Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information for:

Hierarchical Three-Dimensional $NiCo_2O_4$ nanoneedle arrays supported on Ni foam for high-performance supercapacitors

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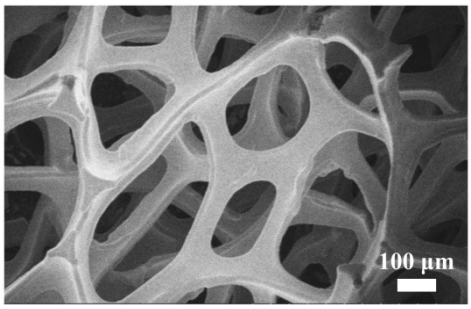

Fig. S1: SEM images of clean Ni foam.

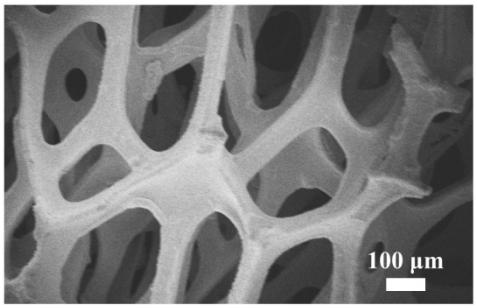

Fig. S2: SEM images of $NiCo_2O_4$ nanoneedle arrays grow on Ni foam.

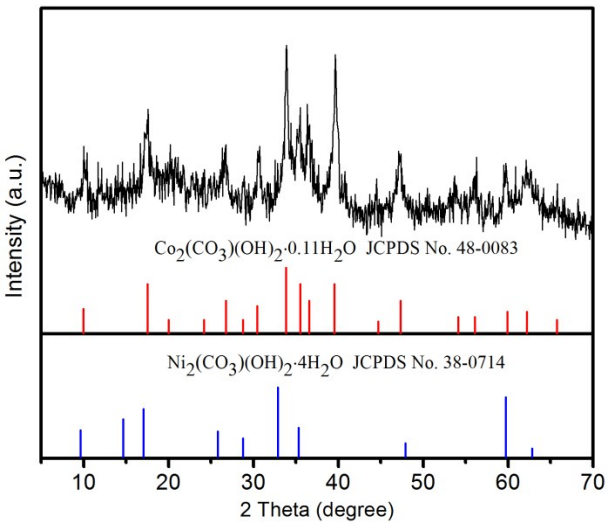

Fig. S3: XRD pattern of the as-prepared precursor.

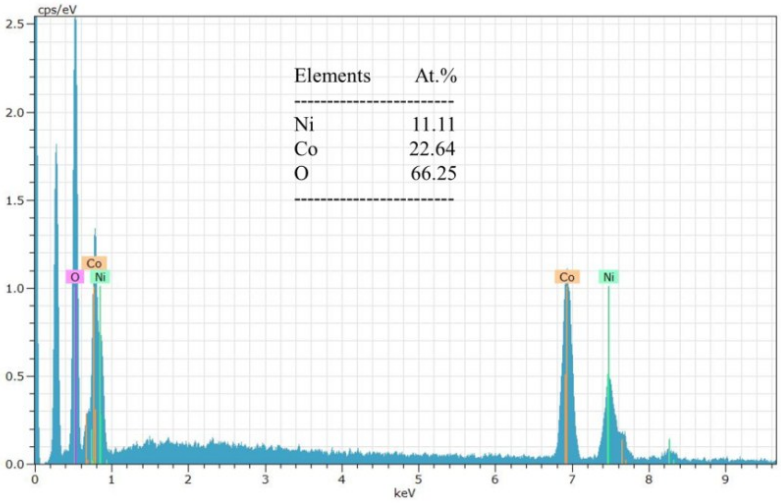

Fig. S4: EDX pattern of the $NiCo_2O_4$ nanoneedle arrays.

