Supplementary Information

Rational Design for Enhanced Mechanical and Kinetic Properties of SnSb-based Yolk-Shell Heterostructure as Long Cycle-Life, High-Rate Na-Ion Battery Anode

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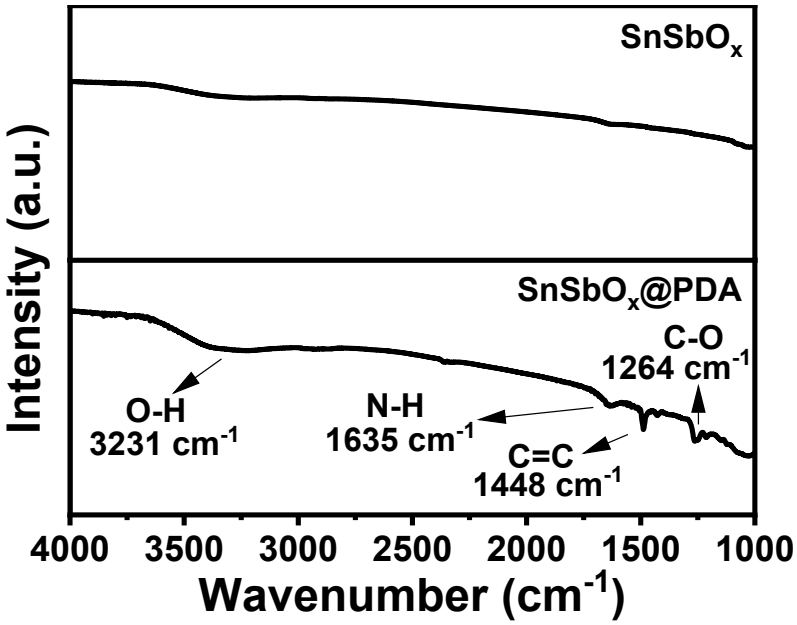


Figure S1. FT-IR spectra of the $SnSbO_x$ and $SnSbO_x$@PDA precursors.

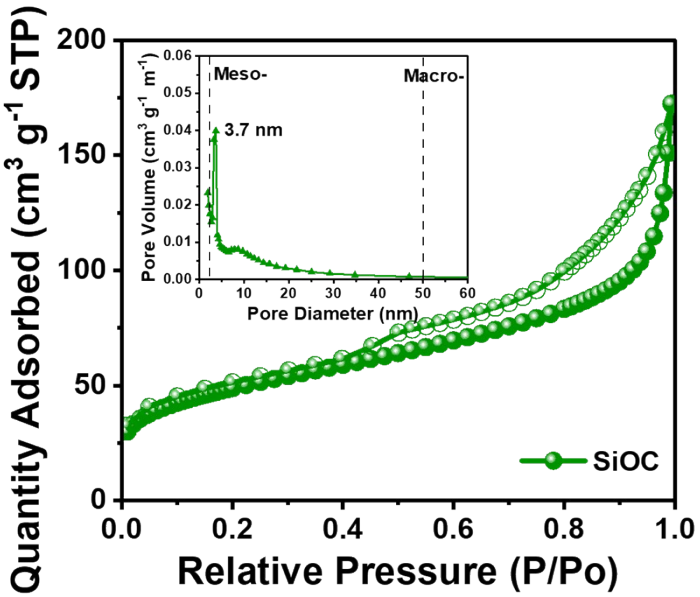


Figure S2. Nitrogen adsorption–desorption isotherm and pore size distribution (inset) of SiOC. (BET surface area and total pore volume of SiOC were measured to be 175.3 m^2 g^{-1} and 0.270 cm^3 g^{-1}, respectively.)

