A New Approach to Quality Control on Microstructural Level by Means of Automated Quantitative Light Microscopy

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Motivation

Lithium-ion-cells are one of the most promising candidates for energy storage. It is widely accepted that the cell's quality is significantly determined by the microstructure of the electrodes.

Automated quantitative light microscopy provides a fast and precise method to determine a variety of microstructural properties such as layer thicknesses, porosity, amount of active material within the active mass coating, as well as phase fraction and distribution of different active materials in blend cathodes.

Experimental

Approach to Evaluate Manufacturing Quality on a Microstructural Scale

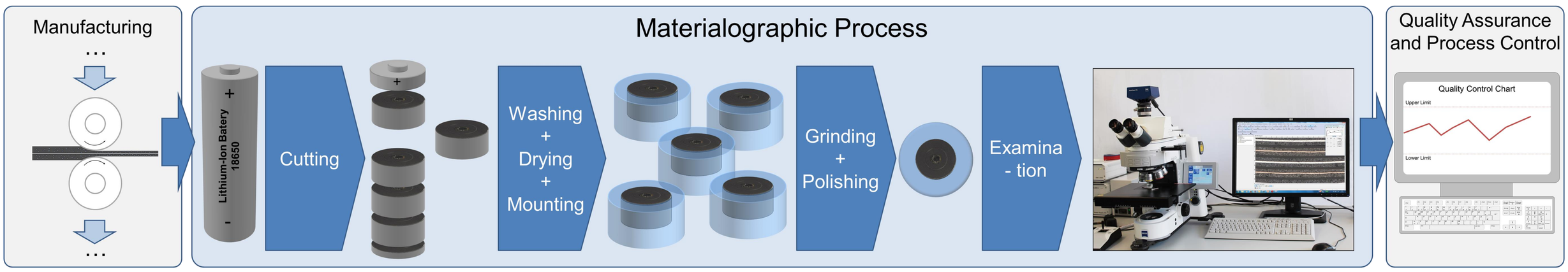
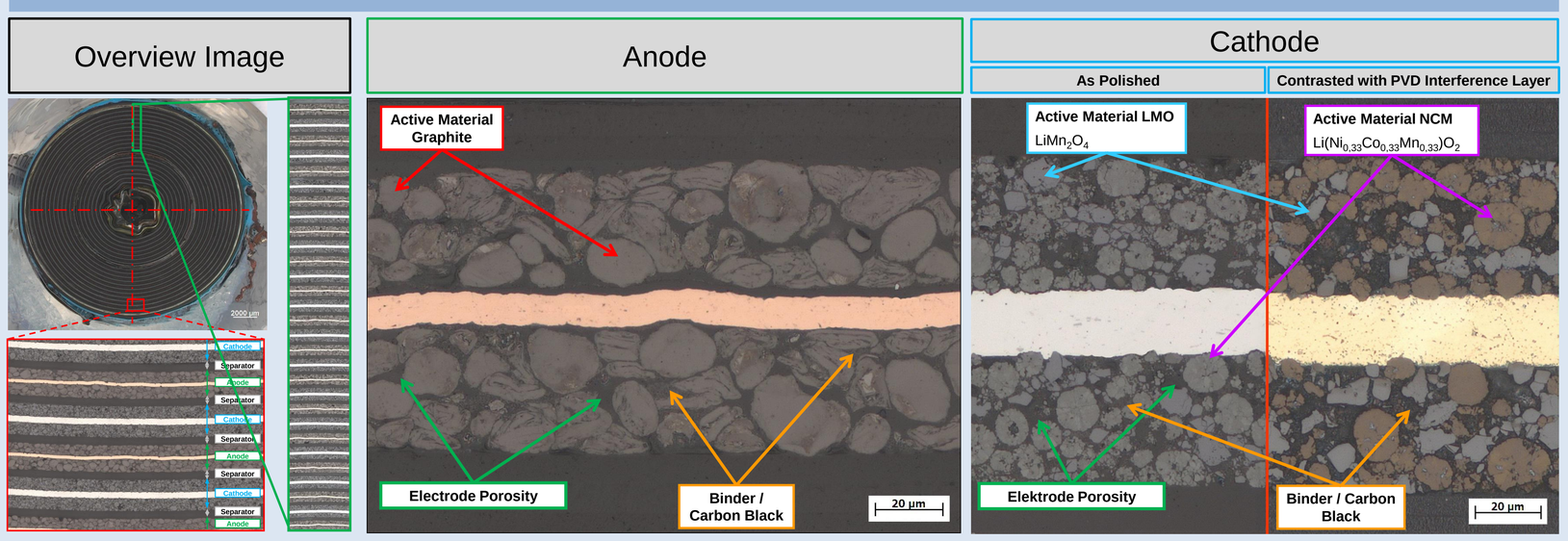


