Hierarchical ternary Ni-Co-Se nanowires for High-Performance Supercapacitor Device Design

Kailu Guo,[a] Shizhong Cui,[a] Hongwei Hou,[b] Weihua Chen[b,*] and Liwei Mi[a,*]

[a] *Center for Advanced Materials Research, Zhongyuan University of Technology, Zhengzhou, Henan 450007, P. R. China.;* [b] *College of Chemistry and Molecular Engineering, Zhengzhou University, Zhengzhou, Henan 450001, P. R. China.*

Determination of the weight of active material: The mass of NiSe on NF was calculated by a common difference method as follows. After the reaction, the weight increment (x mg) of NF can be directly measured by electronic balance. $NiSe_{loading}$=x mg×(M_{NiSe}/M_{Se})=x mg×(138/79)=1.7x mg, where M is the molecular weight or atomic weight. For the content of active material in the exchanged samples, according to our previous work, we have confirmed that the residual NF does not participate in the Co ion exchange reaction. Therefore, the weight of active material for the Co-exchanged samples is the difference of weight between Co-exchanged samples and the residual metal nickel obtained by the above calculations. For the fabricated Ni@Ni-Co-Se//AC ASCs, the active material loading of all the products is about 12 mg cm^{-2}, which is more conducive to the practical application.

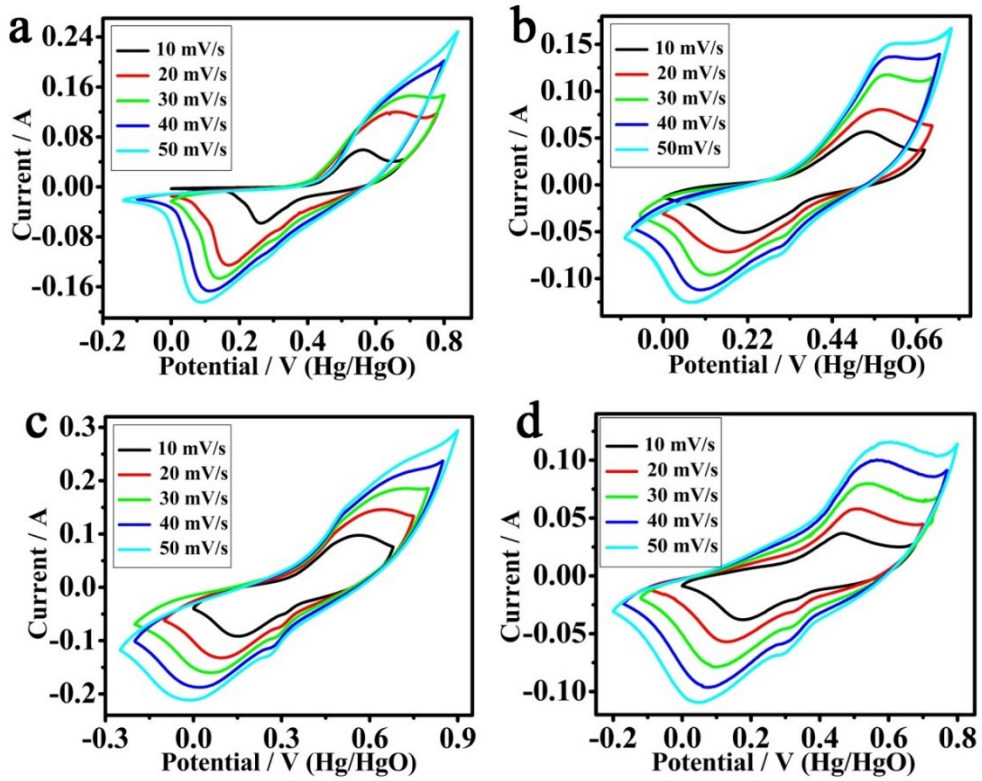

Figure S1. CV curves of (a) Ni@NiSe, (b) Ni@$Ni_{0.8}Co_{0.2}Se$, (c) Ni@$Ni_{0.6}Co_{0.4}Se$ and (d) Ni@Co_9Se_8 at different scan rates from 10 mV s^{-1} to 50 mV s^{-1} in a three-electrode system.

