Supporting Information

Electric field-induced ball-cactus like $CuCo_2S_x(OH)_y$ nano-heterostructure towards high-performance supercapacitors

Faxue Lu[a], Yajun Ji*[a], Dong Shi[a], Junnan Yao[a], Pengcheng Zhang[a], Shixiong Zhang[a]

[a] *School of Materials and Chemistry, University of Shanghai for Science and Technology, Jungong Road 334#, 200093 Shanghai, China.*

*Corresponding author: E-mail: jiyajun@usst.edu.cn Fax: +86 21 65667144; Tel: +86 21 65667144

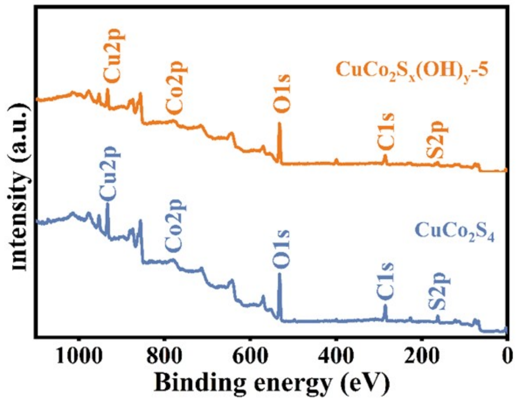

Fig. S1 XPS survey spectrum of the as-synthesized $CuCo_2S_4$ and $CuCo_2S_x(OH)_y$-5

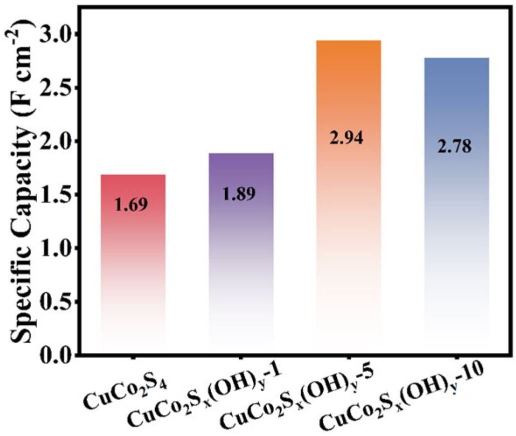

Fig. S2 The comparison of specific capacitance of different electrode materials at the current density of 5 mA cm^{-2}.

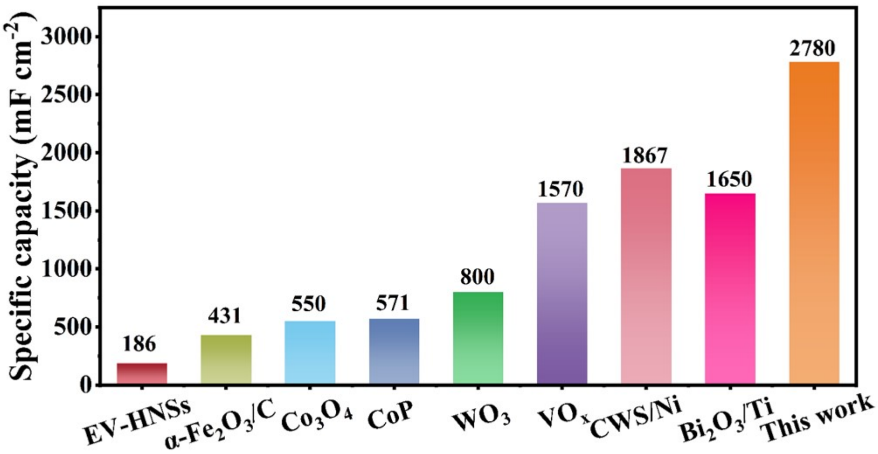

Fig. S3 Comparison of area specific capacitance (mF cm^{-2}) with other reported negative electrode materials.

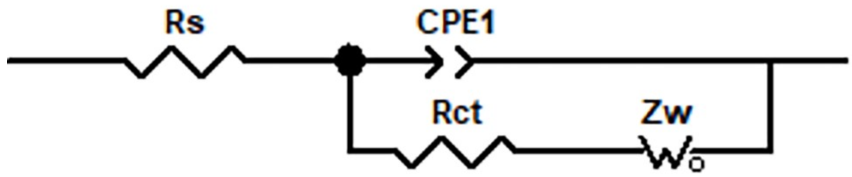

Fig. S4 The equivalent circuit model fitting Nyquist diagram.

