Supporting Information

Self-powered Organolead Halide Perovskite Single Crystal Photodetector Driven by a DVD-based Triboelectric Nanogenerator

Huajing Fang,[a] *Qiang Li,*[a] *Jie Ding,*[a] *Nan Li,*[a] *He Tian,*[b] *Lijing Zhang,*[b] *Tianling Ren,*[b] *Jiyan Dai,*[c] *Liduo Wang,*[a] *and Qingfen 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.

*Correspondence to: yanqf@mail.tsinghua.edu.cn (Q. Yan)

The working principle of the DVD-based TENG can be explained by the coupling between triboelectrification and electrostatic induction. With an applied force, the two friction layers are brought into contact with each other. According to the triboelectric series, electrons are injected from Cu to the polycarbonate (PC) substrate of the DVD, resulting in net negative charges (σ) at the surface of PC. As the force is withdrawn, the contacting surfaces are separated, and an electric potential difference is then established between the Cu and the Al electrodes. Thus, electrons would be transfered from the Al electrode to the Cu electrode to neutralize the positive triboelectric charges. For simplification, the equivalent circuit of the TENG with an external load R is illustrated in Fig. S1(a), in which the TENG can be regarded as a parallel plate capacitor. Based on the electrostatic induction and conservation of charges, we have:[1,2]

$$-\sigma = \sigma_1 + \sigma_2$$

$$\sigma_1 = -\frac{\sigma}{1 + d_1/d_2\varepsilon_{rd}}$$

Where σ, σ_1, and σ_2 is the charge density on the surface of PC layer, Al electrode, and Cu electrode, respectively. d_1 is the thickness of the PC layer, d_2 is the distance between the two plates and ε_{rd} is the relative permittivity of the PC. Because d_1 and ε_{rd} are constant values and the triboelectric charge density σ is stable for a long time,[2] σ_1 is dictated by the gap distance d_2. During a pressing and releasing cycle (see Fig. S1 (b, c)), the variation of d_2 will result in the distribution of charges between Al and Cu electrodes through the external load, which is the experimentally observed electric current.

