Electronic Supplementary Information

Experimental

Preparation of GNS-SnO_2 composite

About 15 g of Graphite (Schunk Graphite Technologies, LLC) bars was crushed and milled with mortar and pestle adding sufficient NMP (Alfa aesar) and subsequently sonication of thick grey NMP medium was also carried out for an hour. This process was continued twice a day and for one week, the NMP evaporation loss might be compensated by maintaining the liquid mass level around 70 ml. After mild centrifugation (2000 rpm), the supernated liquid was taken and diluted to 100 ml with NMP, 22.56 g of $SnCl_2$. $2H_2O$ (Acros Organic), and 0.036 g of CTAB were also dissolved in this NMP medium. Under probe sonicator the solution was agitated and 10% NH_4OH solution was added dropwise, observed formation of the pale white tin hydroxide on the top layer of the solution between the interface NMP and aqueous NH_4OH solutions. The addition of NH_4OH was been continued until the reaction ceases. At the end of the reaction a homogeneous grey mass suspended solution was obtained and subsequently, NMP was evaporated at 110 ºC under continuous stirring. The obtained black mass was washed with NMP followed by water and ethanol to remove CTAB and residual $SnCl_2$. $2H_2O$. Finally, the sample was annealed at 350 ºC in muffle furnace under ambient condition.

Characterisations

The obtained black mass was subjected to physical characterization viz., XRD, SEM, TEM, ^{13}C NMR and laser Raman spectroscopy. The electrochemical characterizations were carried by fabricating CR-2016 coin cell inside the Ar gas filled glove box in which Li metal as counter and reference electrode and 1M $LiPF_6$ in 1:1 EC:DEC as the electrolyte. The working electrode was coated on copper foil by mixing 85:10:5 of GNS-SnO_2:PVdF (in NMP):super-P and vacuum dried at 110 ºC. Electrodes were punched to get 16 mm diameter for assembling coin cell. The impedance measurement was carried out using IM6, BAS instrument, and measurement range for impedance and charge-discharge cycling were done using BaSy Tech battery cycler.

TG/DTA

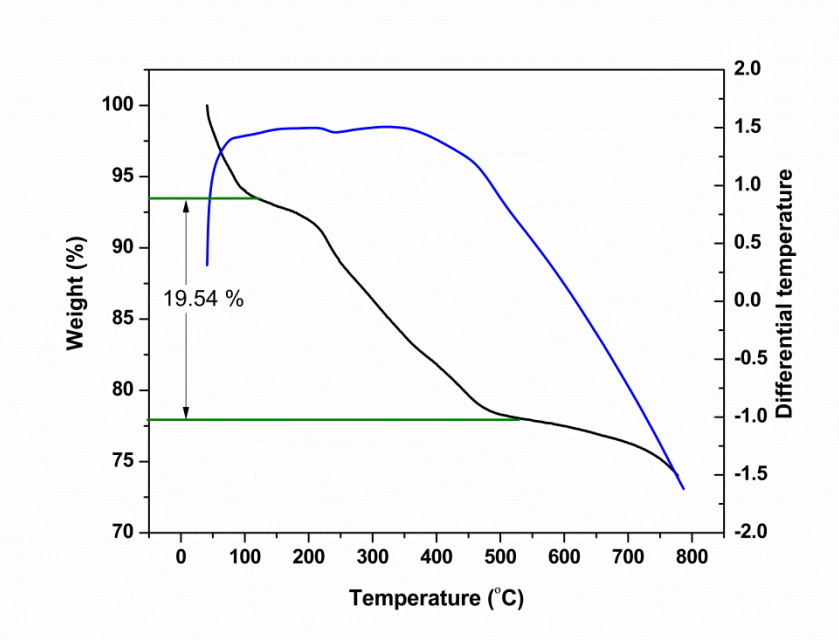

Fig. 1s. TG/DTA plot analysed under air atmosphere at heating rate 10 °C/min

The Thermogravimetry and differential thermal analysis of GNS-Graphene composite results the weight loss region, from around >110 °C (decomposition region of carbon) to <530 °C is calculated to be approximately 19.54 % and consequently, it is due to the graphene decomposition as CO_2.

