Supporting Information for

Graphene-based single fiber supercapacitor with a coaxial structure

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1 Instruments and methods

CV, GCD and EIS measurements were performed using an electrochemical workstation (CHI660e, CH Instruments, Inc.). SEM observations were performed on Hitachi S3000N. POM observations were performed with a Nikon E600POL. XRD tests were performed on were collected with a D/MAX-MB diffractometer using monochromatic Cu Kα1 radiation (λ= 1.5406 Å) at 40 kV. SAXS data were taken in the Shanghai Synchrotron Radiation Facility, using a fixed wavelength of 0.124 nm, a sample-to-detector distance of 5 m and an exposure time of 300 s.

Preparation of PVA gel electrolyte: PVA (1g, Mw 89000-98000, CAS 9002-89-5, sigma-aldrich) dissolved in 10 g 1M H_2SO_4 at 90 ℃.

Prepartion of $EMIMBF_4$ gel electrolyte: EMIMBF4 (2.5 g) and poly(vinylidene fluoride-co-hexafluoropropylene) (1g, Mw ~ 400,0000) were dissolved in 7 mL DMF at 90 ℃.

2 Calculations

Areal, length, mass and volume capacitance (C), power (P), energy (E) are denoted as C_A, C_L, C_m and C_V， P_A, P_L, P_m and P_V, E_A, E_L, E_m and E_V. A, L, m, V are the surface area, length, mass and volume of AGF. The masses of AGF and SGF in GCS are controlled the same.

$$C_A = C / A \qquad P_A = P / A \qquad E_A = E / A$$

$$C_L = C / L \qquad P_L = P / L \qquad E_L = E / L$$

$$C_m = 2C / m \qquad P_m = 2P / m \qquad E_m = 2E / m$$

$$C_V = 2C / V \qquad P_V = 2P / V \qquad E_V = 2E / V$$

The C_m, P_m, E_m and C_v, P_v and E_v are in terms of single electrode. C_A and C_L, P_A and P_L, E_A and E_L are in terms of the total coaxial fiber capacitor.

From CV test

$$C = \frac{1}{2v} \times \oint I \mathrm{d}U / \Delta U$$

$$P = \frac{1}{4} \times \oint I dU$$

$$E = \frac{1}{2v} \times \oint IUdU$$

Where I is the instantaneous current, ΔU is the difference of high voltage limit and low voltage limit, v is the scan rate.[1, 2]

From GCD test,

$$C = \Delta t_{discharge} I / (\Delta U - U_{drop})$$

$$P = I \int U \mathrm{d}t / \Delta t_{discharge}$$

$$E = I \int U \mathrm{d}t$$

Where I is the discharge current, U is the instantaneous voltage, Δ U is the potential window, U_{drop} is the voltage drop in discharge curve.

3 Tables

Table S1. Summary of electrochemical performances of GCS obtained from the CV tests.

Scan rate (mV/s)	C_A (mF/cm^2)	C_L (mF/cm)	C_V (F/cm^3)	C_m (F/g)	P_A (μW/cm^2)	E_A (μWh/cm^2)	P_V (mW/cm^3)	E_V (mWh/cm^3)	P_m (W/kg)	E_m (Wh/kg)
10	204.8	4.63	227.1	181.7	819	17.5	909	19.4	727	15.5
20	179.9	4.07	199.5	159.6	1439	15.4	1596	17.1	1277	13.7
50	141.4	3.20	156.9	125.5	2829	12.3	3137	13.7	2510	10.9
80	118.3	2.68	131.2	105.0	3786	10.4	4199	11.5	3359	9.2
100	106.5	2.41	118.1	94.5	4260	9.4	4725	10.4	3780	8.3
150	85.4	1.93	94.7	75.8	5124	7.6	5683	8.4	4547	6.7
200	71.3	1.61	79.1	63.3	5704	6.3	6326	7.0	5061	5.6

Table S2. Summary of electrochemical performances of GCS obtained from the GCD tests.

