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

Electronic Supporting Information

Fabrication of urchin-like $NiCo_2(CO_3)_{1.5}(OH)_3$@$NiCo_2S_4$ on the Ni foam by ion exchange route and applying to asymmetric supercapacitor

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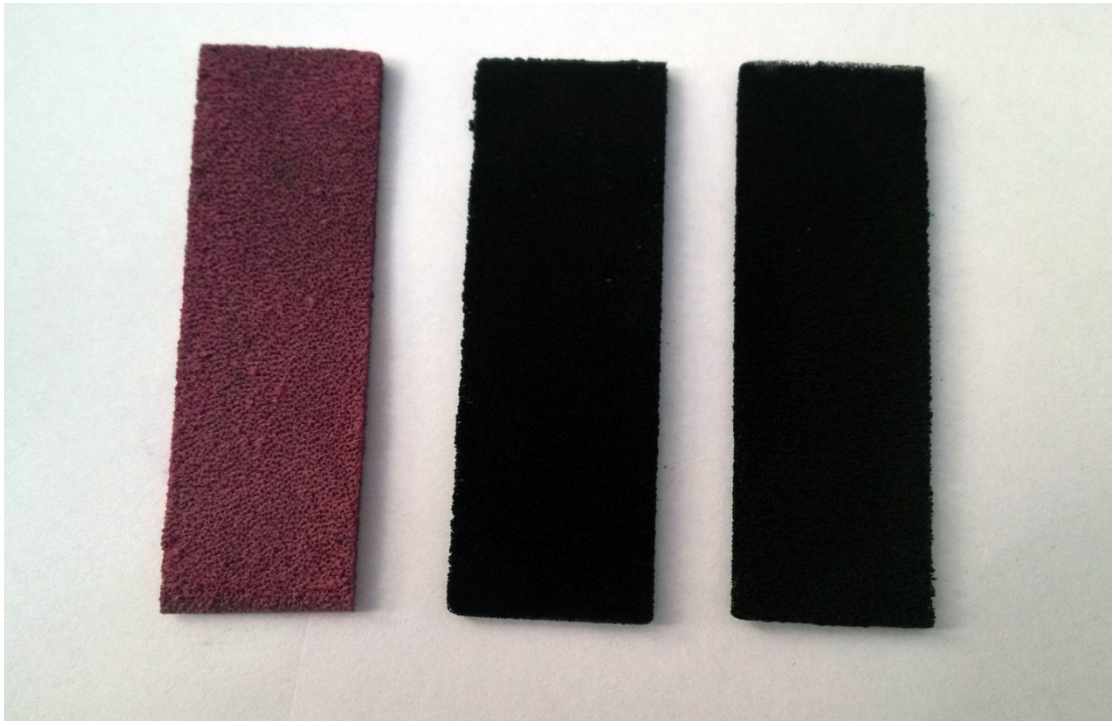

Fig. S1 the photography of urchin-like $NiCo_2(CO_3)_{1.5}(OH)_3$ (left), $NiCo_2S_4$ (middle) and $NiCo_2(CO_3)_{1.5}(OH)_3$@$NiCo_2S_4$ (right).

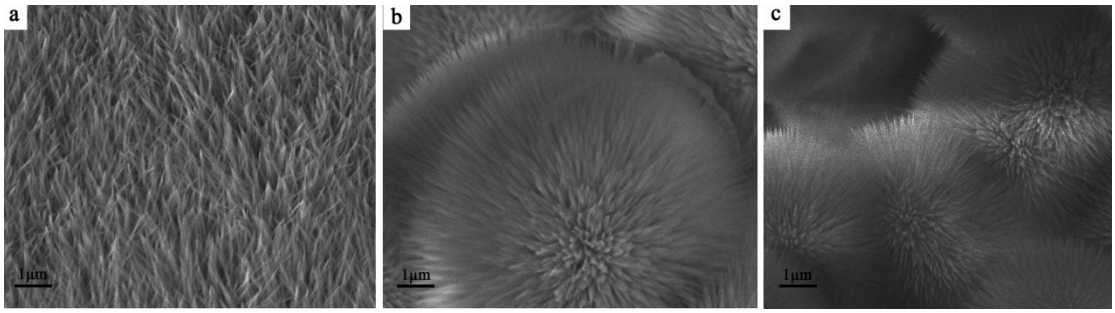

Fig. S2 the SEM images of $NiCo_2(CO_3)_{1.5}(OH)_3$ nanowires (a), urchin-like $NiCo_2(CO_3)_{1.5}(OH)_3$ (b) and urchin-like $NiCo_2S_4$ (c).

