

## Supplementary Information for

# Facile and rapid synthesis of RGO-In<sub>2</sub>S<sub>3</sub> composite with enhanced cyclability and high capacity for lithium storage

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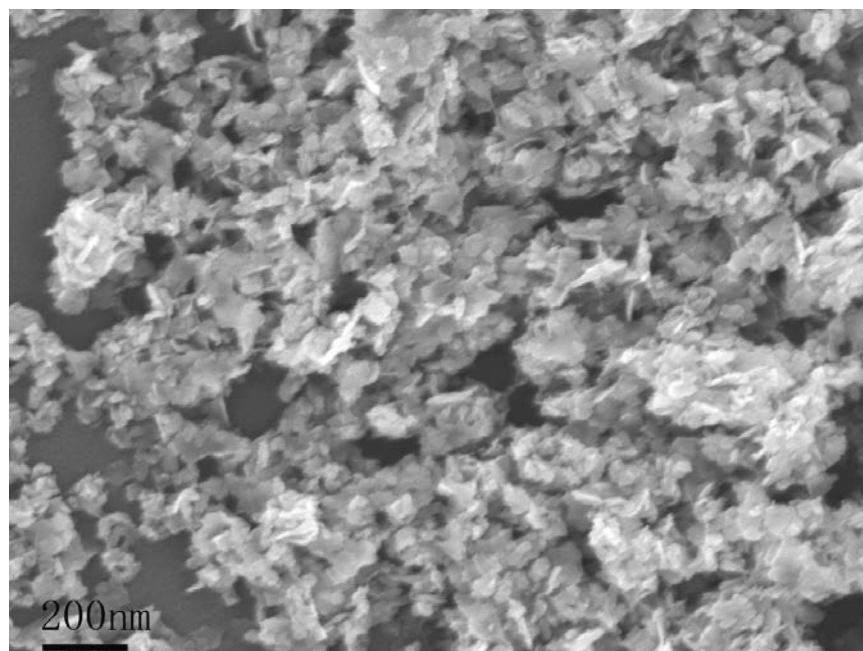
## Experimental section:

**Materials Synthesis:** Graphene oxide sheets (GO) were prepared by a modified Hummer's method<sup>[S1]</sup>. In a typical procedure for the synthesis of reduced graphene oxide-β-In<sub>2</sub>S<sub>3</sub> (RGO-In<sub>2</sub>S<sub>3</sub>) composite, 15 mg GO was dispersed into 15 ml distilled water by ultrasonication for 60 min. Simultaneously, about 0.8 mmol indium ( III ) chloride tetrahydrate (InCl<sub>3</sub>·4H<sub>2</sub>O, Alfa Aesar, 97%) was added to additional 10 ml distilled water and stirred for 60 min. After stirred for 60 min, both solutions were mixed together and stirred for 90 min. Finally, thioacetamide (TAA) was dissolved in above mixed solution and stirred for 10 min. The obtained solution was transferred to a round flask and refluxed at 95 °C for 80 min. After cooling, the as-synthesized yellow products were harvested after centrifuging four times and dried at 40 °C overnight. The pure β-In<sub>2</sub>S<sub>3</sub> sheets were obtained in the absence of GO.

