

Electronic supplementary information (ESI)

Electrosprayed TiO₂ Nanoporous Hemi-spheres for Enhanced Electron Transport and Device Performance of Formamidinium Based Perovskite Solar Cells

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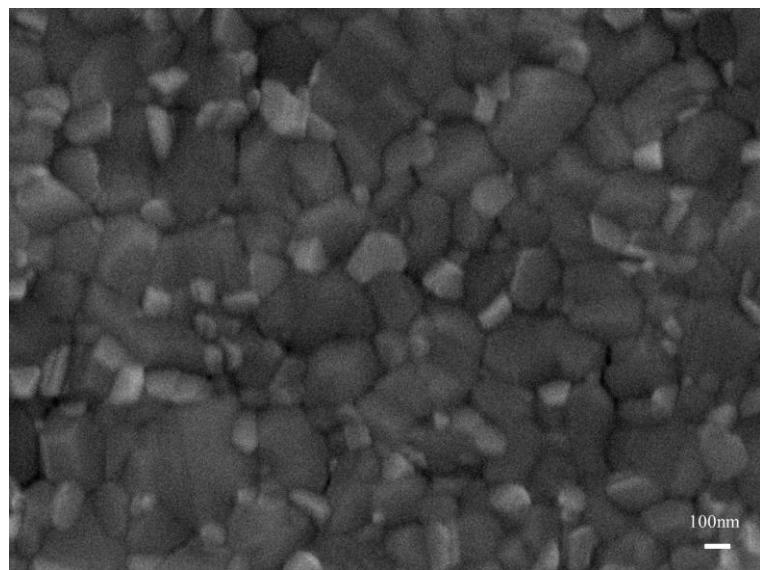


Fig. S1. SEM image of prepared $\text{FA}_{0.81}\text{MA}_{0.15}\text{Pb}(\text{I}_{0.836}\text{Br}_{0.15})_3$ film on top of TiO_2 NPs layer.

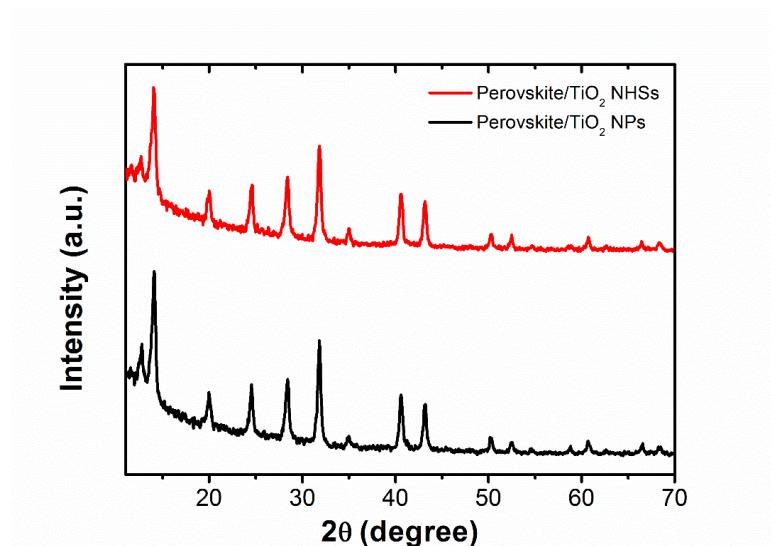


Fig. S2. XRD results of the fabricated $\text{FA}_{0.81}\text{MA}_{0.15}\text{Pb}(\text{I}_{0.836}\text{Br}_{0.15})_3$ films on top of TiO_2 NHSs and NPs layers, respectively.

