Supplementary Material (ESI) for Chemical Communications

Electronic Supplementary Information for
$SnSe_2$ Nanoplates–Graphene Composites as Anode Materials for Lithium Ion Batteries

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Experimental general: Transmission electron microscopy (TEM) and high resolution TEM images were taken using a JEOL 2100F unit operated at 200kV. Samples for TEM were prepared on copper grid by drop-casting methylene chloride solution of the nanomaterials. The scanning electron microscopy (SEM) images and EDS spectrum were obtained by FE-SEM (JSM6700F). Powder X-ray diffraction (XRD) patterns were obtained using a Rigaku MAX-2200 and filtered Cu-Ka radiation. X-ray photoelectron spectroscopy (XPS) was obtained using a Thermo VG and Monochromatic Al-$K\alpha$ radiation. Electrochemical studies were performed using WBCS3000 automatic battery cycler system.

Detail experimental procedure: The used selenium precursor, 1,3-Dimethylimidazoline-2-selenone was prepared by known procedure (also refer to ref.12 in text); 1,3-Dimethylimidazolium iodide (10.0 g, 44 mmol) was treated with K_2CO_3 (30.8g, 224 mmol) in methanol (100 mL) at room temperature for 2 hours. 5 eq. Se powder to 1,3-dimethylimidazolium iodide was added. Then, the reaction mixture was stirred for 1 day at room temperature. After reaction, the insoluble precipitates were removed by filtration and methanol was removed by rotary evaporation. The crude product was extracted using methylene chloride and ammonium chloride aqueous solution. The pure product was isolated by flash column chromatography and then, recrystallized in mixture of ether and hexane.

Oleylamine (10 mL) was dried under vacuum at 110 ^oC for 6 hours. In well-dried oleylamine (5 mL) in 50 mL two neck Schlenk flask, $SnCl_2$ (50 mg, 0.26 mmol) was dissolved under argon. Then, solution temperature was gradually increased to 220 ^oC. The selenium precursor, 1,3-Dimethylimidazoline-2-selenone (90 mg, 0.53 mmol) was dissolved in a mixture of oleylamine (2 mL) and dichloromethane (4 mL) under argon. Using glass syringe, the selenium precursor solution was rapidly injected into the $SnCl_2$-oleylamine solution at 220 ^oC. After heating the reaction mixture for 2 hours, the reaction mixture was cooled to room temperature. The excess methanol was added to induce the precipitation of nanomaterials which was retrieved by centrifugation. This washing process was repeated more than three times and the obtained precipitate was washed with hexane to remove excess surfactant.

Graphene oxides were prepared following the well established oxidation route of graphite. (ref. 6a in text) The obtained graphene oxide (20 mg) and $SnSe_2$ nanoplates (20 mg) were well-dispersed in mixture of acetonitrile (15 mL) and water (5 mL) through sonication. Then, the hydrazine monohydrate (0.40 mL, 8.2 mmol) was added. The reaction mixture was heated at 80 ^oC for 3 hours and during the reaction, the precipitate was gradually formed. The nanocomposites were retrieved by centrifugation, washed with acetone and dried under vacuum.

For electrochemical studies, the $SnSe_2$-graphene composites (80 mg), Super P carbon black (10 mg) and polyvinylidene fluoride binder (10 mg) were mixed in N-methylpyrrolidone (NMP). After coating the copper foil with this mixture, the electrode was dried under vacuum at 120 ^oC overnight. The diameter of copper electrode was 14 mm. The average loading amount of electrode materials was 0.95 mg/cm^2. Cell tests were conducted using coin-type half cells (CR2016 type) with Li metal as the counter electrode and 1M $LiPF_6$ in ethylene carbonate/diethyl carbonate (1:1 v/v) as the electrolyte. The discharge/charge cycle tests were performed using WBCS3000 automatic battery cycler system.

Fig. S1 Magnified TEM images (a.b) of $SnSe_2$ nanoplates and typical cross section SEM image (c) of **SG11**.

