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Assembling of SnO_2 Quantum dots on RGO to form SnO_2/N doped RGO as High-Capacity Anode Material for Lithium Ion Batteries

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Experimental Section：

Synthesis of GO:

GO was synthesized from natural graphite powder according to a modified Hummers method. Briefly, 0.9 g of graphite powder was added into a mixture of 7.2 mL of 98% H_2SO_4, 1.5 g of $K_2S_2O_8$, and 1.5 g of P_2O_5. The solution was kept at 80 ^oC for 4.5 h, followed by thorough washing with water. Thereafter, the as-treated graphite was put into a 250 mL beaker, to which 0.5 g of $NaNO_3$ and 23 mL of H_2SO_4 (98%) were then added while keeping the beaker in the ice bath. Subsequently, 3 g of $KMnO_4$ was added slowly. After 5 min, the ice bath was removed and the solution was heated up to and kept at 35 ^oC under vigorous stirring for 2 h, followed by the slow addition of 46 mL of water. Finally, 40 mL of water and 5mL of H_2O_2 was added, followed by water washing and filtration. The exfoliation of graphene oxide was then dispersed in water (5 mg mL^{-1}) under ultrasonication for 2 h to yield a homogeneous suspension.

Synthesis of SnO_2 quantum dots:

1 mmol $SnCl_4$ and 1 mmol AHA were dissolved in 10 mL water. After ultrasound treatment for 5 minutes, the products were purified by centrifugation and washed with water and acetone for three times.

Synthesis of SnO_2/GO hybrids:

The as-obtained SnO_2 quantum dots were re-dispersed in 10 mL water, then 4 mL GO solution was dropping in slowing. After stirring for 1 hour, the black precipitation was collected by centrifugation and re-dispersed in 10 mL ethanol. After hydrothermal treatment at 140 ^oC for 3 hours, SnO_2/RGO hybrid nanomaterial was obtained.

Synthesis of SnO_2/N doped RGO hybrids:

The dried SnO_2/RGO sample was heated in Ar flow at 450 ^oC for 2 hous at a heating rate of 2 ^oC/min.

Characterization:

The X-ray diffraction patterns of the products were collected on a Rigaku-*D*/max 2500 V X-ray diffractometer with Cu-K_α radiation (λ = 1.5418 Å), with an operation voltage and current maintained at 40 kV and 40 mA. Transmission electron microscopic (TEM) images were obtained with a TECNAI G2 high-resolution transmission electron microscope operating at 200 kV. XPS measurement was performed on an ESCALAB-MKII 250 photoelectron spectrometer (VG Co.) with Al K_α X-ray radiation as the X-ray source for excitation.

Electrochemical measurements:

The test cell consisted of a working electrode and a lithium foil which were separated by a Celgard 2400 membrane. The electrolyte solution was prepared by dissolving 1 M LiPF6 in EC-DMC (1 : 1 w/w). The working electrodes were prepared by casting slurry containing 80 % active material, 10 % acetylene black and 10 % polyvinylidene fluoride (PVDF) onto a copper foil. After vacuum drying at 80 ^oC for about 24 h, the electrode disks were punched and weighed. Each electrode has approximately 1–3 mg of active material. Galvanostatic charge–discharge cycling tests were performed using a LAND CT2001A multi-channel battery testing system in the voltage range between 0.01 and 3 V at room temperature.