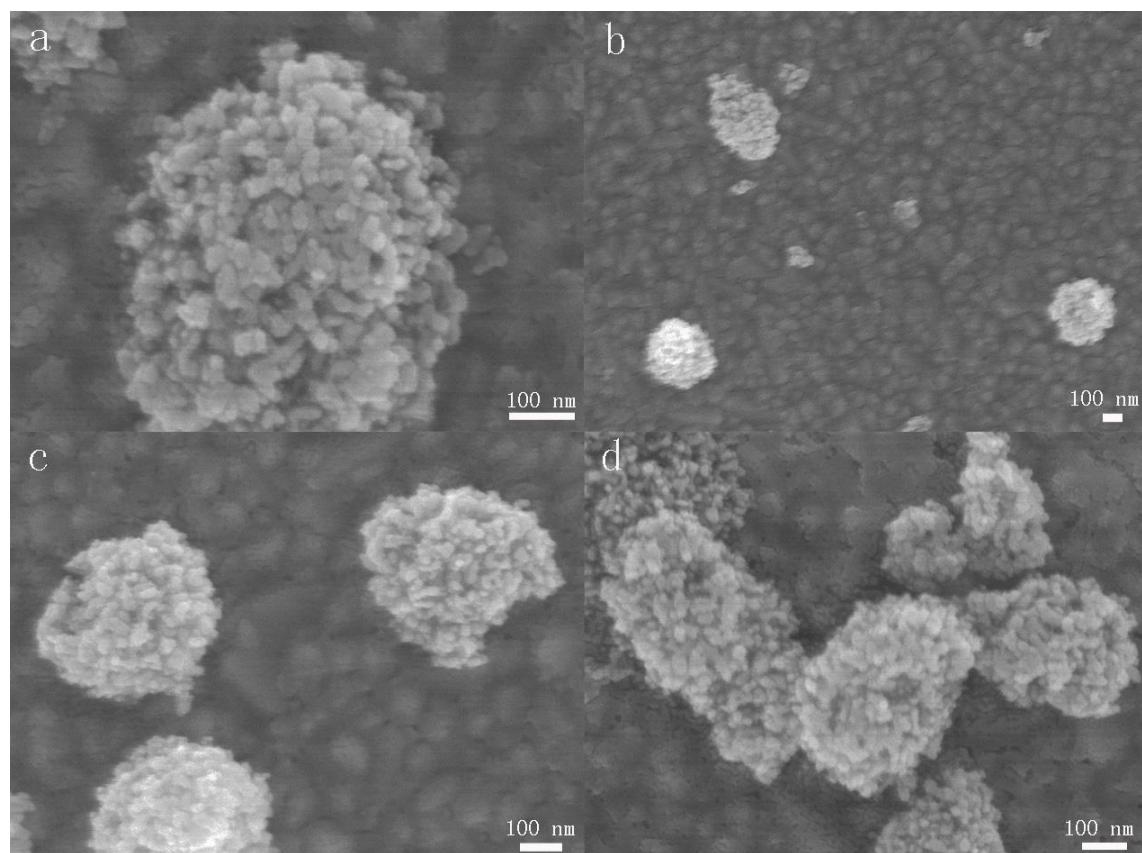


Fig. S3. SEM images of the prepared TiO_2 NHSs. a) shows the nanoporous structure for the prepared NHS; b) shows the TiO_2 NHSs layer with 30 s collecting time, c) shows the TiO_2 NHSs layer with 60 s collecting time and d) shows the TiO_2 NHSs layer with 90 s collecting time. TiO_2 NHSs pile up with the 90 s collecting time.

