Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

High-performance hybrid carbon nanotube fibers for wearable energy storage

Zan Lu[1, 2, 3], Yunfeng Chao[2], Yu Ge[2], Javad Foroughi*[2, 4], Yong Zhao[2], Caiyun Wang[2], Hairu Long[1, 3], Gordon G. Wallace*[2]

1. College of Textiles, Donghua University, 2999 North Renmin Road, Shanghai, China.
2. Intelligent Polymer Research Institute, ARC Centre of Excellence for Electromaterials Science, University of Wollongong, NSW 2522, Australia.
3. Engineering Research Center of Technical Textile, Ministry of Education, Shanghai, China.
4. Illawarra Health and Medical Research Institute, University of Wollongong, NSW 2522, Australia.

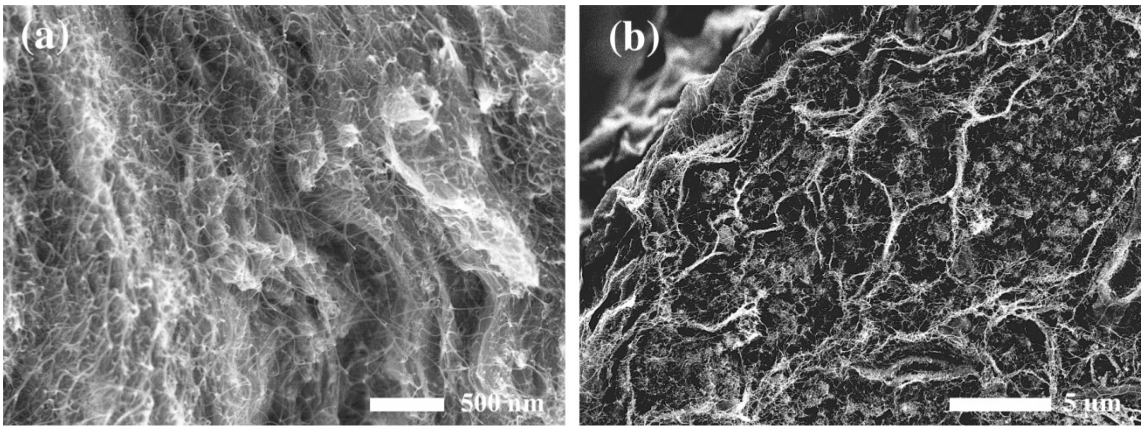

Figure S1. (a) High-resolution SEM images of bulky CNT bundles and (b) pores after freeze dried in the CNT fiber.

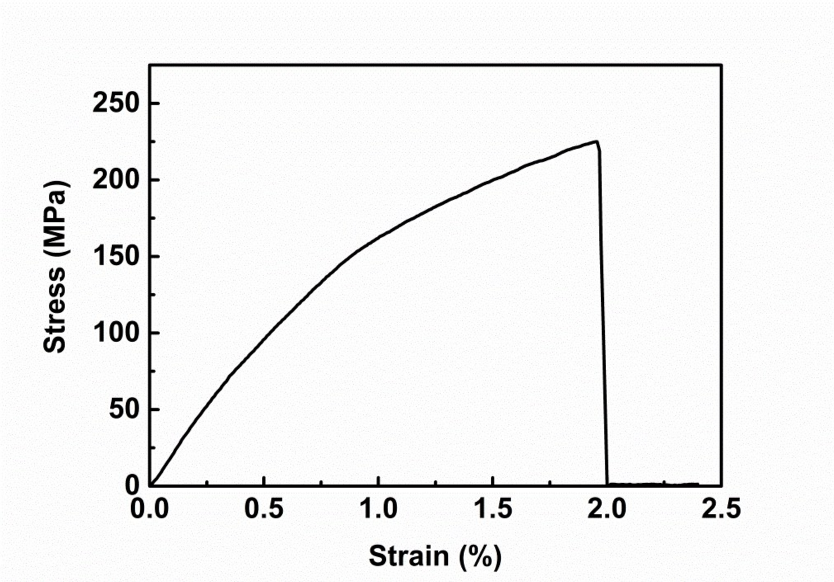

Figure S2. Stress-strain curve of wet-spun CNT fiber.

The mechanical properties of the fibers were measured using a Shimadzu tensile tester (EZ-S) at an extension rate of 2 mm/min. Samples were mounted on laser-cut aperture cards (1 cm length window) with commercial superglue and allowed to air dry.

