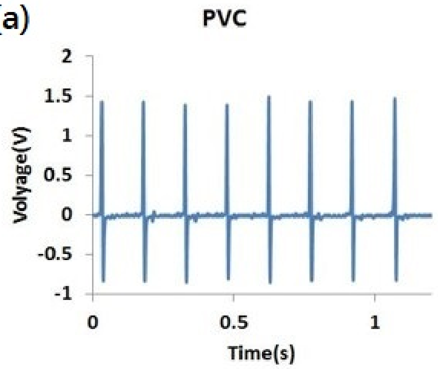
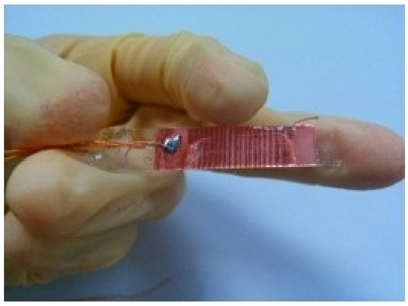
Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

A highly flexible and substrate-independent self-powered deformation sensor based on massively aligned piezoelectric nano-/microfibers

Yiin-Kuen Fuh[1], Jia-Cheng Ye[2], Po-Chou Chen[3], Zih-Ming Huang[3]

<table>
<tr><td>Substrates</td><td>Output Voltage</td><td>figure</td></tr>
<tr><td>PVC</td><td>(a)

</td><td></td></tr>
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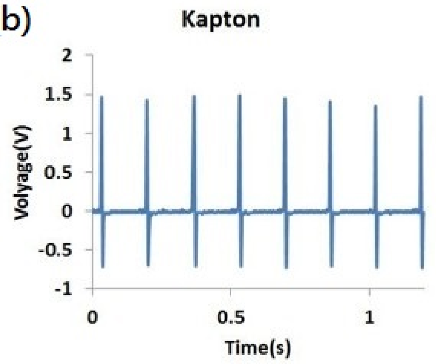
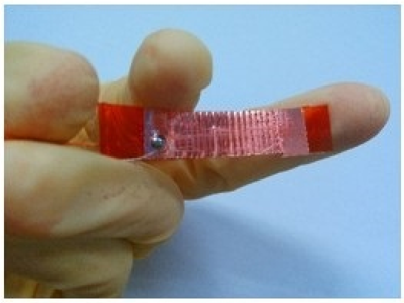

</td><td></td></tr>
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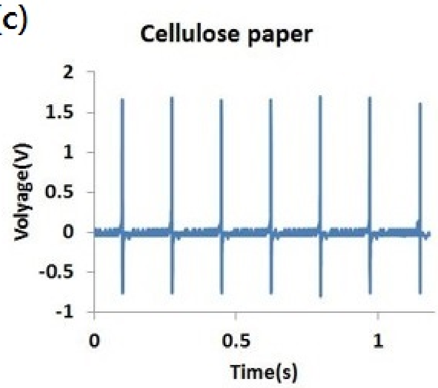
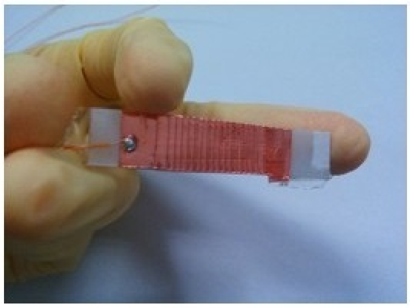
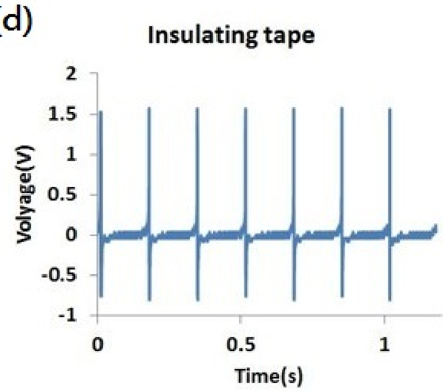
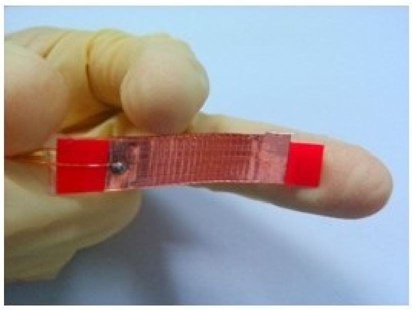

