Finite-element simulations to assess the consequences of cell expansion for different cell geometries

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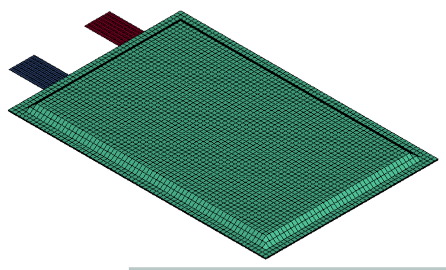
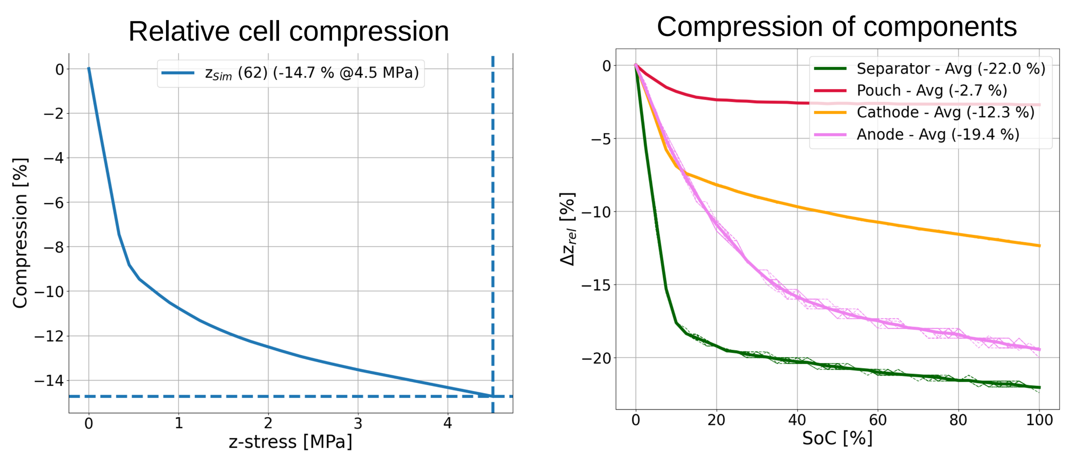
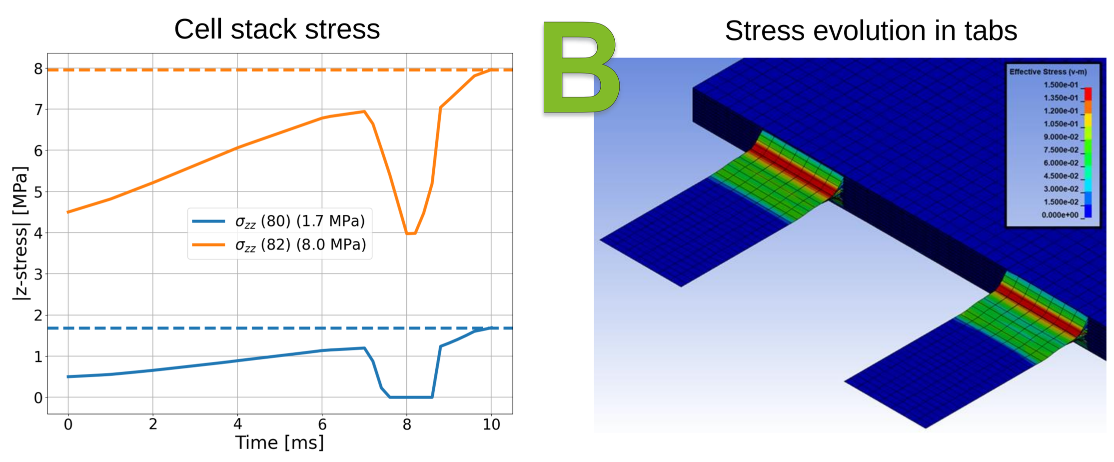
Simulation results Pouch cells



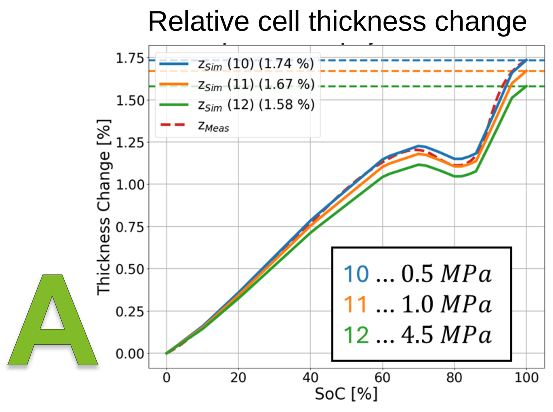
Compression for stacked pouch cells



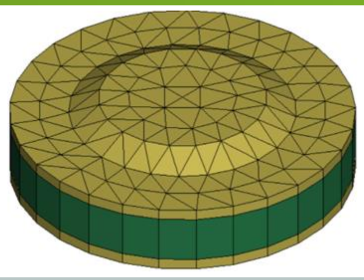
Charging – stacked pouch cells – **fixed** compression



Simulated cell expansion verified by measurements for bi-layer pouch cells.

