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Two dimensional nanomaterials for energy storage applications

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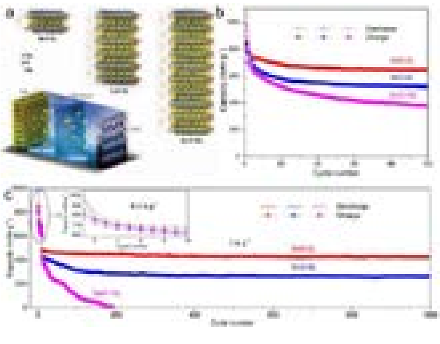
Fast electron and ion transport are important design parameters for nanostructured electrodes for energy storage applications, including batteries and super capacitors. Typically, fast electron transport has been achieved by incorporating conducting additives such as carbon black with the active electrode materials that have low conductivity. Such approach can indeed enhance the overall electronic conductivity of the electrode material in electrochemical energy storage devices. However, fast ion transport cannot be achieved using the same approach. Instead, controlling the dimensionality of the active electrode material has emerged as a powerful method to enhance ion diffusion within the electrode materials in electrochemical storage systems. 2D materials offer a large number of advantages as active electrode materials in batteries and super capacitors. This because the 2D morphology increases the surface area and reduces the ion diffusion distance, effects that can improve electrolyte access to as many active materials atoms as possible, and improve the ion diffusion kinetics. 2D electrode materials offer many other advantages in electrochemical systems. In addition, the 2D material morphology can minimize the volume changes associated with conversion and alloying mobile ion battery electrodes. In some applications, such as catalysis, the 2D materials edge defects can serve as active nucleation sites for catalytic reactions and have been reported to achieve impressive performance compared to commercial catalysts. Until recently, graphene and reduced graphene oxide have been the dominant 2D materials evaluated for energy storage applications. However, many more 2D compounds have emerged and now compete with graphene in performance. Such materials include transition metal chalcogenides (e.g., MoS_2 and WS_2), oxides (e.g., VO_2 and SnO), transition metal carbides or MXenes (e.g., Ti_3C_2 and Ti_2C), and even polymeric and metal organic frameworks. The common factor between all these compounds is their 2D morphology, which provides extreme surface area to volume ratio, which enhances the overall performance of these electrode materials for energy applications. In this presentation, we review recent progress in using 2D nanomaterials for electrochemical energy storage applications, with special focus on super capacitors and Na/Li ion batteries.



Biography

Husam Alshareef is a Professor of Materials Science & Engineering at King Abdullah University of Science & Technology (KAUST) in Saudi Arabia. He holds a PhD from North Carolina State University, USA. His group at KAUST develops semiconductor nanomaterials for electronics and energy applications. The author of 330 scientific articles, he has nearly 75 issued patent, and has given hundreds of international invited and contributed presentations.

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