Electrical Power Generator from Randomly Oriented Electrospun Poly(vinylidene fluoride) Nanofibre Membranes

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Electronic Supplementary Information

S1 Experimental Section

Electrospinning of nanofibres: PVDF pellet (M_W 172,000, Sigma-Aldrich) was dissolved in N, N′-dimethylformamide at 70 °C to prepare PVDF solution (16%, w/v). The homogeneous solution was then transferred into a plastic syringe for electrospinning. A syringe pump (KD Scientific) was used to control the flow rate at 1 ml/h and a high voltage power supply (Gamma High Voltage) was used to generate 15 kV voltage between the syringe needle (21G) and a grounded metal collector (distance 15 cm). The fibres were collected randomly on the collector.

S2 Voltage output of a nanofibre membrane device caused by a pressing-and-holding action

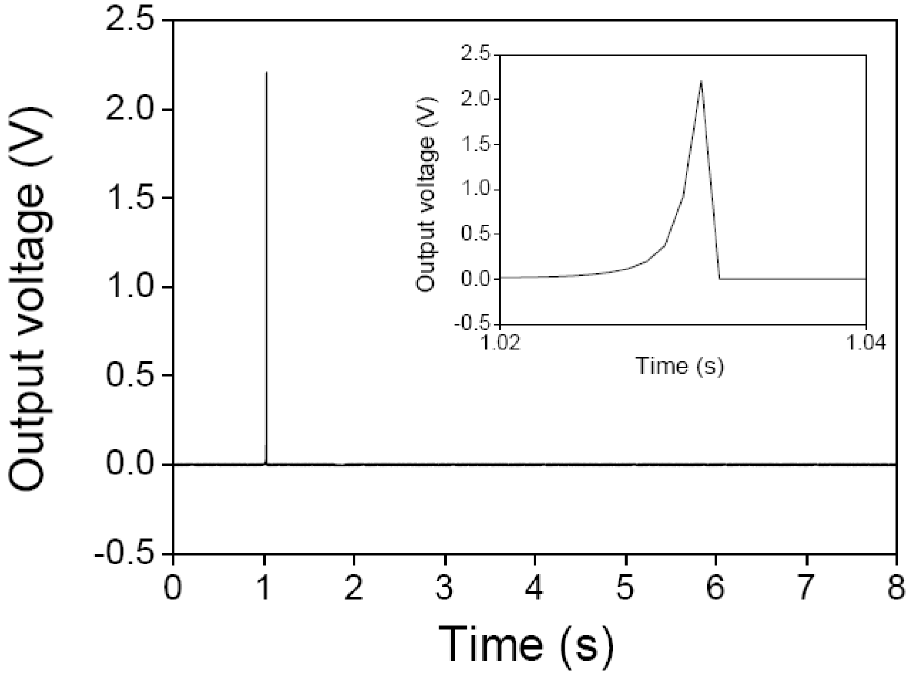


Fig. S1 By pressing and holding a PVDF nanofibre membrane, only the front voltage signal was recorded (inset is the same peak but the time scale only between 1.02 and 1.04 seconds).

