Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Boosting electrochemical properties of $CoCo_2O_4$ porous nanowire arrays by microwave-assisted synthesis for battery-supercapacitor hybrid devices

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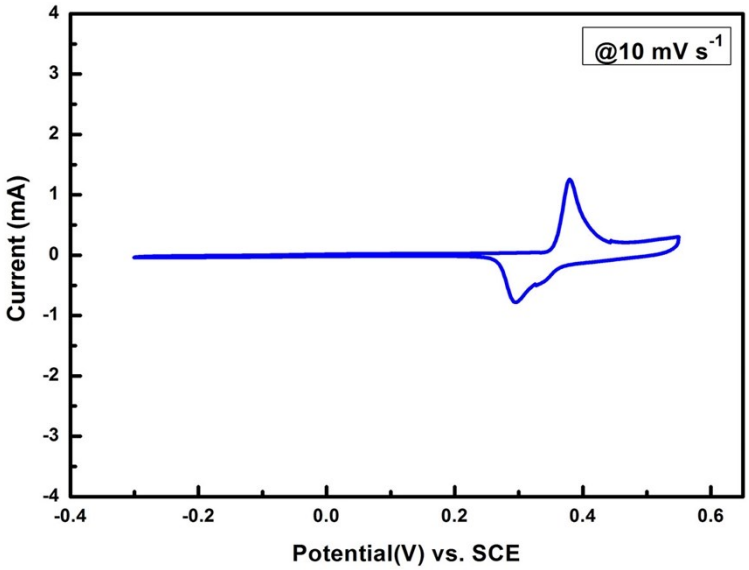

Fig. S1 CV curve at 10 mV s^{-1} of the bare Ni foam.

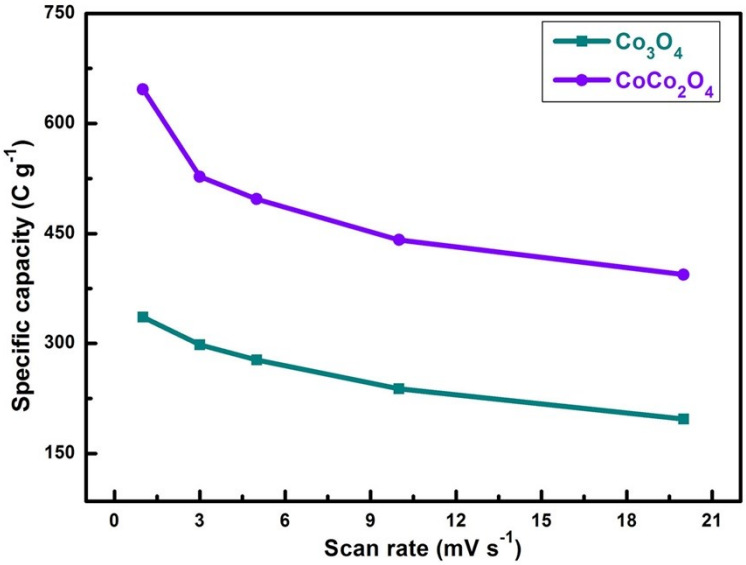

Fig.S2 Specific capacity measured of $CoCo_2O_4$ and Co_3O_4 electrodes at different scan rates.

The specific capacity (C g^{-1}) of the prepared cobalt oxide (Co_3O_4 and $CoCo_2O_4$) in

three-electrode system were measured by cyclic voltammetry (CV) using the following equation (S1).

$$Cs\left(C\ g^{-1}\right) = \frac{\int_{V_1}^{V_2} I_{(V)}\, dV}{2mv} \quad \text{(S1)}$$

where I is the current; m is the mass; v is the potential scan rate and ΔV (V_2-V_1) is the potential window.

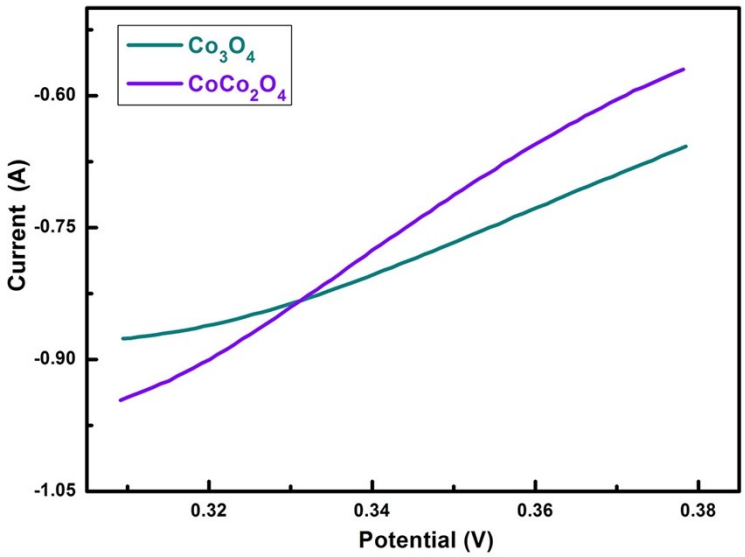

Fig.S3 *I-V* test curves of Co_3O_4 and $CoCo_2O_4$ electrode.