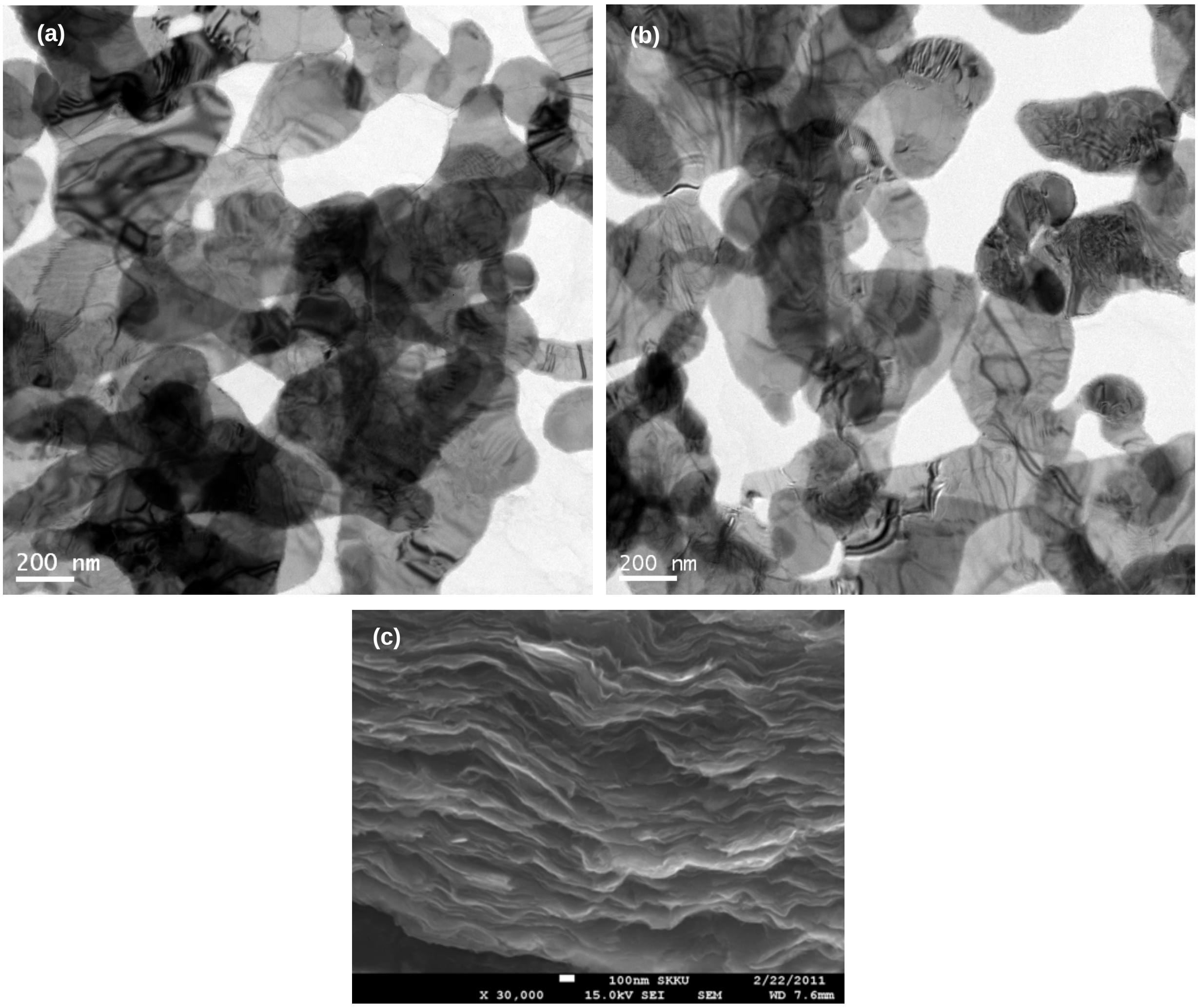


Fig. S2 EDS spectrum (a), power XRD pattern (b) and XPS spectra (c,d) of $SnSe_2$ nanoplates.

