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

Supporting Information

Perovskite photovoltaic fiber and fabric through a mild solution process

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Experimental section

Synthesis of spinnable CNT array. Aligned carbon nanotube (CNT) array was synthesized by a modified chemical vapor deposition. The catalyst containing 5 nm thick Al_2O_3 and 1.2 nm thick Fe was sequentially deposited onto silicon substrate through an electron beam evaporation deposition. The synthesis was carried out in a 2-inch (inner diameter) furnace. Ethylene (90 sccm) was used as carbon source, and a mixture gas of argon (400 sccm) and hydrogen (30 sccm) was used as carrying gas. The optimal growth temperature was 740 ºC for 10 min (*Acta Chim. Sinica* 2012, 70, 1523). The aligned CNT sheet was dry-drawn from the spinnable array.

Synthesis of CH_3NH_3I. To synthesize $CH_3NH_3PbI_3$, a hydroiodic acid/water solution (45 wt%, 12.5 mL) was first added to a methylamine/ethanol solution (6.4 wt%, 124 mL), followed by reaction at room temperature for 2 h. The resulting solution was evaporated at 50 ℃ to produce a white powder of methylamine iodide. The methylamine iodide was then dissolved in ethanol and precipitated by diethyl ether for three times.

Characterization. The structures were characterized by scanning electron microscopy (Hitachi FE-SEM S-4800) and transmission electron microscope (JEOL JEM-2100F). X-ray diffraction patterns were obtained from an X-ray powder diffractometer (Brucker, D8 ADVANCE and DAVINCI.DESIGN). *J-V* curves were produced by a Keithley 2420 Source Meter under illumination of simulated AM1.5 solar light (100 mW cm^{-1}) coming from a solar simulator (Oriel-Sol3A 94023A equipped with a 450 W Xe lamp and an AM1.5 filter). The light intensity was calibrated using a reference Si solar cell (Oriel-91150). The effective area was calculated by multiplying the diameter of the modified stainless steel wire and length of the fiber-shaped perovskite solar cell (PSC).

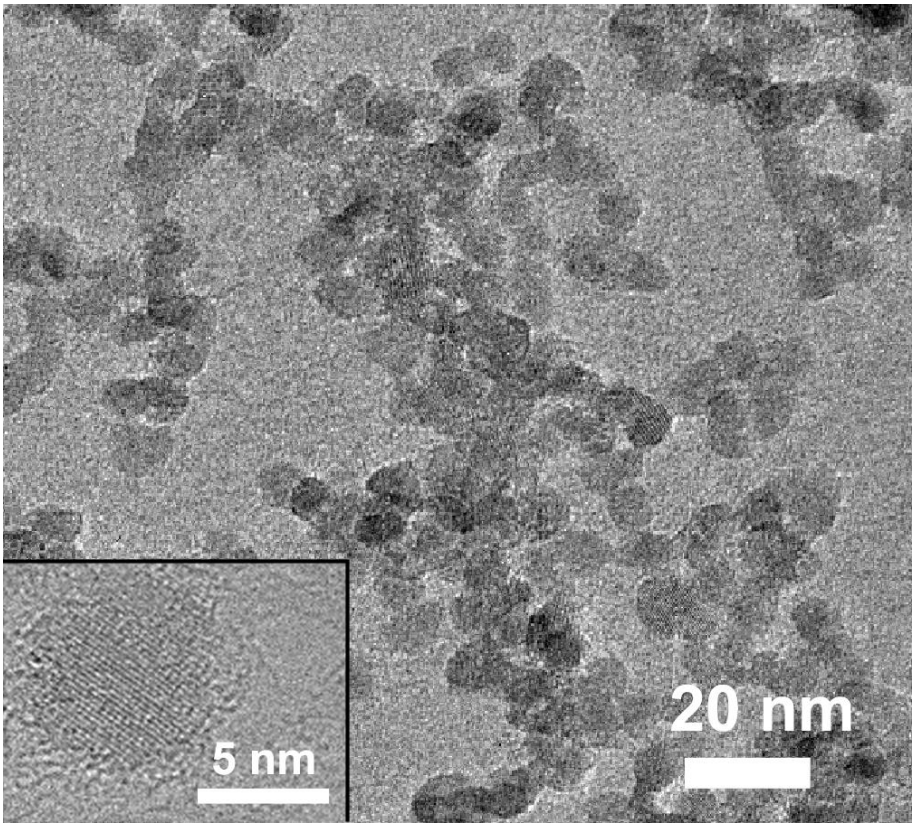

Figure S1. TEM image of ZnO nanoparticles (inserted, magnified image of a ZnO nanoparticle).

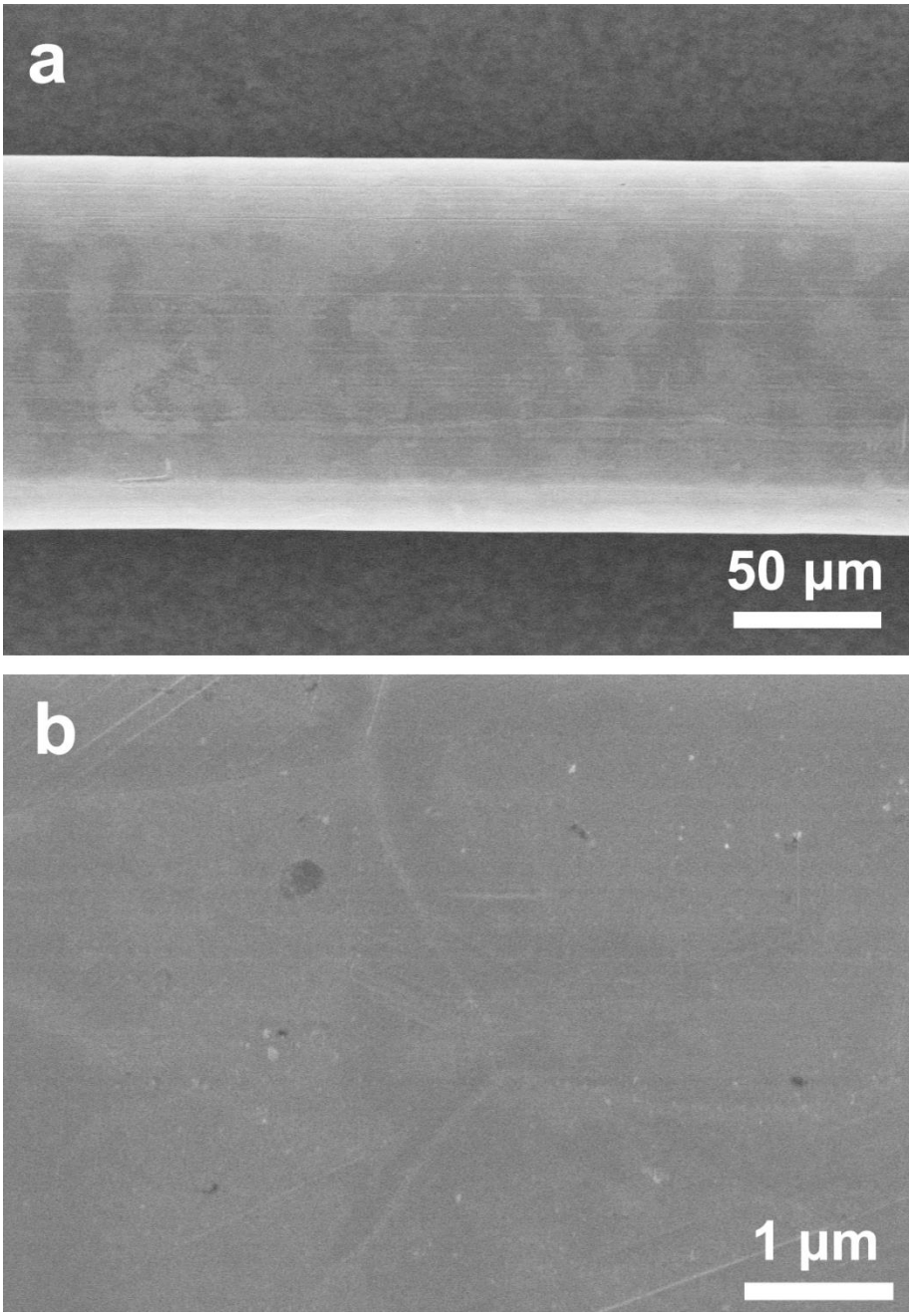

Figure S2. SEM images of a stainless steel wire at low (**a**) and high (**b**) magnifications.

