Electronic Supplementary Material (ESI) for ChemComm.

Versatile Strategy for Ultrathin SnS_2 Nanosheets Confined in N-Doped Graphene Sheets Composite for High Performance Lithium and Sodium-ion batteries

Experimental Section

Synthesis of SnS_2/3DNG: The graphene oxide (GO) was synthesized by a modified Hummers method as the previous report [28]. Briefly, 50 mg GO powder was dissolved in 30 mL of deionized water by ultrasonic dispersion for 30 min forming yellow solution. After that, 2 mmol of $SnCl_4$•$5H_2O$ and 4 mmol CH_4N_2S were added into above solution unter magnetic stirring for 1h. The homogeous mixture was transfered to a refrigerator and frozening for overnight. Then, the precursors were obtained by freez-drying treatment for 24 h and then heated at 400 ℃ for 2 h under Ar atmosphere, and the final black powder is denoted as SnS_2/NGS.

Material Characterization: The X-ray powder diffraction (XRD) pattern was recorded by a Bruker D8 ADVANCE X-ray diffractometer with Cu K_α radiation (λ = 0.15418 nm) at a scanning rate of 4° min^{-1}. Field-emmision scanning electron microscopy (SEM) images were obtained on a ZEISS microscope with an accelerating voltage of 20 kV. Transmission electron microscopy (TEM) images and high-resolution TEM (HRTEM) images were obtained by a JEOL JEM-2000CX instrument. Nitrogen adsorption and desorption isotherm was characterized by a ASAP2020. The XPS experiments were carried out on a PHI-5400 electron spectrometer. The Raman spectrum was performed by a Raman spectrometer (Horiba Xplora). The thermogravimetric analysis (TGA) was conducted on a thermogravimetric analyzer (TGA, SDTA851).

Electrochemical Measurements: The working electrode was prepared by mixing the SnS_2/3DNG powder, acetylene black, and polyvinylidene difluoride (PVDF) in a weight ratio of 70:20:10. The slurry was pasted to Cu foil for LIBs and SIBs, and then dried at 100 °C overnight under vacuum. CR2032-type coin cells were assembled in an argon-filled glovebox. For LIBs half-cells, Li-metal foil use as counter electrode, and 1.0 M $LiPF_6$ dissolved in ethylene carbonate (EC)/dimethl carbonat (DMC)/diethyl carbonate (DEC) (1:1:1 by volume) use as electrolyte. For SIBs half-cells, Na-metal foil used as counter electrode, and 1.0 M $NaClO_4$ in propylene carbonate (PC) with 2% fluoroethylene carbonate (FEC) used as electrolyte. Glass fiber membrane (Whatman GF/D) used as separator. The charge-discharge tests were carried out on LAND CT2001A systems. The cyclic voltammetry (CV) curves and electrochemical impedance spectroscopy (EIS) were tested on VSP electrochemical workstation (Bio-logic, France).

