

# Detection of thickness changes in compressed battery cells

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Battery Experts Forum  
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[www.ise.fraunhofer.de](http://www.ise.fraunhofer.de)

# Detection of thickness changes in compressed battery cells

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2. End-of-line tests in battery cell production
3. Innovation: Integration of thickness measurements
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# Motivation

Detection of thickness changes in compressed battery cells

**1) Improvement of end-of-line quality control in the production of battery cells**

**2) In-situ prognostics for the end-of-life assessment of battery cells**

**3) Assistance in the design of housing of battery modules**

# Thickness changes in Li-ion battery cells

## Reversible thickness changes - Cycling

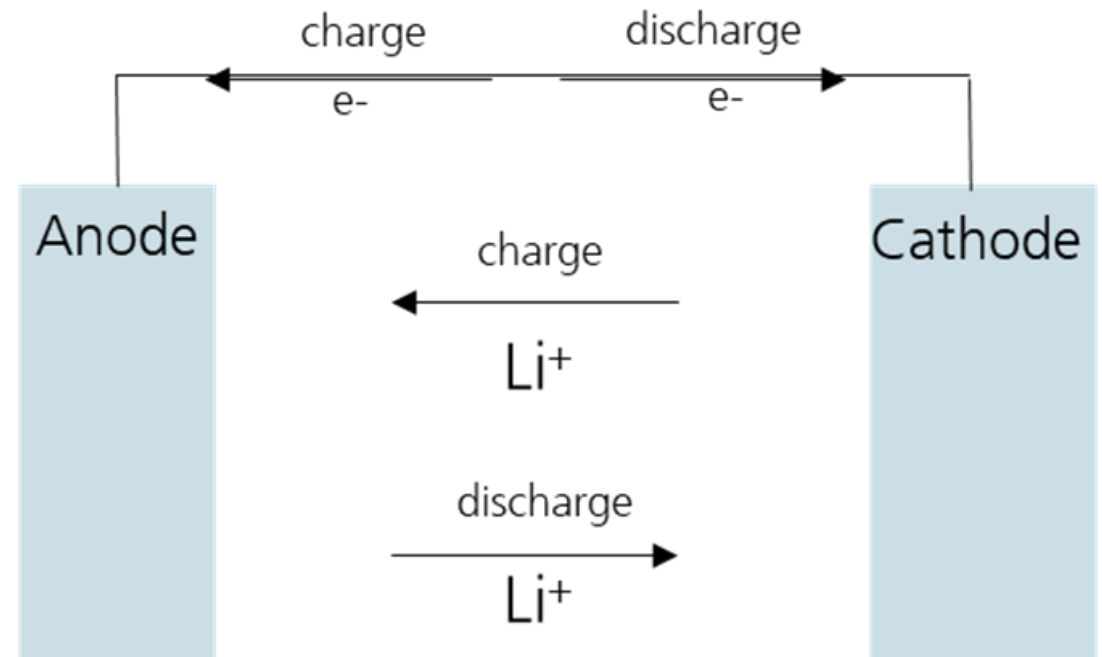
Intercalation of Li-ions within the graphite structure