S3 Electrical outputs with reverse electrode connection

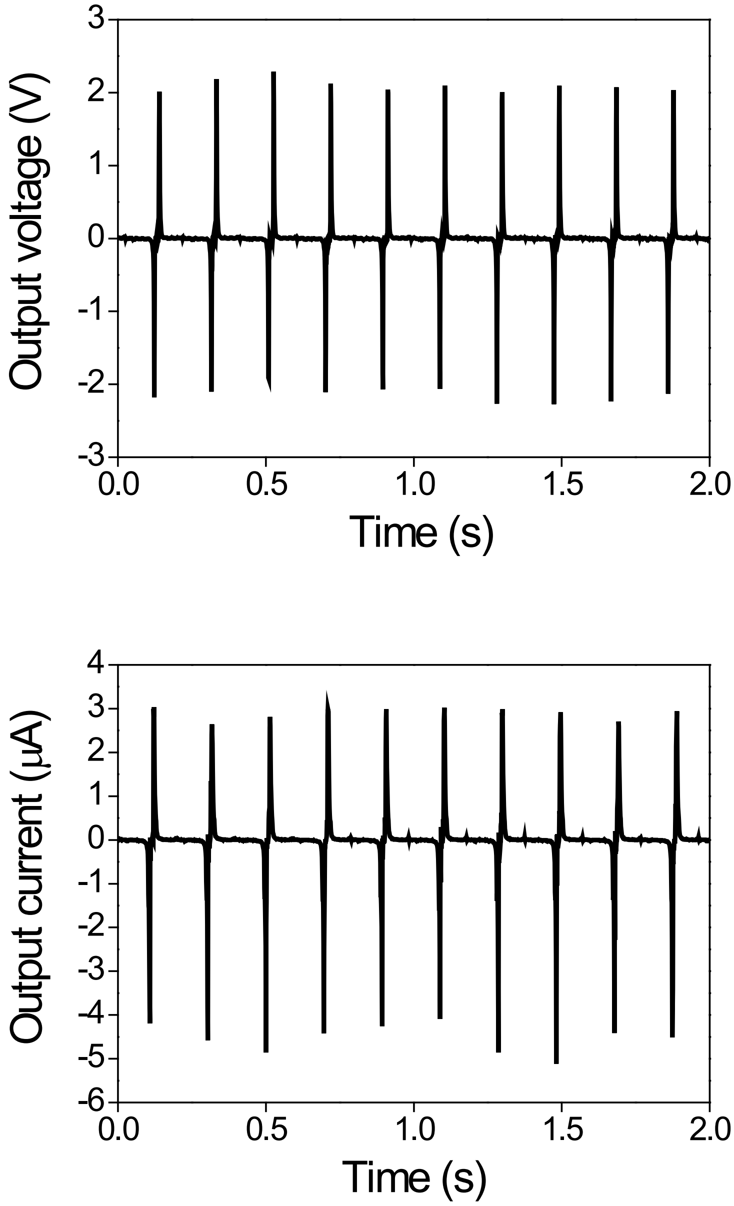


Fig. S2 Electrical outputs of a nanofibre device under 5 Hz repeated compressive impacts with reverse connection (the impacted side was collected to the working electrode, while the opposite side to the counter electrode). The working area of nanofibre membrane was 2 cm^2.

S4 Influence of impact frequency on the current output

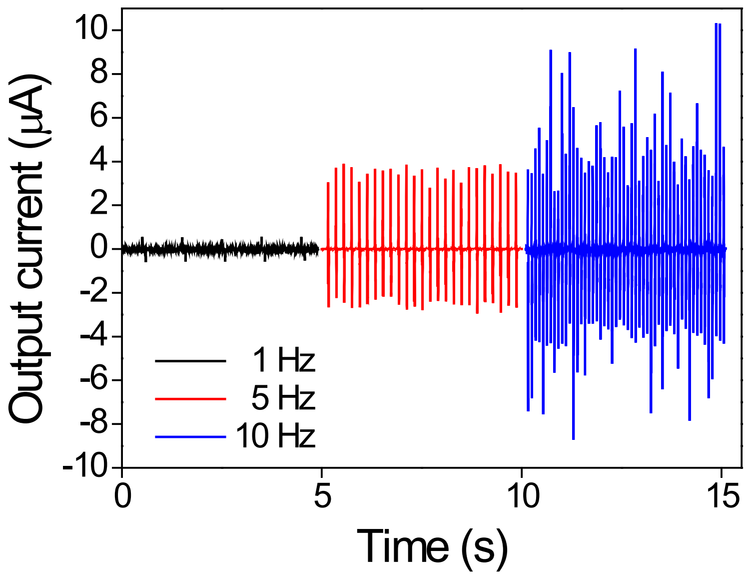
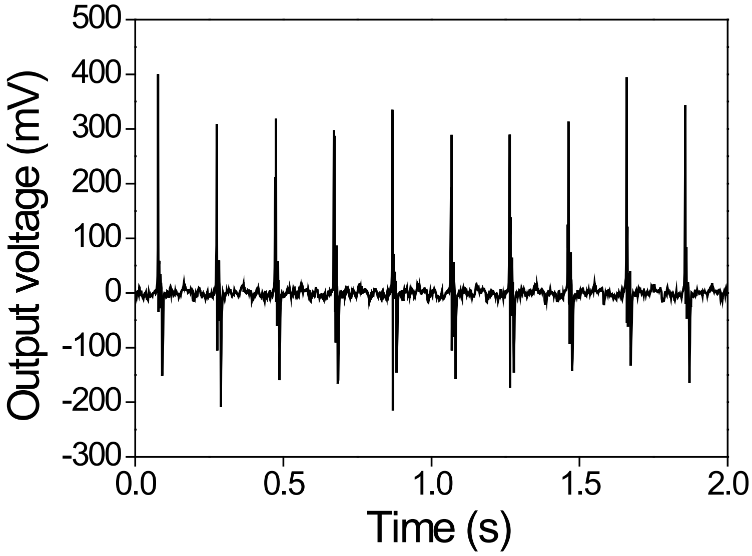


