

Supporting information

Enabling high electrochemical activity of hollow SiO₂ anode by decorating with ultrafine cobalt and carbon matrix for long-lifespan lithium ion batteries

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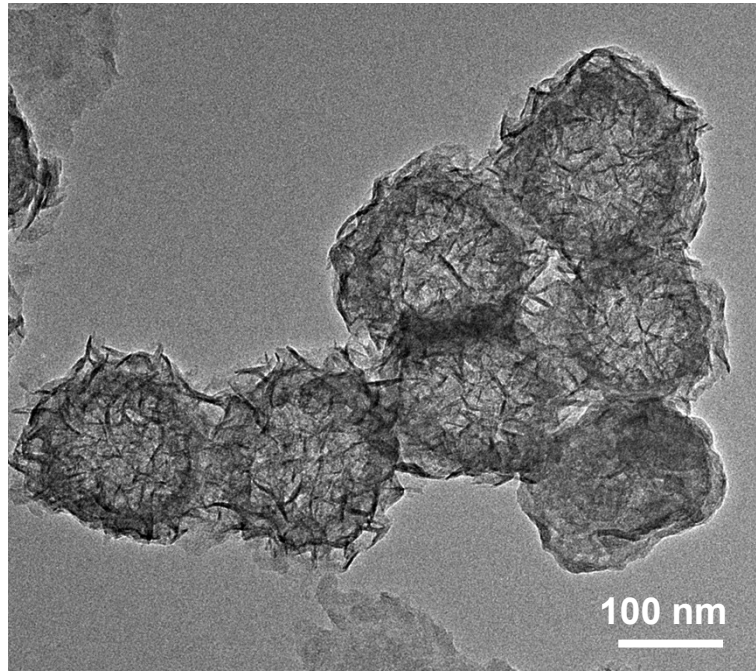


Fig. S1 TEM image of pristine SiO₂/C hierarchical hollow spheres.

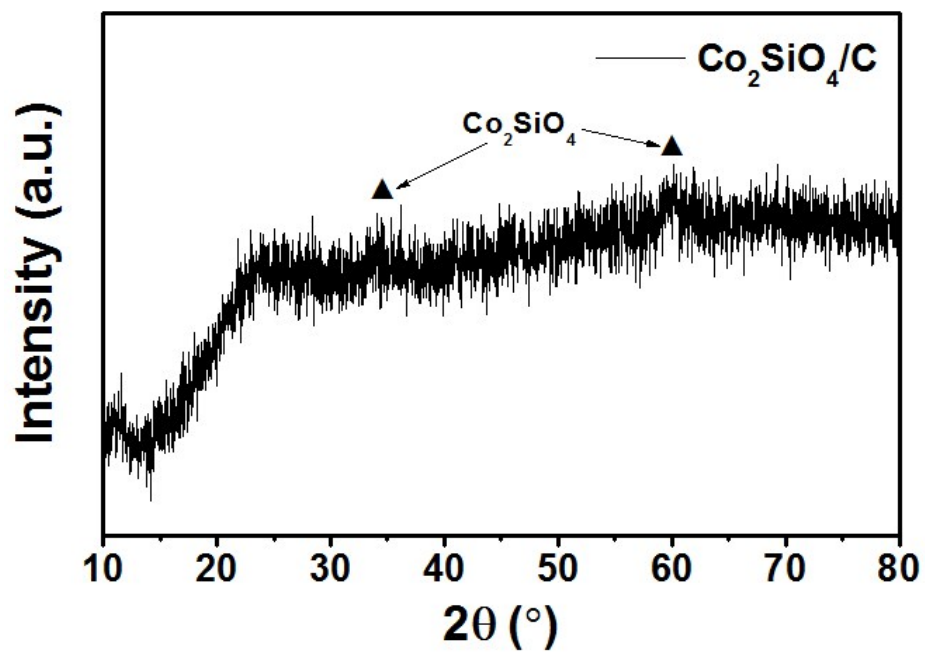


Fig. S2 XRD pattern of the Co₂SiO₄/C intermediate.