Expansion of graphite layers of approx. 30 %

For silicium- based anodes, expansion of approx. 300 %

## Irreversible thickness changes - Aging

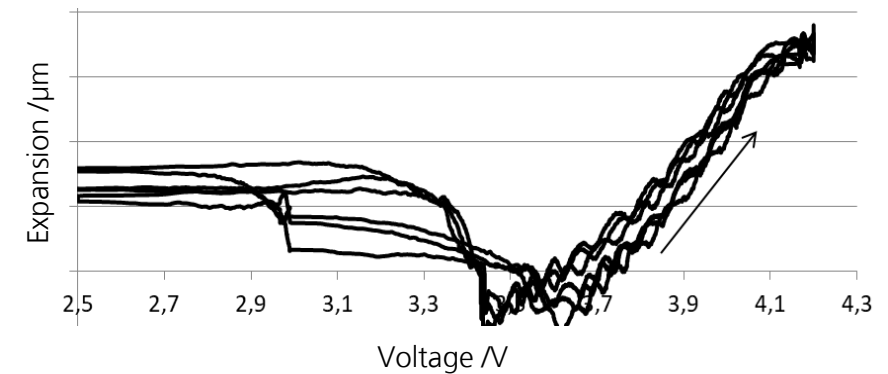
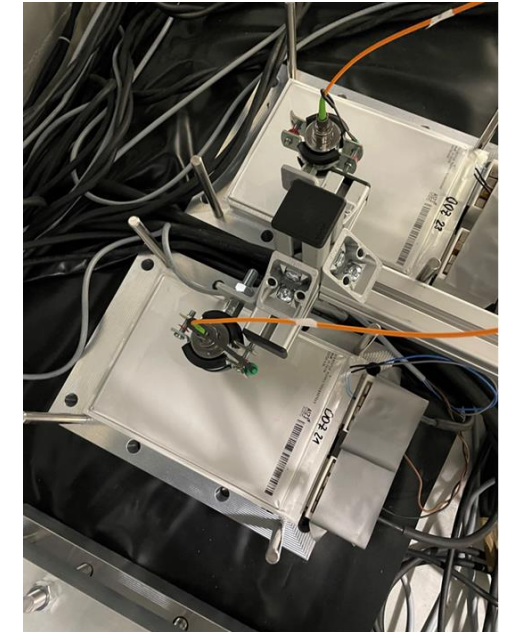
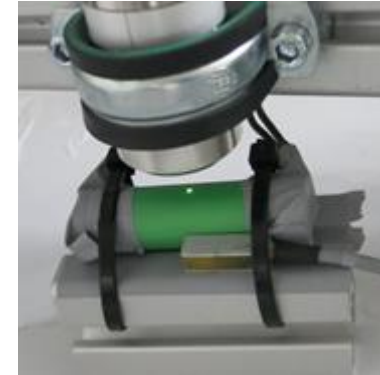
Deposition of SEI and various degradation products



# Thickness changes in Li-ion battery cells

## Reversible thickness changes - Cycling

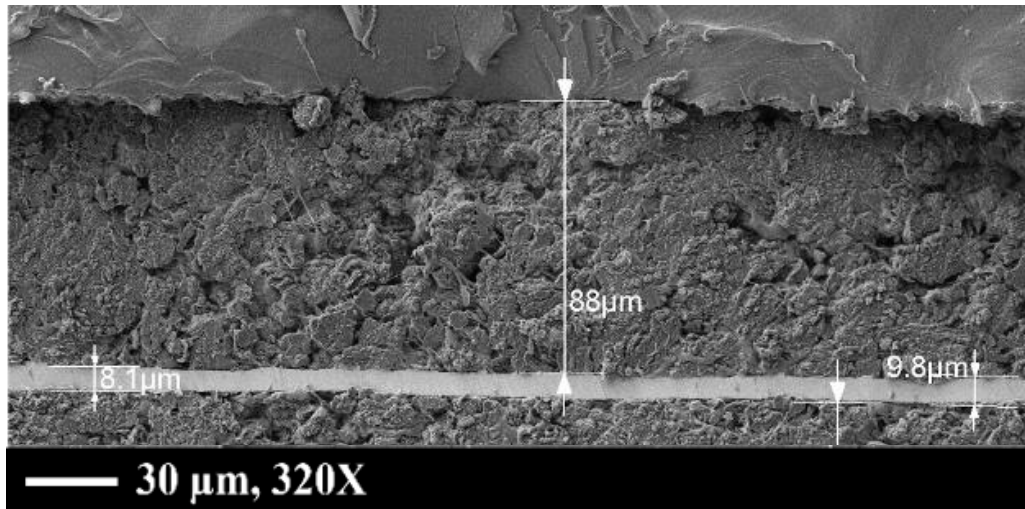
Chemistry	$V_{\max} - V_{\min} / V$	Reversible expansion/ $\mu m$
<b>Cylindrical cell</b>		
NMC/G	4,2 - 2,5	10
LFP/G	3,6 - 2,0	<1
<b>Pouch cell</b>		
NMC/G	4,2 - 2,7	150
LFP/G	3,6 - 2,7	50