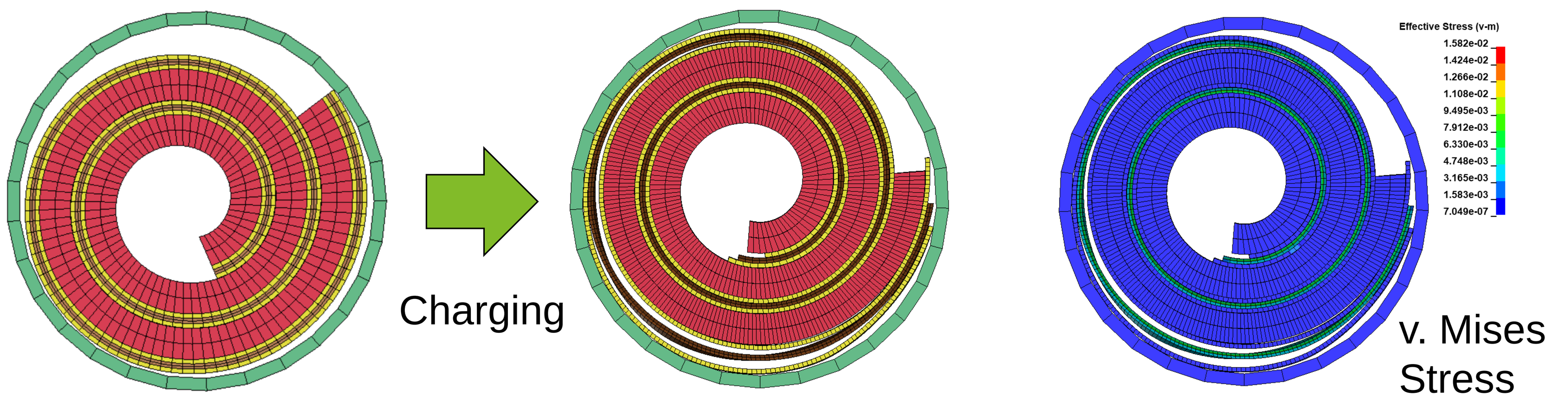


Proof of concept for model transferability on small cylindrical coin cell



Simulation results Cylindrical cells

Apply expansion model to anode and simulate cell charging. Analyse stresses within the cell stack



Challenges:

- Directions of material models
- Boundary conditions & contact formulations
- Verification of results with measurements

Key Results

Material data available for all relevant cell components

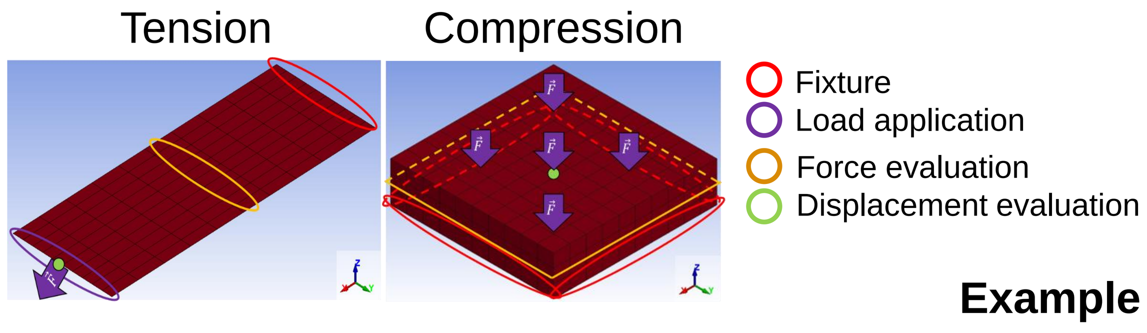
Model can **reproduce measured cell expansion** in pouch cells