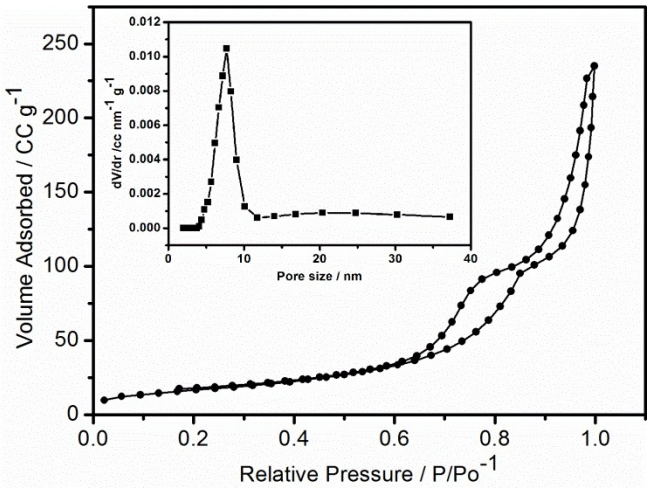

Fig. S5: BET isotherm plots and corresponding BJH pore distributions (insets) of the $NiCo_2O_4$ nanoneedle arrays.

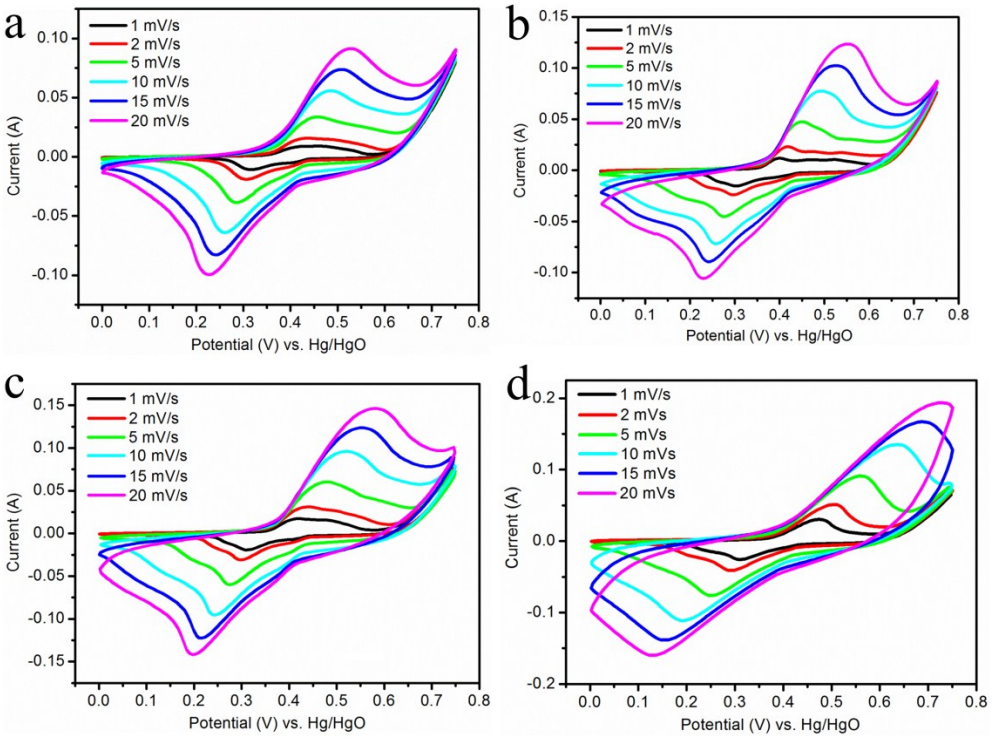

Fig. S6: Cyclic voltammetry curves of the hierarchical $NiCo_2O_4$ array electrodes in a three-electrode cell with 2 M KOH aqueous solution at various scan rates: (a) nanosheet (1 h); (b) nanosheet (2 h); (c) nanosheet-nanoneedle (4 h); (d) nanoneedle (8 h) arrays.

Table S1. Comparison of the electrochemical performances of the 3D hierarchical $NiCo_2O_4$ nanoneedle arrays with other reported ones.