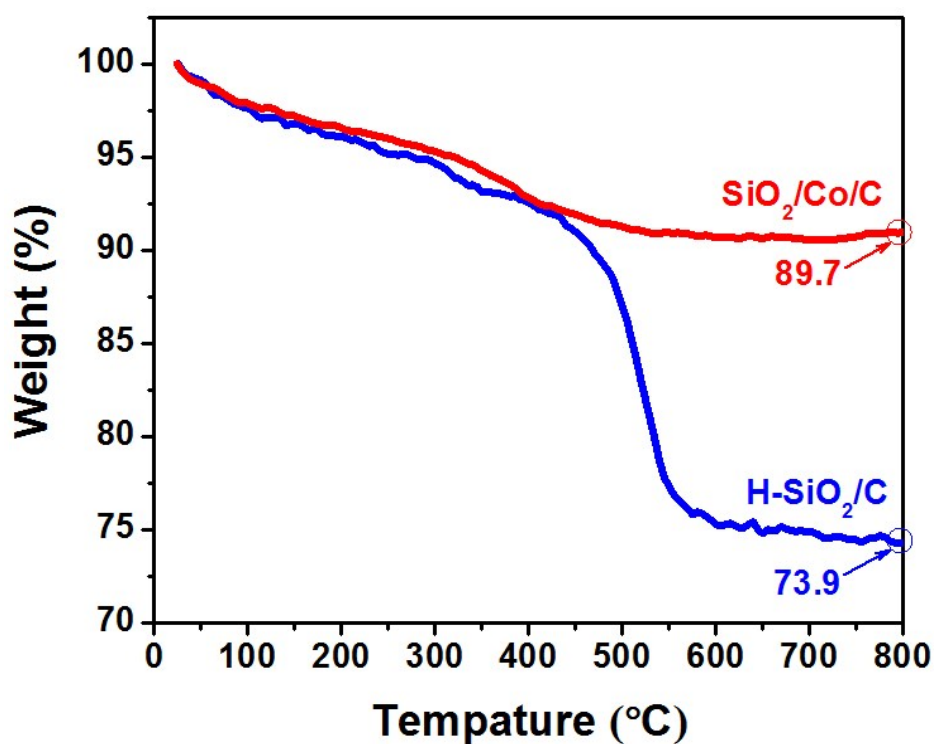


Fig. S3 TG curves of the SiO₂/Co/C and H-SiO₂/C composites.

After TG test in air atmosphere, the final products of the SiO₂/Co/C and H-SiO₂/C composites are SiO₂/Co₃O₄ and SiO₂, respectively. According to the following equations and mass changes revealed from the TG result (Fig. S3), the specific contents of SiO₂, Co and C in the SiO₂/Co/C composite can be calculated to be 55.1, 25.4 and 19.5 wt. % based on the following three equations.

$$\text{SiO}_2 \text{ (wt. \%)} + \text{Co (wt. \%)} + \text{C (wt. \%)} = 100 \quad (1)$$

$$\text{SiO}_2 \text{ (wt. \%)} / \text{C (wt. \%)} = 73.9 / 26.1 \quad (2)$$

$$\text{SiO}_2 \text{ (wt. \%)} + \text{Co}_3\text{O}_4 \text{ (molecular weight)} / 3 \text{ Co (molecular weight)} \times \text{Co (wt. \%)} = 89.7 \quad (3)$$