</td><td></td></tr>
<tr><td>Insulating tape</td><td>(d)

</td><td></td></tr>
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Figure S1 A direct-write, in-situ poled polyvinylidene fluoride (PVDF) nano-/microfiber (NMF) arrays have been successfully deposited on various substrates ranging from (a) PVC (b) Kapton (c) Cellulose paper (d) Insulating tape substrates. The average diameter of the NMF arrays were very uniform under the same NFES setup at approximately 3 µm. The measured open circuit voltage also exhibits consistent electrical output (peak output voltage 1.5- 1.7V) with a total of 500 microfibers continuously deposited in parallel configuration.

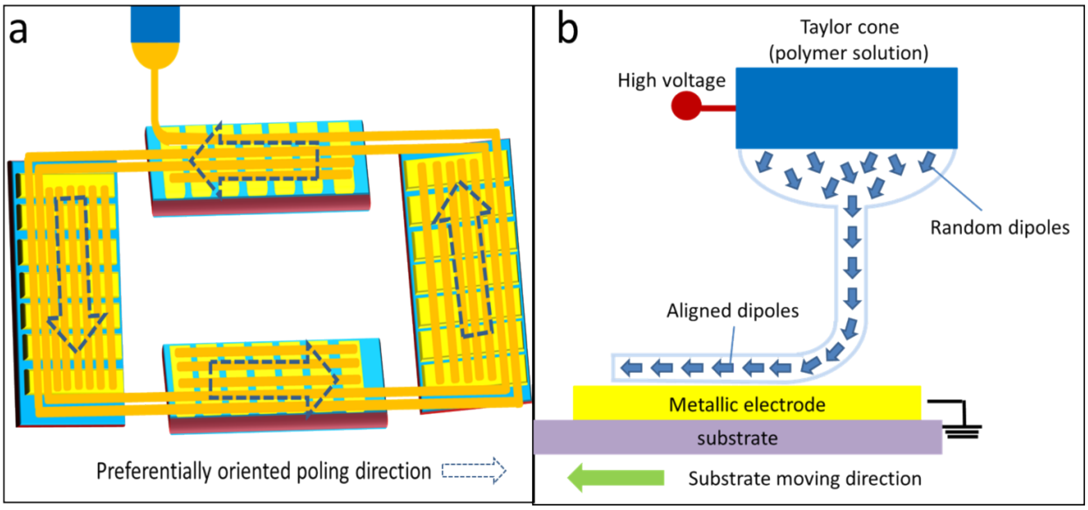

Figure S2. The in situ mechanical stretching and electrical poling during direct-write technique by means of near-field electrospinning (NFES) (a)Schematic diagram of the in-situ electrical poling direct-write and near-field electrospun PVDF fibers with mechanical stretching to construct PG onto a flexible substrate.(b)Near-field electrospinning (NFES) is capable of combining direct-write, mechanical stretching, and in situ electrical poling to precisely deposit piezoelectric nanogenerators onto a flexible or rigid substrate such as plastic or silicon wafers.

