Supporing information

3D hierarchical Co$_3$O$_4$@Co$_3$S$_4$ nanoarrays as cathode materials for asymmetric pseudocapacitor

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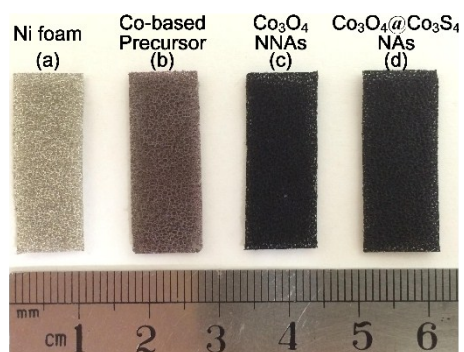
Figure S1 Optical photograph of Ni foam substrate (a), Co-based precursor on Ni foam (b), Co_3O_4 NNAs on Ni foam (c), and $Co_3O_4@Co_3S_4$ NAs on Ni foam (d).
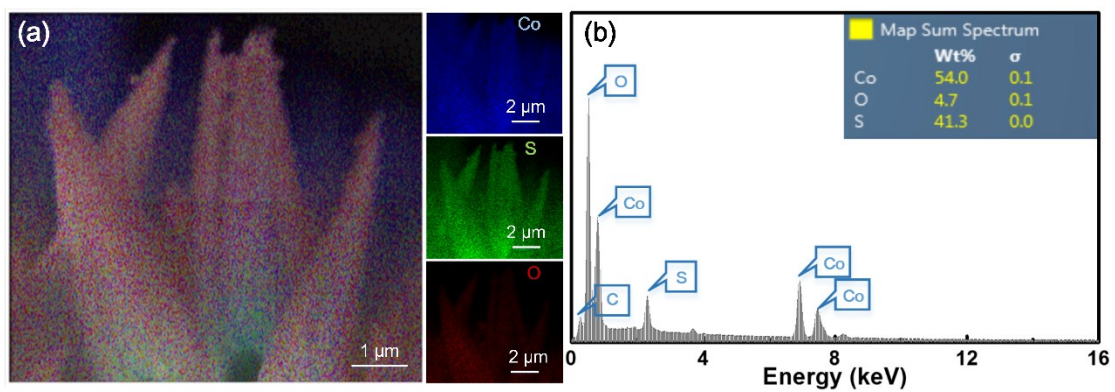
Figure S2 (a) SEM image of the $Co_3O_4@Co_3S_4$ nanostructure and EDS elemental maps of Co, S, and O; (b) EDS elemental spectrum of hybrid NAs.

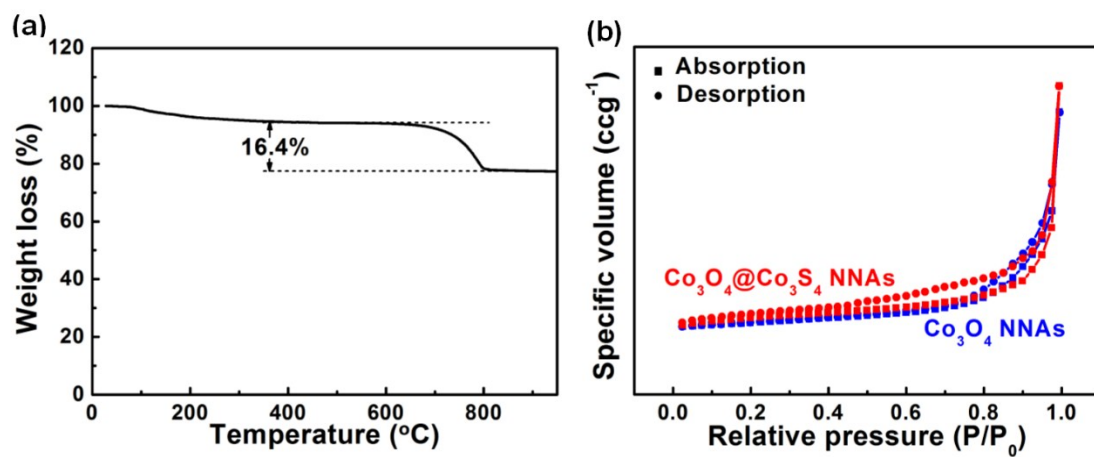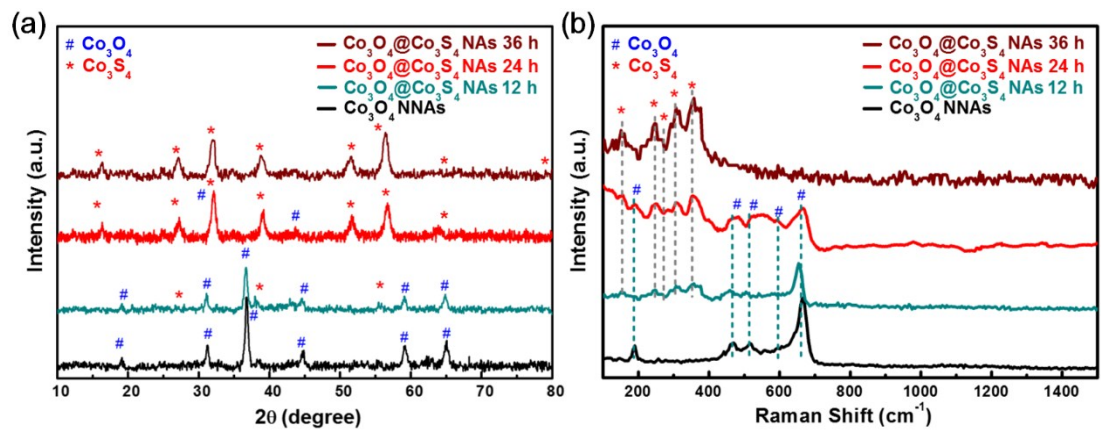**Figure S3** (a) The TGA profile of the $Co_3O_4@Co_3S_4$ NAs; (b) Adsorption-desorption isotherms of the Co_3O_4 NNAs and $Co_3O_4@Co_3S_4$ NAs.