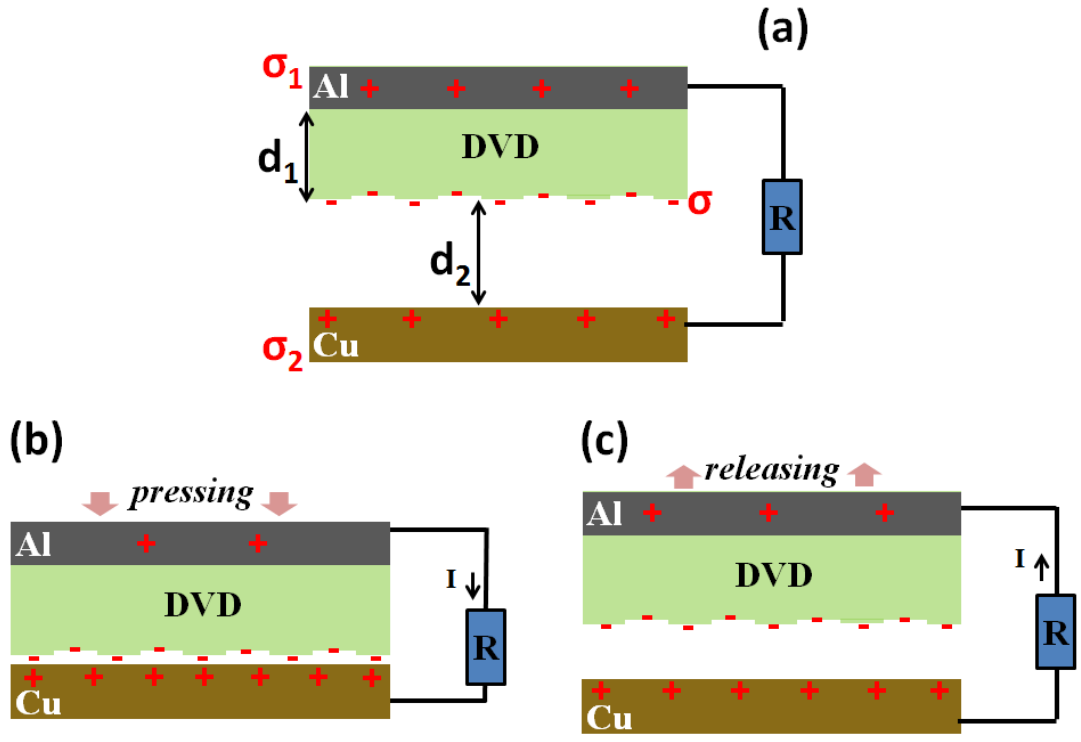

Fig. S1 Working principle of the DVD-based TENG.

Fig. S2 gives a detailed atomic force microscopy (AFM) section analysis of the PC substrate detached from a waste DVD. As we can see, the pits are about 200 nm in depth. The distance between two adjacent pits is about 1.6 μm. Therefore, the PC substrate with periodic nanostructures can work as a friction layer of TENG.

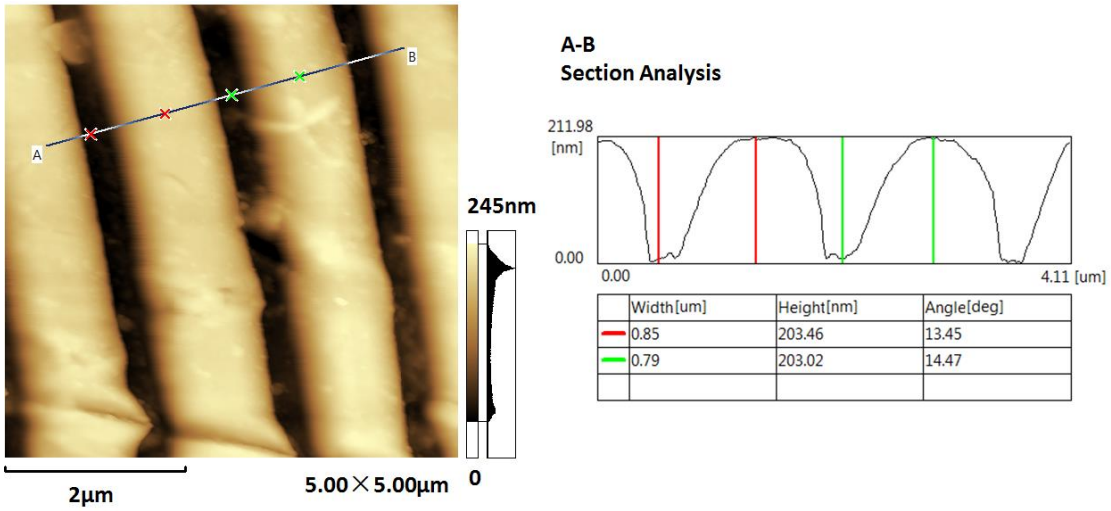

Fig. S2 AFM section analysis of the PC substrate detached from an used DVD.

In the case of reverse connection, the negative output signals were measured. As shown in Fig. S3, the results showed almost the same peak values of the open-circuit voltage and short-circuit current as the ones we got in the forward connection. But the polarities of the signals were reversed. This phenomenon confirms that the electric signals were truly produced by the TENG.

