Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Millisecond-Pulsed Photonically-Annealed Tin Oxide Electron Transport Layers for Efficient Perovskite Solar Cells

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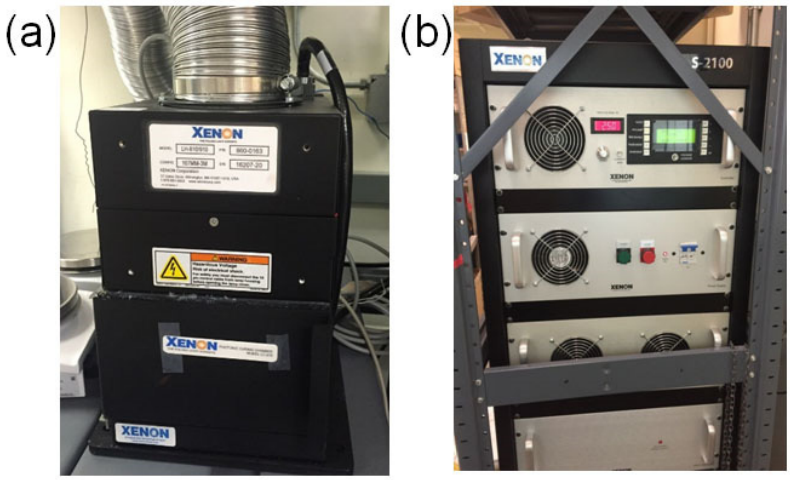

Figure. S1. Photonic annealing system. (a) Photograph of the high-intensity pulsed xenon lamp with 240 nm to 1500 nm broadband emission, 25 mm lamp-to-sample distance, and annealing area of ~80 cm^2. (b) Photograph of the electronic control system for the Xenon Sinteron 2010-S.

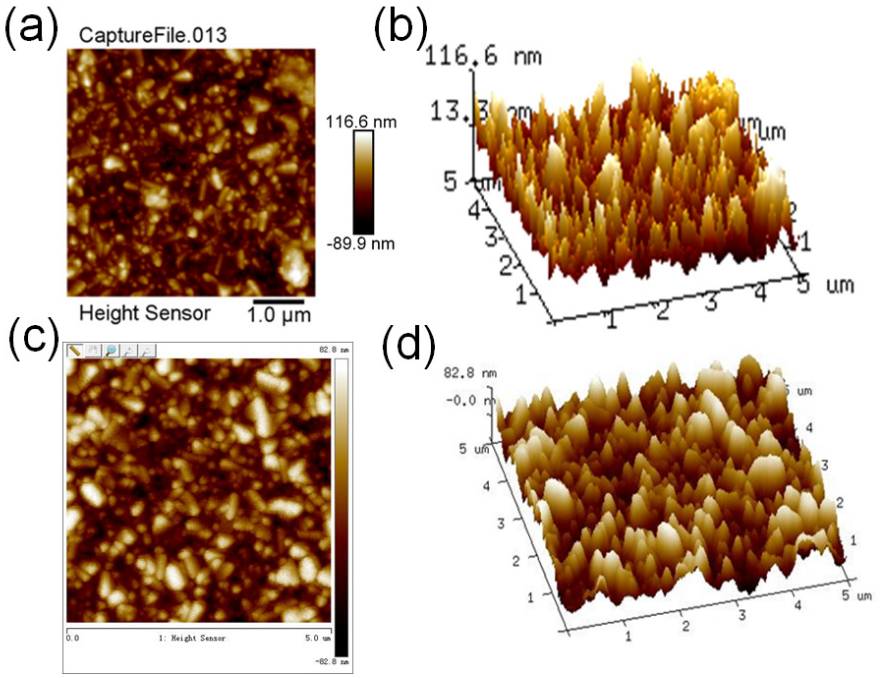

Figure S2. (a,b) Atomic force microscopy images of the SnO_2 film before photonic annealing: (a) topography; (b) 3D rendering. (c,d) Atomic force microscopy images of the SnO_2 film after photonic annealing: (c) topography; (d) 3D rendering.

