Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Core-branched $CoSe_2/Ni_{0.85}Se$ nanotube arrays on Ni foam with remarkable electrochemical performances for hybrid supercapacitors

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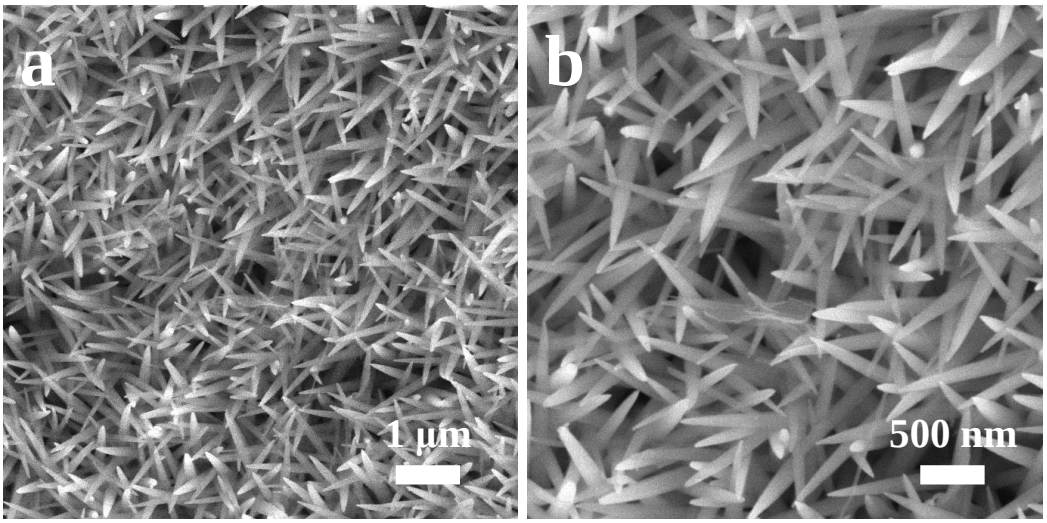

Figure S1 SEM images of Co-precursors on Ni foam.

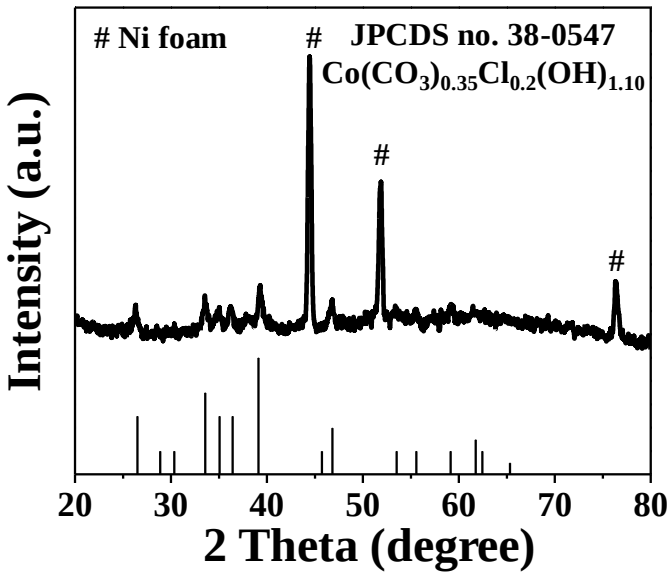

Figure S2 XRD patterns of Co-precursors on Ni foam.

