$Co_{0.85}Se$ Particles Encapsulated in the Inner Wall of Nitrogen-Doped Carbon Matrix Nanotube with Rational Interfacial Bonds for High-Performance Lithium-Ion Batteries

Qi Chen,[a] Qichen Liang,[a] Shu-Ang He,[a] Zhe Cui,[a] Qian Liu,*[,b] Jinqi Zhu[a] and Rujia Zou*[,a]

[a] State Key Laboratory for Modification of Chemical Fibers and Polymer Materials, College of Materials Science and Engineering, Donghua University, Shanghai 201620, China. E-mail: rjzou@dhu.edu.cn

[b] Department of Physics, College of Science, Donghua University, 201620, China. E-mail: qianliu@dhu.edu.cn

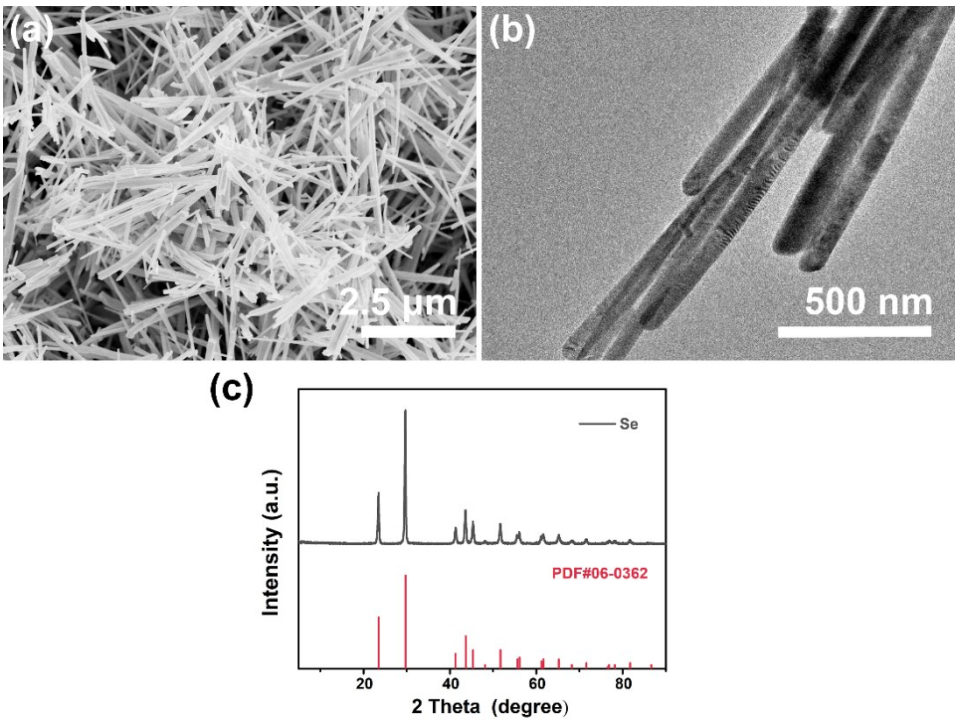

Fig. S1 (a) and (b) SEM and TEM image of Se nanowires. (c) XRD pattern of Se nanowires.

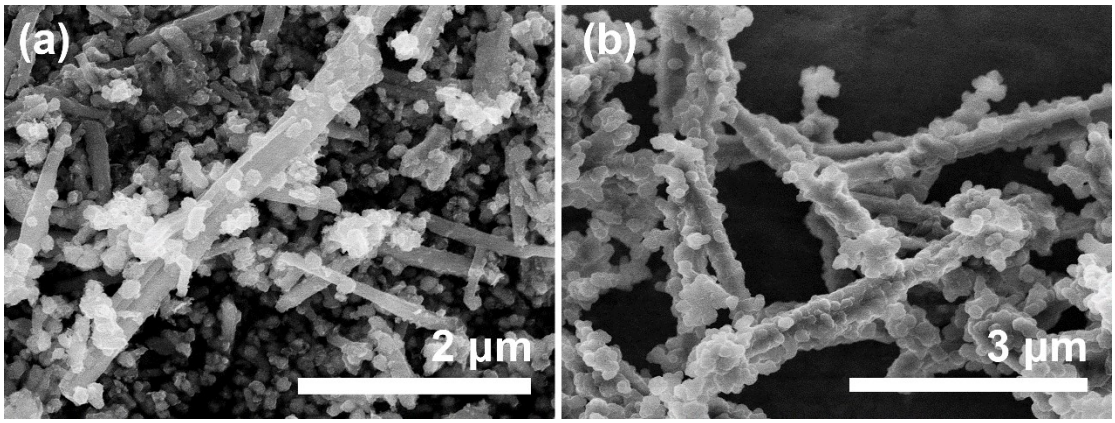

Fig. S2 (a) and (b) SEM image of Se@Co precursor and Se@Co precursor@PDA.