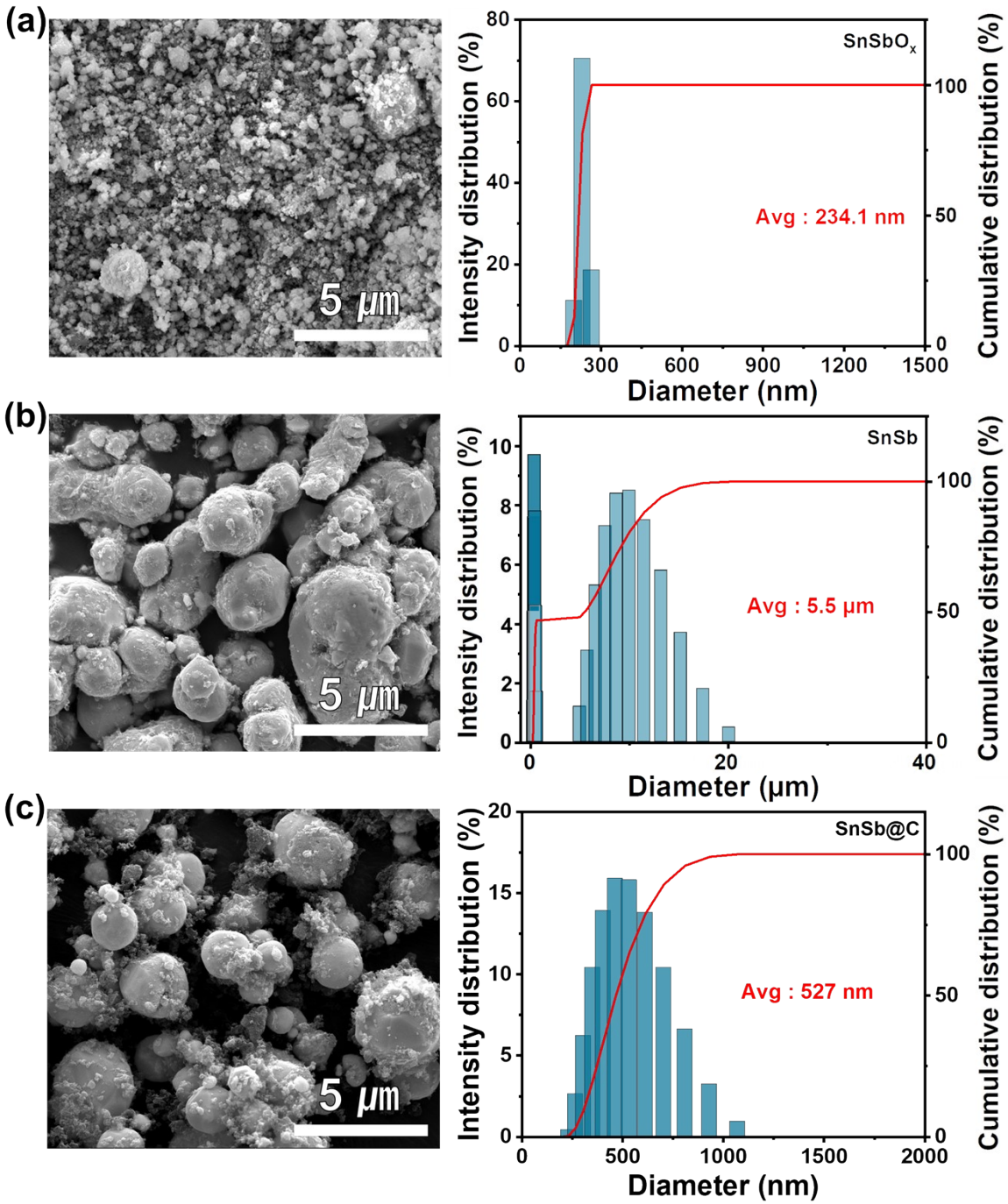


Figure S3. FE-SEM images and DLS particle distribution of (a) $SnSbO_x$, (b) SnSb, and (c) SnSb@C.

