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

Electronic Supporting Information

Reconstructing ZnO quantum dot assembled tubular structures from nanotubes within graphene matrix *via* ongoing pulverization towards high-performance lithium storage†

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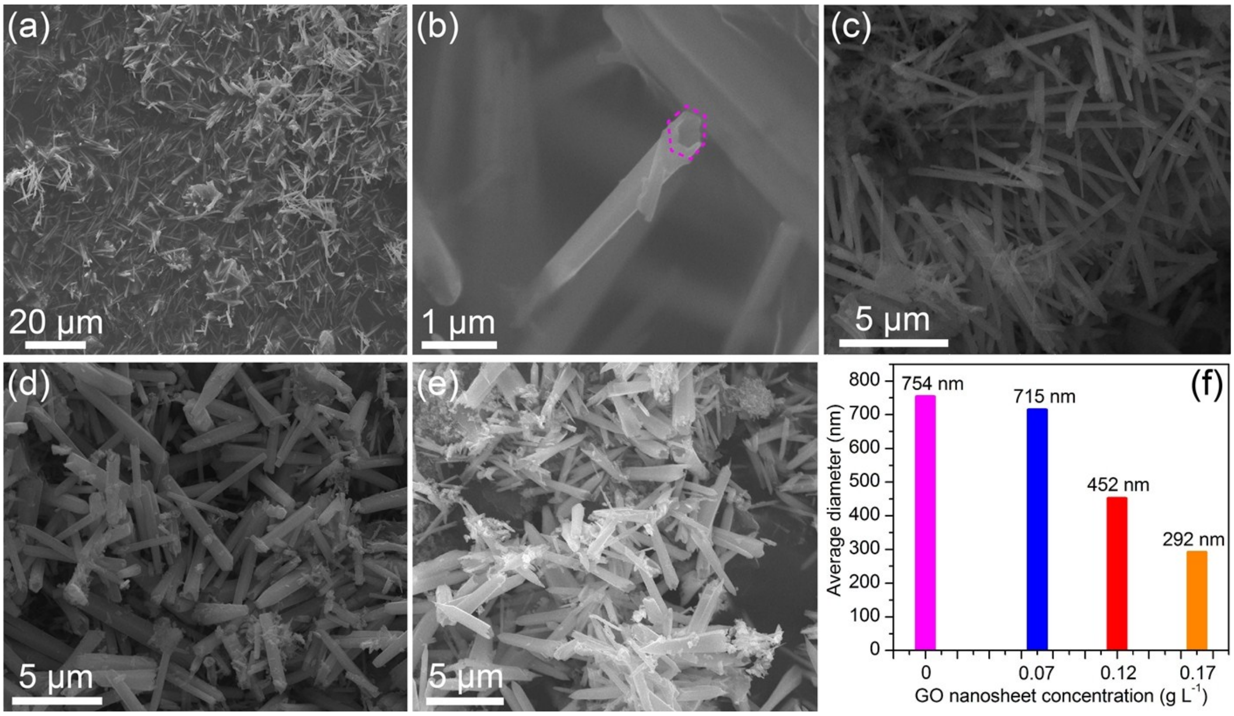

Fig. S1 FESEM images and corresponding histogram showing the morphological evolution of ZnO nanotubes by adding different concentration of GO nanosheets in reaction solution. (a) and (b) 0.17 g L^{-1}, (c) 0.12 g L^{-1}, (d) 0.06 g L^{-1}, (e) 0 g L^{-1}, and (f) The histogram showing relations of average diameters of ZnO nanotubes summarized in above FESEM images and concentration of GO nanosheets in the reaction.

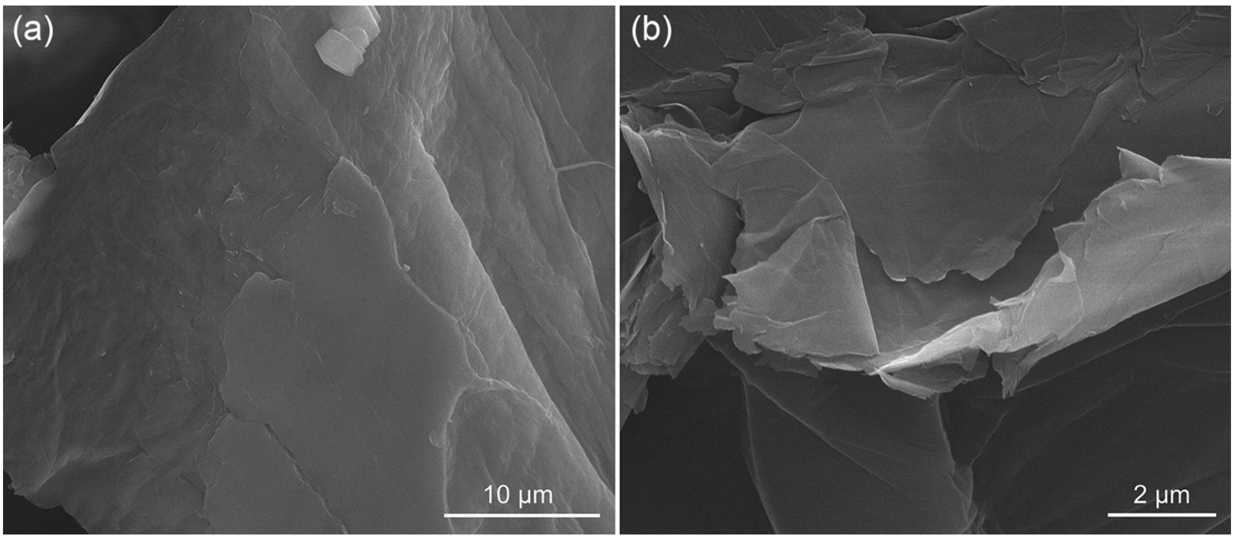

Fig. S2 FESEM images of (a) as-synthesized graphene oxide nanosheets and (b) graphene nanosheets obtained by after reduction heat treatments at 700 °C for 2 h under 5% hydrogen in nitrogen atmosphere.

