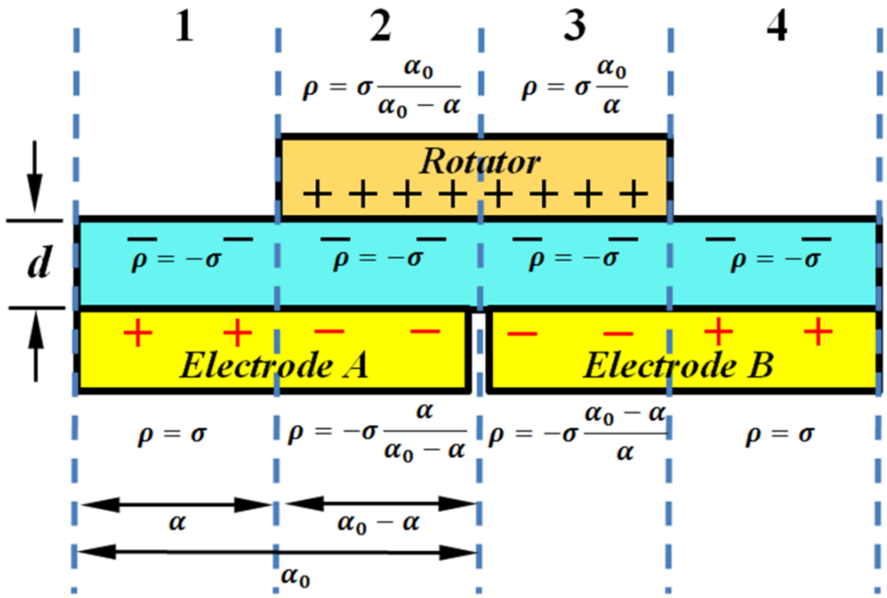
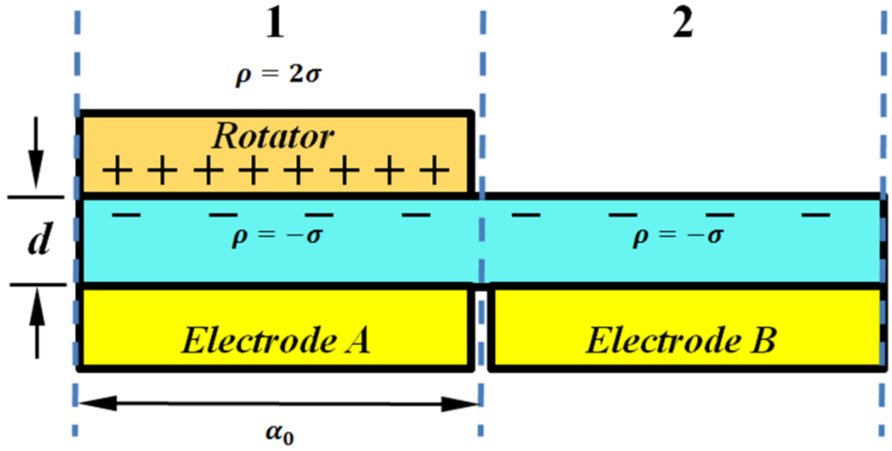
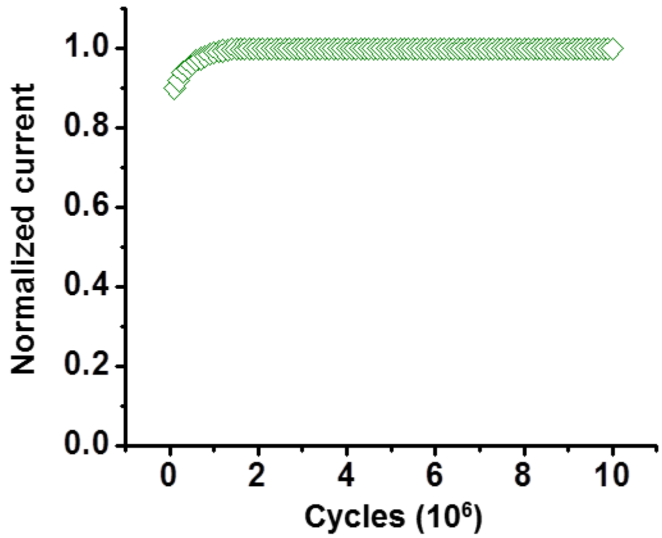


