Electronic Supplementary Material (ESI) for Nanoscale
This journal is © The Royal Society of Chemistry 2015

Electronic Supporting Information

Flexible, Transparent and Exceptionally High Power Output Nanogenerators Based on Ultrathin ZnO Nanoflakes

*Huynh Van Ngoc and Dae Joon Kang**

Department of Physics, Sungkyunkwan University, Suwon 440-746, Republic of Korea.

* Corresponding author: djkang@skku.edu

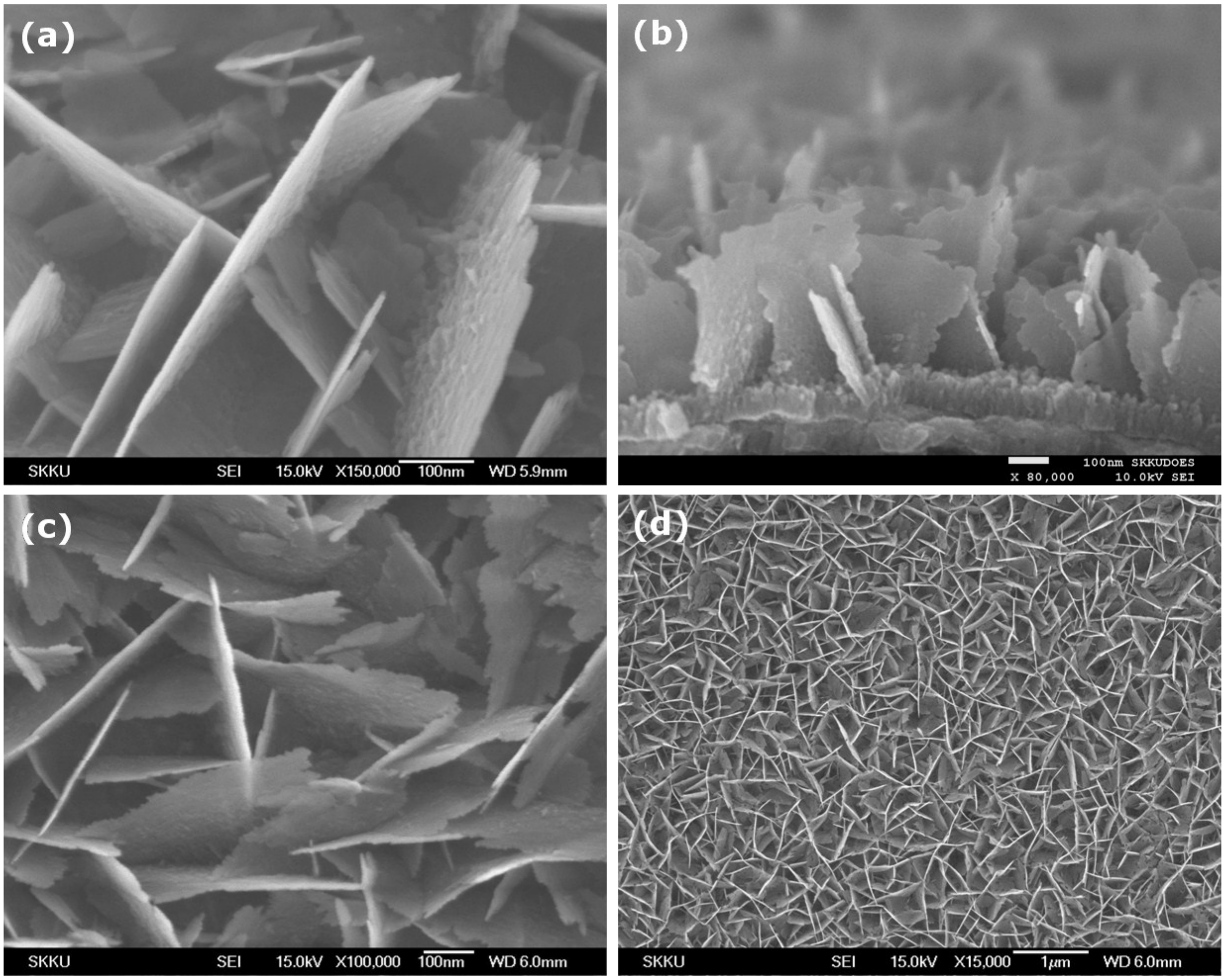

Fig. S1 FE-SEM images of ZnO NFs grown on textile substrates, (a) top and (b) cross-sectional view; (c) and (d) top view of ZnO NFs grown on FTO/glass substrates with different magnifications of (c) 100k and (d) 15k.

