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Supporting Information

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SnO_2 Quantum Dots@Graphene Oxide as a High-Rate and Long-Life Anode Material for Lithium-Ion Batteries

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Supporting Information

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Table S1. A comparison of the electrochemical performance of tin-based electrode for lithium ion battery.*

Sample	High-rate Cycling stability					Reference
	Current Density	2nd Capacity	Cycle number	Capacity retention (vs. 2nd Capacity)	Weight percentage	
SnO_2 QDs@GO	2000	553	2000	86 %	88 %	This work
N-Doped Graphene-SnO_2 Sandwich Paper	100	910	50	90 %	32 %	1
G-M-SnO_2	78.2	1100	50	77 %	80 %	2
GNRs/SnO_2	100	1100	50	75 %	81 %	3
Cross linked RGO/SnO_2	100	1000	200	72 %	68 %	4
Cross linked RGO/SnO_2	500	800	200	64 %	68 %	
the sandwich stacked SnO_2/Cu hybrid nanosheets	1000	600	100	67 %	91 %	5
the sandwich stacked SnO_2/Cu hybrid nanosheets	200	713	150	75 %	91 %	
Bowl-like SnO_2@Carbon Hollow Particles	400	1212	100	80 %	76 %	6
SnO_2@C-HTs	200	875	50	80%	89 %	7
SnO_2⊙TiO_2 electrode	400	883.1	1000	44%	/	8
yolk-shell-structured SnO_2 powders	625	704	40	91 %	/	9
yolk-shell-structured SnO_2 powders	3125	263	40	135 %	/	

SnO_2 -75	100	900	200	61 %	75 %	10
SnO_2/C	1400	916	2000	66 %	60 %	11
$CoSnO_3$⊂pGN	2000	707.5	1500	80 %	75 %	12

*the cycling performance in which the capacity increased too much is not included, for the increased capacity also another unstable phenomenon in the charge/discharge process.

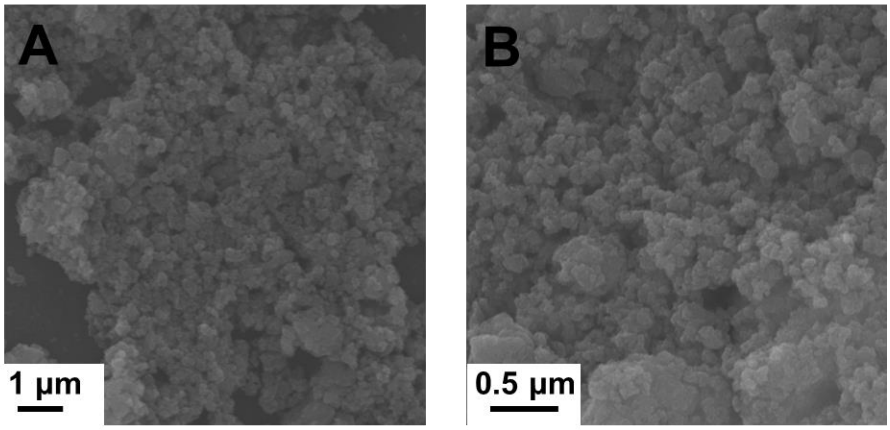

Figure S1. SEM images (A, B) of SnO_2 particles.

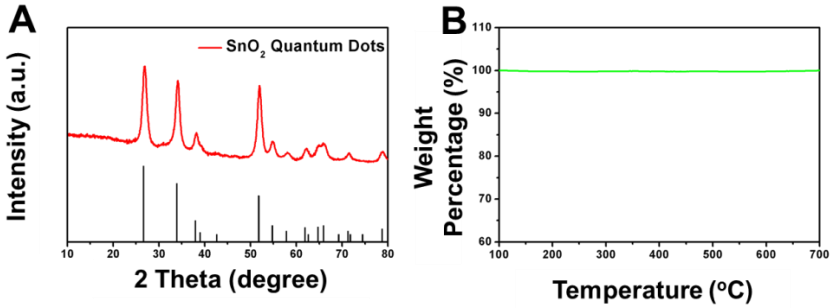

Figure S2. XRD pattern (A) of SnO_2 QDs and TG curve (B) of SnO_2 QDs.