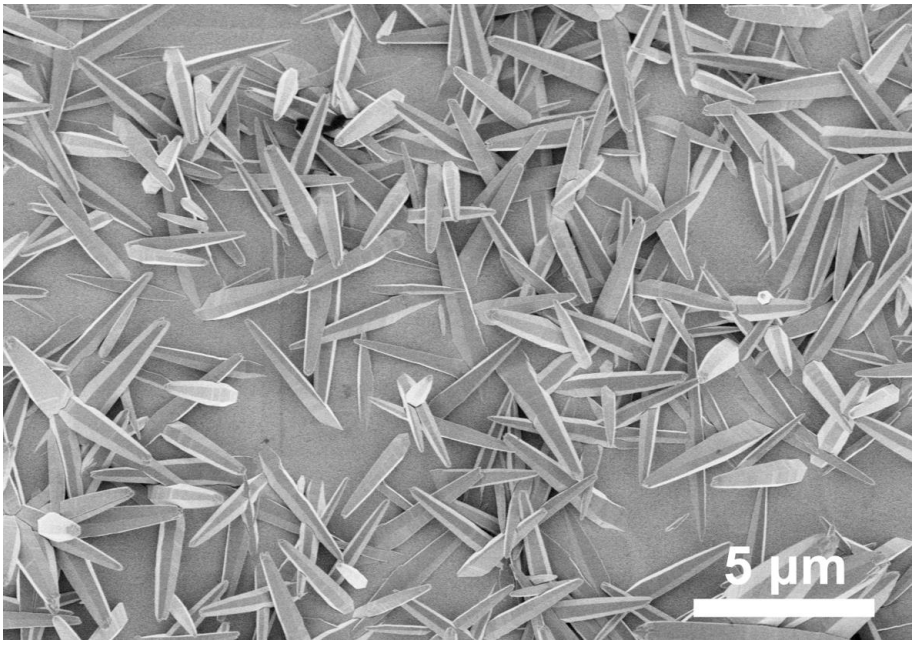

Figure S3. SEM image of ZnO nano-obelisks grown on the stainless wire without the ZnO seed layer.

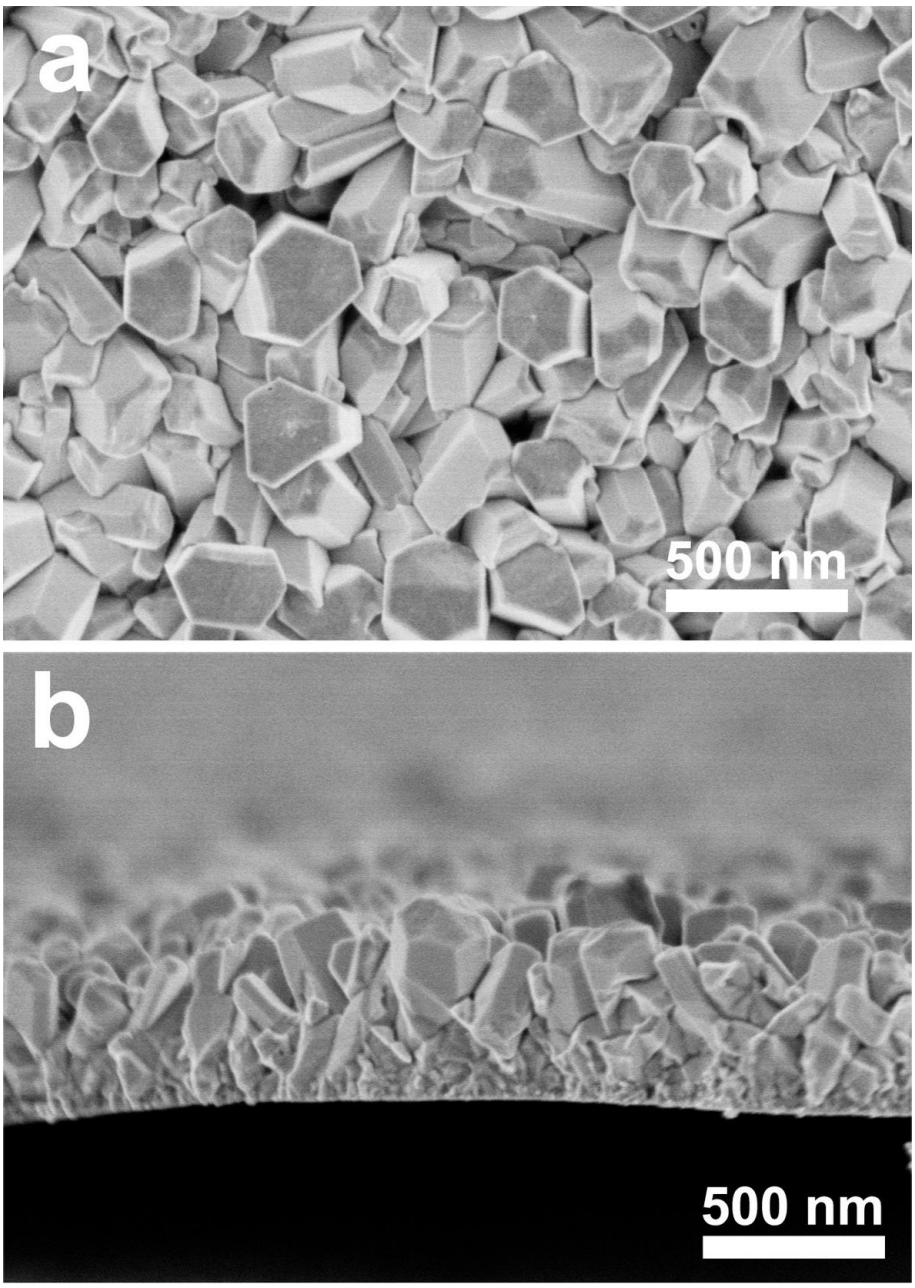

Figure S4. SEM images of ZnO grown without polyethyleneimine (PEI) by top (**a**) and cross section (**b**) views.

