Microfiber- Nanowire Hybrid Structure for Energy Scavenging

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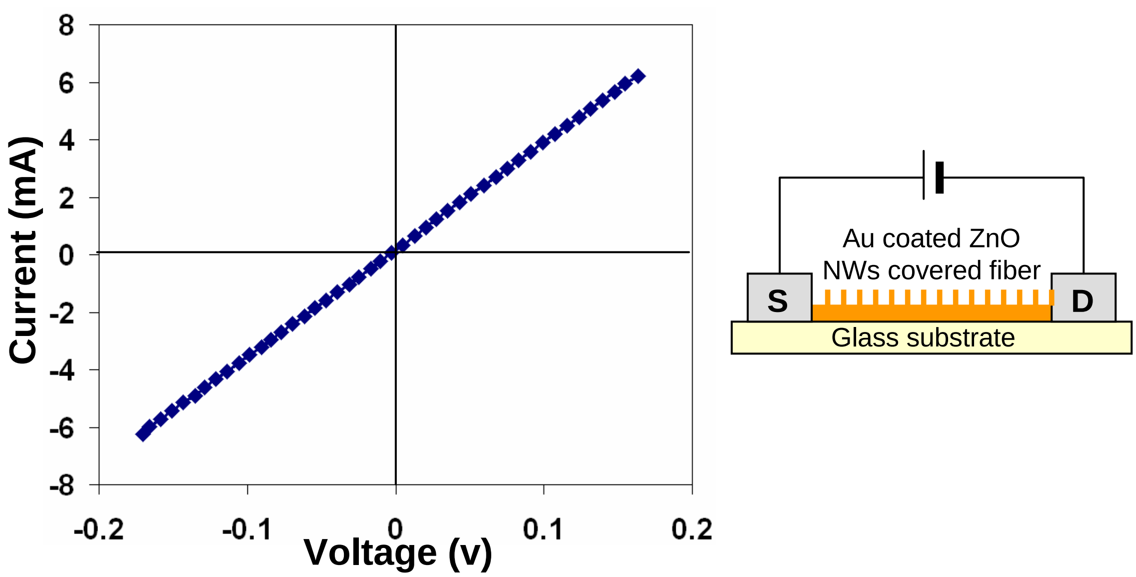


Fig. S1. I-V characteristic of the fiber covered with Au coated NWs that was measured using the circuit as presented at the right-hand side, where silver was used as the electrodes, showing typical Ohmic behavior.