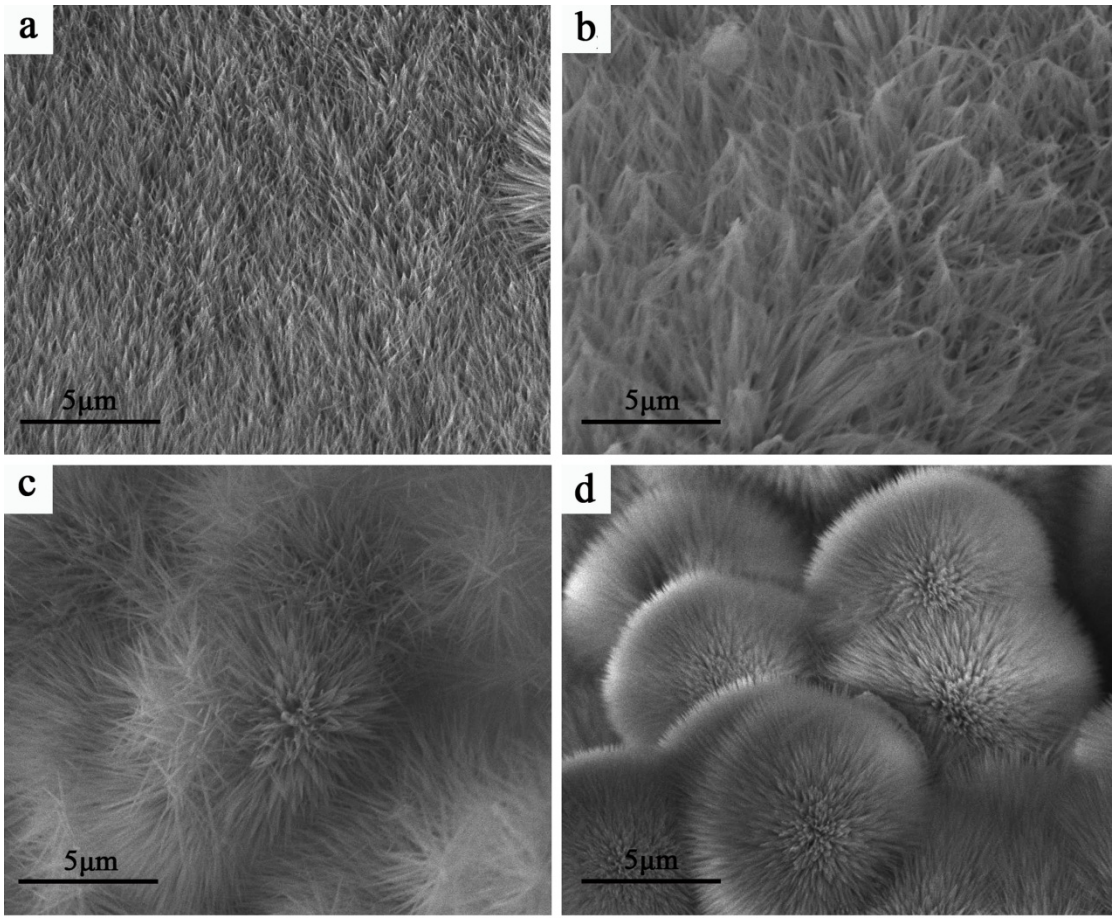

Fig. S3. the SEM images of the precursors at different reaction time, (a) 12h, (b) 16h, (c) 20h, (d) 24h,