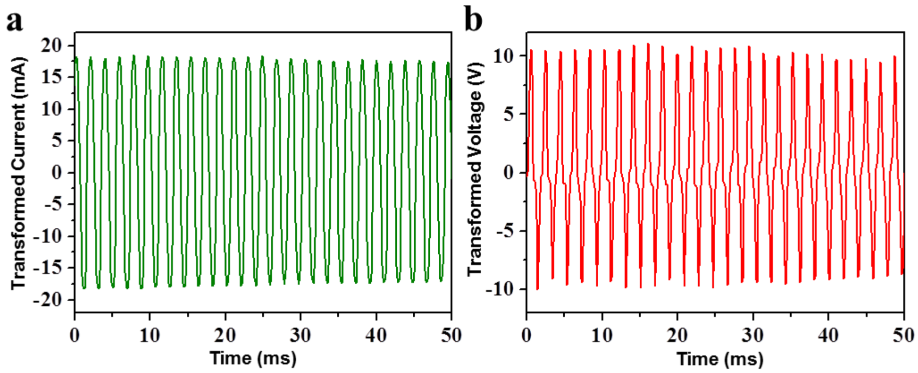
Supplementary Figure 1 │ Schematic illustration of a cross-sectional view of charge distribution in open-circuit condition at the intermediate state.



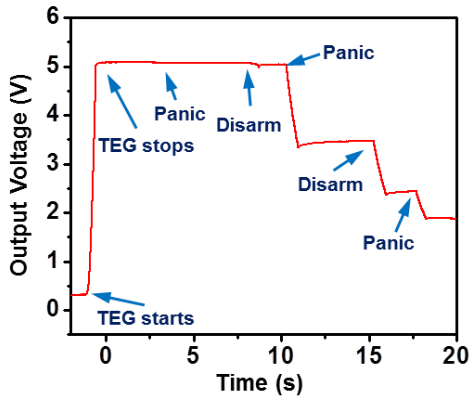
Supplementary Figure 2 │ Schematic illustration of a cross-sectional view of charge distribution in open-circuit condition at the initial state.



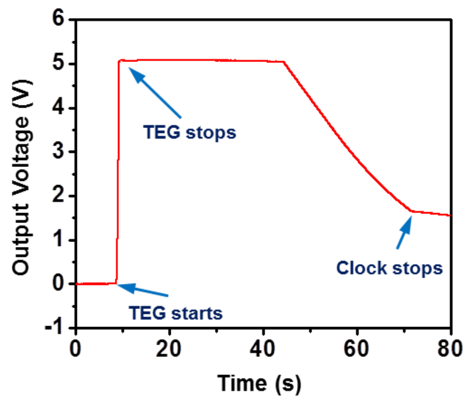
Supplementary Figure 3 │ Normalized current as a function of operation cycles. At the beginning, the increasing current is due to the accumulation of triboelectric charges. After the triboelectric charging saturate, the current output becomes stable.



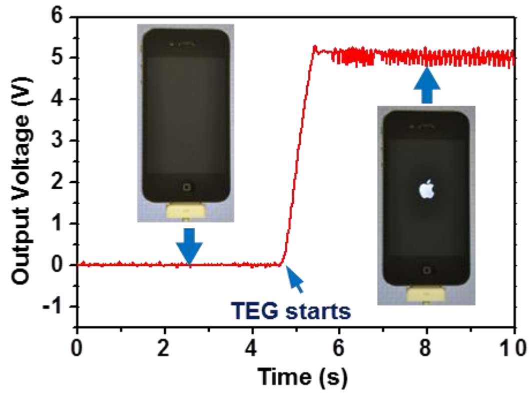
Supplementary Figure 4 │ Transformation of the electric output by a transformer. (**a**) Enhanced output current without external load at a rotation rate of 500 $rmin^{-1}$. (**b**) Reduced output voltage without external load at a rotation rate of 500 $rmin^{-1}$.



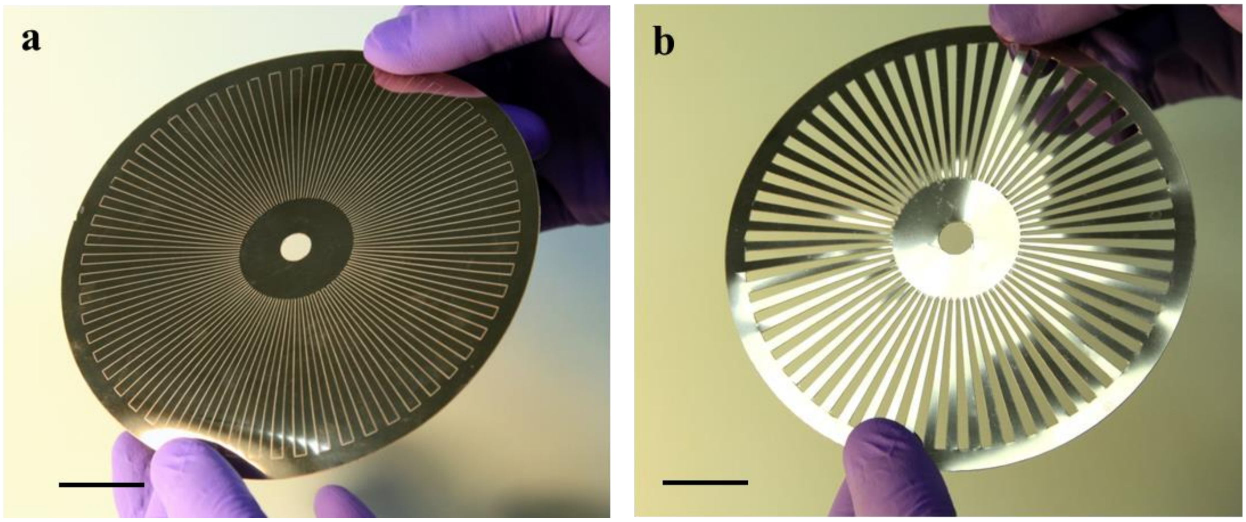
Supplementary Figure 5 │ Output voltage of the power-supplying system when powering a wireless emitter. For the triboelectric generator rotating for less than 1 sec at 3000 $rmin^{-1}$, the system can sustain 5 times of wireless transmission, which enables the alarm to switch between “panic” state and “disarm” state.