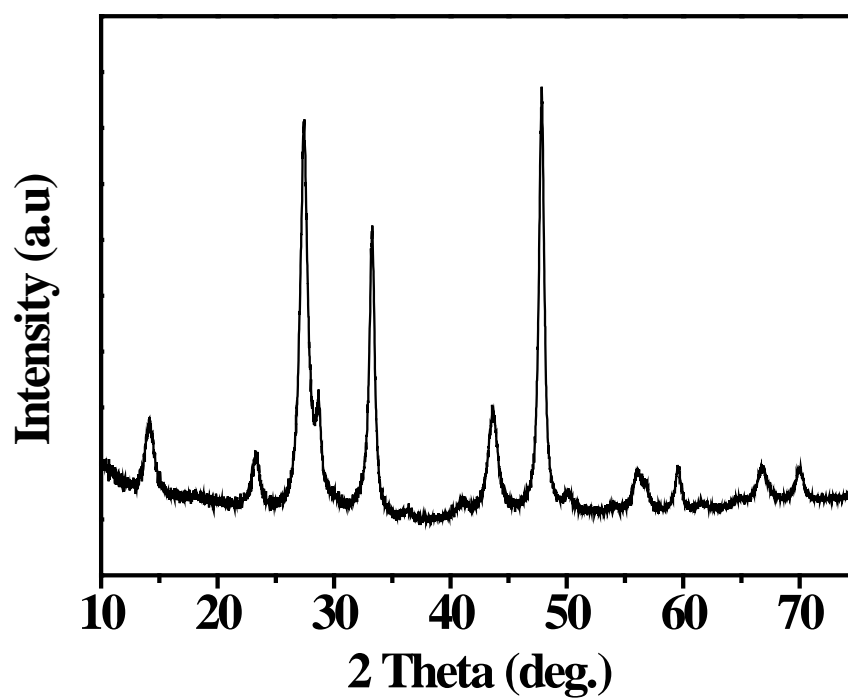
**Materials Characterization:** The morphology, element mapping and energy dispersive spectroscopy (EDS) of as-prepared samples were investigated by using a scanning electron microscopy (SEM) Hitachi S4800 operated at 5 kV. Structures of samples were characterized by using a transmission electron microscopy (TEM) Philips FEI 200CX operated at 160 kV, high resolution transmission electron microscopy (HRTEM) JEOL 2100F with an image-side Cs-corrector operated at 200 kV, and X-ray diffractometer PANalytical X'pert Pro using CuKα radiation (λ=1.5416 Å). Nitrogen adsorption/desorption isotherms were measured on a Beckman coulter omnisorp100cx to evaluate the specific surface area and Barretl-Joyner-Halenda (BJH) pore diameter. Raman spectra were obtained with a Renishaw in Via Raman

microscopy system with a laser wavelength of 532 nm. The RGO content in the as-fresh RGO-In<sub>2</sub>S<sub>3</sub> composite was estimated by TGA (SDT Q600) measurements. X-ray photoelectron spectroscopy (XPS) analyses were performed using a Kratos Amicus XPS. Photoemission was stimulated by monochromated Mg K $\alpha$  radiation (12 kV) with an operating power of 180 W.

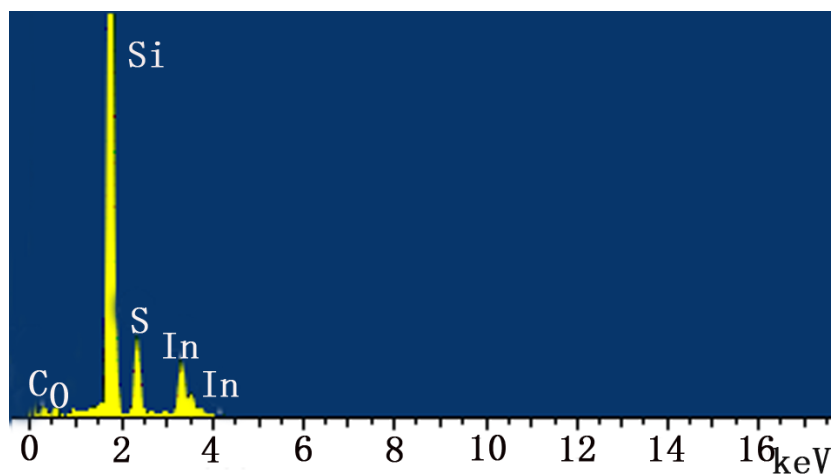
**Electrochemical Measurement:** The electrochemical measurements were carried out using Land CT2001A with lithium metal as the counter and reference electrodes at room temperature. The electrode consists of active material (sheet-on-sheet RGO-In<sub>2</sub>S<sub>3</sub> composite or pure  $\beta$ -In<sub>2</sub>S<sub>3</sub>), conductivity agent (acetylene black), and polymer binder (polyvinylidene difluoride, PVDF, Aldrich) by a weight ratio of approximately 70:20:10, the active material loading in each electrode was typically 1~2 mg. The electrolyte was 1 M LiPF<sub>6</sub> in a 1:1 wt/wt mixture of ethylene carbonate and diethyl carbonate. Cell assembly was carried out in an Ar-filled glove box. The cell was charged/discharged at a fixed voltage window between 5 mV and 3 V. Cyclic voltammogram and AC impedance spectra were carried out using an electrochemical work station (CHI660C) to investigate the electrode reaction processes. The scan range of 5 mV-3 V (vs. Li/Li<sup>+</sup>) was swept at the rate of 0.1 mV/s. AC impedance spectra were performed by applying a sine wave with an amplitude of 5.0 mV in the frequency range from 0.01 Hz to 100 kHz.



