Electronic Supplementary Information

Asymmetric supercapacitors based on nano-architectured NiO/graphene foam and hierarchical porous nitrogen-doped carbon nanotubes with ultrahigh-rate performance

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Calculations of specific capacitance, energy density and power density based on the galvanostatic charge–discharge curves:

(1) In three electrode configuration, specific capacitances derived from galvanostatic tests can be calculated from the equation:

$$C = I\Delta t/m\Delta V \qquad (1)$$

where *I* is the discharging current, *t* is the discharge time, *ΔV* is the potential drop during discharge, and *m* is the mass of active material in the working electrode.

(2) In two electrode **symmetric** cell configuration, specific capacitances derived from galvanostatic tests can be calculated from the equation:

$$C = 2(I\Delta t/m\Delta V) \qquad (2)$$

where *I* is the constant discharge current, Δ*t* is the discharging time, *m* is the mass of **one electrode**, and *ΔV* is the voltage drop upon discharging.

Energy density (E) and power density (P) derived from galvanostatic tests can be calculated from the following equations:

$$E = [C\,(\Delta V)^2]/8 \qquad (3)$$

$$P = E/\Delta t \qquad (4)$$

where *E*, *C*, *ΔV*, *P* and *Δt* are the specific energy, specific capacitance, potential window, specific power and discharge time, respectively.

(3) In two electrode **asymmetric** cell configuration, specific capacitances derived from galvanostatic tests can be calculated from the equation:

$$C = I\Delta t/m\Delta V \qquad (5)$$

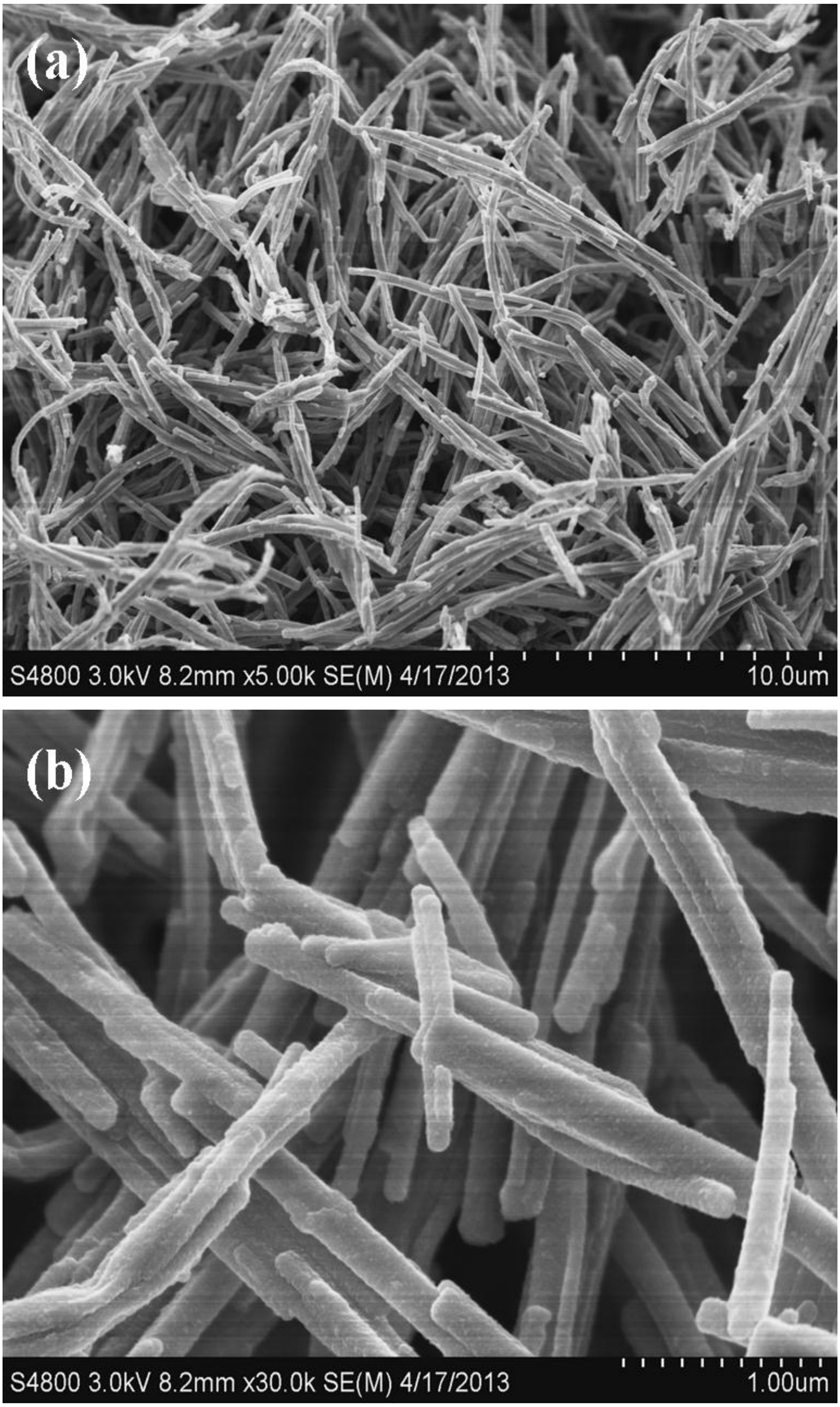
where I is the discharging current, t is the discharge time, ΔV is the potential drop during discharge, and m is the **total mass** of the active electrode materials in the positive and negative electrode.

