

Electronic Supplementary Information for

**Perovskite Solar Cells Based on Bottom-Fused TiO<sub>2</sub> Nanocones**

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## TiO<sub>2</sub> nanoparticle photoanode preparation

The 30 nm-thick compact TiO<sub>2</sub> layer, acting as blocking layer, was deposited onto FTO glass by spray-pyrolyzing a solution of titanium (IV) isopropoxide in ethanol and acetylacetone at 450 °C. Afterwards, TiO<sub>2</sub> nanoparticle layer was prepared by the doctor-blade method using the commercial TiO<sub>2</sub> paste (18NR-T), and then calcinated at 500 °C in air for 30 min before use.

## Sequential deposition process

Firstly, PbI<sub>2</sub> in DMF (462 mg/mL) was spin-coated onto the photoanode and was heated at 70 °C to dry over. Afterwards, the TiO<sub>2</sub>/PbI<sub>2</sub> film was dipped into a 10 mg/mL CH<sub>3</sub>NH<sub>3</sub>I IPA solution for 20 seconds and rinsed with IPA. After drying, the HTM filtration and Au electrode deposition methods were the same as illustrated in the main text.

## Equations for Voc decay curve fitting

SNC-Device:

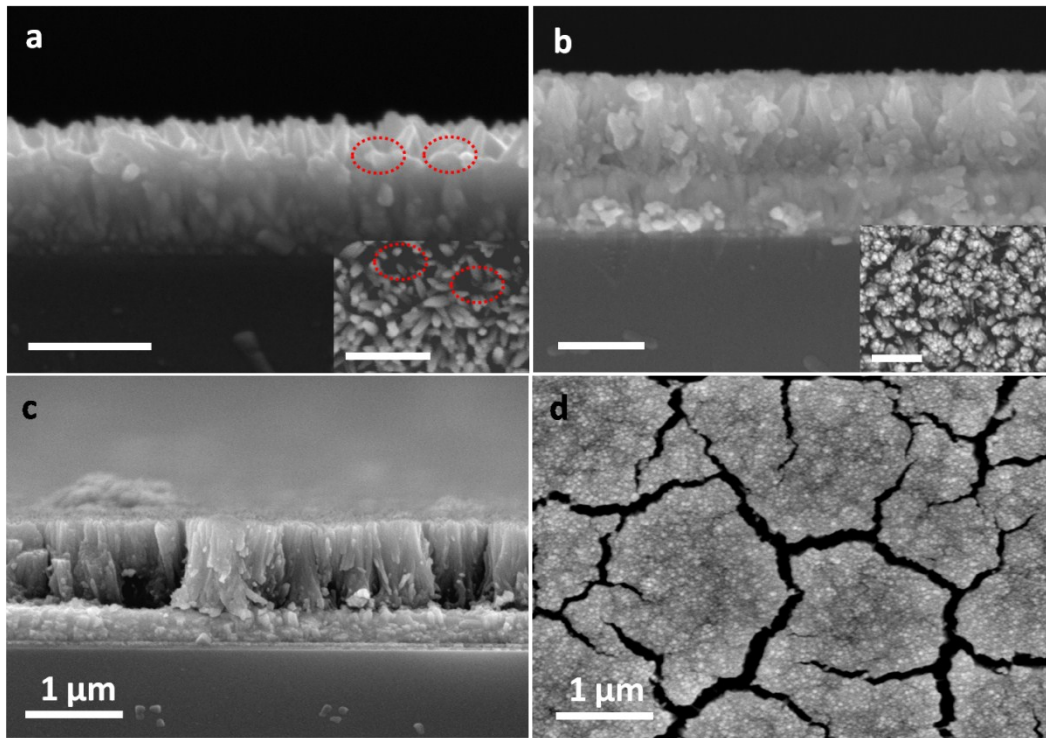
$$V_{oc} = 0.3125 + 1.04028 e^{-\frac{(t - 59.9835)}{0.01038}} + 0.07309 e^{-\frac{(t - 59.9835)}{0.11218}}$$

SNR-Device:

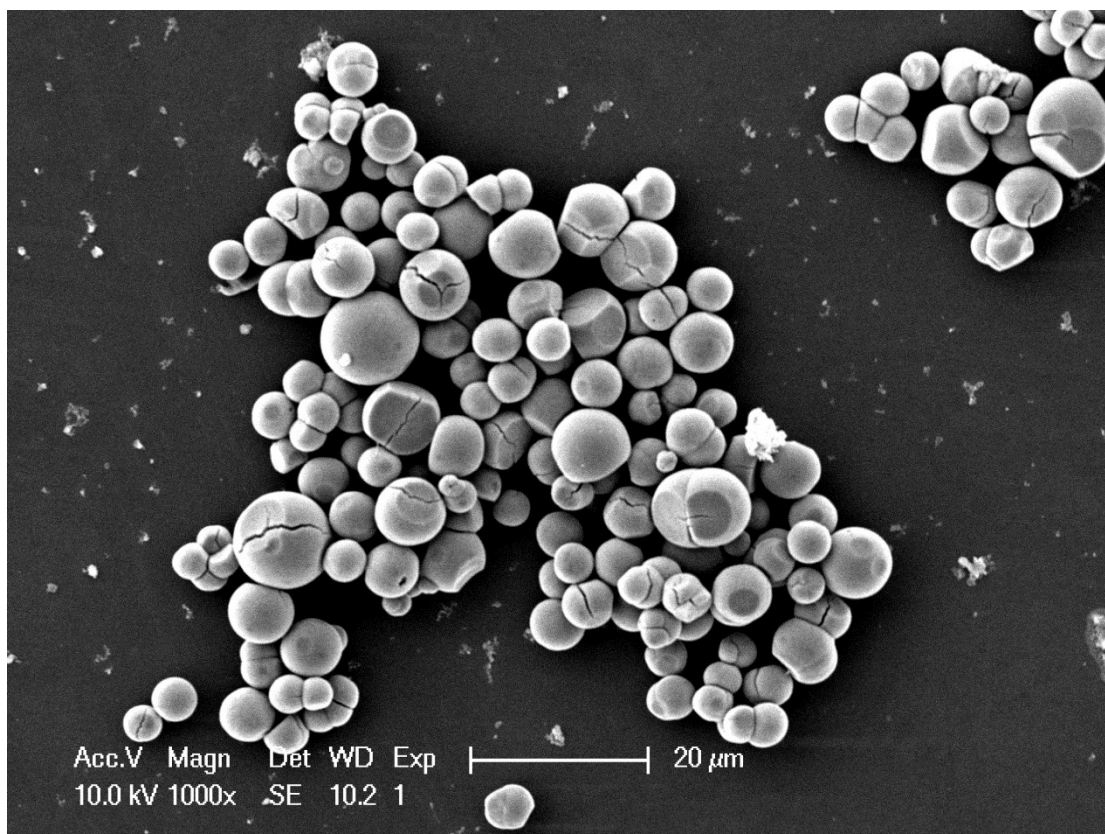
$$V_{oc} = 0.30592 + 0.07266 e^{-\frac{(t - 59.98308)}{0.10858}} + 0.93873 e^{-\frac{(t - 59.98308)}{0.01131}}$$

SNP-Device:

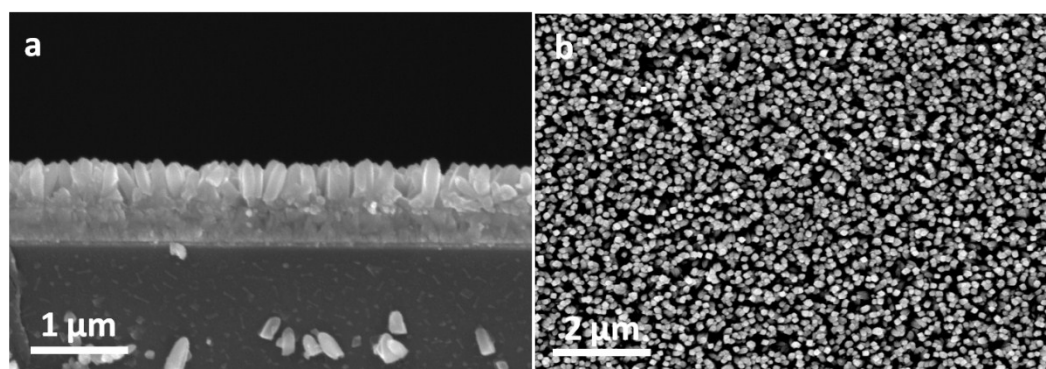
$$V_{oc} = 0.27956 + 0.02549 e^{-\frac{(t - 59.98703)}{0.07442}} + 0.71788 e^{-\frac{(t - 59.98703)}{0.00858}}$$



