Supporting information

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

Bo Liu,‡a Dezhi Kong,‡a,b Ye Wang,a Jun Zhang,c Tupei Chen,c Chuanwei Cheng,b and Hui Ying Yang,a,*

a Pillar of Engineering Product Development, Singapore University of Technology and Design, 8 Somapah Road, Singapore, 487372
b Shanghai Key Laboratory of Special Artificial Microstructure Materials and Technology, School of Physics Science and Engineering, Tongji University, Shanghai 200092, P. R. China
c School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798, Singapore
‡ These authors contribute equally to this work.

*Corresponding author. Tel.: +65 6303 6663; Fax: +65 6779 5161. E-mail address: yanghuiying@sutd.edu.sg (H. Y. Yang)
Figure S1 Optical photograph of Ni foam substrate (a), Co-based precursor on Ni foam (b), Co$_3$O$_4$ NNAs on Ni foam (c), and Co$_3$O$_4$@Co$_3$S$_4$ NAs on Ni foam (d).
Figure S2  (a) SEM image of the Co$_3$O$_4$@Co$_3$S$_4$ 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$_3$O$_4$@Co$_3$S$_4$ NAs; (b) Adsorption-desorption isotherms of the Co$_3$O$_4$ NNAs and Co$_3$O$_4$@Co$_3$S$_4$ NAs.
Figure S4 (a) XRD patterns and (b) Raman spectra of Co$_3$O$_4$ NNAs, Co$_3$O$_4$@Co$_3$S$_4$ NAs 12h, Co$_3$O$_4$@Co$_3$S$_4$ NAs 24h, and Co$_3$O$_4$@Co$_3$S$_4$ NAs 36h.
Figure S5 (a) CV and (b) galvanostatic charge-discharge curves of the Co$_3$O$_4$ NNAs electrode; (c) CV and (d) galvanostatic charge-discharge curves of Co$_3$O$_4$@Co$_3$S$_4$ NAs prepared at 12 h in the second hydrothermal synthesis process; (e) CV and (f) galvanostatic charge-discharge curves of Co$_3$O$_4$@Co$_3$S$_4$ NAs prepared at 36 h in the second hydrothermal synthesis process.
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**Table 1.** Scan-Rate-Dependent Specific Capacitances (F/g) of the Co$_3$O$_4$, Co$_3$O$_4$@Co$_3$S$_4$ 12 h, Co$_3$O$_4$@Co$_3$S$_4$ 24 h, and Co$_3$O$_4$@Co$_3$S$_4$ 36 h Electrodes
Figure S6 (a) Cycling performance of the Co$_3$O$_4$ NNAs and Co$_3$O$_4$@Co$_3$S$_4$ 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$_3$O$_4$ NNAs and Co$_3$O$_4$@Co$_3$S$_4$ NAs electrodes, respectively.
Figure S7 (a) The CV comparison of the activated carbon electrodes and the Co₃O₄@Co₃S₄ 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 Co₃O₄@Co₃S₄//AC ASCs at various scan rates.
Figure S8 (a) CV curves of the Co₃O₄@Co₃S₄//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 Co₃O₄@Co₃S₄//AC ASCs (5 mA cm⁻²); (c) Volumetric capacitance calculated from CV and discharge curves as a function of potential window for the Co₃O₄@Co₃S₄//AC ASCs; (d) CV curves collected at a scan rate of 20 mV s⁻¹ for the Co₃O₄@Co₃S₄//AC ASCs under normal, bending, and twist conditions, and the insets of (d) are the device pictures under test conditions.