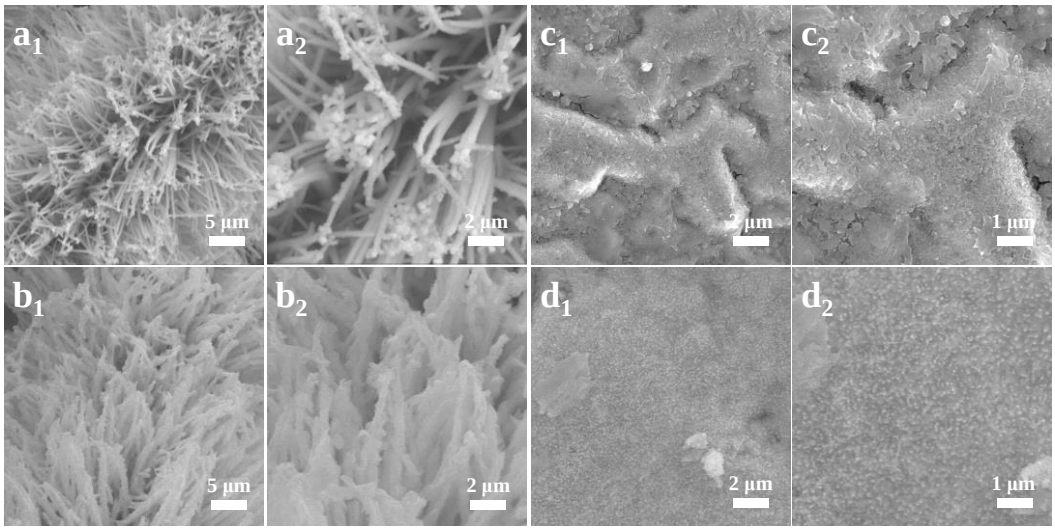

Figure S3 SEM images of (a) $CoSe_2$@CC, (b) E-$CoSe_2$@CC, (c) $Ni_{0.85}Se$@NF and (d) E-$Ni_{0.85}Se$@NF.

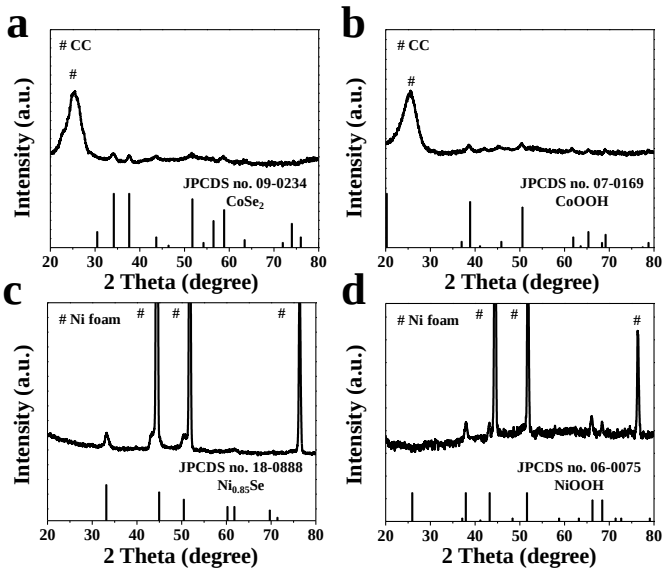

Figure S4 XRD patterns of (a) $CoSe_2$@CC, (b) E-$CoSe_2$@CC, (c) $Ni_{0.85}Se$@NF and (d) E-$Ni_{0.85}Se$@NF.

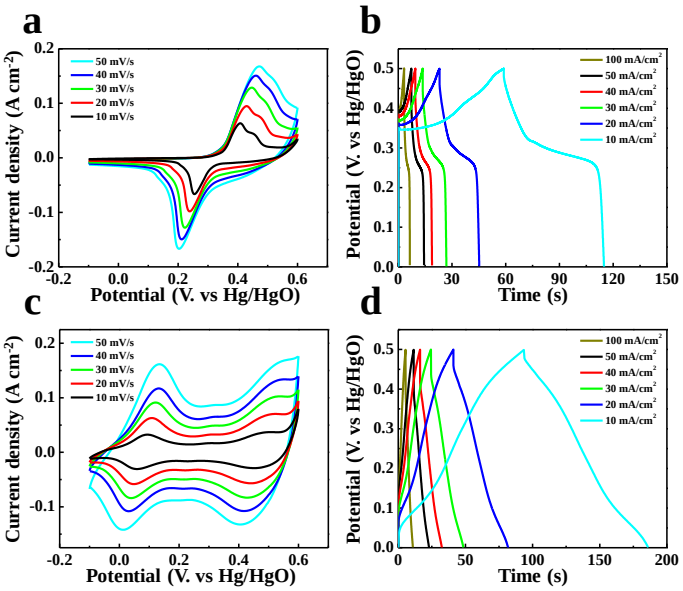

Figure S5 CV and GCD curves of (a, b) E-$Ni_{0.85}Se$@NF and (c, d) E-$CoSe_2$@CC.

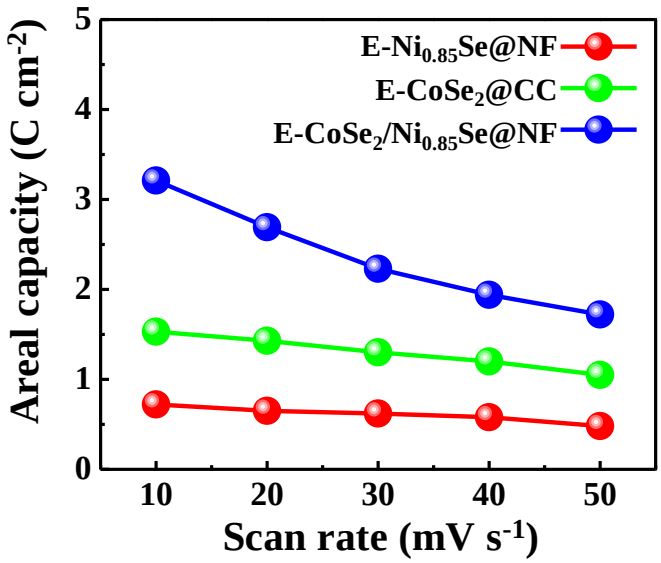

Figure S6 The calculated areal capacity of obtained electrodes via CV measurements.