Nanostructures	Areal capacitance	Special capacitance	Mass loading	Refs
$NiCo_2O_4$ nanoneedle arrays	3.71 F/cm^2 at 1 mA/cm^2	2193 F/g at 1 A/g	1.64 mg/cm^2	This work
$NiCo_2O_4$ nanoneedle arrays	3.12 F/cm^2 at 1.1 mA/cm^2	1118.6 F/g at 5.56 mA/cm^2	0.9 mg/cm^2	[1]
$NiCo_2O_4$ nanoneedle arrays	0.41 F/cm^2 at 10 mA/cm^2		0.3 mg/cm^2	[2]
$Co_{0.5}Ni_{0.5}$ DHs/NiC composites	2.3 F/cm^2 at 2 mA/ cm^2		1.0 mg/cm^2	[2]

$NiCo_2O_4$ nanoneedle arrays	0.66 F/cm^2 at 2 mA/cm^2	660 F/g at 2 A/g		[3]
$NiCo_2O_4$ nanowire arrays	2.01 F/cm^2 at 2 mA/cm^2	~900 F/g at 10 mA/cm^2	1.15 mg/cm^2	[4]
$NiCo_2O_4@MnO_2$ core/shell nanowire arrays	3.31 F/cm^2 at 2 mA/cm^2	1471.4 F/g at 10 mA/cm^2	1.4 mg/cm^2	[4]
$NiCo_2O_4$ nanosheet arrays	3.51 F/cm^2 at 1.8 mA/cm^2	1743.4 F/g at 7.08 A/g	1.2 mg/cm^2	[5]
$Co_3O_4@NiO$ nanowire arrays	2.56 F/cm^2 at 2 A/g	853 F/g at 2 A/g	~ 2.1 mg/cm^2 for Co_3O_4 and ~ 0.9 mg/cm^2 for NiO	[6]
$NiCo_2O_4@$ $NiCo_2O_4$ core/shell nanoflake arrays	2.20 F/cm^2 at 5 mA/cm^2	1115.6 F/g at 5 mA/cm^2	1.34 mg/cm^2 for core and 0.63 mg/cm^2 for shell	[7]

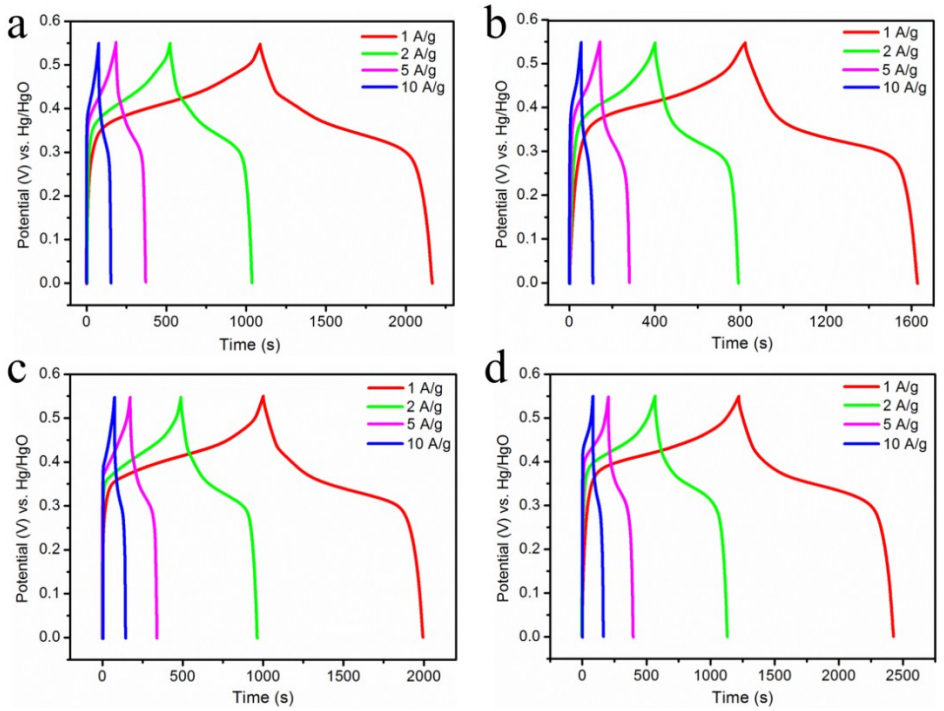

Fig. S7: Charge and discharge curves of (a) nanosheets-1, (b) nanosheets-2, (c) nanosheets-nanoneedles, and (d) nanoneedles at different current densities of 1, 2, 5, and 10 A/g.

