Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

Output Optimized Electret Nanogenerator for Self-Powered Long-Distance Optical Communication System

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Theoretical derivation of the current output of ENG

Considering the actual working process, we can obtain the *Q*-*t* relationship by using the Gauss theorem and Kirchhoff theory:

$$\frac{\partial Q_B(t)}{\partial t} + \frac{Q_B(t)}{RS\varepsilon_0}\left[d_A(t) + \frac{d_p}{\varepsilon_{rp}}\right] + \frac{Qd_p}{RS\varepsilon_{rp}\varepsilon_0} = 0 \tag{1}$$

Where Q, S, d_p, ε_0 and ε_{rp} represents the surface charge, effective area, thickness, vacuum permittivity and permittivity of the electret film, respectively. $Q_B(t)$ represents the surface charges of the ITO film and R is the external load. $d_A(t)$ is the air thickness expressed as follow:

$$d_A(t) = 0.5d_A[1 + \cos(2\pi ft)] \tag{2}$$

The initial conditions are given:

$$Q_B(0) = \frac{-Q}{1 + \varepsilon_{rp}\dfrac{d_A(0)}{d_p}} \tag{3}$$

$$d_A(0) = d_A \tag{4}$$

Then the analytic solution of the equation can be derived:

$$Q_B(t) = -Q\cdot\left[\frac{d_p}{RS\varepsilon_{rp}\varepsilon_0}\int e^{\int\frac{d_A(t) + d_p/\varepsilon_{rp}}{RS\varepsilon_0}dt}dt + \frac{1}{1 + \varepsilon_{rp}d_A/d_p}\right]\cdot e^{-\int\frac{d_A(t) + d_p/\varepsilon_{rp}}{RS\varepsilon_0}dt} \tag{5}$$

According to the definition of current, the current output of the generator is obtained:

$$I(t) = -\frac{\partial Q_B(t)}{\partial t} = \frac{Q}{RS\varepsilon_0}\cdot\{\frac{d_p}{\varepsilon_{rp}} - [d_A(t) + {}^{d}{}_{p}/\varepsilon_{rp}]\cdot[\frac{d_p}{RS\varepsilon_{rp}\varepsilon_0}\int e^{\int\frac{d_A(t) + {}^{d}{}_{p}/\varepsilon_{rp}}{RS\varepsilon_0}dt} d$$

$$\frac{1}{1+\varepsilon_{rp}d_A/d_p}]\cdot e^{-\int\frac{d_A(t) + {}^{d}{}_{p}/\varepsilon_{rp}}{RS\varepsilon_0}dt}\}$$

(6)

Supplementary Table 1. Parameter utilized in the theoretical calculation of the peak current and transferred charges.

Parameter	Value	Parameter	Value
S	12 cm^2	d_A	1.5 mm
R	1 Ω	f	5 Hz
ε_r	2	ε_0	8.85E-12 F/m

Supplementary Figures

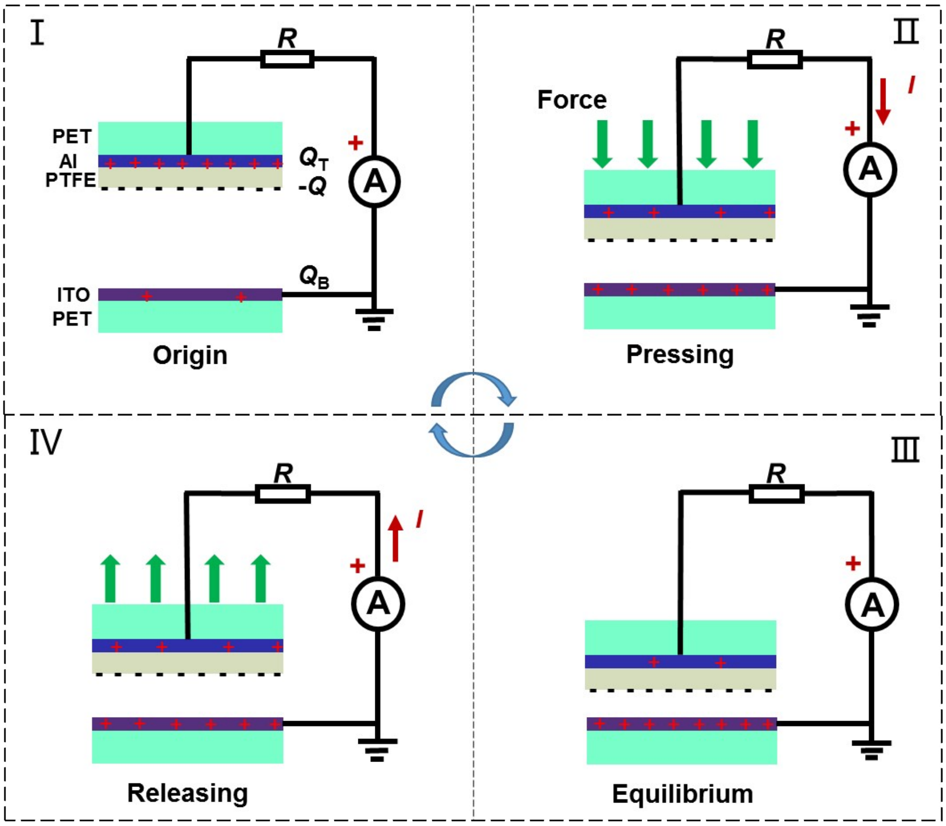

Fig. S1 Schematic diagram showing the working process of an electret NGs when it is at (I) the original, (II) the pressing, (III) the equilibrium, and (IV) the releasing states.