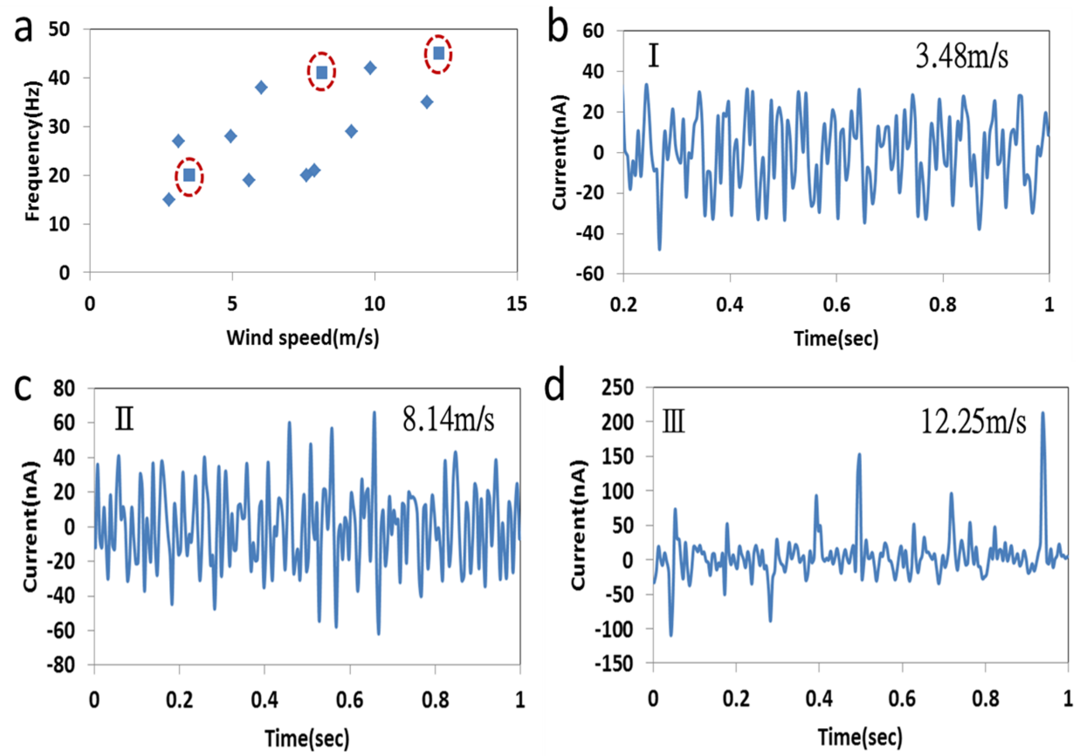

Figure S3. (a) Wind speed dependent fluttering motion and associated frequencies. Due to the higher strain rate generated from the flexible PG as the wind speed increases, the fluttering frequency is measured to follow a similar trend. The output current of the PG was measured under the wind speed of (b) 3.48 m/s, (c) 8.14 m/s, and (d) 12.25 m/s, respectively.

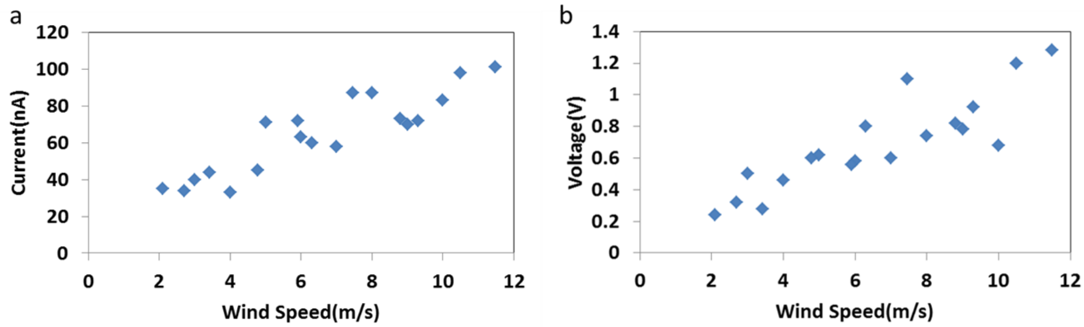

Figure S4. Wind speed dependent performance of the PG. (a) Output current and (b) voltage of the PG according to the increase of wind speed from 0 to 11.39 m/s.