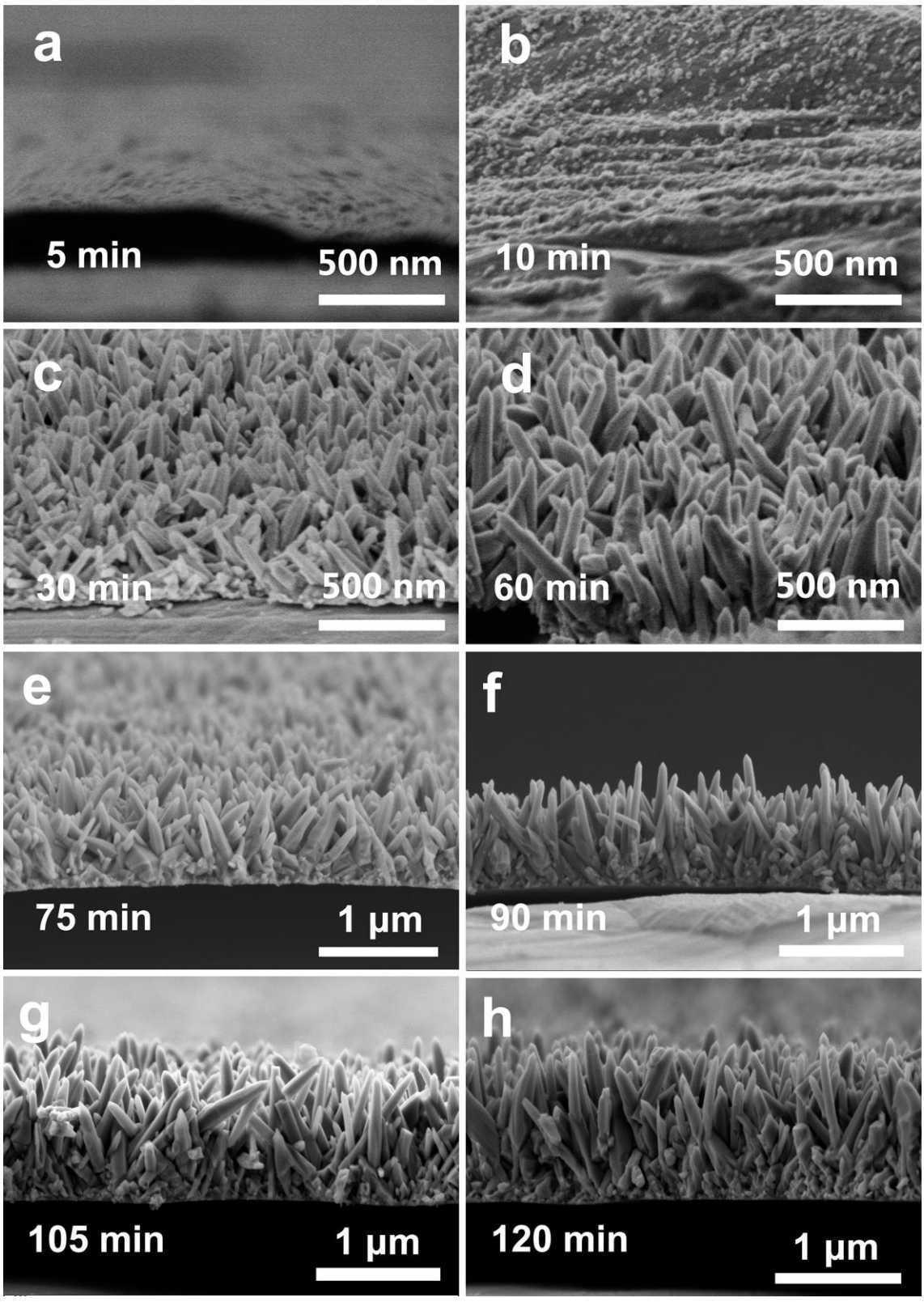

Figure S5. SEM images of the ZnO nano-obelisk array with increasing growth times.

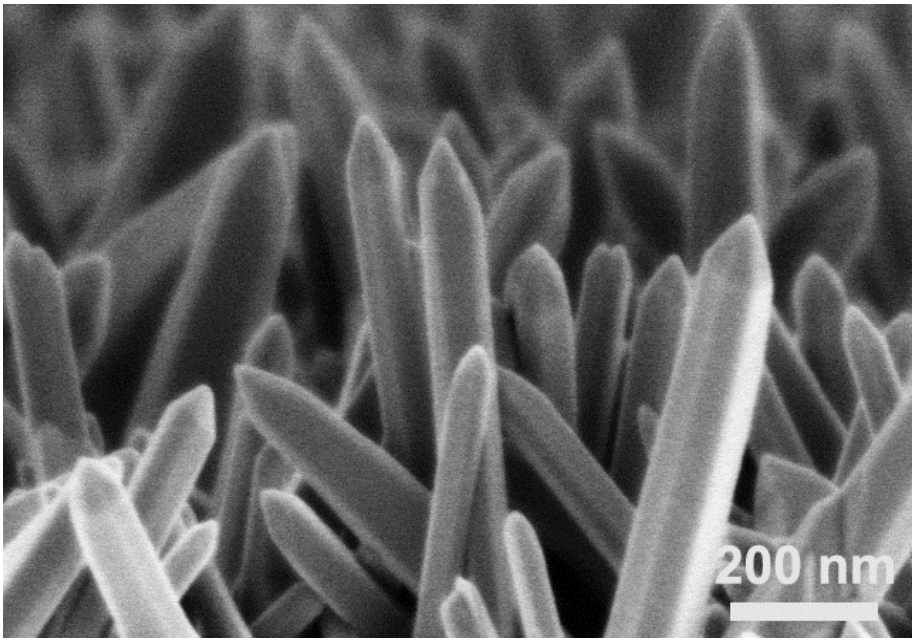

Figure S6. An enlarged SEM image of ZnO nano-obelisks grown on the stainless steel wire.

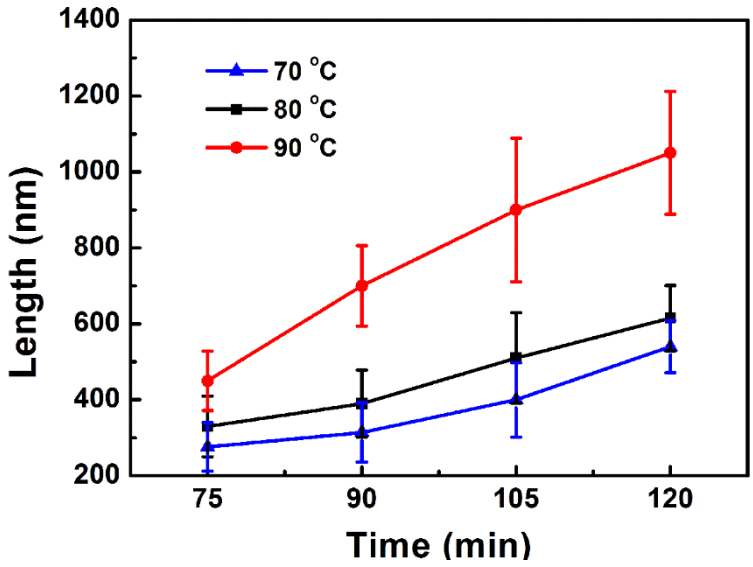

Figure S7. Dependence of ZnO nano-obelisk length on growing time at different temperatures.

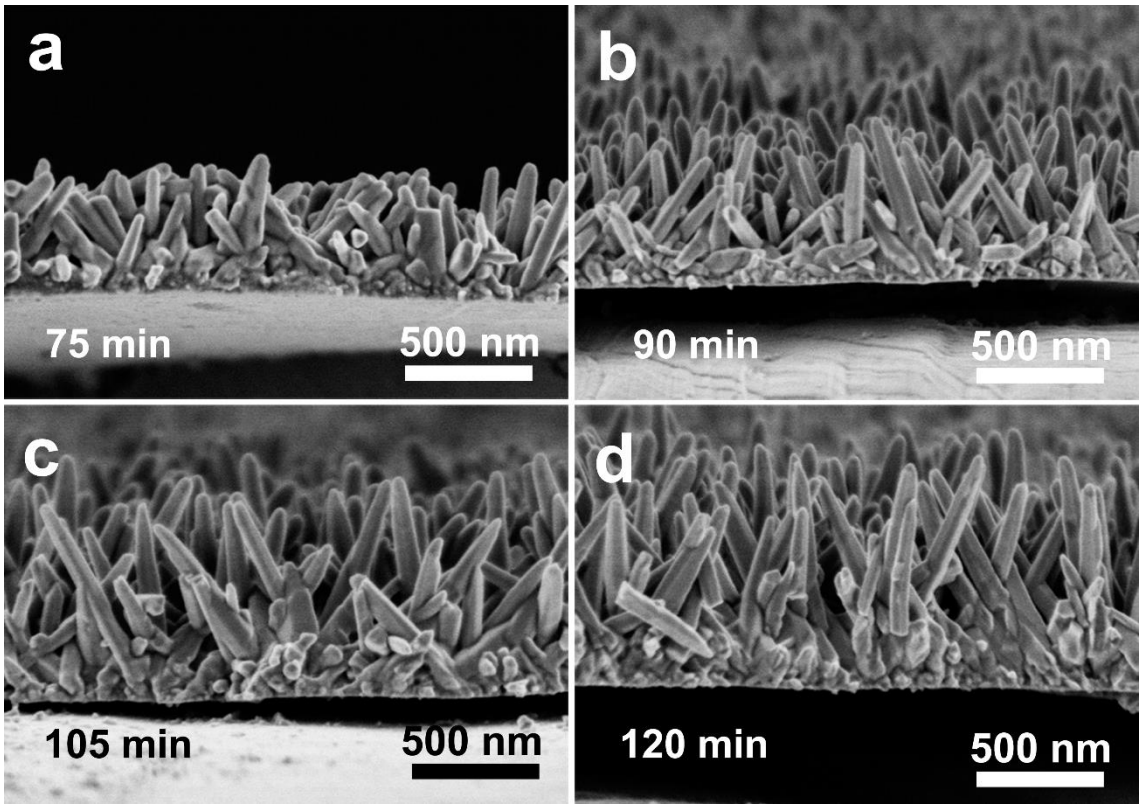

Figure S8. SEM images of the ZnO nano-obelisk array grown for different times at 70 ºC.