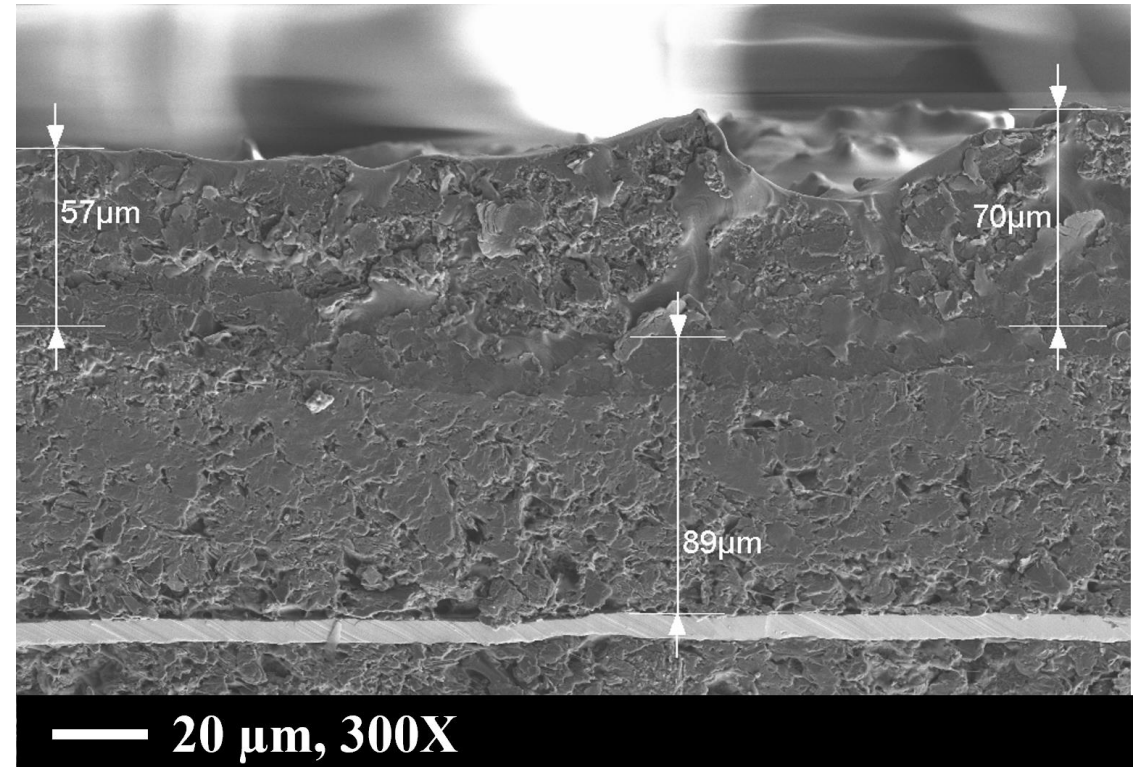
# Thickness changes in Li-ion battery cells

