Mark C. Hersam
Northwestern University, 2220 Campus Drive, Evanston, IL 60208-3108, USA

m-hersam@northwestern.edu

Solution-Processed 2D Materials for Next-Generation Lithium-Ion Batteries

Efficient energy storage systems represent a critical technology across many sectors including consumer electronics, electrified transportation, and a smart grid accommodating intermittent renewable energy sources. Arguably, the most important advance in energy storage over the past three decades is the lithium-ion battery, which was recognized with the 2019 Nobel Prize in Chemistry. However, despite its many successes, issues related to safety, energy density, charging time, and operating temperature range have hindered the large-scale adoption of some of the most revolutionary lithium-ion battery technologies such as electric vehicles and grid-level storage. Nanostructured materials were once thought to present compelling opportunities for next-generation lithium-ion batteries, but inherent problems related to high surface area to volume ratios at the nanometer-scale (e.g., undesirable surface chemical interactions between electrodes and electrolytes) have impeded their adoption for commercial applications. This talk will explore how the chemical inertness and solution processability of select two-dimensional (2D) materials are driving a resurgence in nanostructured lithium-ion battery materials [1]. For example, conformal graphene coatings on lithium-ion battery cathode powders mitigate surface degradation and minimize the formation of the solid electrolyte interphase, thus improving cycling stability. In addition, the high electrical conductivity of graphene reduces cell impedance, resulting in enhanced kinetics that enable high-rate capability and low-temperature performance down to –20 °C [2]. On the other hand, ionogel electrolytes based on ionic liquids and hexagonal boron nitride nanoplatelets enable safe, high-rate operation at high temperatures up to 175 °C, which represents the highest operating temperature to date for solid-state lithium-ion batteries [3].

References

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