Electronic Supplementary Material (ESI) for Energy & Environmental Science

Supplementary Information

Nanogenerator as Active Sensor for Vortex Capture and Ambient Wind-Velocity Detection

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Fabrication of nanogenerator

For fabrication of the composite nanogenerator, commercial PVDF film (Measurement Specialties Inc., 28 μm in thickness) was chosen as the substrate. With its poling direction downwards, a 100 nm thick ITO adhesive layer followed by a 150 nm thick ZnO seed layer was deposited on the top surface of the PVDF substrate. Hydrothermal method was utilized to grow the ZnO NWs. To reduce the substrate deformation during growth progress of ZnO NWs, the bottom surface of the PVDF substrate was bonded on a glass slide. Then, the substrate and glass was placed in an equal molar aqueous solution (0.12 mol) of zinc nitrate hexahydrate ($Zn(NO_3)_2 \cdot 6H_2O$) and hexamethylenetetramine (HMTA). The ZnO NWs were grown in a constant temperature oven (Yamato, DKN402) at 85°C for 5h. The as-grown ZnO NWs had a diameter of 800 nm and a length of 2.8 μm. Under the assistance of ZnO seed layer, these ZnO NWs were densely grown to form a film. A 2 μm thick PMMA insulation layer (MicroChem, 950 PMMA A11) was then spin-coated on the top of ZnO NWs film. Finally, after the substrate was tore from the glass slide, silver paste was painted on the bottom of PVDF film and the top of PMMA layer as the bottom and top electrodes, respectively. Two leads were connected to the bottom and top electrodes for electrical measurements. The voltage and current outputs were measured via low-noise voltage and current preamplifiers (Stanford Research Systems, SR560 and SR570), respectively.

Contrast experiments

To prove the performance enhancement of the composite piezoelectric structure, contrast experiments were carried out under the same testing conditions, a peak stress of 6.1×10^{4} Pa at 2 Hz frequency. As shown in Fig. S1, the peak voltage outputs of ZnO NWs on unpoled PVDF (indicated by ZnO), only poled PVDF (indicated by PVDF) and ZnO NWs on poled PVDF with same direction of *c*-axes of ZnO NWs and poling direction of PVDF (indicated by ZnO - PVDF) were 0.36 V, 0.27 V and 0.13 V, respectively.

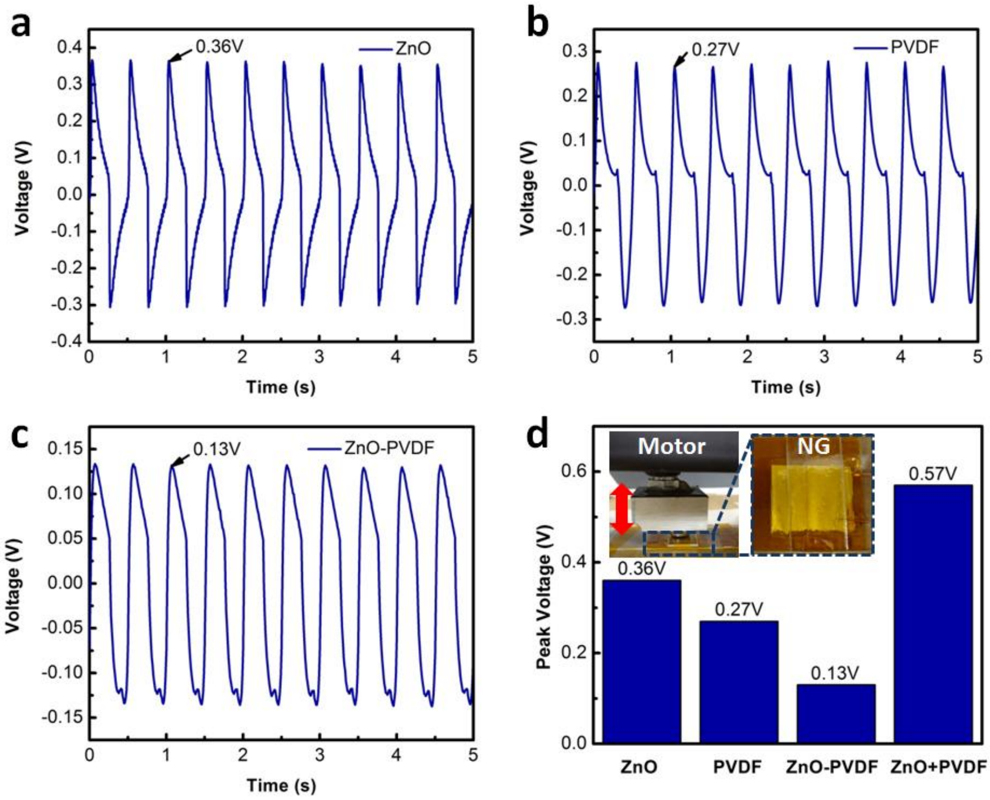

Figure S1. Voltage outputs of generators with different structures. a) ZnO NWs on unpoled PVDF. b) Only poled PVDF. c) ZnO NWs on same directionally poled PVDF. d) Output comparison of different structures.

Geometric dimensions

Fig. S2 shows the geometric dimensions of the bluff body and the NG probe. The bluff body was made of glued glasses, while the NG probe was a NG belt glued on a glass strip.

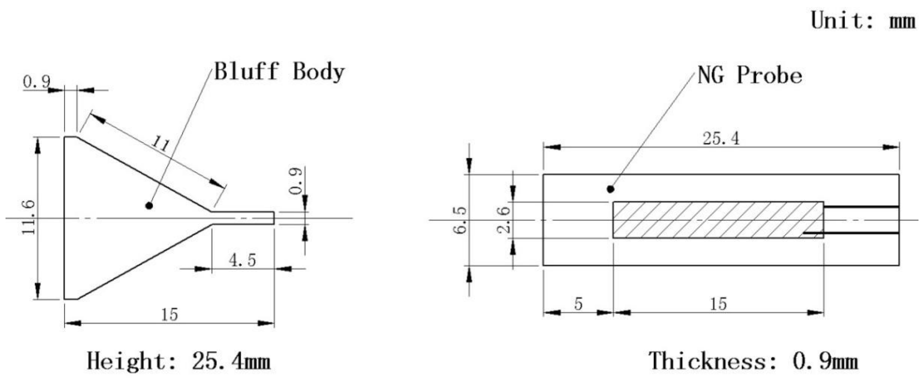

Figure S2. Dimensions of the bluff body and the NG probe.

Video 1

Video 1 shows the vortices produced by the bluff body in Fig. S2.

Video 2

Video 2 shows the voltage output of the NG based active VFD for ambient wind-velocity measurement in outdoor environment.