Irreversible thickness changes - Aging

## SEM images of electrodes



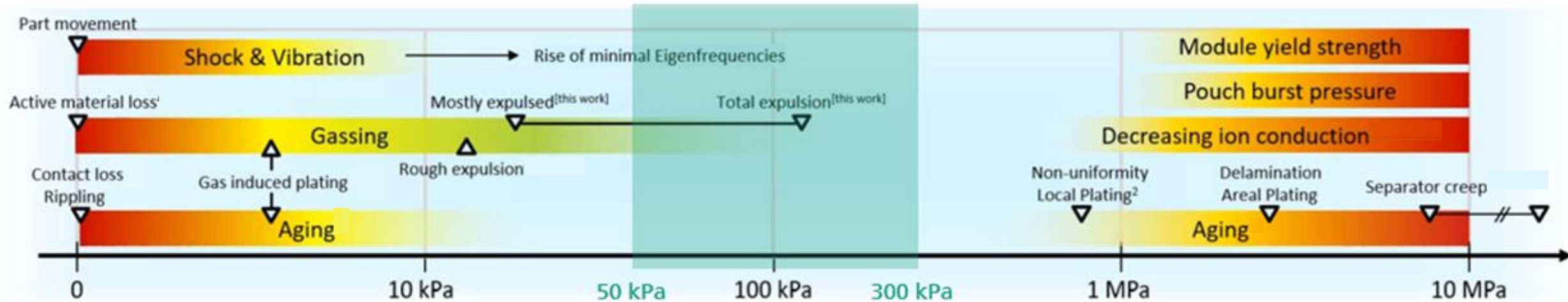
Unaged anode



Aged anode

# Why compressed battery cells?

Fewer degradation processes



Quelle: S. Hahn, Controlling module pressure evolution over lifetime with buffer layers, Slide 3, Advanced Battery Power, 2021

# Motivation

Detection of thickness changes in compressed battery cells

**1) Improvement of end-of-line quality control in the production of battery cells**

2) In-situ prognostics for the end-of-life assessment of battery cells

3) Assistance in the design of housing of battery modules

# Motivation

Improvement of end-of-line quality control in the production of battery cells

**Current approach: Quality control in battery production is performed as an end-of-line test using electrical measurements → broad overview of the battery cell**

	<b>Important quality parameters</b>	<b>Important measurement process in the production</b>
Formation	Cell internal resistance Capacity Temperatur	Calculation Temperature sensor
Degasing	Seal integrity	Pressure test Optical coherence tomography
Aging and End-of-line tests	Self-discharge Capacity Cell internal resistance	Measurement of open-circuit-voltage Calculation Electrochemical impedance spectroscopy

Quelle: <http://battprod.vdma.org>

# Motivation

Improvement of end-of-line quality control in the production of battery cells

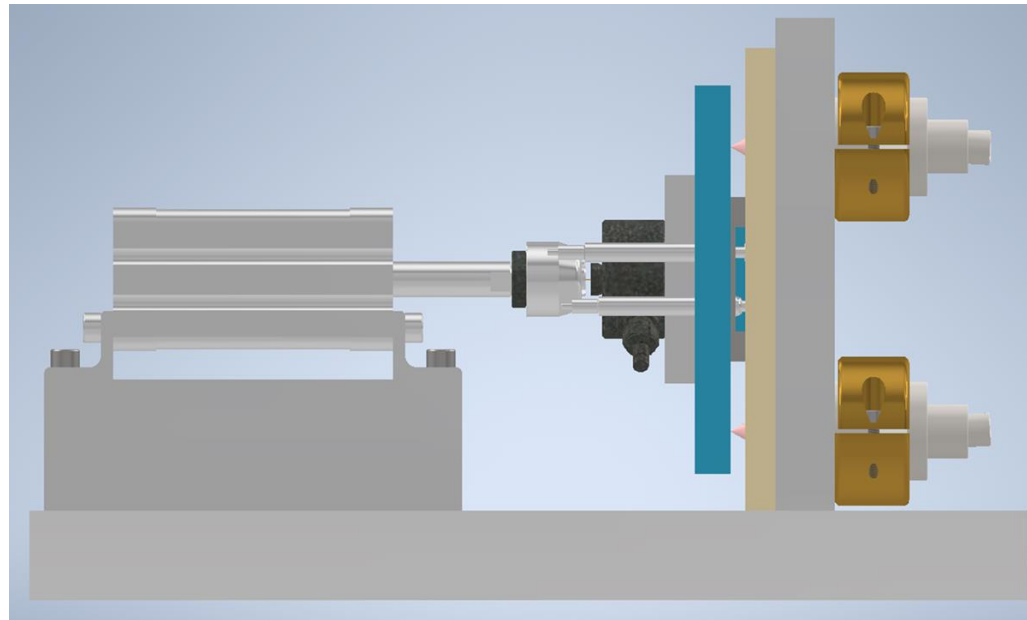
**Innovation: New method integrates measurements of local thickness changes within the battery cell → detailed insights into the uniformity of the performance of the coating**

- Provide insights into the quality of a battery cell at an earlier stage or with greater precision compared to standard electrical measurements
- Identify potential issues in the production process that could lead to faults