Current density (A/g)	Current density (mA/cm^2)	C_A (mF/cm^2)	C_L (mF/cm)	C_V (F/cm^3)	C_m (F/g)	P_A ($\mu W/cm^2$)	E_A ($\mu Wh/cm^2$)	P_V (mW/cm^3)	E_V (mWh/cm^3)	P_m (W/kg)	E_m (Wh/kg)
0.49	1.10	208.4	4.7	231.1	184.9	346.0	14.4	384	16.0	307	12.8
0.61	1.38	208.7	4.7	231.4	185.1	433.2	14.4	480	16.0	384	12.8
1.23	2.76	194.1	4.4	215.2	172.2	857.6	13.1	951	14.6	761	11.6
2.45	5.52	171.0	3.9	189.6	151.7	1639.8	10.7	1819	11.9	1455	9.5
3.68	8.29	149.8	3.4	166.1	132.9	2343.7	9.0	2599	9.9	2079	8.0
5.25	11.83	131.5	3.0	145.8	116.6	3137.7	7.2	3480	8.0	2784	6.4
6.13	13.81	122.9	2.8	136.3	109.0	3506.1	6.4	3889	7.1	3111	5.7

Table S3. Summary of electrochemical performances of organic GCS obtained from the CV tests.

Scan rate (mV/s)	C_A (mF/cm^2)	C_L (mF/cm)	C_V (F/cm^3)	C_m (F/g)	P_A (μW/cm^2)	E_A (μWh/cm^2)	P_V (mW/cm^3)	E_V (mWh/cm^3)	P_m (W/kg)	E_m (Wh/kg)
10	130.8	5.63	76.3	55.7	1570	104	917	61.1	669	44.6
20	97.8	4.20	57.1	41.7	2347	77.4	1371	45.2	1000	33.0
50	51.0	2.19	29.8	21.7	3062	40.4	1788	23.6	1305	17.2
100	28.6	1.23	16.7	12.2	3440	22.6	2009	13.2	1467	9.66
200	17.3	0.745	10.1	7.38	4159	13.5	2429	7.90	1773	5.76

Table S4. Comparison of ESR for GCS and several previously reported fiber supercapacitors.

	ESR	**Reference**
This work	207-250 ohm	
Asymmetric graphene fiber supercapacitor	10000 ohm	J. Mater. Chem. A, 2014, 2, 9736–9743
graphene fiber supercapacitor	870 ohm	Nature Commun. 2013, 5, 3754
All-carbon yarn micro-supercapacitor	163-944 ohm	Adv. Mater. 2014, 26, 4100–4106
Coaxial CNT fiber supercapacitor	~1000 ohm	Adv. Mater. 2013, 25, 6436–6441

4 Figures

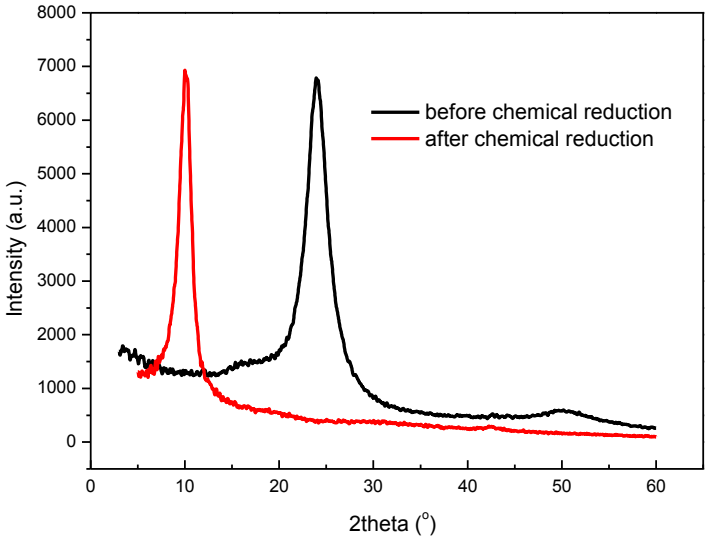

Figure S1. XRD curves for GO fiber and chemically reduced GO fiber (AGF). The d-space changed from 0.8 nm to 0.33 nm after reduction.