The FE-SEM images of the ZnO NFs reveal that the NFs walls are less than 10 nm thickness, and have height of approximately 500 nm, and 1 μm in length.

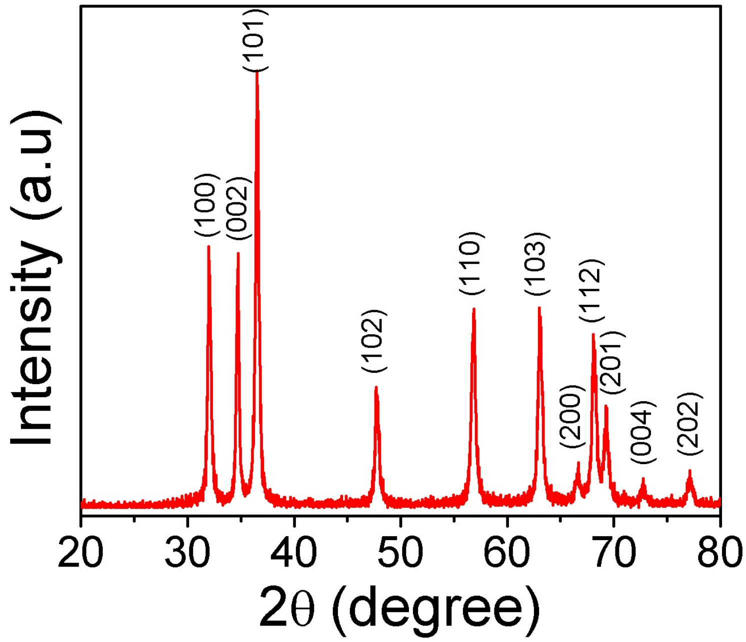

Fig. S2 XRD patterns of synthesized ZnO NFs.

Fig. S2 shows the XRD patterns of the ZnO NFs synthesized at room temperature. All diffraction peaks can be indexed to the hexagonal phase of ZnO, which is in good agreement with the previously reported data (JCPDS 05-0664). This indicates that even the samples synthesized at room temperature have a well-defined crystalline structure. In addition, no other peaks related to impurities were detected in the XRD patterns.