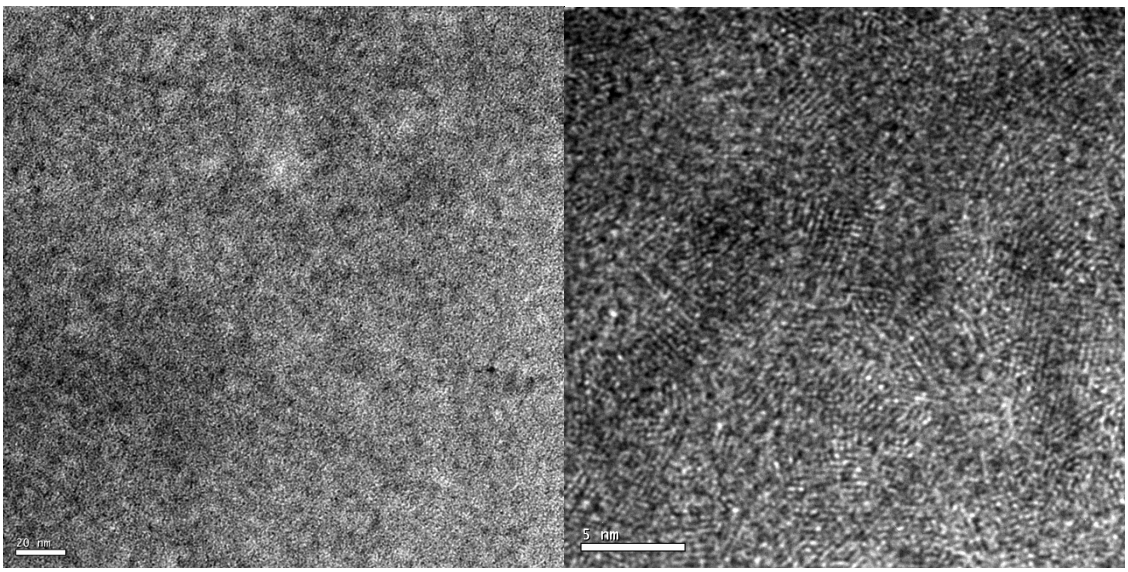

Figure S1. TEM images of SnO_2 quantum dots after the ultrasound treatment.

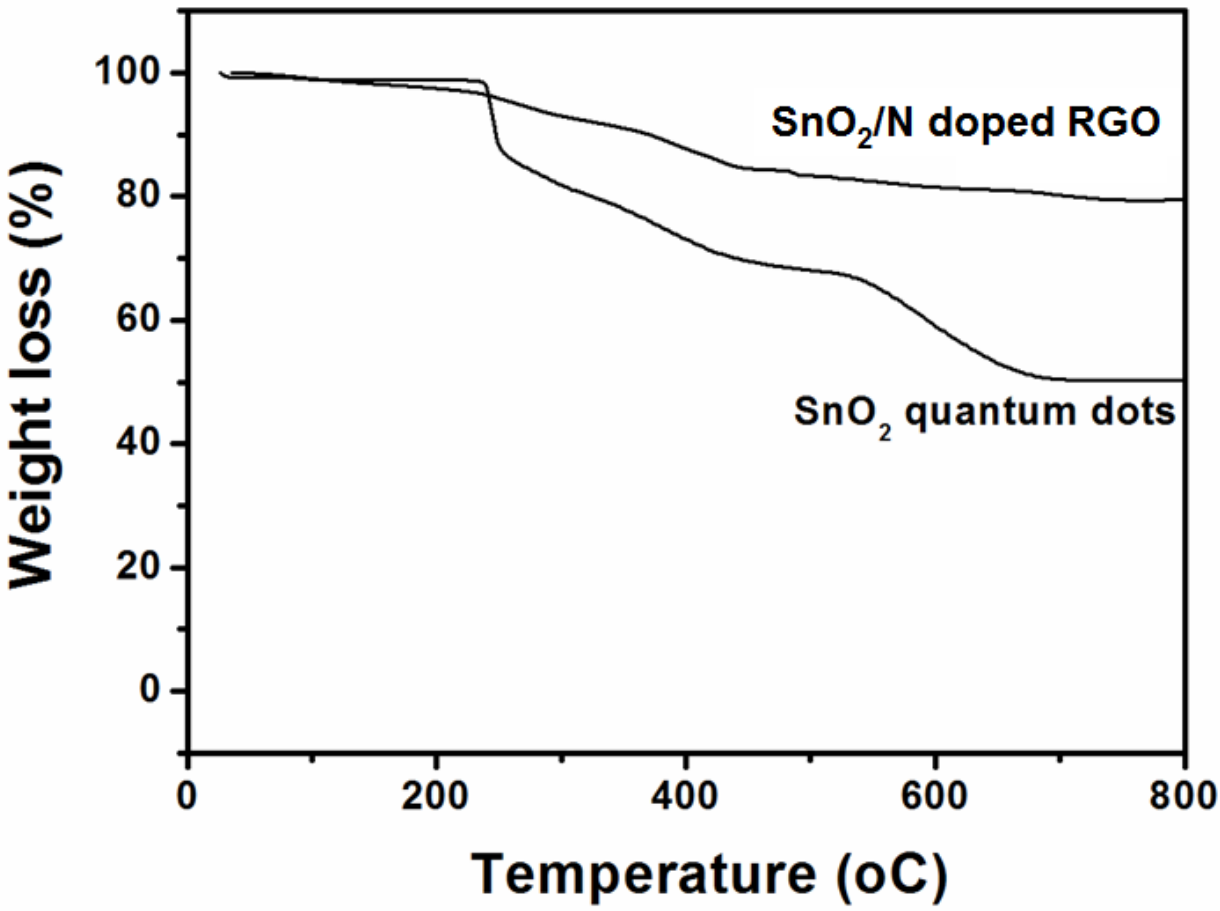

Figure S2. TG curves of SnO_2 quantum dots and SnO_2/N doped RGO.