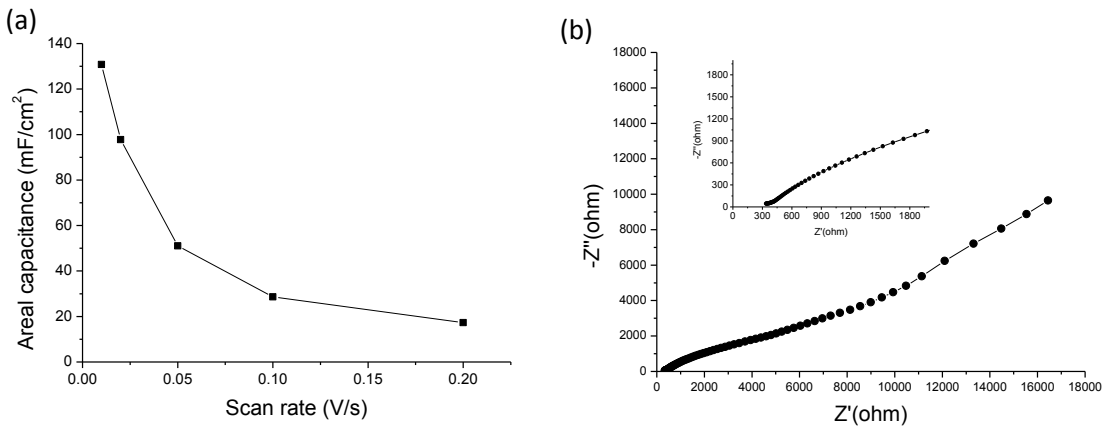

Figure S2. Rate performance (a) and Nyquist plot (b) of organic GCS.

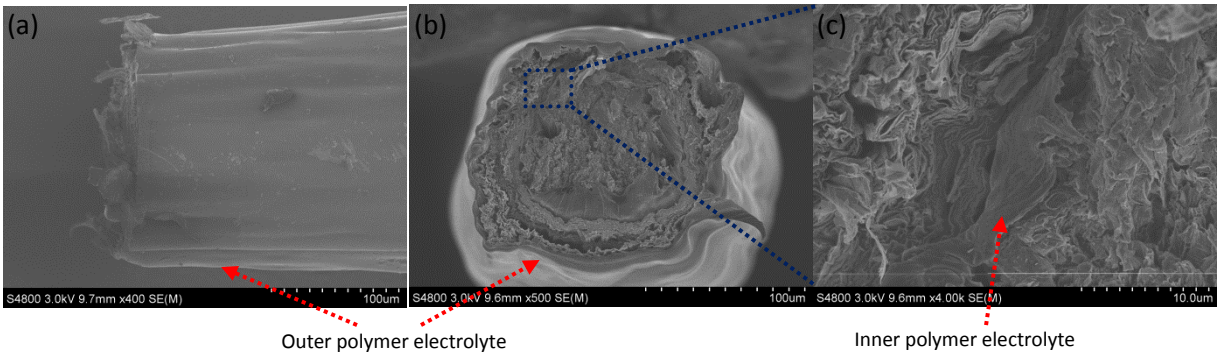

Figure S3. SEM of GCS with outside layer of polymer electrolyte. (a) side view. (b,c) cross section.

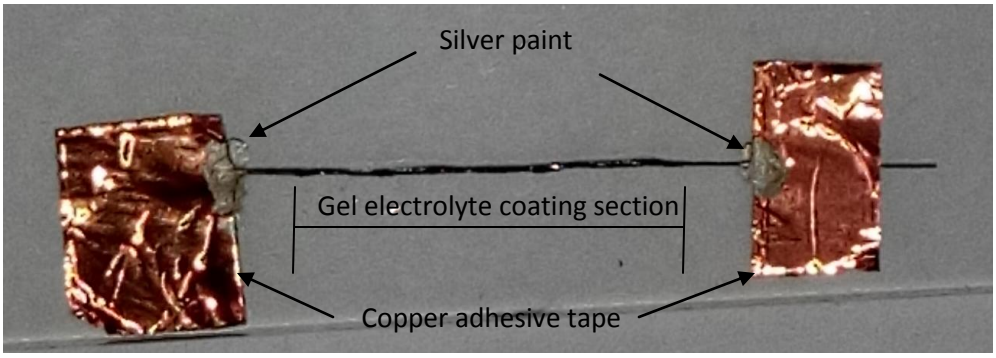

Figure S4. Photo of GCS sample for electrochemical measurement.

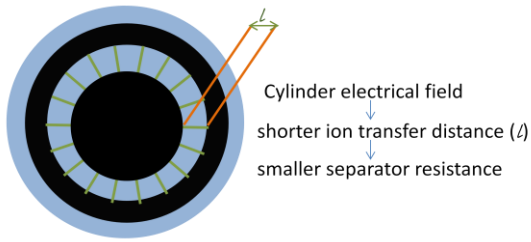

Figure S5. Scheme of the cross section of GCS. The ion transfer distance in the separation layer is marked as *l*. The axis fiber and tubular fiber in a supercapacitor can form a cylinder electrical field, which leads to shorter ion transfer distance, and then smaller separator resistance in the performance of a real supercapacitor.