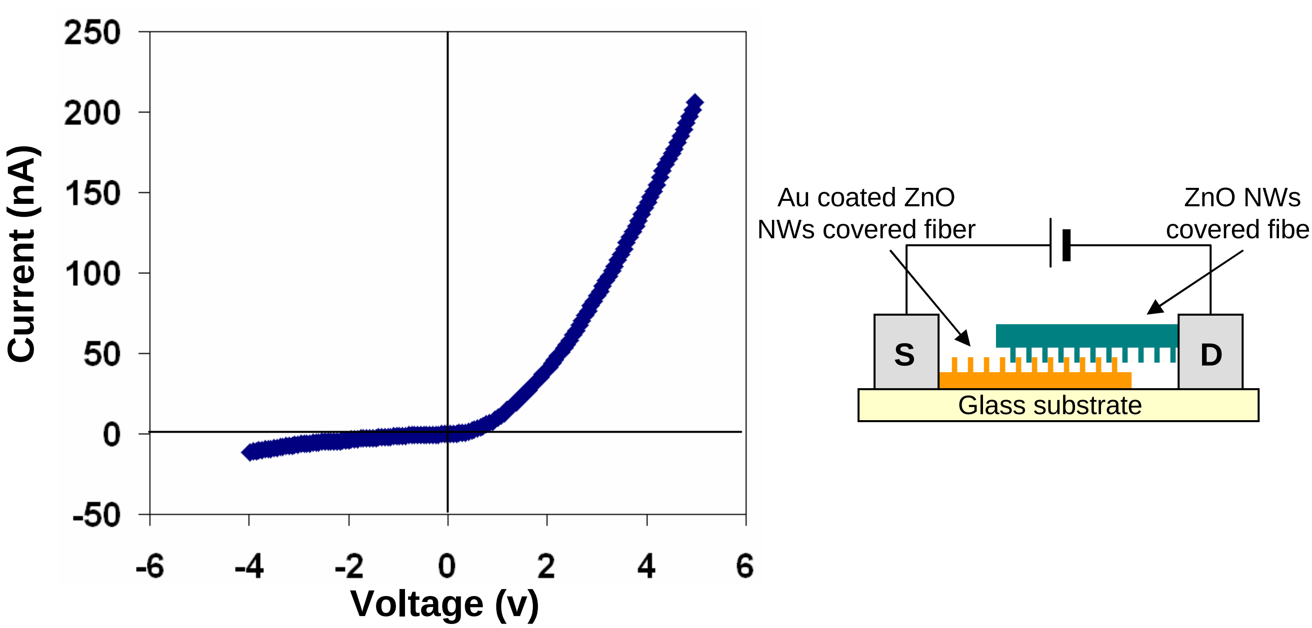
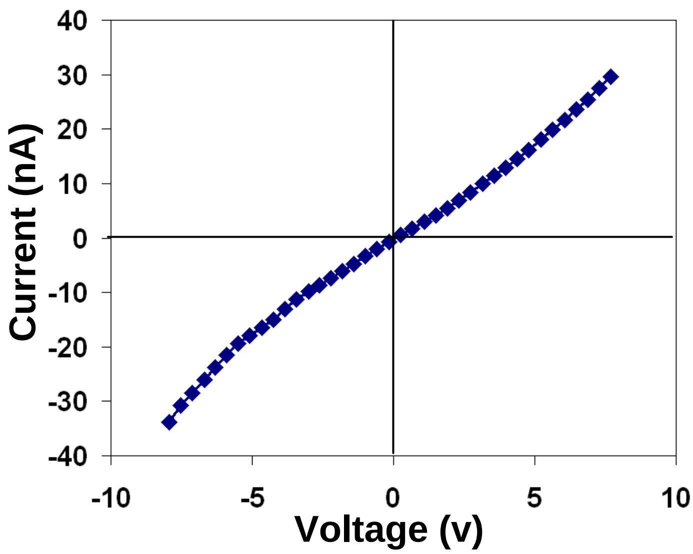


Fig. S2. I-V characteristic of a teeth-to-teeth structure of Au coated ZnO NWs and uncoated ZnO nanowires, which was measured using the circuit as presented at the right-hand side, where silver was used as the electrodes, showing the presence of a Schottky barrier at the teeth interface.



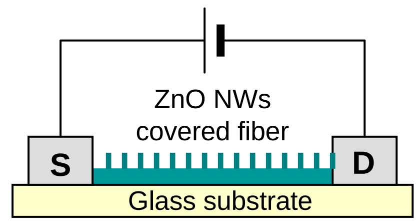


Fig. S3. I-V characteristic of ZnO NW coated fiber measured using the circuit as presented at the right-hand side, where silver was used as the electrodes. The inner resistance of the 4 mm fiber used here is ~ 250 MΩ.