Supplementary Figure 6 │ Output voltage of the power-supplying system when powering a digital clock. For the triboelectric generator rotating for less than 1 sec at 3000 rmin^{-1}, the system can sustain continuous operation of the clock for 60 seconds.



Supplementary Figure 7 │ Output voltage of the power-supplying system when charging a cellphone. For the triboelectric generator rotating at 3000 $rmin^{-1}$, the cellphone turns on automatically as soon as the output voltage reaches 5 V.



Supplementary Figure 8 │ A thin-film based triboelectric generator fabricated on flexible polyamide substrate. a and **b** are stator (scale bar: 2cm) and rotator (scale bar: 2cm), respectively.

Supplementary Note 1 │ Theoretical analysis of operating process in open-circuit condition

Based on the assumption that the thickness of the dielectric layer (FEP) is far smaller than its width feature, a simplified model can be used in which any overlapped region between the rotator and the electrodes can be treated as a parallel-plate capacitor without consideration of edge effect. With triboelectric charge density of $-\sigma$ on the FEP surface, the non-overlapped regions on electrode A and electrode B (regions 1 and 4 in Supplementary Fig. 1, respectively) present a induced charge density of σ. Given that the net charges on both electrodes should be zero in open circuit condition, the induced charge density on overlapped regions (regions 2 and 3) can be expressed as

Overlapped part on electrode A (region 2): $\rho = -\sigma \cdot \frac{\alpha}{\alpha_0 - \alpha}$ (1)

Overlapped part on electrode B (region 3): $\rho = -\sigma \cdot \frac{\alpha_0 - \alpha}{\alpha}$ (2)

where α_0 refers to the central angle of the rotator unit, α refers to rotation angle away from the initial position between 0 and α_0.

Based on the law of charge conservation, the charge density on different regions of the rotator can be expressed as

Region 2 of the rotator: $\rho = \sigma + \sigma \cdot \frac{\alpha}{\alpha_0 - \alpha}$ (3)

Region 3 of the rotator: $\rho = \sigma + \sigma \cdot \frac{\alpha_0 - \alpha}{\alpha}$ (4)

Using the charge density shown in Supplementary S1 and Gauss Theorem, the electric field within the dielectric layer for region 2 and 3 can be respectively given as,

$$E_{region\ 2} = -\frac{\sigma}{\varepsilon_0 \varepsilon_r} \cdot \frac{\alpha}{\alpha_0 - \alpha} \quad (5)$$

$$E_{region\ 3} = -\frac{\sigma}{\varepsilon_0 \varepsilon_r} \cdot \frac{\alpha_0 - \alpha}{\alpha} \quad (6)$$

where ε_r is the relative permittivity of dielectric layer.

Then the potential difference between the rotator and electrode A as well as the potential difference between the rotator and electrode B can be respectively calculated as,

$$U_{rotator} - U_A = \frac{d \cdot \sigma}{\varepsilon_0 \varepsilon_r} \cdot \frac{\alpha}{\alpha_0 - \alpha} \quad (7)$$

$$U_{rotator} - U_B = \frac{d \cdot \sigma}{\varepsilon_0 \varepsilon_r} \cdot \frac{\alpha_0 - \alpha}{\alpha} \quad (8)$$

where d is the thickness of the dielectric layer.