# Innovation

Measurements of local thickness changes within the battery cell during cycling

- Simultaneous measurement of time, voltage, current, temperature, expansion and pressure
- Quick and easy mounting of flat cells
- No extra time required – expansion measurements occur concurrently with the electrical testing



# Research Project: Quaze

Development of a self-learning process for quality determination and improvement in battery cell production and application based on optical sensors



## Topics:

- **Implementation of distance sensors for an extended quality control at the end of the production of the battery cells**
- **Record the volumetric expansion at chosen positions of a large number of battery cells during the formation, end-of-line tests, cycling and end-of-life**
- **Evaluation of acquired data of expansion of battery cells and electrical output by a self-learning algorithm for information about quality of battery cell**

Supported by:



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by the German Bundestag

16BZF361 - Quaze

# Why measure thickness changes in battery cell?

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## Reversible expansion - Cycling

Information about the uniformity of the battery cell: coating of electrodes, wetting of electrolyte, defects

Quantification of lithium intercalation in anode and cathode materials

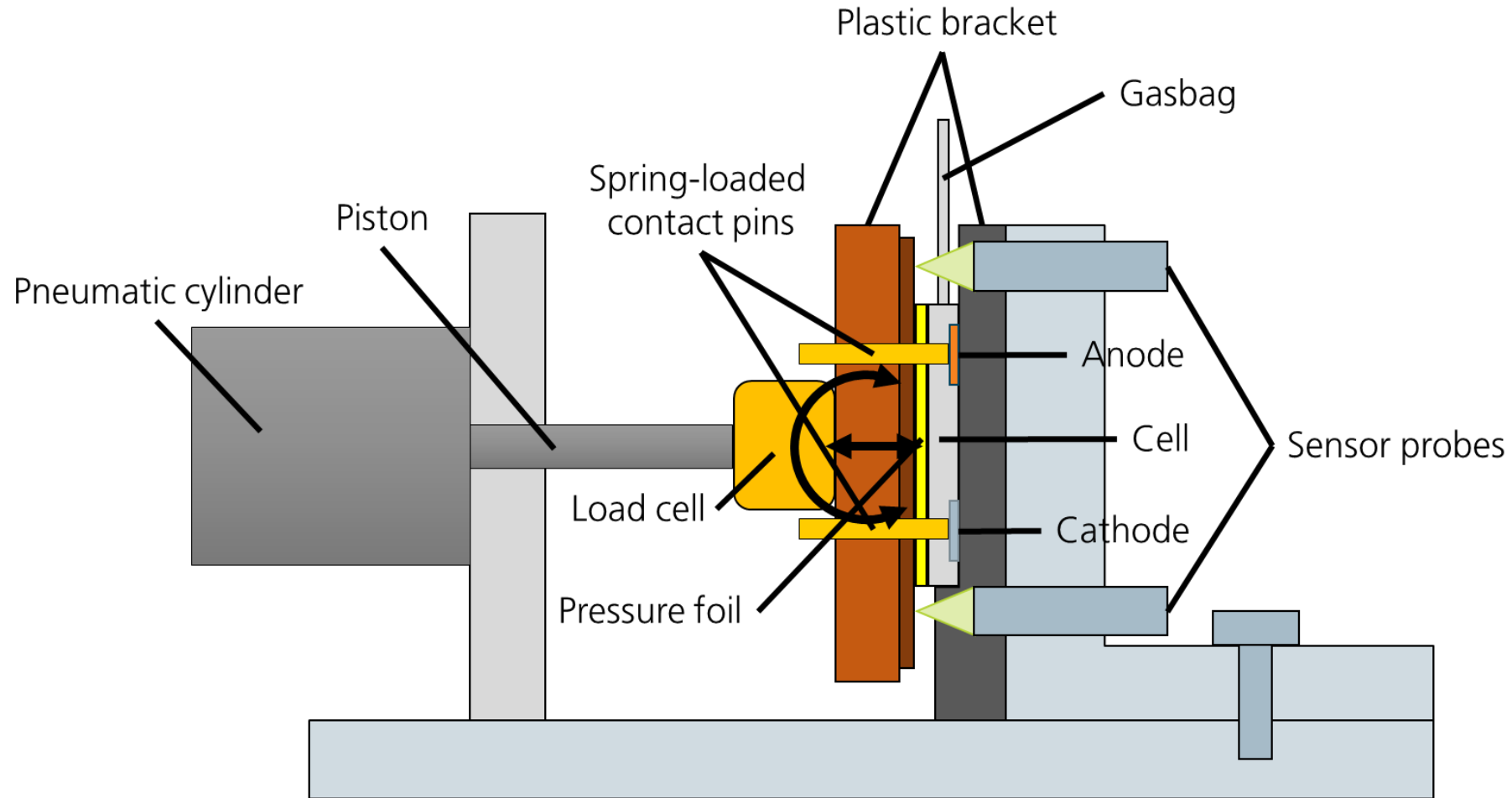
Information for better plan of battery modules: rigidity of housing