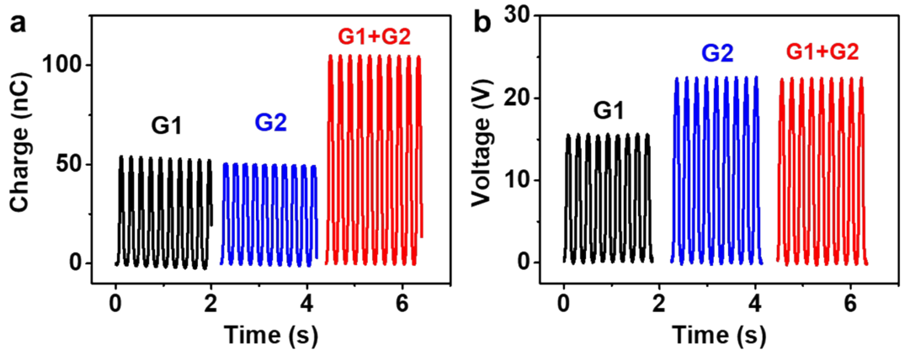

Fig. S2 Voltage and transferred charge of two same ENGs connected in parallel with the same direction.

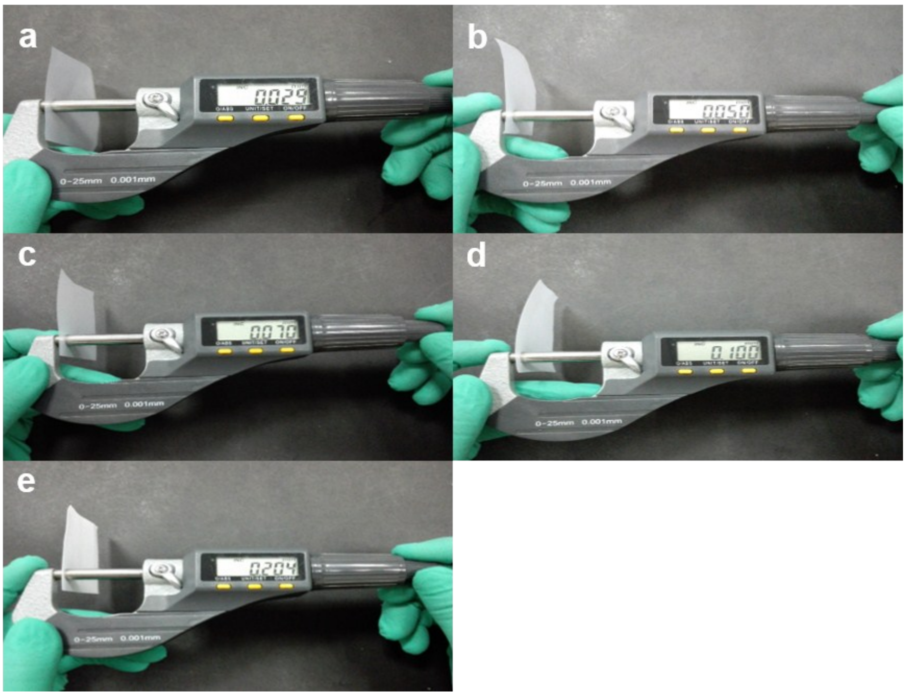

Fig. S3 The digital picture of different thickness PTFE films (a) 30 µm, (b) 50 µm, (c) 70 µm, (d) 100 µm and (e) 200 µm.

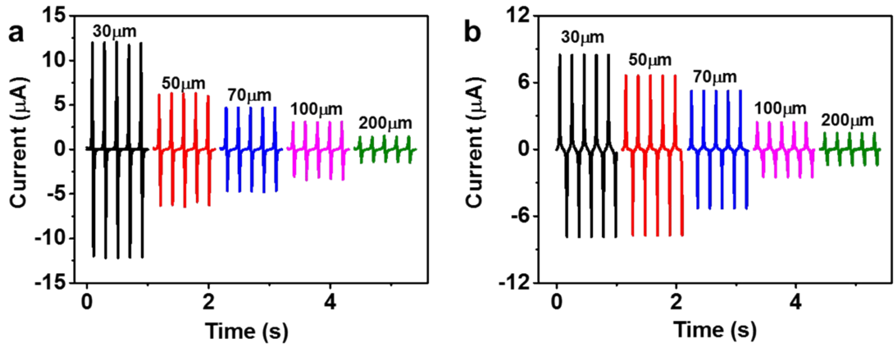

Fig. S4 (a) The stimulated output current-time curves of electret NGs with different thickness PTFE films. (b) The experimental output current-time curves of electret NGs with different thickness PTFE films.