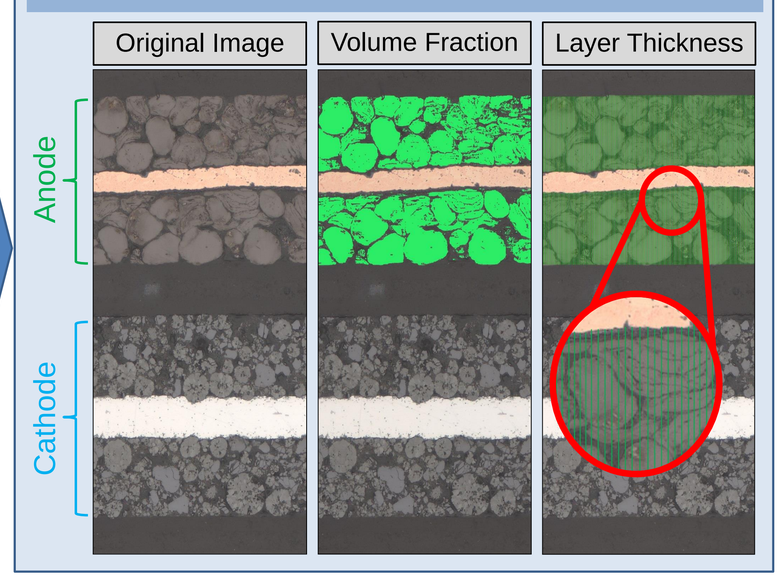
Image Acquisition and Quantitative Structural Analysis (QSA)

Automated Image Acquisition and Microstructure of a Lithium-Ion Battery



- Large area images (from cell core to outer rim) have been acquired using a motorized stage. Each image consists of up to 25 single image (each 180 µm x 135 µm in size).
- Different cathode active materials ($LiMn_2O_4$ and $Li(Ni_{0,33}Co_{0,33}Mn_{0,33})O_2$) can be observed inside the cathode active mass coating.

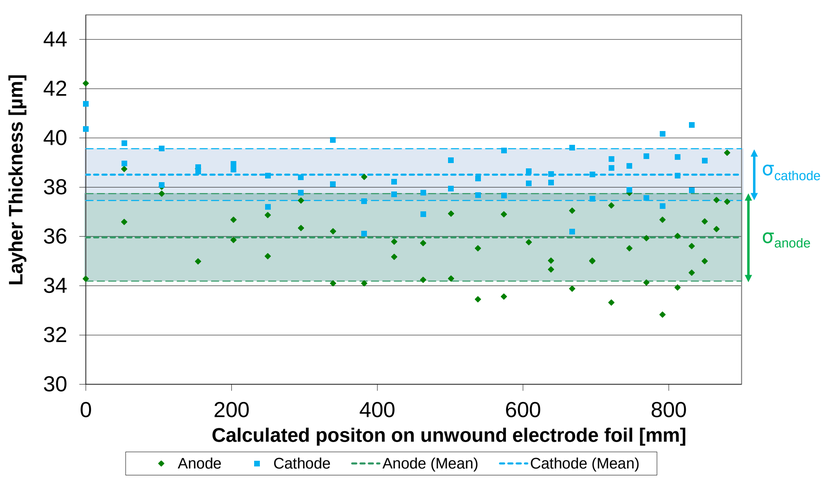
Automated Quantitative Structural Analysis



- All properties are measured automatically for each anode and cathode foil based on the original image with high resolution.