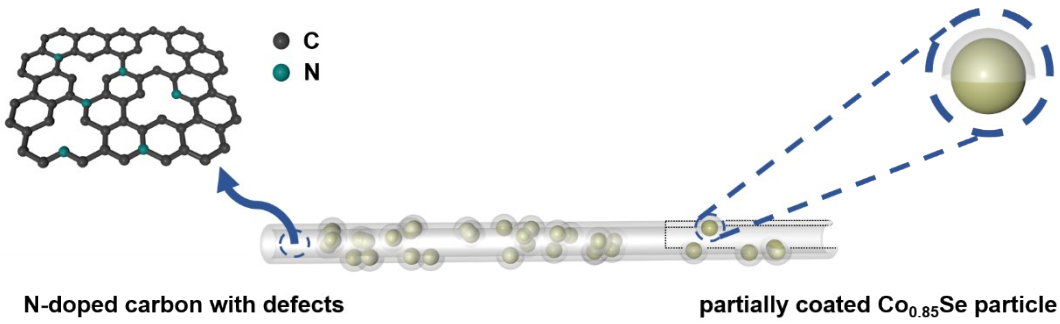

Fig. S3 The detailed composition of $Co_{0.85}Se$@NCMT.

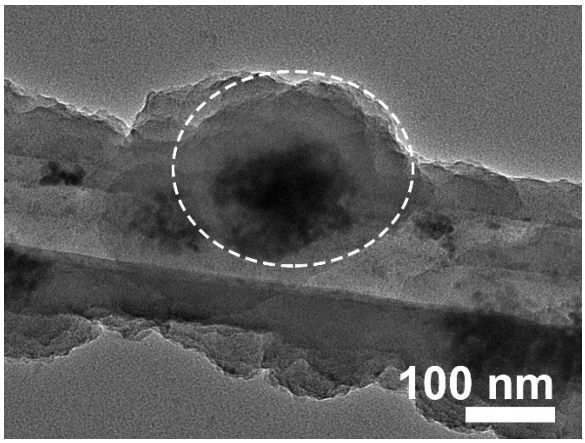

Fig. S4 TEM image of $Co_{0.85}Se$ nanoparticle and N-doped carbon matrix.

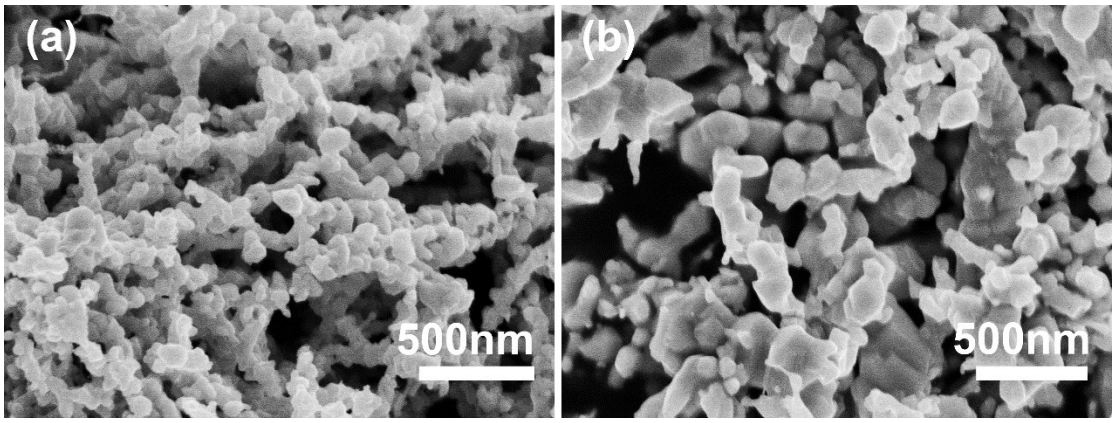

Fig. S5 (a) and (b) SEM image of NCMT@$Co_{0.85}Se$ and $Co_{0.85}Se$ NPs.