Since the rotator made of metal is an equipotential body, the potential difference between the two electrodes (i.e. open-circuit voltage) can be theoretically expressed as

$$V_{oc}(\alpha) = U_A - U_B = \frac{d\cdot\sigma}{\varepsilon_0\varepsilon_r}\cdot\frac{\alpha_0-\alpha}{\alpha} - \frac{d\cdot\sigma}{\varepsilon_0\varepsilon_r}\cdot\frac{\alpha}{\alpha_0-\alpha} \tag{9}$$

which is,

$$V_{oc}(\alpha) = \frac{d\cdot\sigma}{\varepsilon_0\varepsilon_r}\cdot(\frac{\alpha_0-\alpha}{\alpha} - \frac{\alpha}{\alpha_0-\alpha}) \tag{10}$$

However, the above equation S(10) is not applicable when α approaches either o or α_0. When α approaches 0, the V_{oc} obtained by this equation goes to positive infinity. This is because when α has a very small value, the rotator only has a very small overlapped area (region 3 in Supplementary Fig. 1) with electrode B. In this case, the assumption of parallel-plate capacitor does not hold any more. Therefore, deviation occurs. Similarly, when α approaches α_0, the overlapped area between the rotator and electrode A (region 2 in Supplementary Fig. 1) is so small that the basic assumption of parallel-plate capacitor also no longer holds, resulting in negative infinite value of V_{oc} from equation S(10). Therefore, equation S(10) is only used to illustrate the changing trend of the V_{oc} when the rotator spins. In order to calculate the V_o at the initial and final positions, the following derivation based on electrostatics is used.

At region 1 on the left (Supplementary Fig. 2), the net triboelectric charge at the contact interface is σ, while the net triboelectric charge is $-\sigma$ at region 2 on the right. Based on the model of infinitely large plane with uniform charging, the electric potential of electrode A and electrode B with an infinitely far position as a zero-potential reference point can be respectively calculated by

$$U_A = \frac{d\cdot\sigma}{\varepsilon_0\varepsilon_r} \tag{11}$$

$$U_B = -\frac{d\cdot\sigma}{\varepsilon_0\varepsilon_r} \tag{12}$$

Therefore, the V_{oc} at the initial state is

$$V_{oc\,(initial)} = U_A - U_B = \frac{2d\cdot\sigma}{\varepsilon_0\varepsilon_r} \tag{13}$$

Based on the same reasoning, the V_{oc} at the final state is

$$V_{oc\,(final)} = -\frac{2d\cdot\sigma}{\varepsilon_0\varepsilon_r} \tag{14}$$

Consequently, the peak-to-peak value of the V_{oc} is

$$V_{p-p} = \frac{4d\cdot\sigma}{\varepsilon_0\varepsilon_r} \tag{15}$$

Supplementary Note 2│ Theoretical analysis of operating process in short-current condition

Based on the model of volume-changing capacitors, we can assume a voltage (V_{AB})-charge (Q_{AB}) relationship between electrode A and B as follows,

$$V_{AB} = -\frac{1}{C_{AB}} \times Q_{AB} + V_{oc} \tag{16}$$

where C_{AB} is the capacitance between electrode A and B.

C_{AB} can be treated as a series connection of two capacitors, which are the capacitor formed by the rotator and electrode A and the capacitor formed by the rotator and electrode B:

$$C_{AB} = \frac{1}{\frac{1}{C_{Rotator-A}} + \frac{1}{C_{Rotator-B}}} \tag{17}$$

$$C_{Rotator-A} = \frac{\varepsilon_0 \varepsilon_r S(\alpha_0 - \alpha)}{d} \tag{18}$$

$$C_{Rotator-B} = \frac{\varepsilon_0 \varepsilon_r S(\alpha)}{d} \tag{19}$$

where $S(\alpha_0 - \alpha)$ is the overlapped area between the rotator and electrode A, and $S(\alpha)$ is the overlapped area between the rotator and electrode B.

Finally, we can get

$$V_{AB} = -\left[\frac{d \cdot \alpha_0}{\varepsilon_0 \varepsilon_r \cdot \alpha} \cdot \frac{360°}{\alpha_0 - \alpha} \cdot \frac{1}{\pi(r_2^2 - r_1^2)}\right] \times Q_{AB} + \frac{d \cdot \sigma}{\varepsilon_0 \varepsilon_r} \cdot \left(\frac{\alpha}{\alpha_0 - \alpha} - \frac{\alpha_0 - \alpha}{\alpha}\right) \tag{20}$$

where $\gamma_2$is the outer radius of the rotator, and $\gamma_1$is the inner radius of the rotator. In short circuit condition, $V_{AB} = 0$. Therefore, charge transferred between the two electrodes in short circuit condition is,

$$Q_{AB} = \frac{2\alpha - \alpha_0}{360°} \cdot \sigma \cdot \pi(r_2^2 - r_1^2) \tag{21}$$

By submitting $\alpha = 0$ and $\alpha = \alpha_0$ into equation S(20), we can obtain the total charge that transport as the rotator spins from $\alpha = 0$ to $\alpha = \alpha_0$ by the following equation

$$Q = \frac{2\alpha_0}{360°} \cdot \sigma \cdot \pi(r_2^2 - r_1^2) \tag{22}$$