SEM images of NMP exfoliated Graphene

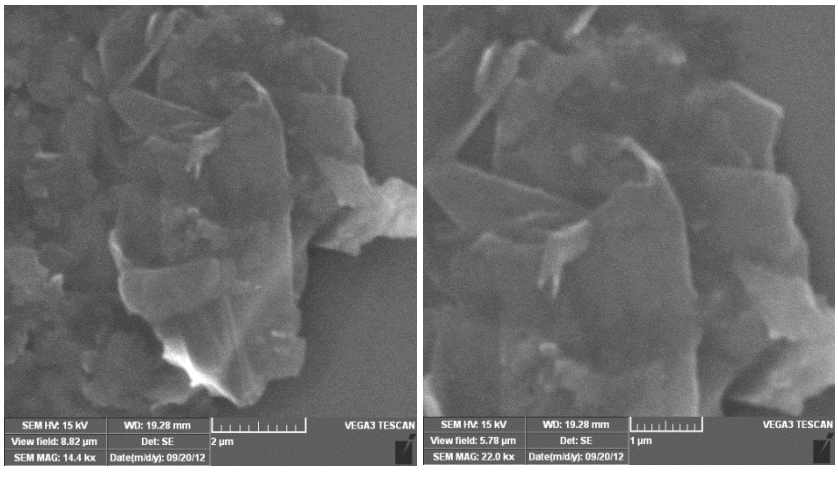

Figure 2s. SEM images of bare graphene sheets at different magnifications

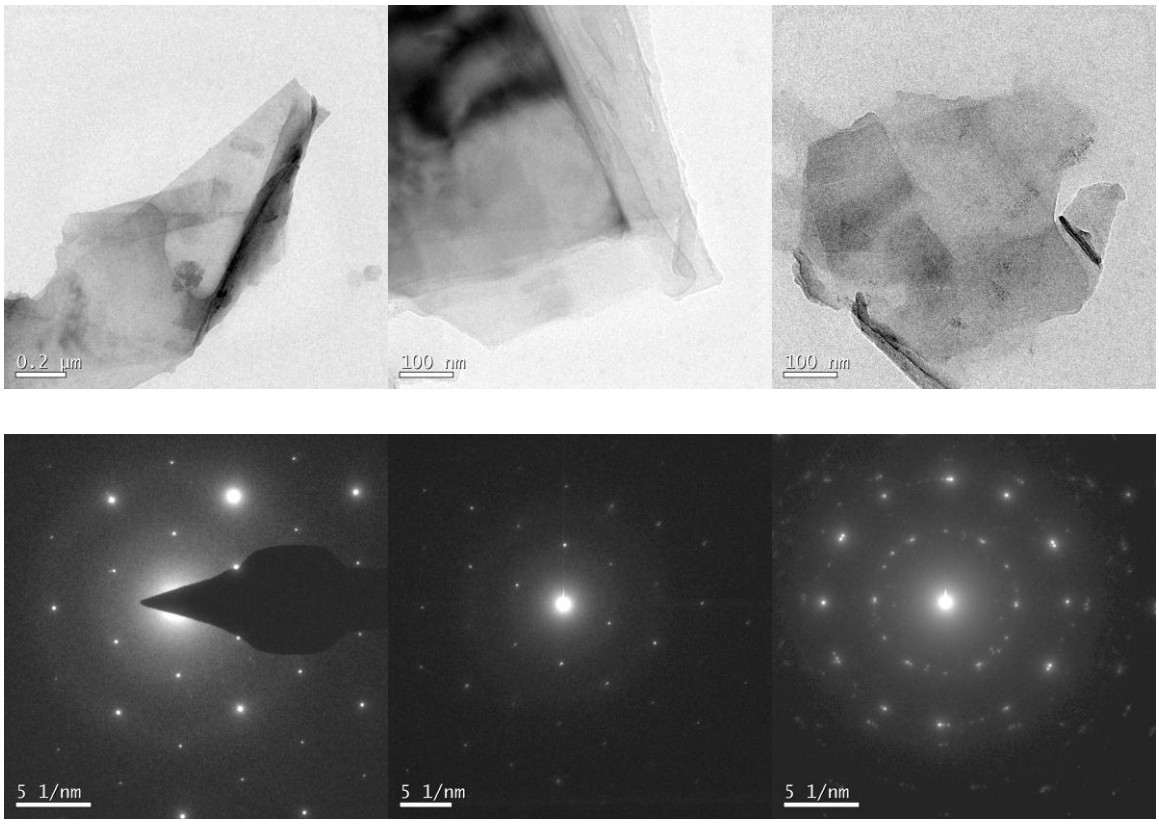

Fig. 3s. TEM images of Graphene nano sheets <5 layers Exfoliated using NMP

The SEM (Fig 2s) and TEM images (Fig 3s) Illustrates the extend of exfoliation of graphite to GNS. The corresponding SAED patterns also support the formation of well exfoliated <5 layers GNS.

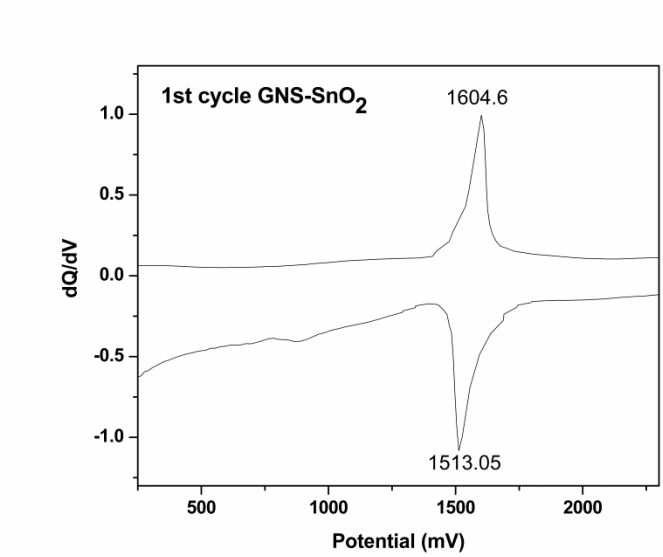

Fig 4s. Differential capacity curve (dQ/dV VS potential plot) of GNS-SnO_2 composite for the 1st charge discharge cycle at 300 mAh g^{-1}

The differential capacity curve of the 1st cycle cycled at 300 mAh g^{-1}. It clearly exhibits the electrochemical alloying de alloying reaction at 1604.6 mV and 1513.05 mV respectively with Li^+ ion as shown below.

$$8.4\ Li^+ + SnO_2 \longleftrightarrow Li_{4.4}Sn + 2Li_2O$$