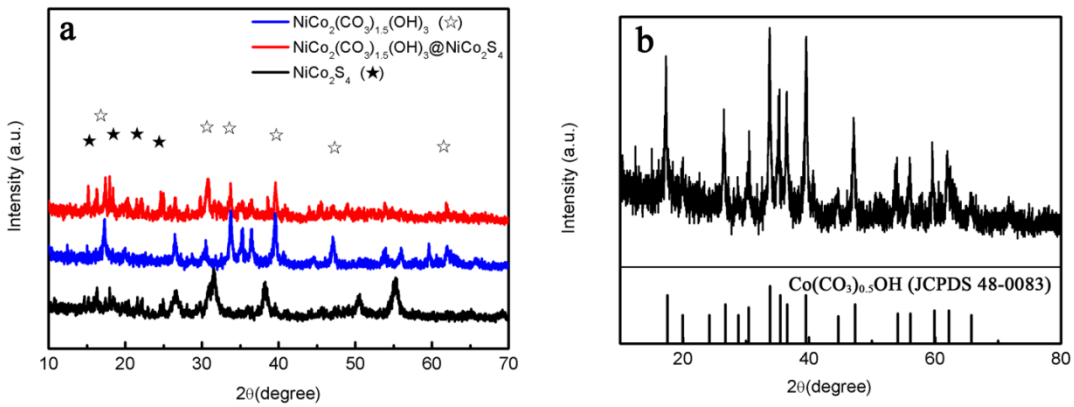

Fig. S4 (a) XRD patterns of $NiCo_2(CO_3)_{1.5}(OH)_3$, $NiCo_2S_4$ and $NiCo_2(CO_3)_{1.5}(OH)_3$@ $NiCo_2S_4$, (b) XRD patterns of $NiCo_2(CO_3)_{1.5}(OH)_3$.

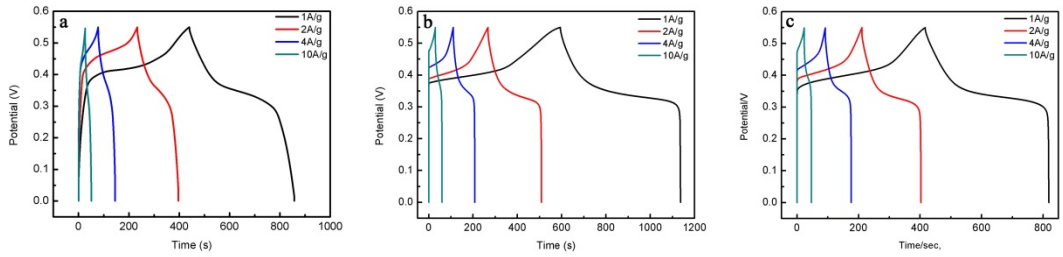

Fig. S5. The GCD curves of different electrode at current density of 1, 2, 4, 10 A g^{-1}. (a) urchin-like $NiCo_2(CO_3)_{1.5}(OH)_3$, (b) urchin-like $NiCo_2S_4$ (c) $NiCo_2(CO_3)_{1.5}(OH)_3$ @$NiCo_2S_4$ nanowires.