Energy density (E) and power density (P) derived from galvanostatic tests can be calculated from the following equations:

$$E = [C\,(\Delta V)^2]/2 \qquad (6)$$

$$P = E/\Delta t \qquad (7)$$

where E, C, ΔV, P and Δt are the specific energy, specific capacitance, potential window, specific power and discharge time, respectively.


(a)
S4800 3.0kV 8.2mm x5.00k SE(M) 4/17/2013
10.0um
(b)
S4800 3.0kV 8.2mm x30.0k SE(M) 4/17/2013
1.00um

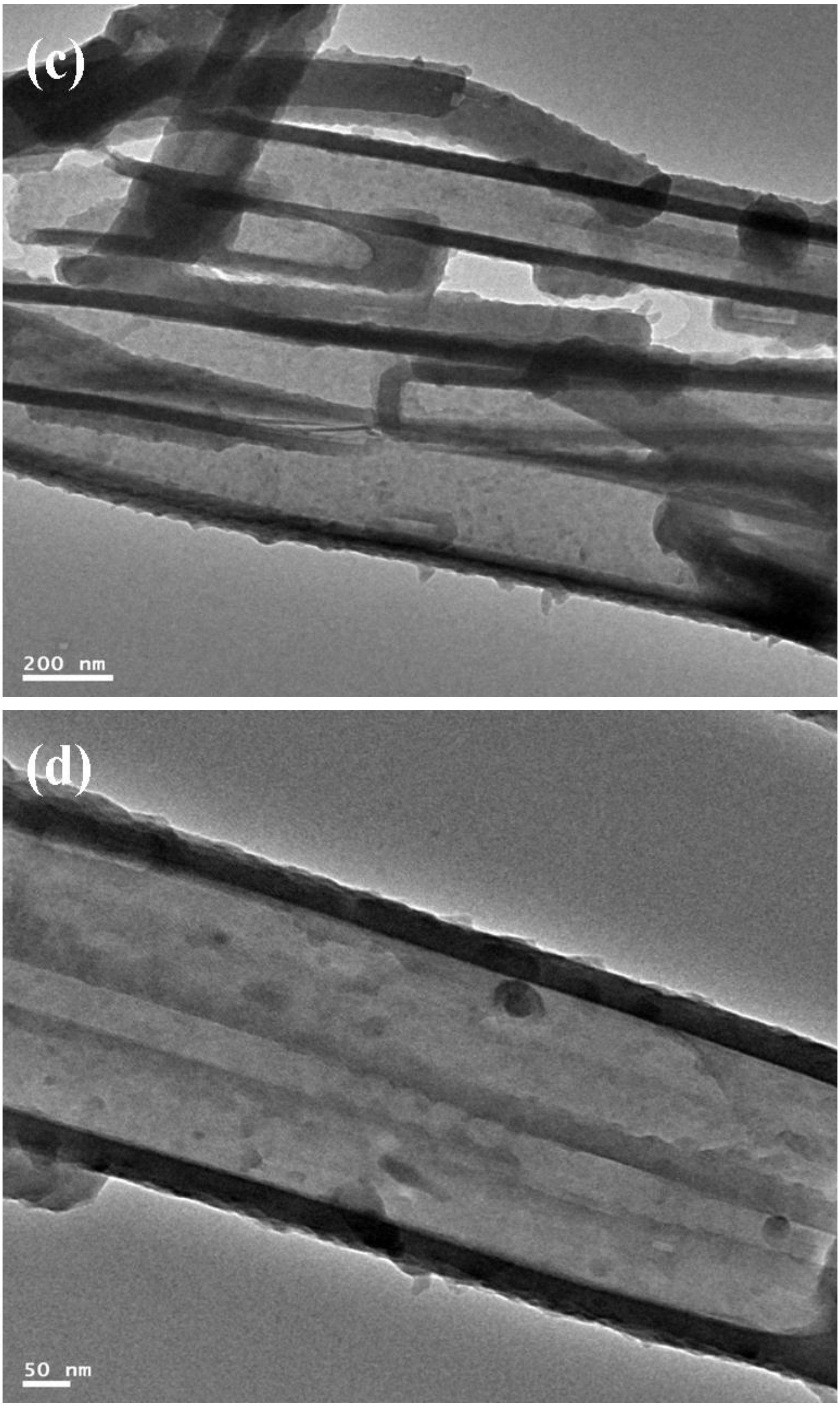
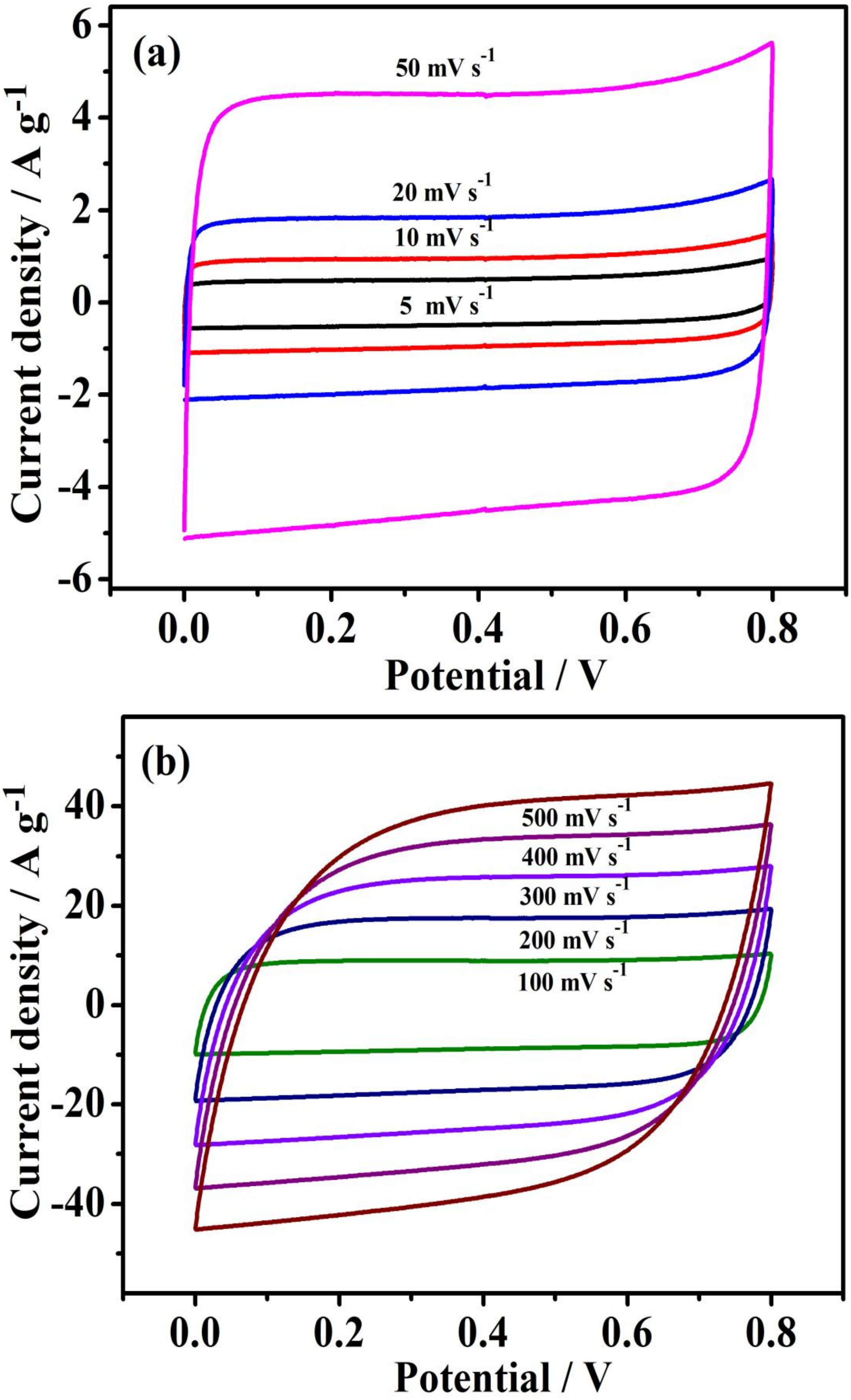