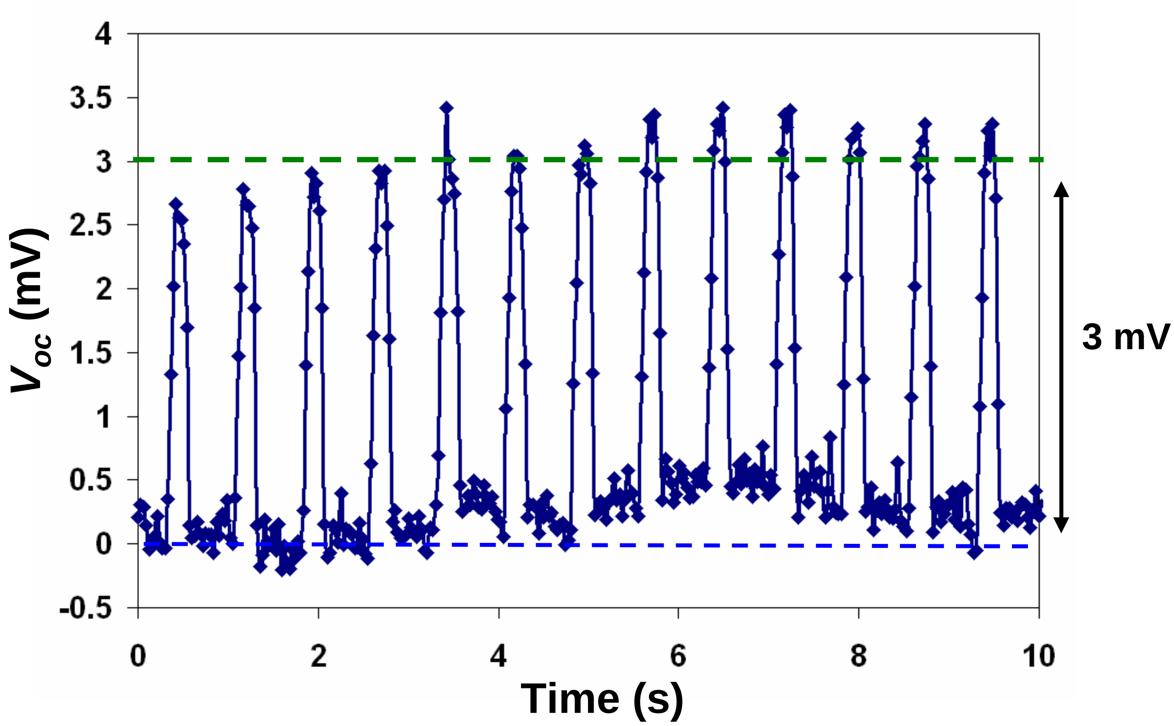


Fig. S4. A fiber nanogenerator with output voltage of 3 mV at 80 rpm frequency. The background introduced by the measurement circuit was removed.

