Supporting Information

$Ni_{0.9}Co_{1.92}Se_4$ Nanostructures: Binder-free Electrode of Coral-like Bimetallic Selenide for supercapacitors

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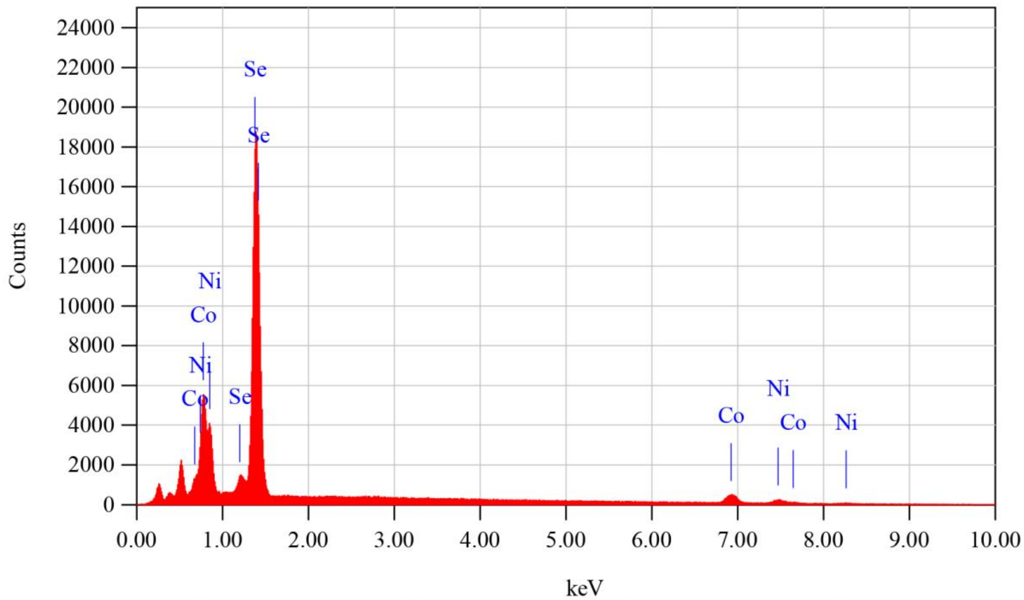
The EDX pattern demonstrate that the sample is mainly composed of Ni, Co and Se elements, except a little oxygen signal which may be from moisture and oxygen adsorbed on the surface of sample. The quantitative analyses about the mass and atom percentage is tabulated as follows.



Element	keV	Mass%	Atom%	K
Ni L*	0.851	17.31	20.29	15.6865
Co L*	0.776	25.91	30.24	29.8140
Se L*	1.379	56.78	49.47	54.4995

Figure S1. EDX pattern of the $Ni_{0.9}Co_{1.92}Se_4$ nanostructures.

The XRD spectra of the Ni-Coprecursor powder showns that the diffraction peaks are well indexed as the $Ni_3(CO_3)(OH)_4{\cdot}4H_2O$ (JCPDS no.16-0164) and $Co(CO_3)_{0.5}(OH){\cdot}0.11H_2O$ (JCPDS no.48-0083).

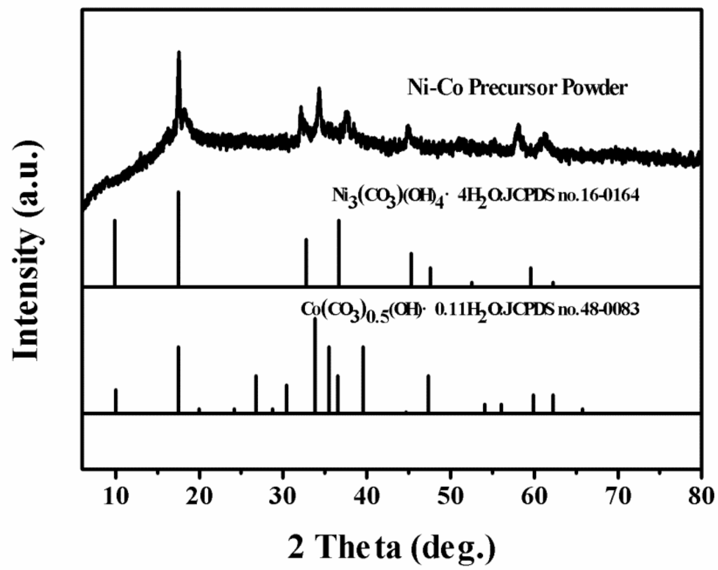


Figure S2. XRD spectra of the Ni-Co precursor powder.