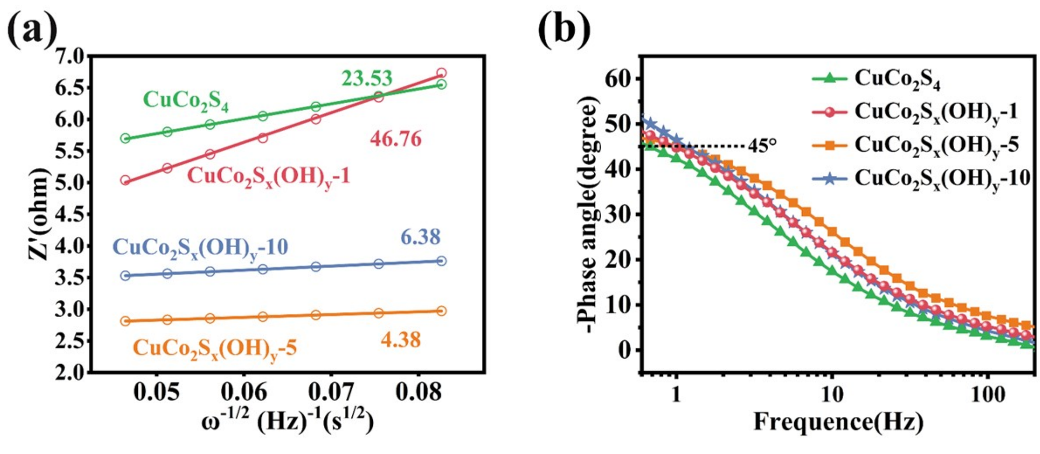

Fig. S5 (a) The linear relation between real part (Z') and the square root of frequency ($\omega^{-1/2}$) at low frequency region; (b) The bode plots of phase angle versus frequency.