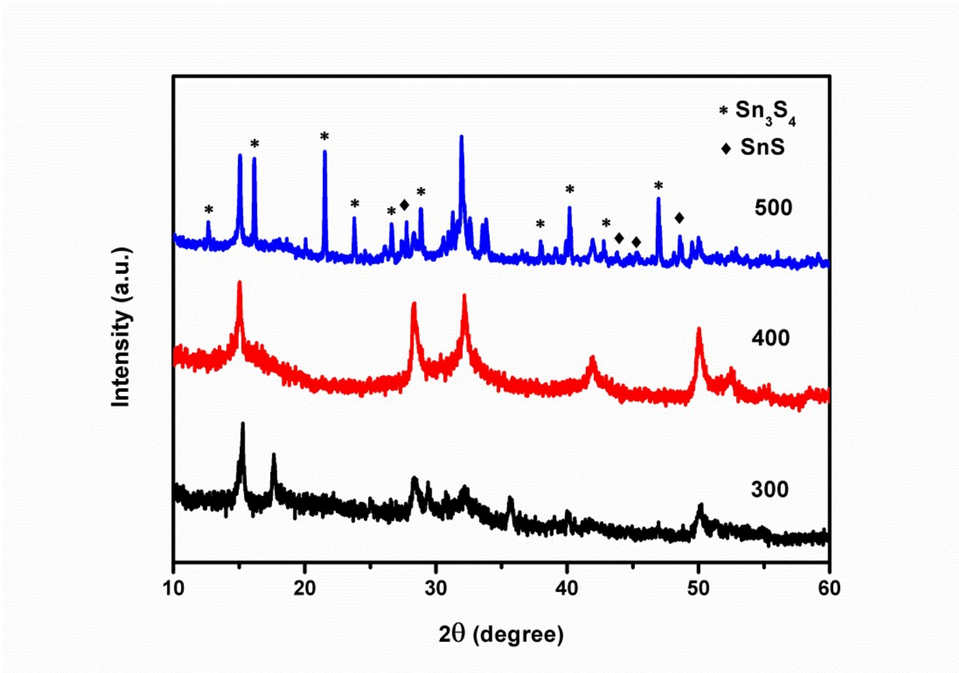

Figure S1. XRD patterns of the precursors are annealed at different temperatures.

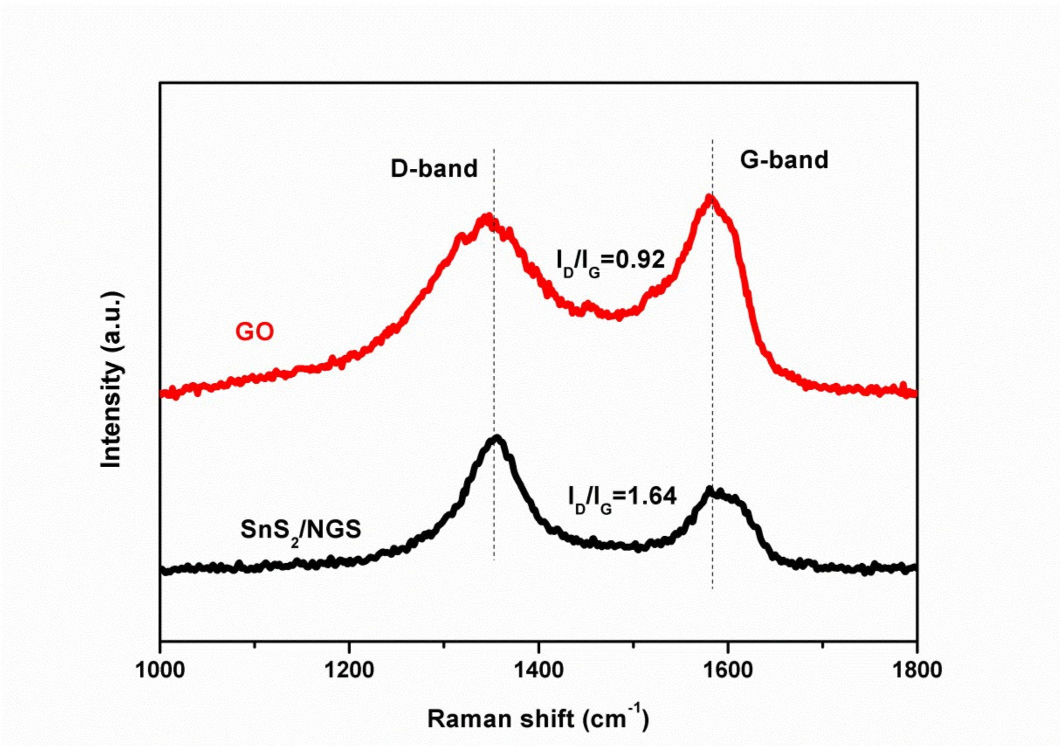

Figure S2. Raman spectra of GO and SnS_2/NGS.