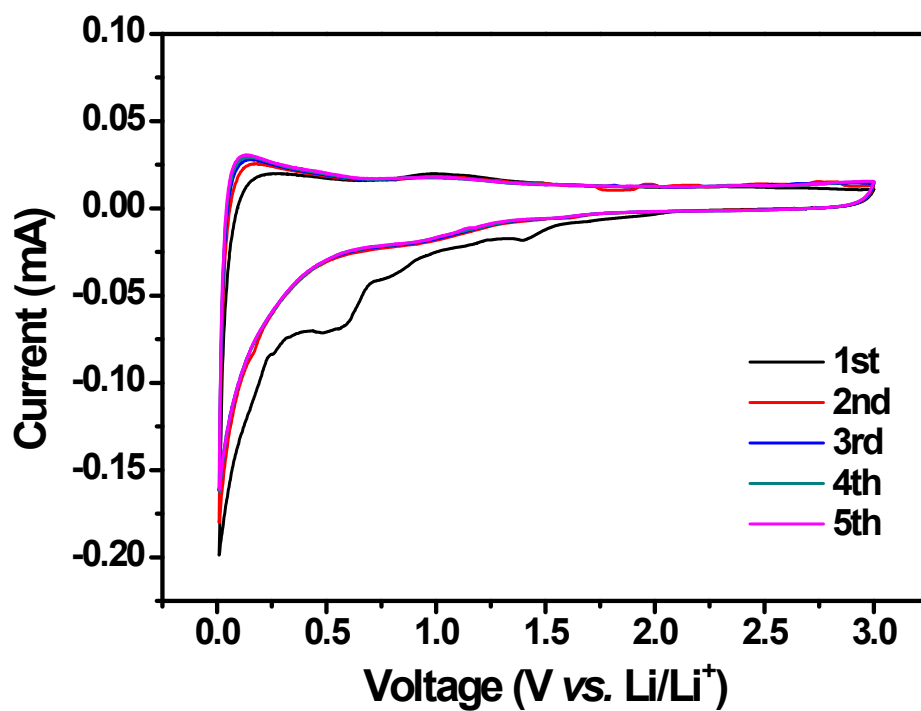


Fig. S4 CV curves of pristine H-SiO₂/C at a scan rate of 0.1 mV s⁻¹ in the potential range from 3.0 to 0.01 V vs. Li⁺/Li.

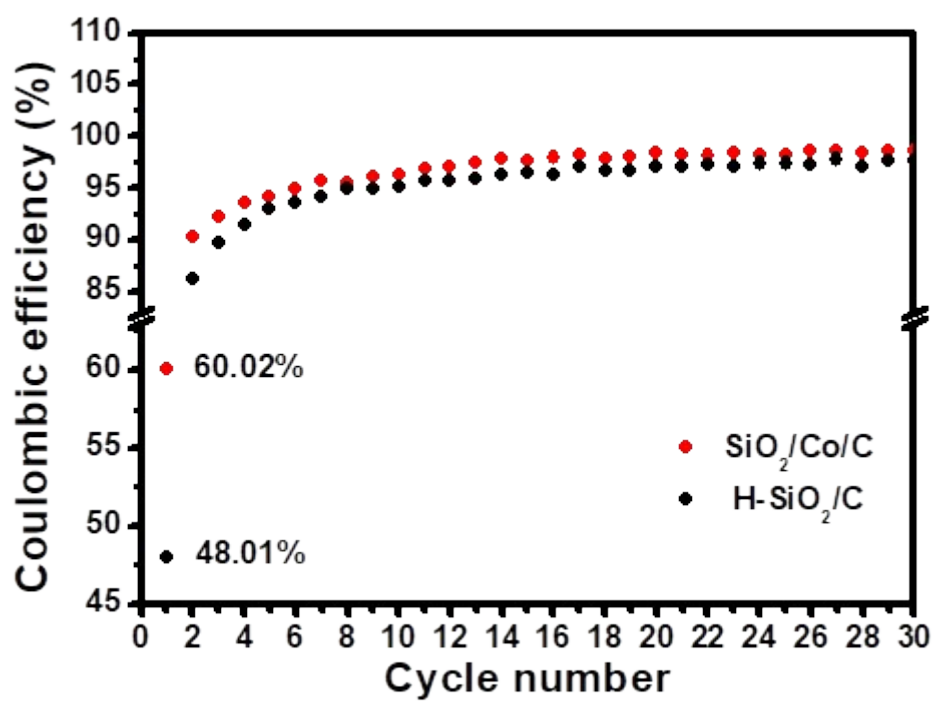


Fig. S5 Coulomb efficiency of SiO₂/Co/C and pristine H-SiO₂/C for the first 30 cycles.

