Graphene-based Electrodes for Energy Storage and Conversion

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Introduction

Energy shortages and environmental pollution are serious challenges that humanity will face for the long-term. There is a growing awareness that nanomaterials will have a profound impact on energy generation, storage, and utilization by exploiting the significant differences of energy states and transport in nanostructures and macrostructures. Nanotechnology-based solutions are being developed for a wide range of energy solutions such as solar cells, hydrogen generation and storage, batteries, and fuel cells.

Graphene is an exciting material with unique features such as a large theoretical specific surface area, high intrinsic mobility, high Young's modulus and thermal conductivity, and good electrical conductivity, meriting attention for applications such as for conductive electrodes, among many other potential applications. Here, we will report to use graphene, nitrogen-doping graphene or its nanocomposites as electrodes Li ion batteries, Li-Air batteries and as Pt support for fuel cells.

Experimental

Graphene oxide was prepared by the modified Hummers method [2]. N-doping in graphene was carried out post-treatment of NH3 [1]. Amorphous and crystalline SnO_2/GNS composites were synthesized by a commercial ALD reactor [2]. Tin (IV) chloride and DI water placed into each reactor were used as a SnO_2 precursor and a reactant, respectively. Nitrogen gas was used as the carrier gas. A regular ALD cycle consisted of an injection of $SnCl_4$, an extended exposure of $SnCl_4$ to GNS, an N_2 purge, an injection of water vapor, an extended exposure of water vapor to GNS, and another N_2 purge. Different ALD cycles were repeated to obtain amorphous or crystalline and SnO_2/ GNS composites. The composite of LiFePO4 and grapheme was synthesized by sol-gel method [3,4].

Results and Discussion

In the first part, we first compared graphene and nitrogen-doping graphene with commercial graphite as anodes for Li ion batteries [1]. Further, we successfully uniformly deposited crystalline and amorphous SnO_2 on both sides of graphene nanosheets (GNS), by using an atomic layer deposition (ALD) method, as anodes for lithium ion batteries and showed the excellent stability of amorphous SnO2 on grapheme [2]. The addition of grapheme in LiFePO4 can significantly improve the performance of the composites [3,4].

In the second part, we will report that graphene nanosheets (GNSs) as cathode for Li-Air batteries had shown a capacity of up to 8,706 mAh g-1[5]. Further, it was found that nitrogen-doped graphene nanosheet (N-GNS) cathode materials delivered a discharge capacity of up to 11,660 mAh g-1, increasing about 40% of the discharge capacity compared to GNSs. The electrocatalytic activity of N-GNSs for oxygen reduction in the non-aqueous electrolyte is 2.5 times that of GNSs [6]. Further, S-doped graphene has significant influence on morphology of the product [7].

In the third part, we applied graphene as a support to deposit Pt electrocatalysts for PEM fuel cell applications.

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