Supporting Information

Yolk-double shell structured bread-like Si@Z-700N@void@C nanocomposites as high-stable anode for lithium-ion batteries

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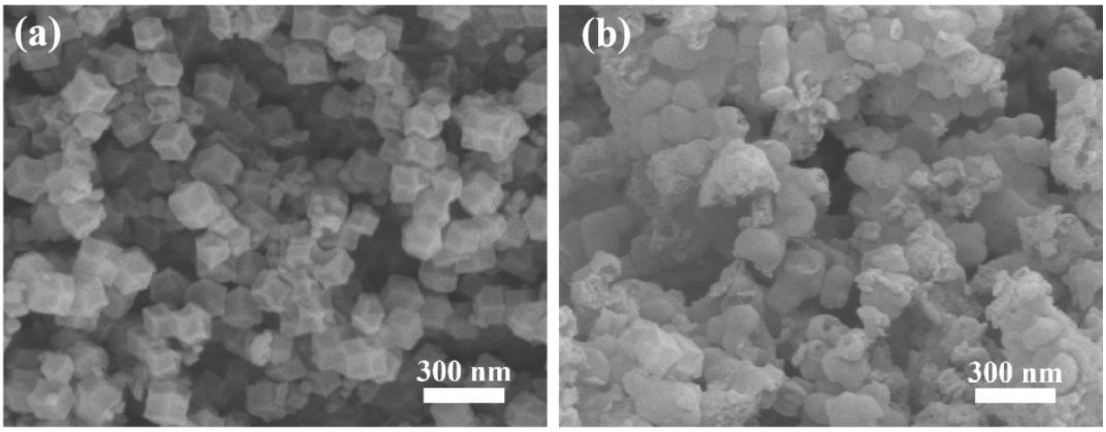

Figure S1. SEM images of (a) Si@Z-700N, (b) Si@Z-700N@C.

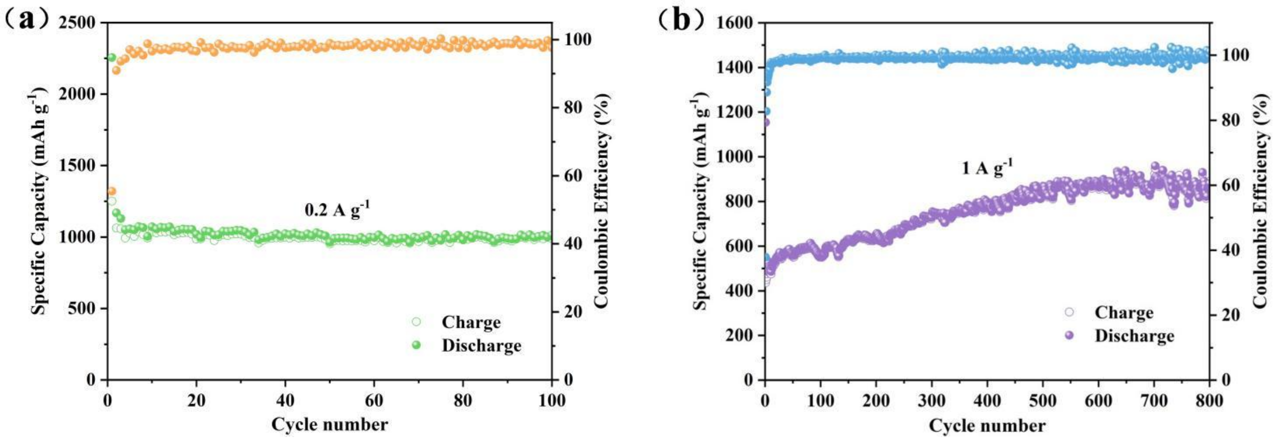

Fig. S2. The cycling performance diagram of Si@Z-700N@void@C electrode (a) 100 cycles at 0.2 A g^{-1}, (b) 800 cycles at 1 A g^{-1}

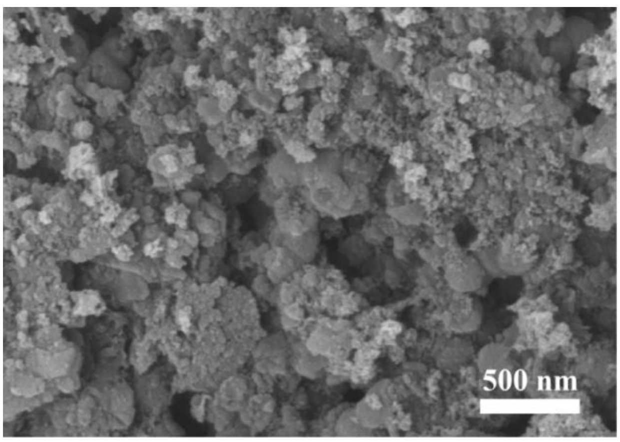

Fig. S3. SEM image of Si@Z-700N@void@C composite after 800 cycles at 1 A g^{-1}

Table S1. Structural parameters of crystalline silicon.