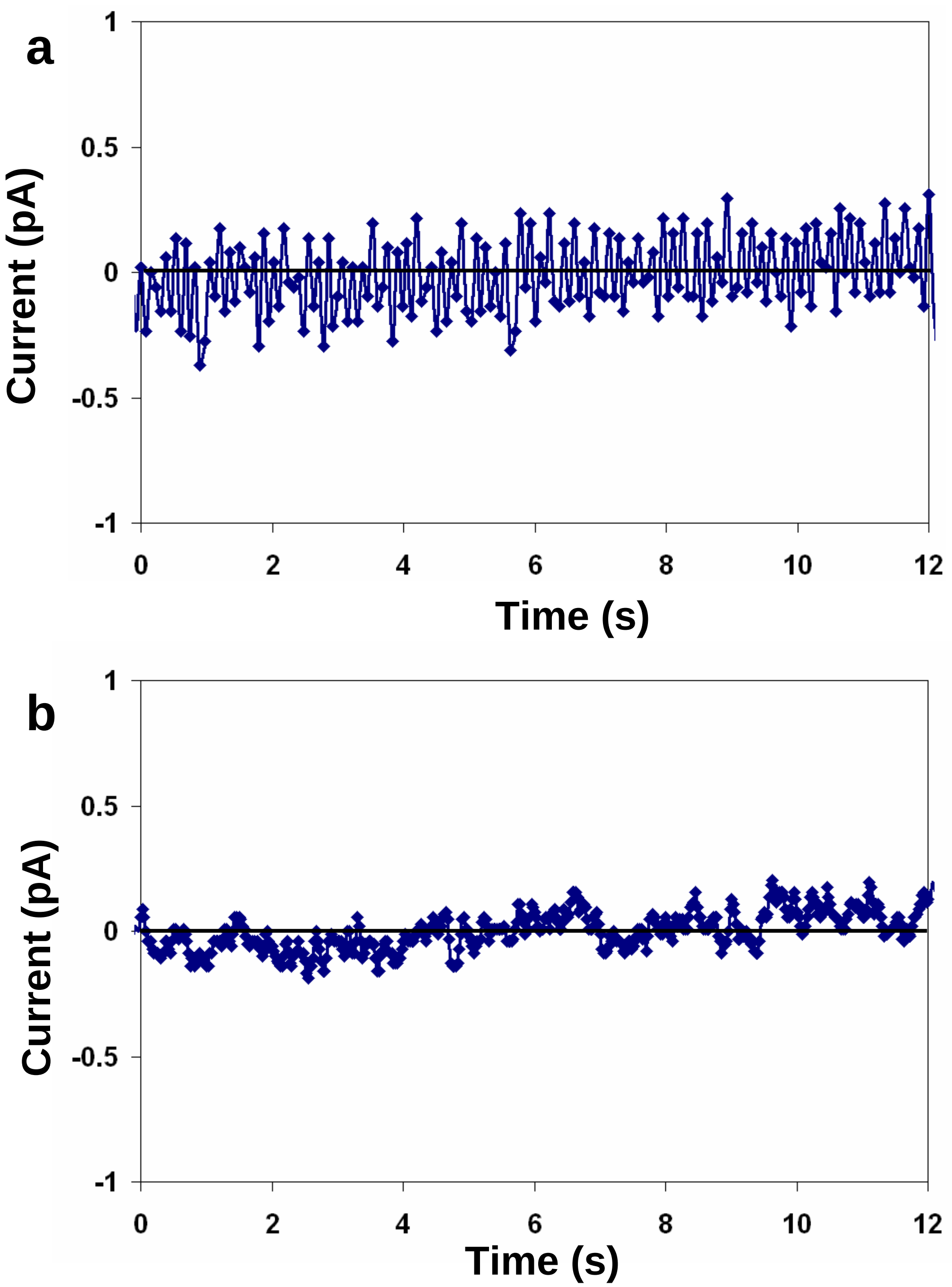


Fig. S5. Current output of a teeth-to-teeth structure made by two identical uncoated ZnO NWs grown on fibers (top) and two identical Au coated fibers (lower), showing no response to the mechanical vibration at a frequency of 80 rpm. Such a structure effectively produce no output current, indicating that friction induced charging is not present in our current experimental set up. The background introduced by the measurement circuit was removed.