Figure S4 (a) XRD patterns and (b) Raman spectra of Co₃O₄ NNAs, Co₃O₄@Co₃S₄ NAs 12h, Co₃O₄@Co₃S₄ NAs 24h, and Co₃O₄@Co₃S₄ NAs 36h.
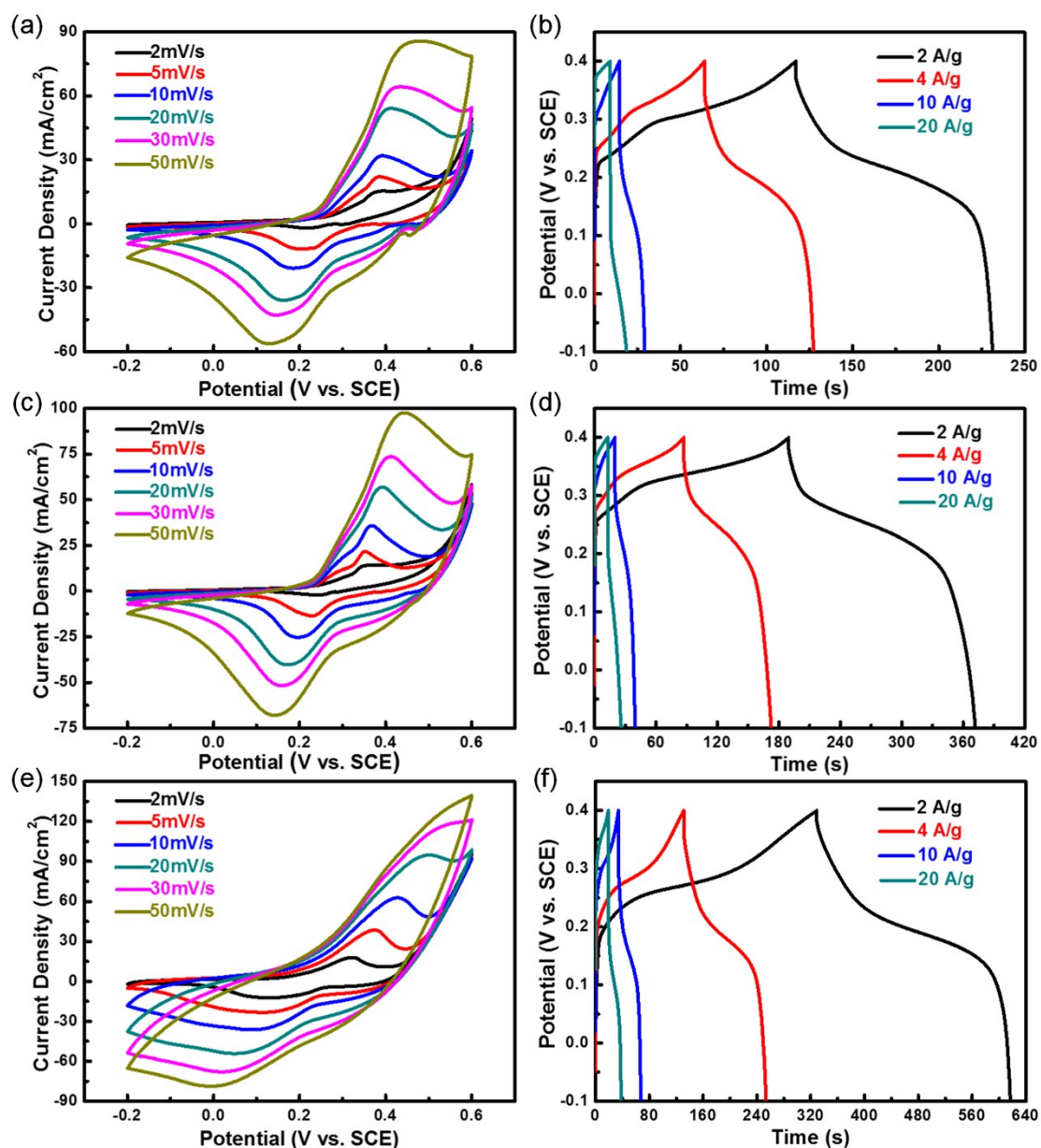
Figure S5 (a) CV and (b) galvanostatic charge-discharge curves of the Co_3O_4 NNAs electrode; (c) CV and (d) galvanostatic charge-discharge curves of $Co_3O_4@Co_3S_4$ NAs prepared at 12 h in the second hydrothermal synthesis process; (c) CV and (d) galvanostatic charge-discharge curves of $Co_3O_4@Co_3S_4$ NAs prepared at 36 h in the second hydrothermal synthesis process.

