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

Supporting Information

An advanced sandwich-type architecture of $MnCo_2O_4$@N-C@MnO_2 as an efficient electrode material for a high-energy density hybrid asymmetric solid-state supercapacitor

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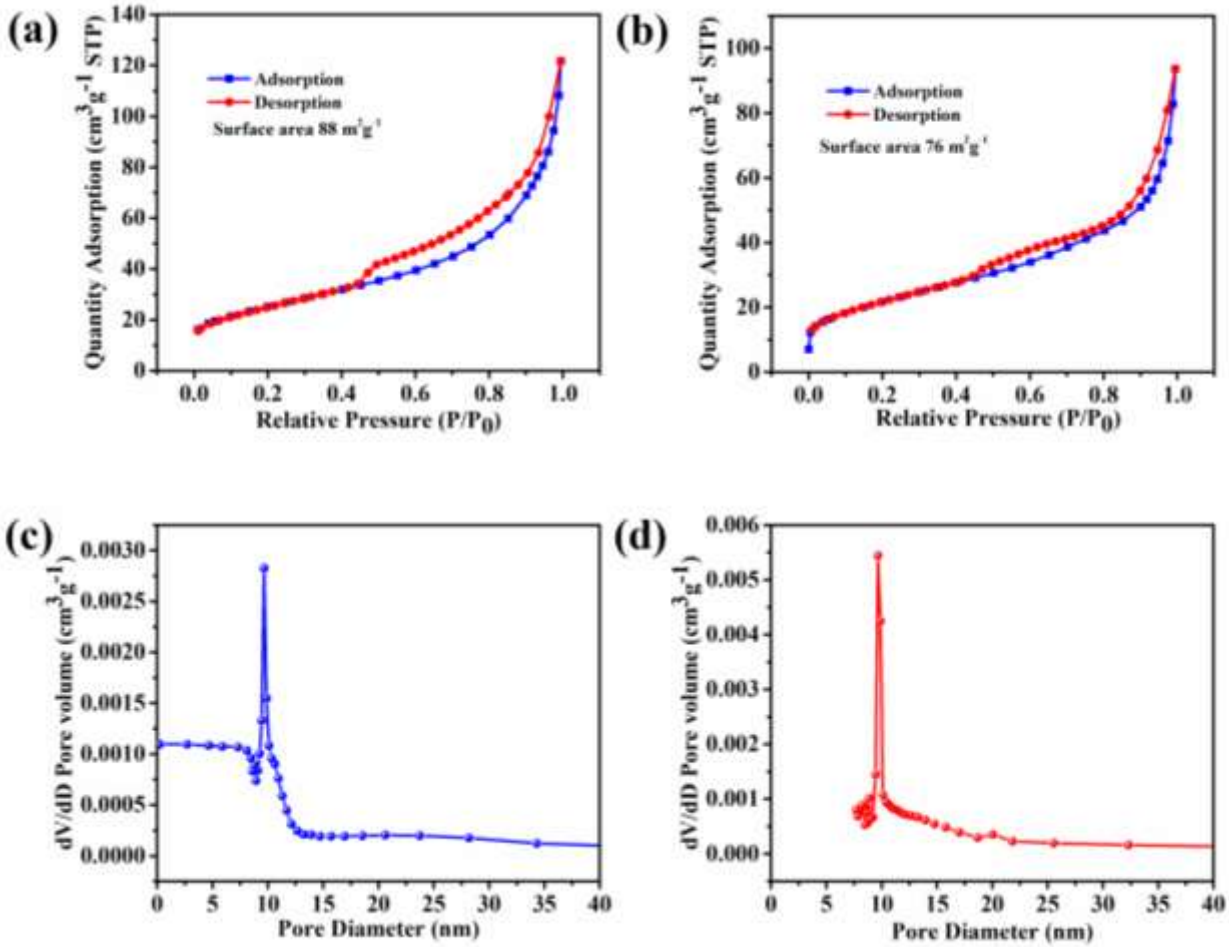

Figure S1. N_2 adsorption-desorption isotherm of (a) $MnCo_2O_4$@N−C, (b)$MnCo_2O_4$ and Pore size distribution (c) $MnCo_2O_4$@N−C,(d) $MnCo_2O_4$.

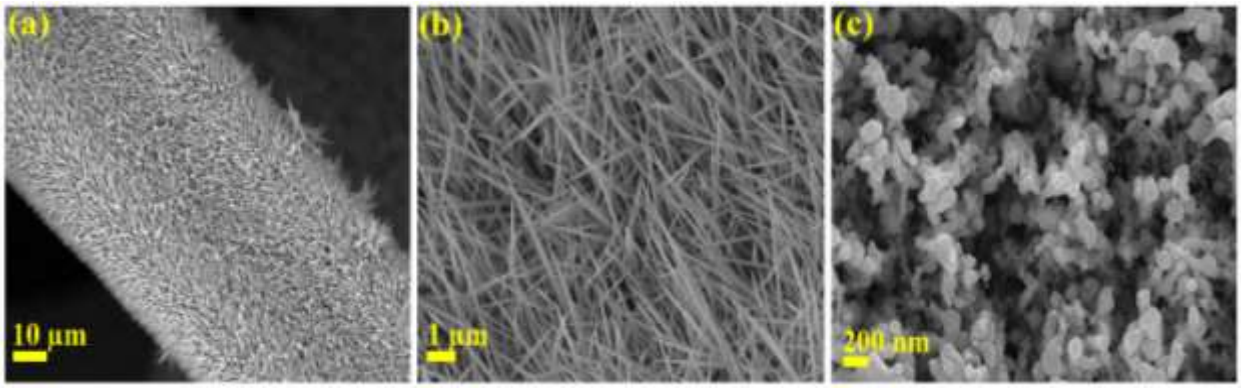

Figure S2. Low and high magnification FE-SEM images of (a and b) $MnCo_2O_4$ calcined under argon atmosphere (c) $MnCo_2O_4$ calcined under air atmosphere.