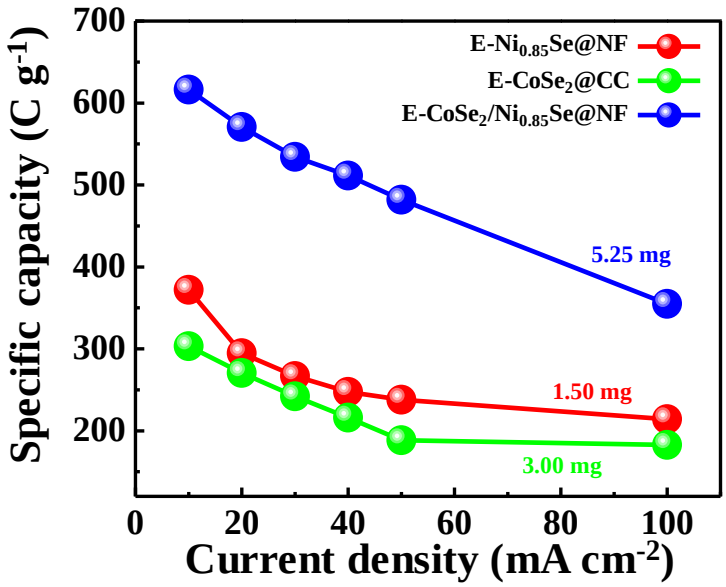

Figure S7 The calculated specific capacity of obtained samples

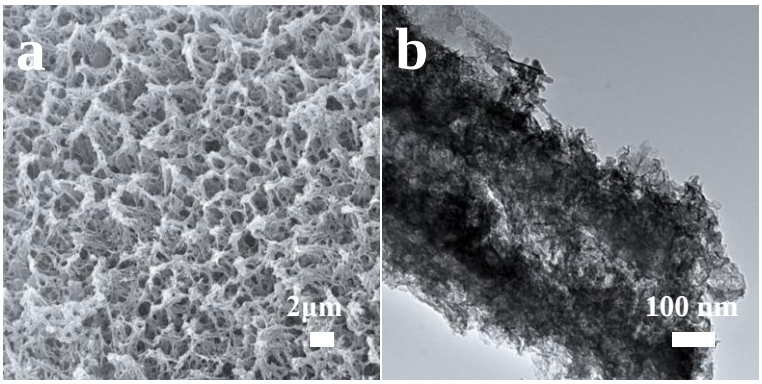

Figure S8 SEM and TEM images of E-$CoSe_2$/$Ni_{0.85}Se$@NF after cycling test.

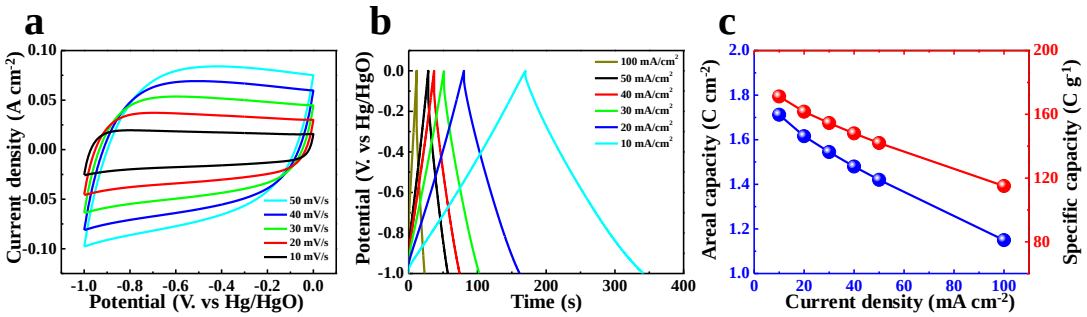

Figure S9 (a) CV, (b) GCD curves and (c) corresponding calculated capacity of AC.