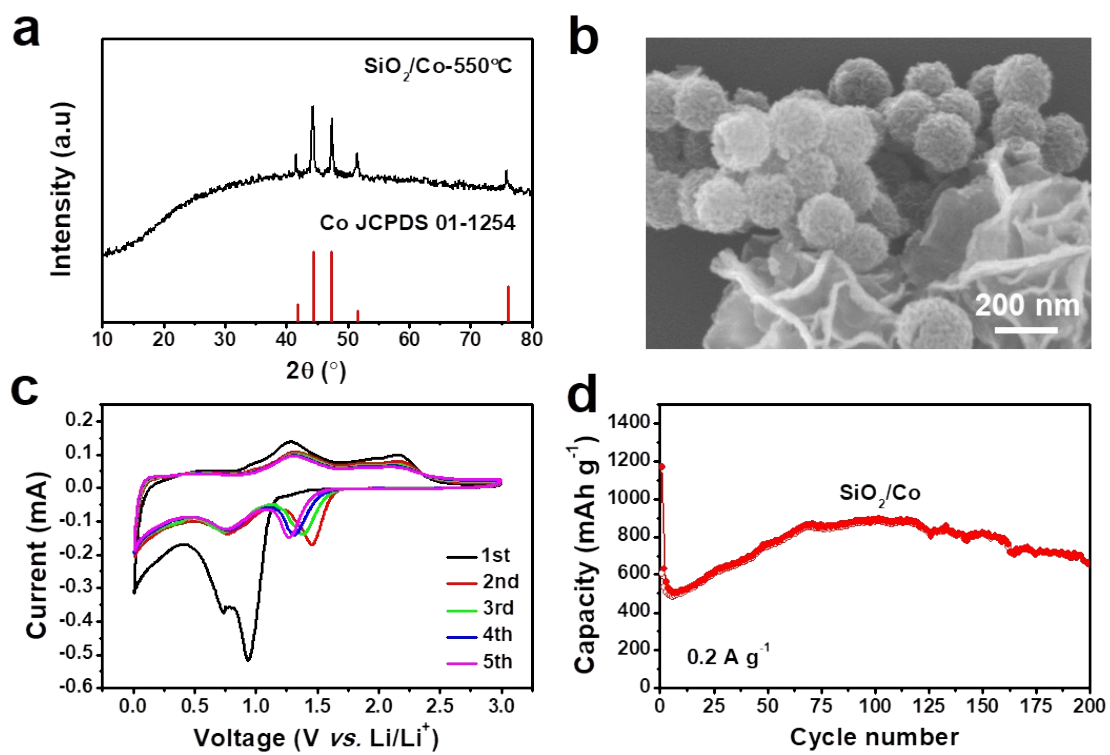


Fig. S6 (a)XRD pattern, (b) SEM image, (c) CV curves and (d) cycling performance of the SiO_2/Co composite.

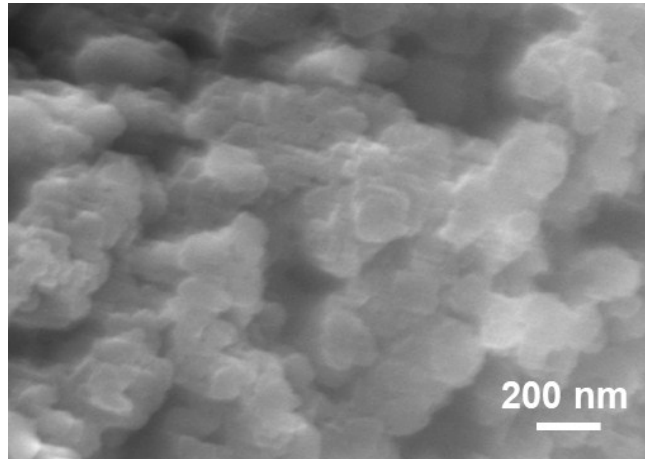


Fig. S7 SEM image of SiO₂/Co/C after 50 discharge/charge cycles at 0.2 A g⁻¹.

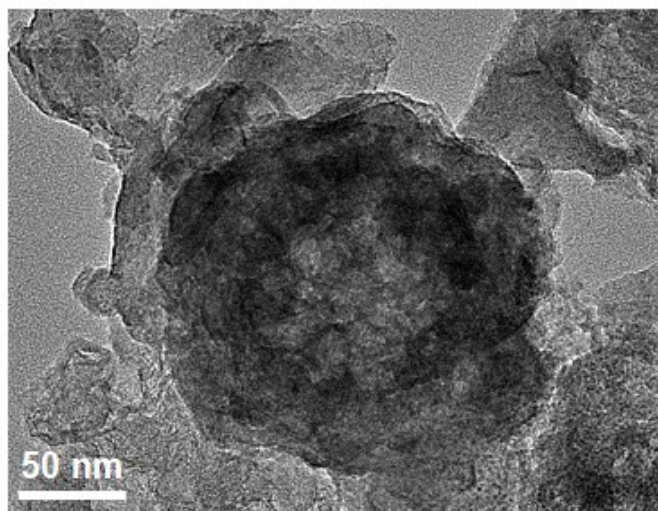


Fig. S8 TEM image of $\text{SiO}_2/\text{Co}/\text{C}$ after 20 discharge/charge cycles at 0.2 A g^{-1} .