**Figure S1.** SEM images of TiO<sub>2</sub> nanostructures on FTO synthesized with (a) 0.1 ml, 5 (b) 0.2 ml, (c-d) 0.3 ml TBO using methanol as solvent. (c) Cross-sectional image. (d) Top-view image. For (a-b), bottom right insets are the top-view images. The circled area in (a) is the substrate where there are no nanocones.

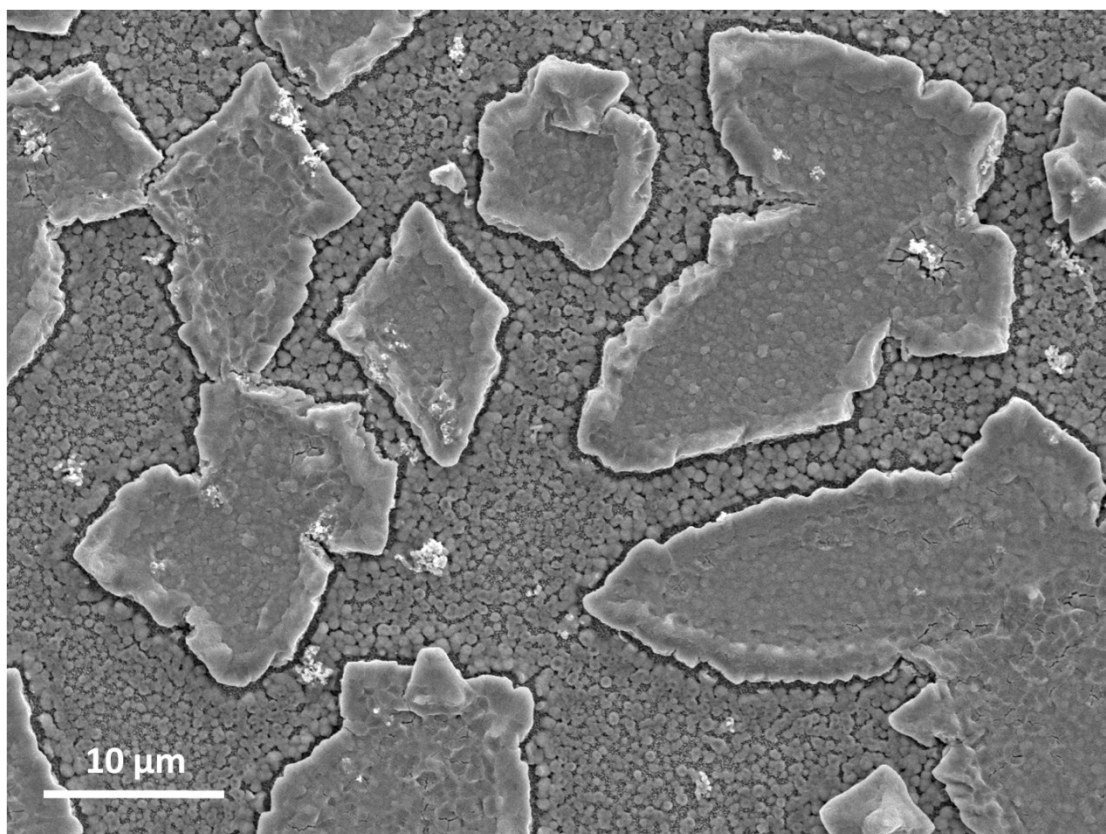