4 mmol of $Co(NO_3)_2 \cdot 6H_2O$ is dissolved in 80 mL of deionized water to form a homogeneous pink solution, followed by the addition of 12 mmol of NH_4F and 24 mmol of urea, respectively. The solution and the pretreated Ni foam were transferred into a 100 mL Teflon-lined stainlesssteel autoclave, which was sealed and maintained at 120°C for 6h.After the autoclave cooled down to room temperature, the precursor on Ni foam was washed with ethanol and deionized water several times and dried at 80°C for 6h.Then,200 mg of sodium selenite (Na_2SeO_3) and 10 mL of hydrazine hydrate were added into the 70 mL of absolute ethanol solution with precursor on Ni foam, and the mixture was kept in the autoclave at 140°C for 12h. After the autoclave cooled down to room temperature,washed with ethanol and deionized water several times and dried at 80°C for 6h,we get the black sample of $Co_{0.85}Se$ on Ni foam.

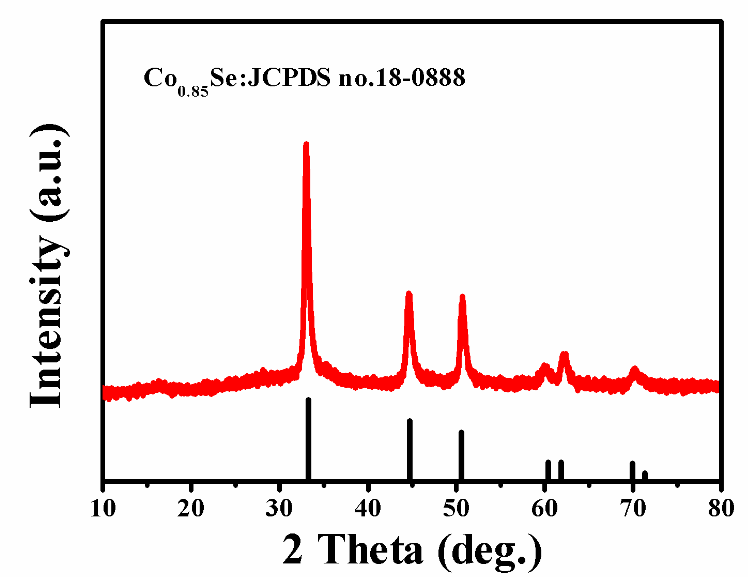


Figure S3. XRD spectra of the $Co_{0.85}Se$ powder.

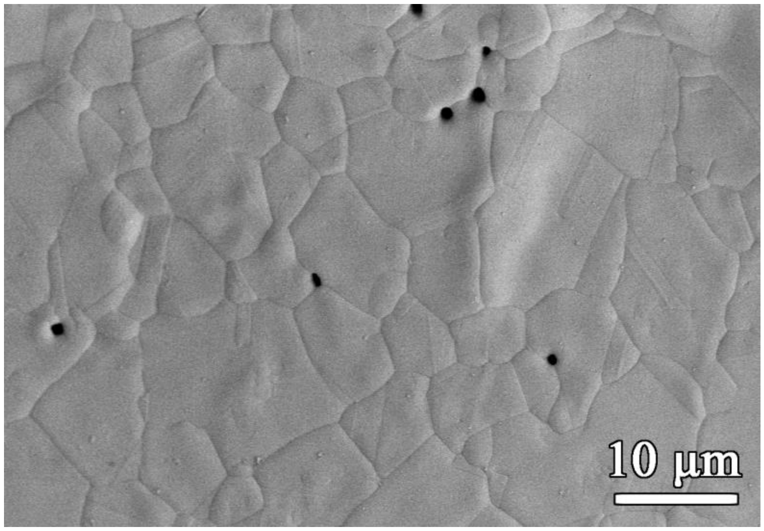


Figure S4. FESEM image of the Ni foam.