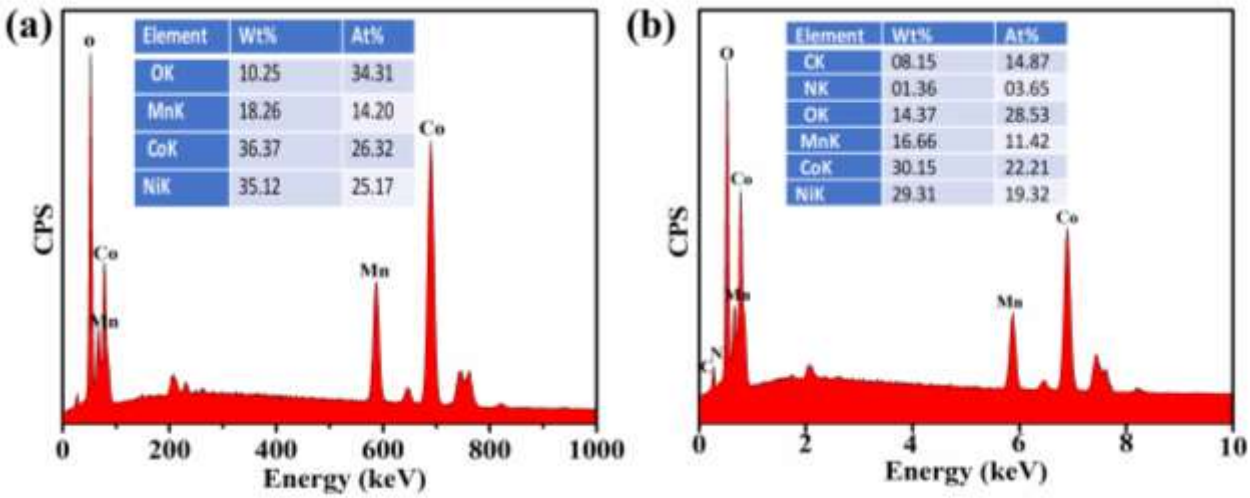

Figure S3. EDAX spectra of (a) $MnCo_2O_4$ nanowire (b) $MnCo_2O_4$@N–C core@shell.

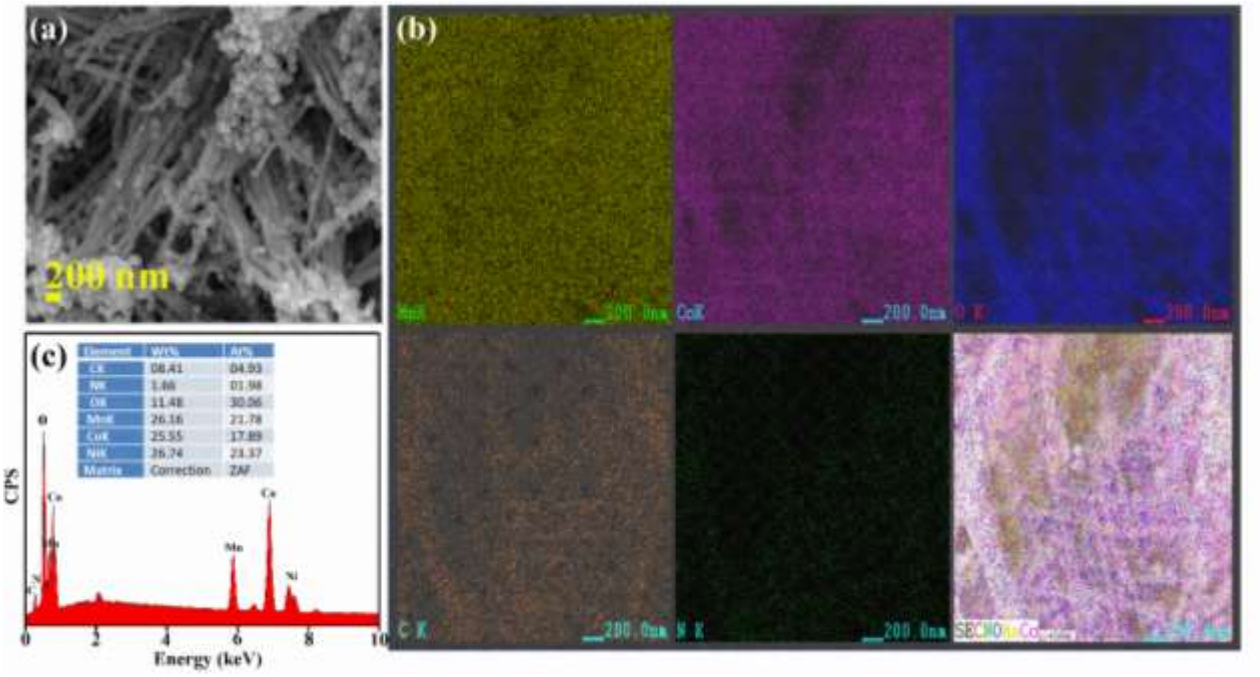

Figure S4. (a and b) The Color mapping spectra (c) EDAX of $MnCo_2O_4$@N–C@MnO_2 nanowire.