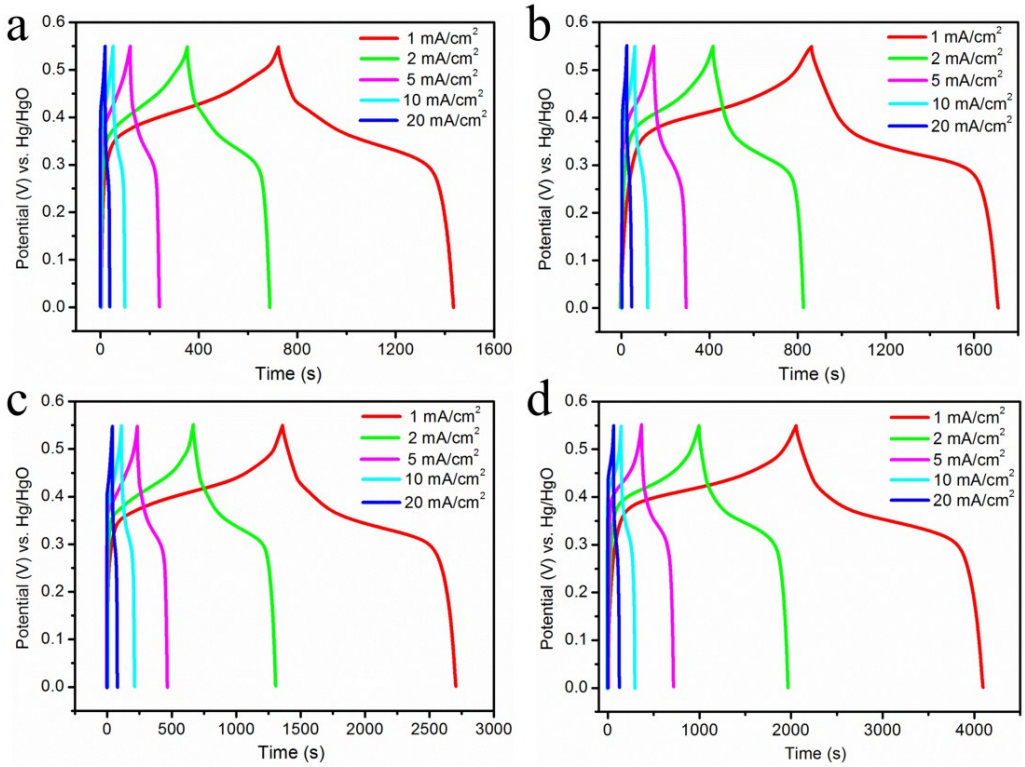

Fig. S8: Charge and discharge curves of (a) nanosheets-1, (b) nanosheets-2, (c) nanosheets-nanoneedles, and (c) nanoneedles at different current densities of 1, 2, 5, 10, and 20 mA/cm^2.