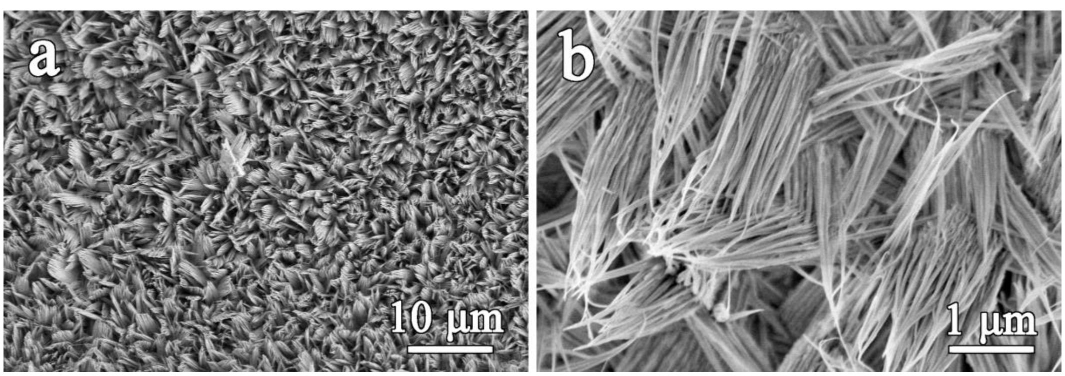


Figure S5. (a) SEM and (b)FESEM images of the $Co_{0.85}Se$ precursor on Ni foam at different magnifications.