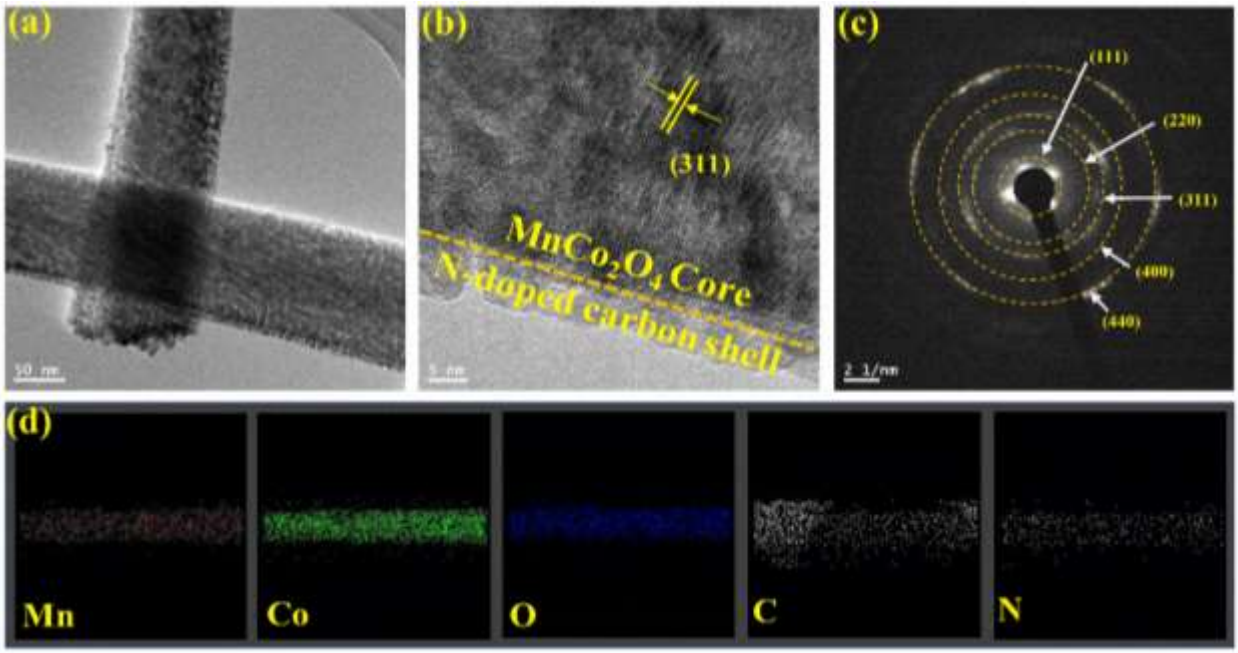

Figure S5. (a and b) High magnification HR-TEM, (c) SAED pattern and (d) color mapping of $MnCo_2O_4$@N–C core@shell.

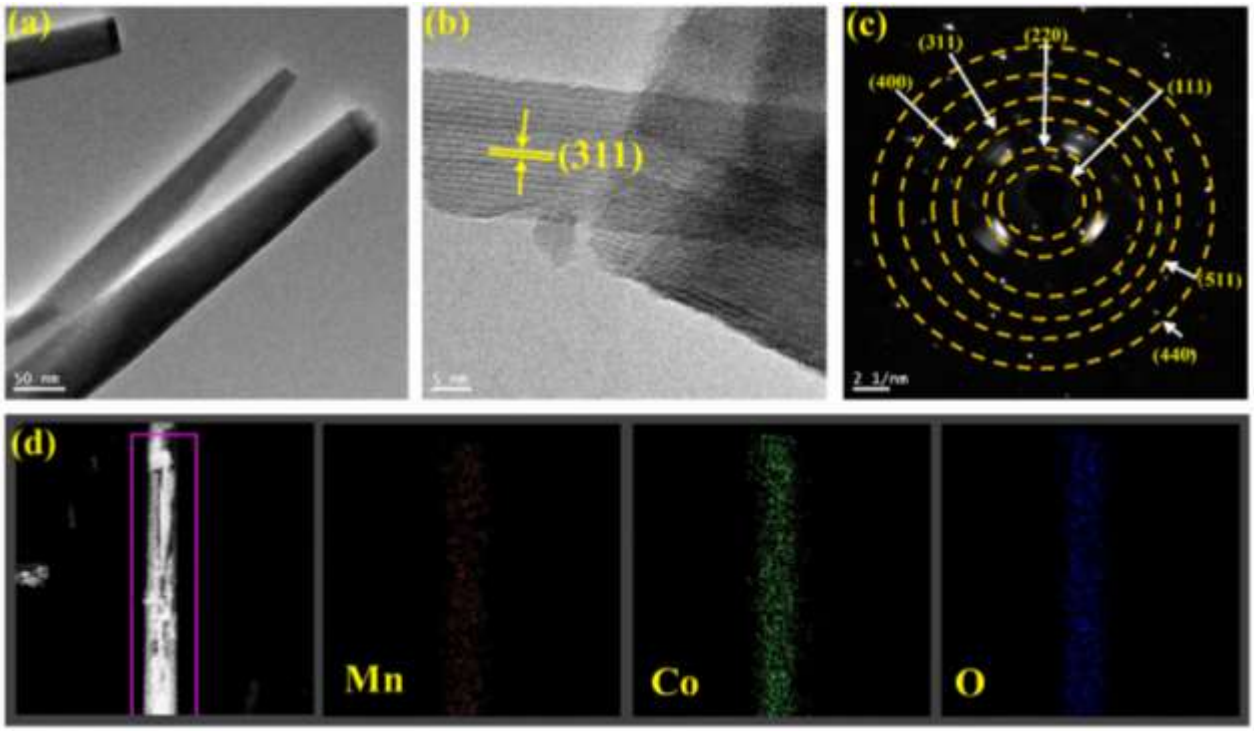

Figure S6. (a and b) High magnification HR-TEM, (c) SAED pattern and (d) color mapping of $MnCo_2O_4$.