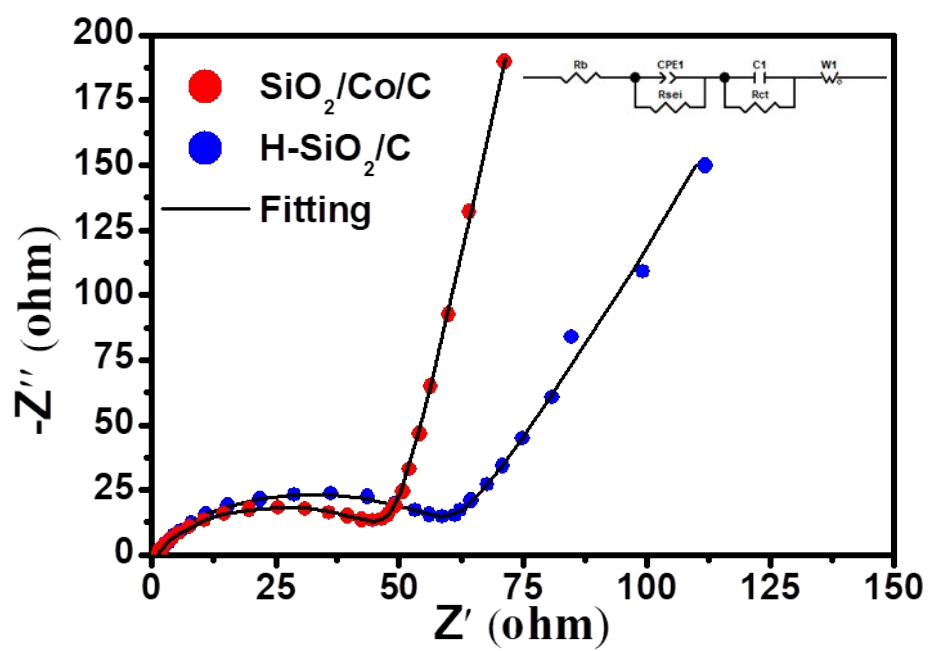


Fig. S9 Nyquist plots of SiO₂/Co/C and pristine H-SiO₂/C.