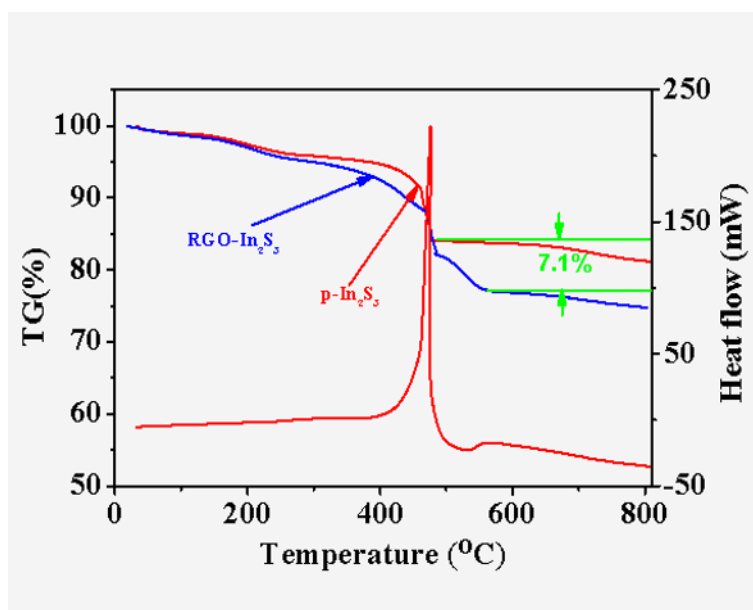
**Fig. S1** SEM image of as-prepared pure  $\beta$ - $\text{In}_2\text{S}_3$  sheets



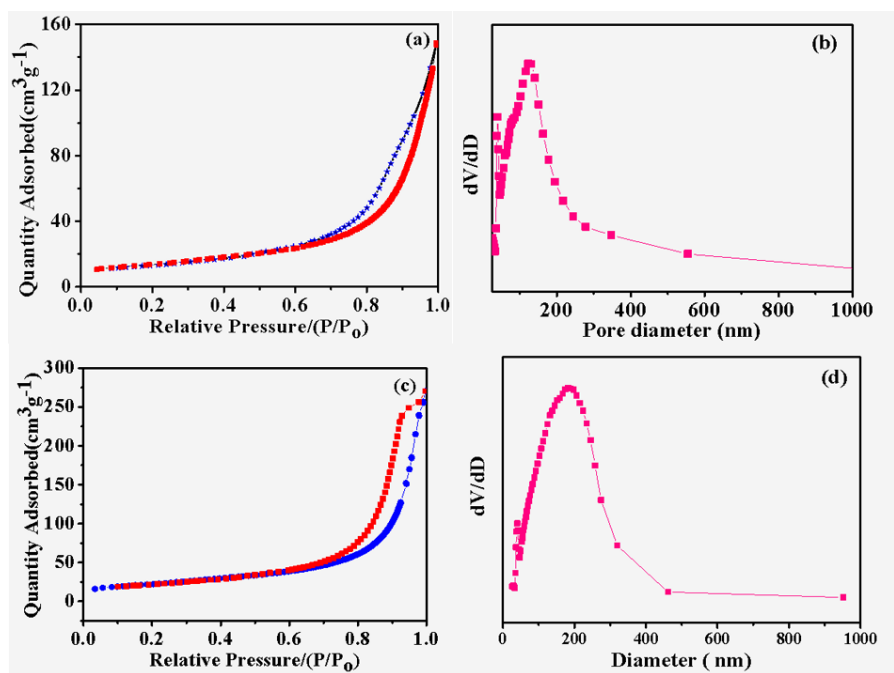
**Fig. S2** XRD pattern of as-prepared pure  $\beta$ - $\text{In}_2\text{S}_3$  sheets