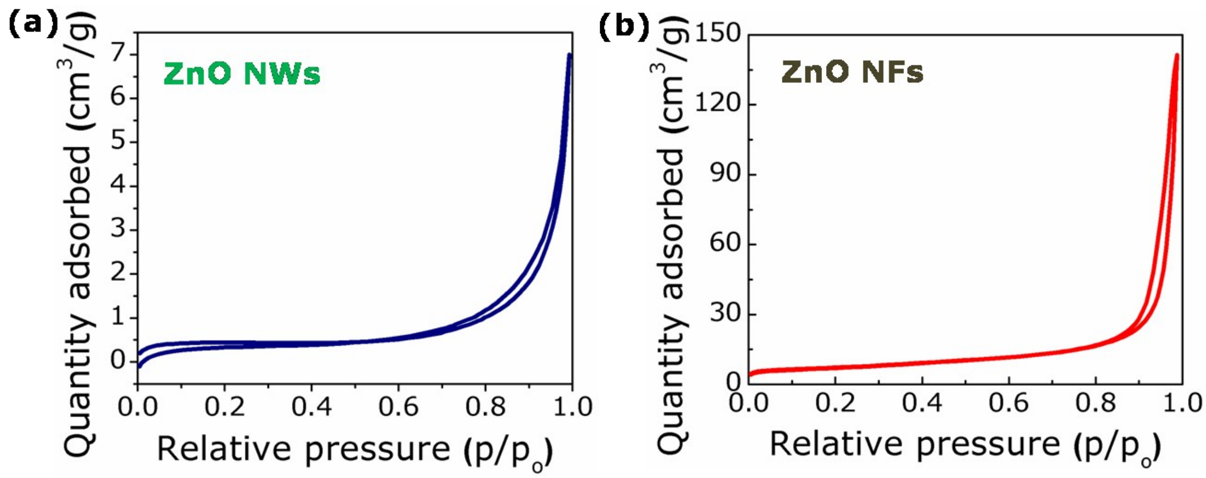

Fig. S3 Nitrogen adsorption isotherms for (a) ZnO NWs and (b) ZnO NFs. According to the nitrogen adsorption isotherms, the ZnO NF samples exhibited specific surface areas of 25.18 m^2 g^{-1}, which are much larger than that of the ZnO NWs (1.75 m^2 g^{-1}).

The nitrogen adsorption-desorption isotherms of the ZnO NFs/ZnO NWs were conducted at 77 K using a Quantachrome Autosorb-1C instrument. The samples were then degassed at 200 °C for 15 h before taking gas adsorption measurements. The specific surface area and the pore size distribution of the samples were derived using the Brunauer-Emmett-Teller method.

