German Aerospace Center
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Institute of Engineering Thermodynamics

The Segmented Battery Cell : Measurement of Current Density Distribution and locally-resolved Impedance Spectroscopy

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Motivation

Trend in the development of lithium-ion-batteries goes towards manufacturing of **large-format cells** to increase system energy density.

Challenges:
Inhomogeneous load and thermal gradients over cell-stack become more pronounced. This leads to

- **inhomogeneous aging** due to unfavorable current, SOC and temperature distribution,
- **local increase of impedance and temperature hot-spots.**

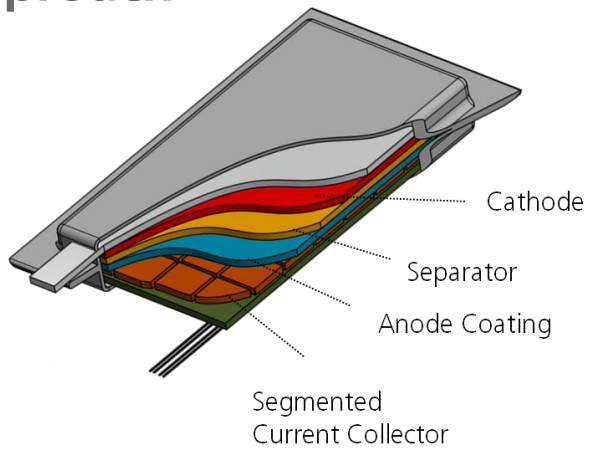
➢ Critical for longevity, performance and safety!

Concept and approach

Obtaining information on how material properties, cell design & charge/discharge parameters influence local gradients is critical to

- maintain inside a safe operating window,
- to optimize performance and
- facilitate longer lifetime.

➢ Combination of simulation AND experiments to monitor local gradients and aging behavior



The segmented cell* approach

- Segmented current collector coated with active material,
- analogous to printed circuit-board technology,
- segments are individually contacted and current over each segment is measured.

* N. Wagner, A. Dreizler, D. Schneider. DE102017109233A1, 2017

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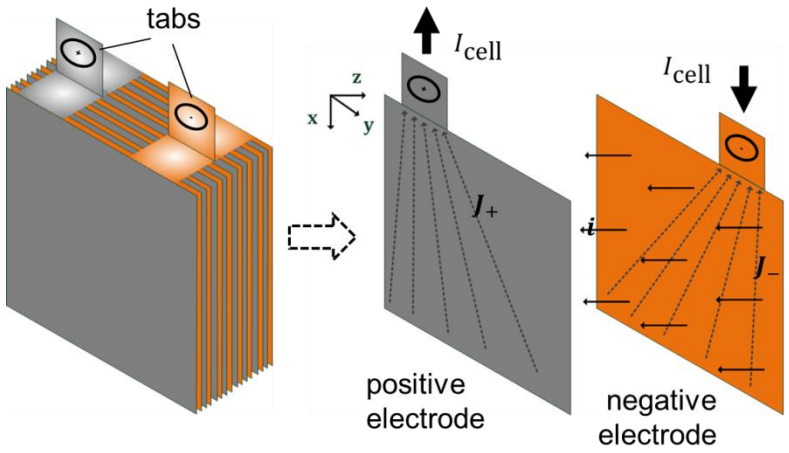
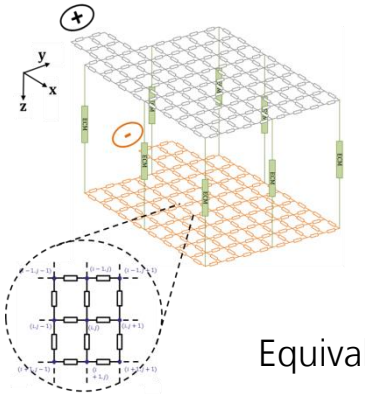
Modelling and simulation of current density distribution

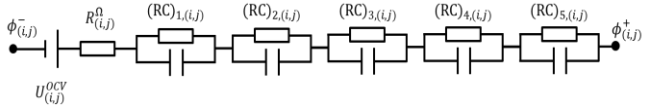
Impedance-based network-model

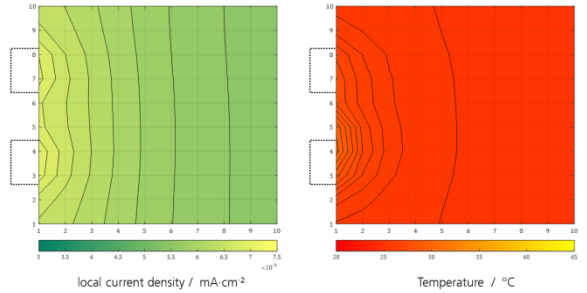




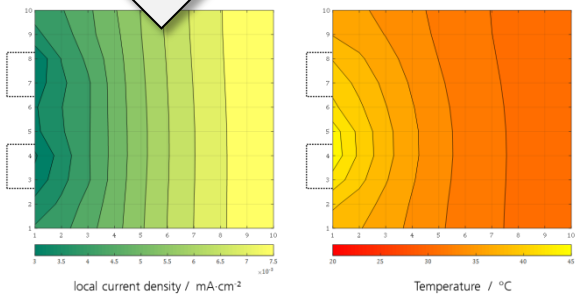
Current is distributed over network of resistances, each element with given *U-I* characteristics

