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Measurement resolution limits of local thermal inhomogenities on lithium-ion pouch cells

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State-of-the-Art – Inhomogenities

- Inhomogeneities due to dilation [1]
- Cycling of anode and cathode will lead to reversible and irreversible thickness growth [2,3]
- Local pressure can change current distribution in battery cells [4]
- Cell capacity of aged pouch cell strongly depends on its position [5]
- High heat evolution during charging/discharging at cathode tab [6]

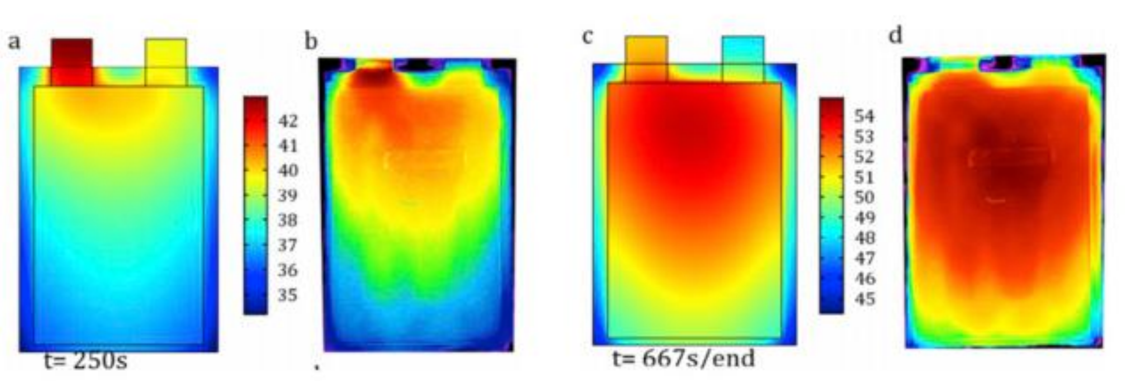


Fig.1: Temperature spreading at constant C-rates of 5C – Simulation vs. experiment [6]

High resolution – What is the limit?

Thermal conductivity properties:

- Effective perpendicular thermal conductivity of cell stacks: $\mathbf{0{,}5–1{,}35\ W/mK}$ [7]
- Effective parallel thermal conductivity of the cell stacks: $\mathbf{66–72\ W/mK}$ [7]
- No specific considerations of thermal conductivity properties of pouch material in literature

Theoretical influences on thermal conductivity:

- Gas bubbles and local thickness changes due to SEI growth or plating change thermal conductivity properties → temperature gradients
- Electrolyte distribution variable due to flexible pouch → temperature gradients

State-of-the-Art – Thermal characterisation

Recent focus on:

- Heat evolution and heat distribution during fast charging [6]
- Safety considerations, temperature monitoring detecting thermal runway [8]
- Cell cooling strategies aiming performance advantages [8]

Missing information on:

- Inhomogeneous aging caused by inhomogeneous temperature distribution
- Detection of local aging differences through temperature measurements

Results

Material research:

- Heat transfer in pouch material: perpendicular vs. parallel thermal conductivity
  - Distance based thermal conductivity investigations using **Pt100**
  - Observation of temperature distribution using a **heat camera**
  - Distance dependent material research

→ **No** identification of heat source below 2.5 cm distance

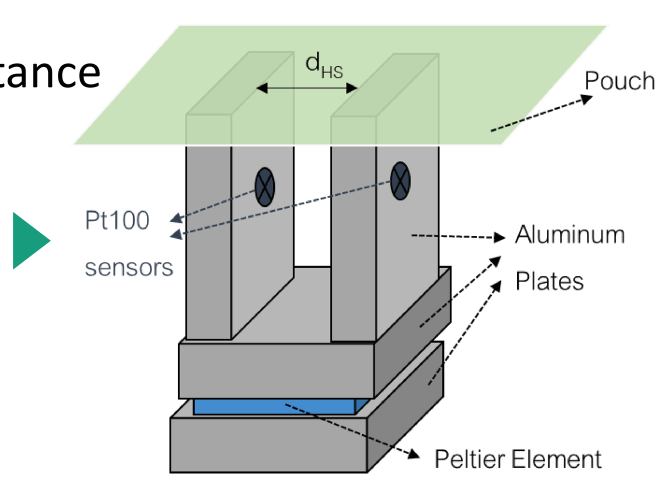


Fig.2: Variable distance set-up for perpendicular heat transfer investigation of pouch materials

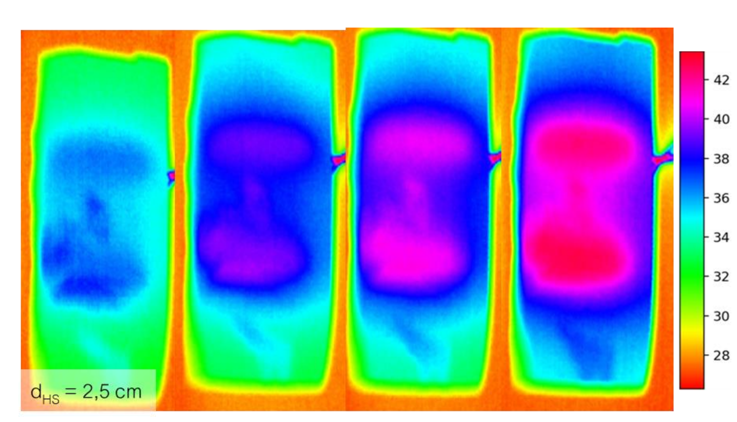


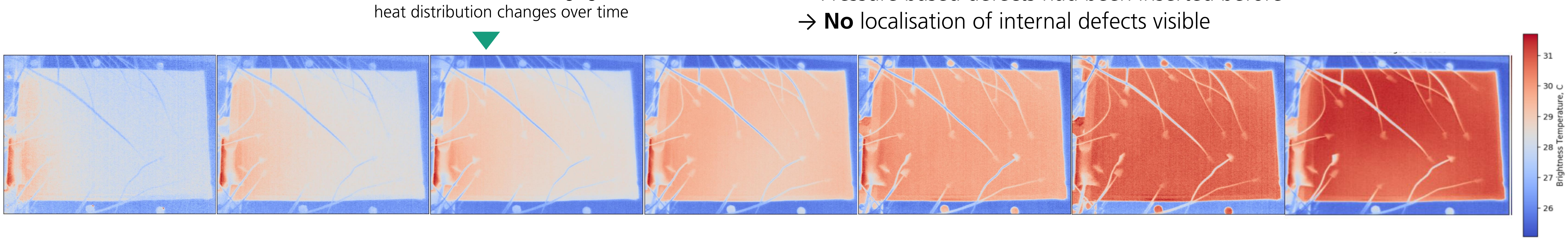
Fig.3: Heat transfer in a commercial pouch at 2.5 cm heat plate distance (d_{HS})

Cell observation:

- Commercial LFP based and NMC based lithium-ion pouch cells were blackened and analysed both by Pt100 and by using a heat camera
- Pressure based defects had been inserted before

→ **No** localisation of internal defects visible

Fig.4: Heat IR camera measurements for 1C charging – heat distribution changes over time



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Project 'OrtOptZelle': Aims

- Prolong the lifetime by applying a total or partial compression on the battery cell. The well-defined and locally-resolved compression limits the expansion during charging/discharging
- Exact investigation of locally distributed aging processes
- Precise measurements of the areal distribution of volume changes, temperature gradients and current density on the battery cell during charging/discharging

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