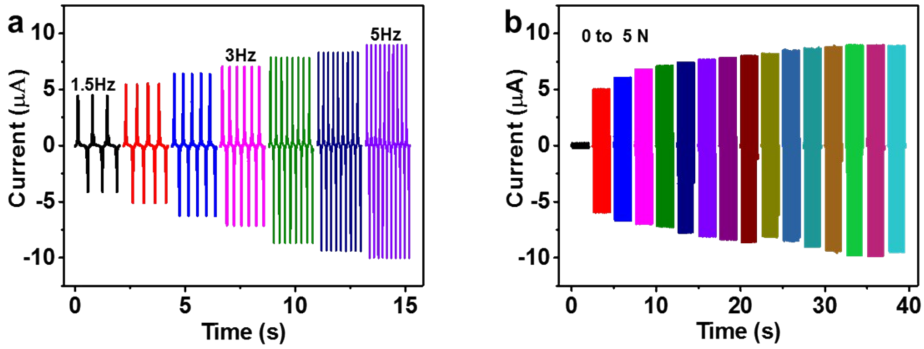

Fig. S5 (a) The output current-time curves of electret NGs with 30 μm PTFE film varied with stimulated frequency of 1 to 5 Hz at a given force of 5 N. (b) The output current-time curves of electret NGs with 30 μm PTFE film varied with stimulated force of 0.2 to 5 N at a given frequency of 5 Hz.

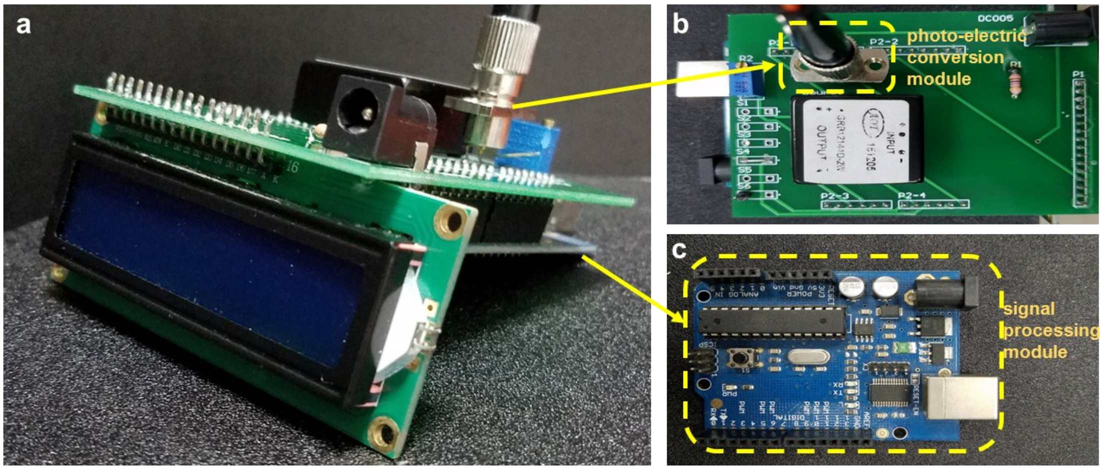

Fig. S6 Digital picture of (a) the receiving terminal, (b) the photoelectric conversion module and (c) the signal-processing module.

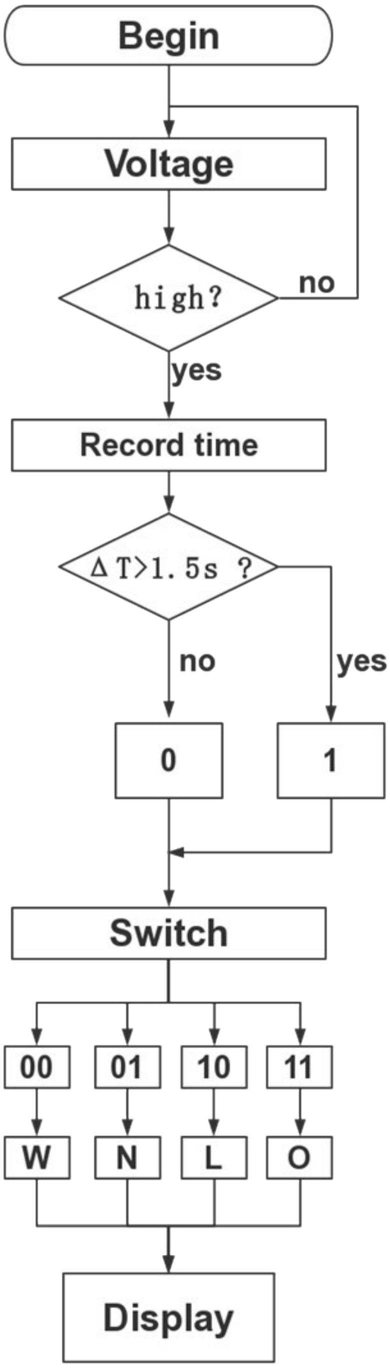

Fig. S7 The program flow chart showing the working steps of SLOCS.