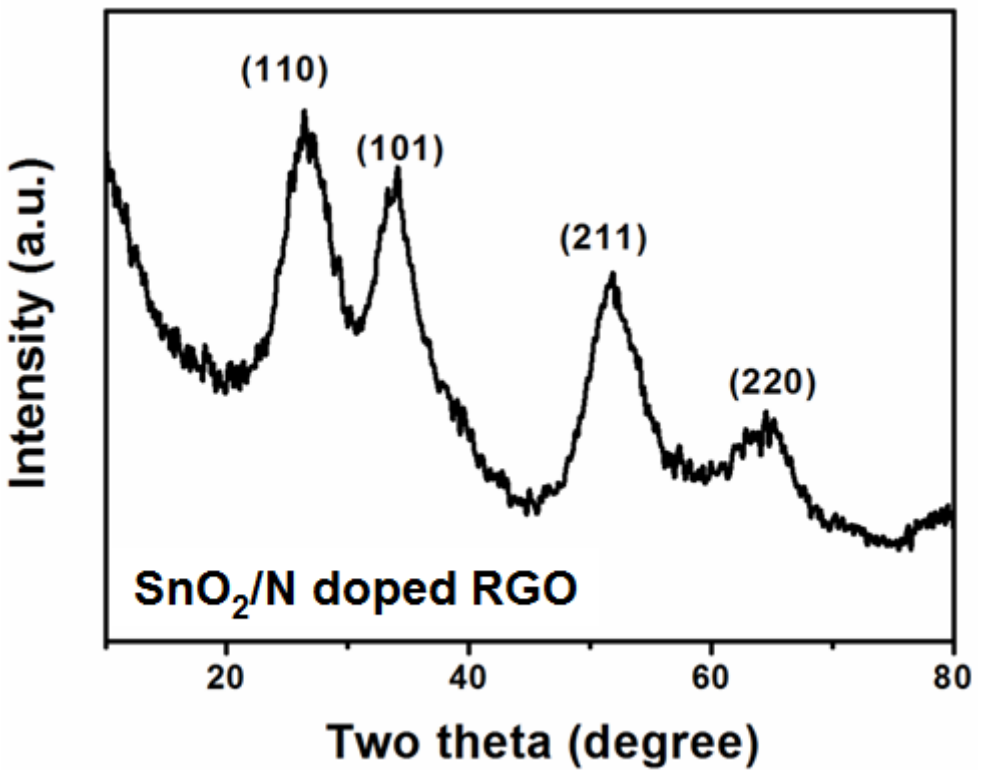

Figure S3. XRD data of SnO_2/N doped RGO.

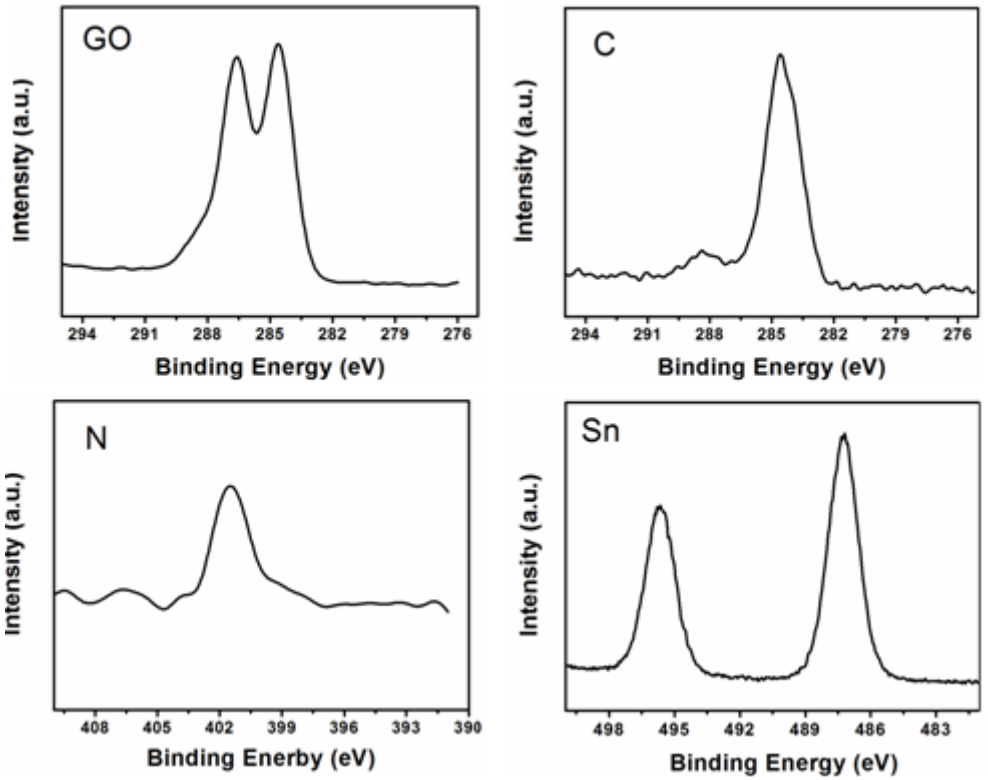

Figure S4. XPS data of GO and C, N, Sn in SnO_2/N doped RGO.