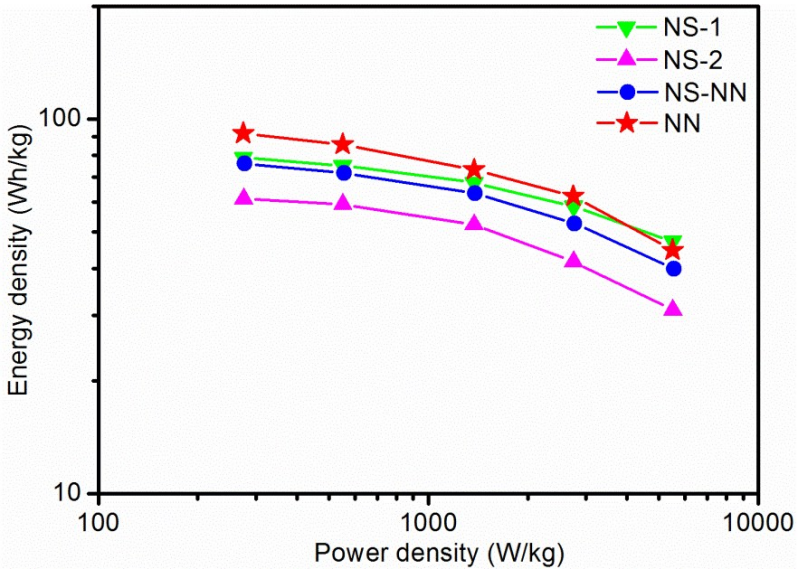

Fig. S9: Ragone plot of the power and energy density of (a) nanosheets-1, (b) nanosheets-2, (c) nanosheets-nanoneedles, and (d) nanoneedles at different current densities of 1, 2, 5, 10 and 20 A/g.

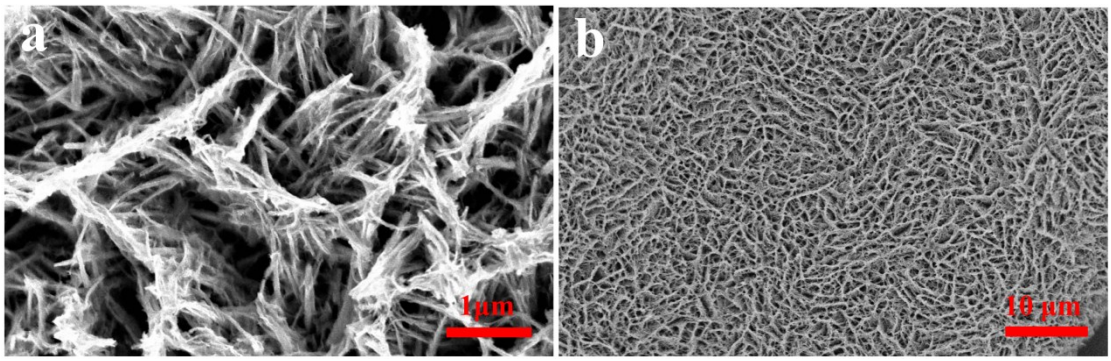

Fig. S10: SEM image of $NiCo_2O_4$ nanoneedle arrays after 2000 cycles.

[1] G. Q. Zhang, H. B. Wu, H. E. Hoster, M. B. Chan-Park and X. W. Lou, *Energy Environ. Sci.*, 2012, **5**, 9453-9456.

[2] L. Huang, D. C. Chen, Y. Ding, S. Feng, Z. L. Wang and M. L. Liu, *Nano Lett.*, 2013, **13**, 3135-3139.

[3] D. Y. Zhang, H. L. Yan, Y. Lu, K. W. Qiu, C. L. Wang, C. C. Tang, Y. H. Zhang, C. W. Cheng, Y. S. Luo, Nanoscale Res Lett., 9 (2014) 139-148.

[4] L. Yu, G. Q. Zhang, C. Z. Yuan and X. W. Lou, *Chem. Commun.*, 2013, **49**, 137-139.

[5] G. Q. Zhang, X. W. Lou, Adv. Mater., 25 (2013) 976-979.

[6] X. H. Xia, J. P. Tu, Y. Q. Zhang, X. H. Wang, C. D. Gu, X.-b. Zhao, H.J. Fan, ACS Nano, 6 (2012) 5531-5538.

[7] X. Y. Liu, S. J. Shi, Q. Q. Xiong, L. Li, Y. J. Zhang, H. Tang, C. D. Gu, X. L. Wang and J. P. Tu, *ACS Appl. Mater. Interfaces*, 2013, **5**, 8790-8795.