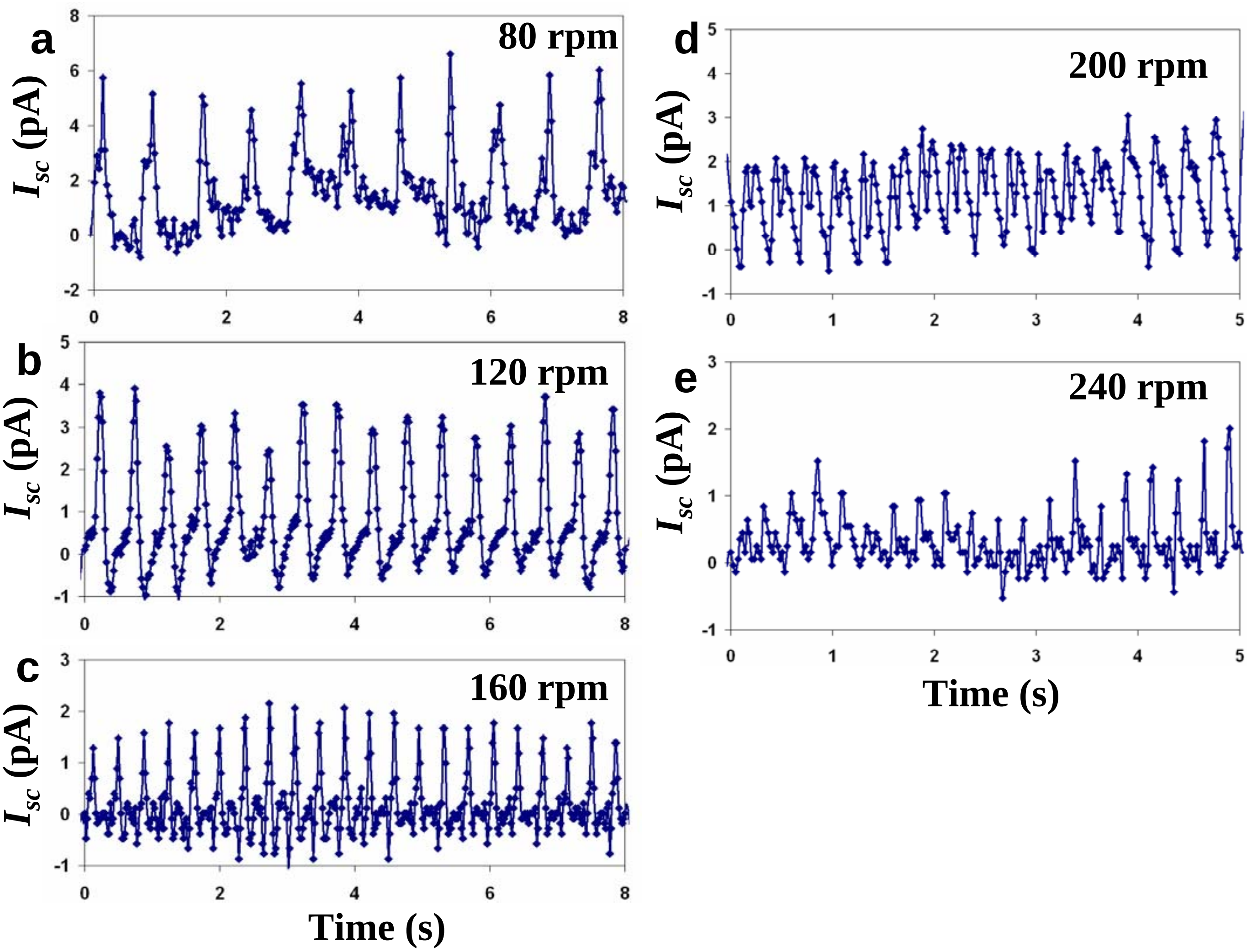


Fig. S6. Current output of a fiber nanogenerator at mechanical vibration frequency of 80 (a), 120 (b), 160 (c), 200 (d) and 240 (e) rpm, respectively. The background introduced by the measurement circuit was removed.

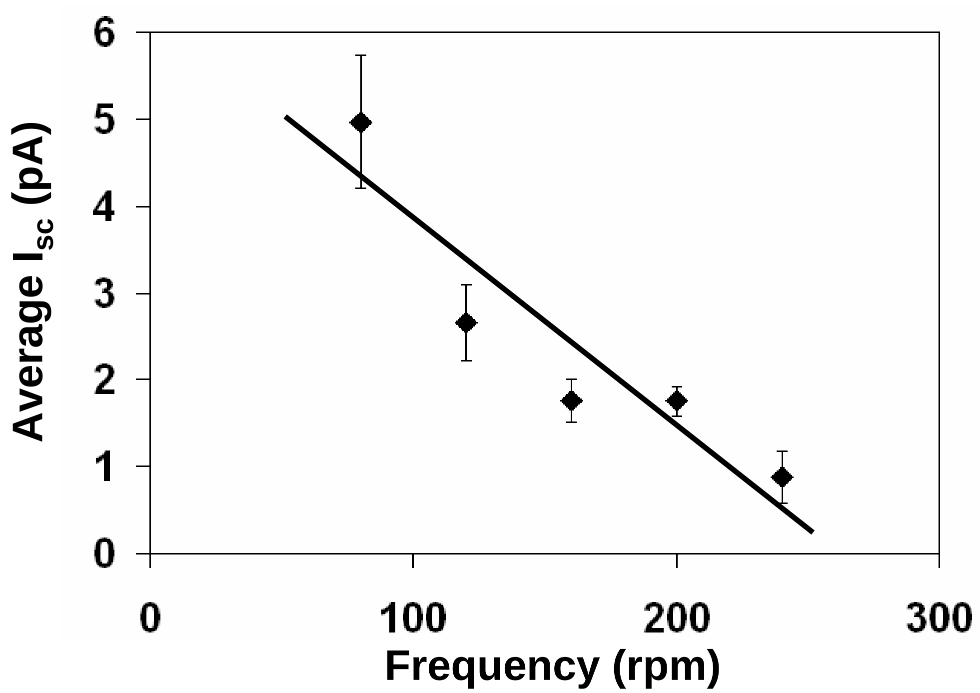


Fig. S7. A plot of the average magnitude of I_{sc} as a function of the driving frequency.