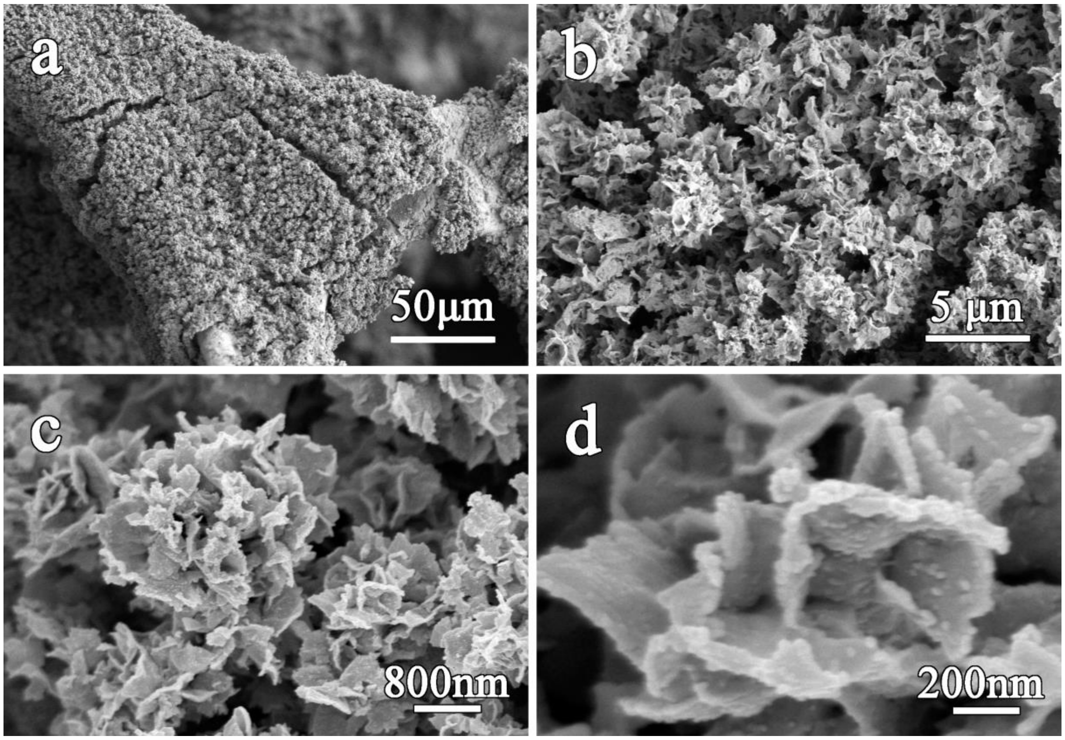


Figure S6. (a,b) SEM and (c,d) FESEM images of the $Co_{0.85}Se$ on Ni foam at different magnifications.

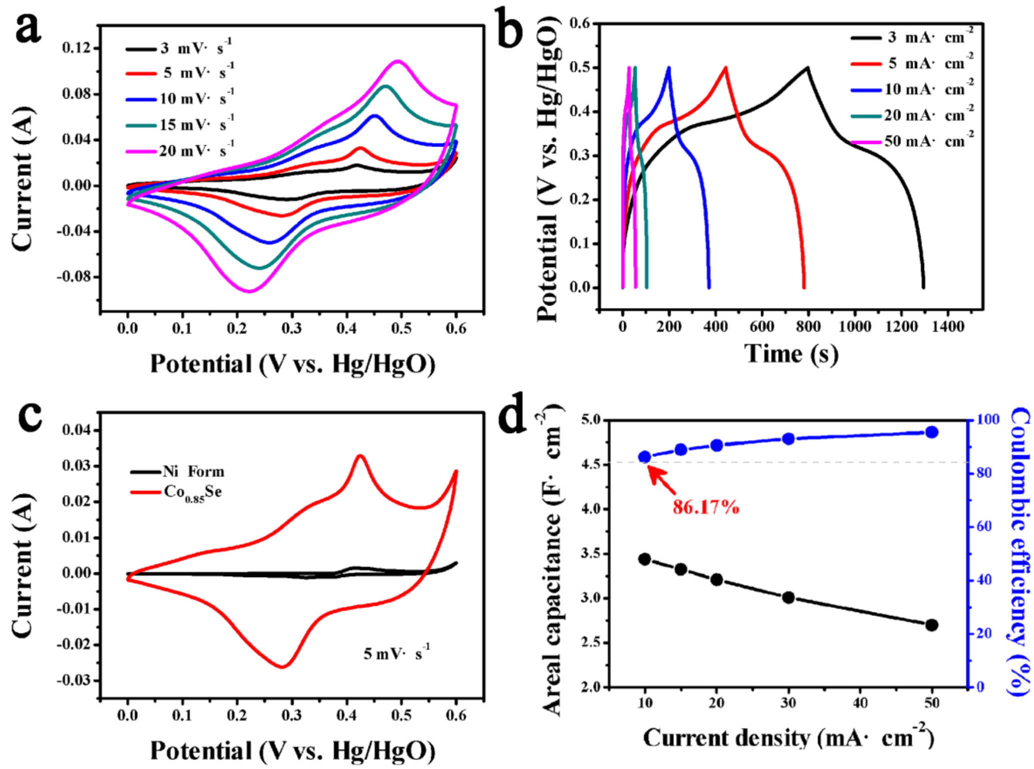


Figure S7. Electrochemical performances of the as-prepared samples: (a) CV curves of $Co_{0.85}Se$ on Ni foam at the scan rates from 3to 20 mV·s^{-1}; (b) GCD curves of the $Co_{0.85}Se$ on Ni foam at the current densities from 3 to 50 mA·cm^{-2}; (c) the CV curves of Ni foam and $Co_{0.85}Se$ on Ni foam at a scan rate of 5 mV·s^{-1}; (d) the areal capacitance and the coulombic efficiency of the $Co_{0.85}Se$ on Ni foam at the current densities from 10 to 50 mA·cm^{-2}.