Table 1. Scan-Rate-Dependent Specific Capacitances (F/g) of the Co_3O_4, $Co_3O_4@Co_3S_4$ 12 h, $Co_3O_4@Co_3S_4$ 24 h, and $Co_3O_4@Co_3S_4$ 36 h Electrodes

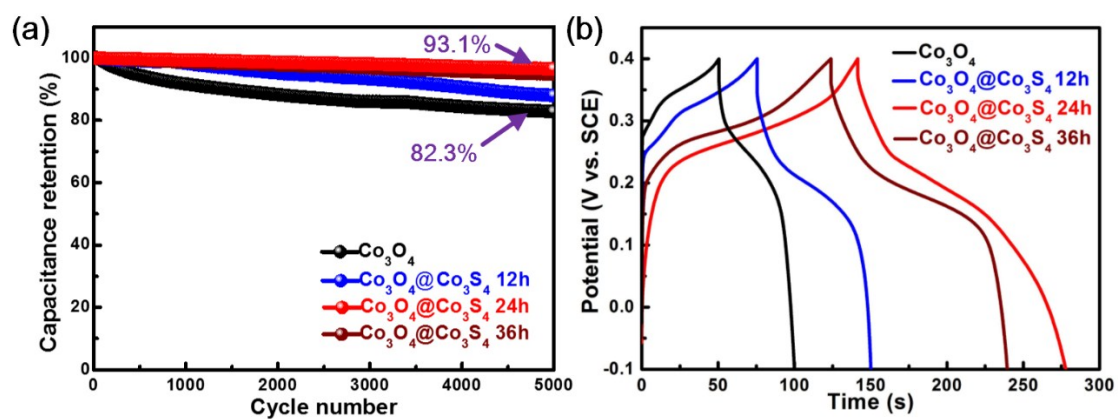|	scan rate (mV/s)					
	2	5	10	20	30	50
Co_3O_4	765.6	317.2	186.2	127.6	98.5	74.2
$Co_3O_4\Theta Co_3S_4$ (12 h)	911.5	410.4	288.5	242.2	218.1	184.4
$Co_3O_4\Theta Co_3S_4$ (24 h)	1284.3	631.9	425.1	311.1	283.7	206.7
$Co_3O_4\Theta Co_3S_4$ (36 h)	1161.5	642.7	447.9	316.7	258.9	177.4

Figure S6 (a) Cycling performance of the Co_3O_4 NNAs and $Co_3O_4@Co_3S_4$ NAs electrodes prepared at different reaction durations in the second hydrothermal synthesis process ; (b) Galvanostatic charging/discharging curves of the last cycle at 4 A g^{-1} after 5000 cycles for the Co_3O_4 NNAs and $Co_3O_4@Co_3S_4$ NAs electrodes, respectively.