## Irreversible expansion- Aging

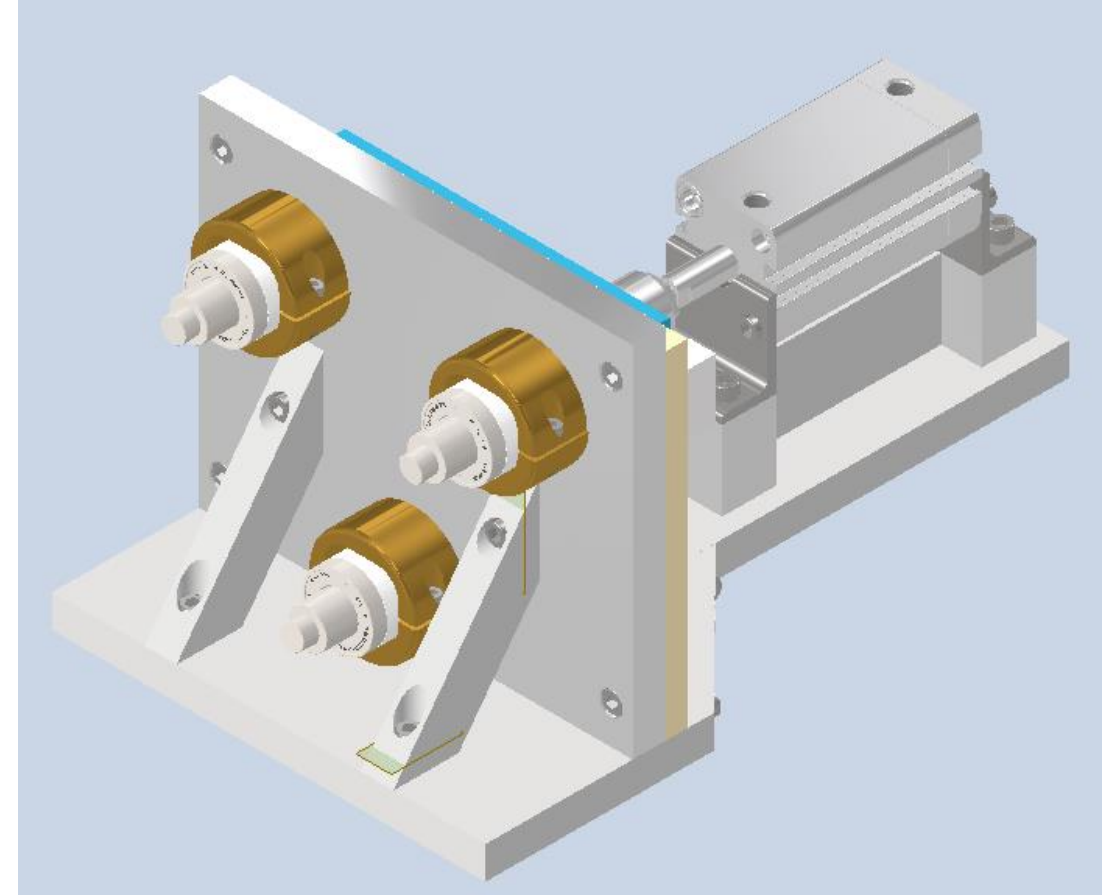