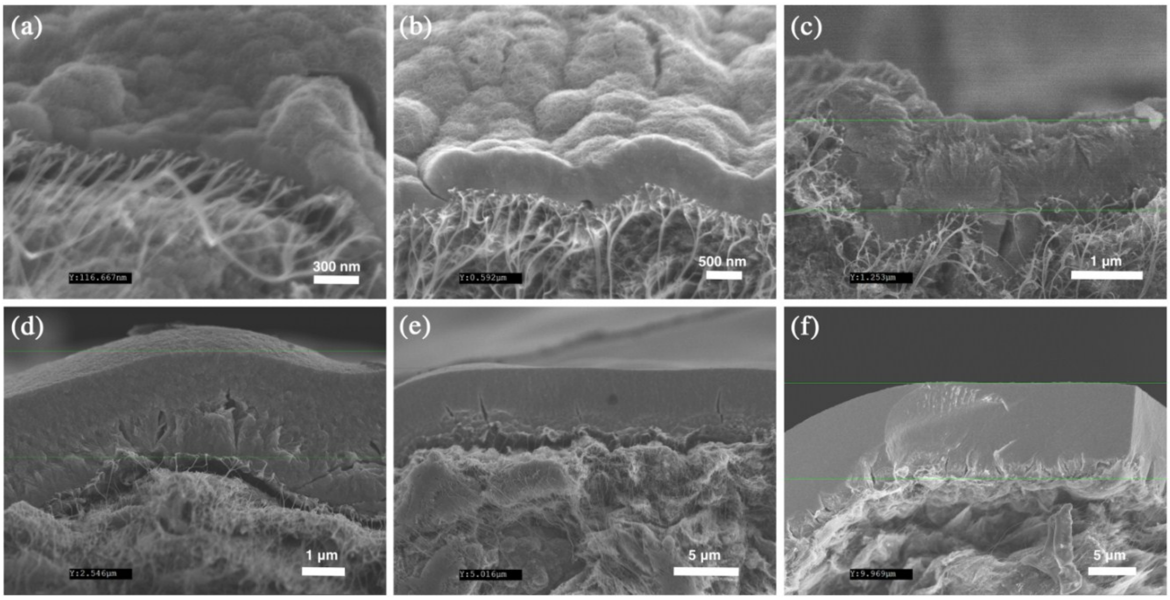

Figure S3. SEM images of thicknesses of MnO_2 layer grown on the CNT fiber with different deposition times: (a) 10 s, (b) 3 min, (c) 5 min, (d) 10 min, (e) 20 min, and (f) 60 min.

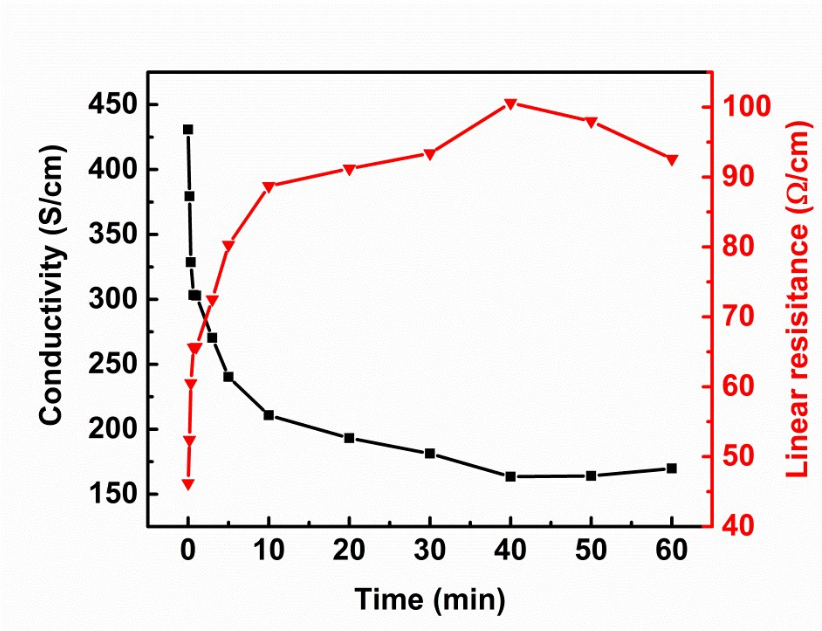

Figure S4. Conductivities of MnO_2-CNT composite fibers with different deposition times ranging from 10 s to 20 min.