Samples	Average Crystallite Size(nm)	Dislocation density	Lattice Strain(nm^{-2})
Before carbonization			
Si@Z-700N	27.2	0.00164	0.00369
Si@Z-700N@C	27.1	0.00128	0.00378
Si@Z-700N@void@C	27.7	0.00134	0.00375
After carbonization			
Si@Z-700N	30.4	0.00182	0.00347
Si@Z-700N@C	30.7	0.00112	0.00326
Si@Z-700N@void@C	30.5	0.00149	0.00319

Table S2. Comparison of Electrochemical Performance of Si/C composites.

Composites	Current density (A g^{-1})	Cycle number	Capacity after cycles (mAh g^{-1})	Initial CE(%)	Ref
TSC-PDA-B	0.1	200	1113	71.0	[1]
hollow Si/SiO_2@C	0.5	200	1170	58.5	[2]
Si@C@ZIF-67-800N	1	300	852	79.0	[3]
Si@SiO_2@NC	1	100	641	81.0	[4]
Si@GC/PAC	0.1	200	600	60.2	[5]
N- Graphene/SiOC	1	1000	415	70.0	[6]
Si/C-3	0.5	200	571	70.1	[7]
Si@Z-700N@void@C	1	800	866	55.4	this work

Table S3. Impedance parameters of Si@Z-700N, Si@Z-700N@C and Si@Z-700N@void @C electrodes.

Samples	R_s (Ω)	R_f (Ω)	R_{ct} (Ω)	W_1 (Ω $S^{-1/2}$)	CPE1(F)	CPE2(F)
Before cycling						
Si@Z-700N	31.24		343.4	0.3143	2.16E-5	
Si@Z-700N@C	27.57		173.9	0.3249	1.81E-5	
Si@Z-700N@void@C	7.79		45.4	0.3316	1.35E-5	
After 500th cycle						
Si@Z-700N	28.29	50.58	182.7	0.3049	4.32E-6	4.47E-5
Si@Z-700N@C	20.32	49.82	48.4	0.2815	5.67E-6	5.01E-5
Si@Z-700N@void@C	6.56	34.87	21.5	0.2186	8.37E-6	8.11E-6

References:

[1] Hu, L.; Luo, B.; Wu, C.; Hu, P.; Wang, L.; Zhang, H. Yolk-shell Si/C composites with multiple Si nanoparticles encapsulated into double carbon shells as lithium-ion battery anodes. *J. Energy Chem.* **2019**, *32*, 124-130.

[2] Wang, H.; Xu, H.; Jia, K.; Wu, R. ZIF-8-Templated Hollow Cubelike Si/SiO_2@C Nanocomposites for Superior Lithium Storage Performance. *Acs Appl. Energ. Mater.* **2019**, *2*, 531-538.

[3] Hu, L.; Luo, B.; Wu, C.; Hu, P.; Wang, L.; Zhang, H. Yolk-shell Si/C composites with multiple Si nanoparticles encapsulated into double carbon shells as lithium-ion battery anodes. *J. Energy Chem.* **2019**, *32*, 124-130.

[4] Yu, Y.; Zhan, Z.; Xu, Q.; Shen, K. Dual Stabilized Architecture of Si@SiO_2/N-Doped Carbon Composite Synthesized via Oxygen Plasma Method as Anode for High-performance LIBs. *Chem. Lett.* **2020**, *49*, 423-427.

[5] Ou, J.; Li, B.; Deng, H.; Li, K.; Wang, H. A carbon-covered silicon material modified by phytic acid with 3D conductive network as anode for lithium-ion batteries. *Adv. Powder Technol.* **2023**, *34*, 103891.

[6] Naveenkumar, P.; Maniyazagan, M.; Yang, H.; Kang, W. S.; Kim, S. Nitrogen-doped graphene/silicon-oxycarbide nanosphere as composite anode for high-performance lithium-ion batteries. *J. Energy Storage* **2023**, *59*, 106572.

[7] Zhang, J.; Zuo, S.; Wang, Y.; Yin, H.; Wang, Z.; Wang, J. Scalable synthesis of interconnected hollow Si/C nanospheres enabled by carbon dioxide in magnesiothermic reduction for high-performance lithium energy storage. *J. Power Sources* **2021**, *495*, 229803.