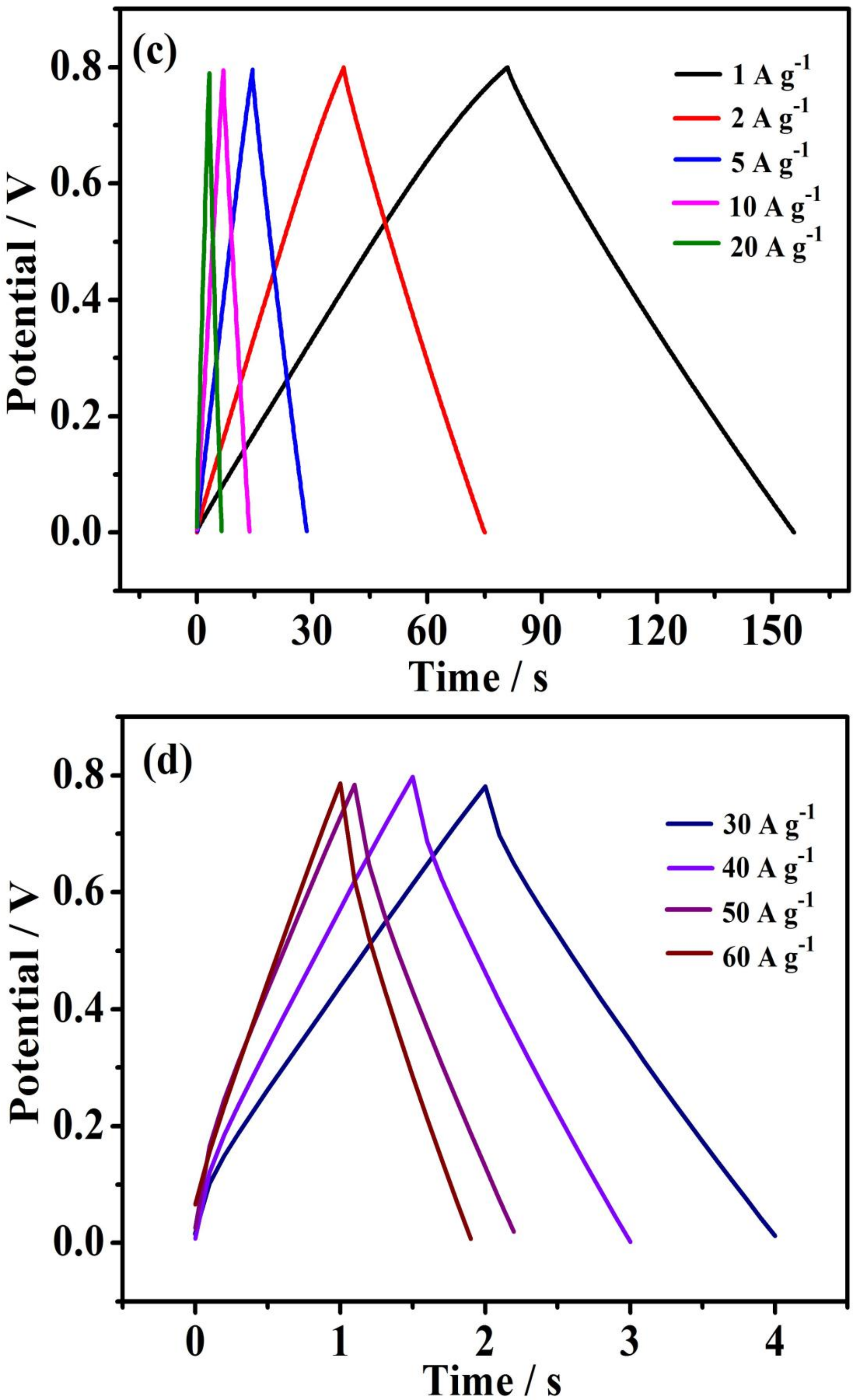
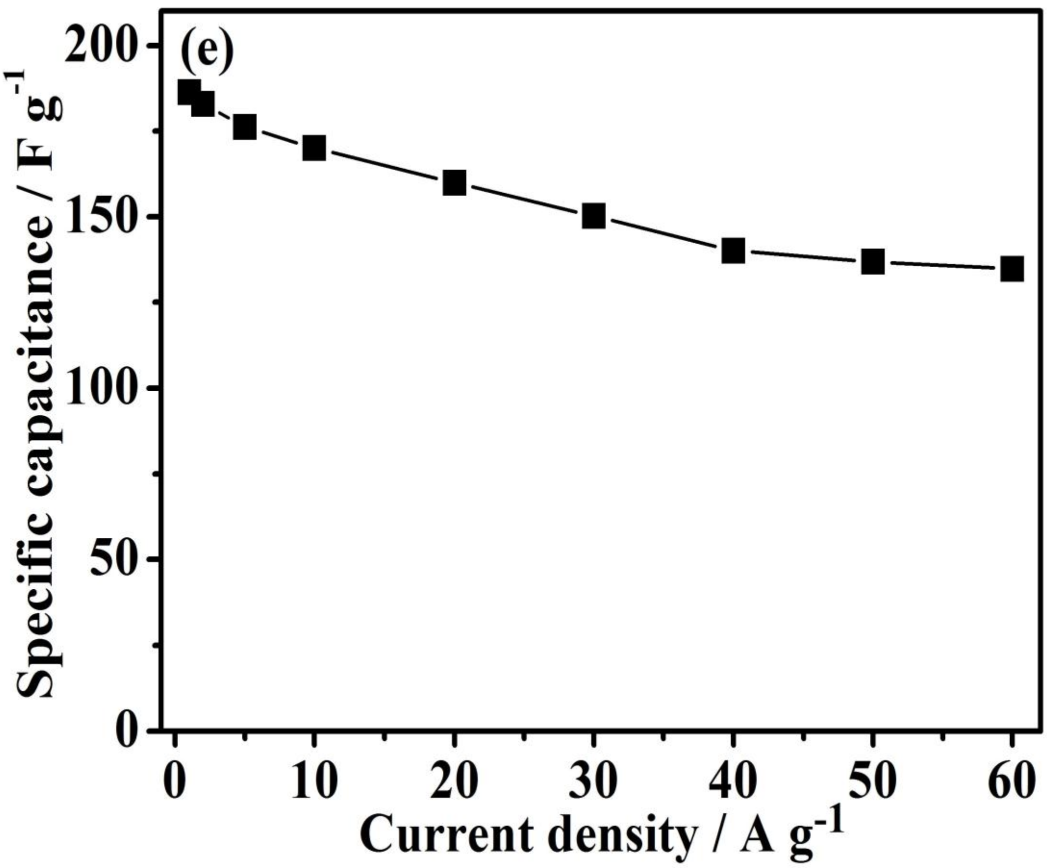
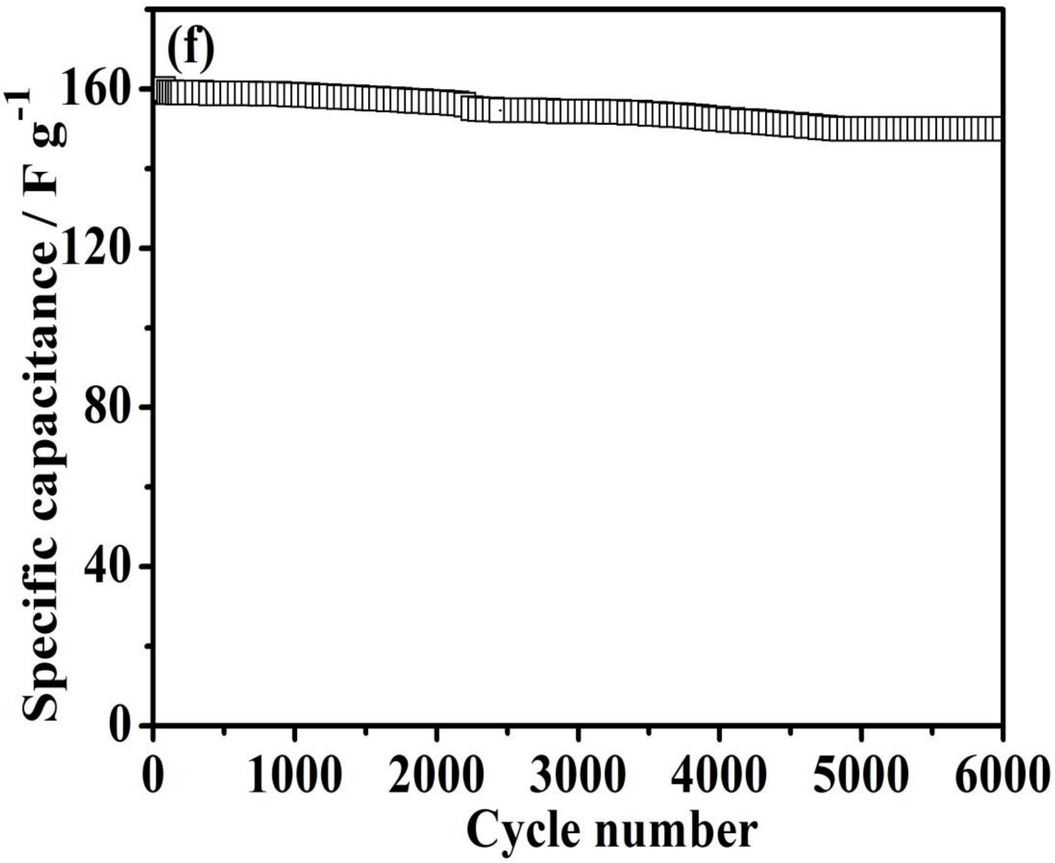