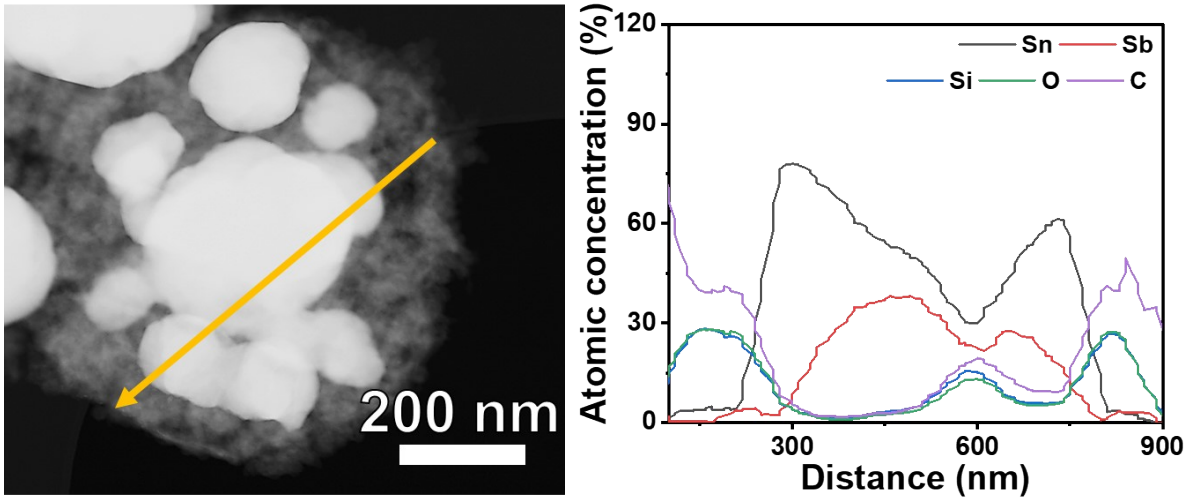


Figure S4. EDS line-scan profile of the SnSb@C-SiOC nanohybrid particle.

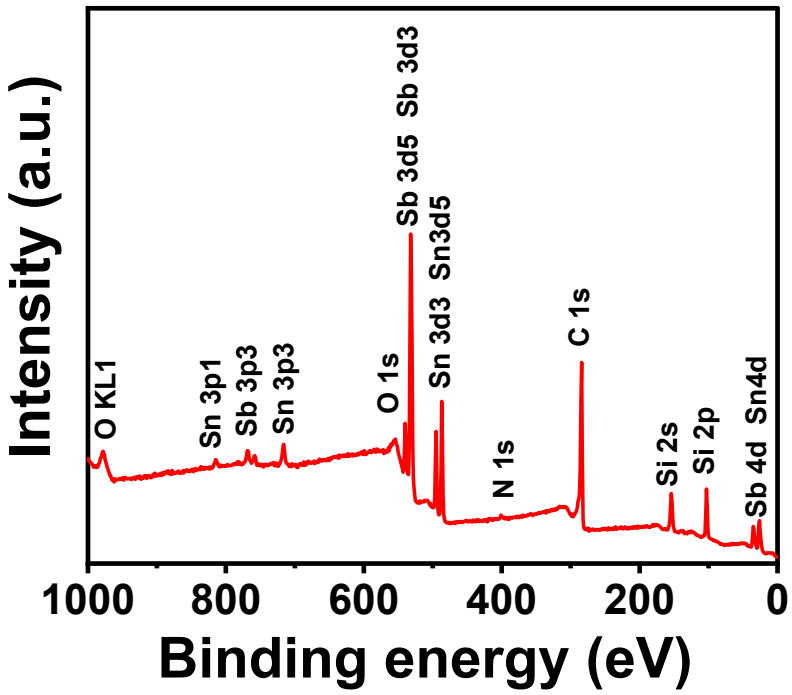


Figure S5. XPS survey spectrum of SnSb@C-SiOC.