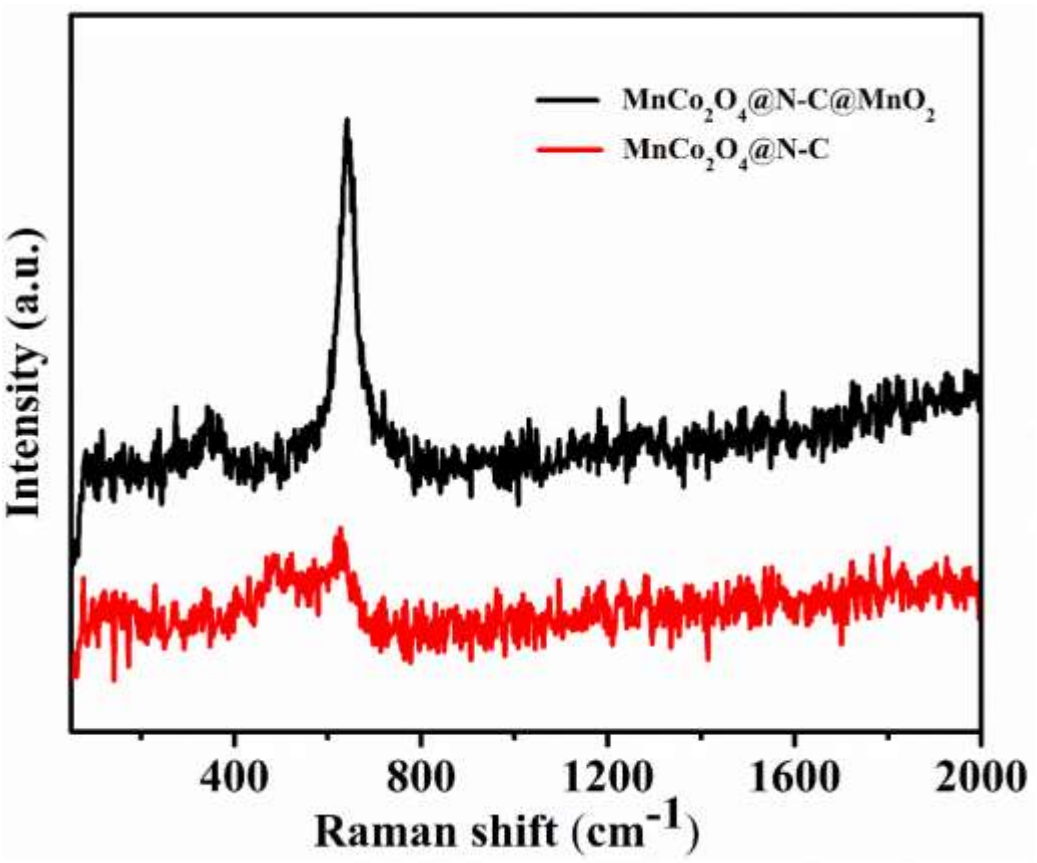

Figure S7. The Raman spectrum of $MnCo_2O_4$@N–C@MnO_2 and $MnCo_2O_4$@N–C.