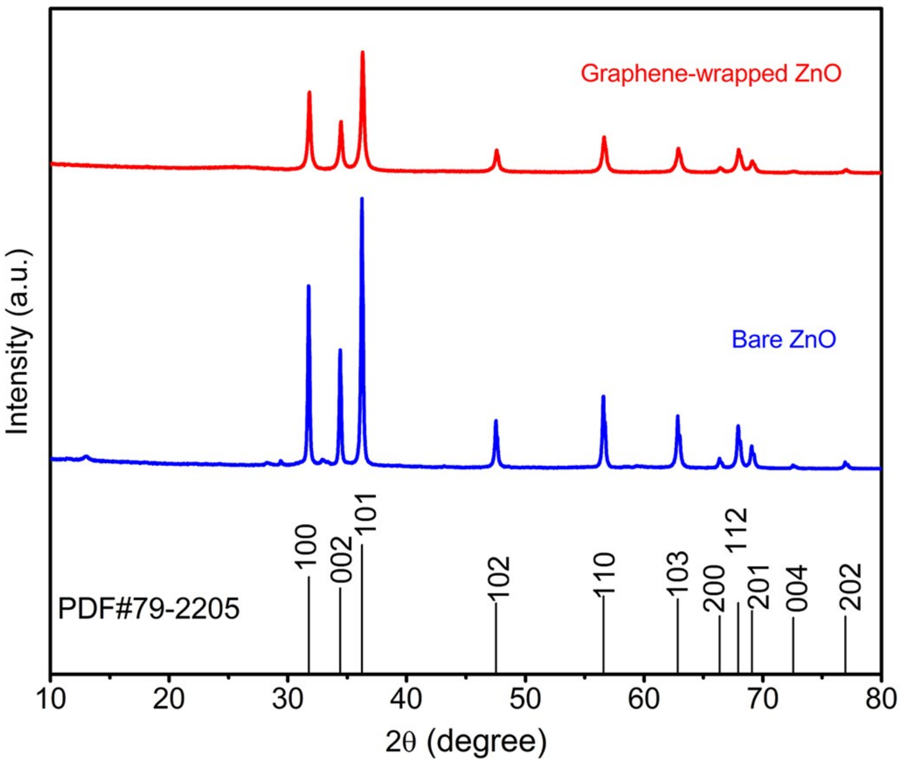

Fig. S3 XRD patterns of post-annealed graphene-wrapped ZnO nanotubes and bare ZnO nanotubes.

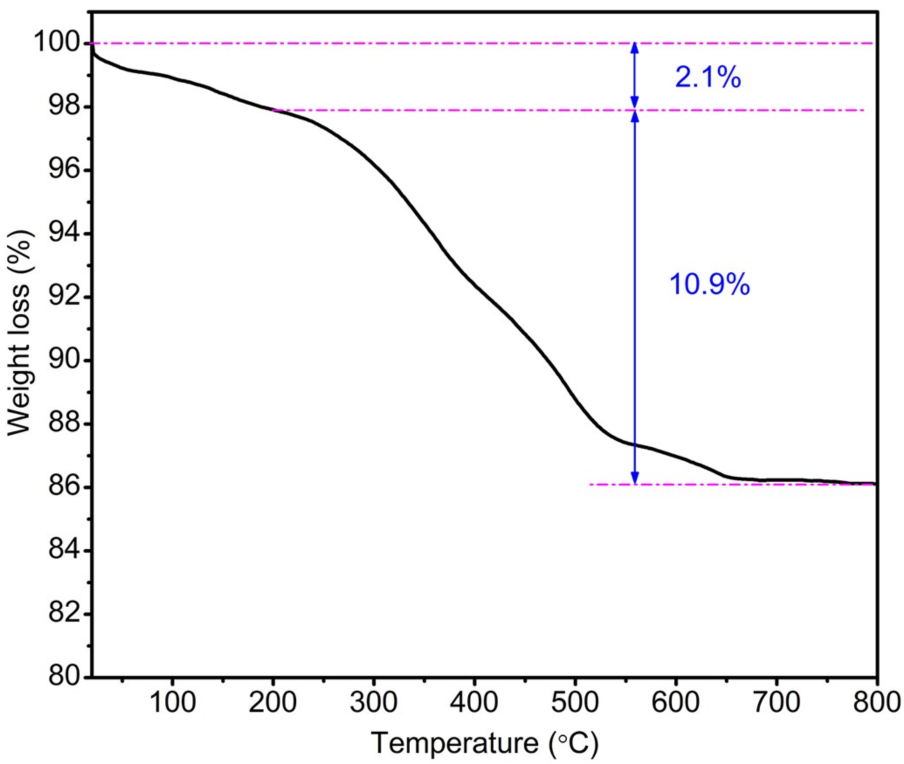

Fig. S4 The TGA curve of the post-annealed graphene-wrapped ZnO.