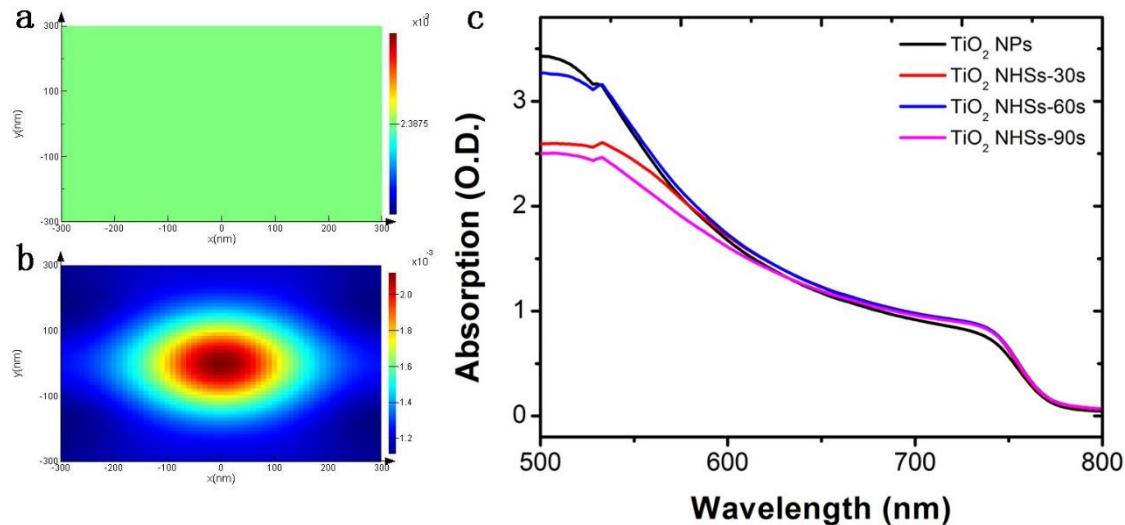


Fig. S4. The simulated optical power distribution at TiO_2 /perovskite interface of a) FTO/C- TiO_2 /Meso- TiO_2 NPs/perovskite and b) FTO/C- TiO_2 / TiO_2 NHS-60 s/perovskite samples; c) the absorption spectra of the FTO/C- TiO_2 /Meso- TiO_2 /perovskite samples based on TiO_2 NPs and TiO_2 NHSs with different collecting times (30 s, 60 s and 90 s). The FDTD model were set as follows, for a): radius of TiO_2 NHS was 200 nm, distance between two adjacent TiO_2 NHSs centres was 600 nm, and thickness of TiO_2 NHS-60 s/perovskite layer was 600 nm; and for b): thickness of meso- TiO_2 NPs layer was 200 nm and thickness of perovskite layer was 600 nm, and both input light wavelengths were 700 nm.

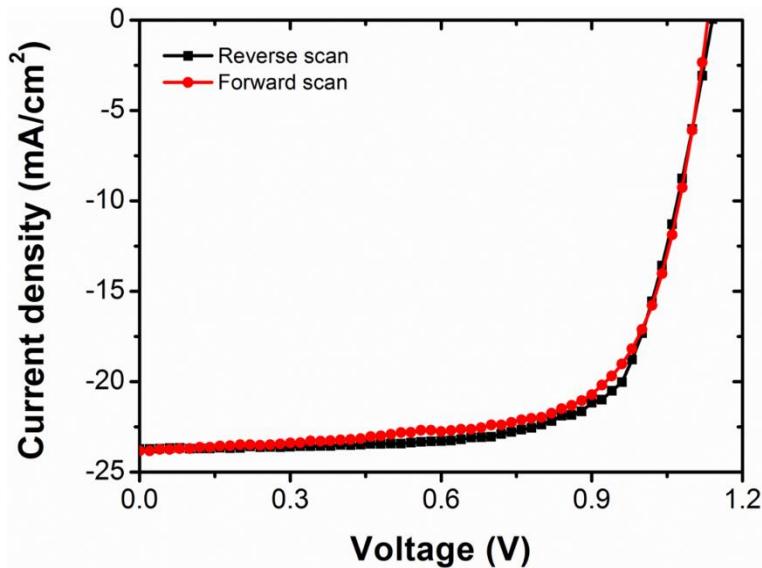


Fig. S5. J - V characteristics of the PSC based on TiO_2 NHSs measured under simulated 1 sun condition with forward and backward scans. As for the reverse scan: J_{sc} : 23.8 mA/cm^2 ; V_{oc} : 1.14 V; FF:0.72 and PCE of 19.6%. Little hysteresis can be seen in this kind of device.