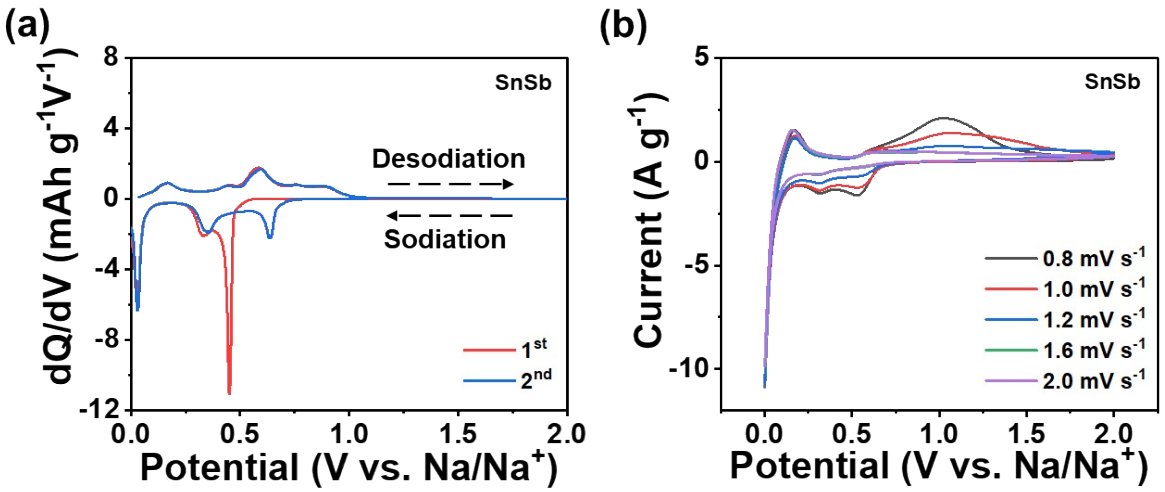


Figure S6. (a) dQ/dV plots of SnSb at 0.1 Ag^{-1} for the 1st and 2nd cycles. (b) CV curves of the SnSb electrode at different scan rates from 0.8 to 2.0 mV s^{-1} in a voltage range of 0.001–2.0 V.

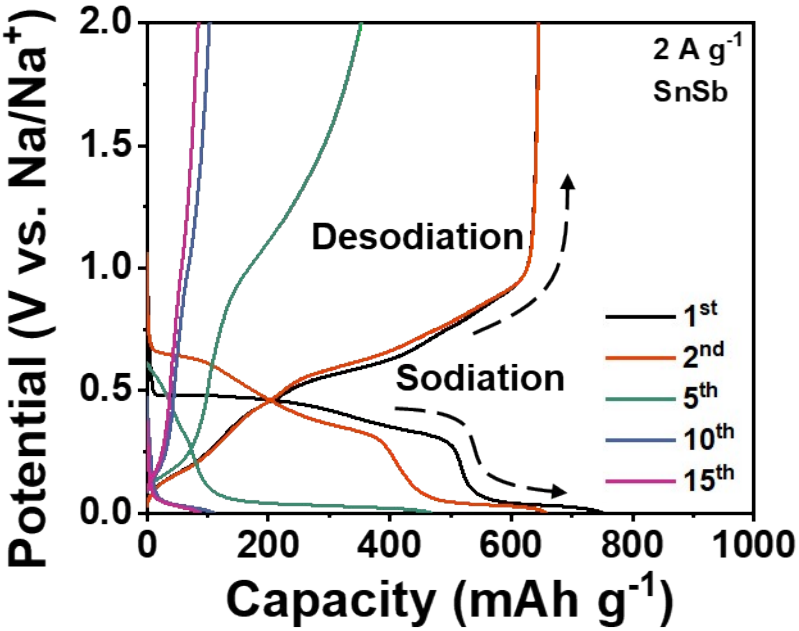


Figure S7. GCD profiles of the SnSb cell at several number of cycles (1st, 2nd, 5th, 10th, and 15th).

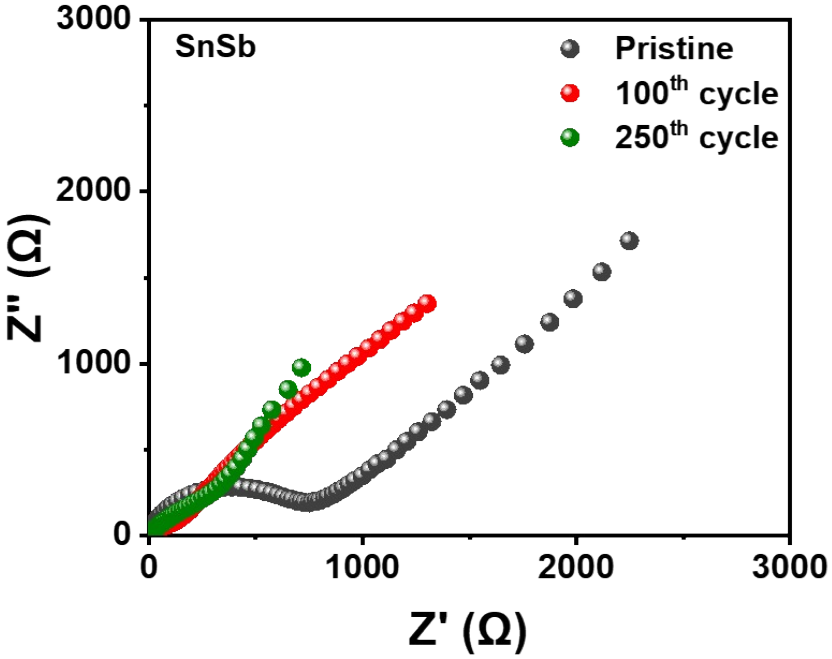


Figure S8. Nyquist plot of the SnSb electrode before and after the 100th and 250th cycles.

