Electrical detection of lithium plating markers in lithium-ion batteries

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Lithium plating (accumulation of metallic lithium) is a safety-critical phenomenon that occurs mainly during fast charging of lithium-ion batteries at cold temperatures. It is caused on the anode by the limited capability to absorb lithium ions at the desired rate. Reversible and irreversible plating can be accompanied by the formation of dendrites and lead to safety-critical short circuits. Irreversible plating additionally leads to a significant capacity loss due to the loss of cyclable lithium. To optimize battery lifetime and safety for all requirement profiles, it is central to detect the formation of metallic lithium and dendrites at an early stage.

For this purpose, charge/discharge cycle tests with different test conditions (variable temperature/C-Rate) were performed on graphite/LCO based cells (C_n=850mAh). In subsequent differential voltage analyses (DVA), electrical markers for indications of limiting lithium-ion uptake as well as lithium stripping were investigated (see e.g. Figure 1).

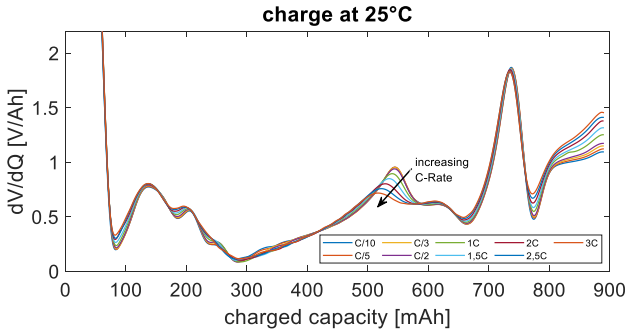

Figure 1: DVA curves for charging at various C-Rates at room temperature (25°C)

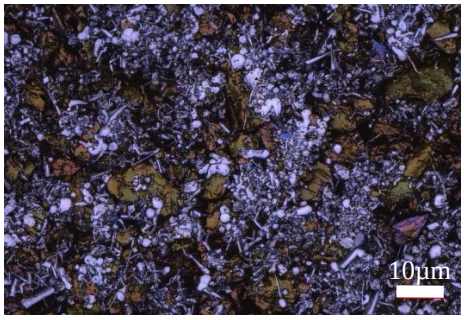

Figure 2: Laser microscope image of a graphite anode surface (after 4C charging at -5°C)

To confirm the indicators, selected aging points were examined using post-mortem analysis. Figure 2 e.g. shows the graphite anode surface of a strongly plated cell in a laser microscope image (after 4C charging at -5°C).

The knowledge thus gained could provide both rapid and accurate feedback on the impact of temperature and charge rate on the behavior of lithium plating. In addition, the further development of electrical tests could enable better safety testing of cells.