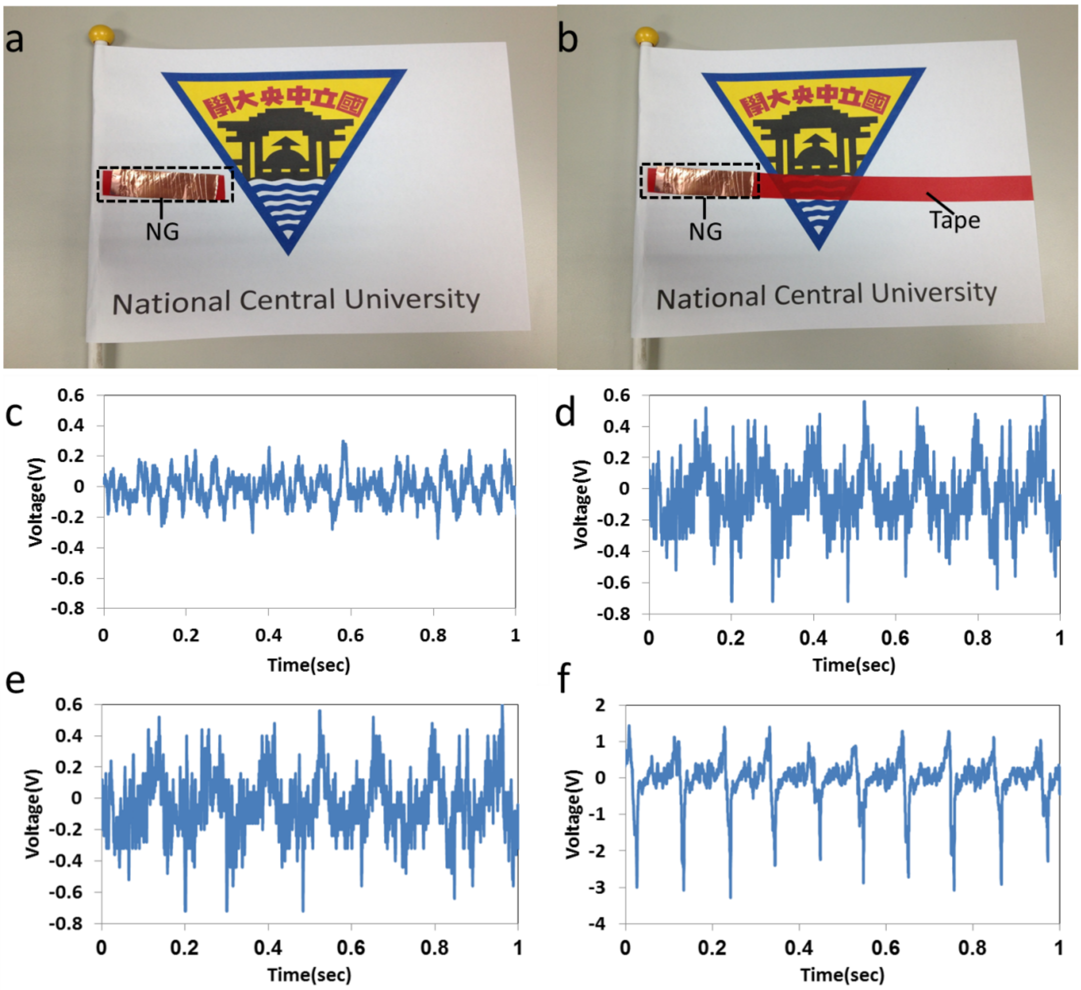

Figure S5. Performance enhancement using a novel elongated structure to harvest the full fluttering motion under various air-flow velocities.(a) The PG attached at position I of the flag surface.(b) The PG attached at position I with an elongated structure.(c-d) Voltage Output improvement for wind speed of 3.41 m/s.(e-f) Three-fold increase of output voltage for wind speed of 11.39 m/s.