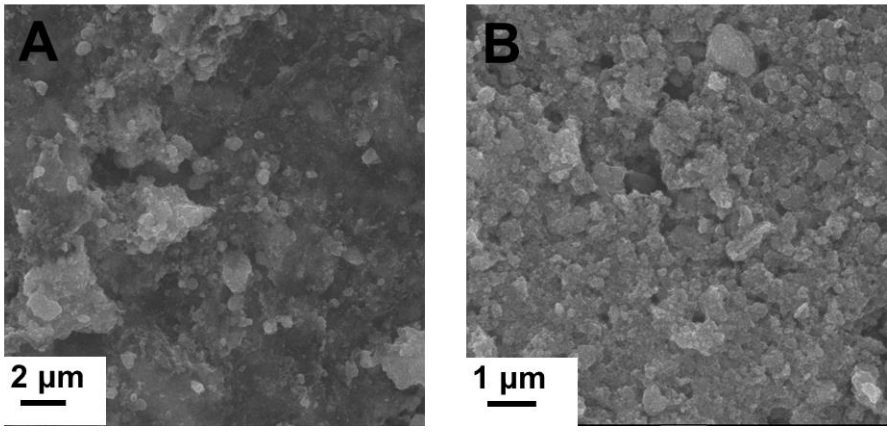

Figure S3. SEM images (A, B) of SnO_2/GO composite.

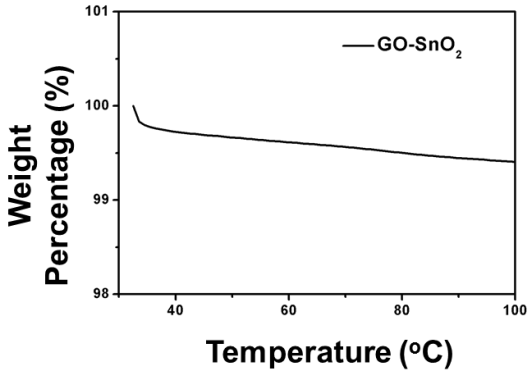

Figure S4. TG curve of SnO_2 QDs@GO at temperature from 30 to 100 °C.

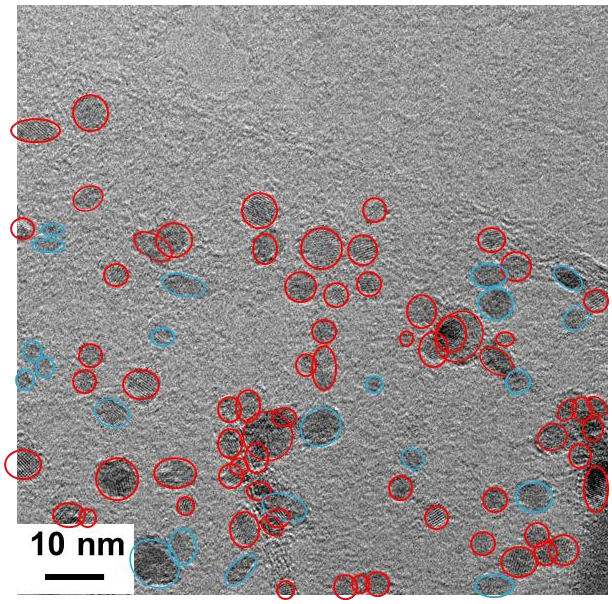

Figure S5. TEM image of SnO_2 QDs@GO. SnO_2 QDs in red circle exhibits the adjacent lattice fringes of 0.34 nm, while the ones in blue circle shows no obvious lattice fringes.

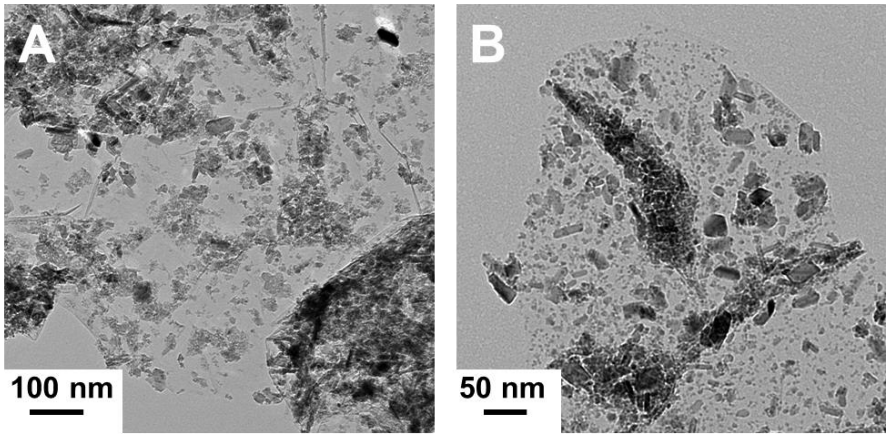

Figure S6. TEM images of SnO_2 QDs@GO composite when the amount of $KMnO_4$ is 1.5 g.