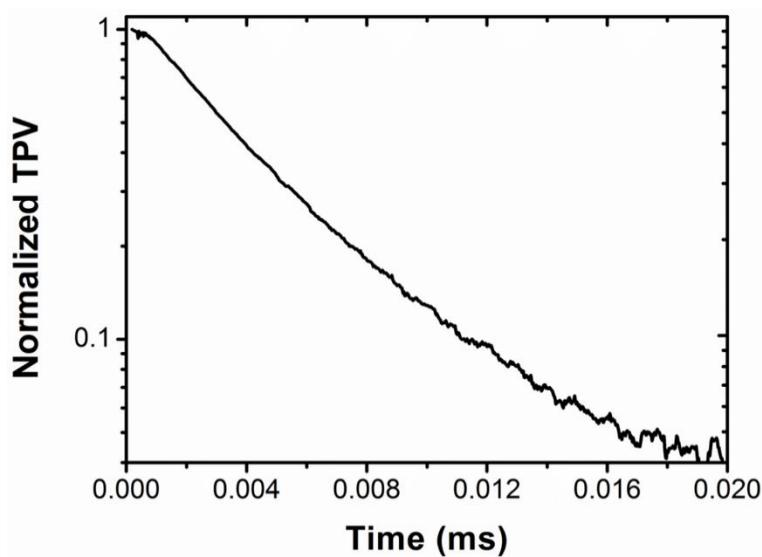


Fig. S6. TPV result of the control group device (based on TiO_2 NPs). The TPV lifetime is just 4 μs when the back level is 1 V.

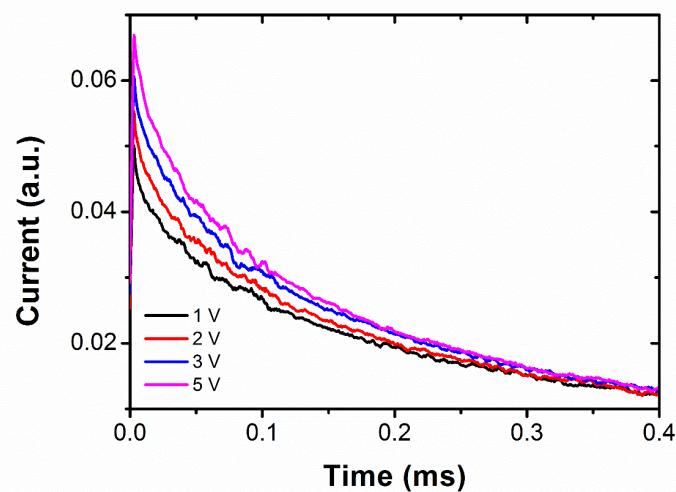


Fig. S7. TOF result of the TiO_2 NHSs device with different positive background voltages.

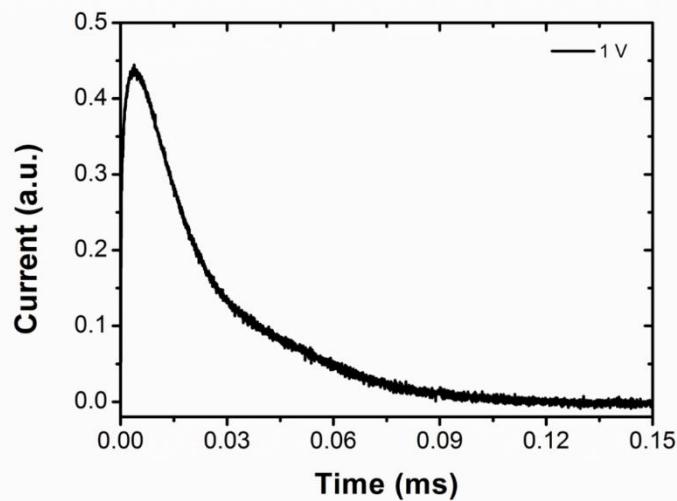


Fig. S8. TOF result of the control group device (based on TiO_2 NPs) with positive 1 V background voltage. Hole mobility of $1.0 \times 10^{-3} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ is obtained for the control group device (the thickness of the perovskite/HTM heterojunction is 650 nm).

Table S1. Photovoltaic parameters for the stability of perovskite solar cell measured under simulated 1 sun (solar cell was encapsulated and stored in a dessicator).

	V_{oc} (V)	J_{sc} (mA/cm ²)	FF	PCE (%)
Initially	1.14	23.8	0.71	19.3
10 days	1.15	23.9	0.71	19.6
20 days	1.14	23.7	0.70	19.1
60 days	1.13	23.6	0.69	18.6

Table S2. The lifetime versus voltage parameters extracted from TPV experiment with an error range of $\pm 2\%$.

Back (mV)	200	400	500	800
Lifetime (μs)	174	164	115	102