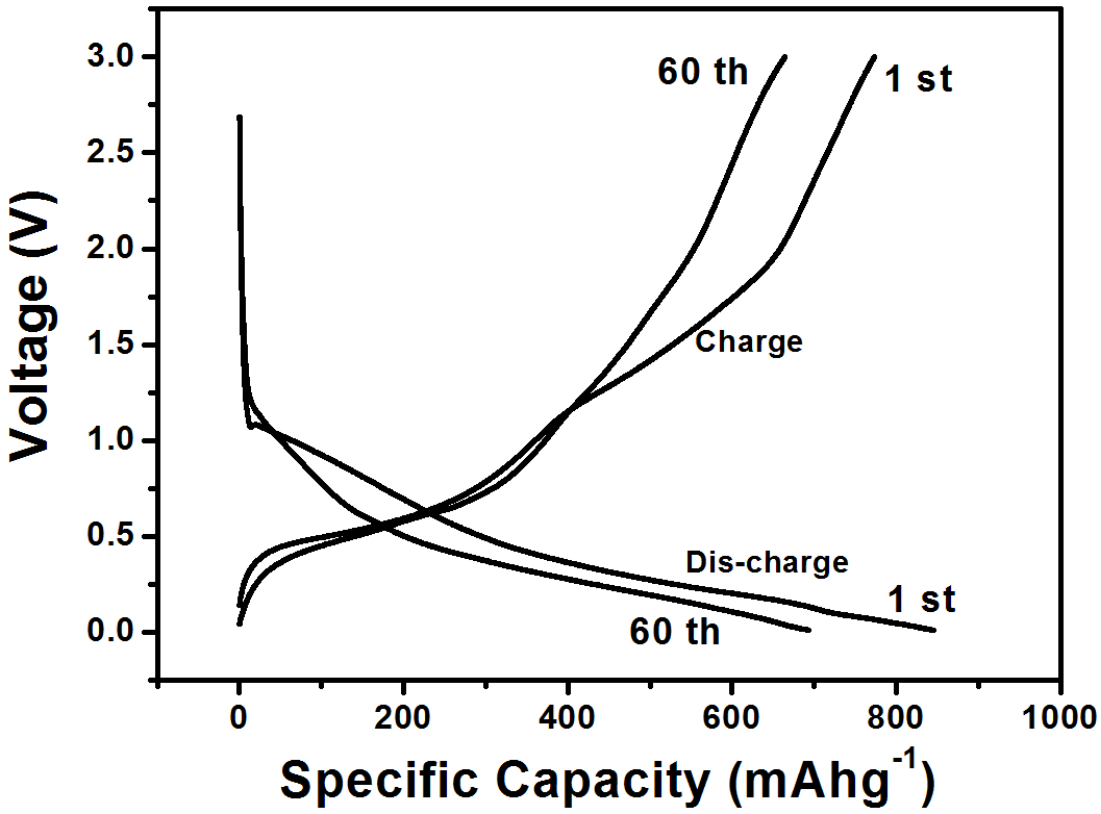

Figure S5. discharge-charge curves of SnO_2/N doped RGO at the ratio of 100 mAg^{-1}.

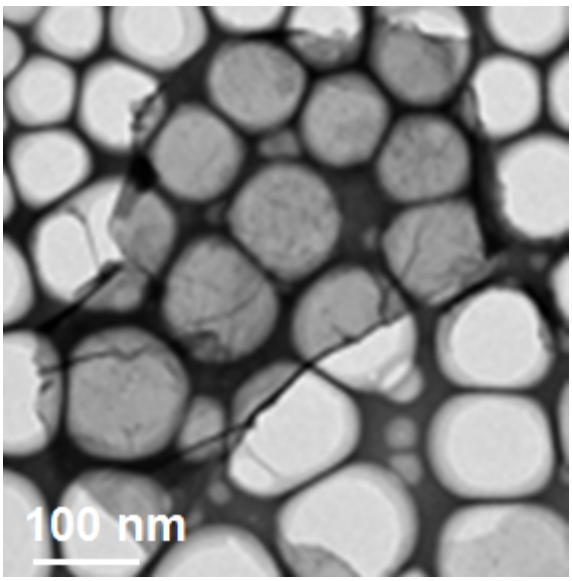

Figure S6. TEM image of GO.