Tab.S1 Battery-supercapacitor hybrid device performances of Co_3O_4-based electrode materials prepared by different methods reported in the literature.

Single Electrode				Battery-supercapacitor hybrid device					
Structure of Co_3O_4 based material	**Method of synthesis**	**Specific capacitance**	**Retention**	**Assembly**	**Specific capacitance**	**Energy density (Wh/kg)**	**Power density (W/kg)**	**Retention**	**Reference**
Co_3O_4	Soak-adsorption	314 C g^{-1}/785 F g^{-1} (0.5A g^{-1})	93% (5000 cycles @ 5A g^{-1})	Co_3O_4//AC	/	13	257	85.9% (10000 cycles @ 5A g^{-1})	[1]
Co_3O_4/rGO-C	Template nano-casting technique	354.6 C g^{-1}/709.1 F g^{-1} (1A g^{-1})	91.2% (6000 cycles @ 50mV s^{-1})	Co_3O_4/rGO-C//rGO	154.2 F g^{-1} (1A g^{-1})	48.2	750.5	88.7% (5000 cycles @ 50mV s^{-1})	[2]
C/ Co_3O_4	Calcination	169.2 C g^{-1}/423 F g^{-1} (1A g^{-1})	83% (2000 cycles @ 3A g^{-1})	C/Co_3O_4//AC	60.76 F g^{-1} (1A g^{-1})	21.1	790	/	[3]
Co_3O_4/$NiCo_2O_4$	Hydrothermal	134.2 C g^{-1}/335.5 F g^{-1} (0.5A g^{-1})	73.6% (5000 cycles @ 10A g^{-1})	Co_3O_4//AC	15 F g^{-1} (0.5A g^{-1})	5.2	26.5 W/kg	87.6% (3000 cycles @ 1A g^{-1})	[4]
Co_3O_4/MnO_2	Annealing	292 F g^{-1} (4A g^{-1})	87.4% (5000 cycles @ 10A g^{-1})	Co_3O_4/MnO_2// AC	57.7 F g^{-1} (2A g^{-1})	46.2	/	84.5% (5000 cycles @ 10 A g^{-1})	[5]

Co_3O_4	Hydrothermal	598.5 C g^{-1} (1A g^{-1})	93.7% (8000 cycles @ 10A g^{-1})	Co_3O_4//AC	99.0 F g^{-1} (1A g^{-1})	22.5	800	91.8% (10000 cycles @ 10 A g^{-1})	6
NiMn LDH@Co_3O_4	Hydrothermal	243.2 C g^{-1}/607.9 F g^{-1} (0.5A g^{-1})	97% (1000 cycles @ 5A g^{-1})	NiMn LDH@Co_3O_4 // activated graphene	97.3 F g^{-1} (0.5 A g^{-1})	26.49	350	73 % (5000 cycles @3 A g^{-1})	7
$NiCo_2O_4$/ MWCNT/RGO	Hydrothermal	400.5 C g^{-1}//890 F g^{-1} (1A g^{-1})	91% (4000 cycles @ 5A g^{-1})	$NiCo_2O_4$/ MWCNT/RGO//AC	94.2 F g^{-1} (1A g^{-1})	34.5	750	90.2% (5000 cycles @ 10A g^{-1})	8
Co_3O_4	Electrochemical deposition	403 C g^{-1}/806 F g^{-1}	90.8% (5000 cycles @ 15A g^{-1})	Co_3O_4//AC	81 F g^{-1} (1A g^{-1})	25.3	752	86.5% (4000 cycles @ 5A g^{-1})	9
Co_3O_4@MnO_2	Hydrothermal	336 C g^{-1}/560 F g^{-1} (0.2A g^{-1})	95% (5000 cycles @ 5A g^{-1})	Co_3O_4@MnO_2//activated GO	49.8 F g^{-1} (1A g^{-1})	17.7	158	81.1% (10000 cycles @ 3A g^{-1})	10
$CoCo_2O_4$	**Microwave assisted hydrothermal**	**743.8 C g^{-1} (1A g^{-1})**	**89.7% (5000 cycles @ 15A g^{-1})**	**$CoCo_2O_4$//m-CNT**	**80.2 F g^{-1} (124.3 C g^{-1}) (1A g^{-1})**	**26.8**	**775.4**	**82.3% (5000 cycles @ 3A g^{-1})**	**This work**

Tab.S2 Summary the values of different components in the fitting of EIS data.