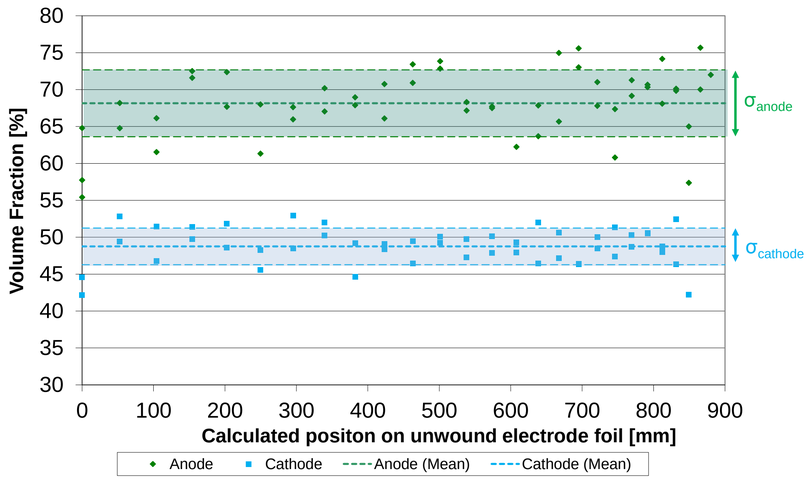
Results – Profiles of Anode and Cathode Layer Thickness, Volume Fraction and Local Cell Balancing

Layer Thickness



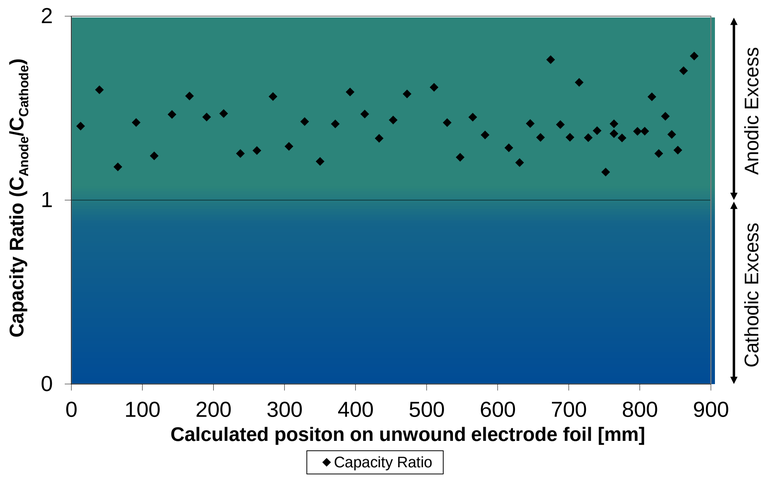
Anode layer thickness ranges from 32 µm up to 42 µm (mean: 36 µm) where cathode layer thickness scatters in between 36 µm and 41 µm (mean: 38 µm).

Volume Fraction



The volume fraction of active material inside the anode and cathode shows values between 55 vol% and 75 vol%. (anode) and 42 vol% and 53 vol% (cathode).

Cell Balancing



The local capacity ratio (local cell balancing) exhibits values from about 1.1 up to 1.8 with a mean of 1.4.

Conclusions and Prospects

- Light microscopy in combination with quantitative structural analysis is a powerful, fast and therefore cost effective tool to determine various microstructural features of electrode foils, that significantly determine the quality of the electrodes.
- The proposed approach can easily be integrated in both quality assurance (QA) and research and development (R&D) processes.

Acknowledgements

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