Supporting Information

Sandwich-like SnS_2/graphene multilayers for efficient lithium/sodium storages

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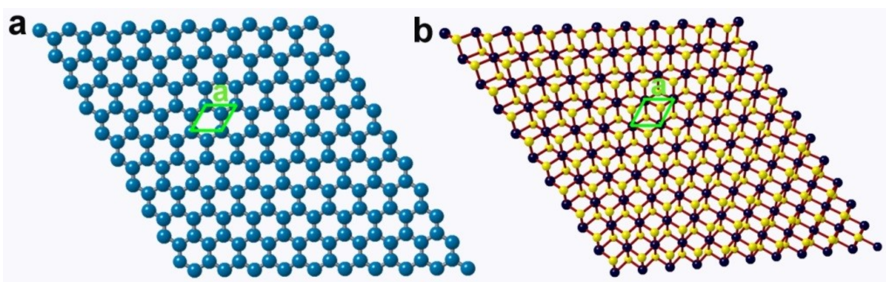

Fig. S1 In-plane structures of (a) graphene nanosheet with a hexagonal unit cell, a = 0.2460 nm, and (b) SnS_2 nanosheet with a hexagonal unit cell, a = 0.3649 nm. To attain full hybridization via a solution-phase direct assembly method, the mixing mass ratio was calculated based on a hypothesized area-matching model. As an approximate, the ideal graphene structure was used to estimate the area matching between PDDA-graphene and SnS_2. The area weight density for graphene is $W(\text{graphene}) = 2M(\text{C}) / (a \times a \times \sin 120° \times N_A)$, and the one for SnS_2 is $W(SnS_2) = 2M(SnS_2) / (a \times c \times N_A)$, where N_A is Avogadro's number, M(C) and $M(SnS_2)$ are the formula weights of carbon and SnS_2, respectively. Accordingly, the mass ratio between SnS_2 and PDDA-graphene under the area balance 1:1 is $m(SnS_2)/m(\text{graphene}) = W(SnS_2)/W(\text{graphene})$ = ~3.45:1.

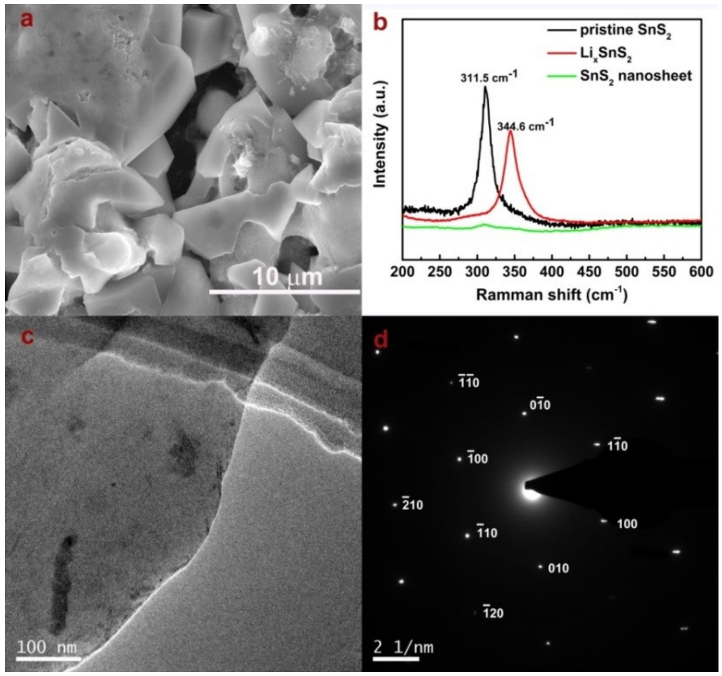

Fig. S2 (a) SEM image of the Li_xSnS_2. (b) Raman spectra of the pristine SnS_2, Li_xSnS_2 and exfoliated SnS_2 nanosheets. (c) TEM image and (d) corresponding SAED pattern of the exfoliated SnS_2 nanosheets.