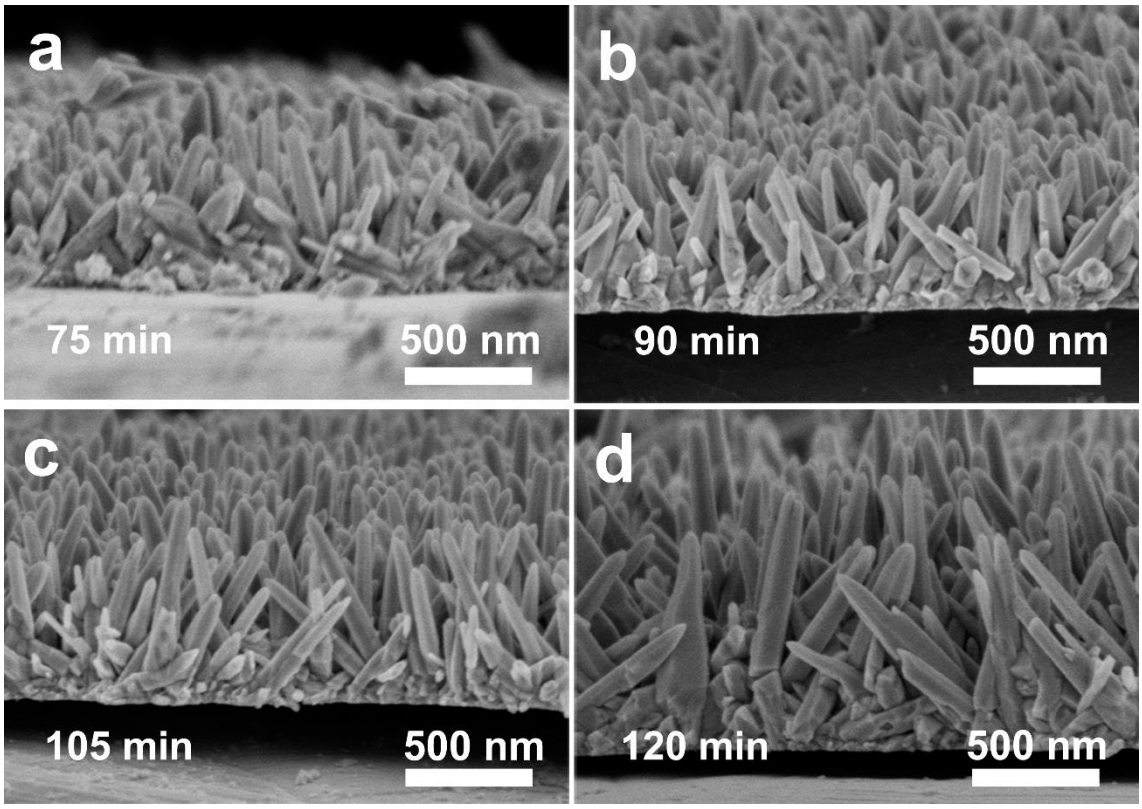

Figure S9. SEM images of ZnO nano-obelisks grown for different times at 80 ºC.

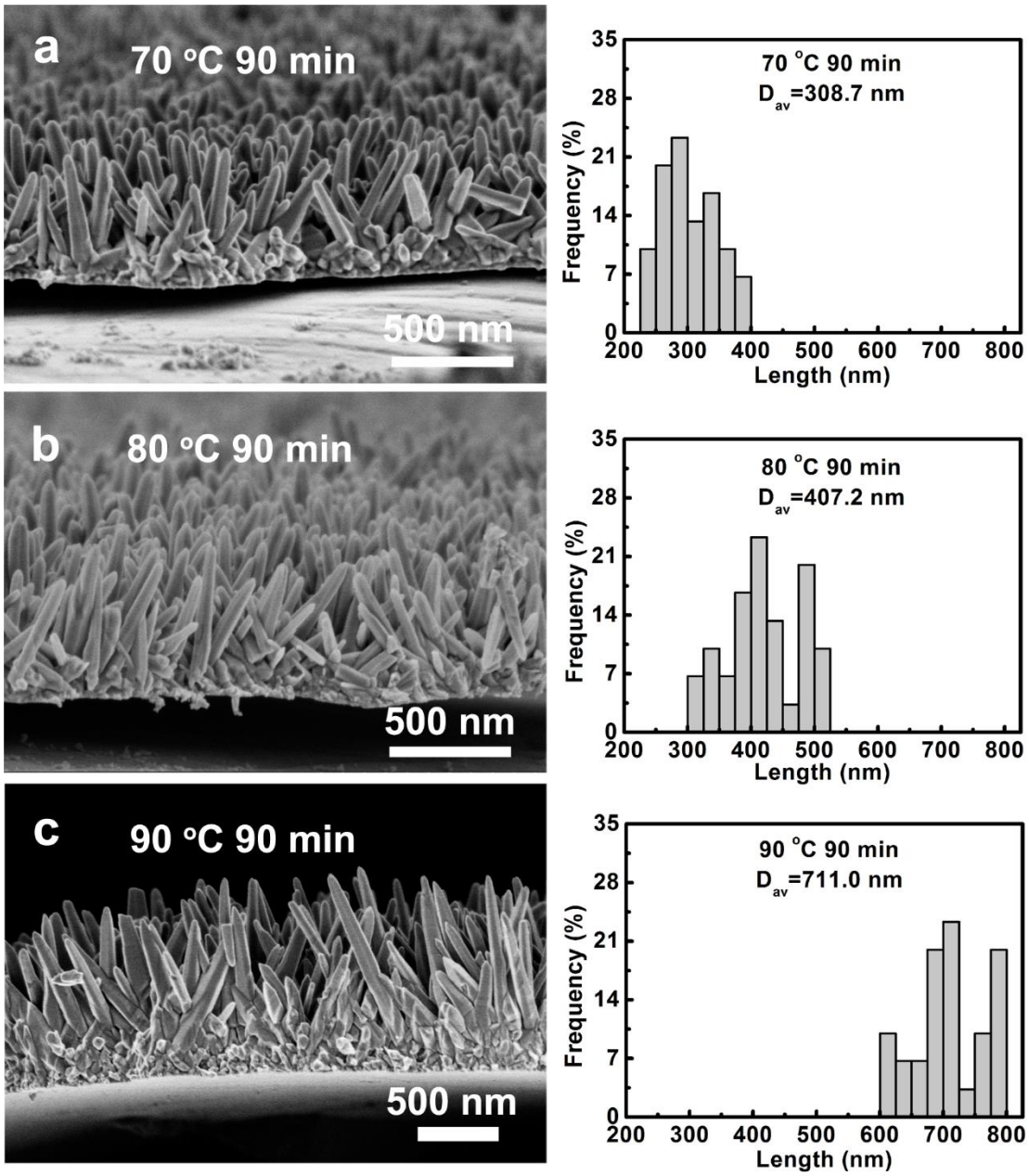

Figure S10. SEM images and length distributions of ZnO nano-obelisks grown for 90 min at different temperatures of 70 ºC (**a**), 80 ºC (**b**) and 90 ºC (**c**).

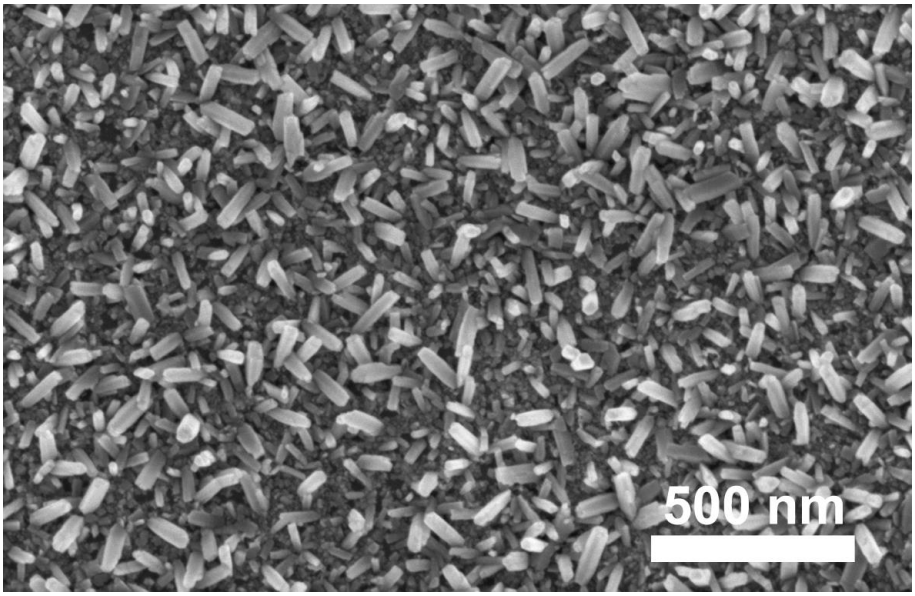

Figure S11. SEM image of ZnO nanorods grown for 90 min at 50 ^{o}C.