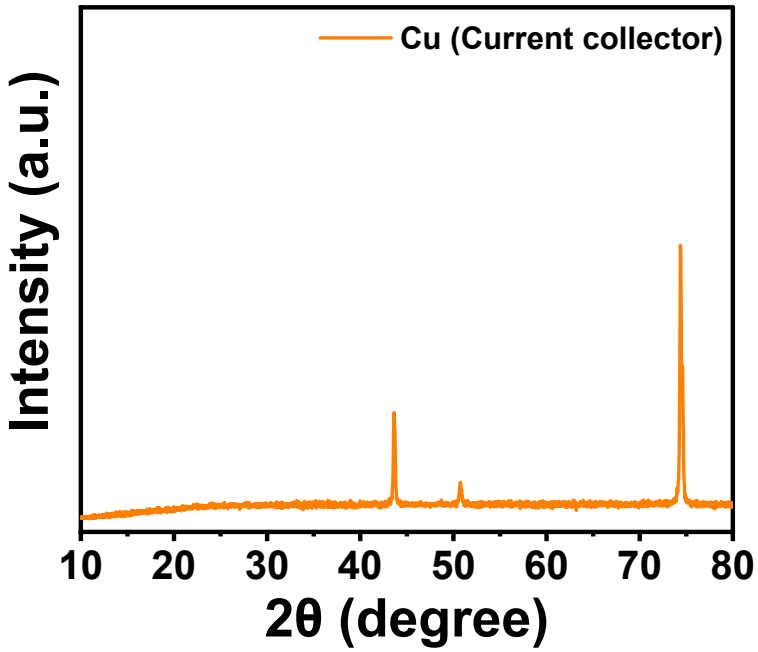


Figure S9. XRD pattern of the Cu current collector.

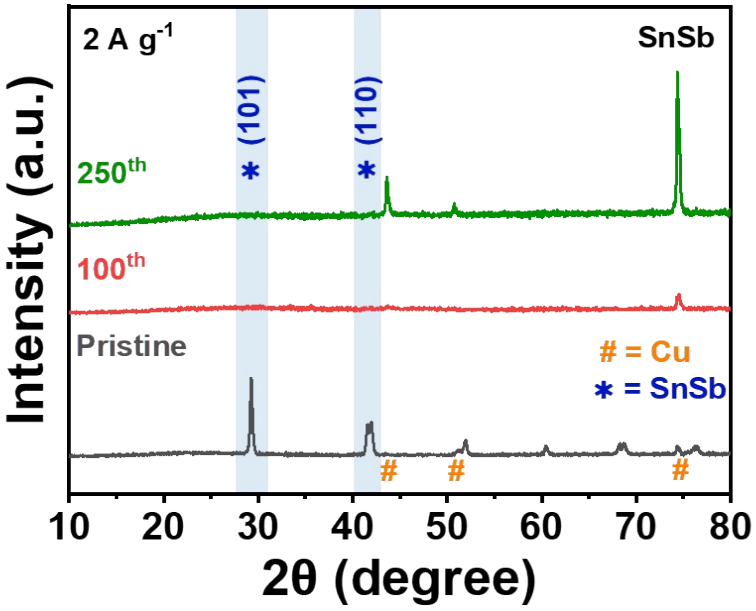


Figure S10. *Ex-situ* XRD patterns of the SnSb electrode before and after cycling (100th and 250th) at 2.0 A g^{-1}.