Fig. S3 Current output from a 2 cm^2 nanofibre membrane device at different impact frequencies

S5 Voltage outputs generated by compressively impacting a commercial piezoelectric PVDF film



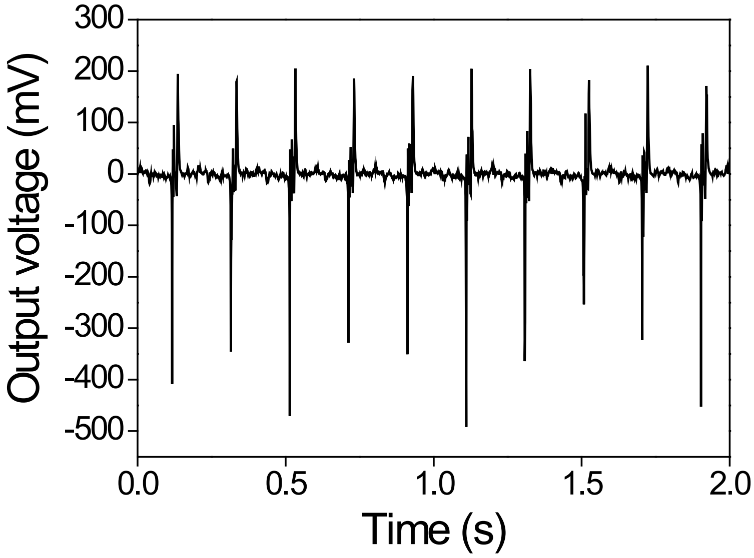


Fig. S4 Voltage outputs generated by pressing both sides of a commercial piezoelectric PVDF film (Working area = 2 cm^2, thickness = 110 μm, impact frequency = 5 Hz).

S6 Rectified current output from a nanofibre power generator

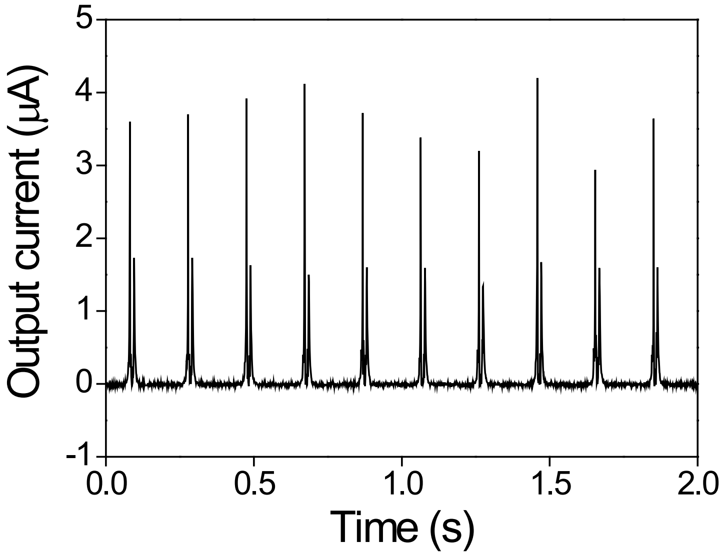


Fig. S5 Rectified current outputs from a nanofibre power generator.

S7 Long term working stability

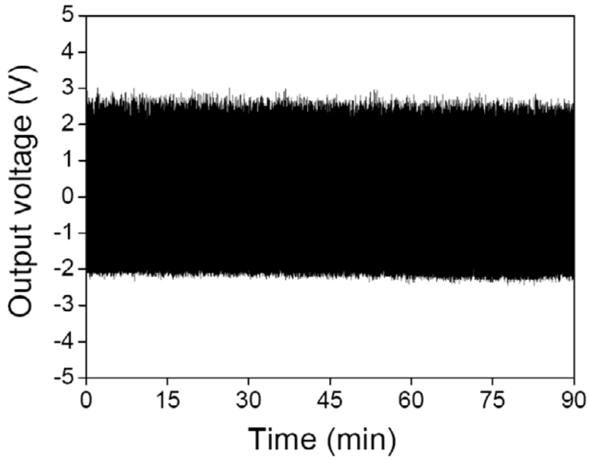


Fig. S6 Long term working stability of nanofibre device

S8 Calculation of energy conversion efficiency

Electrical energy (W_e) generated from one press-release cycle on a 2 cm^2 nanofibre membrane power generator at 1, 5 and 10 Hz was calculated as 0.43, 10.92 and 74.23 μJ, respectively, according to equation $W_e = \int VIdt$.

