# Graphene Materials for Advanced Energy Storage

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Abstract

Graphene is a one atom thick two-dimensional material that exhibits exceptional physical and electronic properties, and offers alternatives for applications in energy storage devices, nanoelectronics, spintronics, biosensors, and medicine. I will describe innovative approaches for the design and synthesis of hierarchical three dimensional graphene hybrid materials which possess characteristics including ultra large surface area, tunability, mechanical durability and high conductivity which are appealing to diverse energy storage systems. Rapid charging and discharging supercapacitors are promising alternative energy storage systems for applications such as portable electronics and electric vehicles. Integration of pseudocapacitive metal oxides with structured nanomaterials has received a lot of attention recently due to their superior electrochemical performance. In order to realize high energy density supercapacitors, we developed a scalable method to fabricate MGM (graphene/MWNT/$MnO_2$) and RGM (graphene/MWNT/$RuO_2$) hybrid systems. The RGM electrode shows outstanding gravimetric and per-area capacitive performance (specific capacitance: 502.78 $Fg^{-1}$, areal capacitance: 1.11 $Fcm^{-2}$). The high specific/areal capacitance and extended operational voltage window of 1.5 V lead to an exceptionally high energy density of 39.28 $Whkg^{-1}$ and power density of 128.01 $kWkg^{-1}$. Next, I will talk about three-dimensional cone-shape carbon nanotube clusters decorated with amorphous silicon for lithium ion battery anodes. An innovative silicon decorated cone-shape CNT clusters (SCCC) is prepared by depositing amorphous silicon onto CCC via magnetron sputtering. The seamless connection between silicon decorated CNT cones and graphene facilitates the charge transfer in the system and provides a binder-free technique for fabricating lithium ion batteries. Lithium ion batteries based on this novel 3D SCCC architecture demonstrated a high reversible capacity of 1954 $mAhg^{-1}$ and excellent cycling stability. Such multi-scale engineered materials could have wide range implications to facilitate new technological innovations in energy storage.

References

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