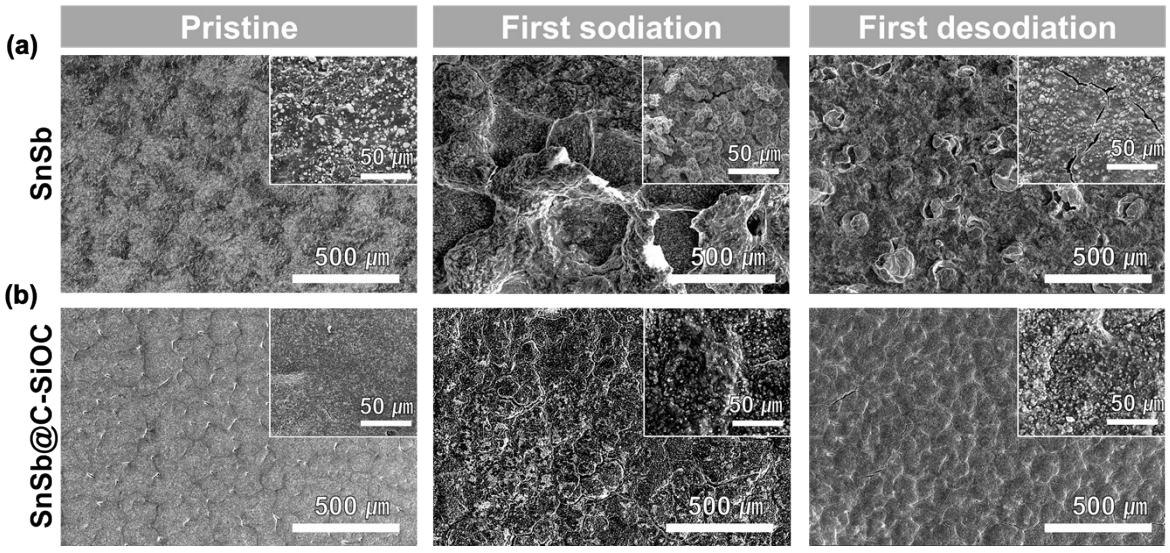


Figure S11. Top-view SEM images of the electrode surface. (a) SnSb and (b) SnSb@C-SiOC electrode in pristine, first sodiated, and first desodiated states.

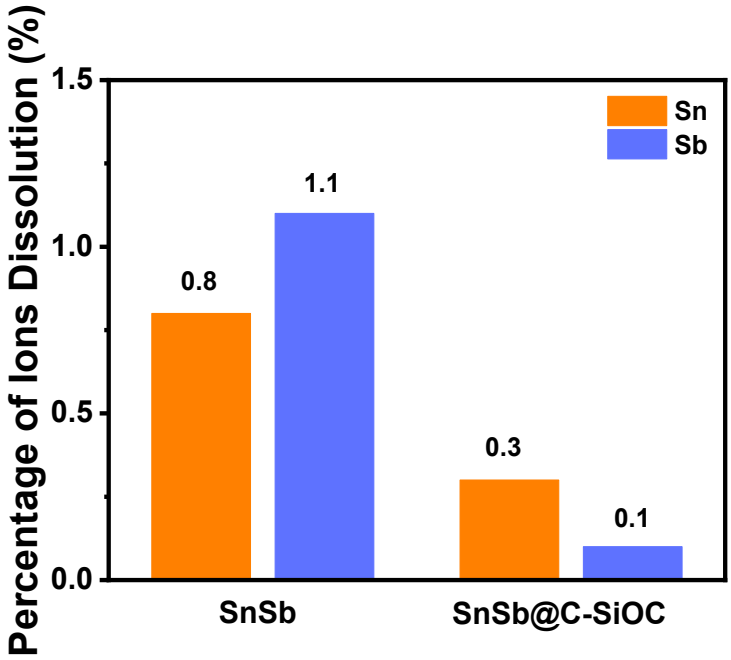


Figure S12. ICP-OES measurement of metal (Sn and Sb) dissolution from SnSb and SnSb@C-SiOC electrode after the 100th cycle at 2.0 A g^{-1}.

