Controllable Synthesis of Hollow Copper Oxide Encapsulated into N-doped Carbon Nanosheets as High-Stability Anodes for Lithium-Ion Batteries

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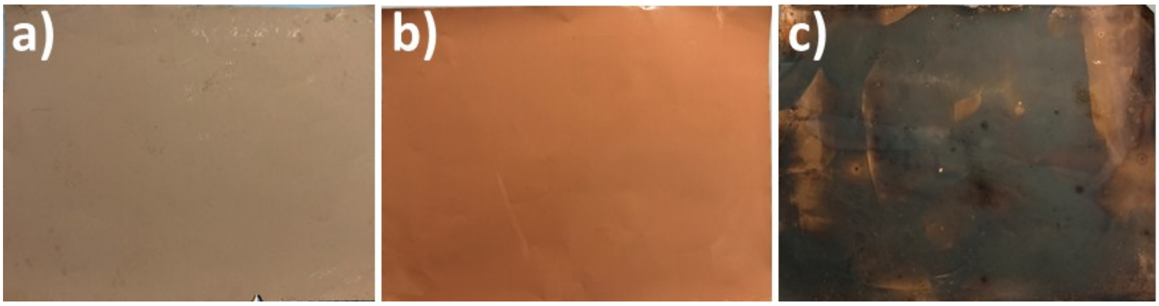

Fig. S1 Optical images showing a) CuO/Cu foil, b) PVP/CuO/Cu foil and c) hollow Cu@NCSs/Cu foil.

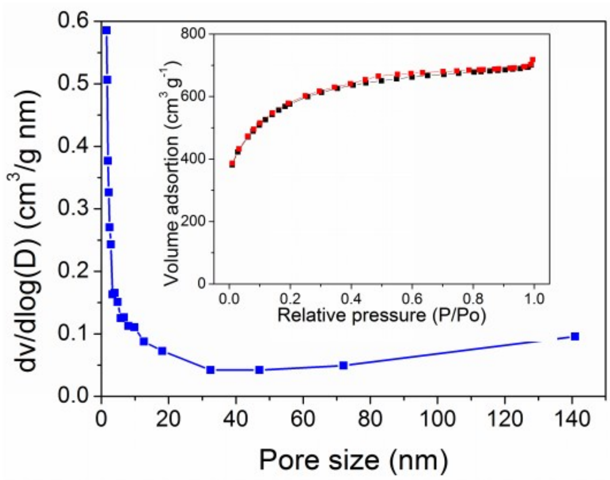

Fig. S2 pore size distribution and nitrogen adsorption-desorption isotherms (inset) of the hollow Cu@NCSs composites.

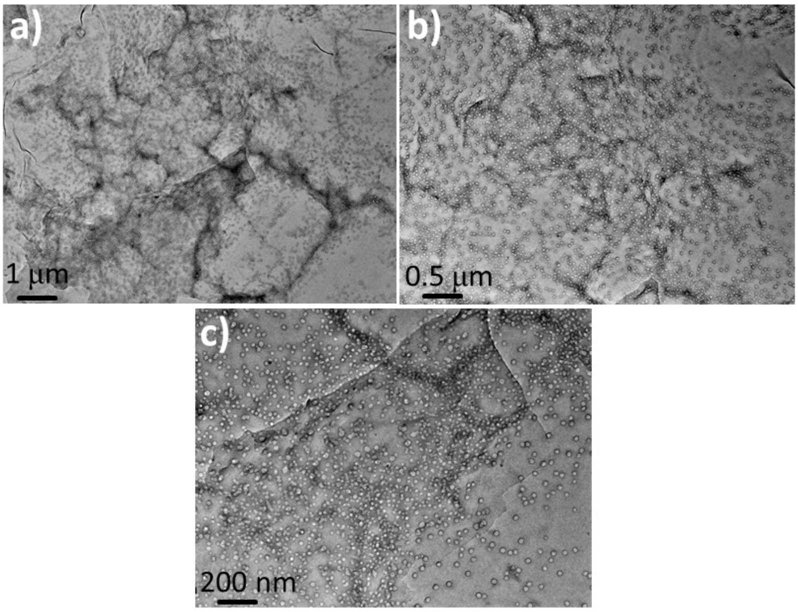

Fig. S3 TEM images of the as-prepared NCSs.