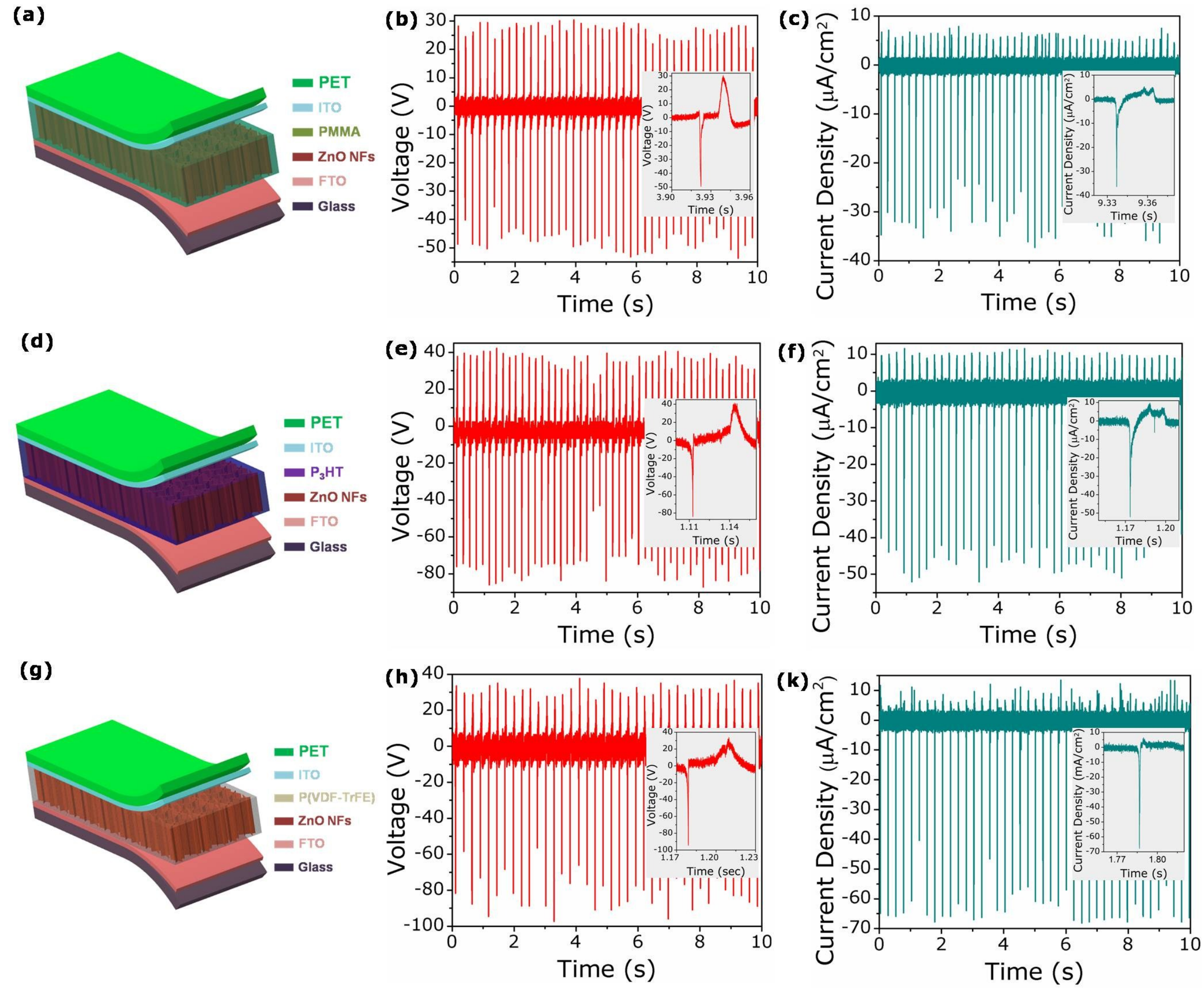

Fig. S4 The effects of the different coating layers on the ZnO NFNGs. (a) Device structure, (b) open-circuit voltage, and (c) short-circuit current density of PMMA-coated ZnO NF-based NGs; (d, e, f) P_3HT-coated ZnO NFs; and (g, h, k) P(VDF-TrFE)-coated ZnO NFs.

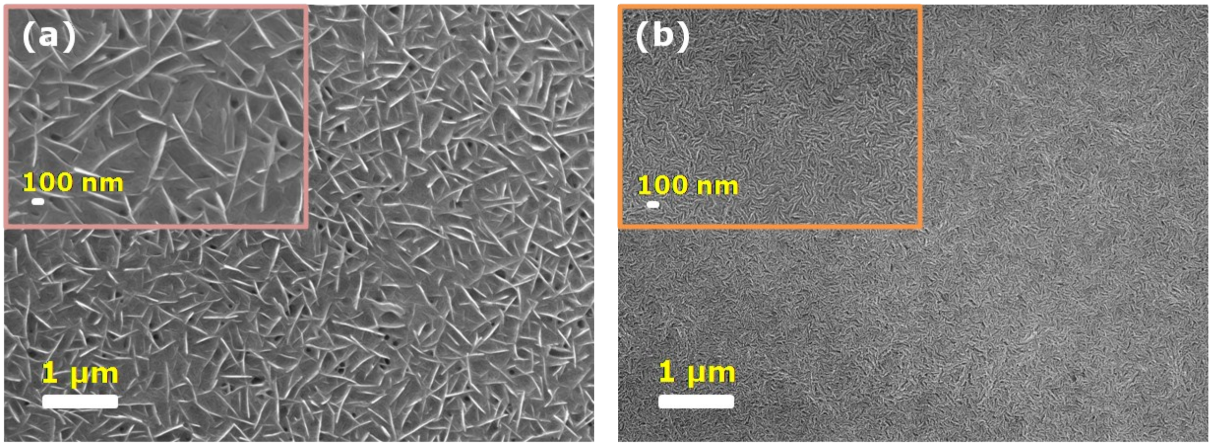

Fig. S5 P(VDF-TrFE) coating on ZnO NFs. (a) 0.4-wt% and then (b) 10-wt% concentration of P(VDF-TrFE) in a DMF solvent.