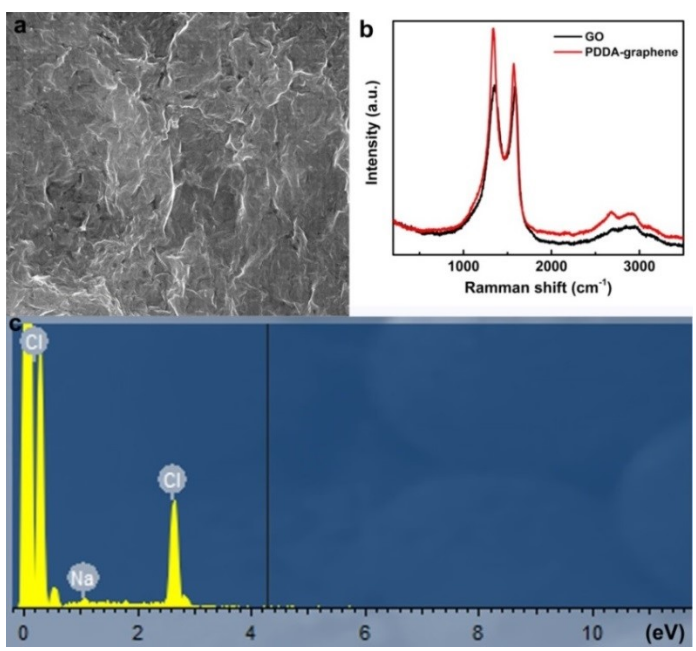

Fig. S3 (a) SEM image and (c) the corresponding EDS image of PDDA-graphene nanosheets. (b) Raman spectra of GO and PDDA-graphene nanosheets.

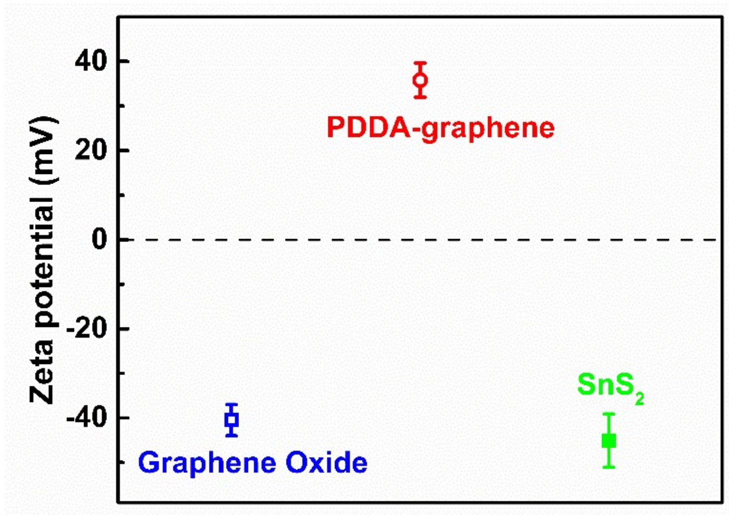

Fig. S4 Zeta-potentials of suspensions for the graphene oxide, PDDA-graphene and the exfoliated SnS_2 nanosheets.