The electrical conductivity of the as-prepared CNT and CNT/MnO_2 fibers has been measured under laboratory humidity and temperature conditions by an in-house linear four-point probe cell. A linear four-point probe conductivity cell with uniform 2.54 mm probe spacing was employed to measure the conductivity of the fibers using a galvanostatic current source and a digital multimeter. The conductivity of the fiber was calculated using

$$\sigma = \frac{dI_g}{SV_d}$$

where σ (S/cm) is the electrical conductivity of the measuring fiber, d (cm) is the spacing between working probes and I_g (A) is the galvanostatic current applied by the current source, S (cm^2) is defined as the cross-section area of fiber and V_d (V) is the direct voltage calculated by the digital multimeter.

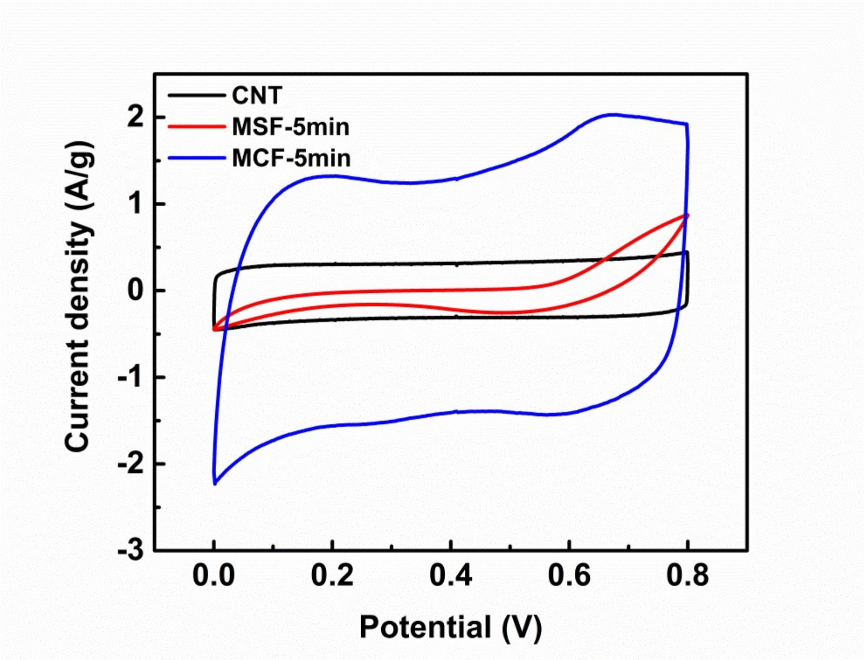

Figure S5. Cyclic voltammograms of a bare CNT fiber, 5 min MnO_2 deposited CNT fiber and stainless steel wire at a specific scan rate of 20 mV/s.

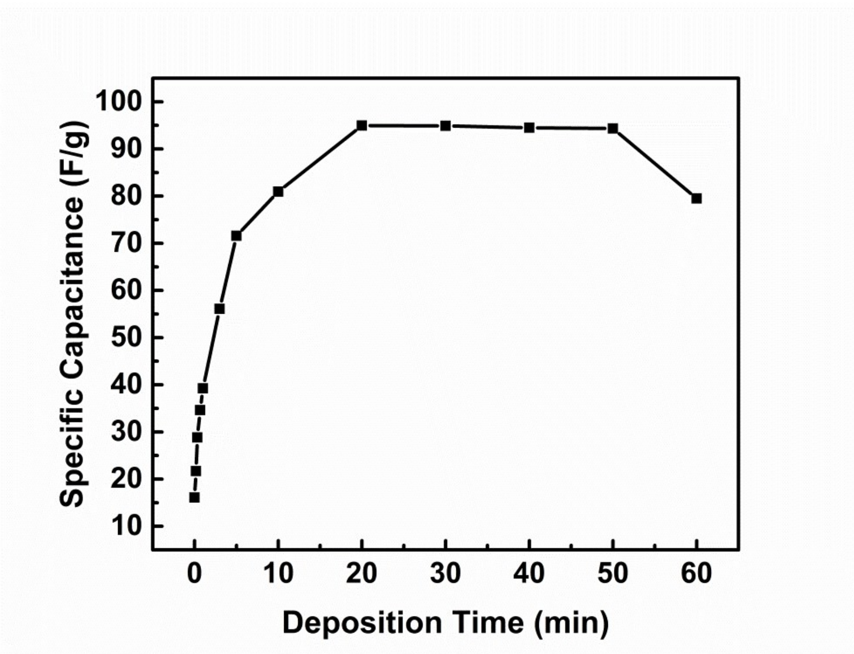

Figure S6. Specific capacitances of MnO_2 deposited CNT fibers with different deposition times ranging from 10 s to 60 min at a scan rate of 20 mV/s.