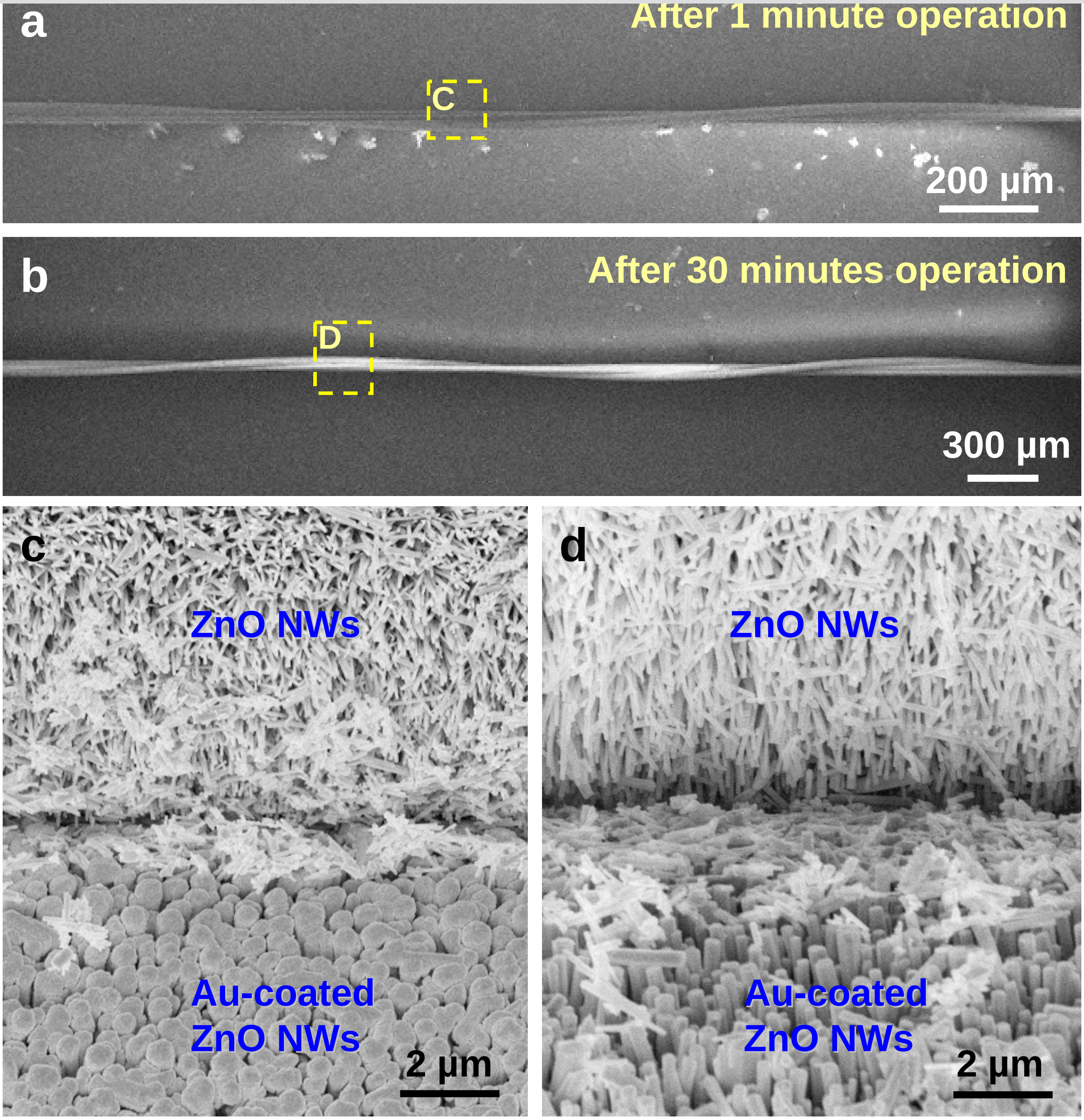
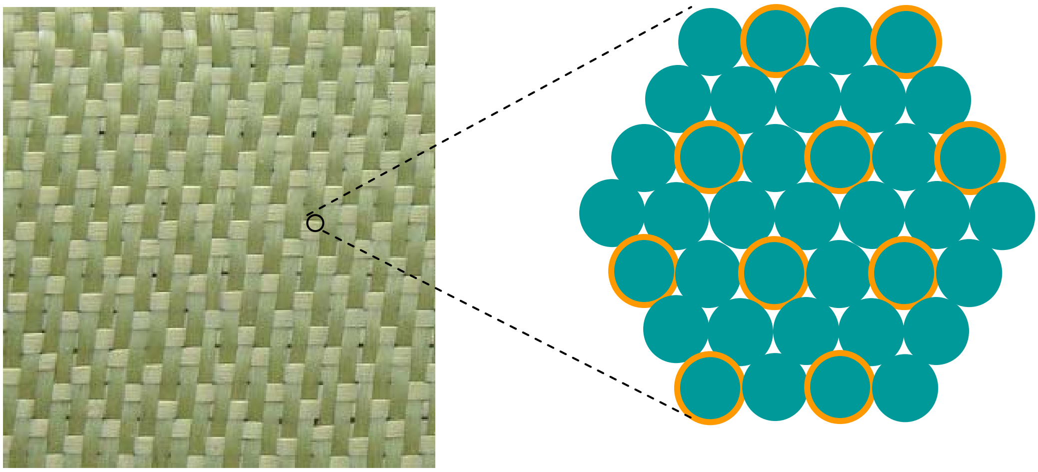