Fig. S1 (a, b) FESEM and (c, d)TEM images of PPy nanotubes.


(a)
50 mV s-1
20 mV s-1
10 mV s-1
5 mV s-1
Current density / A g-1
Potential / V
(b)
500 mV s-1
400 mV s-1
300 mV s-1
200 mV s-1
100 mV s-1
Current density / A g-1
Potential / V


(c)
1 A g-1
2 A g-1
5 A g-1
10 A g-1
20 A g-1
Potential / V
0.0
0.2
0.4
0.6
0.8
0
30
60
90
120
150
Time / s
(d)
30 A g-1
40 A g-1
50 A g-1
60 A g-1
Potential / V
0.0
0.2
0.4
0.6
0.8
0
1
2
3
4
Time / s


(e)
Specific capacitance / F g^{-1}
0
50
100
150
200
0
10
20
30
40
50
60
Current density / A g^{-1}


(f)
Specific capacitance / F g^{-1}
0
40
80
120
160
0
1000
2000
3000
4000
5000
6000
Cycle number

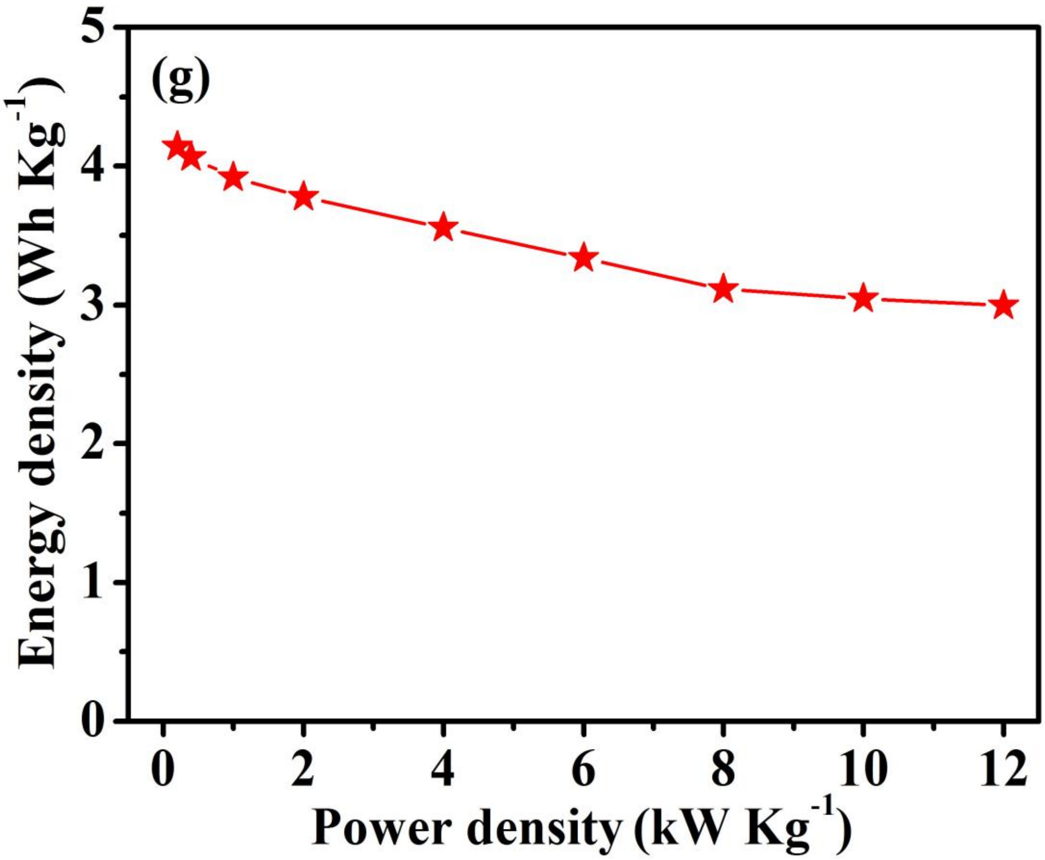


