Electronic Supplementary Information

High performance triboelectric nanogenerator for self-powered non-volatile ferroelectric transistor memory

Huajing Fang,[a] Qiang Li,[a] Wenhui He,[a] Jing Li,[a] Qingtang Xue,[b] Chao Xu,[a] Lijing Zhang,[a] Tianling Ren,[b] Guifang Dong,[a] H.L.W. Chan,[c] Jiyan Dai*[c] and Qingfeng Yan*[a]

[a] Department of Chemistry, Tsinghua University, Beijing, 100084, China
[b] Institute of Microelectronics, Tsinghua University, Beijing 100084, China
[c] Department of Applied Physics, The Hong Kong Polytechnic University, Hong Kong, China.
E-mails: jiyan.dai@polyu.edu.hk (J. Y. Dai); yanqf@mail.tsinghua.edu.cn (Q. Yan)

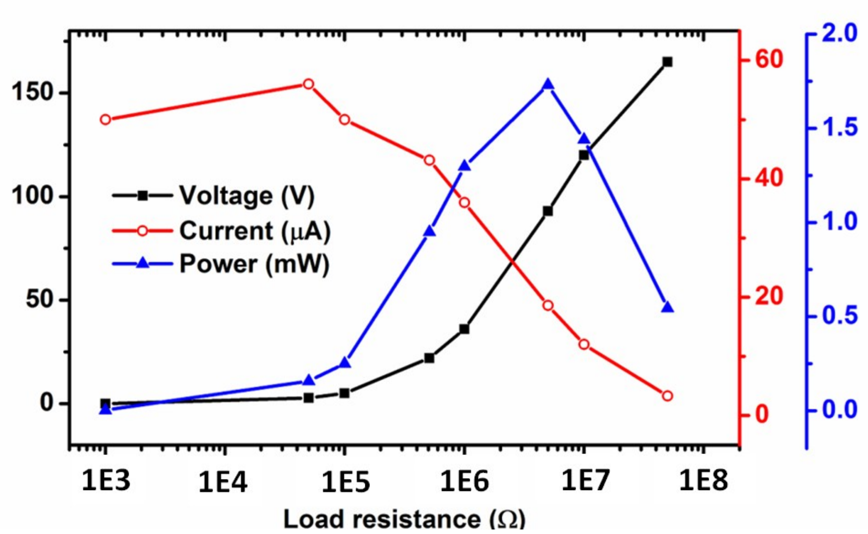

Fig. S1 The current, voltage and power as a function of the load resistance

The output performance of TENG will varies when connecting to the external loads with different resistance. In this regard, we systematically studied the output performance of our arch-shaped TENG on a series of different resistances, from 1 kΩ to 50 MΩ. As depicted in Fig. S1, the current drops with the increase of the external resistance, while the voltage across the load shows a rising tendency. As a consolidated result, the power initially rises at the low resistance region and then declines significantly at the higher resistance region. The maximum instantaneous power value is ~1.8 mW at a resistance of 5 MΩ. The effective area of TENG is 3cm × 3cm, so the output power density is about 2 W/m^2.

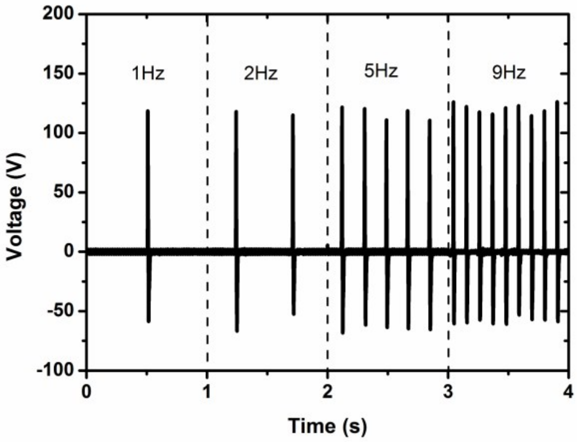

Fig. S2 The output voltage with different tapping frequency

To investigate the relationship between the tapping frequency and the output voltage of the TENG, we carried out a set of systematic measurements by using a vibration exciter to exert a slight tapping force to the TENG with different frequencies. As illustrated in Fig. S2, with the tapping frequency being raised from 1 Hz to 9Hz, the open circuit voltage is almost a constant and kept at about 125V. Clearly, the output voltage is independent of the frequency because the response signal of TENG is a sharp peak which exhibits no hysteresis with the almost constant tapping force.