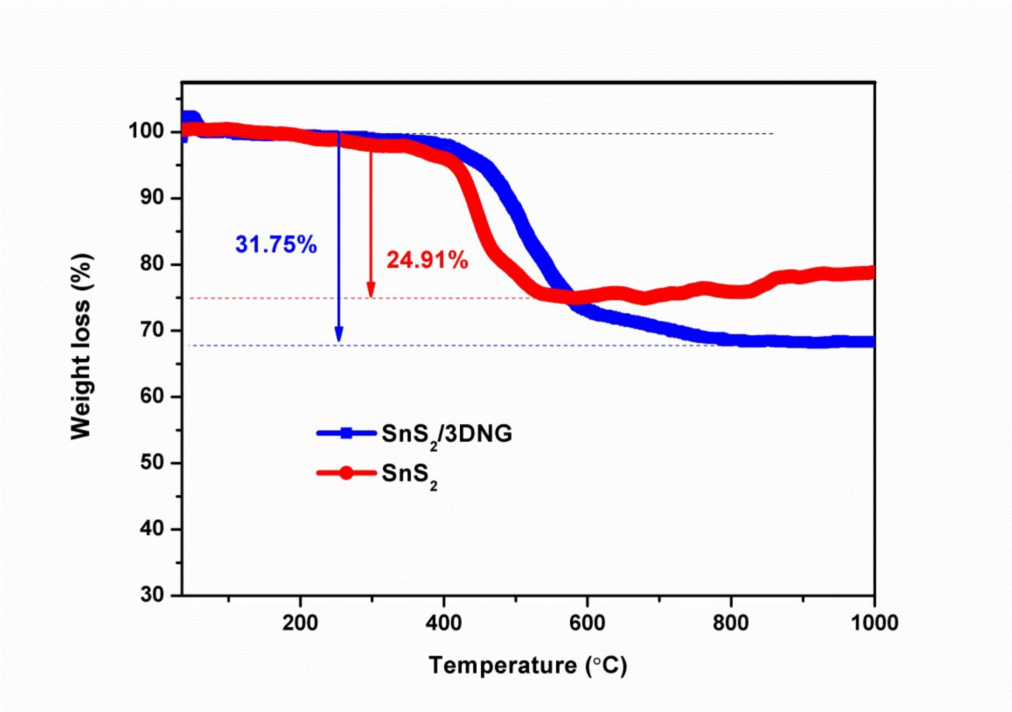

Figure S3. TGA curves in the air atmosphere of the SnS_2 and SnS_2/NGS.

