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MODELING OF LITHIUM-ION CELLS WITH LASER-STRUCTURED GRAPHITE ANODES

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There is a wide field of application of lithium-ion batteries and their performance is permanently enhanced. However, particularly lithium-ion batteries with high energy density encounter limitations to deliver their energy with rising discharge currents. Polarization caused by mass transport limitations is a main reason that deteriorates the rate capability [1]. Structuring of electrodes improves the mass transport of lithium-ions in the electrolyte and thereby the cell performance. Previously manufactured coin cells with $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ (NMC) cathodes and laser-structured graphite anodes showed an increased capacity retention compared to cells with unstructured anodes [2].
Based on this measurement data, a homogenized three-dimensional physical-chemical model including a representative hole structure was developed and validated. The model adequately conforms with the discharged capacity and the transient voltage response of the cells comprising unstructured and structured graphite anodes.
Below discharge currents of 1C, the structuring process has no influence on capacity retention as mass transport limitations in the anode play only a minor role. As the discharge current increases, simulation results verified that lithium-ion concentration gradients in the electrolyte cause a premature termination of the discharge process. These concentration gradients are mainly caused by the highly tortuous transport paths in the anode due to the flake-like graphite particles [3]. Structuring of the anode reduces through-plane concentration gradients and achieves a more homogeneous active material utilization. A maximum capacity retention improvement of 10–15% at a 3C discharge rate was achieved with the laser-structuring process, which could be verified with the presented model.

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