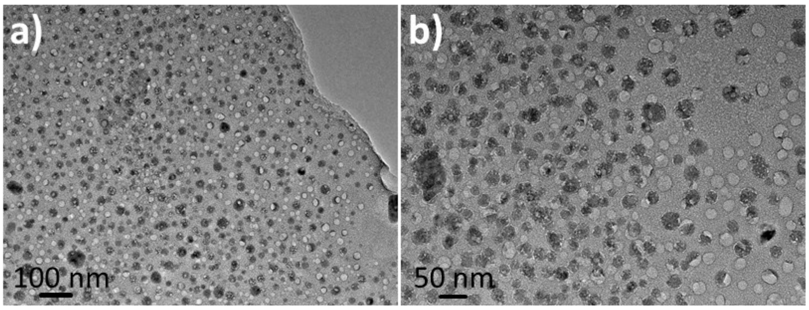

Fig. S4 TEM images of the as-prepared CuO NPs@NCSs composites.

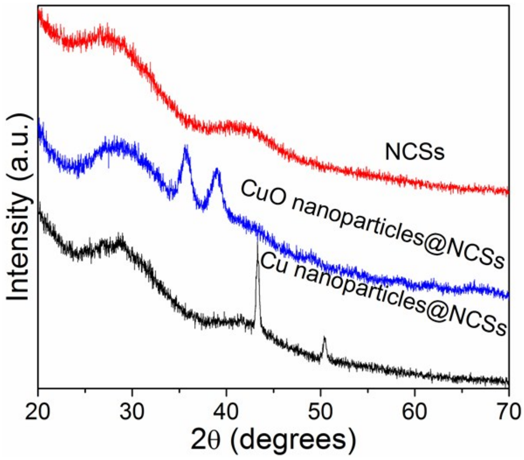

Fig. S5 a) XRD patterns of NCSs, Cu NPs@NCSs and CuO NPs@NCSs composites.

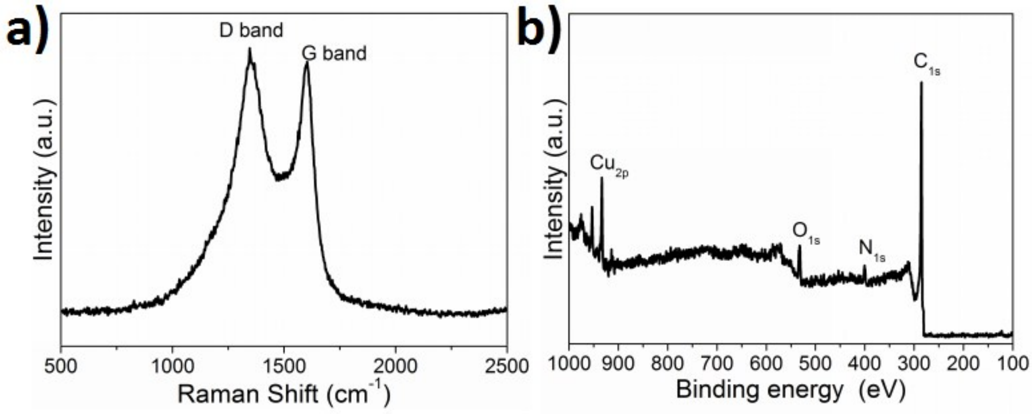

Fig. S6 a) Raman spectra and b) XPS spectrum of the CuO NPs@NCSs composites.

Fig. S7 SEM images of the hollow CuO@NCSs composites.

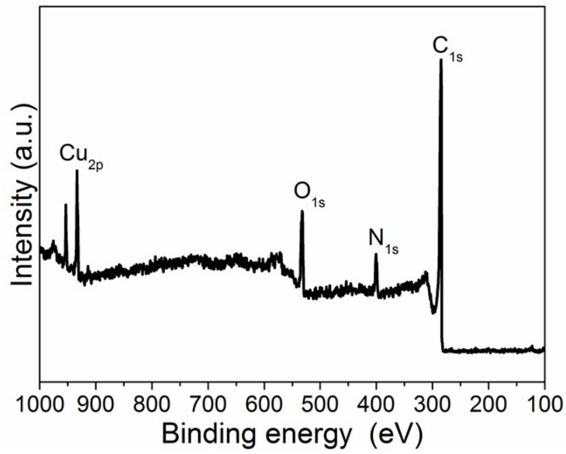

Fig. S8 XPS spectrum of the hollow CuO@NCSs composites.