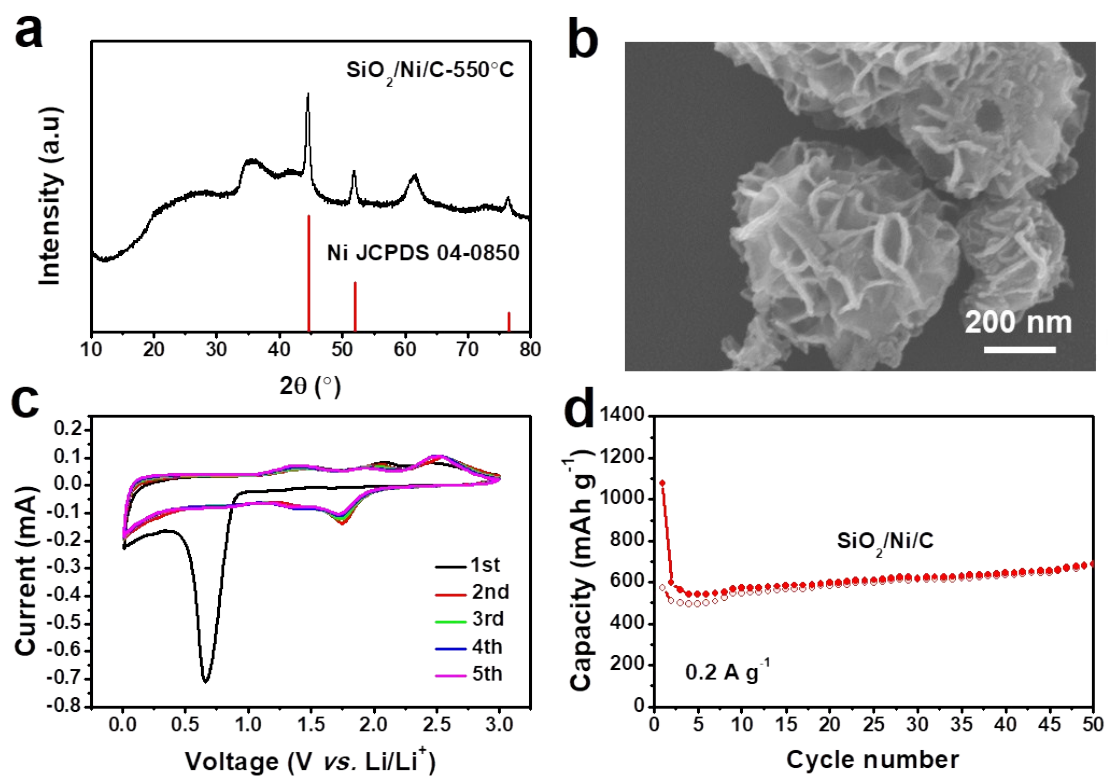


Fig. S10 (a)XRD pattern, (b) SEM image, (c) CV curves and (d) cycling performance of the $\text{SiO}_2/\text{Ni}/\text{C}$ composite.

Table S1 Comparison of lithium storage properties of various SiO₂-based anode materials.

SiO ₂ -based anode materials	Current density (A g ⁻¹)	Capacity (mAh g ⁻¹)	Cycle number	Rate capability (mAh g ⁻¹)	Ref.
nanofibrous SiO ₂ /C	0.1	400	200	263 (0.5 A g ⁻¹)	22
N-OMC/SiO ₂	0.2	630	100	372 (0.5 A g ⁻¹)	25
hollow porous SiO ₂	0.1	919	30	377 (0.5 A g ⁻¹)	27
hollow porous SiO ₂ nanobelts	0.1	1012	100	390 (1.0 A g ⁻¹)	28
HSiO ₂ @CN	0.2	810	100	378 (5.0 A g ⁻¹)	30
SiO ₂ /Cu/PAN-C	0.11	450	185	352 (0.44 A g ⁻¹)	31
multi-shell hollow SiO ₂	0.1	750	500	289 (1.0 A g ⁻¹)	33
H-SCC	0.05	776.1	100	492 (0.5 A g ⁻¹)	35
Ni/SiO ₂	0.1	676	50	337 (10.0 A g ⁻¹)	43
SiO ₂ /Sb@CNF	0.2	700	400	520 (2.0 A g ⁻¹)	S1
SiO ₂ /MXene microspheres	0.2	799	100	517 (3.0 A g ⁻¹)	S2
SiO ₂ -C	0.1	693	100	232 (1.5 A g ⁻¹)	S3
SiO _x /C	0.1	550	180	390 (0.8 A g ⁻¹)	S4
silica/carbon	0.1	820	100	255 (5.0 A g ⁻¹)	S5
SiO ₂ /Co/C	0.2	1050	200	439 (5.0A g ⁻¹)	This
	1.0	548	1000		work

References

- [S1] H. Wang, X. Yang, Q. Wu, Q. Zhang, H. Chen, H. Jing, *ACS Nano*, 2018, 12, 3406.
- [S2] G. Mu, D. Mu, B. Wu, C. Ma, J. Bi, L. Zhang, H. Yang, F. Wu, *Small*, 2020, 16, 1905430.
- [S3] S. Ali, S. Jaffer, I. Maitlo, F. K. Shehzad, Q. Wang, M. Y. Akram, Y. He, J. Nie, *J. Alloy. Compoud.*, 2020, 812, 152127.
- [S4] B. Zhang, H. Wang, C. Liu, D. Li, H. K. Kim, C. Harris, C. Y. Lao, A. Abdelkader, K. Xi, *J. Alloy. Compoud.*, 2019, 801, 658.
- [S5] X. Yang, H. Ma, G. Zhang, X. Li, *Adv. Mater. Interfaces*, 2019, 6, 1801809.