Mechanical energy (W_m) was calculated using an indirect method based on the energy consumed to cause compressive deformation of the nanofibre member as:

$$W_m = \frac{1}{2} M V_i^2 * \frac{S_I}{S_w}$$

Where V_i is the initial impact speed. M is the object mass that can be obtained from the maximum load in the load-displacement curve of nanofibre membrane (Fig. S7). S_w is the area of nanofibre membrane, and S_I is the area of the indenter used to deform the membrane.

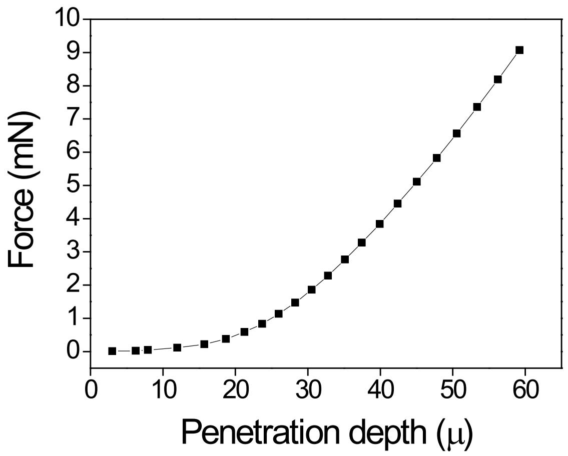


Fig. S7 Load displacement curve of nanofibre membrane

The calculated mechanical energies at different initial impact speeds were 5.45, 136.3 and 545.17 μJ, respectively. The energy conversion efficiencies are 7.89%, 8.01% and 13.62%.

S9 Voltage outputs generated by bending and tapping a nanofibre membrane device

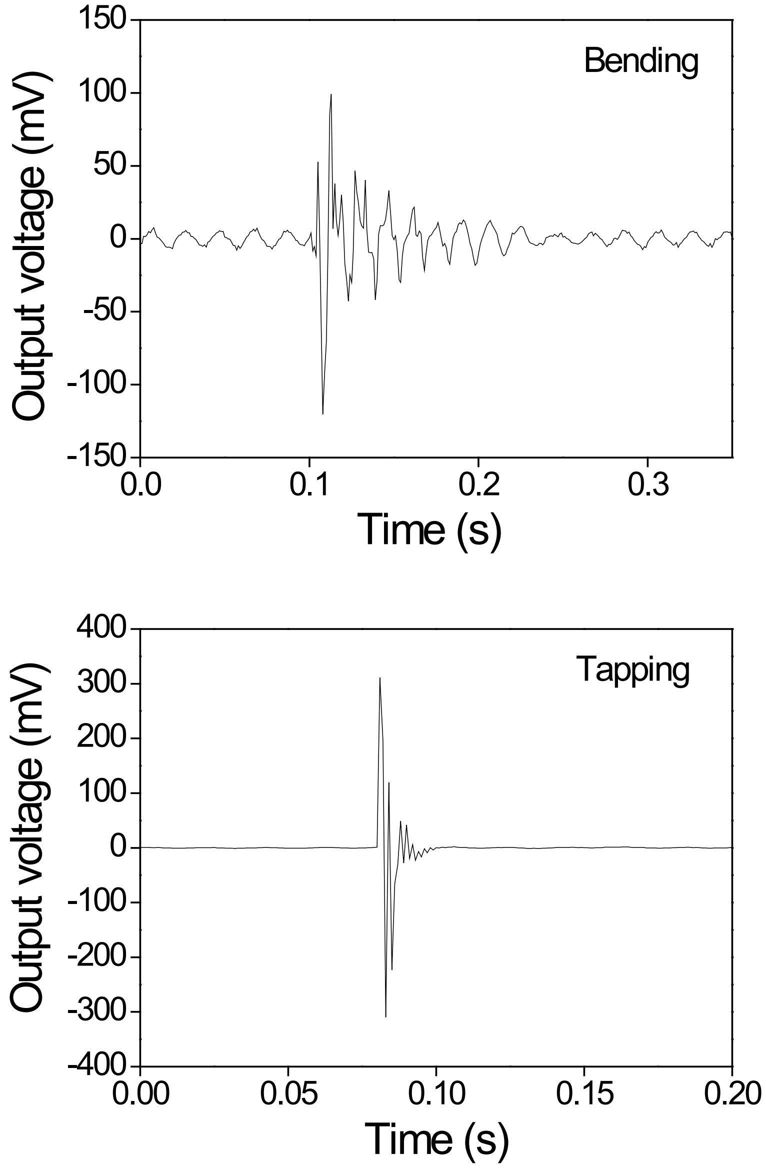


Fig. S8 Voltage outputs generated by bending and tapping a nanofibre membrane device.