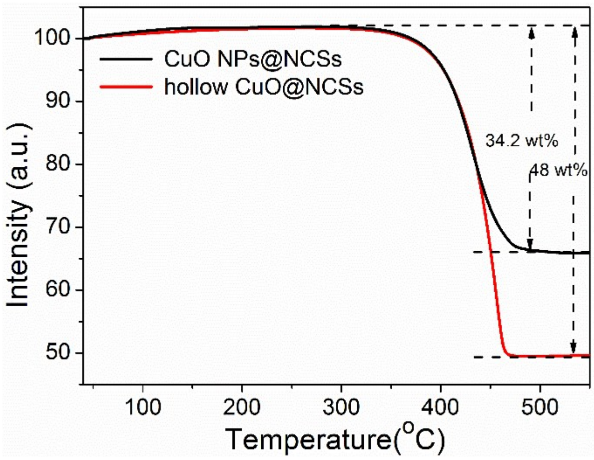

Fig. S9 TGA results of the hollow CuO@NCSs and CuO NPs@NCSs composites.

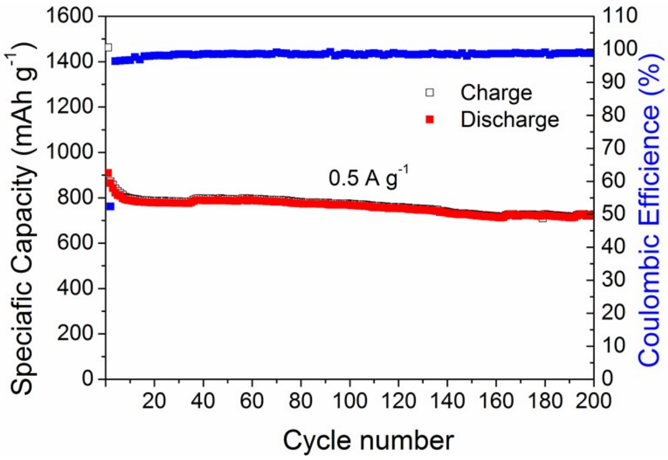

Fig. S10 Discharge-charge capacities and Coulombic efficiencies of the hollow CuO@NCSs composites over 200 cycles at 0.5 A g^{-1}.

Table S1. The physical parameters of the hollow CuO@NCSs composites.

Samples	C (wt%)	O (wt%)	N (wt%)	Cu (wt%)	I_D/I_G
the hollow CuO@NCSs	41.9	13.1	6.8	38.2	1.05

Table S2 Comparison of electrochemical performances of the CuO@NCSs electrodes with previously reported CuO electrodes.

Electrode materials	Synthetic method	Electrode formulation[a]	Cycling stability (A/B/n)[b]	Ref.
CuO + Cu + GQDs	Electrochemical anodization + annealing	80:10:10	-/-/-	S1
CuO/CNT nanocomposite	Hydrothermal + chemical transformation	80:5:15	650/67/100	S2
CuO@C multi-yolk-shell octahedra	Hydrothermal + thermal treatment	80:10:10	612/250/100	S3
Cu nanosheets@CuO nanorods	Hydrothermal	80:10:10	220/67/200	S4
Carbon@CuO hollow spherical particles	Spray pyrolysis	80:10:10	750/670/300	S5
CuO nanowires	Thermal treatment	--:--:--	445/1000/600	S6
Nanoporous CuO/Cu composite	Corroding method	70:20:10	600/500/200	S7
CuO/GO	Hydrothermal	80:10:10	500/335/500	S8
3D hierarchical CuO mesocrystals	Nonclassical crystallization	80:10:10	525/67/500	S9
Porous CuO nanotubes/graphene	Microwave-assisted method + annealing	90:5:5	442/500/250	S10
CuO/Cu/C hybrid	Electrospinning method	80:10:10	442/1000/400	S11
3D CuO nanostructures	One-step thermal heating	80:10:10	210/500/500	S12
CuO-rGO	Spray-drying	70:20:10	676/2000/200	S13
Yolk–shell $CuO@CuFe_2O_4$	Interfacial reaction + thermal heating	70:20:10	505/500/200	S14
Co_3O_4/CuO composites	Dealloying + thermal heating	70:15:15	600/1000/400	S15
F-CuO hollow octahedra	Hydrothermal + annealing	80:10:10	533/1000/400	S16
Hollow CuO@NCSs composites	Chemical vapor and solid deposition + thermal treatment	70:20:10	688/2000/1000	This work

a Weight ratio of the active material, carbon and binder. PVDF was used as binder if not mentioned. Other values used were specified.

b A/B/n means the capacity of A (mAh g^{-1}) remained after n cycles at the certain currentdensity of B (mA g^{-1}).

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