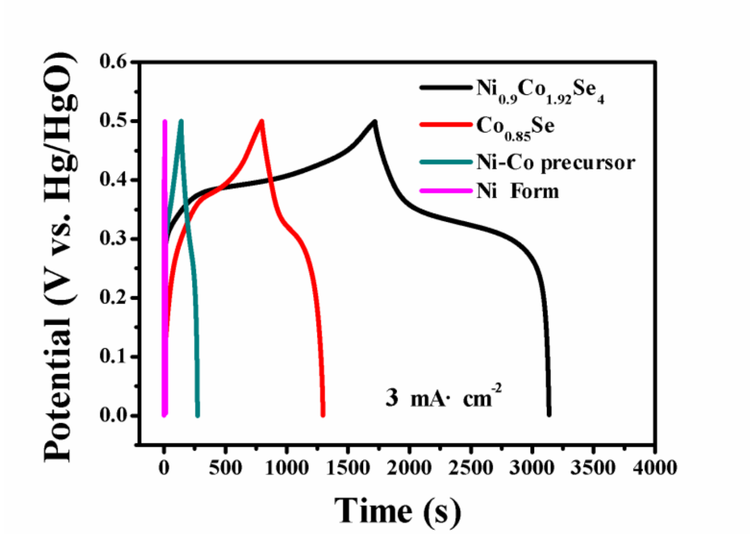


Figure S8. Electrochemical performance comparison of the Ni foam, $Co_{0.85}Se$, Ni-Co precursor and $Ni_{0.9}Co_{1.92}Se_4$ nanostructures on Ni foam of GCD curves at the current density of 3 mA·cm^{-2}.

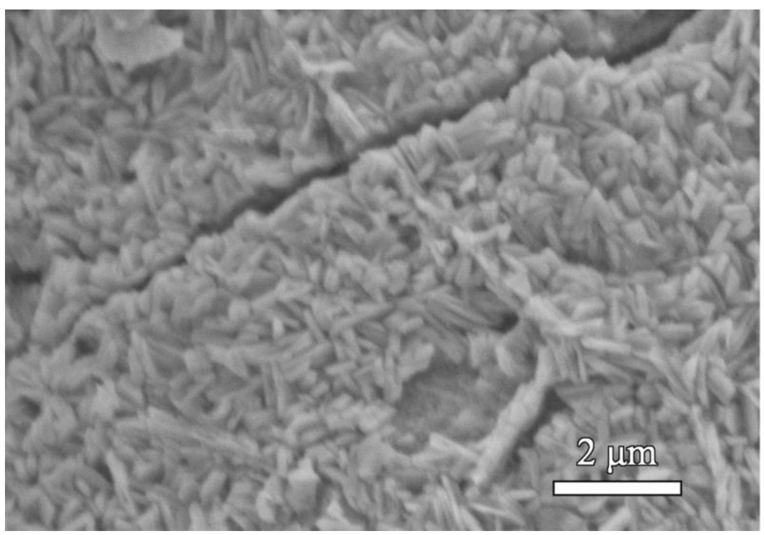


Figure S9. SEM image of the $Ni_{0.9}Co_{1.92}Se_4$ nanostructures on Ni foam after 5000 cycles.