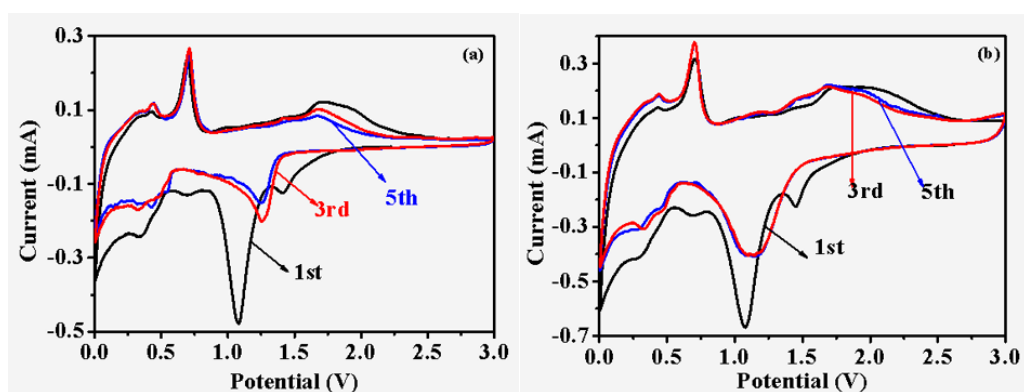
**Fig. S3** Energy-disperse spectroscopy of as-prepared RGO-In<sub>2</sub>S<sub>3</sub> composite.



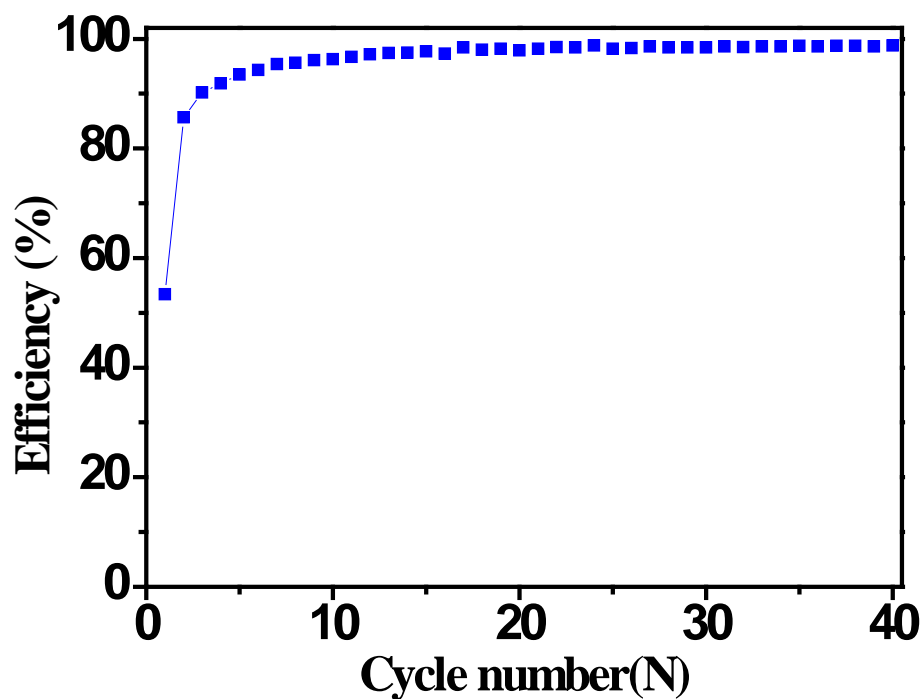
**Fig. S4** TGA curves of RGO-In<sub>2</sub>S<sub>3</sub> composite and pure  $\beta$ -In<sub>2</sub>S<sub>3</sub> sheets. The measurement was taken in air with a heating rate of 10 °C min<sup>-1</sup>. The content of RGO was estimated to be about 7.1 wt.% by the difference of weight loss of RGO-In<sub>2</sub>S<sub>3</sub> and pure  $\beta$ -In<sub>2</sub>S<sub>3</sub>.