Figure S12. SEM image of ZnO nanomaterials grown for 90 min at 100 ºC.

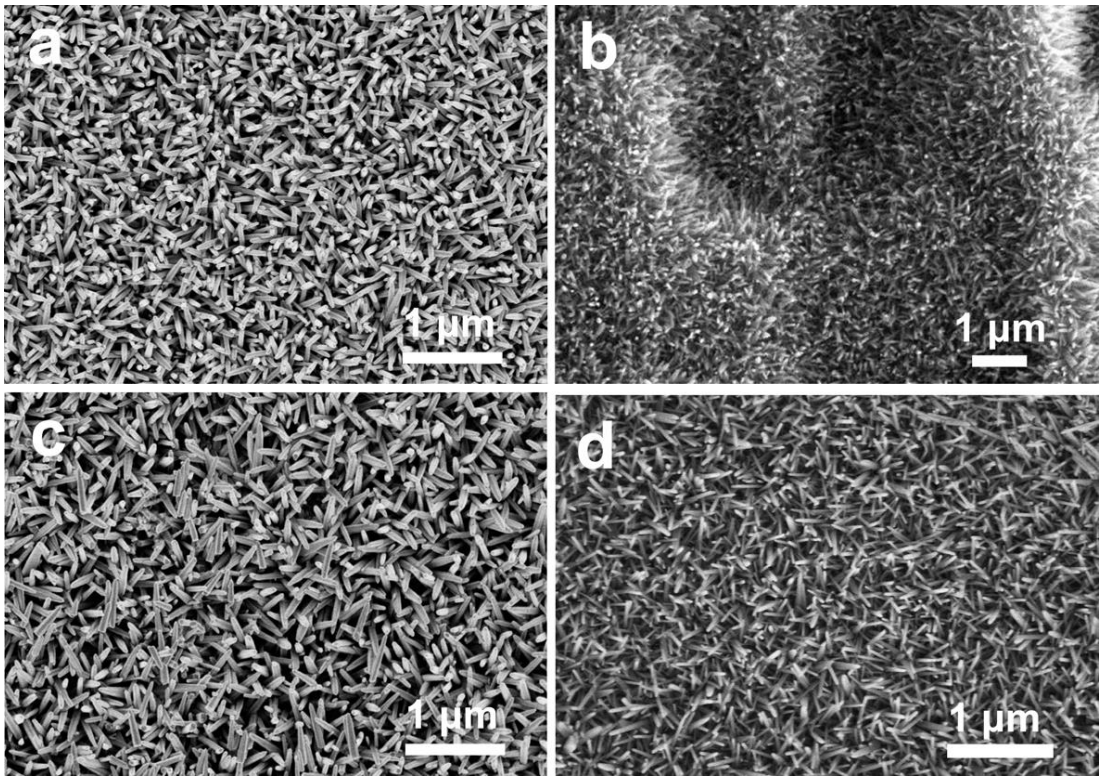

Figure S13. SEM images of the ZnO nano-obelisk array grown on different substrates. **a**. Stainless steel foil. **b**. Titanium wire. **c**. Copper foil. **d**. Fluorine-doped tin oxide glass.

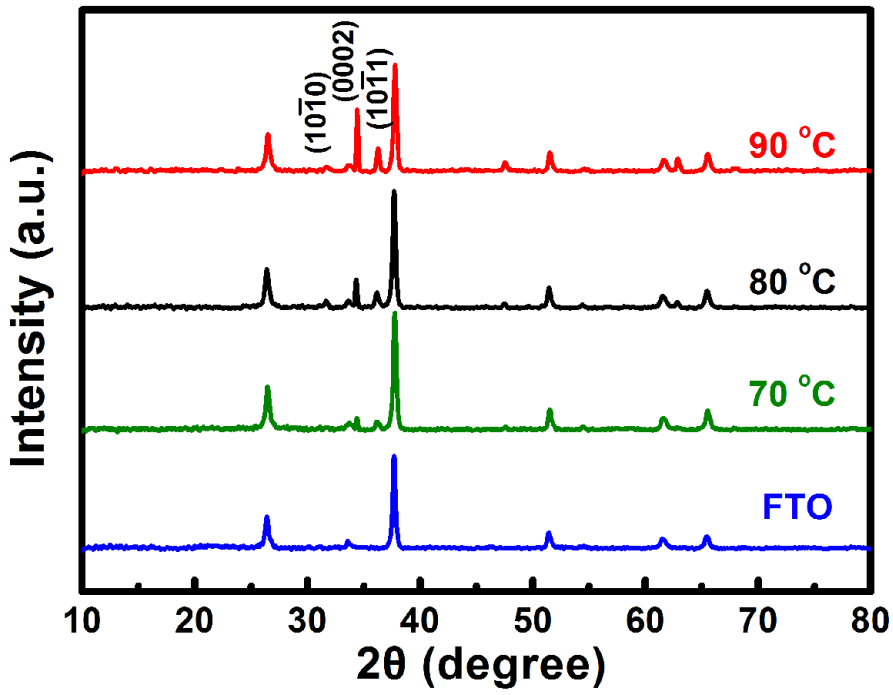

Figure S14. X-ray diffraction (XRD) patterns of ZnO nano-obelisks grown at different temperatures.

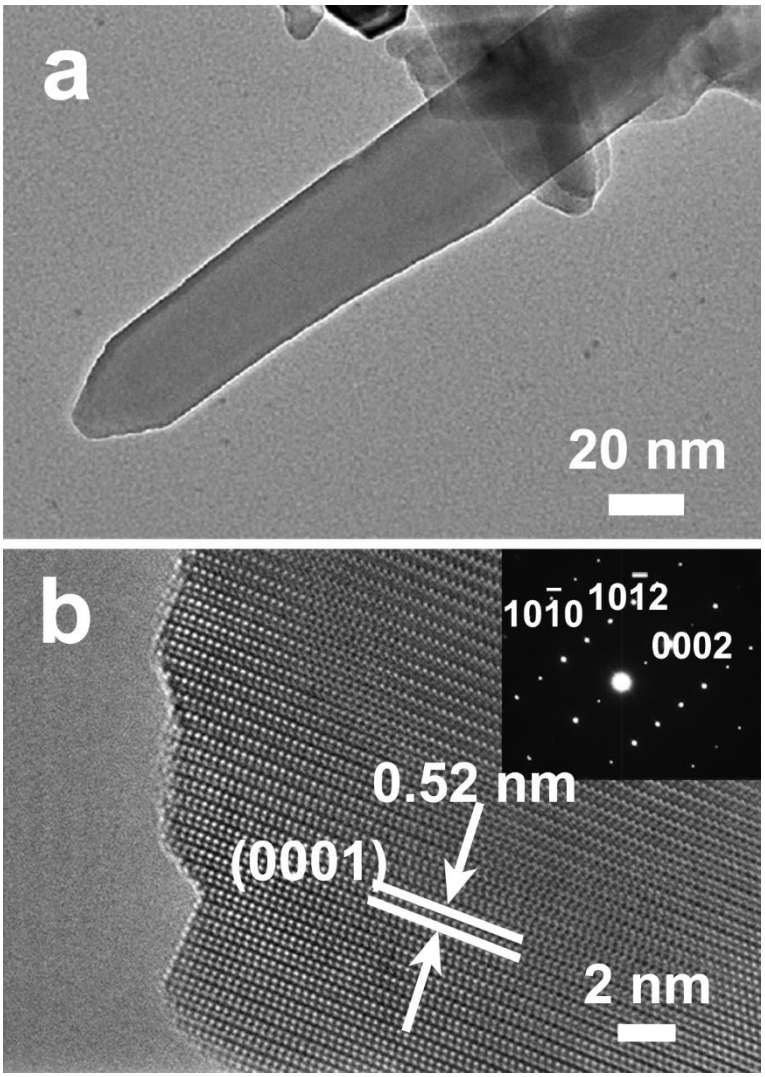

Figure 15. a and **b**. TEM images of ZnO nano-obelisks (Inserted at **b**, electron diffraction pattern of the selected area) at low and high magnifications, respectively.