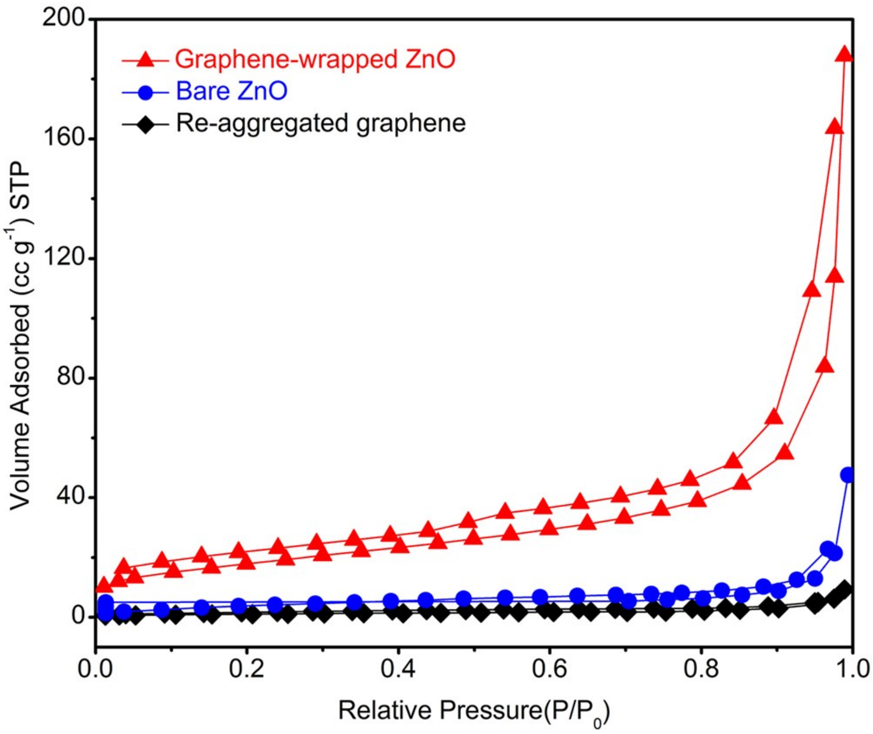

Fig. S5 N_2 adsorption-desorption isotherm of the post-annealed graphene-wrapped ZnO, bare ZnO and re-aggregated graphene.

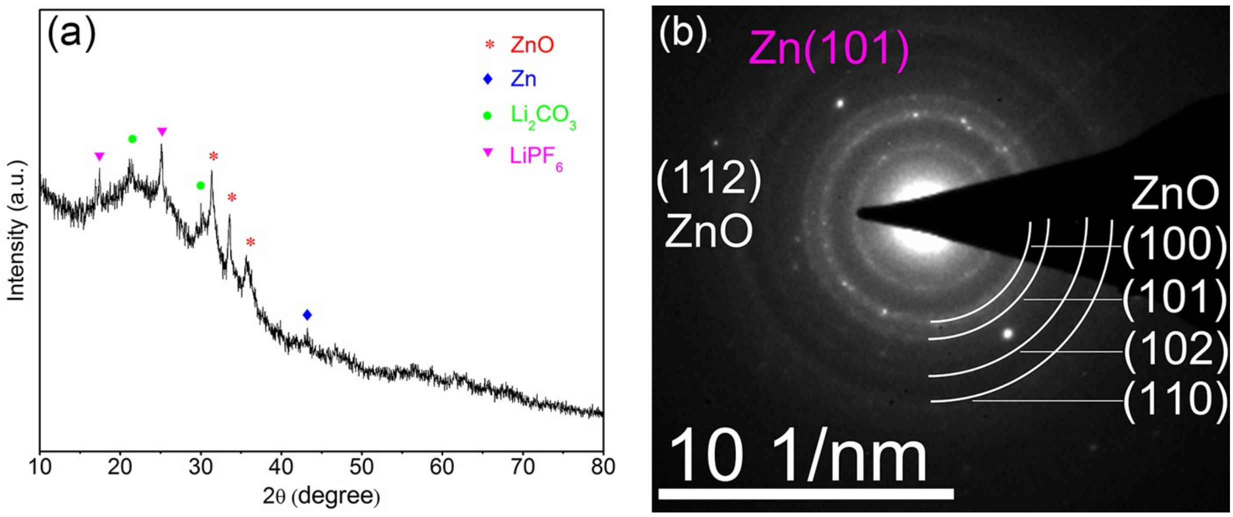

Fig. S6 (a) XRD pattern and (b) SAED of the graphene-wrapped ZnO electrode after 1000 discharge/charge cycles at a current density of 2000 mA g^{-1}.