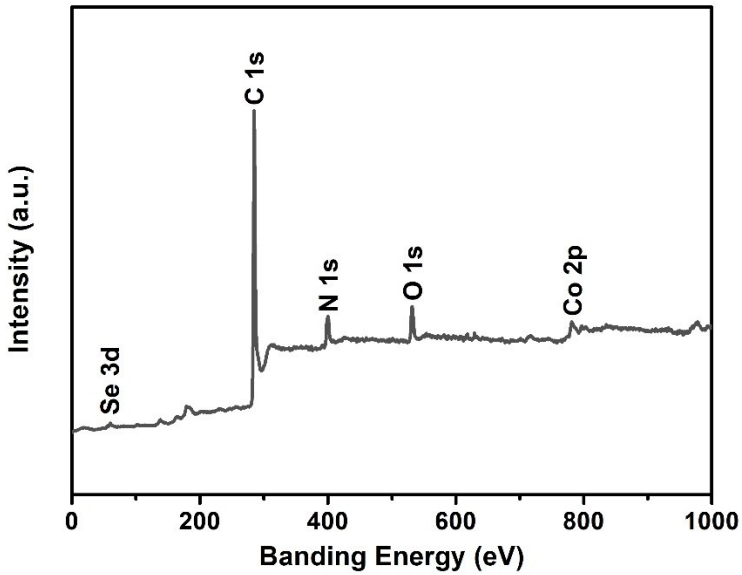

Fig. S6 The survey XPS spectrum of the $Co_{0.85}Se$@NCMT.

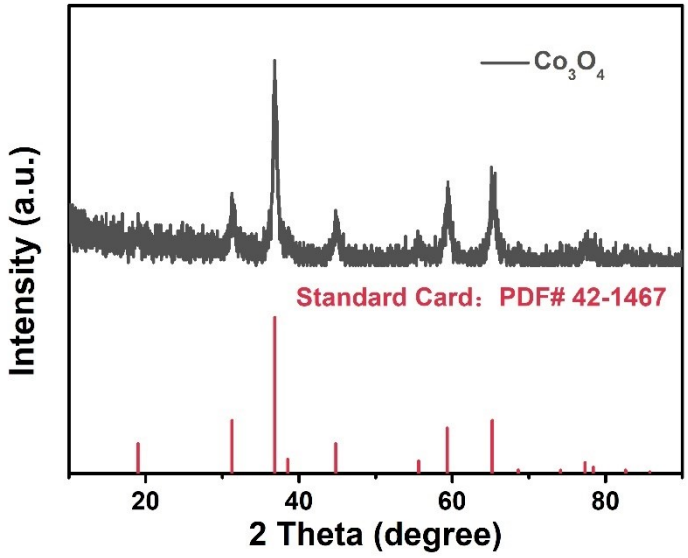

Fig. S7 The XRD pattern of Co_3O_4 after TG analysis.