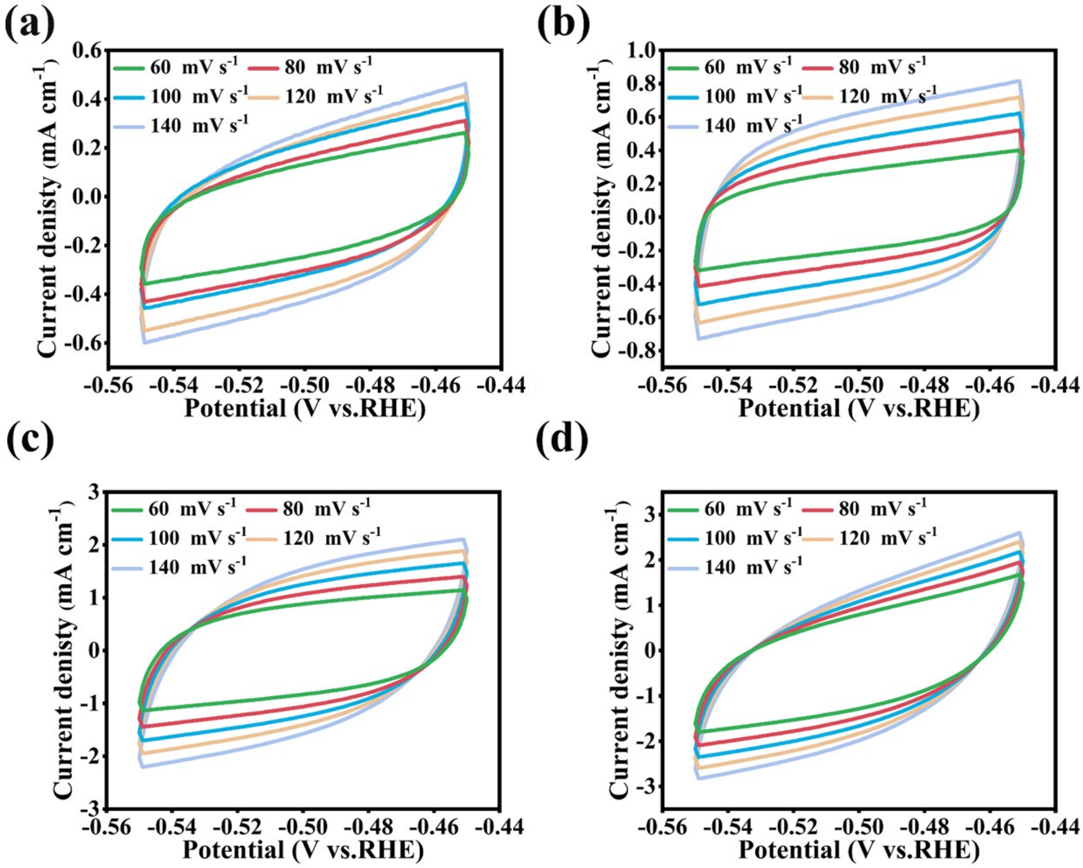

Fig. S6 CV curves of (a) $CuCo_2S_4$, (b) $CuCo_2S_xOH_y$-1, (c) $CuCo_2S_xOH_y$-5 and (d) $CuCo_2S_xOH_y$-10 at different scan rates (from 60 to 140 mV s^{-1}) with the potential range of -0.55 V to -0.45 V.

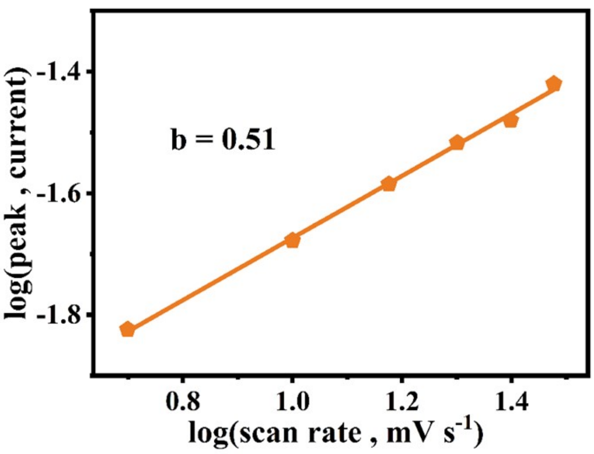

Fig. S7 Plot of the anodic peak current density against the scan rate for $CuCo_2S_xOH_y$-5 electrode.

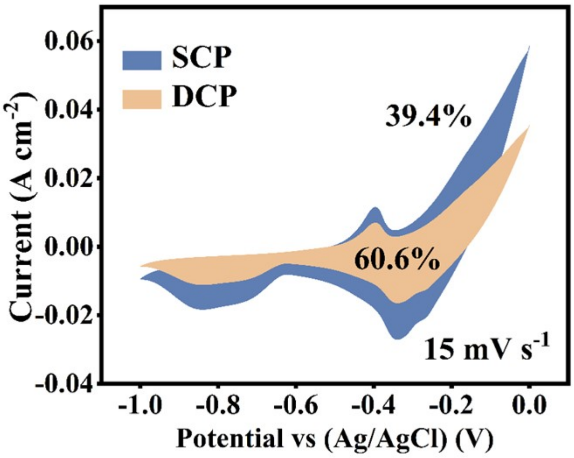

Fig. S8 The surface contribution and diffusive contribution of the $CuCo_2S_xOH_y$-5 electrode at the scan rate of 15 mV s^{-1}.

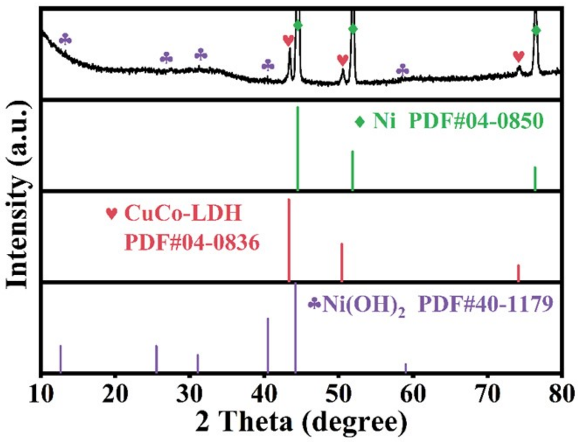

Fig. S9 XRD patterns of the as-synthesized CuCo-LDH@$Ni(OH)_2$.

