Nanomaterials for Energy Storage

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Commercial lithium-ion (Li-ion) batteries using the Ni- and Co-based intercalation-type cathodes and graphite-based anodes suffer from low specific energy, high toxicity and high cost. Further increase in the energy storage characteristics of such cells is challenging because capacities of such intercalation compounds approach their theoretical values and further increase in their maximum voltage induces serious safety concerns.[1] The growing market for portable energy storage is undergoing a rapid expansion as new applications demand lighter, smaller, safer and lower cost batteries to enable broader use of plug-in hybrid and pure-electric vehicles and renewable energy sources, such as solar and wind. Conversion-type cathode and anode materials are some of the key candidates for the next-generation of Li-ion batteries.[2] However, conversion-type materials typically suffer from high resistance, small capacity utilization at room temperature, dissolution of active material (or active material components) during cycling, irreversible structural changes, irreversible electrolyte consumption and overall relatively fast capacity fading with cycling.

Here I will discuss our prior studies on the development of electrochemically stable conversion-type anodes and the formation of Sila Nanotechnologies, Inc., a Georgia Tech startup founded to further develop, scale-up and commercialize advanced materials for energy storage applications. I will also share some of our recent progress in the successful applications of multiple complimentary approaches to engineer nanocomposite materials to overcome the limitations of conversion-type cathodes and dramatically enhance electrochemical performance of sulfur/lithium sulfide (S/Li_2S)-Li, selenium (Se)-Li and metal fluoride (MF)-Li cells.[3-7] We demonstrated S-Li and MF-Li cells capable of achieving near-theoretical capacity utilization, remarkable stability and excellent rate performance exceeding state-of-the art. In addition, we demonstrated the ability of certain electrolytes to successfully prevent the cathode dissolution and leaching via in-situ formation of a Li ion permeable protective surface layer.[8, 9] This layer forms as a result of electrolyte reduction/oxidation reactions during the first cycle of the conversion reaction, thus minimizing the capacity losses during cycling. Published, recently accepted and latest unpublished studies will be presented.

References:

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