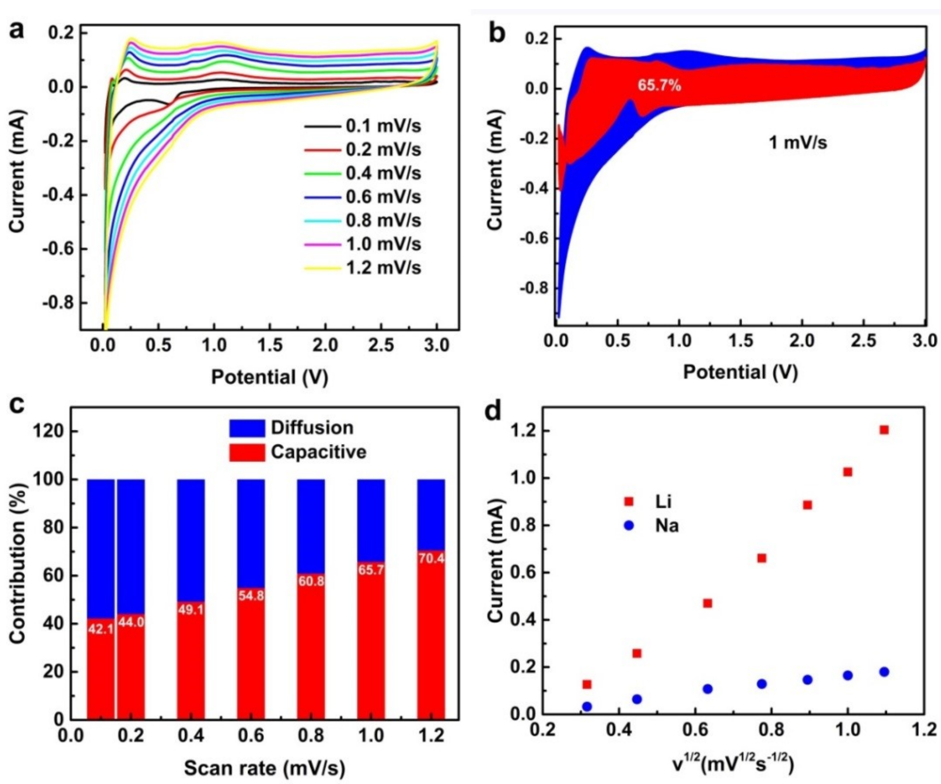

Fig. S5 (a) CV curves of the SnS_2/graphene multilayers anode under different scan rates for sodium storage. (b) Normalized contribution ratio of the capacitive to diffusion currents for the SnS_2/graphene multilayers at a scan rate of 1 mV s^{-1}. (c) Contribution of the capacitive and diffusion-controlled charge transport processes at different scan rates. (d) Linear relationship between anode peak current (i_p) and square root of scan rate ($v^{1/2}$) for two kinds of batteries.

The Randles-Sevcik equation is utilized to calculate the diffusion coefficients (D, $cm^2 s^{-1}$) of lithium and sodium ions during discharge and charge processes.

$$i_p = 2.69 \times 10^5 n^{3/2} A D_{1/2} v^{1/2} C_{Li^+/Na^+}$$

where i_p is the anodic peak current (A), n is the transferring electron number per molecule oxidized, A is the surface area of electrode (cm^2), v is the scan rate (V s^{-1}), and C_{Li^+/Na^+} is the concentration of Li^+ or Na^+ in electrolyte (1 mol L^{-1}). According to the above equation, we can know that there is a linear relationship between i_p and $v^{1/2}$. Based on the varied anodic i_p at different scan rates, the fitting lines are presented in Fig. S5d. The slopes of the SnS_2/graphene multilayers anodes are 1.39 and 0.19 for LIB and SIB, respectively. Then, we can calculate the lithium and sodium diffusion coefficients in the SnS_2/graphene multilayers based on the charge number of the oxidation reaction and the specific area of the electrode, which are 1.04×10^{-8} and 1.86×10^{-10} cm^2/s, respectively.

Table s1 Comparison of the cycling stability and rate capability of the SnS_2-based composites electrodes.