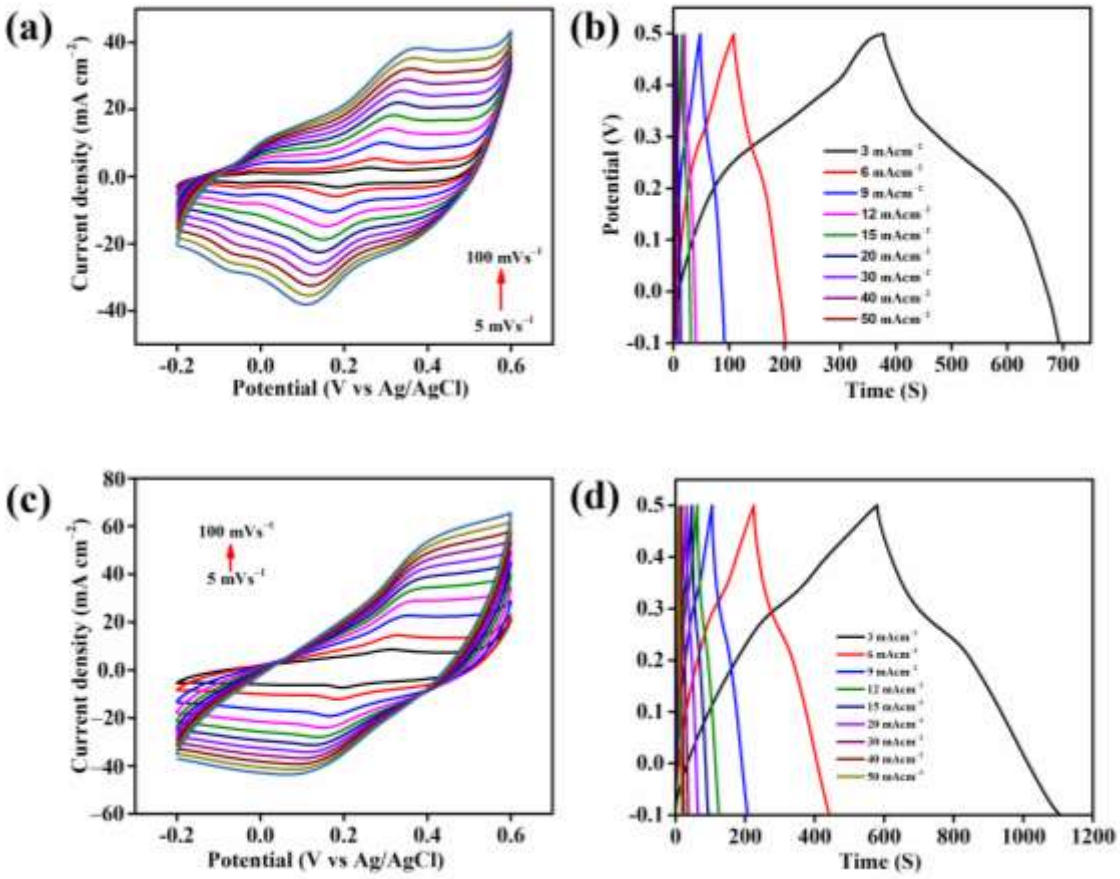

Figure S8. CV and GCD plot of (a, b) pure 1D $MnCo_2O_4$ and (c, d) $MnCo_2O_4$@N-C.

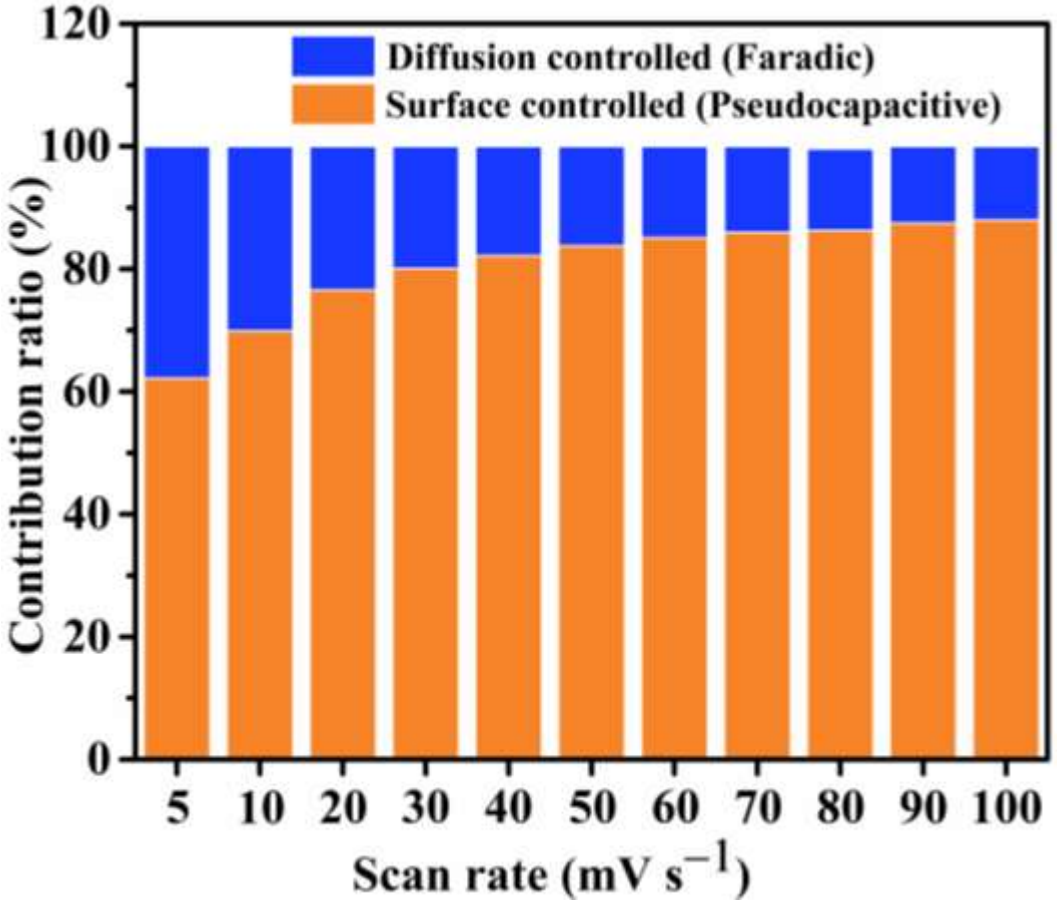

Figure S9. Bar chart showing the percentage of Faradic and pseudocapacitive contribution in at different scan rates of $MnCo_2O_4$@N–C@MnO_2.