Fig. S8. (a, b) Low magnification and (c,d) high magnification SEM images of two-fiber based nanogenerator after mechanical rubbing/sliding at 80 rpm for 1 and 30 min, respectively, show no significant damage to the nanowires grown on the fiber surface.



Output power density calculation

Case 1: Cylindrical fibers

With an output current of 4 nA using a surface coated fiber, and for an average output voltage of 3 mV with an output pulse width of 0.2 s, the output power P = 4 nA x 3 mV / 0.2 s = 60 pW.

The area of contact between the two adjacent fiber is A = 5 um x 5 mm. Thus, the total output power per unit contact area:

$$p = P / A = 2.4 \times 10^{-3} \text{ W/m}^2$$

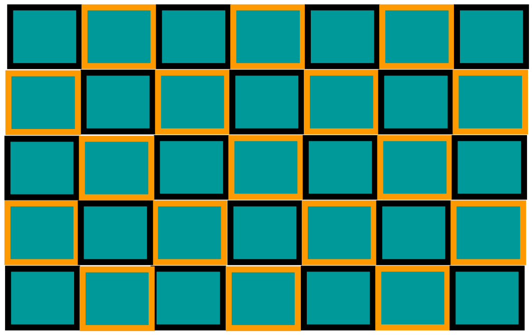
For a typical Kevlar 29 Style 735 Ballistic Fabric: the fiber radius r = 10 um, number of filaments per yarn is 1000, the diameter of the yarn is estimated to be

$$R = (1000)^{1/2} r = 316 \text{ um}$$

The total length of yarn to make 1 square meter fabric is : $1\text{m}^2/2R$ = 1580 m, where a factor of 2 is introduced to consider the double count of the contact area between the fibers. Consider the hexagonal close packing among the fibers (see figure above), if the average contact width between the fiber is ~ r, the total contact area among the fibers for 1 square meter of fabric is:

$$A1 = 1580 \text{ m} \times 1000 \times (r) = 7.9 \text{ m}^2$$

The power generated by such a large contact area is: A1 P = 7.9 * (2.4×10^{-3}) = 19 mW, which is the output power of 1 m^2 fabric.



Case 2: Square fibers

To make an estimation for the maximum power output, we assumed that a square fiber (side length L = 10 um) could be made (see the diagram above). In such a case the contact between the coated and uncoated fibers is 100%. The total contact area among the fibers for 1 square meter of fabric is:

$$A1 \approx 1580 \text{ m} \times 1000 \times (2L) = 31.6 \text{ m}^2$$

The power generated by such a large contact area is: A1 P = 31.6 * (2.4×10^{-3}) = 76 mW per square meter of fabric.