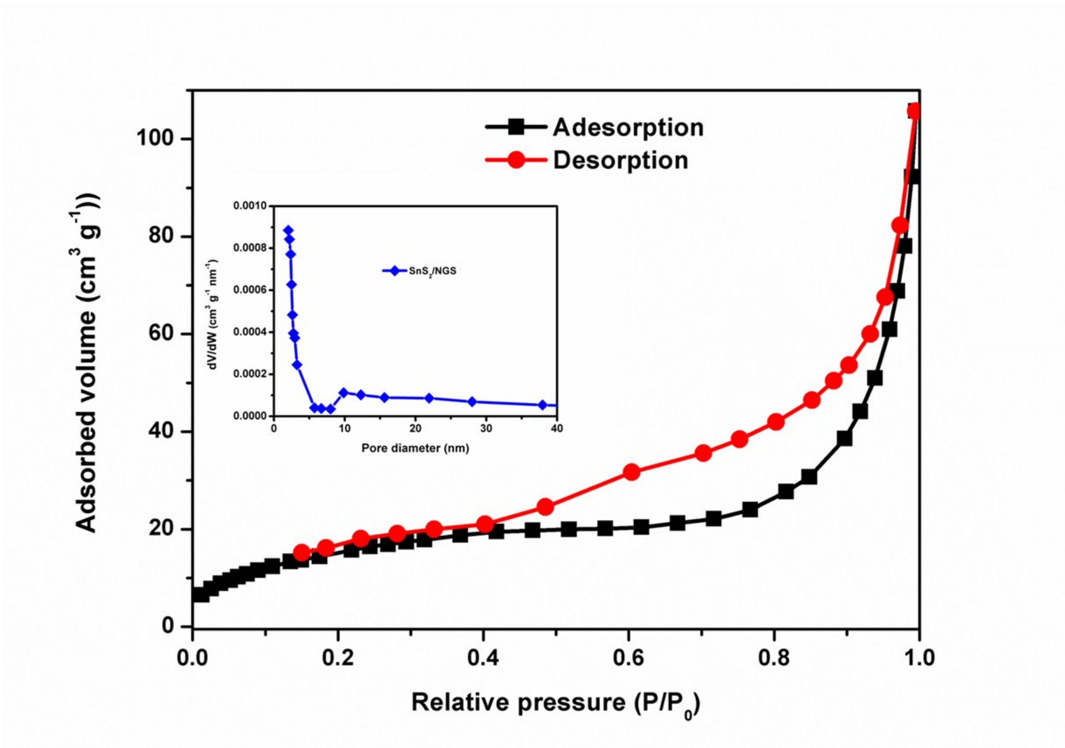

Figure S4. The nitrogen adsorption/desorption isotherm plots. Pore (inset) size distribution of SnS_2/NGS.

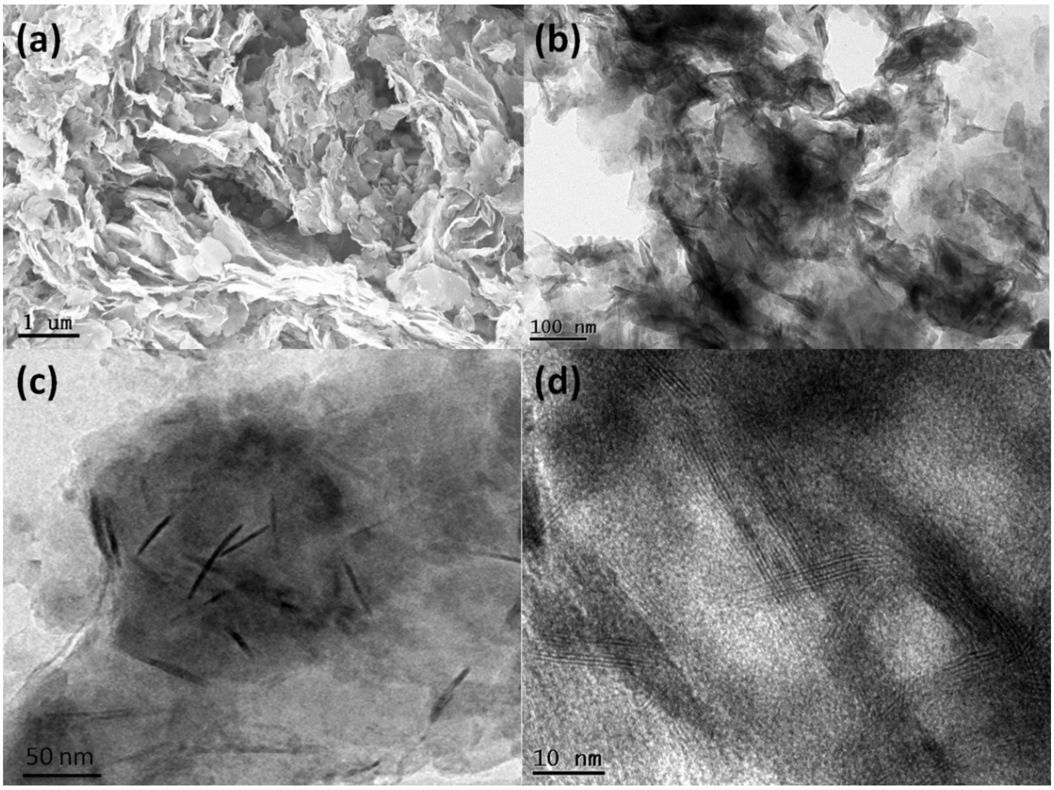

Figure S5. The detail morphology of SnS_2/NGS. (a) SEM image, (b) and (d) TEM images, (d) HRTEM image.