To achieve a uniform coating on P(VDF-TrFE), a 10-μm-thick P(VDF-TrFE) ferroelectric layer was prepared by mixing P(VDF-TrFE) in N,N-dimethylformamide (DMF) and coating the layer twice, first at 0.4 wt% and then at 10 wt%. This solvent was then applied to the ZnO NFs via dip coating. Thermal annealing (2 h at 80 °C and 2 h at 130 °C in air) was conducted to form β-phase-dominant P(VDF-TrFE).[1, 2]

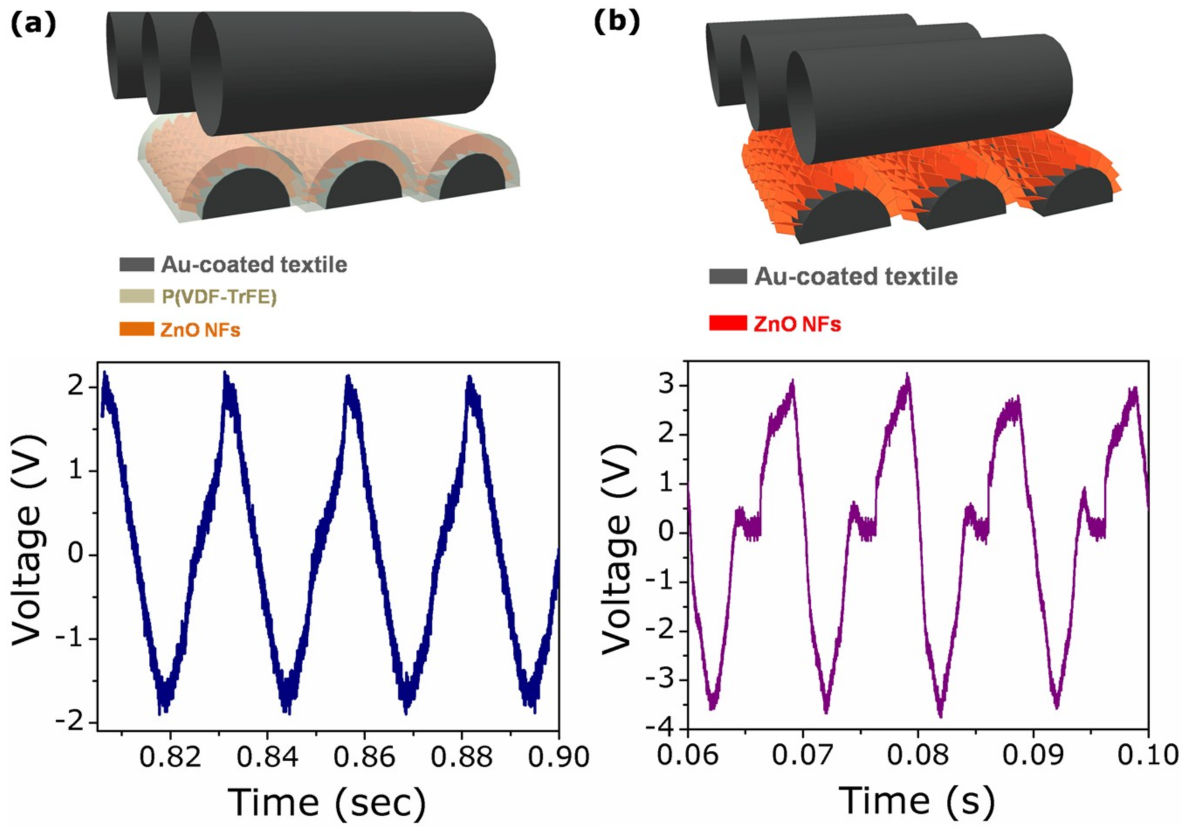

Fig. S6 A 100 dB, 100 Hz sonic wave generated open-circuit output voltages in (a) a textile electrostatic NG based on P(VDF-TrFE) coated on ZnO NFs and (b) a textile ZnO NF piezoelectric NG without an insulating layer.

