Reaction temperature modulating crystal grain size and optoelectronic properties of perovskite film for solar cell application

Xiaodong Ren,ª Zhou Yang, *ª Dong Yang,ª Xu Zhang,ª Dong Cui,ª Yucheng Liu,ª Qingbo Wei,ª Haibo Fan,ª Shengzhong (Frank) Liu*^{a, b}

a. Key Laboratory of Applied Surface and Colloid Chemistry, National Ministry of Education; Institute for Advanced Energy Materials, School of Materials Science and Engineering, Shaanxi Normal University, Xi'an 710119, China

b. Dalian Institute of Chemical Physics, Dalian National Laboratory for Clean Energy,
Chinese Academy of Sciences, Dalian, 116023, China

Corresponding author: Prof. Shengzhong (Frank) Liu, email: liusz@snnu.edu.cn (szliu@dicp.ac.cn); Dr. Zhou Yang, email: zyang@snnu.edu.cn.



Figure S1. XRD pattern of perovskite films formation process as function of reaction time at different reaction temperature: (a) 150 °C, (b) 175 °C, (c) 200 °C.



Figure S2. The morphology evolution of films during transformation from PbI_2 to $CH_3NH_3PbI_3$ at different temperature: (a)-(c) at 150 °C, (d)-(f) at 175 °C and (g)-(i) at 200 °C. The scale bar in (a) represents 1 µm and works for all other images.



Figure S3. Statistical analysis of the perovskite solar cells fabricated at different temperature: (a) 150 °C, (b) 175 °C, (c) 200 °C. Histograms of the efficiency based on 30 samples with a structure of $FTO/bl-TiO_2/CH_3NH_3PbI_3/Spiro-OMeTAD/Au$. The distributions of the efficiency are close to a Gaussian distribution.



Figure S4. The cross-sectional SEM images of perovskite solar cells with different thickness: (a) 600 nm, (b) 500 nm and (c) 400 nm. The scale bar in figure S4a represents for 1 μ m and works for all other images.

Absorber	Jsc	Voc	FF	PCE
thickness	mA/cm ²	V		%
400 nm	20.2 ± 0.876	0.968 ± 0.021	0.646 ± 0.032	12.6 ± 1.26
500 nm	19.9 ± 0.941	0.950 ± 0.012	0.648 ± 0.029	12.3 ± 0.995
600 nm	20.0 ± 0.735	0.939 ± 0.013	0.647 ± 0.031	12.1 ± 0.1.05

Table S1. The photovoltaic parameters of perovskite solar cells with different absorber thicknesses.