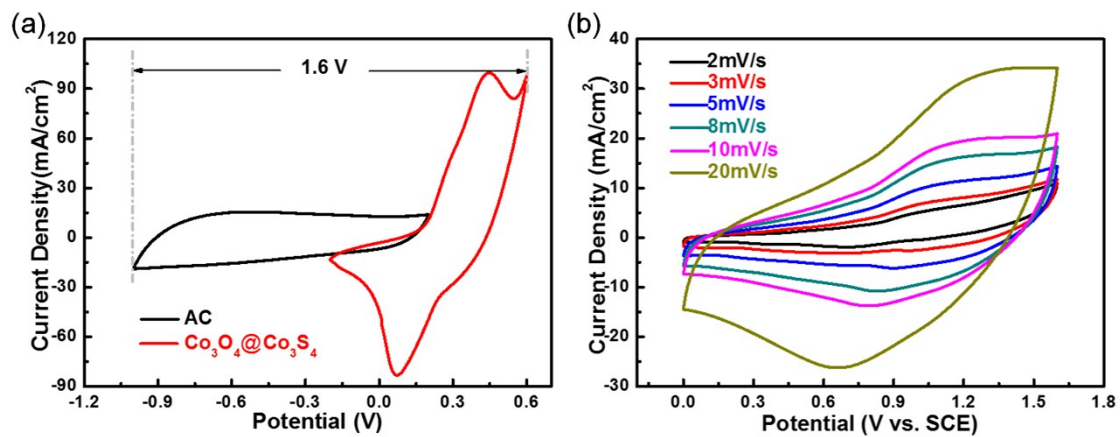**Figure S7** (a) The CV comparison of the activated carbon electrodes and the $Co_3O_4@Co_3S_4$ NAs electrodes in -0.2 to 0.6 V and -1.0 to 0.2 V at a scan rate of 30 mV s^{-1}; (b) CV curves of the $Co_3O_4@Co_3S_4$//AC ASCs at various scan rates.
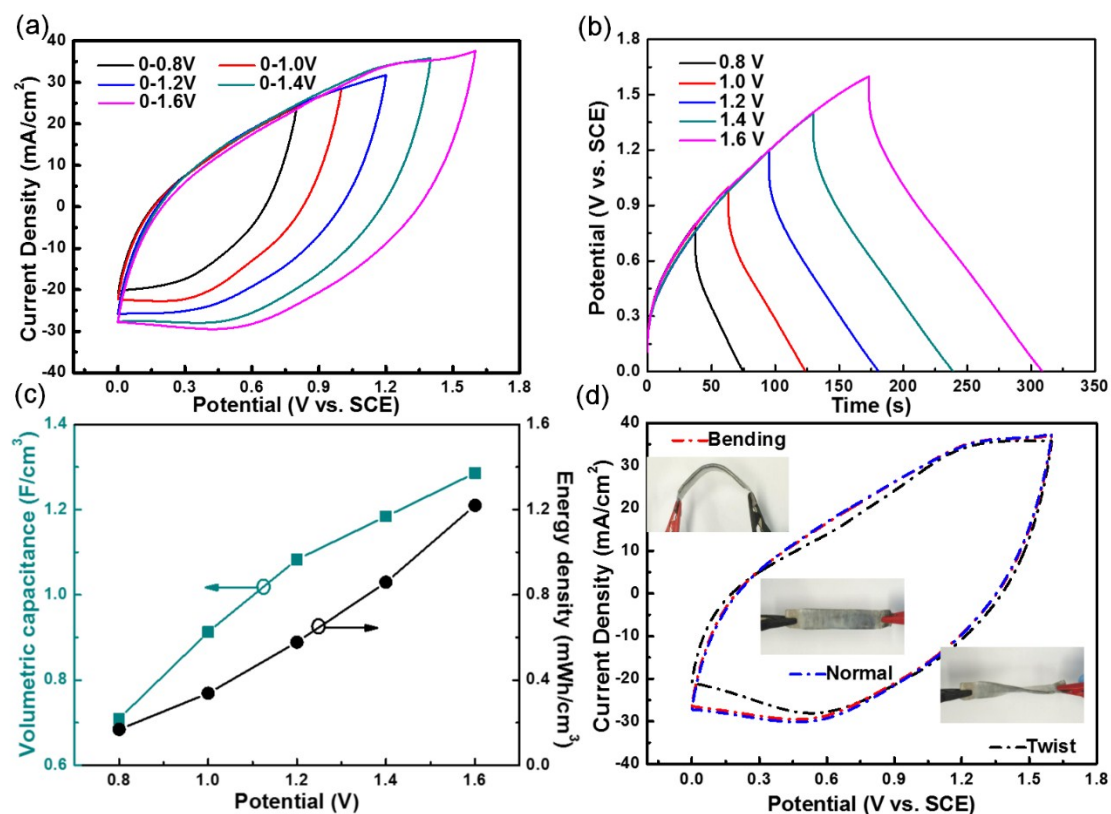
Figure S8 (a) CV curves of the $Co_3O_4@Co_3S_4$//AC ASCs measured at various potential windows with a scan rate of 20 mV s^{-1}; (b) Galvanostatic discharge-charge curves collected at different potential windows for the $Co_3O_4@Co_3S_4$//AC ASCs (5 mA cm-2); (c) Volumetric capacitance calculated from CV and discharge curves as a function of potential window for the $Co_3O_4@Co_3S_4$//AC ASCs; (d) CV curves collected at a scan rate of 20 mV s^{-1} for the $Co_3O_4@Co_3S_4$//AC ASCs under normal, benting, and twist conditions, and the insets of (d) are the device pictures under test conditions.