Graphene-Silicon Composites for Li-ion Battery Anodes

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Abstract

Silicon has remarkable properties to replace the presently used graphite as an anode in Li-ion batteries. There is abundance of Si in nature, it can potentially be produced at a low cost, it is environmentally benign, and has a high theoretical capacity which is an order of magnitude higher than that of the conventionally used graphite [1]. However, in practice, silicon suffers from massive cracking and degradation when it is being employed as an anode. The rapid fade is also accelerated by the continuous generation of SEI (Solid electrolyte interface) layer on the silicon surface. Carbon coating or scaffolding of silicon particles has proved to be the most reliable way to avoid the SEI formation. The formation of such an effective carbon scaffold for silicon can be an extremely challenging yet the most important step towards the utilisation of silicon. Amongst all existing forms of carbon, graphene has the most exceptional set of properties. It possesses almost metallic conductivity [2], very high flexibility [3] and a large specific surface area [4]. These properties can perfectly alleviate the inherent problems of low conductivity and cracking associated with the cycling of silicon. Graphene will additionally benefit the rate capability of Si based anode by increasing the transport of ions and electrons within the electrode microstructure. Last but not the least the exceptionally high thermal conductivity of graphene [5] will reduce the risk of any thermal run away in a cell and significantly improve the safety of high energy Li-ion cells.

We have synthesised composite Si-graphene anodes using nano-silicon and reduced graphene oxide. The electrodes exhibit reduced internal resistance during cycling compared to electrodes without graphene which in turn might lead to improved overall performance.

References

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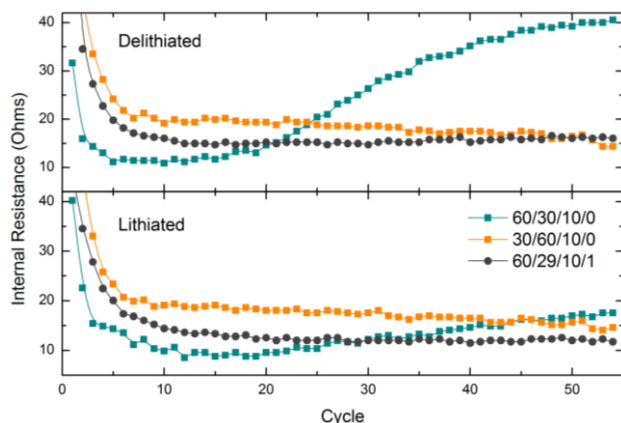
Figures

Figure1: Internal resistance versus cycle number measured for selected Si-C based materials with electrode composition in wt.% as indicated in the figure legend (Silicon/Carbon-black/Binder (CMC)/reduced graphene oxide). The electrode containing just small amounts of reduced graphene oxide shows significant less internal resistance after cycling. Typical loading of the active material was 0.2-0.5 mg/cm^2.