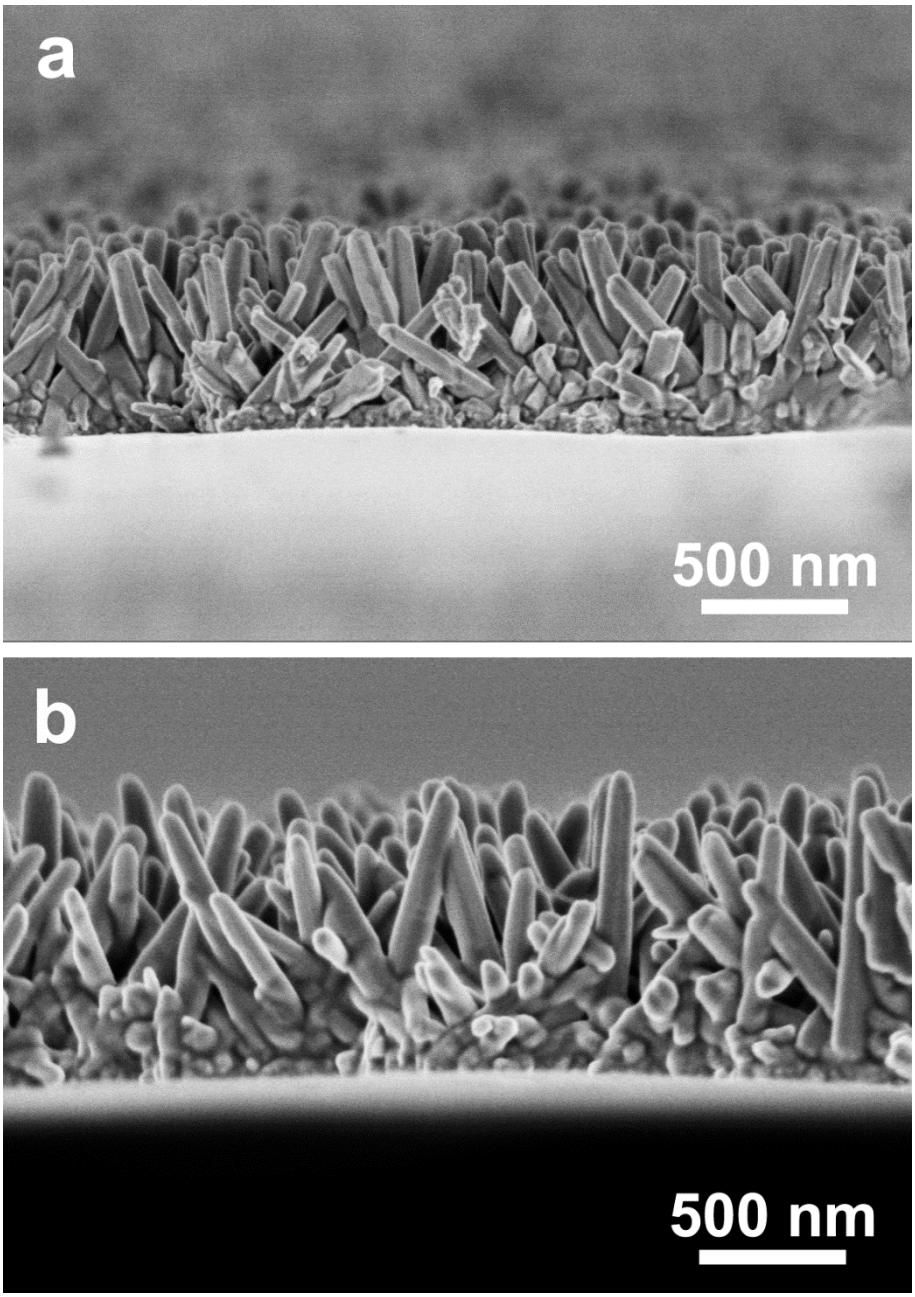

Figure S16. ZnO nano-array grown for 90 min (**a**) and 120 min (**b**) at 60 ^{o}C.

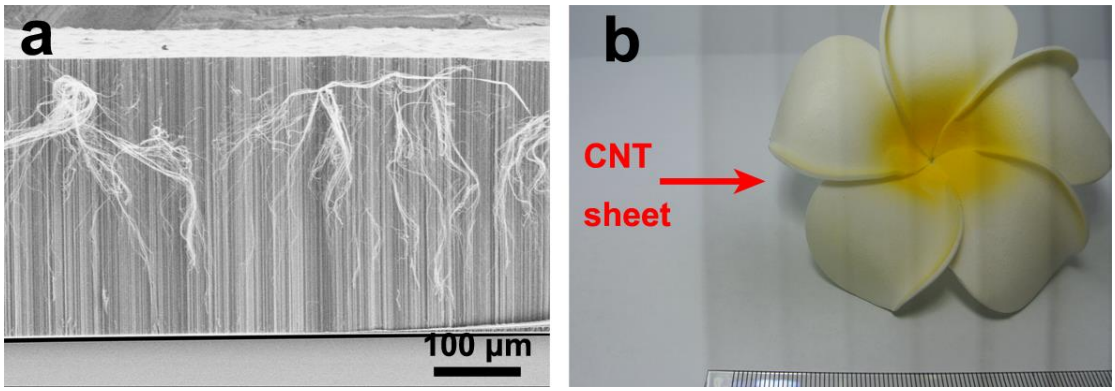

Figure S17. a. SEM image of a spinnable CNT array. **b**. Photograph of a transparent CNT sheet.

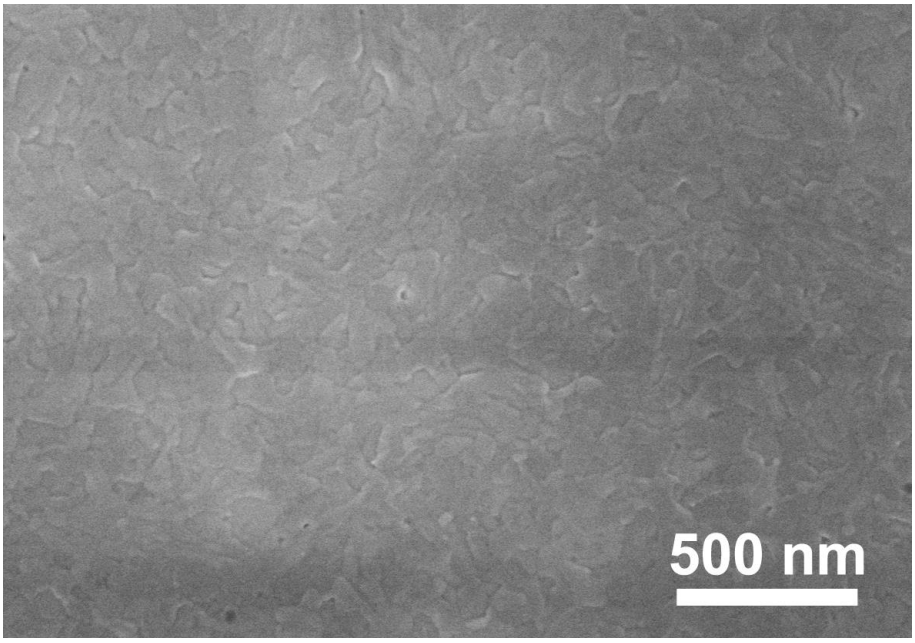

Figure S18. SEM image of PbI_2 layer coated on the ZnO nano-obelisk array.