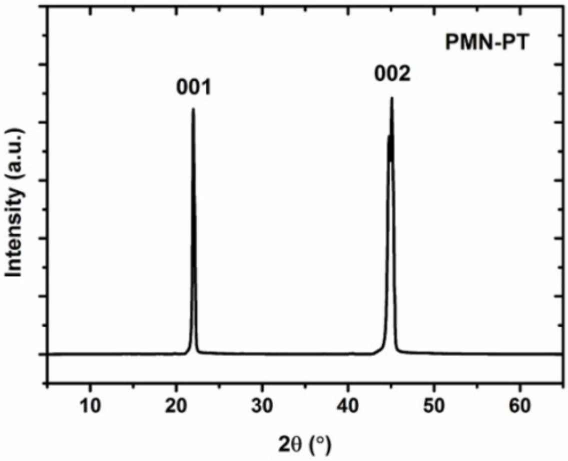

Fig. S3 The XRD pattern of the [001]-oriented PMN-PT single crystal.

Fig. S3 shows the XRD pattern of the [001]-oriented PMN-PT single crystal. The sharp XRD peaks of (001) and (002) make sure that the as-prepared specimen is along [001] direction, indicating that the measurement data of the electric properties after poling by the TENG is credible. Moreover, the (002) reflection splits into two peaks, indicating that the chemical composition of the single crystals is near the morphotropic phase boundary (MPB) as designed.

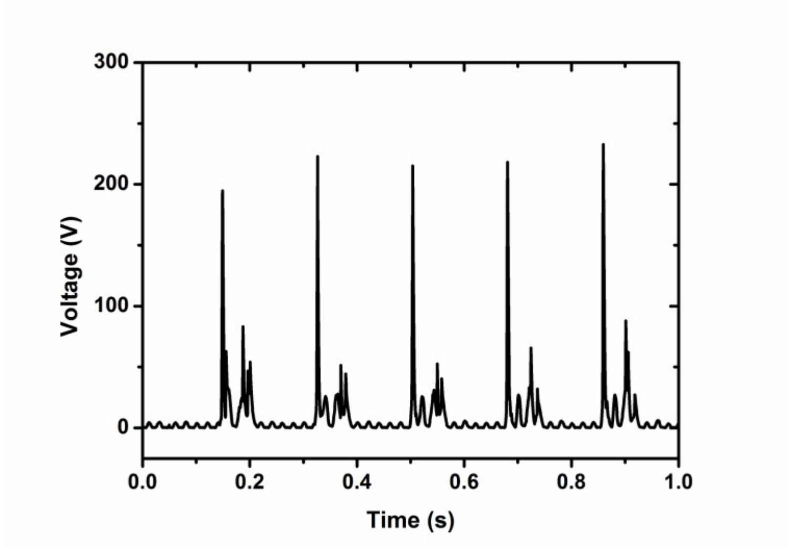

Fig. S4 The rectified output voltage of the TENG utilized for polling the ferroelectric material

As demonstrated in Fig. 4a, a full-wave bridge rectifier was employed to convert the generated alternating current (AC) signals into direct current (DC) pulses, and the rectified DC pulses could directly pole the PMN-PT crystal. Fig. S4 showed the rectified voltage. As seen, the AC signals has been transferred to pulses in the same direction simply by the rectifying bridge.

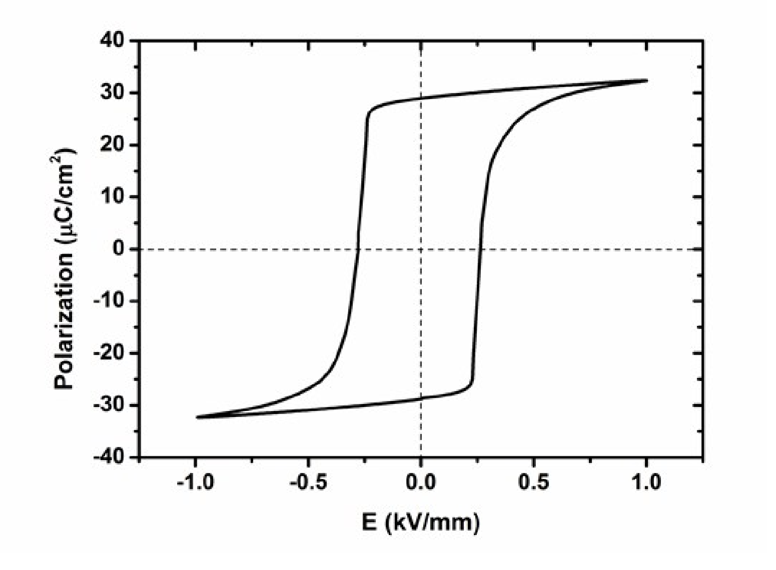

Fig. S5 The P-E loop of the [001]-oriented PMN-PT single crystal.

The P-E hysteresis loop of the PMN-PT single crystal measured at room temperature is shown in Fig. S5. As we can see, the remnant polarization P_r of the PMN-PT slice is 29 μC/cm^2. Such a large P_r enables the operation of our ferroelectric FET memory device. In addition, the coercive field E_c is about 260 V/mm. Therefore, the FET with PMN-PT insulator of 100 um in thickness can be switched by the TENG successfully.