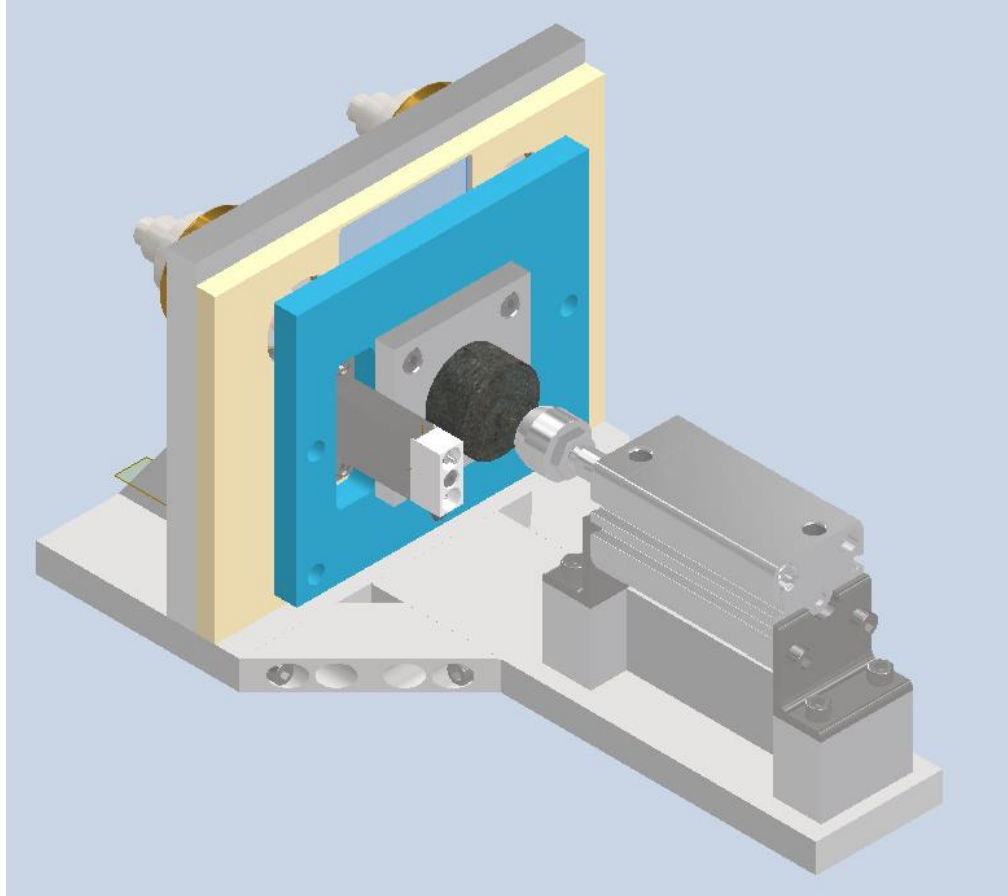
Possible prognosis of state-of-health and end-of-life