S10 Chain conformations of different PVDF crystal phases

α phase

β phase

δ phase

γ phase

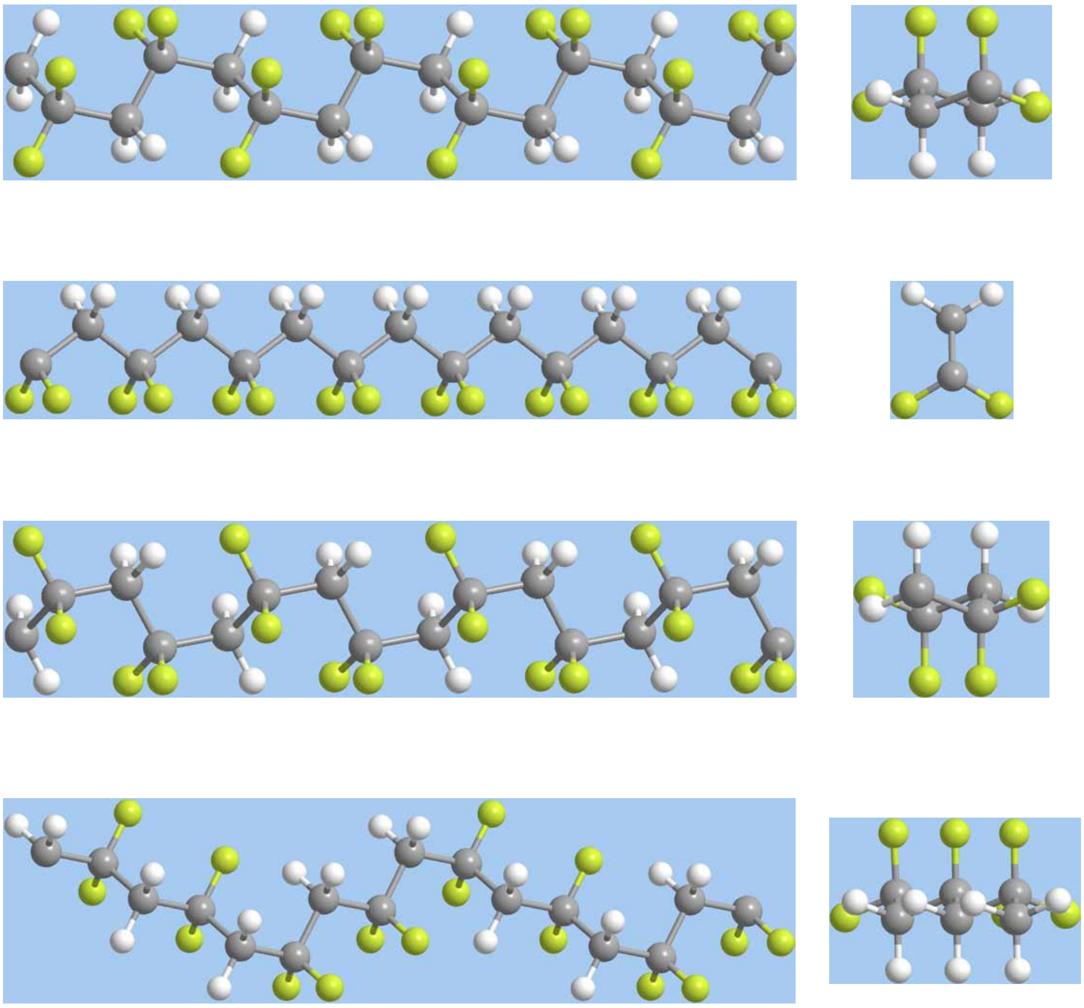


Fig. S9 Chain conformations of different PVDF crystal phases.

S11 VIDEO

A video showing a blue LED is lit up by a nanofibre membrane power generator.