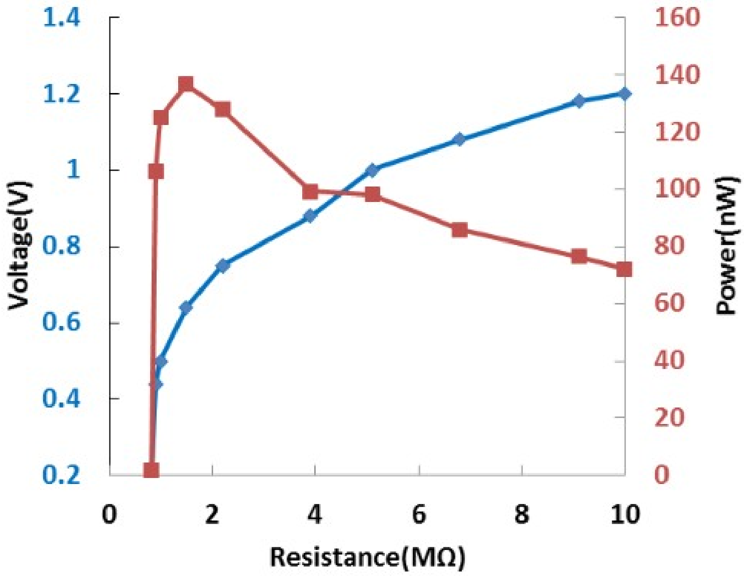

Figure S6. Output power and conversion efficiency of a typical NFES NFs based PVDF device. The output power estimation of the optimized value of 136 nW with a matched resistance of 1.5 MΩ by adopting the former experiment which the dimension 5 cm × 2 cm × 0.08 cm with 500 PVDF NFs and diameter in the range of 0.9-2.9μm, operating at the 10 Hz, corresponding to the strain rate of 0.5%.

For conversion efficiency of a typical NFES PVDF device based on NFs were calculated before and can also be referred to [10]. It was experimentally found that the energy conversion efficiency of NFES fiber-based powergenerators was found to be average of 12.5%, a value that is much greater than piezoelectric PVDF thin films (0.5-4%).

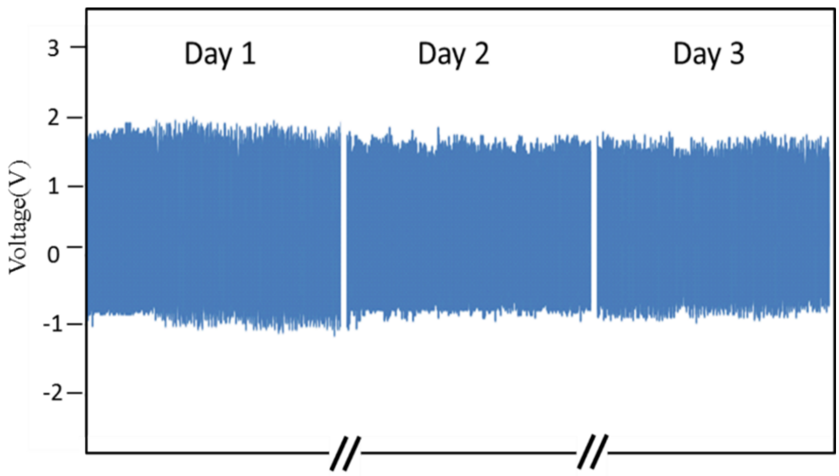

Figure S7. Long-term stability tests. Output voltage of a PVDF PG was put under 15 Hz of continuous cycles of stretching and releasing for 3 days, demonstrating the stability of the PG. The PG was continuously run each day for 3 h.

[1*] Shao-Yu Chen “1.7 V Nanogenerator Realized via Direct-write, In-situ Poled Near-field Electrospun Nanofibers on Flexible Substrate”, master thesis, National Central University, 2012