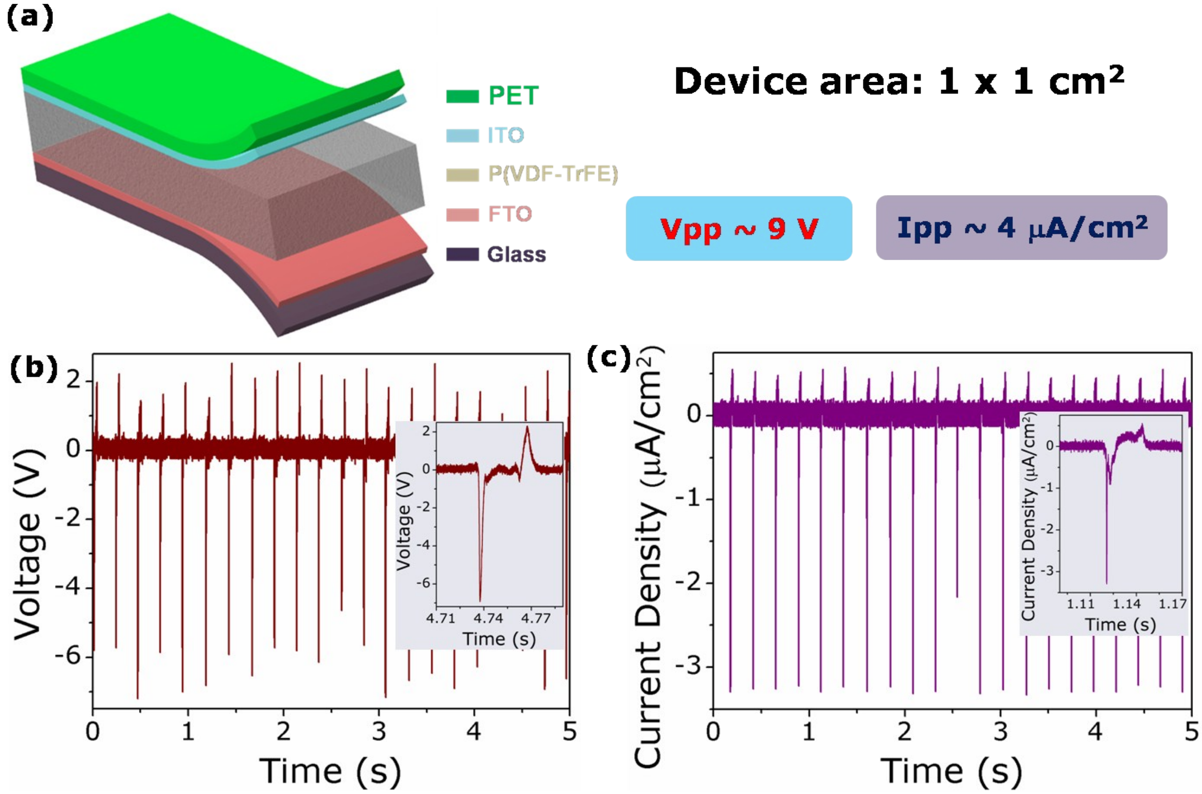

Fig. S7 NG-based triboelectric effects. (a) Device structure, (b) open-circuit voltage, and (c) short-circuit current density of the P(VDF-TrFE)-coated FTO/glass substrate-based NG.