Materials		Initial discharge capacity (mAh g^{-1}), Initial coulombic efficiency, (Current density, (mA g^{-1}))	Cycling stability capacity (mAh g^{-1}), (Cycle number, Current density (mA g^{-1}))	Rate capability (mAh g^{-1}),(Current density (A g^{-1}))					Ref.
SnS_2/graphene multilayers	**Li**	**1016,61%(200)**	**160(2000,2000)**	**502(0.1)**	**330(0.5)**	**273(1)**	**206(2)**	**171(3)**	**This work**
	Na	**1001,41.6%(200)**	**142(1000,1000)**	**415(0.1)**	**282(0.2)**	**225(0.3)**	**185(0.5)**	**141(1)**	
SnS_2/graphene AS	Li	4030, 37% (50)	656(50, 30)	642(0.05)	525(0.1)	419(0.25)	325(0.5)	240(1)	**s1**
SnS_2@graphene	Li	1740, (330)	504(200,330)						**s2**
SnS_2-RGO	Li	1505,71.6%	657(40,660)						**s3**
graphene/SnS_2/CC	Li	1987.4, 52.5% (500)	638.1(150,500)	725.9(0.3)	723.8(0.6)	641.2(1)	540(1.5)	419(2)	**s4**
MC-SnS2 NSs	Li	1552.9(100)	428.8(50,100)						**s5**
SnS_2-rGO	Li	1032,73.4% (100)	534(100,100)						**s6**
SnS_2–graphene	Li	967.6,79.2 % (0.2C)	570.0(30,0.2C)						**s7**
SnS_2/polypyrrole	Li	1567,76.6% (100)	523(30,100)						**s8**
rGO-SnS_2 Hybrid	Li	1600, (100)		600(0.1)				400(1.2)	**s9**
SnS_2/3DG hybrid	Li	1559,53.1%(200)	451(50,1000)	771(0.2)	570(0.5)	529 (0.8)	433(1)	174(2)	**s10**
LEGr@SnS_2	Li	1061,75%(300)	664 (200,300)	1022(0.1)	983(0.2)	682(0.5)	557(0.8)	467(1)	**s11**
SnS_2@G	Li	1339,54.1%(20)	670(60,20)	632(0.04)	607(0.08)	572(0.16)	519(0.32)	463(0.64)	**s12**
SnS_2/GNS-RS	Li	1724, (58.4)	577(50,58.4)	1000(0.006)	1000(0.03)	900(0.06)	700(0.29)	300(0.58)	**s13**
NC/SnS/G	Li	2070.3,62%(100)	500(25,100)	740 (0.1)	555 (0.2)	370 (0.5)	230 (1)	120 (2)	**s14**
tin sulfides/NRGO	Li	1240,47%(200)	562(200,200)	597(0.2)				402(2)	**s15**
SnS_2 NP/GNs	Li	1830,49%(100)	~600(150,100)	731(0.1)	674(0.5)	621(1)	525(5)	200(10)	**s16**
TC-RGO-CNT	Li	1401,50%(50)	500(150,50)	600(0.05)	500(0.1)	340(0.2)	300(0.4)	100(0.8)	**s17**
C-SnS_2@rGO	Li	2349,58.1%(100)	704.0(1000,2000)	1298(0.05)	1203 (0.1)	1021 (0.5)	930 (1)	749 (2)	**s18**
SnS_2/Graphene/SnS_2	Li	1733.6,81%(100)	1357(200,100)	1342 (1)	1244 (2)	1067 (5)	844 (10)		**s19**
	Na	1860,66.8%(100)	1133(100,100)	1295 (0.1)		950 (5)	765 (10)		
SnS_2–NGS	Li	922.5,66%(200)	914(150,800)	1183(0.2)	1020(0.5)	880(1)	750(2)	200(8)	**s20**
	Na		450(100,200)	630(0.2)	500(0.5)	430(1)	342(2)	180(8)	
SnS_2 NC/EDA–RGO	Na		480(1000, 1000)	760(0.18)	630(0.46)	560(0.93)	510(1.86)	315(7.43)	**s21**

SnS_2/G	Na	1250.1,69% (200)	200(100,200)	650(0.2)				326(4)	**s22**
SnS_2−RGONRP	Na	660,74.7% (200)		508(0.1)	426 (0.5)	398 (1)	307 (5)	244 (10)	**s23**

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