The specific capacitance of a single electrode in the three-electrode system was calculated by using the CV curves as the following equation:

$$C_m = \frac{Q}{2m\Delta V} = \frac{1}{2vm\Delta V}\int_{V_-}^{V_+} I(V)dV$$

where Q is the total voltammetric charge obtained by integrating the positive and negative sweeps ($I(V)$ is the current) of a CV curve, v is the scan rate, and $\Delta V = (V_+ - V_-)$ represents the scanned potential window used in the three-electrode cell in this study. The specific capacitance of a solid state supercapacitor was calculated from a galvanostatic charge-discharge curves using:

$$C = \frac{2I\Delta t}{m\Delta V}$$

where Δt is the discharge time, I is the current applied on one electrode, m is the mass of one electrode in the symmetric supercapacitor, ΔV is the potential window of the discharging process. The energy density (E) and power density (P) of the device could be calculated by the following equations:

$$E = \frac{1}{2}C\Delta V^2$$

$$P = \frac{E}{t}$$

where C is the specific capacitance of the device, ΔV is the potential window, t is the discharge time.

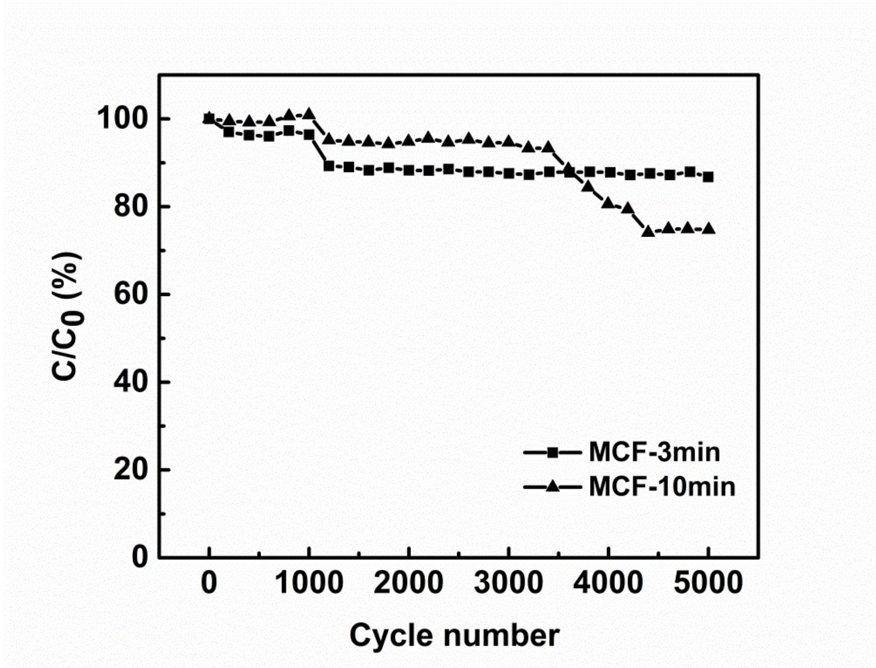

Figure S7. Cyclic retentions of MnO_2 deposited CNT fiber-based supercapacitors with a deposition time of 3 min and 10 min.

In order to prevent the absorption of moisture in the room, the PVA-LiCl covered supercapacitor was sealed with parafilm when the cyclic retention experiment was taking place.

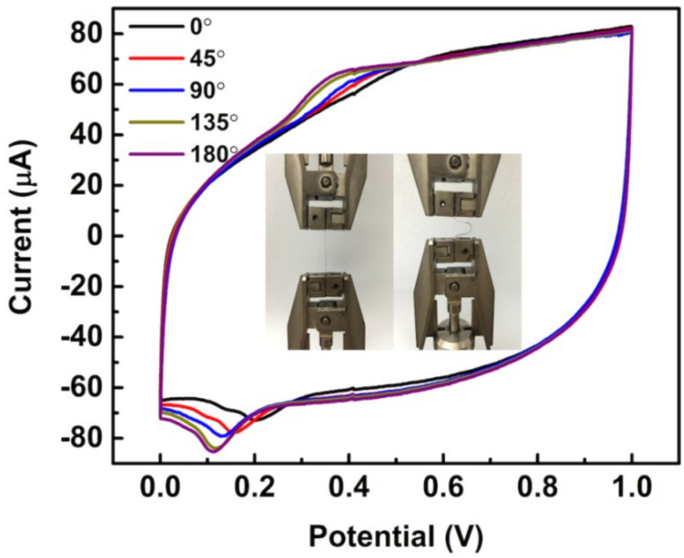

Figure S8. Cyclic voltammograms of the supercapacitor with different bending angles from 0° to 180° at a scan rate of 50 mV/s.