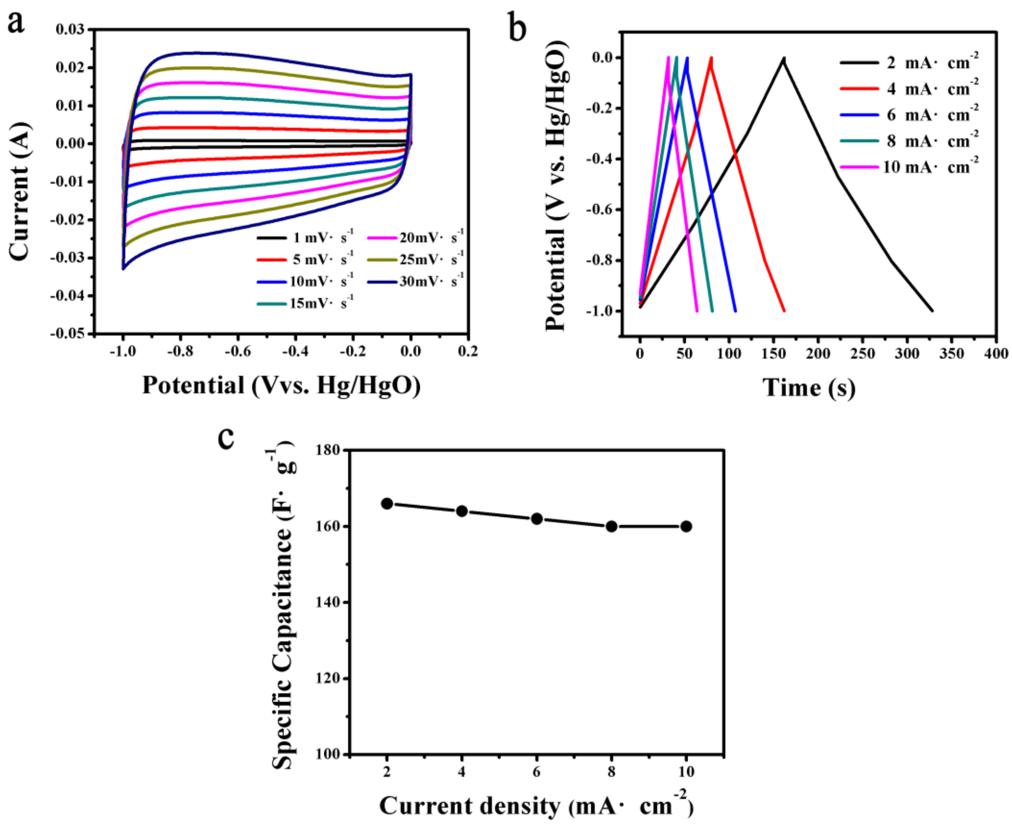


Figure S10. Electrochemical performance of the as-prepared samples: (a) CV curves of AC at the scan rates from 1 to 30 mV·s^{-1}; (b) GCD curves of AC at the current densities from 2 to 10 mA·cm^{-2}; (c) the specific capacitance of AC at different current densities.