**Figure S2.** TiO<sub>2</sub> spheres synthesized without placing FTO substrate in the reactor.

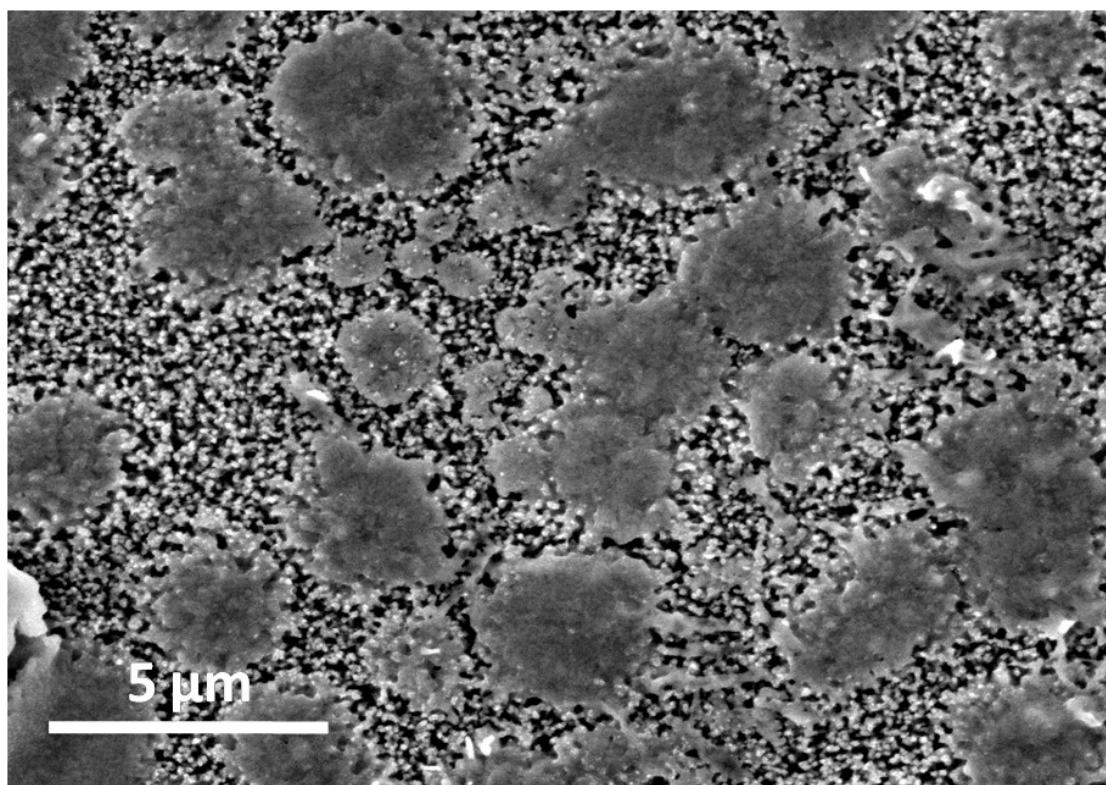


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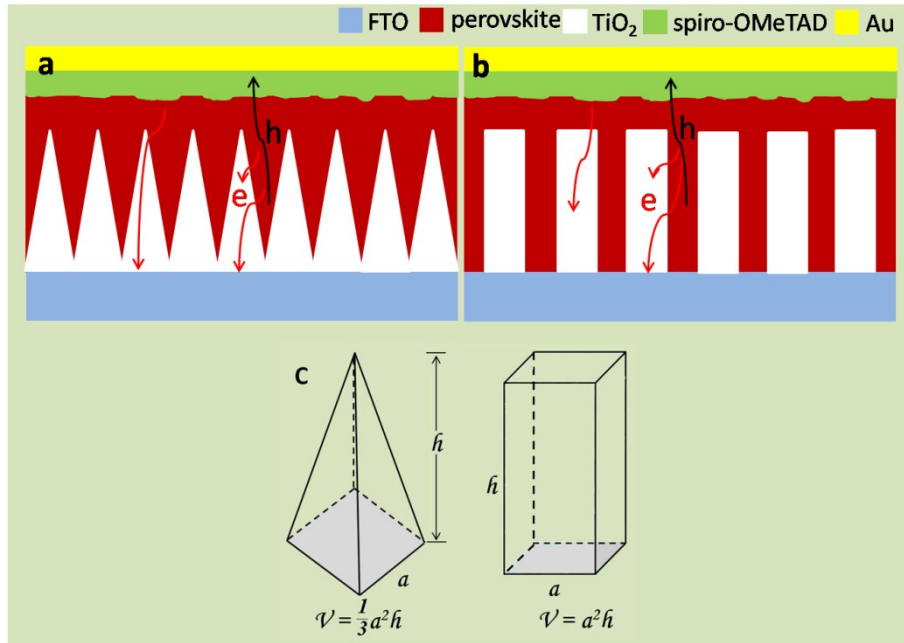
**Figure S3.** SEM images of TiO<sub>2</sub> nanorods on FTO synthesized with 0.15 ml TBO using isopropanol as solvent. (a) Cross-sectional image. (b) Top-view image.