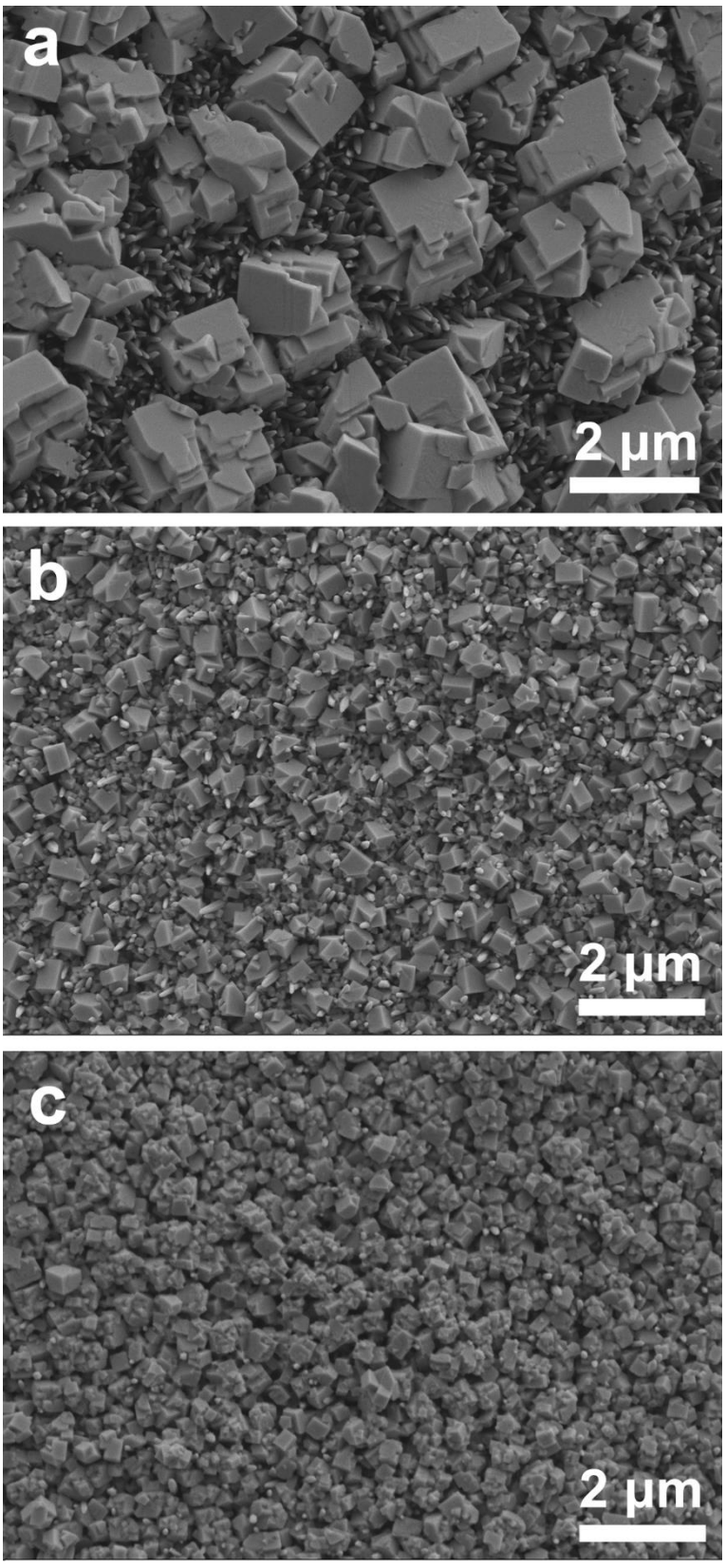

Figure S19. SEM images of the perovskite layer with different CH_3NH_3I concentrations of 4 mg mL^{-1} (**a**), 6 mg mL^{-1} (**b**) and 8 mg mL^{-1} (**c**).

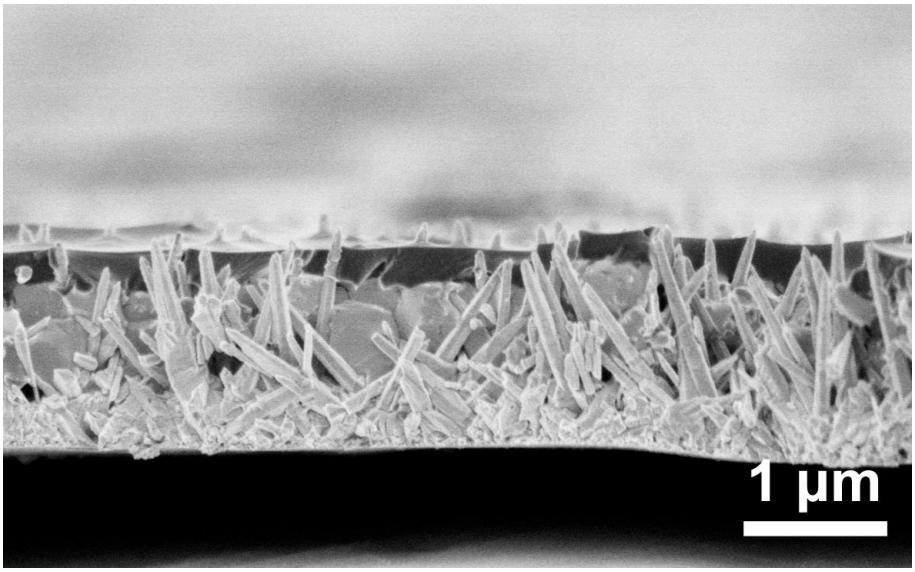

Figure S20. SEM image of the large perovskite crystals by a cross-sectional view.

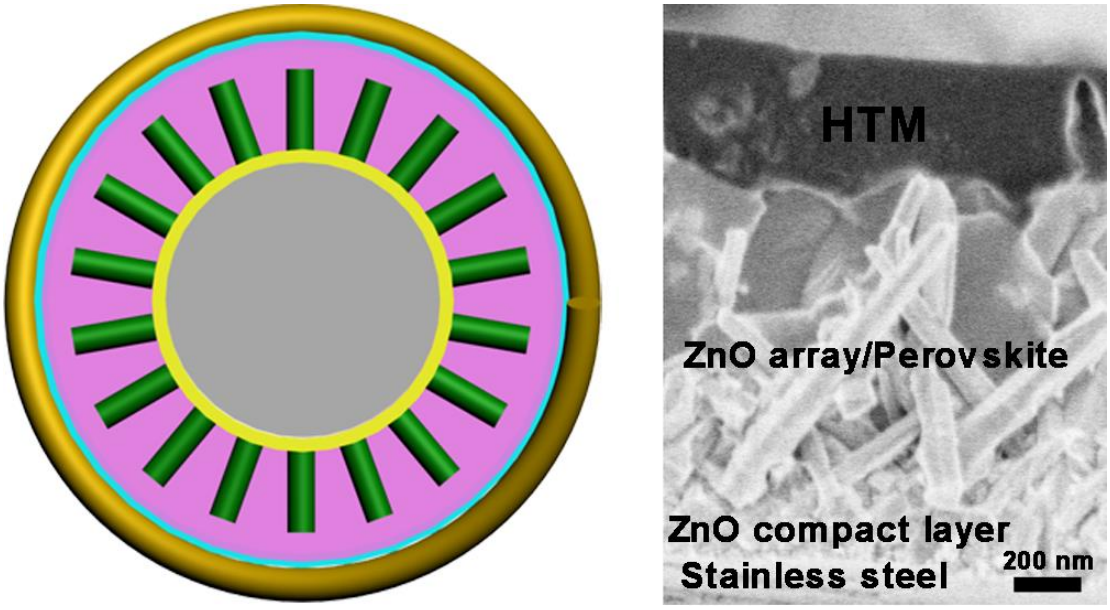

Figure S21. Schematic illustration and SEM image of a perovskite solar cell fiber by a top view with the complete structure.

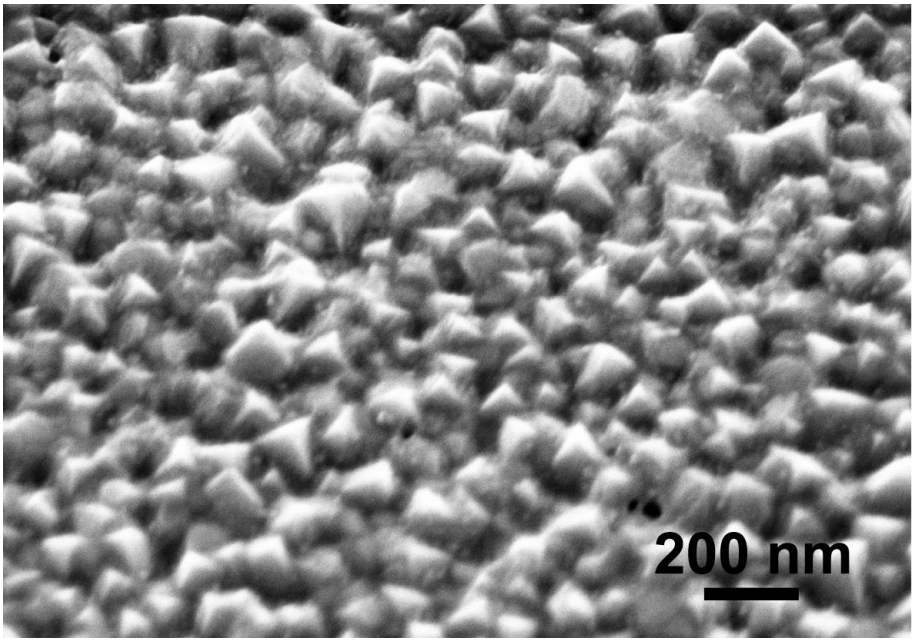

Figure S22. SEM image of perovskite crystals deposited on the ZnO seed layer around a stainless steel wire.