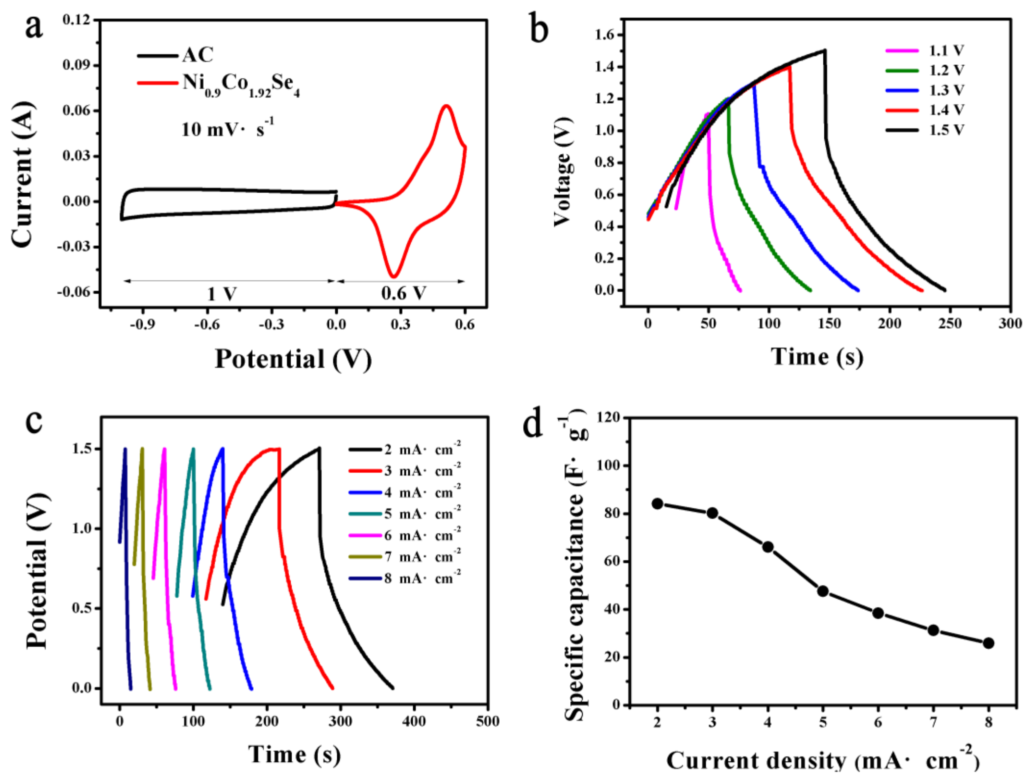


Figure S11. Electrochemical performance of the as-prepared samples: (a) CV curves of the $Ni_{0.9}Co_{1.92}Se_4$ nanostructures and AC with their corresponding potential window at the scan rate of 10 $mV{\cdot}s^{-1}$; GCD curves of the $Ni_{0.9}Co_{1.92}Se_4$//AC asymmetric supercapacitor: (b) at the different voltages and (c) at the current densities changing from 2 to 8 $mA{\cdot}cm^{-2}$; (d) the specific capacitance of the asymmetric supercapacitor at different current densities.

Table S1. Comparison of $Ni_{0.9}Co_{1.92}Se_4$ nanostructures and some similar previously reported materials.

Nanostructures	Areal Capacitance	Specific Capacitance	Rate capability	Power density	Capacitance retention	Reference
Hollow $Co_{0.85}Se$ nanowire array on Carbon Fiber Paper	0.93 $F\cdot cm^{-2}$ @ 2 $mA\cdot cm^{-2}$	674 $F\cdot g^{-1}$ @ 2 $mA\cdot cm^{-2}$	65.9% from 2 to 15 $mA\cdot cm^{-2}$	10.19 $Wh\cdot kg^{-1}$@ (550 $W\cdot kg^{-1}$)	89.00% after2000 cycles@10$mA\cdot cm^{-2}$	1
$GeSe_2$ Nanostructures	240 $\mu F\cdot cm^{-2}$ @ 10$mA\cdot cm^{-2}$	300 $F\cdot g^{-1}$ @ 1 $A\cdot g^{-1}$	60% from 1 to 10 $A\cdot g^{-1}$		77.50% after 2000 cycles@10$mA\cdot m^{-2}$	2
$CoNi_2S_4$Nanosheet Arrays Supported on Nickel foams	6.39$F\cdot cm^{-2}$ @ 5$mA\cdot cm^{-2}$	2906 $F\cdot g^{-1}$ @ 5 $mA\cdot cm^{-2}$	78% from 5 to 50 $mA\cdot cm^{-2}$	33.9 $Wh\cdot kg^{-1}$@ (409 $W\cdot kg^{-1}$)	77.96% after 3000 cycles@30$mA\cdot cm^{-2}$	3
$Co_{0.85}Se$ on Ni foam	3.44 $F\cdot cm^{-2}$ @ 3 $mA\cdot cm^{-2}$	430.0 $F\cdot g^{-1}$ @ 3 $mA\cdot cm^{-2}$	68% from 3 to 50 $mA\cdot cm^{-2}$			Additional experiment
Ni-Co precursor	0.80 $F\cdot cm^{-2}$ @ 3 $mA\cdot cm^{-2}$	145.3 $F\cdot g^{-1}$ @ 3 $mA\cdot cm^{-2}$	5.1% from 3 to 50 $mA\cdot cm^{-2}$			This work
$Ni_{0.9}Co_{1.92}Se_4$ on Ni foam	6.43 $F\cdot cm^{-2}$ @ 2 $mA\cdot cm^{-2}$	1021.1 $F\cdot g^{-1}$ @ 2 $mA\cdot cm^{-2}$	77% from 2 to 50 $mA\cdot cm^{-2}$	26.29 $Wh\cdot kg^{-1}$@ (265 $W\cdot kg^{-1}$)	88.39% after 5000 cycles@20$mA\cdot cm^{-2}$	This work

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