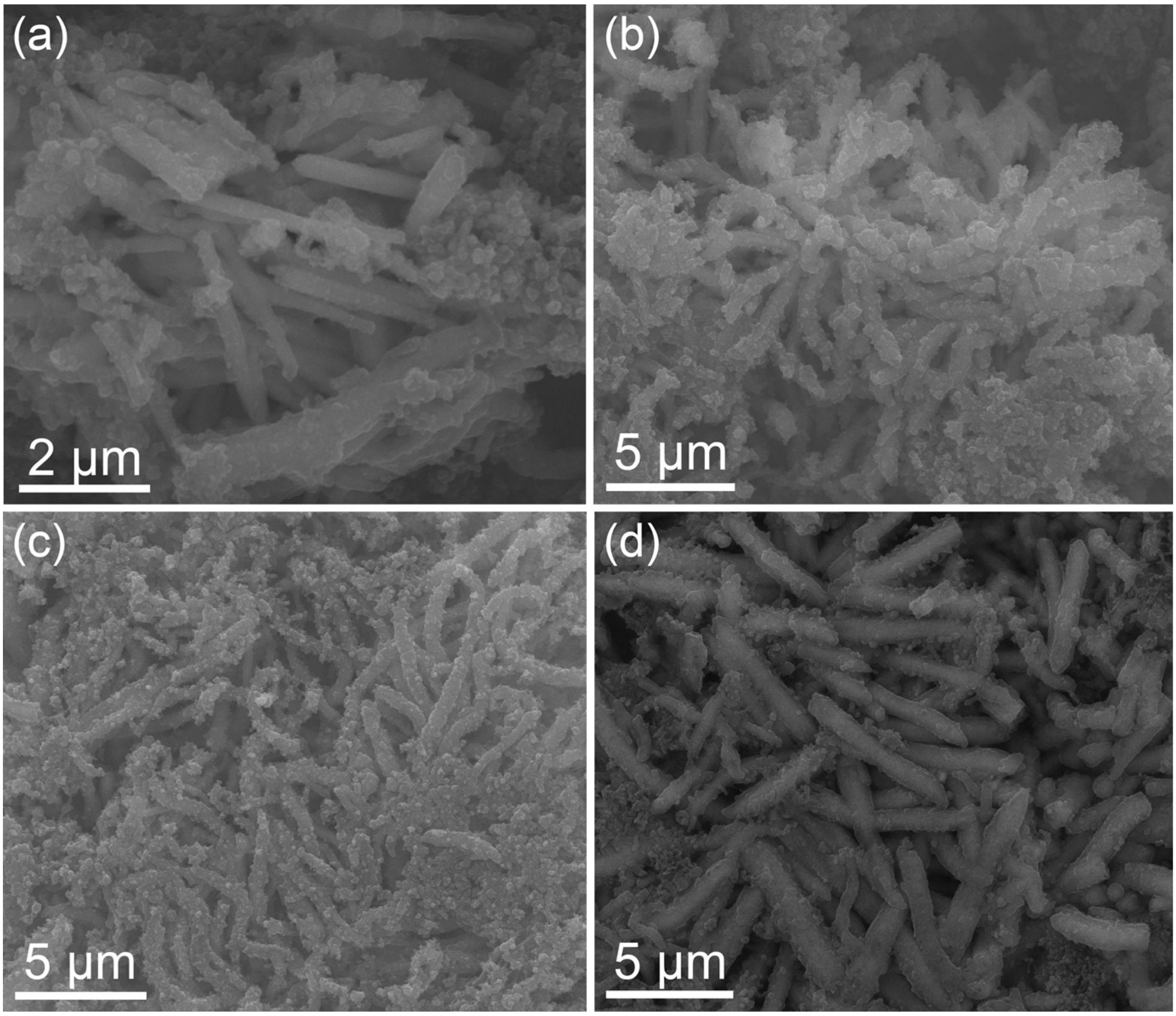

Fig. S7 FESEM images of graphene-wrapped ZnO electrodes after (a) 2, (b) 100, (c) 400 and (d) 700 discharge/charge cycles at a current density of 2000 mA g^{-1}.

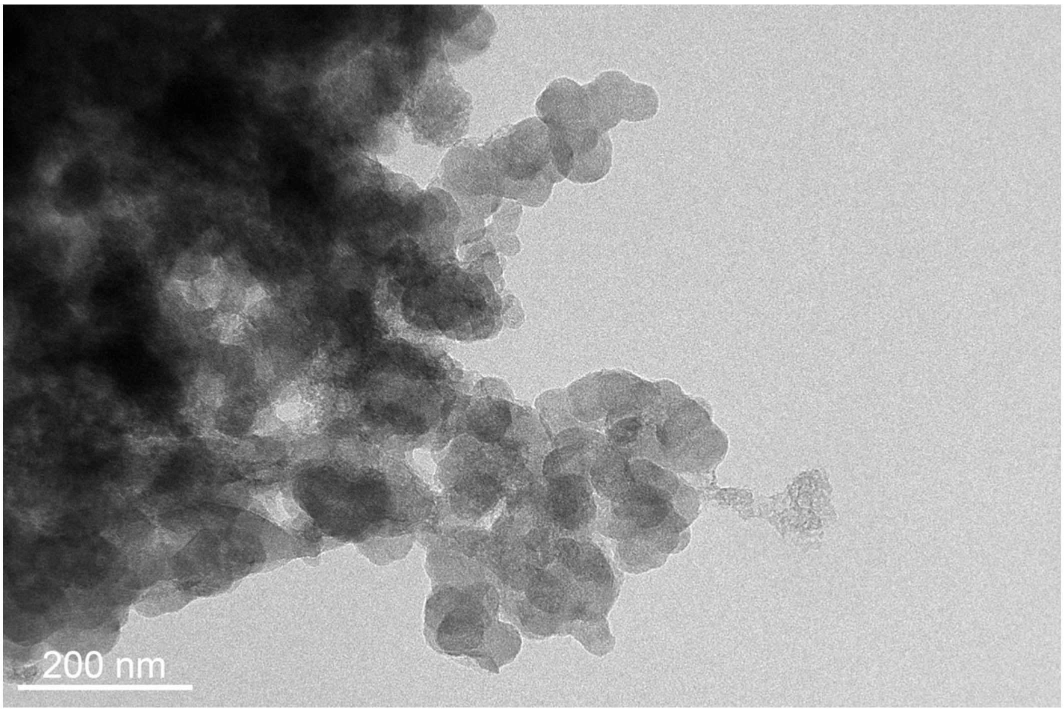

Fig. S8 TEM image of the graphene-wrapped ZnO electrode after 100 discharge/charge cycles at a current density of 2000 mA g^{-1}.