Parameter	Value	
	Hydrothermal synthesis Co_3O_4	Microwave synthesis $CoCo_2O_4$
R_s (Ω)	0.257	0.362
C_d (F)	1.137	1.085
R_{ct} (Ω)	1.119	0.712
W_2 ($\Omega.s^{-0.5}$)	1.710	0.979

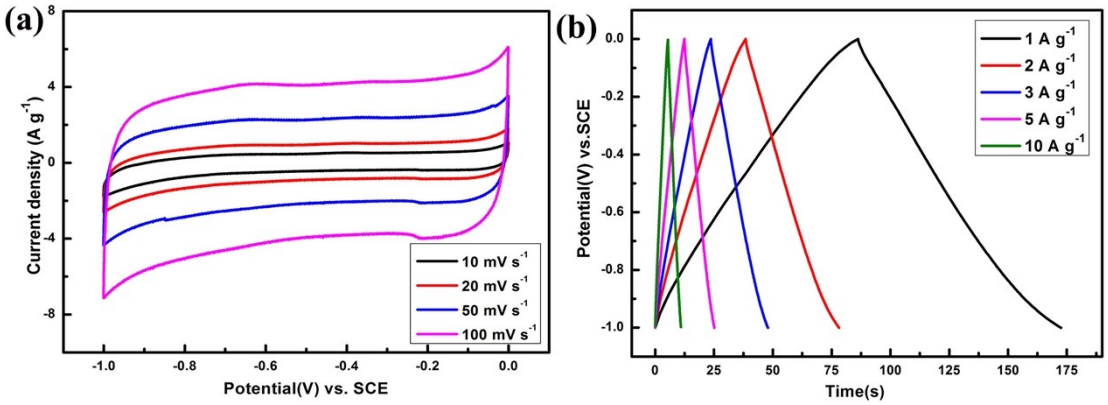

Fig.S4 CV curves at different scan rates (a), and GCD curves at different current densities (b) of the m-CNT electrode.

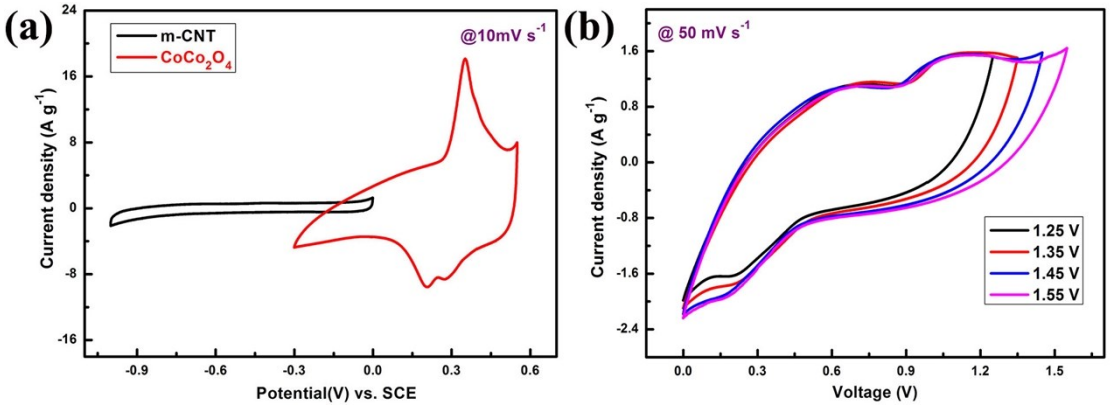

Fig.S5 (a) Comparative CV curves of m-CNT and $CoCo_2O_4$ electrodes in a three-electrode system at 10 mV s^{-1}. (b) CV curves of the BSH device measured at different potential windows at 50 mV s^{-1}.

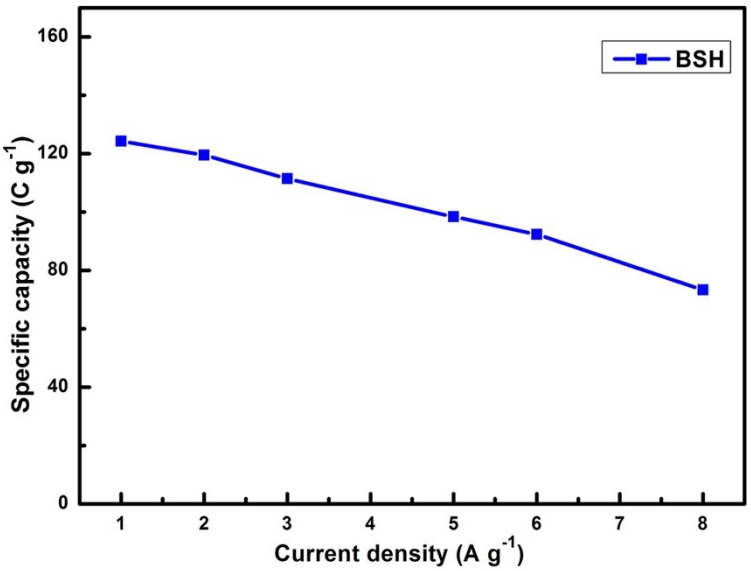

Fig.S6 Specific capacitance measured of $CoCo_2O_4$//m-CNT BSH at different current densities.

Tab.S3 Summary the values of different components in the fitting of EIS data.

Parameter	Value	Deviation
R_1 (Ω)	0.591	0.126
C_1 (F)	0.456	0.403
C_2 (F)	0.041	0.097
R_2 (Ω)	1.764	0.355
W_2 ($\Omega.s^{-0.5}$)	1.518	0.862

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