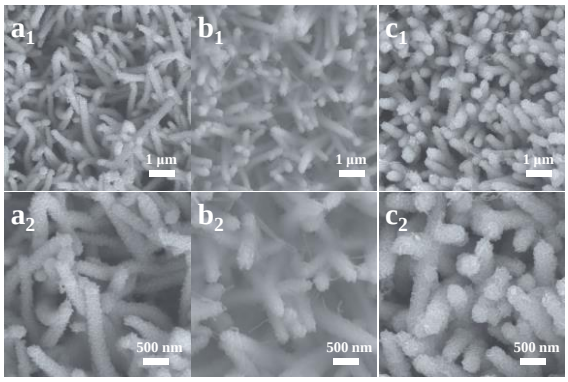

Figure S10 SEM images of (a) $CoSe_2/Ni_{0.85}Se$-4, (b) $CoSe_2/Ni_{0.85}Se$-8 and (c) $CoSe_2/Ni_{0.85}Se$-12.

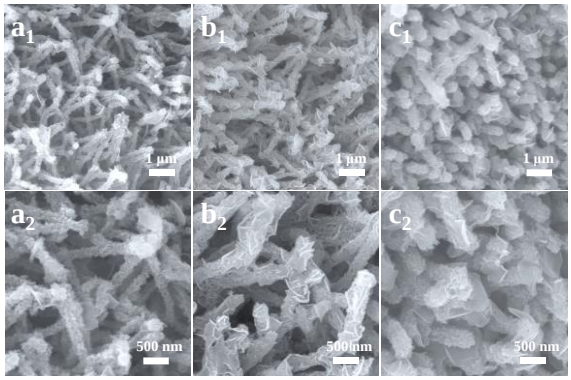

Figure 11 SEM images of (a) E-$CoSe_2/Ni_{0.85}Se$-4, (b) E-$CoSe_2/Ni_{0.85}Se$-8 and (c) E-$CoSe_2/Ni_{0.85}Se$-12.

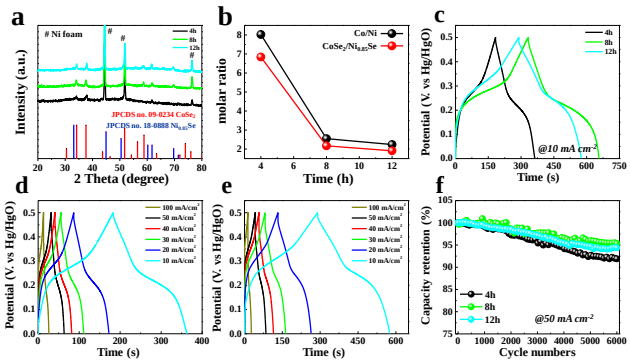

Figure 12 (a) XRD patterns of $CoSe_2/Ni_{0.85}Se$-4, $CoSe_2/Ni_{0.85}Se$-8 and $CoSe_2/Ni_{0.85}Se$-12. (b) The Co/Ni molar ratio and the molar ratio of $CoSe_2$ and $Ni_{0.85}Se$ in obtained samples based on ICP-OES analysis. (c) GCD curves of E-$CoSe_2/Ni_{0.85}Se$-4, E-$CoSe_2/Ni_{0.85}Se$-8 and E-$CoSe_2/Ni_{0.85}Se$-12 at the

current density of 10 mA cm^{-2}. GCD curves of (d) E-$CoSe_2$/$Ni_{0.85}Se$-4 and (e) E-$CoSe_2$/$Ni_{0.85}Se$-12. (f) The cycling performances of obtained electrodes.

