

## Hierarchical Nanostructured Core-Shelled Sn@C Nanoparticles Embedded in Graphene Nanosheets as High Performance Anodes for Lithium Ion batteries

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### Introduction:

Lithium ion battery (LIB) is a novel recyclable energy system, which can address both the energy shortage and environmental pollution problems. Designing novel anode electrodes, especially nanosized materials, is one of key solutions due to its unique properties in advanced LIB [1-2]. Sn-based nanomaterials are considered to be potential candidates because of its high lithium storage capability. However, one of major drawbacks hampering its industrial application is the poor cycling performance. The controlled synthesis of Sn@C core-shelled structure and dispersion of Sn based nanocrystals on ductile carbonaceous support such as graphene, which could serve as a buffer matrix to maintain the electrode integrity during the charge/discharge process, are effective strategy to solve the problem [3]. In this presentation, we will report our recent work about Sn@C core-shelled structure on graphene as anodes for LIB [3,4].

### Experimental

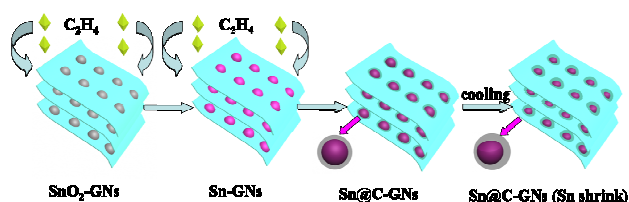
The hierarchical carbon encapsulated tin (Sn@C) embedded graphene nanosheets (GNs) composites (Sn@C-GNs) have been successfully fabricated via a simple and scalable one-step chemical vapor deposition procedure [4]. First, ethylene reduces SnO<sub>2</sub> supported on GNs to metallic Sn nanoparticles, and then carbon, originating from the decomposition of ethylene, forms a shell at the surface of Sn nanoparticles. In the subsequent cooling process, the Sn droplet will transform into solid Sn nanoparticles, accompanied with volume shrinkage, resulting void space at the interface of Sn core and carbon shell. The scheme for synthesis procedures are shown in figure 1.

### Results and discussion

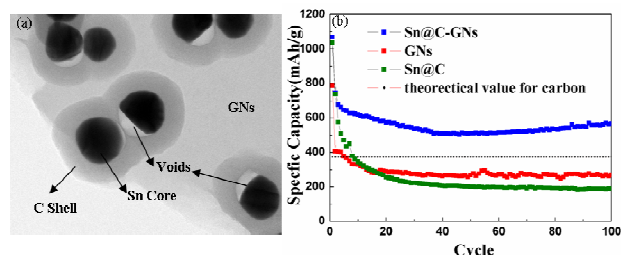
Figure 2a shows the high resolution TEM image of Sn@C-GNs nanostructure. With GNs, the supported Sn@C nanostructure exhibits a uniform thickness of the outer carbon shell, inner tin core and some voids exist in the core-shelled nanostructures. Figure 2b shows the electrochemical performances of the hybrid electrodes compared with that of pure GNs and Sn@C composites. It is found that the hierarchical nanocomposites exhibit an initial discharge capacity as high as 1069 mAh g<sup>-1</sup>. More importantly, after 100 cycles, the discharge capacity still remains at 566 mAh g<sup>-1</sup> which is higher and more stable than pure GNs and Sn@C composites. The highly stable and reversible capacity is benefitting from the protective carbon matrix, voids and the flexible GNs substrate.

### Conclusions:

Sn@C-GNs composite has been successfully synthesized by an effective one-step CVD strategy. The core-shell nanostructured Sn@C composites embedded in GNs exhibit high lithium storage capacities compared with pure GNs and Sn@C composites without GNs due to the flexible carbon shell, the encapsulated voids between Sn core and carbon shell caused by Sn shrinkage, and GNs, which can buffer the huge Sn core volume change during cycling. Such results demonstrate that the hierarchical Sn@C-GNs can act as an alternative anode for EVs and HEVs applications.



**Figure 1.** Schematic sketch for the Sn@C-GNs composites growth procedures



**Figure 2.** (a) TEM image and (b) cycling performance of Sn@C-GNs nanocomposites

### References

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