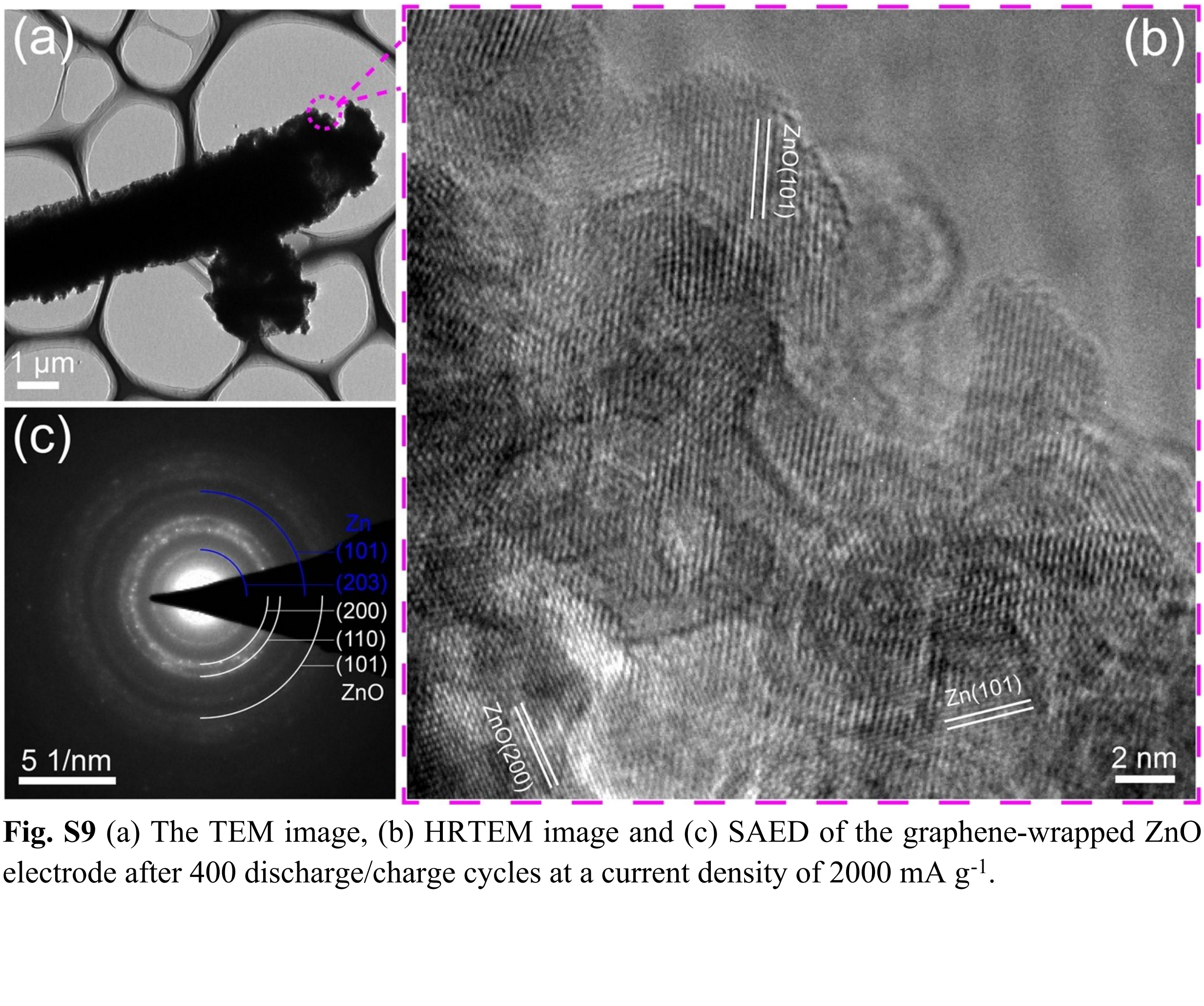

Fig. S9 (a) The TEM image, (b) HRTEM image and (c) SAED of the graphene-wrapped ZnO electrode after 400 discharge/charge cycles at a current density of 2000 mA g^{-1}.