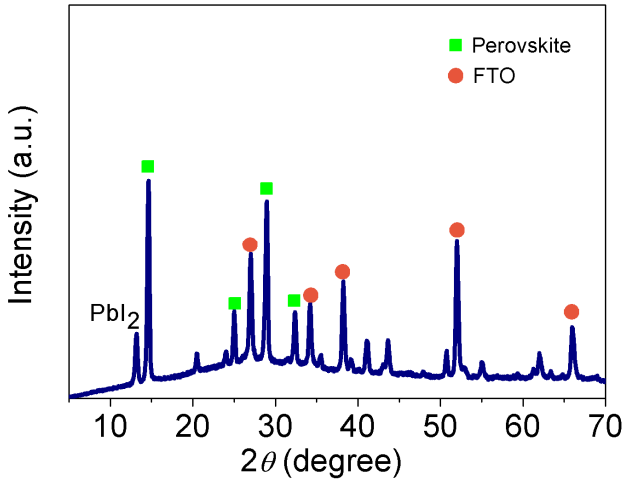

Figure S3. XRD pattern of a perovskite $CH_3NH_3PbI_3$ film coated on a SnO_2/FTO substrate.

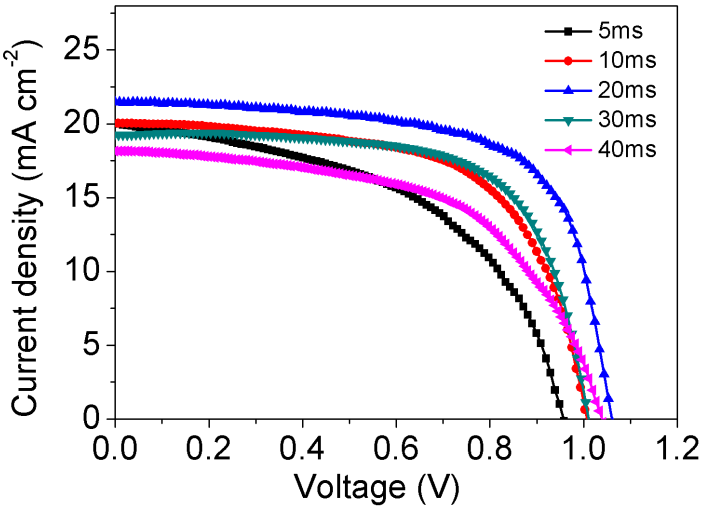

Figure S4. *J-V* curves of the perovskite solar cells based on SnO_2 ETLs prepared with different photonic annealing times.

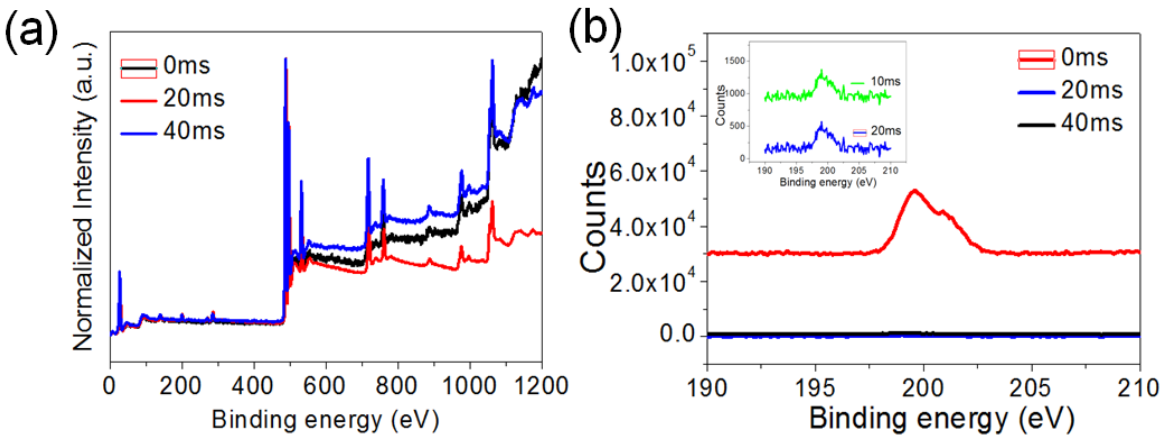

Figure S5. XPS spectra for the SnO_2 films coated on FTO substrates with different photonic annealing times: (a) survey; (b) Cl 2p. The inset in (b) shows a magnified view for 10 ms and 20 ms photonic annealing times.