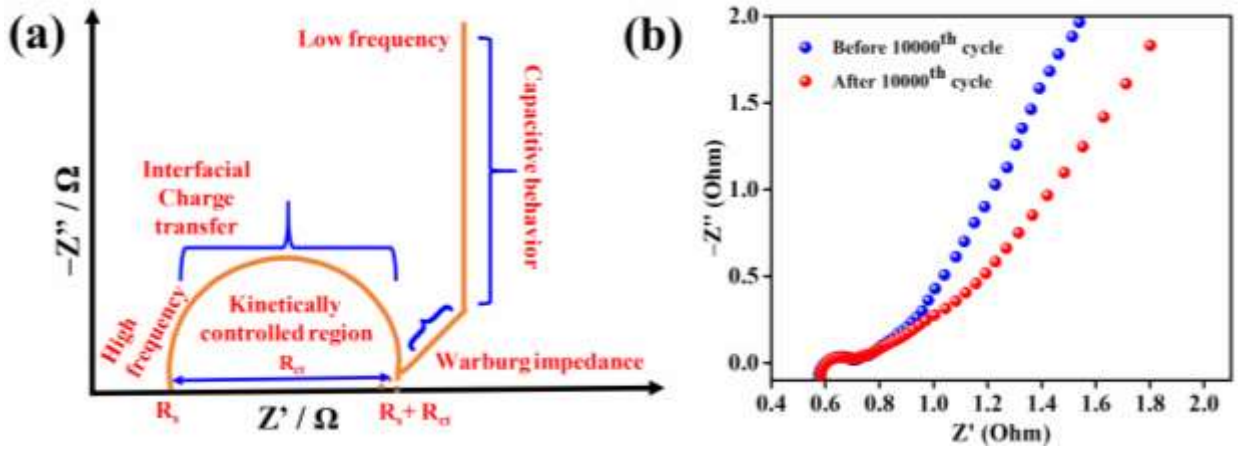

Figure S10. (a) The schematic representation of ideal EIS plot (b) The EIS Nyquist plot of $MnCo_2O_4$@N–C@MnO_2 electrode before and after 10,000 cycles.

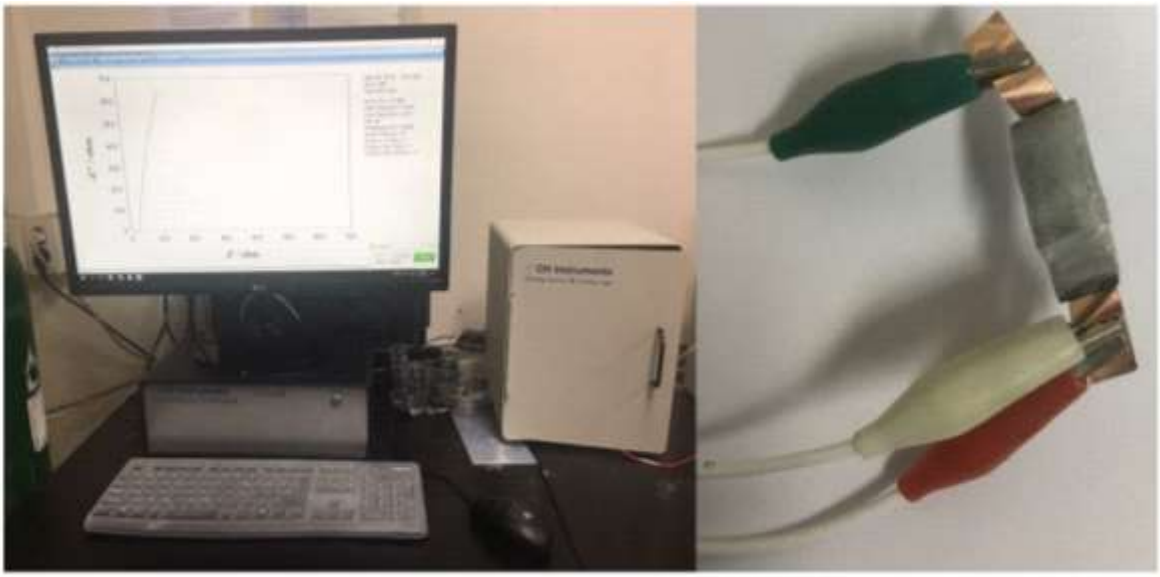

Figure S11. The digital photograph of the final fabricated asymmetric device setup.