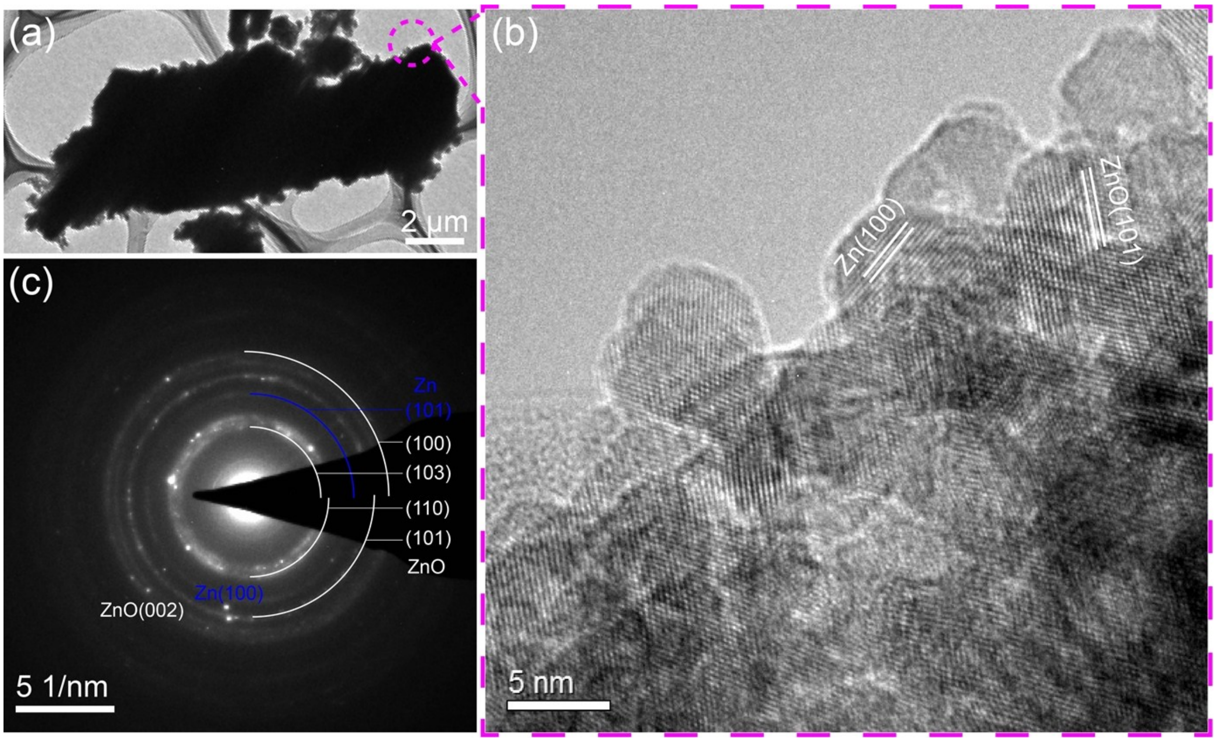

Fig. S10 (a) The TEM image, (b) HRTEM image and (c) SAED of the graphene-wrapped ZnO electrode after 400 discharge/charge cycles at a current density of 2000 mA g^{-1}.

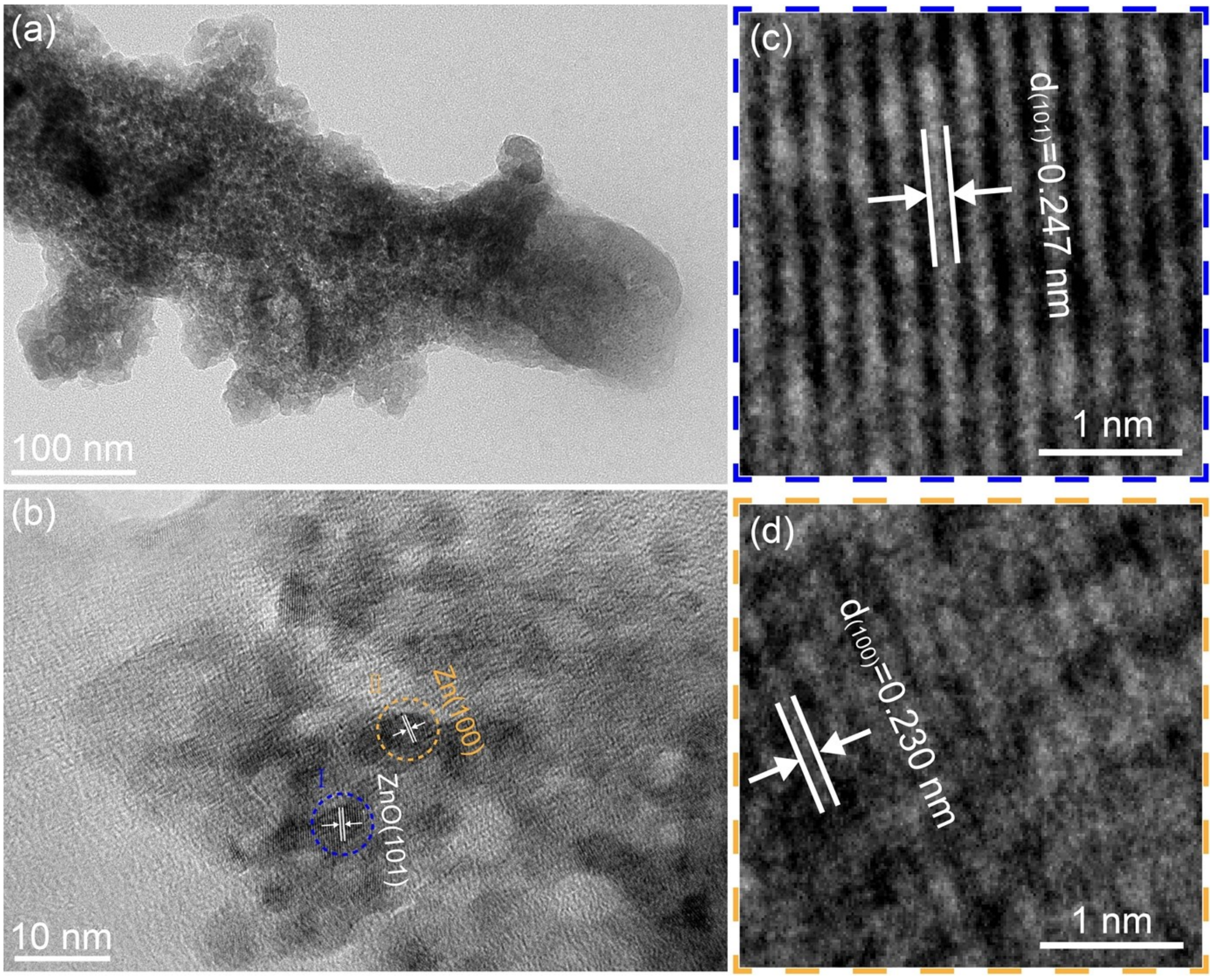

Fig. S11 TEM images of the graphene-wrapped ZnO quntom dots assembled tubular structure after completion of 1000 discharge/charge cycles at a current density of 2000 mA g^{-1}. (a) TEM and (b) HRTEM images. (c) and (d) Magnified HRTEM images corresponded to region I and II outlined by dashed line in (b).