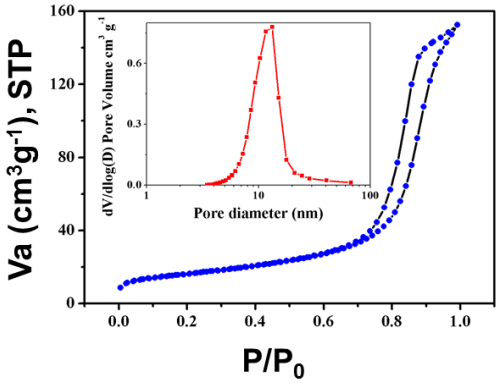

Figure S7. Nitrogen adsorption/desorption isotherms of SnO_2 QDs. Inset is the corresponding pore size distribution of SnO_2 QDs.

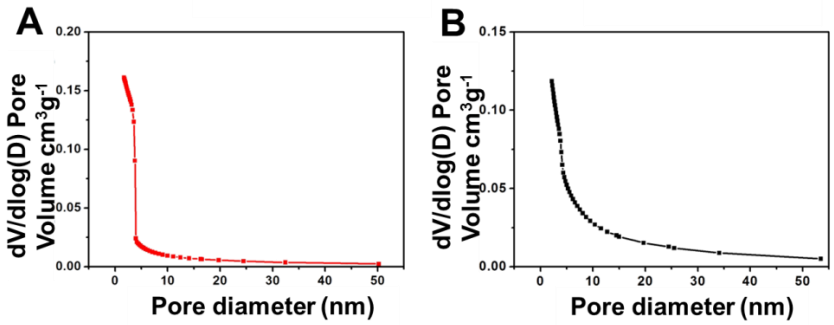

Figure S8. Pore size distribution of SnO_2 QDs@GO composite and SnO_2/GO.

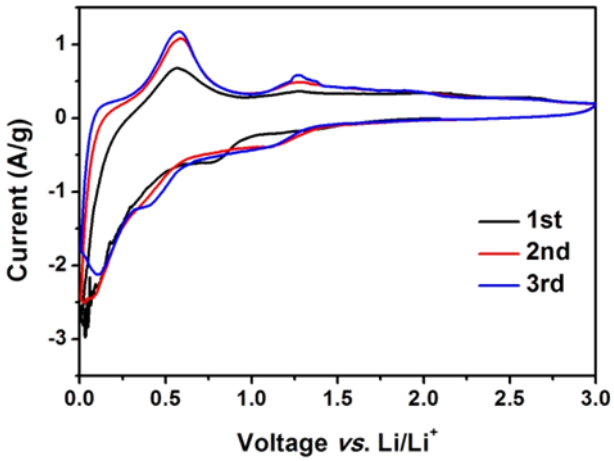

Figure S9. CV curves of SnO_2 QDs@GO at scan rate of 0.1 mV s^{-1}.

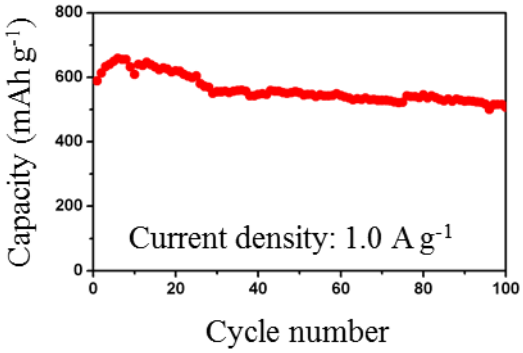

Figure S10. Cycling performance of SnO_2 QDs@GO/$LiFePO_4$ lithium ion battery at 1.0 A g^{-1}.

Figure S11. Digital image of a light-emitting diode lighted by SnO_2 QDs@GO/$LiFePO_4$ lithium ion battery.

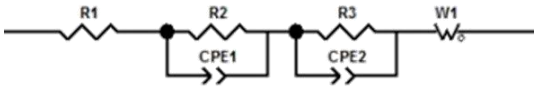

Figure S12. The representive equivalent circuit model.