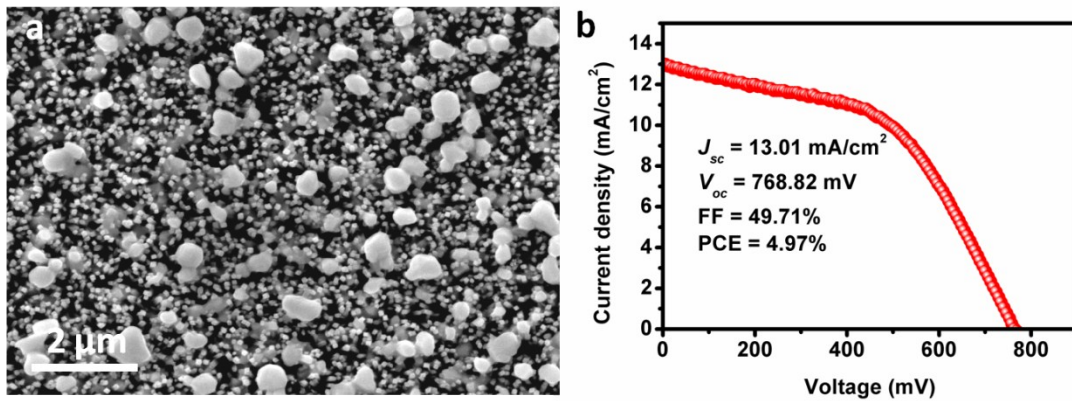
**Figure S4.** 2 M CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> coated seeded-NCs.



**5 Figure S5.** 1.25 M CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> coated seeded-NCs.



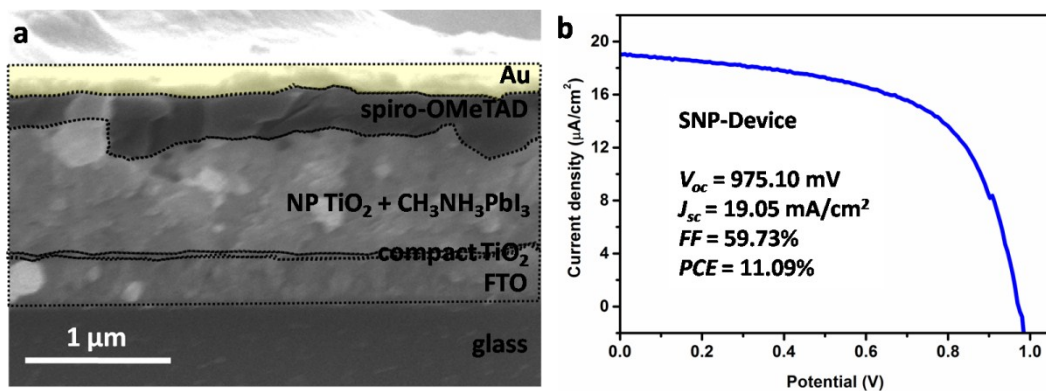
**Figure S6.** Schematic illustrations of the devices and nanostructures. (a) SNC-Device. (b) SNR-Device. (c) An individual TiO<sub>2</sub> nanocone and a rectangular nanorod.



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**Figure S7.** (a) Top-view SEM image of CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub>/NCs obtained by sequential deposition method. (b)  $J$ - $V$  characteristic of the device fabricated following the sequential deposition method.





**Figure S8.** (a) Cross-sectional SEM image of seeding spin-coated nanoparticle device (SNP-Device). (b)  $J$ - $V$  characteristic of the SNP-Device.



**5 Figure S9.** Digital photos of  $\text{CH}_3\text{NH}_3\text{PbI}_3$  sensitized NCs.