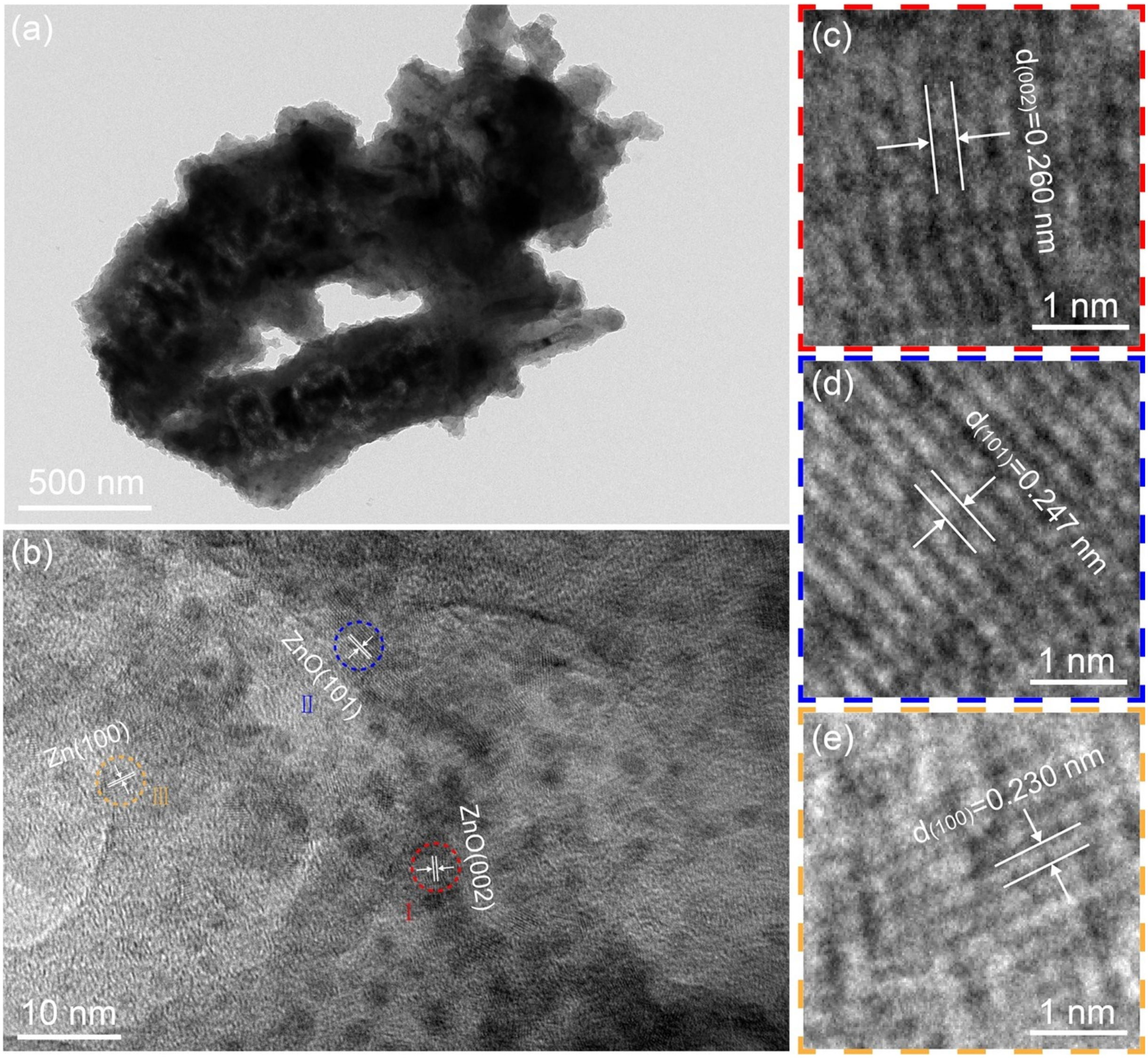

Fig. S12 TEM images of the graphene-wrapped ZnO quntom dots assembled tubular structure after completion of 1000 discharge/charge cycles at a current density of 2000 mA g^{-1}. (a) TEM and (b) HRTEM images. (c), (d) and (e) Magnified HRTEM images corresponded to region I, II and III outlined by dashed line in (b).