Fig. S2 Electrochemical characterization of the HPNCNTs//HPNCNTs symmetric supercapacitor. (a, b) CV curves of the HPNCNTs//HPNCNTs symmetric supercapacitor at various scan rates in 1M KOH. (c, d) Charge–discharge curves of the HPNCNTs//HPNCNTs symmetric supercapacitor at various current densities (ranging from 1 to 60 A g^{-1}). (e) Specific capacitance of the HPNCNTs//HPNCNTs symmetric supercapacitor as a function of current density. (f) Cycle performance of the HPNCNTs//HPNCNTs symmetric supercapacitor measured at 20 A g^{-1} for 6000 cycles. (g) Energy and power density of the HPNCNTs//HPNCNTs symmetric supercapacitor.

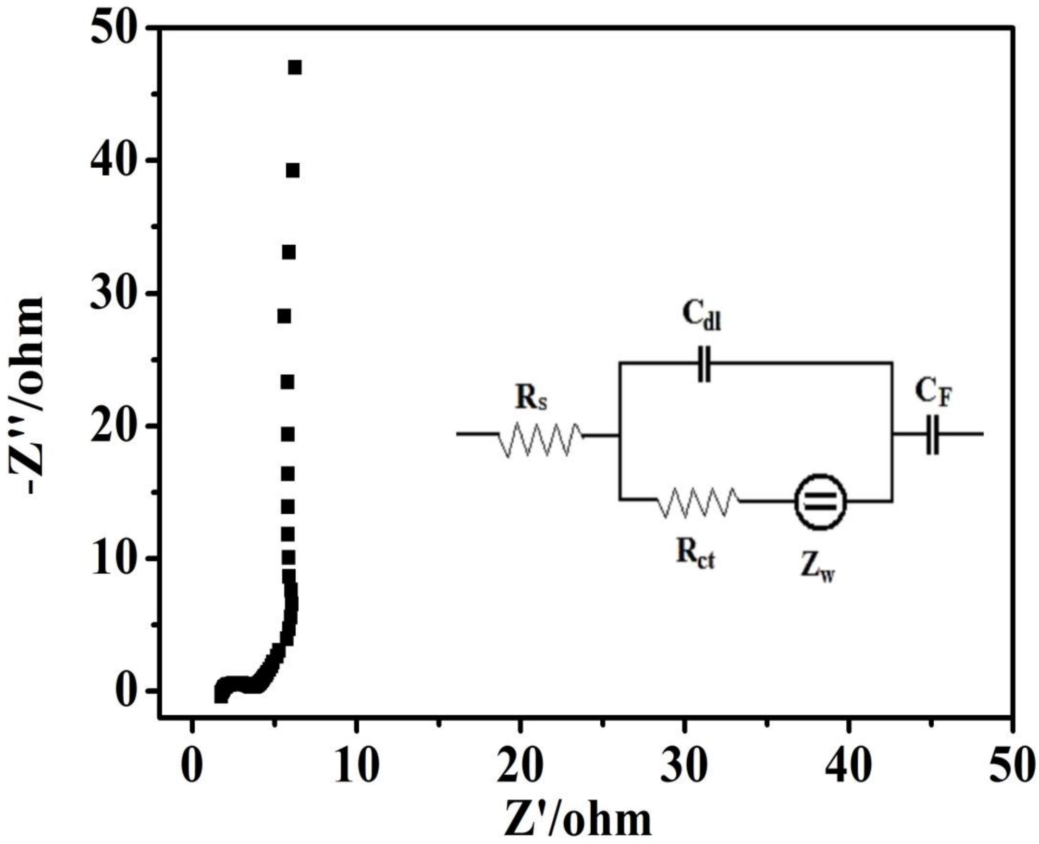


Fig. S3 Nyquist plot of the NiO/GF//HPNCNTs asymmetric supercapacitor with the equivalent circuit in the inset.