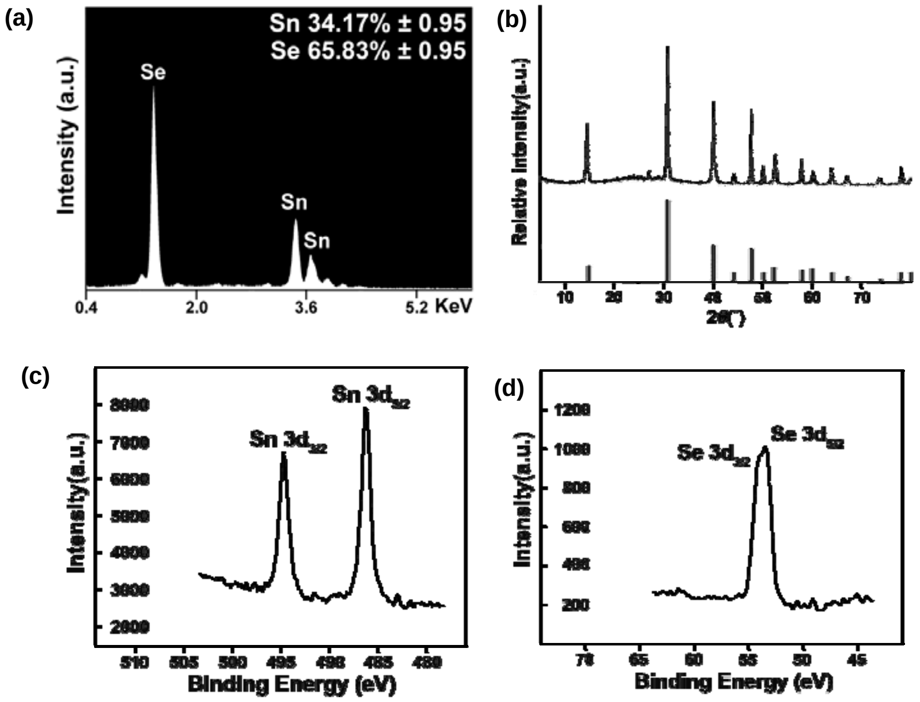
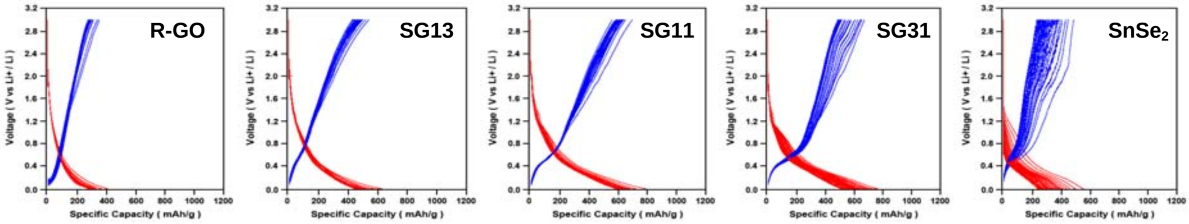
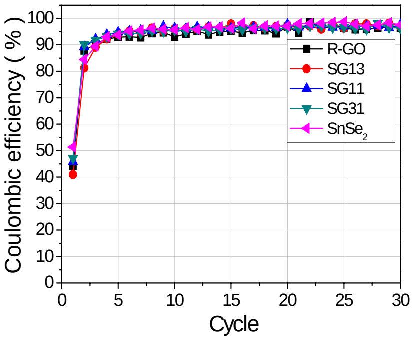


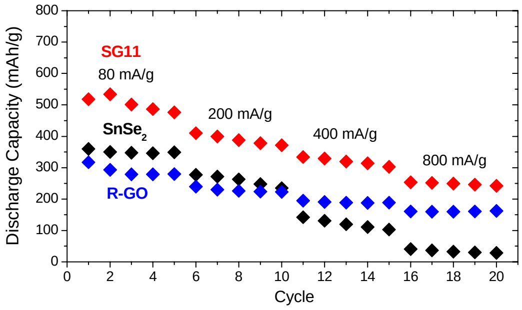
Fig. S3 Electrochemical performance of the coin cells.



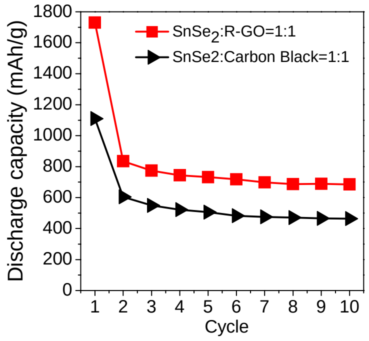
(a) Charge (blue)-Discharge (red) curves (the first discharge curves were omitted.)



(b) Coulombic Efficiencies



(c) Rate capability test of **SG11**, **SnSe$_2$**, Reduced-Graphene Oxides (**R-GO**)



(d) Comparison study on cells made of SG11 and mixture of SnSe2 & carbon black

As shown in discharge curve of SnSe$_2$ in Figure S3a, the shoulder was observed at 0.36V. In composites, as the ratio of SnSe$_2$ in composites increased, the intensity of shoulder at 0.36V increased due to the contribution of SnSe$_2$ in lithium storage. The existence of graphene in composites enhanced the stability of shoulder peaks. The coulombic efficiencies of all cells rapidly increased up to 95% in the first five cycles and maintained around 98% in the following cycles. The rate capability of **SG11** was compared with SnSe$_2$ only and reduced graphene oxide samples. compared with SnSe$_2$, the existence of graphene in composites improved the rate-capability of materials. Also, the reduced graphene oxide maintained efficiently the discharge capacities at higher current density.