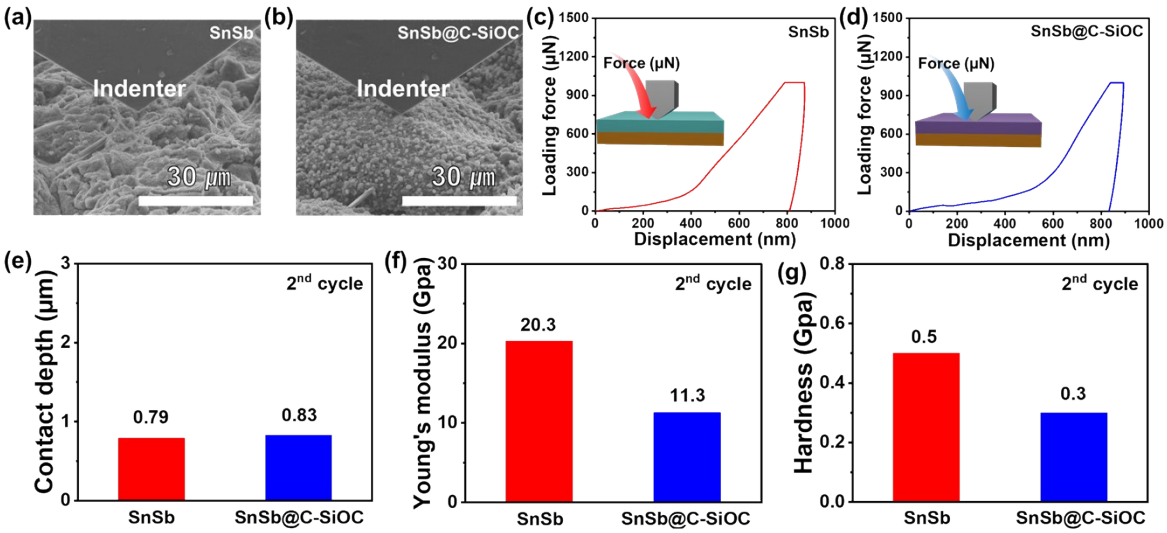


Figure S13. (a–b) Overview SEM images of nano-indentation analysis to obtain mechanical properties of the SnSb-based electrodes. (c–d) Loading force–displacement curves, (e) contact depth, (e) Young's modulus, and (g) hardness of SnSb and SnSb@C-SiOC after the 2nd cycle.

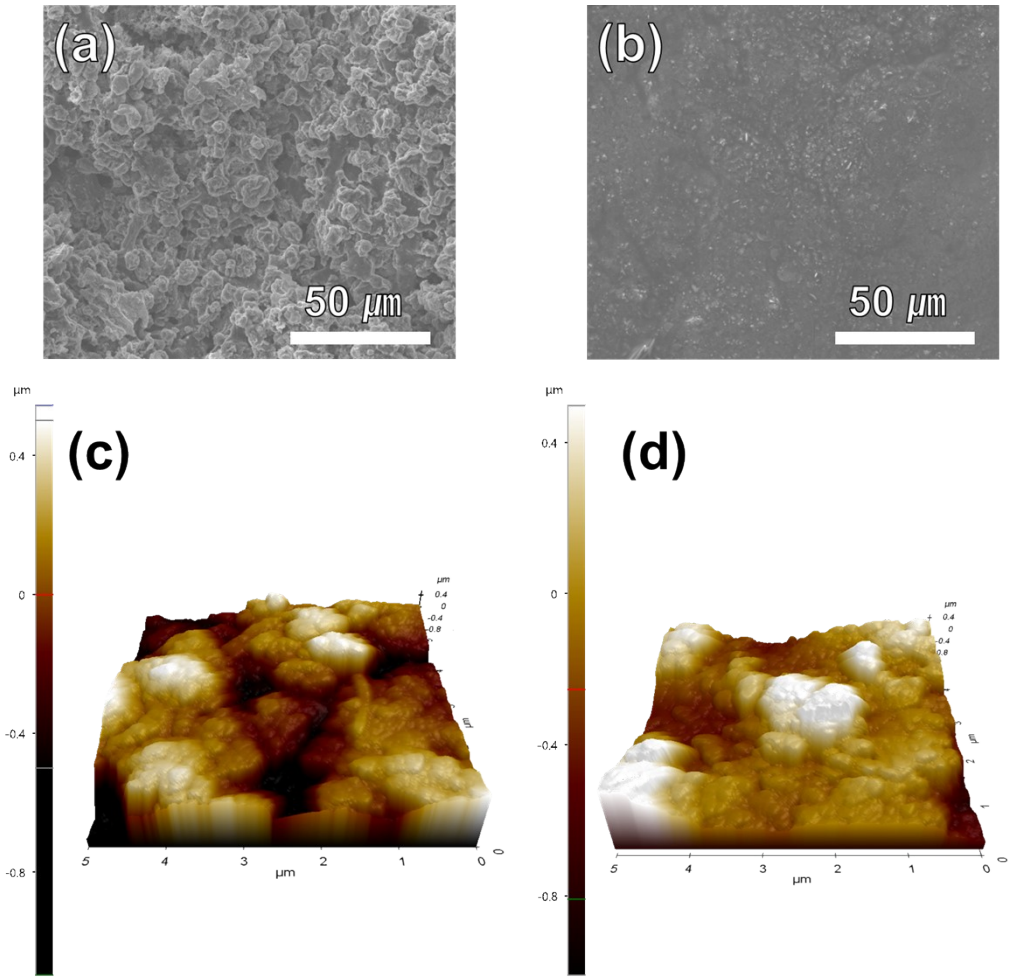
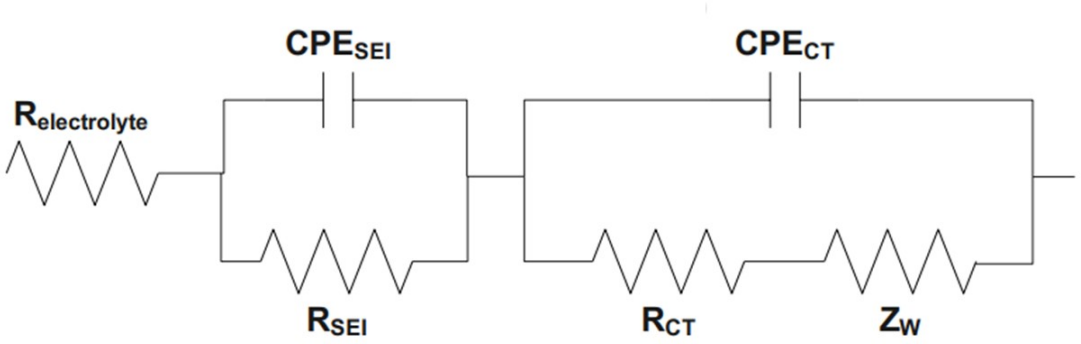