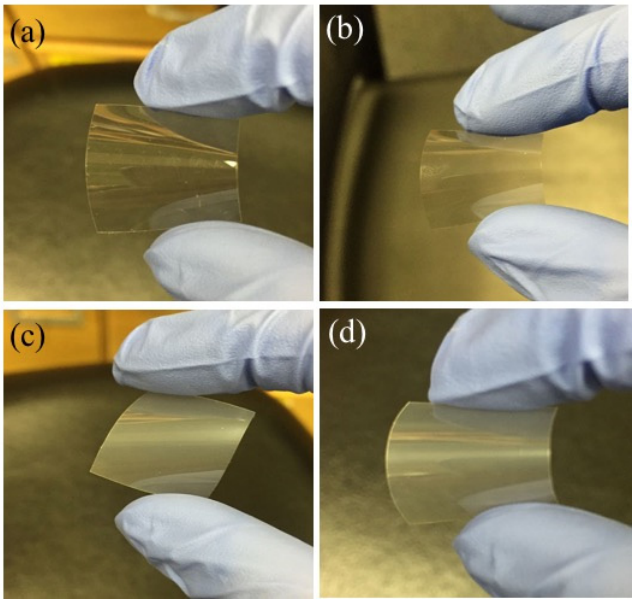

Figure S6. Photographs taken before and after photonic annealing with the optimized conditions for (a,b) PET and (c,d) PEN, confirming the compatibility of flexible substrates with this treatment.

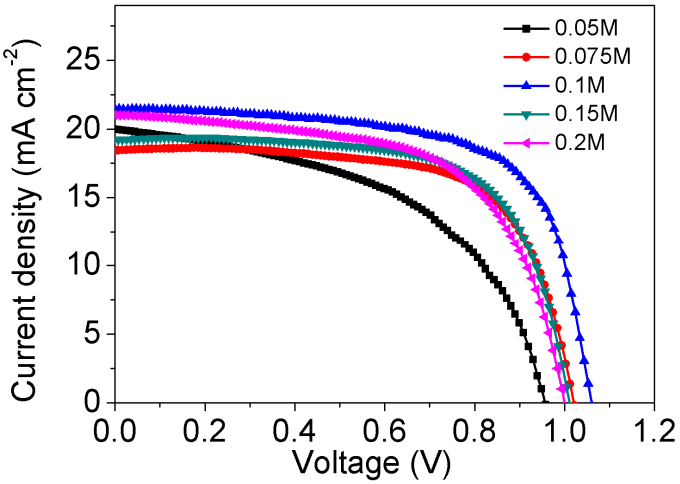

Figure S7. *J-V* curves of the perovskite solar cells based on SnO_2 ETLs prepared with different $SnCl_4$-based precursor solution concentrations.

Table S1. Photovoltaic parameters of the perovskite solar cells based on SnO_2 ETLs prepared with different photonic annealing times.

Time (ms)	V_{OC} (V)	J_{SC} (mA cm^{-2})	FF	PCE (%)
5	0.96	20.0	0.51	9.79
10	1.00	20.0	0.62	12.6
20	1.06	21.4	0.67	15.3
30	0.99	19.3	0.58	11.1
40	1.02	18.2	0.56	10.1

Table S2. Photovoltaic parameters of the perovskite solar cells based on SnO_2 ETLs prepared with different $SnCl_4$-based precursor solution concentrations.

Conc. (M)	V_{OC} (V)	J_{SC} (mA cm^{-2})	FF	PCE (%)
0.05	0.96	20.6	0.60	11.8
0.075	1.01	18.8	0.68	12.9
0.10	1.06	21.4	0.67	15.3
0.15	1.00	19.4	0.67	13.1
0.20	1.00	21.0	0.61	12.8