We also prepared different electrodes by selenizing Co-precursor/Ni foam at 120 ^oC for different hydrtohermal durations (4, 8 and 12 h). For convenience, the different electrodes were denoted as $CoSe_2$/$Ni_{0.85}Se$-4, $CoSe_2$/$Ni_{0.85}Se$-8 and $CoSe_2$/$Ni_{0.85}Se$-12. As shown in **Figure S10**, all obtained samples show the core-branched nanostructures. It can be found that the core-branched nanutubes are becoming thicker and wider when the hydrothermal time increases from 4 h to 12 h. After electrochemical activation, the core-branched nanostructures in E-$CoSe_2$/$Ni_{0.85}Se$@NF are still maintained while more small nanosheets are formed on the surface (see **Figure S11**). XRD pattern in **Figure S12a** confirms that all the peaks in obtained electrodes could be indexed to $CoSe_2$ (JPCDS no. 09-0234) and $Ni_{0.85}Se$ (JPCDS no. 18-0888), except for the peaks from Ni substrates. The mass loadings of $CoSe_2$/$Ni_{0.85}Se$-4, $CoSe_2$/$Ni_{0.85}Se$-8 and $CoSe_2$/$Ni_{0.85}Se$-12 were estimated to about 4.13, 5.25 and 6.02 mg cm^{-2}. Further, we have conducted the inductively coupled plasma optical emission spectroscopy (ICP-OES) analysis to investigate the Ni/Co ratio. As shown in **Figure S12b**, the Co/Ni molar ratio of $CoSe_2$/$Ni_{0.85}Se$-4, $CoSe_2$/$Ni_{0.85}Se$-8 and $CoSe_2$/$Ni_{0.85}Se$-12 is 8.02/1, 2.55/1 and 2.24/1. Consequently, the molar ratio of $CoSe_2$ and $Ni_{0.85}Se$ in $CoSe_2$/$Ni_{0.85}Se$-4, $CoSe_2$/$Ni_{0.85}Se$-8 and $CoSe_2$/$Ni_{0.85}Se$-12 are calculated to about 6.84/1, 2.17/1 and 1.91/1. In other words, the contents of $CoSe_2$ and $Ni_{0.85}Se$ could be simply controlled by selenizing Co-precursor/Ni foam with different hydrtohermal durations. As shown in **Figure S12c**, E-$CoSe_2$/$Ni_{0.85}Se$-8 electrode showed the longest discharge time at 10 mA cm^{-2}, indicating the highest specific capacity. And all samples also showed the good cycling stability, as shown in **Figure S12f**.

Table S1. The specific capacity of various electrodes in the three-electrode system in references

electrode materials	mass loading (mg cm^{-2})	areal capacity	specific capacity	reference
$NiSe_2$ cubes	3.9	~1.55 C cm^{-2}	~397 C g^{-1}	1
$Co_{0.85}Se$ on Ni foam	1	~0.76 C cm^{-2}	757.9 C g^{-1}	2
$Ni_{0.9}Co_{1.92}Se_4$ on Ni foam	6.3	~3.2 C cm^{-2}	511 C g^{-1}	3
$(Ni,Co)_{0.85}Se$ nanotube on CFC	-	~1.17 C cm^{-2}	-	4
Co-Cd-Se on Ni foam	2.0	~1.05 C cm^{-2}	526 C g^{-1}	5
$CoSe_2$ nanosheet on carbon cloth	0.53	~0.15 C cm^{-2}	285.3 C g^{-1}	6
$NiCoSe_2$ Hollow Sub-Microspheres	7	3.15 C cm^{-2}	450 C g^{-1}	8
$CoSe_2$ nanoarrays on carbon cloth	1.8	~0.55 C cm^{-2}	303.8 C g^{-1}	9
$Ni_{0.34}Co_{0.66}Se_2$ on carbon cloth	4.8	~1.31 C cm^{-2}	273 C g^{-1}	10
double-shelled N-doped $CoSe_2$/C	-	-	399 C g^{-1}	11
NiSe@$MoSe_2$ on Ni foam	-	-	461.5 C g^{-1}	12
hollow, sea-urchin-like $Ni_{0.5}Co_{0.5}Se_2$	3	~1.57 C cm^{-2}	524 C g^{-1}	13
$Co_{0.85}Se$@ $CoNi_2S_4$/GF	7	2.1 C cm^{-2}	300 C g^{-1}	14
E-$CoSe_2$/$Ni_{0.85}Se$ nanotube arrays	5.25	3.24 C cm^{-2}	617.1 C g^{-1}	This work

Table S2. Comparison of the electrochemical performance of as-fabricated ASC device with those in previous reports.

Supercapattery device	Energy density ($Wh\ kg^{-1}$)	Corresponding Power density ($W\ kg^{-1}$)	Reference
$Co_{0.85}Se$//AC	39.7	789.6	2
$Ni_{0.9}Co_{1.92}Se_4$//AC	26.29	265	3
$Ni_{0.85}Se$@MoSe//graphene	25.5	420	7
$NiCoSe_2$//AC	25.5	3750	8
$CoSe_2$ nanoarrays//carbon nanowall	32.2	1914.7	9
NiSe@$MoSe_2$//N-PMCN	32.6	415	12
$Ni_{0.5}Co_{0.5}Se_2$//RGO	37.5	745	13
Graphene wrapped Ni_3S_2//N-Graphene	32.6	399.8	15
Co_9S_8@$Ni(OH)_2$//AC	31.35	252.8	16
$NiCo_2S_4$@$Co(OH)_2$//AC	35.89	400	17
E-$CoSe_2$/$Ni_{0.85}Se$ nanotube arrays//AC	40.5	538	This work

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