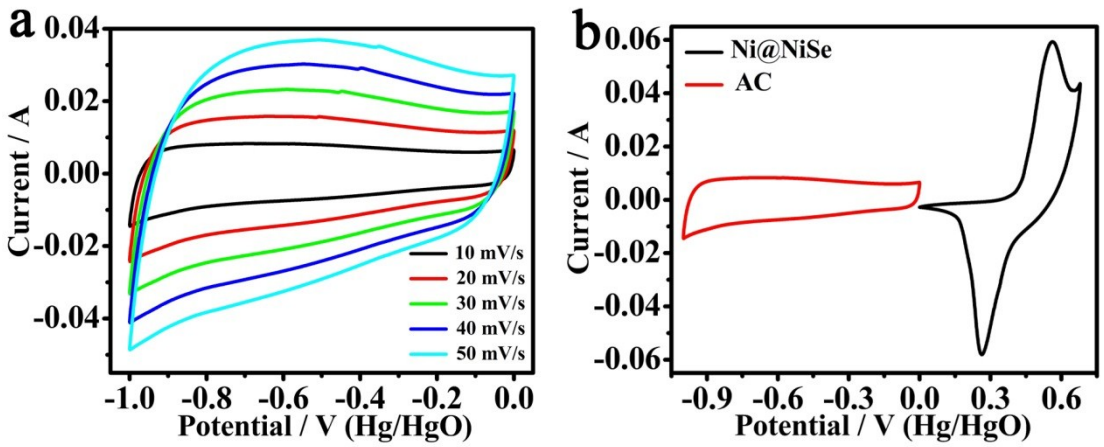

Figure S2. (a) CV curves of AC at different scan rates from 10 mV s^{-1} to 50 mV s^{-1}. (b) CV curves of Ni@NiSe and AC electrodes measured at a scan rate of 10 mV s^{-1} in a three-electrode system.

Table S1. The results of EDX from Ni@NiSe, Ni@$Ni_{0.8}Co_{0.2}Se$, Ni@$Ni_{0.6}Co_{0.4}Se$ and Ni@Co_9Se_8.

Sample / Element	Ni@NiSe	Ni@$Ni_{0.8}Co_{0.2}Se$	Ni@$Ni_{0.6}Co_{0.4}Se$	Ni@Co_9Se_8
Ni	**49.67**	**47.74**	**35.02**	**13.38**
Co	**-**	**10.49**	**21.36**	**45.46**
Se	**50.33**	**41.77**	**43.61**	**41.16**

Table S2. The detailed data of energy density and power density of Ni@NiSe, Ni@$Ni_{0.8}Co_{0.2}Se$, Ni@$Ni_{0.6}Co_{0.4}Se$ and Ni@Co_9Se_8//AC supercapacitor devices.

		Data						
Ni@NiSe	**E (Wh/kg)**	**18.8**	**17.0**	**16.8**	**13.1**	**11.5**	**10.3**	**9.5**
	P (W/kg)	**37.7**	**57.1**	**96.3**	**197.2**	**410.9**	**628.7**	**1032.3**
Ni@$Ni_{0.8}Co_{0.2}Se$	**E (Wh/kg)**	**32.1**	**31.2**	**29.8**	**26.9**	**23.7**	**20.6**	**17.0**
	P (W/kg)	**37.9**	**57.4**	**96.8**	**200.3**	**444.9**	**721.1**	**1526.8**
Ni@$Ni_{0.6}Co_{0.4}Se$	**E (Wh/kg)**	**20.9**	**19.8**	**14.0**	**12.2**	**11.4**	**10.2**	**9.4**
	P (W/kg)	**37.7**	**56.8**	**95.1**	**193.6**	**392.9**	**612.1**	**1062.9**
Ni@Co_9Se_8	**E (Wh/kg)**	**22.9**	**22.4**	**22.2**	**20.6**	**19.4**	**18.6**	**16.9**
	P (W/kg)	**38.1**	**57.6**	**98.9**	**203.7**	**449.0**	**768.3**	**1685.1**

Table S3. the comparison on the electrochemical performance of our $Ni@Ni_{0.8}Co_{0.2}Se$//AC asymmetric device with other metal-selenide-based ASC devices from literature.

Device	Specific capacitance	Energy density	Power density	Mass loading of positive electrode	Source
$Ni_{0.67}Co_{0.33}Se$//RGO	176 C g^{-1} (1 A g^{-1})	36.7 Wh Kg^{-1}	750 W kg^{-1}	2.5 mg cm^{-2}	J. Mater. Chem. A, **2015**,3, 23653-23659
$Ni_{0.9}Co_{1.92}Se_4$//AC	80 F g^{-1} (2 mA cm^{-2})	26.29 Wh Kg^{-1}	265 W kg^{-1}	-	RSC Adv., **2016**,6, 75251-75257
$(Ni,Co)_{0.85}Se$// graphene film	529.3 mF cm^{-2} (1 mA cm^{-2})	2.85 mWh cm^{-3}	10.76 mW cm^{-3}	5.63 mg cm^{-2}	Nano Energy 24 (**2016**) 78–86
$Co_{0.85}Se$//AC	0.33 F cm^{-2} (1 mA cm^{-2})	6×10^{-5} Wh cm^{-2}	-	1.35 mg cm^{-2}	ACS Appl. Mater. Interfaces **2014**, 6, 18844−18852
$Ni_{0.85}Se$//AC	92.9 F g^{-1} (1 A g^{-1})	32.2 Wh Kg^{-1}	789.6 W kg^{-1}	1.2 mg cm^{-2}	RSC Adv., **2015**, 5, 81474–81481
La_2Se_3//graphite	8.13 F g^{-1} (5 mV s^{-1})	1.6 Wh kg^{-1}	960 W kg^{-1}	-	ChemPlusChem **2015**, 80, 1478–1487
$Ni_{0.8}Co_{0.2}Se$//AC	**86 F g^{-1} (1 A g^{-1})**	**32.1 Wh kg^{-1}**	**37.9 W kg^{-1}**	**12 mg cm^{-2}**	**Our work**