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# Study Of Inhomogeneity In Large Format Li-Ion Cells With Different Multiphysics Models

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## Abstract

Large format Li-Ion battery cells (LIBC), often employed in electric vehicles (EV), show notable gradients in current and temperature distribution (see Figure 1). This inhomogeneity can influence the cell's safety and accelerate battery aging. It is, however, difficult to determine the local temperature and current inside the LIBC experimentally for a detailed analysis.

Thus, 3 different models were developed with COMSOL Multiphysics to investigate the spatial differences. The thermal and electrochemical behaviour of a battery are closely linked. So the models were developed using both the COMSOL Lithium-Ion Battery and the Heat Transfer Interface. All are based on the work of Newman et al. [e.g. [1]&[2]]

To investigate the cross-plane distribution, which is especially hard to attain, 2D (see Figure 1c)) models are sufficient.
For large automotive LIBC the in-plane distribution is equally interesting. Thus a fully coupled 3D (see Figure 1b)) model can provide the most accurate and detailed simulation results. It is, however, computationally expensive and numerically unstable.
A lumped P3D model [3] can provide some spatial information and computes remarkably faster and more reliable.
Simulation results are validated with a surface temperature distribution measurement experiment. Commercially available 63Ah pouch bag LIBCs with a nickel manganese cobalt oxide (NMC) cathode are equipped with a matrix of temperature sensors attached to the top surface and discharged at different C-Rates and temperatures. For better control of the surface temperature boundary conditions the experiments is repeated with an aluminum cooling plate at the bottom.

Multiphysics simulations like these offer a good idea of the spatial current- and temperature distribution inside a LIBC. This information is hard to measure and can help to design safer and more reliable batteries without extensive expensive, time consuming and potentially risky experiments.

## Reference

[1] Doyle et al., Modeling of Galavanostatic Charge and Discharge of of the Lithium/Polymer/Insertion Cell; 1993; J. Electrochem. Soc., Vol. 140, No. 6

[2] Bernardi et al.; General Energy Balance for Battery Systems; 1985; J. Electrochem. Soc.: Vol. 132, No. 1

[3] R. Arunachala et al.; 2015; Influence of Cell Size on Performance of Lithium Ion Battery; Oral presentation at Kraftwerk Batterie Aachen

## Figures used in the abstract

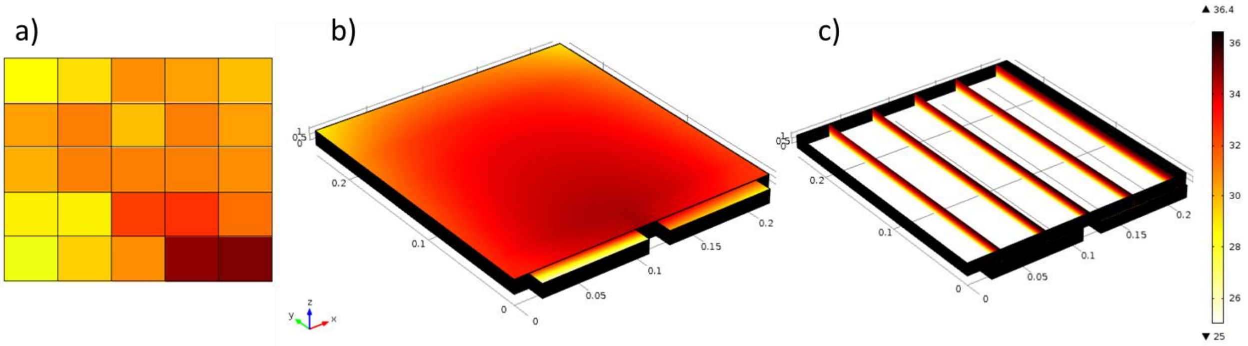


**Figure 1**: Temperature distribution of a 63Ah Cell at 25°C after 1150s of 3C discharge and with aluminium cooling plate at the bottom surface: a) measurement with temperature sensor matrix, b) simulation surface plane, c) simulation cross-plane