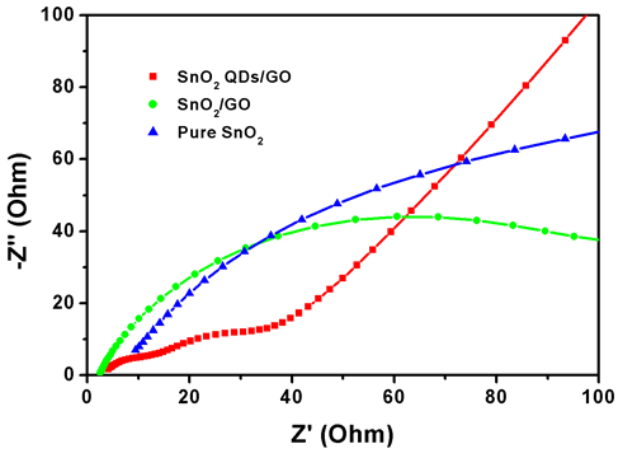

Figure S13. Enlarged impedance responses of SnO_2 QDs@GO, SnO_2/GO composite, and SnO_2 particles.

1. X. Wang, X. Cao, L. Bourgeois, H. Guan, S. Chen, Y. Zhong, D.-M. Tang, H. Li, T. Zhai, L. Li, Y. Bando, D. Golberg, N-Doped Graphene-SnO_2 Sandwich Paper for High-Performance Lithium-Ion Batteries. *Adv. Funct. Mater.*, 2012, 12: 2682–2690.
2. S. Yang, W. Yue, J. Zhu, Y. Ren, X. Yang, Graphene-Based Mesoporous SnO_2 with Enhanced Electrochemical Performance for Lithium-Ion Batteries. *Adv. Funct. Mater.*, 2013, 23: 3570–3576.
3. J. Lin, Z. Peng, C. S. Xiang, G. D. Ruan, Z. Yan, D. Natelson, J. M. Tour, Graphene Nanoribbon and Nanostructured SnO_2 Composite Anodes for Lithium Ion Batteries. *ACS nano*, 2013, 7:6001-6006.
4. L. Wang, D. Wang, Z. H. Dong, F. X. Zhang, J. Jin, Interface Chemistry Engineering for Stable Cycling of Reduced GO/SnO_2 Nanocomposites for Lithium Ion Battery. *Nano Lett.*, 2013, 13: 1711–1716.
5. J. W. Deng, C. L. Yan, L. C. Yang, S. Baunack, S. Oswald, H. Wendrock, Y. F. Mei, O. G. Schmidt, Sandwich-Stacked SnO_2/Cu Hybrid Nanosheets as Multichannel Anodes for Lithium Ion Batteries. *ACS Nano*, 2013, 7: 6948–6954.
6. J. Liang, X. Y. Yu, H. Zhou, H. B. Wu, S. Ding, X. W. Lou, , Bowl-like SnO_2@Carbon Hollow Particles as an Advanced Anode Material for Lithium-Ion Batteries. *Angew. Chem. Int. Ed.*, 2014, 53: 12803–12807.
7. L. Zhang, G. Zhang, H. B. Wu, L. Yu, X. W. Lou, Hierarchical Tubular Structures Constructed by Carbon-Coated SnO_2 Nanoplates for Highly Reversible Lithium Storage. *Adv. Mater.*, 2013, 25: 2589–2593.
8. C. Guan, X. H. Wang, Q. Zhang, Z. X. Fan, H. Zhang, H. J. Fan, Highly Stable and Reversible Lithium Storage in SnO_2 Nanowires Surface Coated with a Uniform Hollow

Shell by Atomic Layer Deposition. *Nano Lett.*, 2014, 14: 4852–4858.

9. Y. J. Hong, M. Y. Son, Y. C. Kang, One-Pot Facile Synthesis of Double-Shelled SnO_2 Yolk-Shell-Structured Powders by Continuous Process as Anode Materials for Li-ion Batteries. *Adv. Mater.*, 2013, 25: 2279–2283.
10. L. Wang, D. Wang, Z. Dong, F. Zhang, J. Jin, Interface Chemistry Engineering of Protein-Directed SnO_2 Nanocrystal-Based Anode for Lithium-Ion Batteries with Improved Performance. *Small*, 2014, 10: 998–1007.
11. A. Jahel, C. M. Ghimbeu, L. Monconduit, C. Vix-Guterl, Confined Ultrasmall SnO_2 Particles in Micro/Mesoporous Carbon as an Extremely Long Cycle-Life Anode Material for Li-ion Batteries. *Adv. Energy Mater.*, 2014, 4: 1400025.
12. C. Wu, J. Maier, Y. Yu, Sn-Based Nanoparticles Encapsulated in a Porous 3D Graphene Network: Advanced Anodes for High-Rate and Long Life Li-Ion Batteries. *Adv. Funct. Mater.* 2015, doi: 10.1002/adfm.201500514.