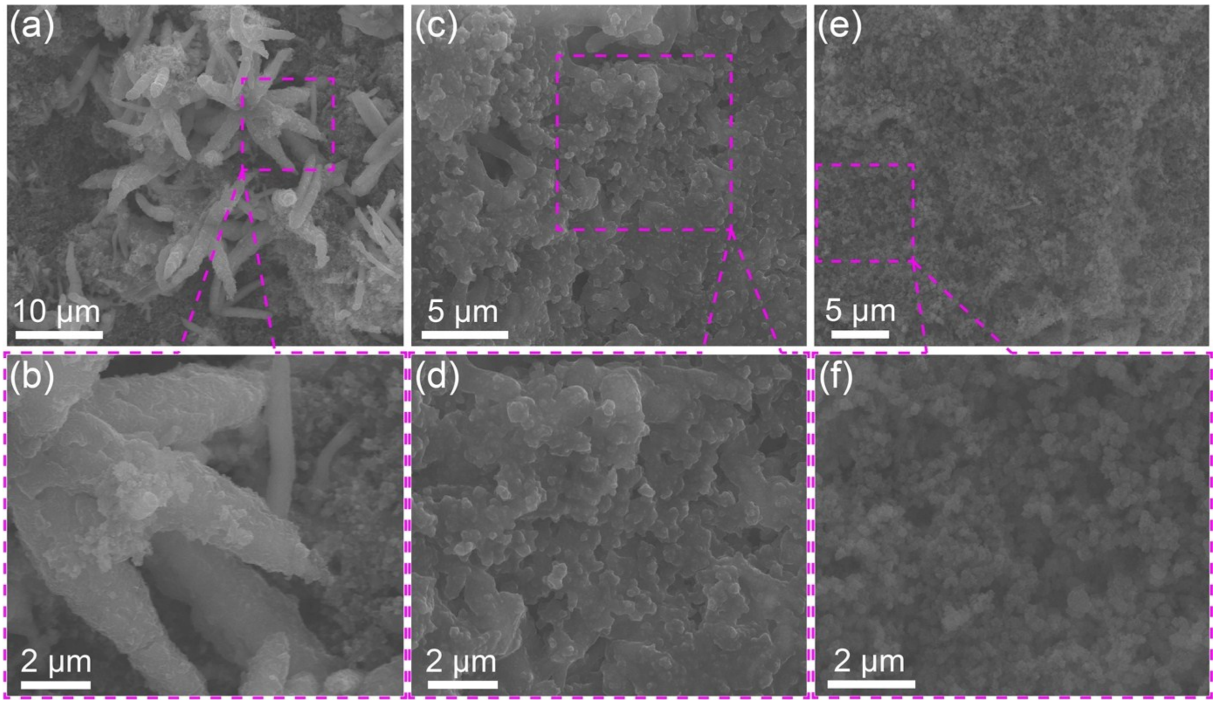

Fig. S13 FESEM images the cycled bare ZnO electrode after (a) and (b) 2 discharge/charge cycles, (c) and 100 discharge/charge cycles, and (e) and (f) 1000 discharge/charge cycles at a current density of 2000 mA g^{-1}.

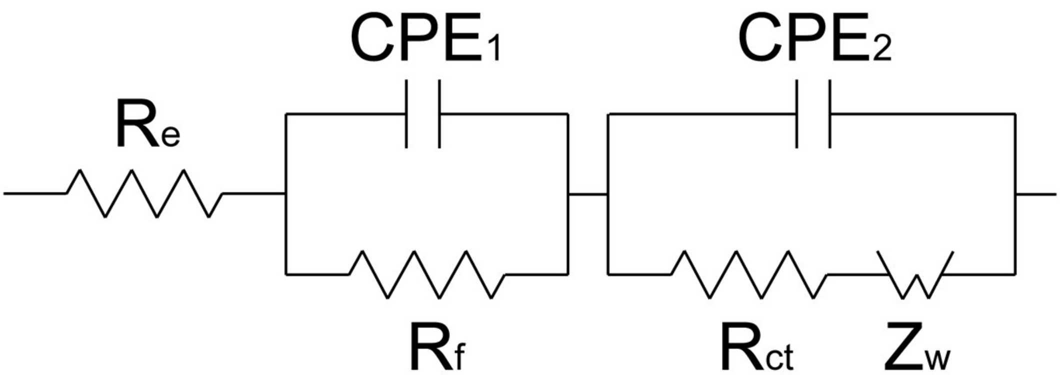

Fig. S14 The equivalent circuit used to fit the Nyquist plots of the graphene-wrapped ZnO and bare ZnO electrodes, In this model, R_e represents the internal resistance of cells, and R_f and CPE_1 are associated with the resistance and constant phase element of SEI film, respectively. R_{ct} and CPE_2 depict the charge transfer resistance and constant phase element of the electrode/electrolyte interface, respectively. Meanwhile, Z_W is the Warburg impedance.

Table S1. Summary of the electrochemical performance of various ZnO-based anode materials for lithium-ion batteries.

Materials	Morphology	Discharged capacity ($mAh\ g^{-1}$)	Cycles	Current density ($mA\ g^{-1}$)	Ref.
ZnO	Hierarchical flower-like nanospheres	381	30	493.5	28
ZnO	Ultralong mesoporous nanowires	392	50	98.7	29
ZnO	Ultrathin nanotubes	386	50	494	30
ZnO	Mesoporous nanosheets	421	100	20	31
ZnO	Dandelion-like nanorod arrays	310	40	--	32
Au–ZnO	Hierarchical flower-like nanostructures	392	50	120	33
Al- ZnO	Nanoparticles	418	--	50	34
ZnO-Ag−C	Porous microspheres	729	200	100	5
ZnO/Graphene	Nanocrystals	~300	25	50	17
Al-ZnO-graphene	Aerogel composite	490	100	100	6
ZnO/MWCNT	Nanotube Nanocomposite	460	100	197.4	35
ZnO/Ketjenblack	Porous structure	538.4	100	100	36
ZnO/Graphene	Nanotubes	1058 747 683 891	200 200 200 1000	100 200 500 2000	Our work

Table S2. Kinetic parameters of graphene-wrapped ZnO and bare ZnO electrodes before and after different galvanostatic discharging/charging cycles.

Graphene-wrapped ZnO electrodes	R_{ct} (Ω)	Bare ZnO electrodes	R_{ct} (Ω)
Before cycling	26.4	Before cycling	36.7
After 2 cycles	28.3		
After 50 cycles	214.7		
After 100 cycles	245.9	After 100 cycles	301.4
After 400 cycles	38.1		
After 700 cycles	33.1		
After 1000 cycles	13.9	After 1000 cycles	313.2