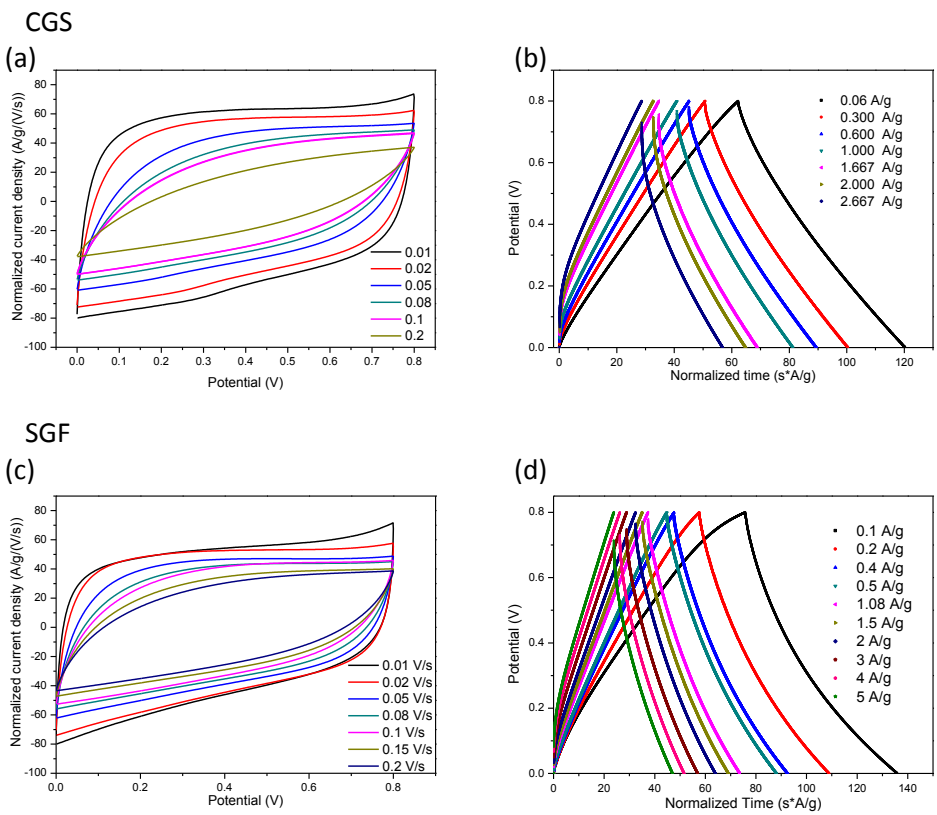

Figure S6. Electrochemical properties of AGF (a,b) and SGF (c,d).

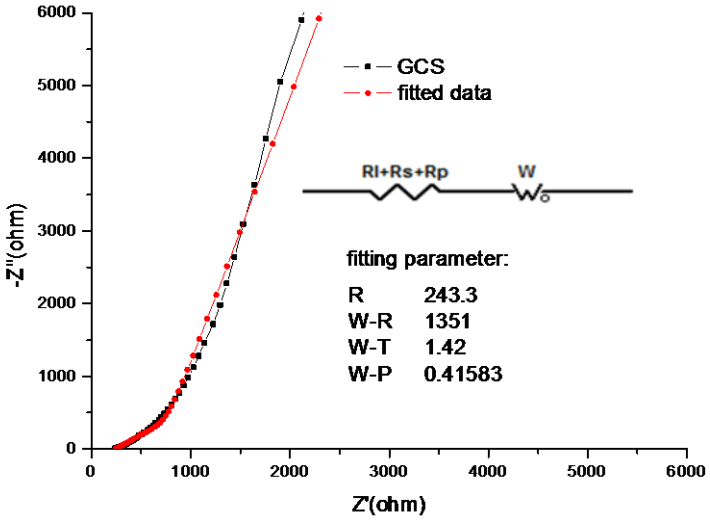

Figure S7. Fitted data for Nyquist for GCS. The insect is the equivalent circuit of GCS.

1. P. Yang and W. Mai, *Nano Energy*, 2014, **8**, 274-290.

2. V. T. Le, H. Kim, A. Ghosh, J. Kim, J. Chang, Q. A. Vu, D. T. Pham, J.-H. Lee, S.-W. Kim and Y. H. Lee, *ACS Nano*, 2013, **7**, 5940-5947.