Equivalent circuit model, here





Start and end of 5C-discharge



Model is parametrized by electrochemical experiments:

- Pseudo-OCV curve at C/25
- Polarization resistance of each element is parametrized by impedance spectroscopy measurement of full cell

- Current density distribution, SOC and temperature gradients can be modelled as function of cycling conditions, cell geometry and SOH.
- Aging can be implemented *via* parametrization (OCV and EIS),
- ➢ **Locally-resolved EIS** for more accurate parametrization (local aging behavior) …

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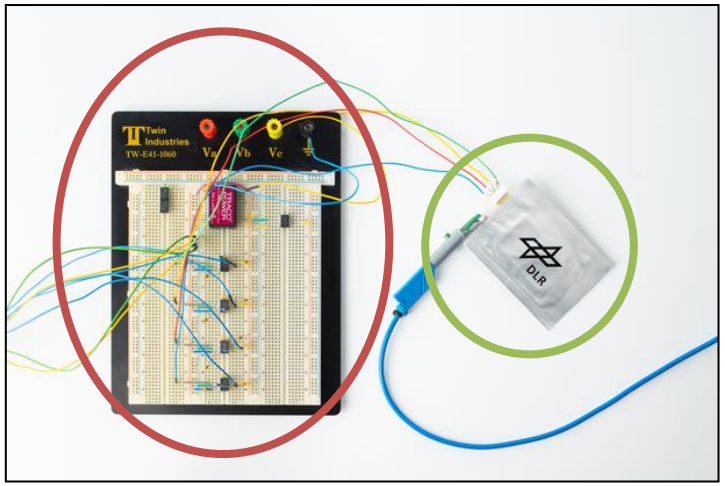
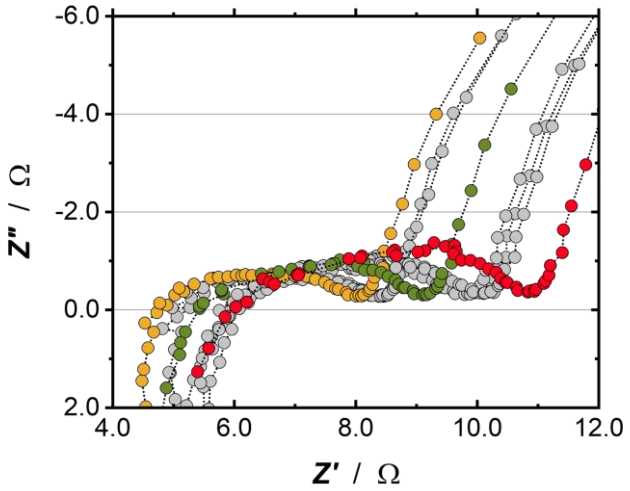
Experimental measurement of local parameters

Experimental set-up

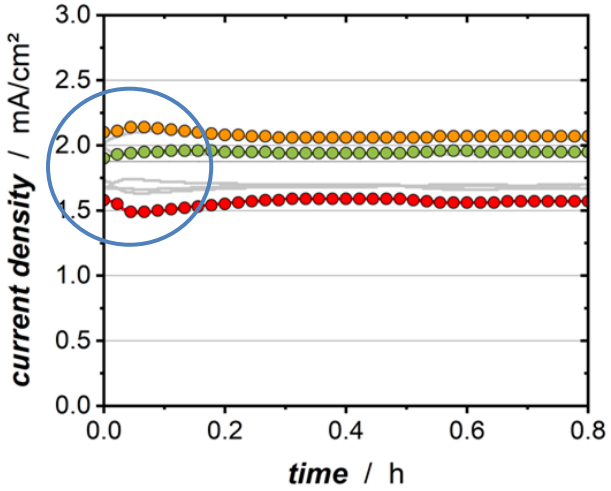


- in-house developed circuit board connected to ZAHNER potentiostat with PAD4 add-on card for parallel signal input
- 30 mAh graphite-NMC622, 15 cm² pouch cell, 8 equally distributed segments on anode current collector

Nyquist-plot of parallel EIS measurements on each segment @ SOC50



measured current density on each segment during 1C charge



- Experimental current distribution correlates well with measured impedance distribution (see colors of curves),
- Proof-of-Concept of characterization technique successfully demonstrated,
- integration of local data into network model.

Next steps:

- systematic investigation of inhomogeneous aging during long-term cycling,
- Influence of cycling conditions and cell design.

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