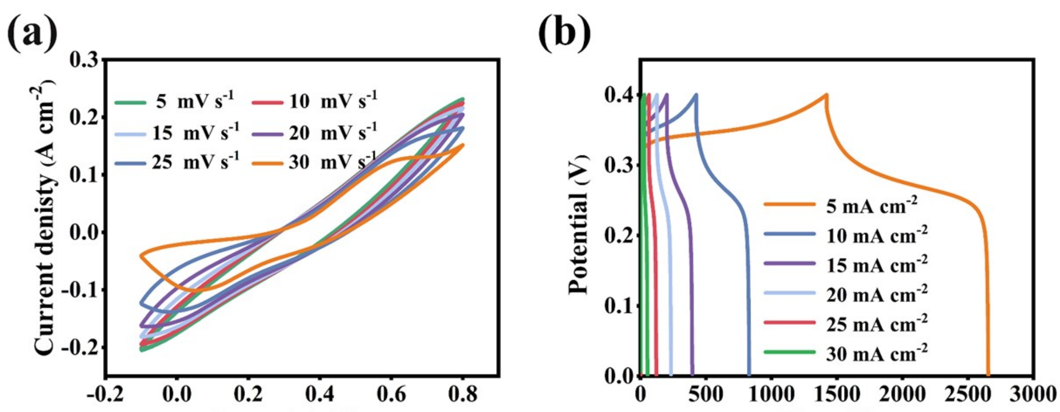

Fig. S10 (a) CV curves of CuCo-LDH@$Ni(OH)_2$ electrode at different scan rates from 5 mV s^{-1} to 30 mV s^{-1} and (b) the corresponding

GCD curves at different current densities from 5 mA cm^{-2} to 30 mA cm^{-2}.

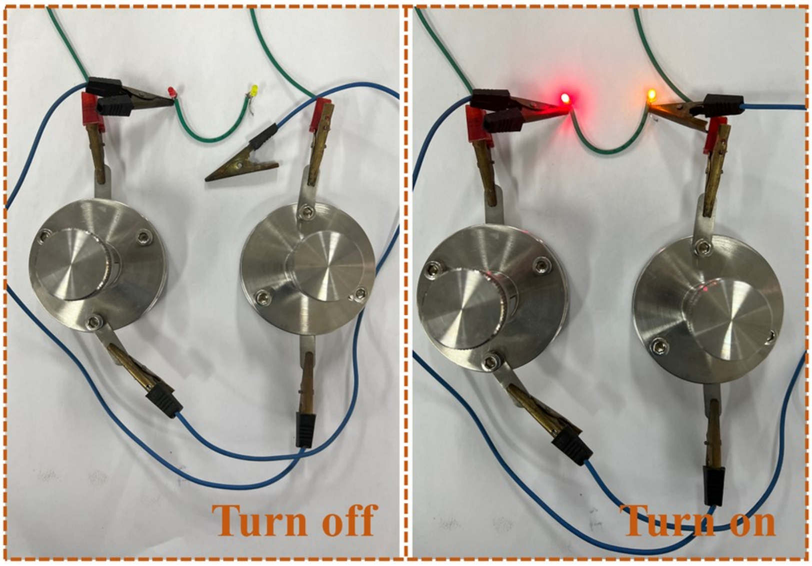

Fig. S11 Two LED lights powered by two series connected HSC devices.

Table S1 Comparison of the internal resistance (Rs) value and charge-transfer resistance (Rct) value of $CuCo_2S_4$ and $CuCo_2S_xOH_y$-1, $CuCo_2S_xOH_y$-5 and $CuCo_2S_xOH_y$-10.

Sample	Rs (Ω)	Rct (Ω)
$CuCo_2S_4$	3.5	2.8
$CuCo_2S_xOH_y$-1	3.2	2.1
$CuCo_2S_xOH_y$-5	2.2	1.0
$CuCo_2S_xOH_y$-10	2.7	2.1