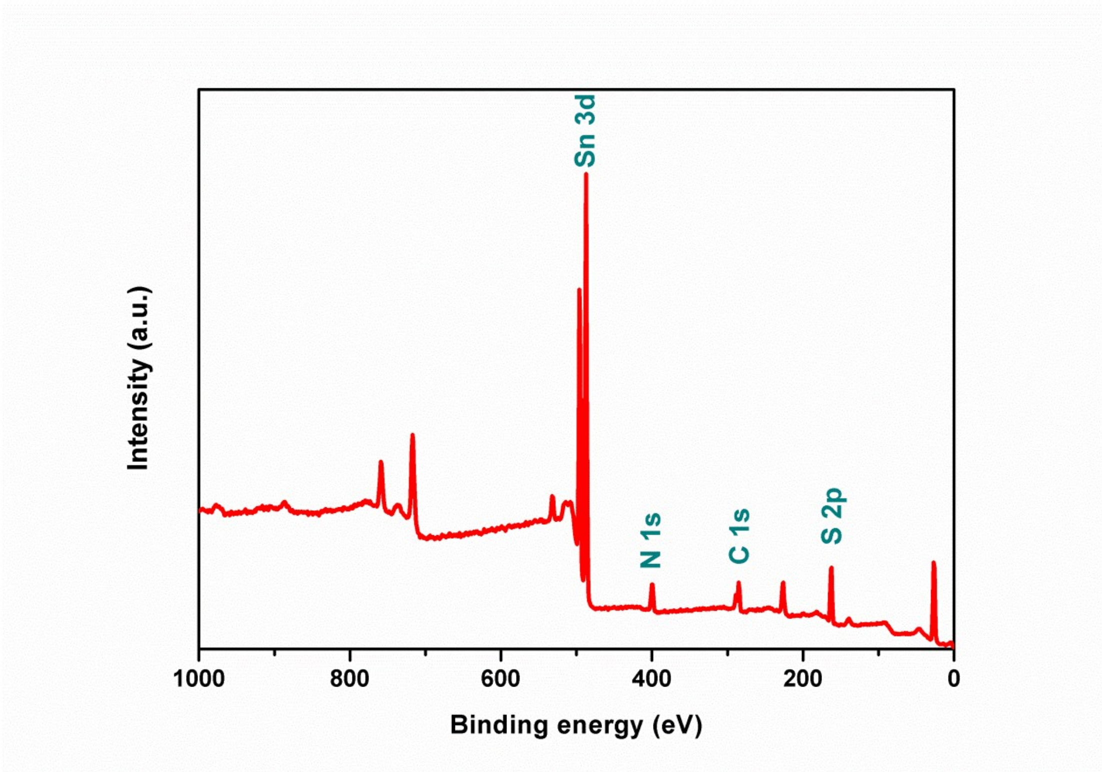

Figure S6. XPS survey spectrum of SnS_2/NGS.

