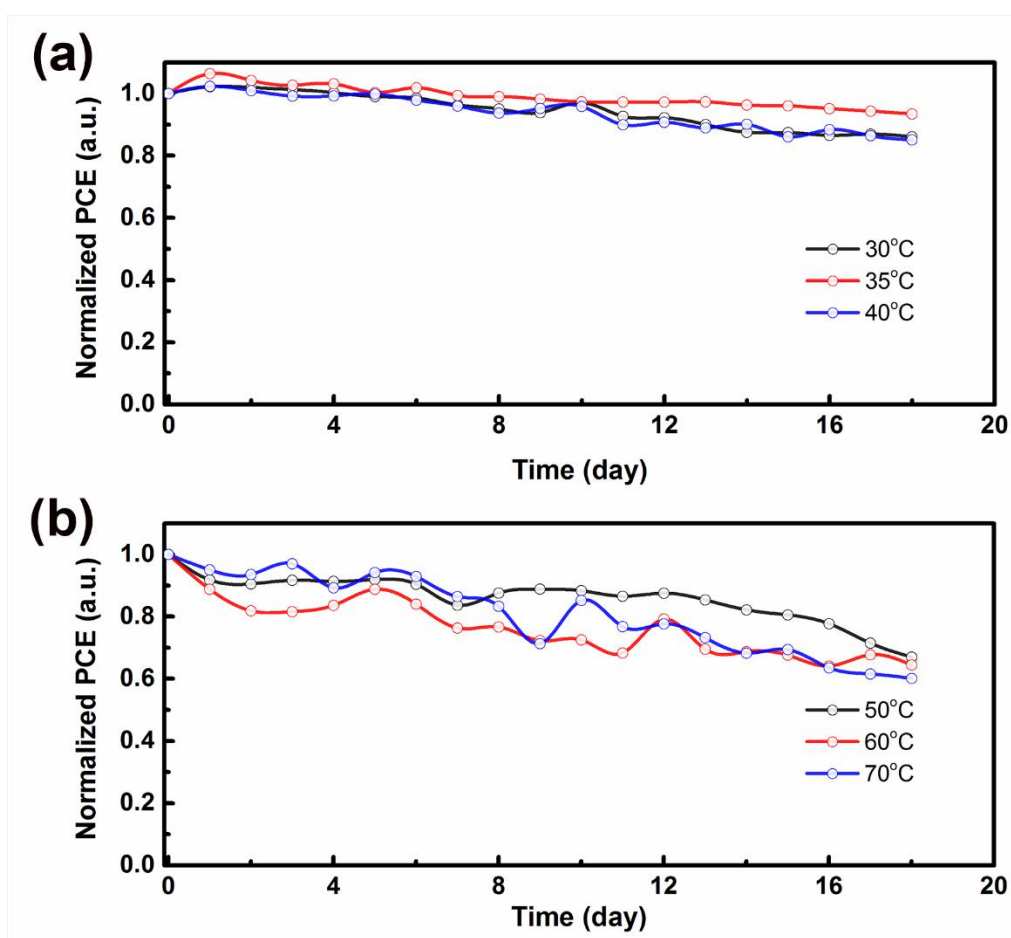


Fig. S7 Stability testing (storing 18 days in glove box at room temperature) for PSCs prepared at different substrate temperatures.