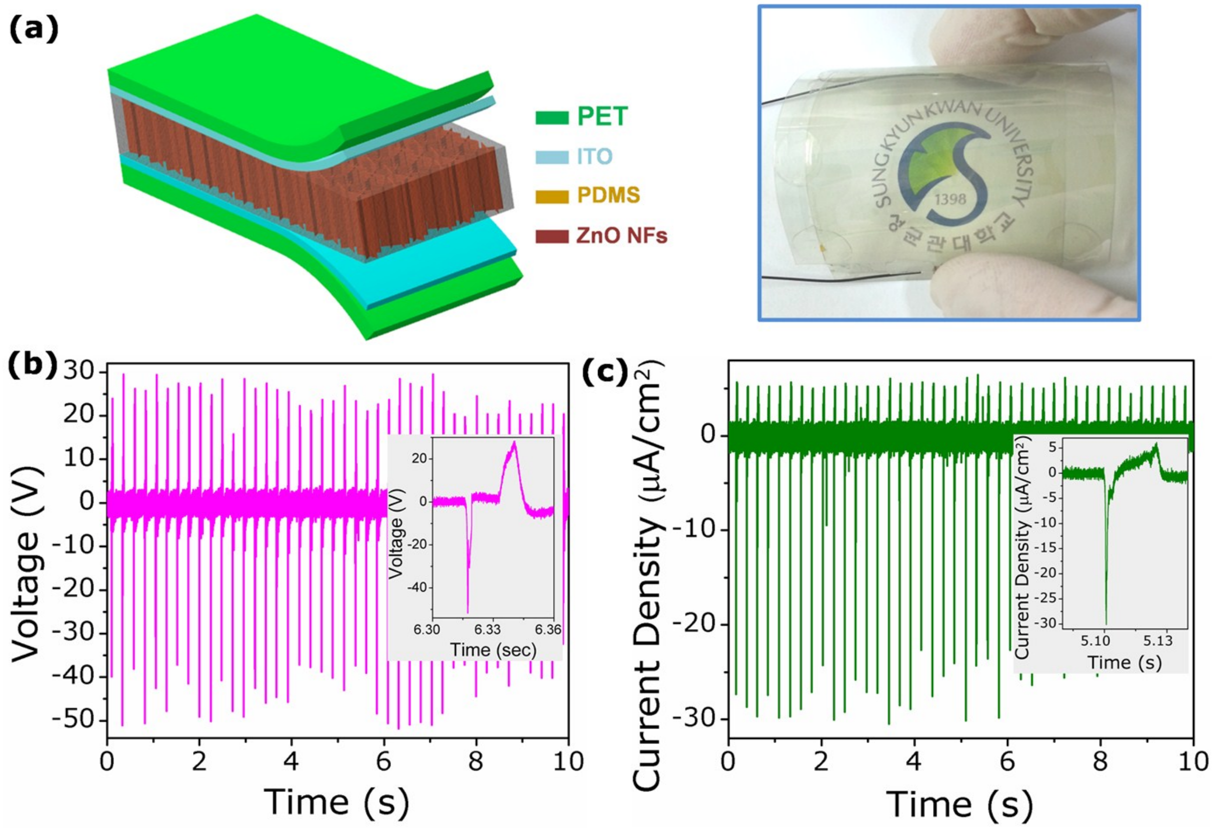

Fig. S8 PDMS-coated ZnO NF-based NGs grown on an ITO/PET substrate. (a) Device structure and photographic image, (b) open-circuit voltage, and (c) short-circuit current density.

References

1 S. Cha, S. M. Kim, H. Kim, J. Ku, J. I. Sohn, Y. J. Park, B. G. Song, M. H. Jung, E. K. Lee, B. L. Choi, J. J. Park, Z. L. Wang, J. M. Kim and K. Kim, *Nano Lett.,* 2011, **11**, 5142–5147.

2 S. J. Kang, Y. J. Park, J. Sung, P. S. Jo, C. Park, K. J. Kim and B. O. Cho, *Appl. Phys. Lett.,* 2008, **92**, 012921.