

Lithium Deposition on Graphite Anodes – Post-Mortem Experiments vs. Simulations

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Li-ion cells are widely used in mobile applications. However, their life-time is limited by aging mechanisms on the material level, such as deposition of metallic Li on graphite anodes and subsequent reaction with electrolyte. Besides its strongly limiting effect on battery life-time, Li deposition can also lead to a drastic decrease of safety due to increased exothermic reactions [1]. Li deposition is often called 'Li plating', although 'plating' refers to homogeneous films only. The reason is that in most studies on this topic, the cells are not disassembled and the exact position of the deposited Li (in-plane or through-plane) remains unknown. Therefore, this is the topic of the present poster.

The reason for Li deposition are negative anode potentials vs. Li/Li^+ , which are assessable by measurements with reference electrodes [2] or by simulations [3]. Local variations of the anode potential can for example be caused by temperature gradients, differences in current density or by local inhomogeneity in Li-ion cells. These local differences of the anode potential can lead to local Li deposition.

On the present poster, selected results from three publicly funded projects including Post-Mortem analysis and simulation are combined to give an overview on different forms of Li deposition. While the simulations allow detailed manipulation/variation and analysis on the microscopic level for the situation during the first charging cycle, Post-Mortem analysis shows the situation after cycling experiments.

Detailed analysis by Glow discharge optical emission spectroscopy (GD-OES) depth profiling and scanning electron microscopy (SEM) in combination with ion-beam cross-sections shows that Li is mostly deposited on the anode surface. Since this was observed with the graphite anodes taken from seven different types (cathodes: NCA, LFP, NMC) of commercial Li-ion cells cycled under Li deposition conditions, this seems to be a general trend. The experimental finding is in full agreement with independently performed simulations taking typical microstructures of graphite anodes into account.

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[1] M. Fleischhammer et al., J. Power Sources. 274 (2015) 432–439.

[2] T. Waldmann et al., J. Electrochem. Soc. 163 (2016) A1232–A1238.

[3] S. Hein, A. Latz, Electrochimica Acta. 201 (2016) 354–365.