Strong **increase in stack stress** for fixed compression for pouch cells

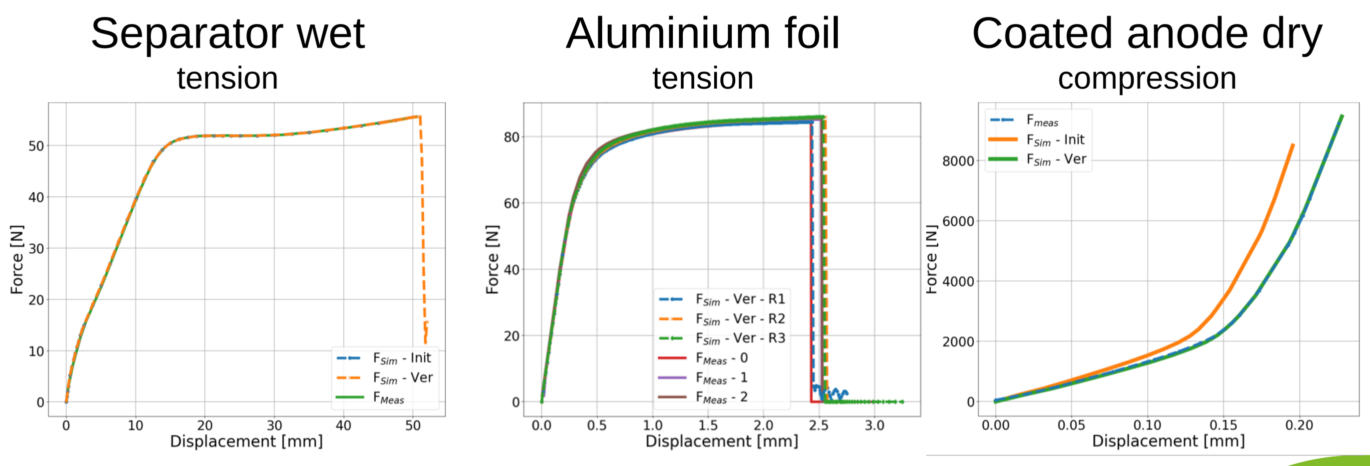
Model can be transferred to simulate cylindrical cells (**Upscaling**)

Results – Material tests

Material model optimisation by simulation of mechanical tests



Example results



Outlook

Further upscale the model to 21700 cylindrical cells

Perform a simulation study on the rolling process to include production-related stresses

Simulation specifications

Pouch cells:

Two simulation steps: Compression & Charging

Applied pressure: **0.5 MPa**

Two constraint situations:

A **Flexible** compression: Cell is allowed to expand

B **Fixed** compression: Total cell thickness cannot change

Models were first set up for bi-layer pouch cells, then virtually scaled up to **stacked pouch cells** and **cylindrical cells** with rolled electrodes.

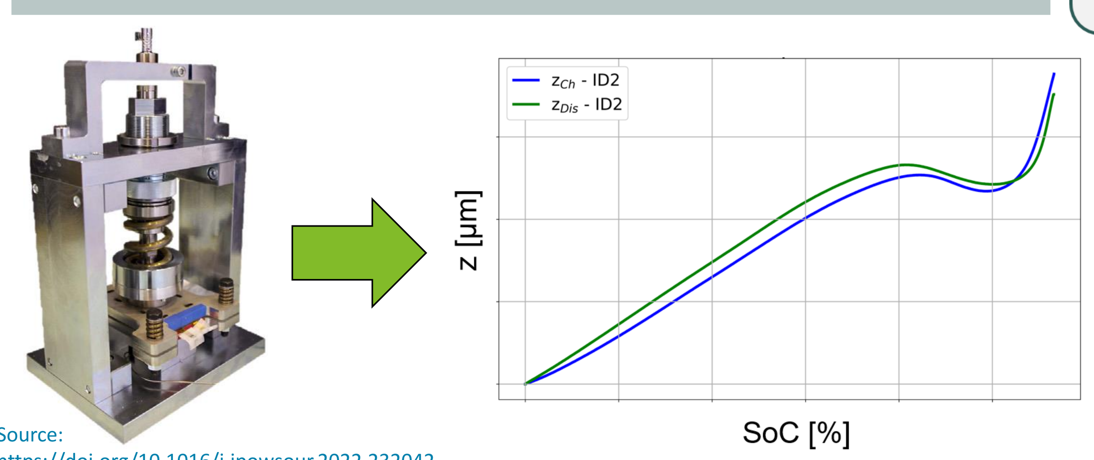
Parameterisation

Method: Tensile & Compression Tests

- Use test data to describe material behaviour
- Considered:
  - tensile & compressive properties
  - elastic & plastic deformation
  - anisotropy & strain rate
  - electrolyte influence
  - material failure

Method: Dilatometry

Measure expansion of pressurised bi-layer pouch cells containing a **silicon anode**