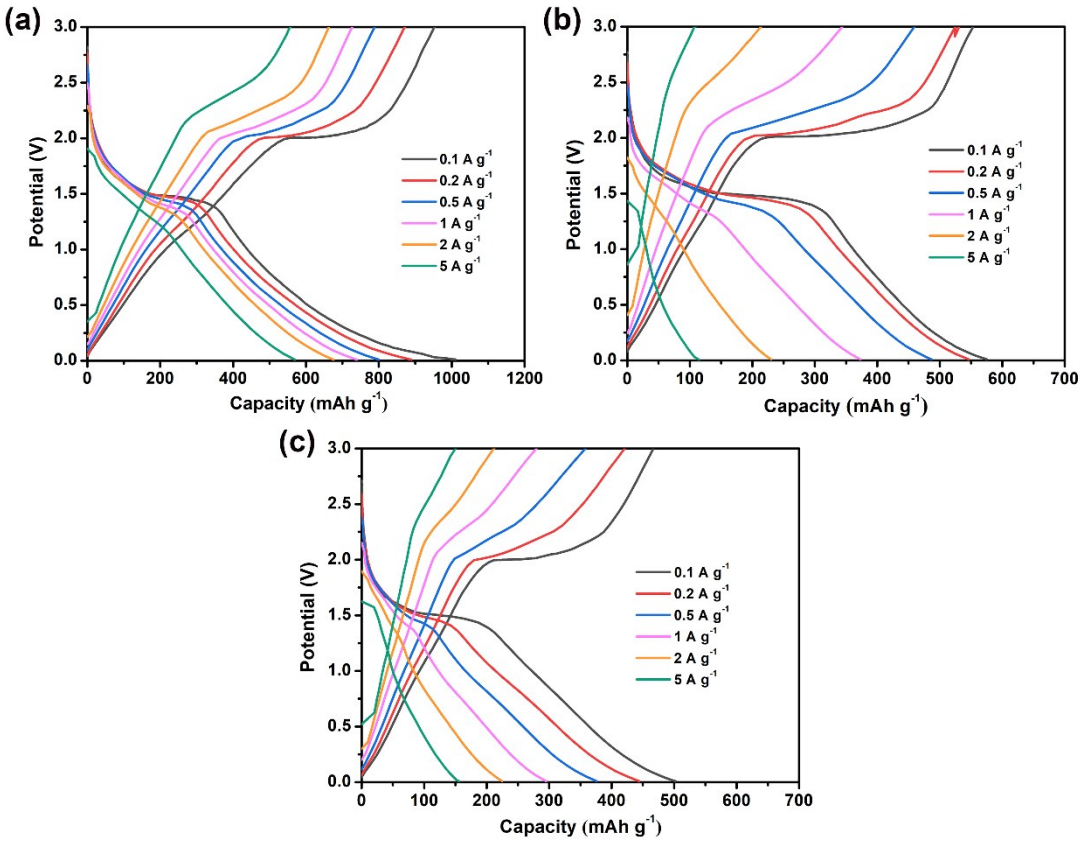

Fig. S8 Discharge-charge profiles at different current densities of $Co_{0.85}Se$@NCMT (a), NCMT@$Co_{0.85}Se$ (b) and $Co_{0.85}Se$ NPs (c).

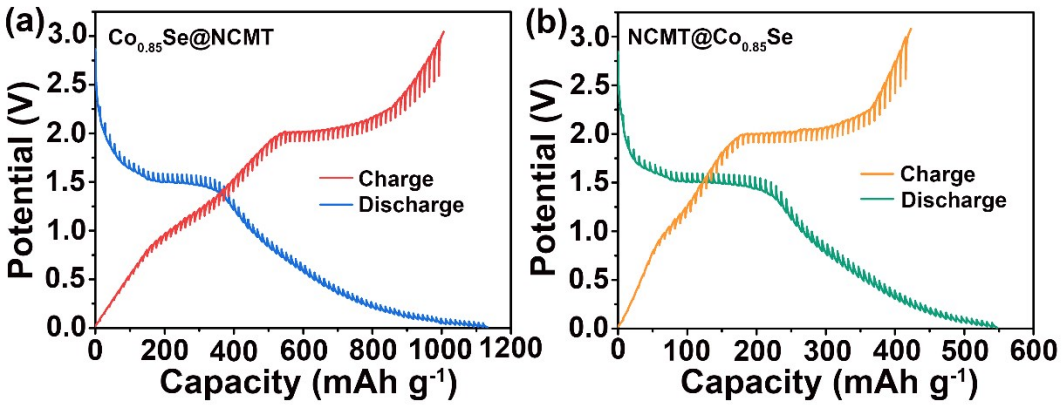

Fig. S9 GITT voltage profiles of the $Co_{0.85}Se$@NCMT (a) and NCMT@$Co_{0.85}Se$ (b).

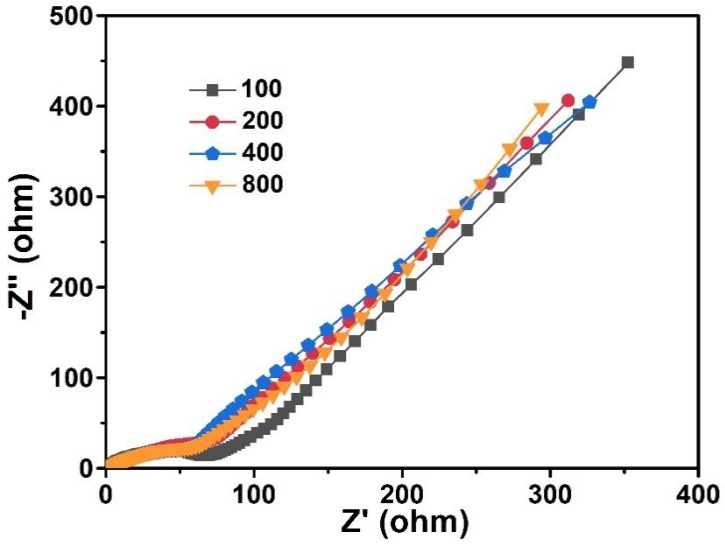

Fig. S10 Nyquist plot of the $Co_{0.85}Se$@NCMT electrodes after different cycles.

