DEGRADATION ANALYSIS OF HYBRID SILICON-TIN ANODE FOR LITHIUM ION BATTERIES

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This study investigates modes of degradation in hybrid silicon-tin anodes for Li-ion batteries, with emphasis on the electrode architecture. In recent years, considerable studies have shown that crystalline Si is a promising negative electrode candidate, with a specific capacity of 3579 mAh/g which is ca. 10 times the specific capacity of graphite. However, Si still has major performance issues associated with it, predominantly the volume expansion (up to 280%) which can result in cracking and pulverisation of active particles. Addition of tin to the silicon-based anode enhances performance by way of the decreased resistance from metallic tin improving cycling stability and charge capacity. The electrode macro and micro-cracking in the silicon based electrodes results in disintegration of the electrode architecture and leads to formation of “dead spots” (or loss of active materials). Incorporation of tin into the system is thought to help in reducing these electrically separated dead spots due to its conductive properties. The performance synergy between silicon and tin outperforms the individual contribution of each material alone.

It is imperative to comprehensively understand the fundamental degradation mechanisms inside anode microstructures and at their interfaces. X-ray computed tomography (CT), FIB-SEM tomography in conjunction with impedance spectroscopy and associated physical characterization, will be employed to capture and quantify key aspects of the evolution of internal morphology and resistance build up. This includes characterisation of SEI growth, porosity changes and conductive network breakdown during charge-discharge operation. The study will also include *in-situ* and *operando* tomography and diffraction experiments for clearer insights into key degradation processes, such as delamination, initiation and propagation of particle cracking as well as time-resolved identification of phase transformations. Tomography has been proven to be an effective tool to explore the hierarchical structure of battery electrodes and for diagnosing battery failure mechanisms at multiple- length scales. This approach will enable us to observe and quantify failures in Li-ion batteries at the electrode level, and thus facilitate construction of better electrode architectures.

This study aims to characterise electrode structures to be able to develop and correlate microstructural architecture with performance. It is anticipated that this study will influence major improvements in the design of Li-ion battery materials and their processing which in turn positively impact cell performance.