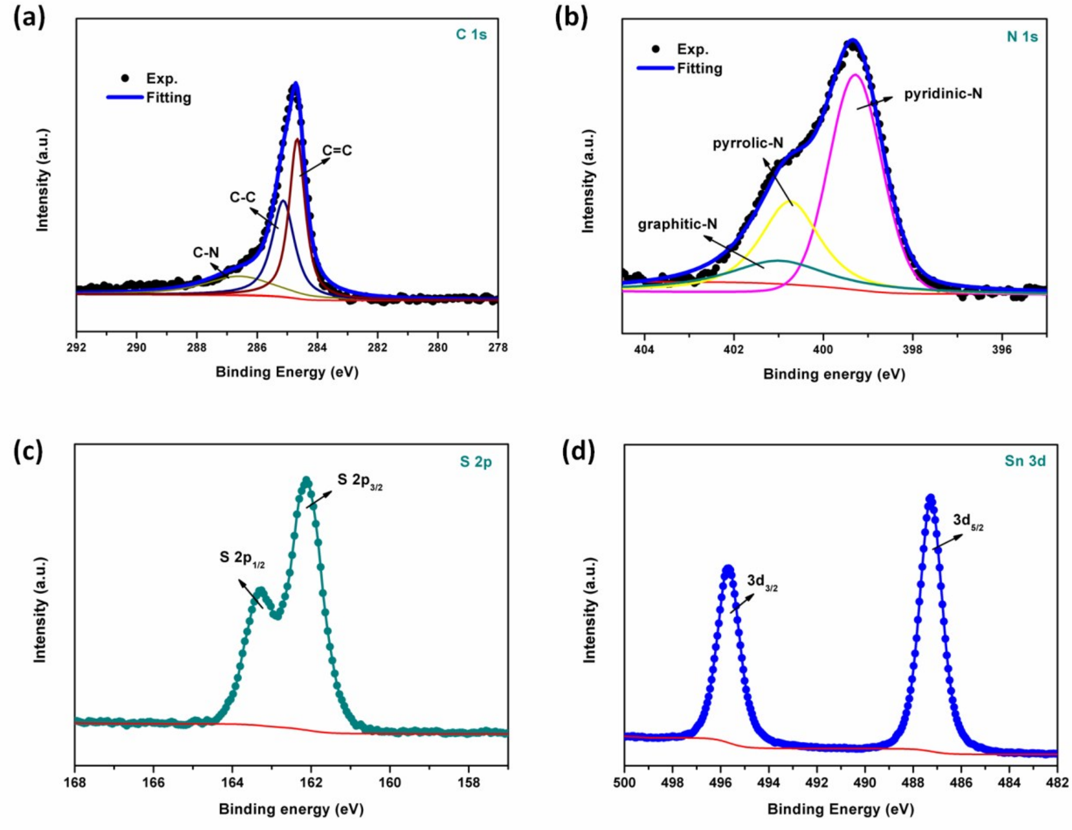

Figure S7. High-resolution XPS spectra of (a) C 1s, (b) N 1s, (c) S 2p and (d) Sn 3d of the SnS_2/NGS.

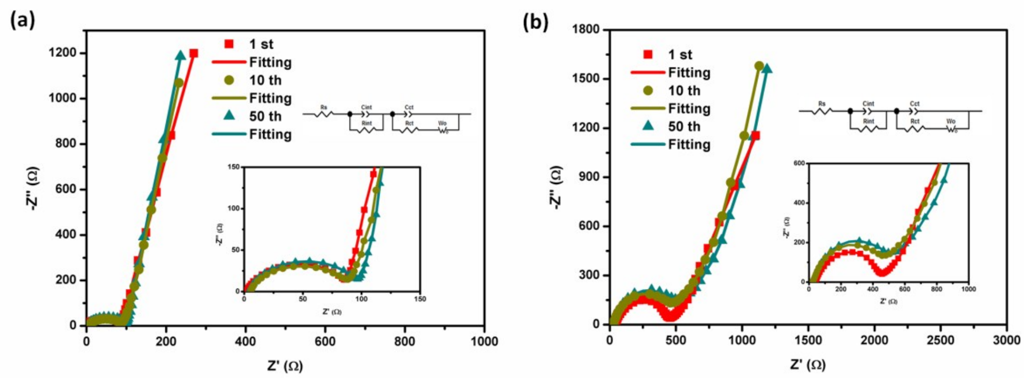

Figure S8. Nyquist plots of SnS_2/NGS electrode at different cycles for (a) LIBs, (b) SIBs. Insets depict the equivalent circuit and enlarged spectra high frequency.