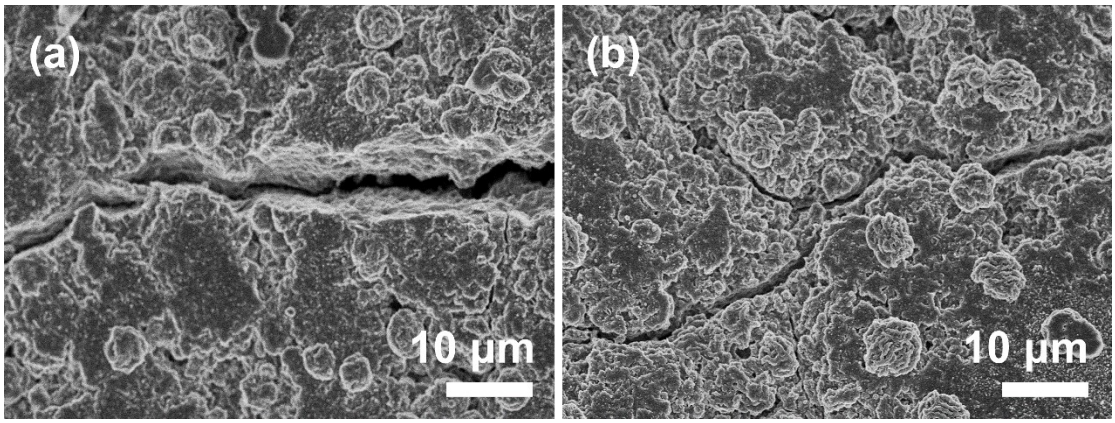

Fig. S11 (a) NCMT@$Co_{0.85}Se$ electrode after 100 cycles. (b) $Co_{0.85}Se$ NPs electrode after 100 cycles.

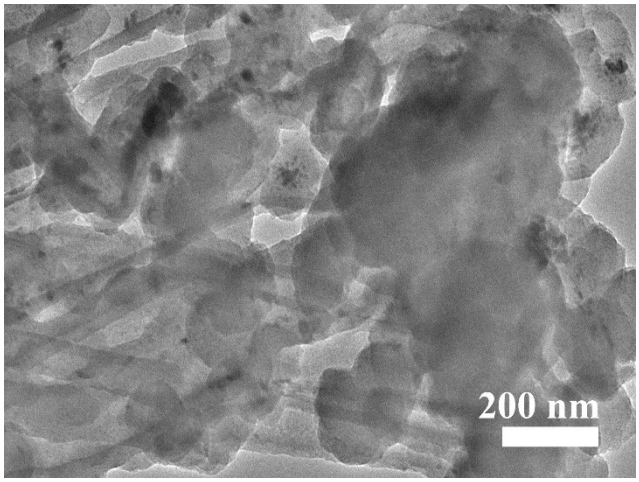

Fig. S12 The TEM image of NCMT@$Co_{0.85}Se$ electrode after 100 cycles.

Table S1. Comparison of the cycle performances of $Co_{0.85}Se$@NCMT electrode with other $CoSe_x$-based anode materials reported in the literature.

Electrodes	Current density (A g^{-1})	Cycle number	Initial capacity (mAh g^{-1})	Reversible capacity (mAh g^{-1})	Capacity retention (%)	Ref.
$Co_{0.85}Se$@NCMT	**0.2** **5**	**100** **800**	**775.5** **465.1**	**884.7** **462.9**	**114.1** **99.5**	**This work**
$CoSe_2$/NC	0.1 1	100 500		438 282.1		Ref. 41
CoSe/NC	1	100	808	796	98.5	Ref. 22
CoSe/Co@NC	0.2 1	100 500		630 640		Ref. 42
ZnCoSe@NC	1	1000	610	768	125.9	Ref. 43
CoSe–rGO	2	500	954.9	764.8	80.1	Ref. 23
CoSe@PCP	0.2	100		675		Ref. 35
CoSe@carbon nanoboxes	0.2 0.5 1	100 100 100	796 752 721	860 711 660	108.1 94.5 91.6	Ref. 44
Pure $Co_{0.85}Se$ nanosheets	0.2 0.5	50 50	650 576	516 295	79 51	Ref. 18
NC@$Co_{0.85}Se$	0.2 5	100 500	890 610	636 399	71.5 65.4	Ref. 45
$Co_{0.85}Se$-2/NPC-5	1	200	663.6	638.4	96.2	Ref. 21
$Co_{0.85}Se$/NC	1	300	890	726	81.6	Ref. 46