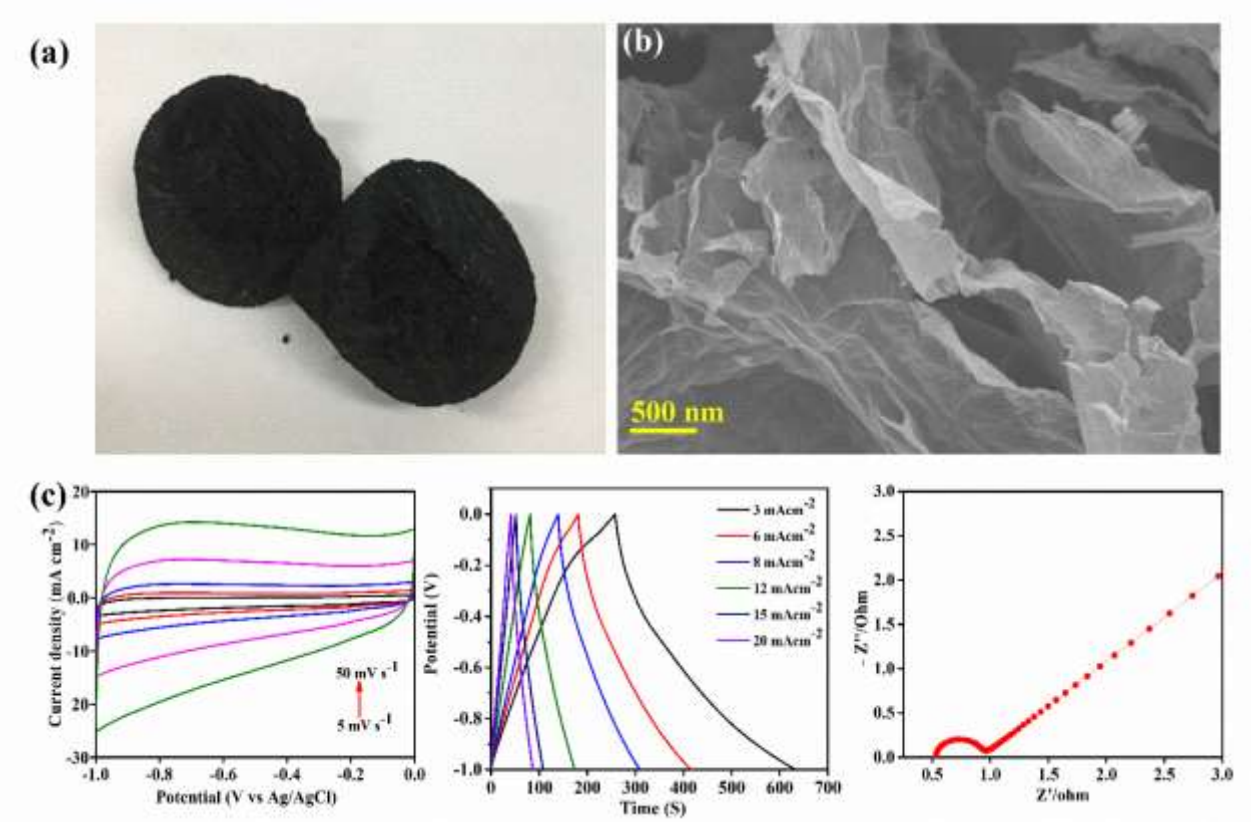

Figure S12. (a) Photograph of the N–doped graphene hydrogel(NGH) (b) FE-SEM image of the NGH (c) Electrochemical performance of the NGH.

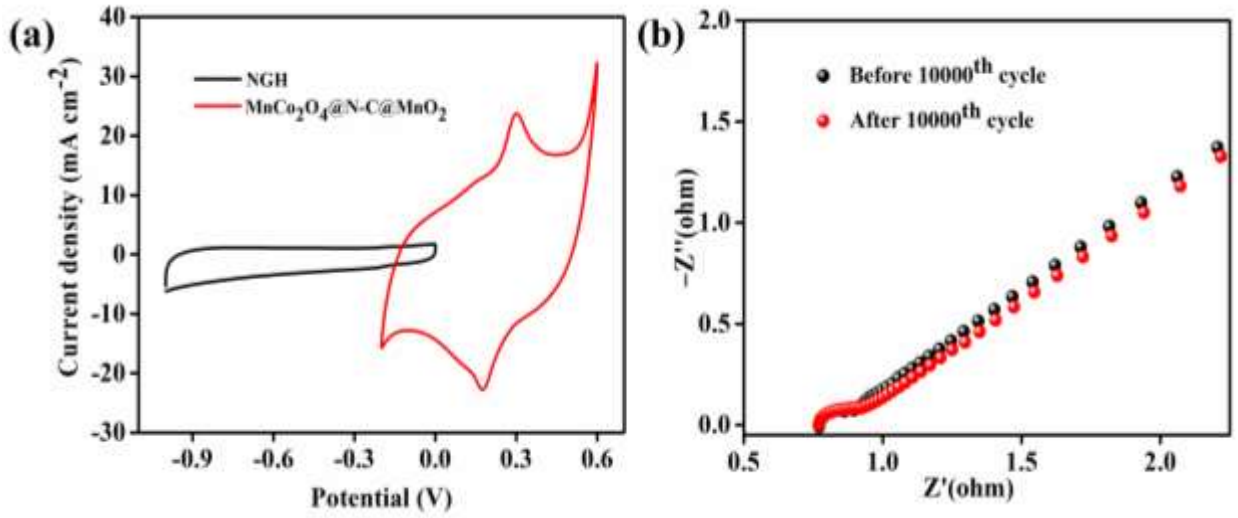

Figure S13. (a) $MnCo_2O_4$@N–C@MnO_2 and NGH measured the CV at scan rate 10 mV s^{-1} (b) EIS Nyquist plot $MnCo_2O_4$@N–C@MnO_2//NGH device before and after 10,000 cycles.

Table S1. Comparison of electrochemical performance of $MnCo_2O_4$@N-C@MnO_2 electrode with recently reported core@shell electrode material.

Electrode material	Areal capacitance/capacity [F cm^{-2}/mA h cm^{-2}]	Specific capacitance/capacity [F g^{-1}/mA h g^{-1}]	Current density	Electrolyte	Stability (cycles)	Reference
CoO@MnO_2	–	1,835 F g^{-1}	1 A g^{-1}	6 M KOH	97.7% (10,000)	[1]
Co_3O_4@MnO_2	–	1,693 F g^{-1}	1 A g^{-1}	1 M LiOH	89.8% (10,000)	[2]
α-MnO_2 NWs@δ-MnO_2 core-shell	–	231 F g^{-1}	1 A g^{-1}	6 M KOH	98.1% (10,000)	[3]
Cobalt-doped MnO_2 yolk−shell	–	350 F g^{-1}	0.1 A g^{-1}	1 M Na_2SO_4	90% (1,000)	[4]
TiO_2@MnO_2@C	–	488 F g^{-1}	1 A g^{-1}	1 M Na_2SO_4	97.4% (10,000)	[5]
$MnCo_2O_4$ @$Ni(OH)_2$	–	2,154 F g^{-1}	5 Ag^{-1}	2 M KOH	90% (2,500)	[6]
$NiCo_2O_4$@MnO_2	5.3 F cm^{-2}	–	1 mA cm^{-2}	6 M KOH	90.1% (5,000)	[7]
$MnNiCoO_4$@MnO_2	–	1,931 F g^{-1}	0.8 A g^{-1}	6 M KOH	91.2% (6,000)	[8]
MnO_2/carbon	–	628 F g^{-1}	1 A g^{-1}	3 M KOH	98.5%	[9]

