Supplementary Material

Carbon nitride supported ultra-fine bismuth sulfide based supercapacitor for low frequency oscillator application

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The specific capacitance (C_P) for the three electrode system was estimated from the equation (1).

$$C_P = \frac{I \times \Delta T}{\Delta V \times m} \ (F.g^{-1}) \ldots (1)$$

Where, I (mA) represent the charge-discharge current, ΔV (V) represents the potential window, ΔT (s) represents the discharge time and m (mg) represents the mass of electrode material.

The specific capacity for the symmetric device was calculated from equation (2).

$$Q_S = (I/m)\frac{t}{3.6} \ (mAh.g^{-1}) \ldots (2)$$

Where, I/m denotes the specific current ($A.g^{-1}$), m is mass of the electrode material (g) and t is the discharge time (s).

The specific energy (E_d) and specific power (P_d) of the device were determined from the equations (3) and (4), respectively.

$$E_d = \frac{V \int I dt}{2 \times 3.6 \times m} (WhK.g^{-1}) \ldots (3)$$

$$P_d = \frac{3600 \times E_d}{\Delta\, t} \ (WK.g^{-1}) \ldots (4)$$

Table S1: Capacitance and / or capacity comparison data of some reported bismuth sulfide based materials.

Material	Method	Electrolyte ($mol.dm^{-3}$)	Capacitance/ Capacity (3-electrode system)	Capacitance/ Capacity (2-electrode system)	Retention	Ref.
Bi_2S_3	HT	Na_2SO_4 (1)	185.7 $F.cm^{-2}$ @ 1 $mA.cm^{-2}$	–	–	1
BGNS	HT	KOH (2)	396 $F.g^{-1}$ @ 1 $A.g^{-1}$	–	75 % @ 100 cycles at 1 $A.g^{-1}$	2
Bi_2S_3-G	HT	Na_2SO_4 (1)	396 $F.g^{1}$ @ 5 $mV.s^{1}$	–	75 % @ 5000 cycles at 5 $A.g^{-1}$	3
Bi_2S_3	HT	KOH (1)	245.5 $mAh.g^{-1}$ @ 0.5 $A.g^{-1}$	148.7 $F.g^{-1}$ @ 1 $A.g^{-1}$	98.7 % @ 2000 cycles at 3 $A.g^{-1}$	4
Bi_2S_3-MoS_2	HT	KCl (1)	1.45 $F.cm^{-2}$ @ 10 $mA.cm^{-2}$	–	96.5 % @ 1000 cycles at 10 $mA.cm^{-2}$	5
CNBS	WCS	KOH (2)	190 $F.g^{-1}$ @ 1.5 $A.g^{-1}$	101.7 $mAh.g^{-1}$ @ 0.02 $A.g^{-1}$	99 % @ 500 cycles at 0.12 $A.g^{-1}$	This work

Table S2: Fitting parameters extracted from the equivalent circuit model.

Serial number	Component	Value
1.	R_1	1.101 Ohm
2.	Q_2	$1.142e^{-3}$ F.s^(a - 1); where a2 = 0.6392
3.	R_2	191.5 Ohm
4.	s1	73058 Ohm.s^-1/2
5.	Q_3	$65.9e^{-6}$ F.s^(a - 1); where a3 = 0.989 6
6.	R_3	0.059 8 Ohm

References:

1. L. Ma, Q. Zhao, Q. Zhang, M. Ding, J. Huang, X. Liu, Y. Liu, X. Wu and X. Xu, Controlled assembly of Bi_2S_3 architectures as Schottky diode, supercapacitor electrodes and highly efficient photocatalysts. *RSC. Adv.* 4, 41636-41641 (2014).

2. G. Nie, X. Lu, J. Lei, L. Yang and C.J.E.A. Wang, Facile and controlled synthesis of bismuth sulfide nanorods-reduced graphene oxide composites with enhanced supercapacitor performance. *Electrochim. Acta*. 154, 24-30 (2015).

3. H. Lu, Q. Guo, F. Zan and H. Xia, Bi_2S_3 nanoparticles anchored on graphene nanosheets with superior electrochemical performance for supercapacitors. *Mater. Res. Bull.* 96, 471-477 (2017).

4. X. Zhai, J. Gao, X. Xu, W. Hong, H. Wang, F. Wu and Y. Liu, 3D interconnected Bi_2S_3 nanosheets network directly grown on nickel foam as advanced performance binder-free electrode for hybrid asymmetric supercapacitor. *J. Power Sources* 396, 648-658 (2018).

5. Y. Ma, Y. Jia, L. Wang, M. Yang, Y. Bi and Y. Qi, One-pot synthesis of hierarchical Bi_2S_3-MoS_2 nanosheet array with high electrochemical performance. *J. Power Sources* 342, 921-928 (2017).