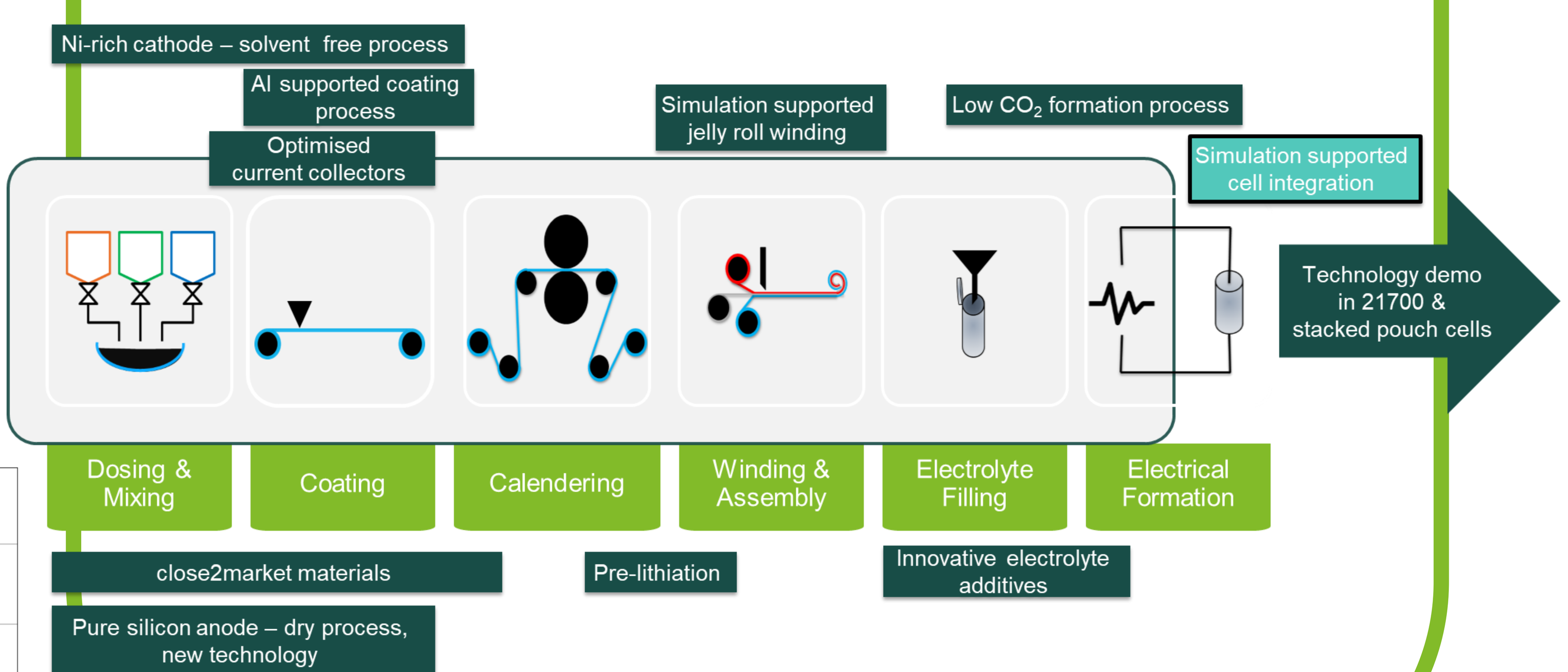


Source: https://doi.org/10.1016/j.jpowsour.2022.232042

The *greenSPEED* approach

Developing a battery cell consisting of electrodes manufactured using innovative dry processes **to reduce energy consumption**, **lower the carbon footprint** and achieve **ZERO emissions of VOCs** (Volatile Organic Compounds).

Achieving European **leadership in battery production** with **lower carbon footprint**.



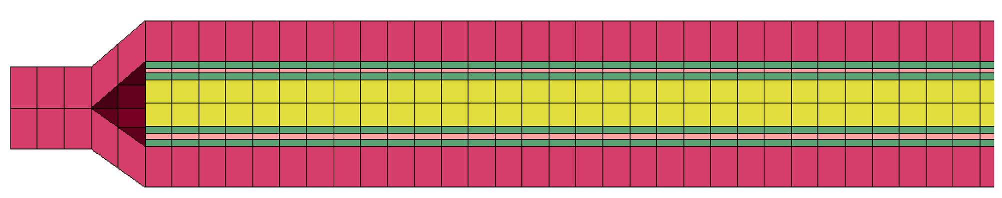
Innovation in *greenSPEED* for battery production steps

Modelling approach

Method: Finite Element | LS-DYNA

Meso-mechanical approach: All cell components are modelled separately (but homogeneously within each layer) to obtain information about **mechanical stresses inside the cell**

Example: Bi-layer pouch cell



Legend: Pouch foil, Separator, Anode active, Cathode active, Cu, Al collectors / tabs modelled as 2D shell elements

Features:

- All cell stack components plus tabs
- Boundary conditions / constraints
- Validated material models
- Expansion model for silicon anode
- Flexibility for different cell geometries

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Further information

www.greenspeed-project.eu

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