					(2,000)	
MnO_2 nanoflake/CNT	–	370 F g^{-1}	0.5 A g^{-1}	1 M Na_2SO_4	100% (4,000)	[10]
CC@$ZnCo_2O_4$@MnO_2	3.6 F cm^{-2}	–	2 mA cm^{-2}	2 M KOH	95.5% (5,000)	[11]
$MnCo_2O_4$@MnO_2	–	858 F g^{-1}	1 A g^{-1}	3 M KOH	88% (5,000)	[12]
$MnCo_2O_4$ Nanowire@MnO_2	–	2,262 F g^{-1}	1 Ag^{-1}	6 M KOH	87.1% (5,000)	[13]
$MnCo_2O_4$@$CoMoO_4$	–	2,115.4 F g^{-1}	1.1 A g^{-1}	1 M KOH	119% (5,000)	[14]
$MnCo_2O_4$@Ni_3S_2	–	2807 F g^{-1}	3 A g^{-1}	6 M KOH	92% (5,000)	[15]
$MnCo_2O_4$@$MnMoO_4$ CSNs	–	885 C g^{-1}	3 A g^{-1}	6 M KOH	95% (5,000)	[16]
MNA-$MnCo_2O_{4.5}$	–	517.9 C g^{-1}	3.6 A g^{-1}	3 M KOH	98.3% (1,000)	[17]
Co_3O_4@$MnCo_2O_4$	–	736.5 F g^{-1}	1 mA cm^{-2}	3 M KOH	76.9% (3,000)	[18]
porous $MnCo_2O_4$ nanorod	–	845.6 F g^{-1}	1 A g^{-1}	2 M KOH	90.2% (2,000)	[19]
CoO@MnO_2	3.03 F cm^{-2}	1515 F g^{-1}	2.0 mA cm^{-2}	6 M KOH	–	[20]

porous C/MnO_2	–	392 F g^{-1}	0.5 A g^{-1}	1 M Na_2SO_4	–	[21]
CuO@C@MnO_2	–	650 F g^{-1}	0.4 Ag^{-1}	1 M Na_2SO_4	97.2% (2,000)	[22]
$CoMoO_4$@C@MnO_2	–	1,824 F g^{-1}	3 A g^{-1}	3 M KOH	82% (5,000)	[23]
$NiCo_2O_4$@MnO_2	–	913.6 F g^{-1}	0.5 A g^{-1}	1 M KOH	87.1% (3,000)	[24]
$NiCo_2O_4$–MnO_2/ graphene	5.15 F cm^{-2}	2,577 F g^{-1}	1 A g^{-1}/ 2 mA cm^{-2}	6 M KOH	94.3% (5,000)	[25]
MnO_2/C	–	497 F g^{-1}	1 A g^{-1}	1 M Na_2SO_4	90% (5,000)	[26]
$MnCo_2O_4$@ N-C@MnO_2	**0.75 mA h cm^{-2}/ 312 mA hg^{-1}**	**2,955 F g^{-1}**	**3 mA cm^{-2}**	**3 M KOH**	**89.6% 10,000**	**This work**

Table S2. Comparison of $MnCo_2O_4$@N-C@MnO_2//NGH asymmetric capacitor.

Material Cathode//Anode	Working potential (V)	Energy density (Wh kg^{-1})	Power density (W kg^{-1})	Electrolyte	Stability (cycles)	References
$ZnCo_2O_4$@MnO_2//AC	1.6	29.4	628.4	PVA/KOH	95.3% (3,000)	[27]
$MnCo_2O_4$@$CoMoO_4$//AC	1.6	37.5	527.8	1 M KOH	–	[14]
$MnCo_2O_4$@CoS//AC	1.6	55.1	477.3	PVA/KOH	91 % (6,000)	[28]
MnO_2/C/MECN‖active carbon/Ni-foam	2.0	55.5	4000	1 M Na_2SO_4	87.6% (5,000)	[26]
$NiCo_2O_4$–MnO_2/GF //CNT/GF	1.5	55.1	187.5	–	89.4% (2,000)	[25]
CuO@MnO_2/MEGO	1.8	22.1	85600	1 M Na_2SO_4	101.5% (10,000)	[29]
$FeCo_2O_4$@MnO_2//AC	1.6	22.6	406.01	3 M KOH	90.1% (5,000)	[30]
$MnCo_2O_4$@$MnMoO_4$//AC	1.6	49.4	815	6 M KOH	91% (5,000)	[31]
MnO_2@$NiCo_2O_4$//AC	1.6	26.6	800	–	–	[32]
MnO_2/C/Ag//AC	1.7	48.3	851.7	3 M KOH	98.5% (2,000)	[33]
$MnCo_2O_4$@Co_3O_4//AC	1.5	31	208.5	2 M KOH	101.2% (8,000)	[34]
rGO-$MnCo_2O_4$//AC	1.5	19	1551	3 M LiOH	-	[35]
NHCSs@MnO_2//AC	1.8	43.9	408	1 M Na_2SO_4	81.4% (4,000)	[36]

$MnCo_2O_4$@NF//rGO	1.6	53.7	1600	2 M KOH	82% (5,000)	[37]
$MnCo_2O_4$@N-C@MnO_2	**1.6**	**68.2**	**749.2**	**PVA/KOH**	**91.1 % (10,000)**	**This work**

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