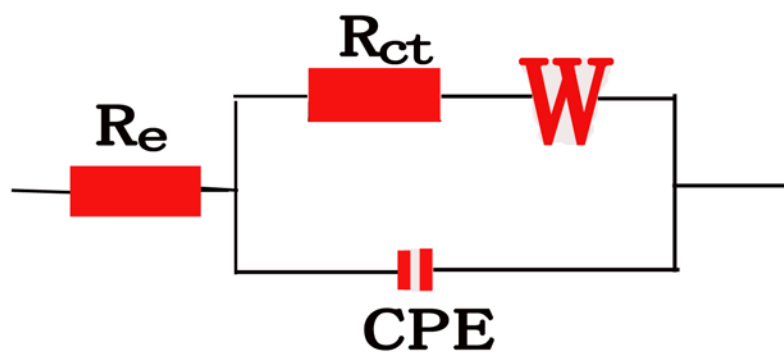
**Fig. S5** Adsorption–desorption isotherm and pore size distribution of the pure  $\beta\text{-In}_2\text{S}_3$  sheets (a and b) and RGO- $\text{In}_2\text{S}_3$  composite (c and d). The RGO- $\text{In}_2\text{S}_3$  composite exhibits a specific surface area of  $79.6 \text{ m}^2/\text{g}$  and an average pore diameter of 173 nm, whereas the pure  $\beta\text{-In}_2\text{S}_3$  sheets exhibit a specific surface area of  $48.4 \text{ m}^2/\text{g}$  and an average pore diameter of 120 nm.



**Fig. S6** Cyclic voltammogram of the pure  $\beta\text{-In}_2\text{S}_3$  (a) and RGO- $\text{In}_2\text{S}_3$  (b) electrodes.



**Fig. S7** Coulombic efficiency of pure  $\beta$ - $\text{In}_2\text{S}_3$  electrode charged/discharged at a current density of  $100 \text{ mA g}^{-1}$ .



**Fig. S8** Modified Randles equivalent circuit for RGO- $\text{In}_2\text{S}_3$  composite and pure  $\beta$ - $\text{In}_2\text{S}_3$  electrode/electrolyte interface.  $R_\Omega$  and  $R_{ct}$  are the ohmic resistance (total resistance of the electrolyte, separator and electrical contact) and charge-transfer resistance, respectively. CPE is the constant phase-angle element, involving double layer capacitance, and W (Warburg impedance) relates to the diffusion of lithium ions into the bulk electrodes.

**Table S1** Kinetic parameters of RGO-In<sub>2</sub>S<sub>3</sub> composite and pure β-In<sub>2</sub>S<sub>3</sub> electrodes

Sample	$R_{\Omega}$ ( $\Omega$ )	$R_{ct}$ ( $\Omega$ )	$i_0$ $\mu\text{A cm}^{-2}$
RGO-In <sub>2</sub> S <sub>3</sub>	9.6	68	20
In <sub>2</sub> S <sub>3</sub>	8.8	122	11

Note: The exchange current density  $i_0$  is calculated according to the equation of  $i_0 = RT/nFR_{ct}$ ,  $R$  is the gas constant,  $T$  is the absolute temperature,  $n$  is the number of transferred electrons,  $F$  is the Faraday constant. According to the work in ref. [S2],  $n$  is estimated to be 4.33.

### Supporting references

[S1] W. S. Hummers and R. E. Offeman, *J. Am. Chem. Soc.*, 1958, **80**, 1339.

[S2] W. H. Ho, C. F. Li, H. C. Liu and S. K. Yen, *J. Power Sources*, 2008, **175**, 897.