Figure S14. (a–b) Top-view SEM and (c-d) AFM topography images of SnSb and SnSb@C-SiOC electrode surface after the 100th cycle, respectively.

Table S1. BET surface area and porous characteristics of SiOC and SnSb@C-SiOC.

Sample	BET Surface Area ($m^2 g^{-1}$)	Total pore volume ($cm^3 g^{-1}$)
SiOC	175.3	0.27
SnSb@C-SiOC	57.3	0.12

Table S2. Fitted equivalent circuit values of SnSb and SnSb@C-SiOC electrodes using the Z-view program.



Sample	Component	Resistance (Ω)		
		Fresh electrode	100th cycle	250th cycle
SnSb	R_{ele}	2.3	1.4	5.4
	R_{SEI}	464.5	112.4	150.5
	R_{ct}	164.5	15.4	27.9
SnSb@C-SiOC	R_{ele}	6.6	0.7	0.3
	R_{SEI}	125.0	0.6	0.4
	R_{ct}	160.3	1.6	1.5

Table S3. Summary of sodium storage performance of various SnSb-based anodes for SIBs.

Active Material	1st cycle capacity (mAh g^{-1} at mA g^{-1})	1st Coulombic efficiency (%)	Cycle performance (mAh g^{-1} at mA g^{-1})	Cycle stability (%)	Reference
SnSb/CNT@GS	422 at 100	62.0	396 at 100	77.0 at 100th cycle	31
B-SnSb/NCFs	831.8 at 100	72.9	486.9 at 100	42.7 at 400th cycle	23
SnSb/C	490 at 50	75.3	265 at 100	70.0 at 200th cycle	38
3D SnSb@N-PG	500 at 100	50.4	400 at 100	40.3 at 100th cycle	13
SnSb/N-PCNWs	517 at 50	68.7	180 at 2000	100 at 10000th cycle	11
SnSb-G composite	455.6 at 200	76	281.8 at 2000	89.1 at 1000th cycle	26
SnSb/C nanocomposite	544 at 100	75.1	435 at 50	80 at 50th cycle	39
SnSb@rGO@CNF	788.6 at 100	61.4	422.1 at 100	87.2 at 200th cycle	40
Our work	**543.0 at 100**	**84.3**	**444.0 at 2000**	**83.9 at 250th cycle**	