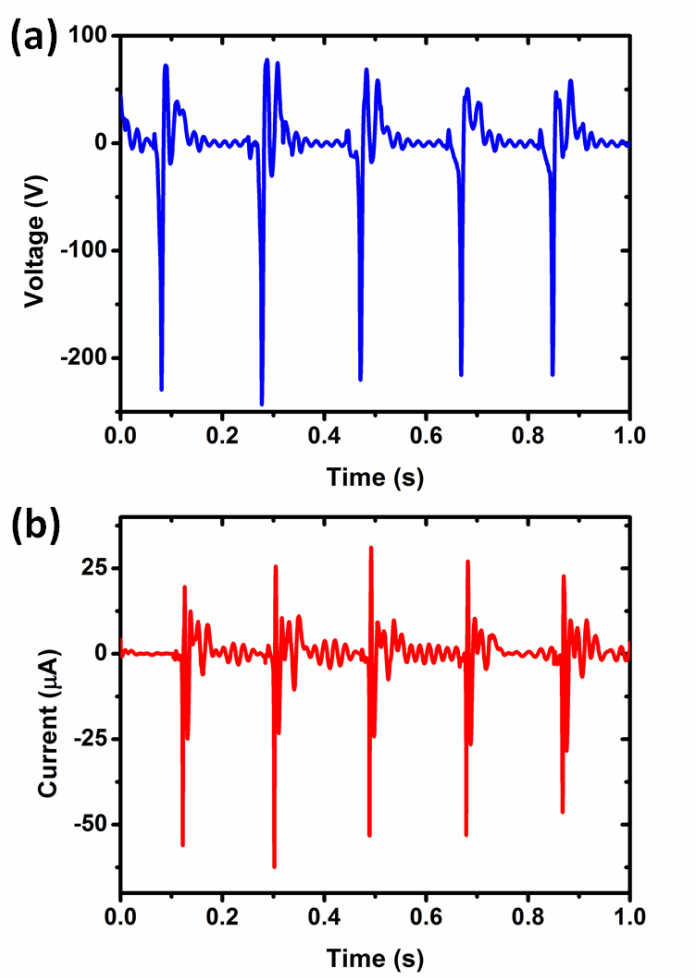

Fig. S3 The measured (a) open-circuit voltage and (b) short-circuit current of the TENG in a reverse connection.

Fig. S4 shows the regulated voltage after applying a commercial Zener diode. All the peak values keep at a constant of ~ 105 V, indicating a perfect voltage regulation. Thus, using this regulated voltage to drive the photodetector is a fundamental solution to fine quantitative study.

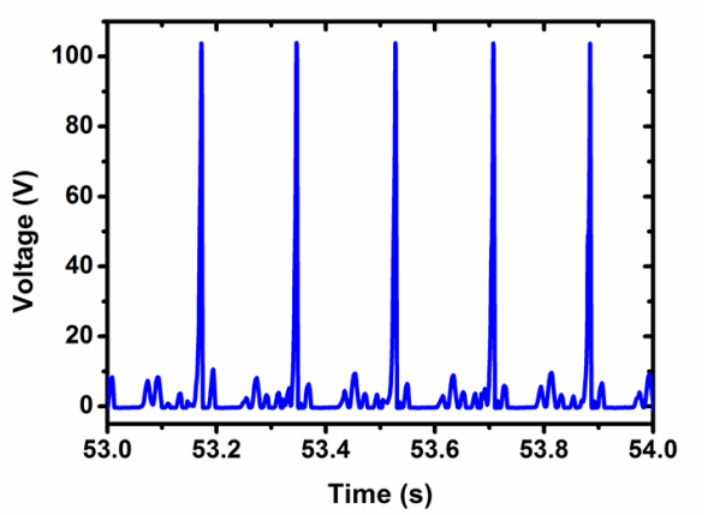

Fig. S4 The measured voltage regulated by a commercial Zener diode.

References

1 Z. H. Lin, G. Zhu, Y. S. Zhou, Y. Yang, P. Bai, J. Chen and Z. L. Wang, *Angew. Chem. Int. Ed.*, 2013, **52**, 5065-5069.

2 J. W. Zhong, Q. Z. Zhong, F. R. Fan, Y. Zhang, S. H. Wang, B. Hu, Z. L. Wang and J. Zhou, *Nano Energy*, 2013**, 2,** 491-497.