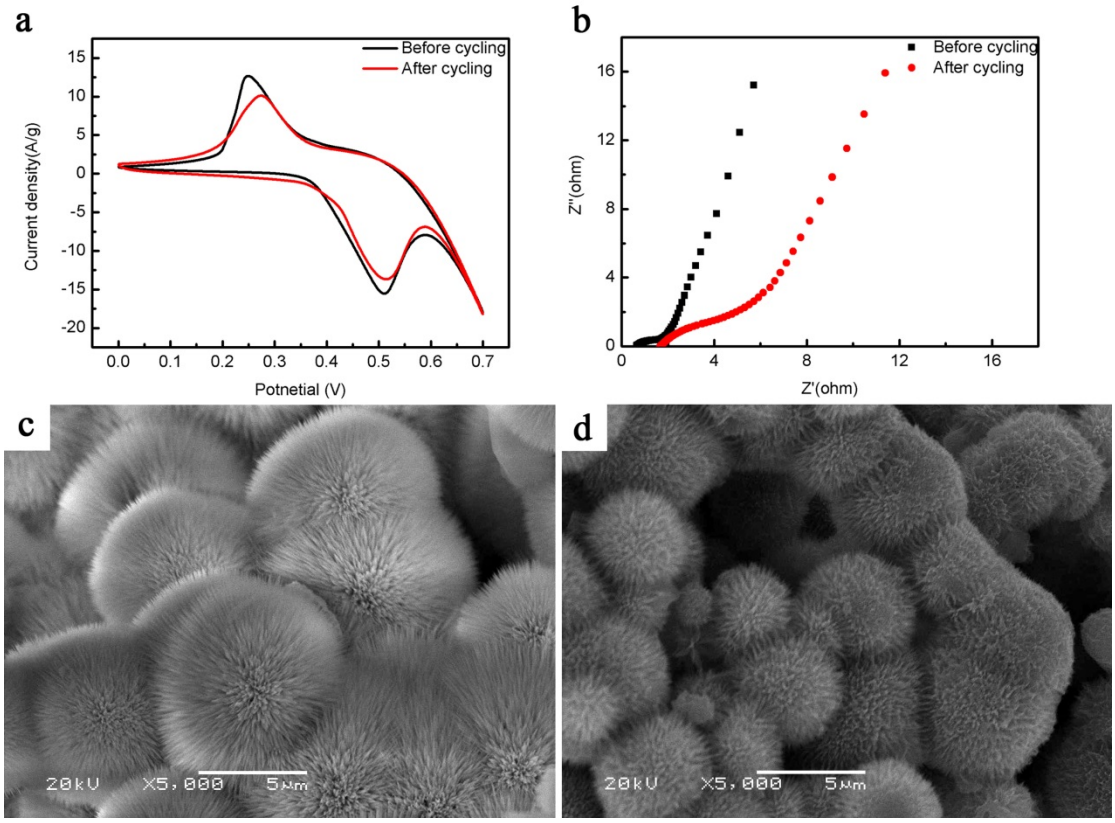

Fig. S6 (a) the CV curves of before and after cycling, (b) the EIS plots of before and after cycling (c) the SEM image of before cycling, (d) the SEM image of after cycling.

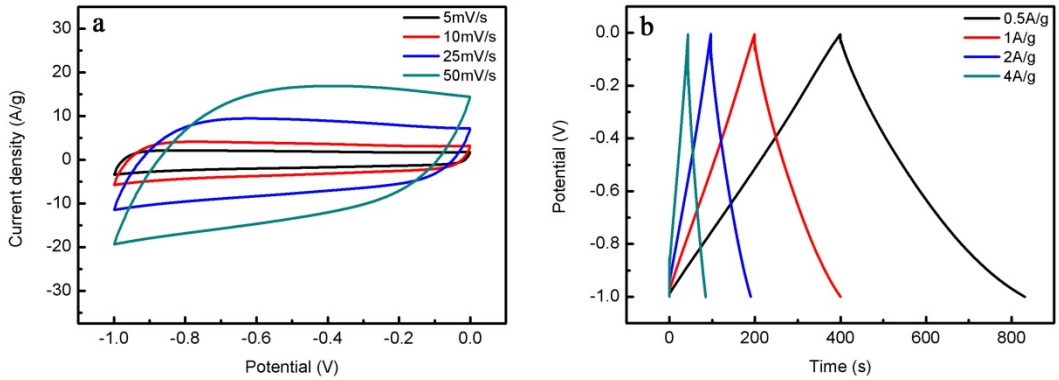

Figure S7. (a) CV curves of AC electrode at different scan rate, (b) charge-discharge curves of AC electrode at different current densities.

Table S1. Comparison of the maximum energy densities, corresponding average power densities and voltage range of the reported nickel, colbat or bimetal oxide/hydroxide/sulfides based asymmetric supercapacitors and the present work.

Positive materials//negative materials	Energy density ($W\ h\ kg^{-1}$)	Power density ($W\ kg^{-1}$)	Voltage range	Ref.
Nickel cobalt LDHs//AC	23.7	280	0-1.2	[1]
$NiCo_2S_4$//RGO	31.5	156.6	0-1.6	[2]
$Co_{0.45}Ni_{0.55}O$-RGO//RGO	35.3	330	0-1.5	[3]
Ni_3S_2/MWCNT-NC//AC	19.8	798	0-1.6	[4]
$NiCo_2O_4$-CQDs//AC	27.8	128	0-1.5	[5]
CoS_x-NSA//rGO	14.68	369	0-1.55	[6]
$Ni(OH)_2$@3D Ni//AC	21.8	660	0-1.3	[7]
CoO@PPy//AC	43.5	87.5	0-1.8	[8]
Co_3O_4//AC	34	225	0-1.5	[9]
$Ni(OH)_2$//AC	35.7	490	0-1.3	[10]
$NiCo_2O_4$@MnO_2//AC	35	163	0-1.5	[11]
$NiCo_2(CO_3)_{1.5}(OH)_3$@$NiCo_2S_4$ //AC	42.55	458.8	0-1.6	This work

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