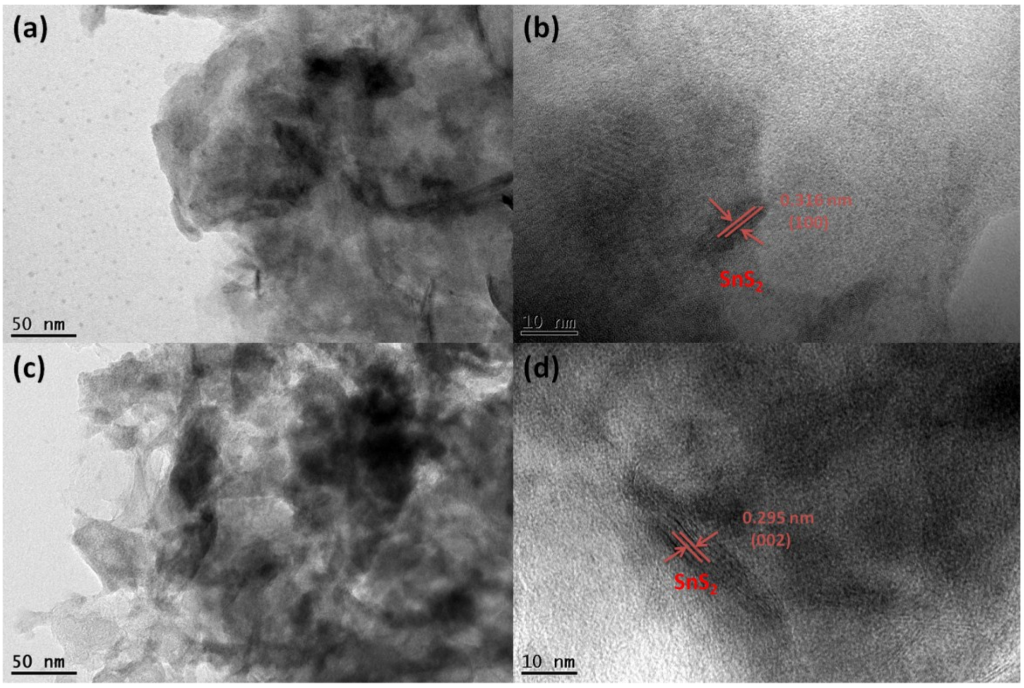

Figure S9. TEM images of SnS_2/NGS after 50 cycles at 0.1 A g^{-1}. (a, b) lithium-ion battery (c, d) sodium-ion battery.

Table S1. Equivalent circuit parameters of the SnS_2/NGS electrode for LIBs and SIBs.

Sample	Cycle number	R_s/Ohm	R_{int}/Ohm	R_{ct}/Ohm
SnS_2/NGS for LIBs	1^{st} cycle	2.5	67.8	10.1
	10^{th} cycle	4.4	64.6	12.4
	50^{th} cycle	5.6	54.8	17.6
SnS_2/NGS for SIBs	1^{st} cycle	24.0	383.4	24.7
	10^{th} cycle	32.2	358.0	45.7
	50^{th} cycle	20.2	358.8	36.2

Table S2. Comparison of the electrochemical performance for SnS_2-based anode in the previous literature with our sample

Electrode materials	Application	Rate perfomance	Cycling performance	Ref
SnS_2/G-As	LIBs	240 mAh g^{-1} at 1000 mA g^{-1}	656 mAh g^{-1} at 50 mA g^{-1} after 30 cycles	1
SnS_2/VACNTs	LIBs	223 mAh g^{-1} at 2000 mA g^{-1}	551 mAh/g at 100 mA g^{-1} after 100 cycles	2

SnS_2-NGS	LIBs	200 mAh g^{-1} at 10000 mA g^{-1}	914 mAh g^{-1} at 800 mA g^{-1} after 150 cycles	3
	SIBs	148 mAh g^{-1} at 10000 mA g^{-1}	450 mAh g^{-1} at 200 mA g^{-1} after 100 cycles	
Net-like SnS_2	LIBs	358.71 mAh g^{-1} at 800 mA g^{-1}	401.31 mAh g^{-1} at 100 mA g^{-1} after 100 cycles	4
c-SnS_2 NSA	SIBs	140 mAh g^{-1} at 5000 mA g^{-1}	420 mAh g^{-1} at 500 mA g^{-1} after 100 cycles	5
SnS_2-G	LIBs	498 mAh g^{-1} at 8000 mA g^{-1}	826 mAh g^{-1} at 500 mA g^{-1} after 200 cycles	6
SnS_2/NRGO	LIBs	402 mAh g^{-1} at 2000 mA g^{-1}	297 mAh g^{-1} at 200 mA g^{-1} after 200 cycles	7
SnS_2/graphene	SIBs	321 mAh g^{-1} at 5000 mA g^{-1}	458 mAh g^{-1} at 500 mA g^{-1} after 250 cycles	8
LL-SnS_2/G	LIBs	567.78 mAh g^{-1} at 2000 mA g^{-1}	696.27 mAh g^{-1} at 200 mA g^{-1} after 180 cycles	9
SnS_2/NGS	LIBs	488 mAh g^{-1} at 8000 mA g^{-1}	763 mAh g^{-1} at 500 mA g^{-1} after 200 cycles	This work
	SIBs	364 mAh g^{-1} at 5000 mA g^{-1}	453 mAh g^{-1} at 500 mA g^{-1} after 200 cycles	

Reference

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