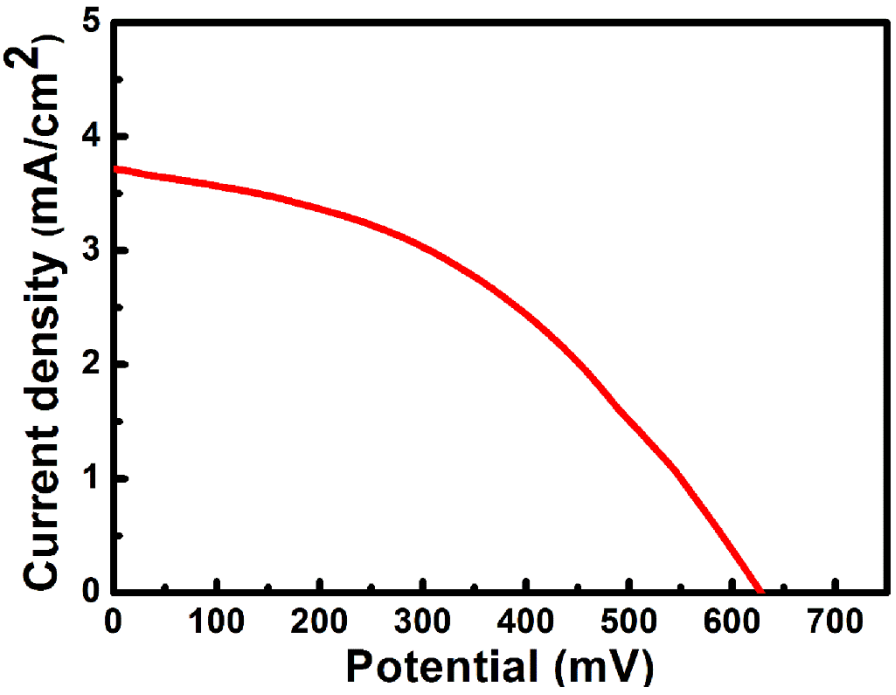

Figure S23. *J-V* curve of a fiber-shaped PSC based on the ZnO seed layer.

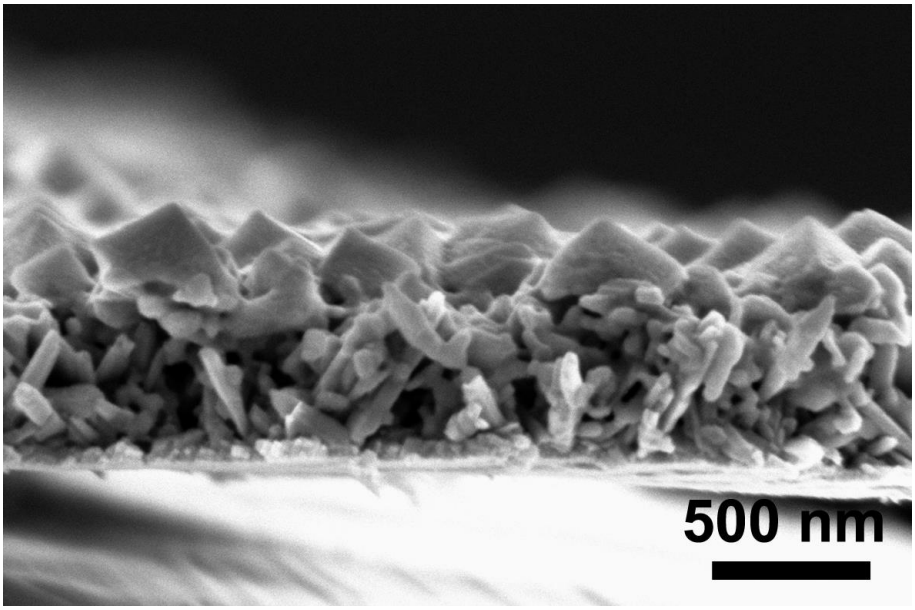

Figure S24. SEM image of the perovskite material coated on the ZnO nanorods.

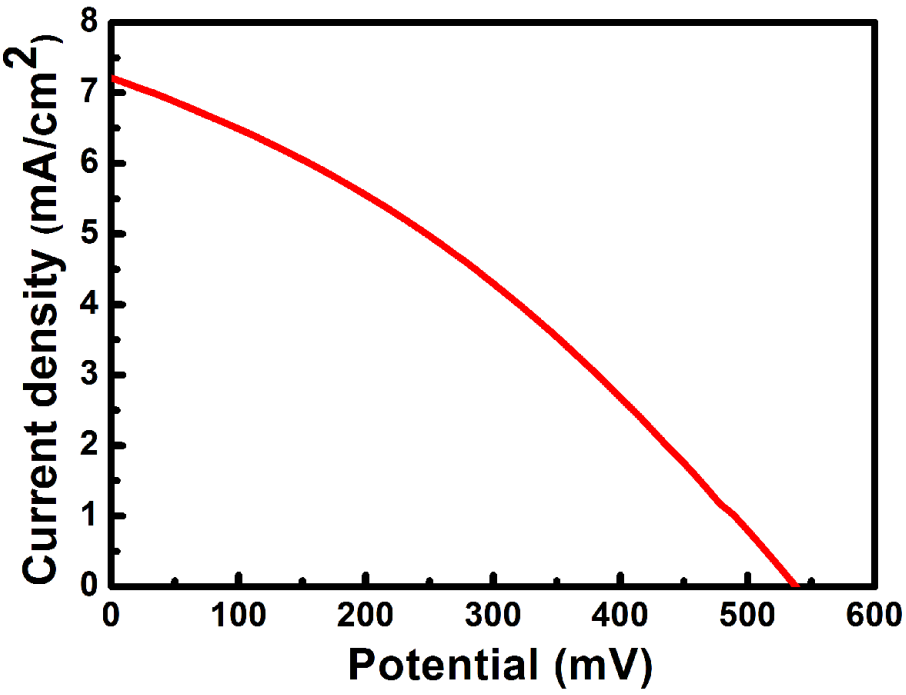

Figure S25. *J-V* curves of a fiber-shaped PSC based on the ZnO nanorods.

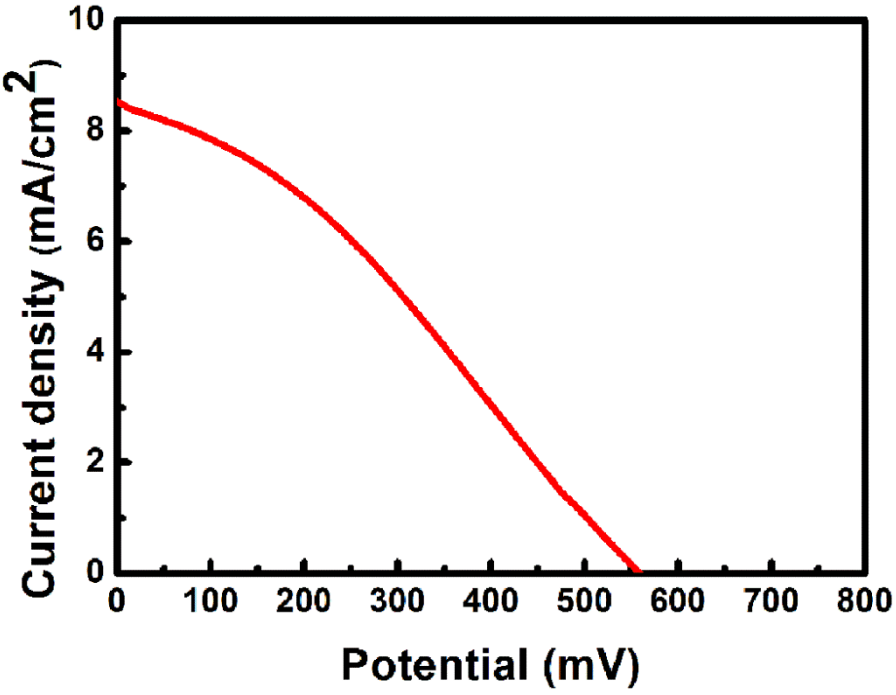

Figure S26. *J-V* curve of a PSC fabric.