Information for better plan of battery modules: rigidity of housing

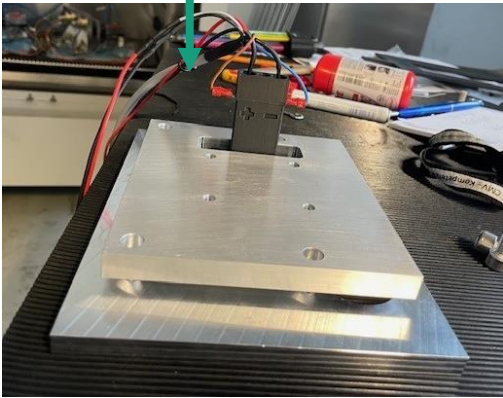
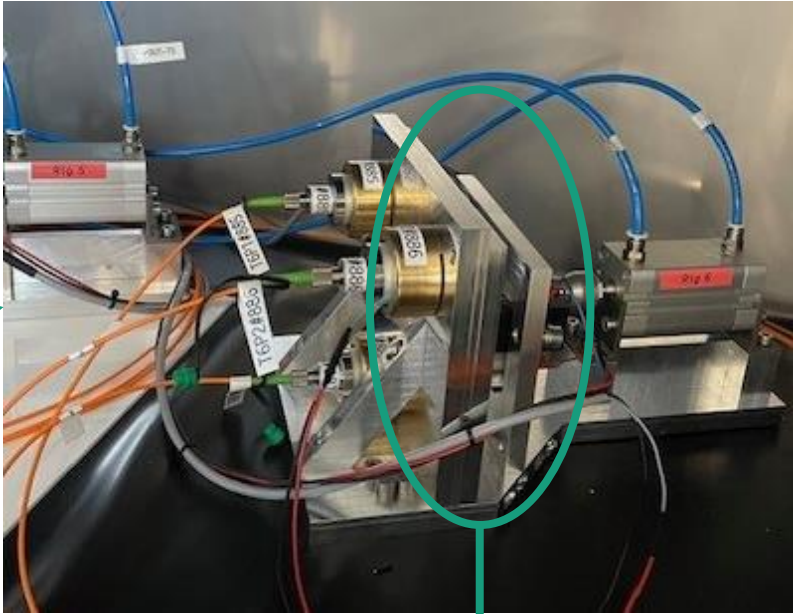
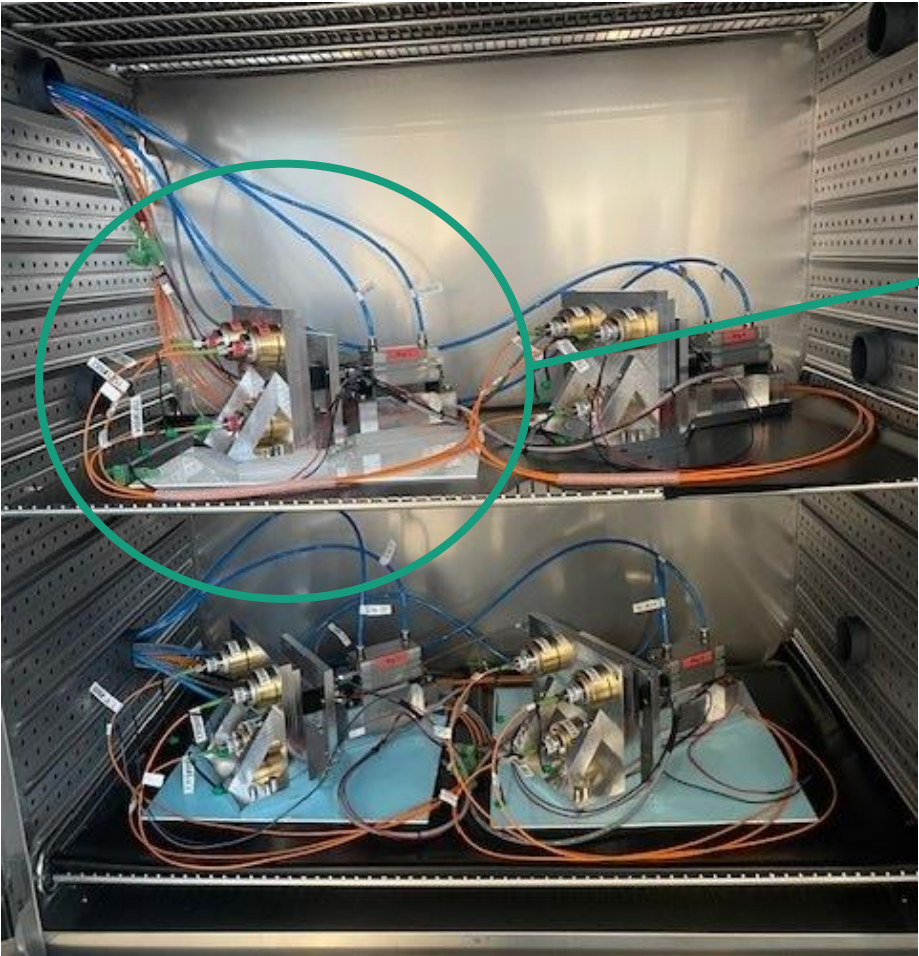
# Development of the test facilities for the investigation of locally differentiated expansion of battery cells



# Development of the test facilities for the investigation of locally differentiated expansion of battery cells

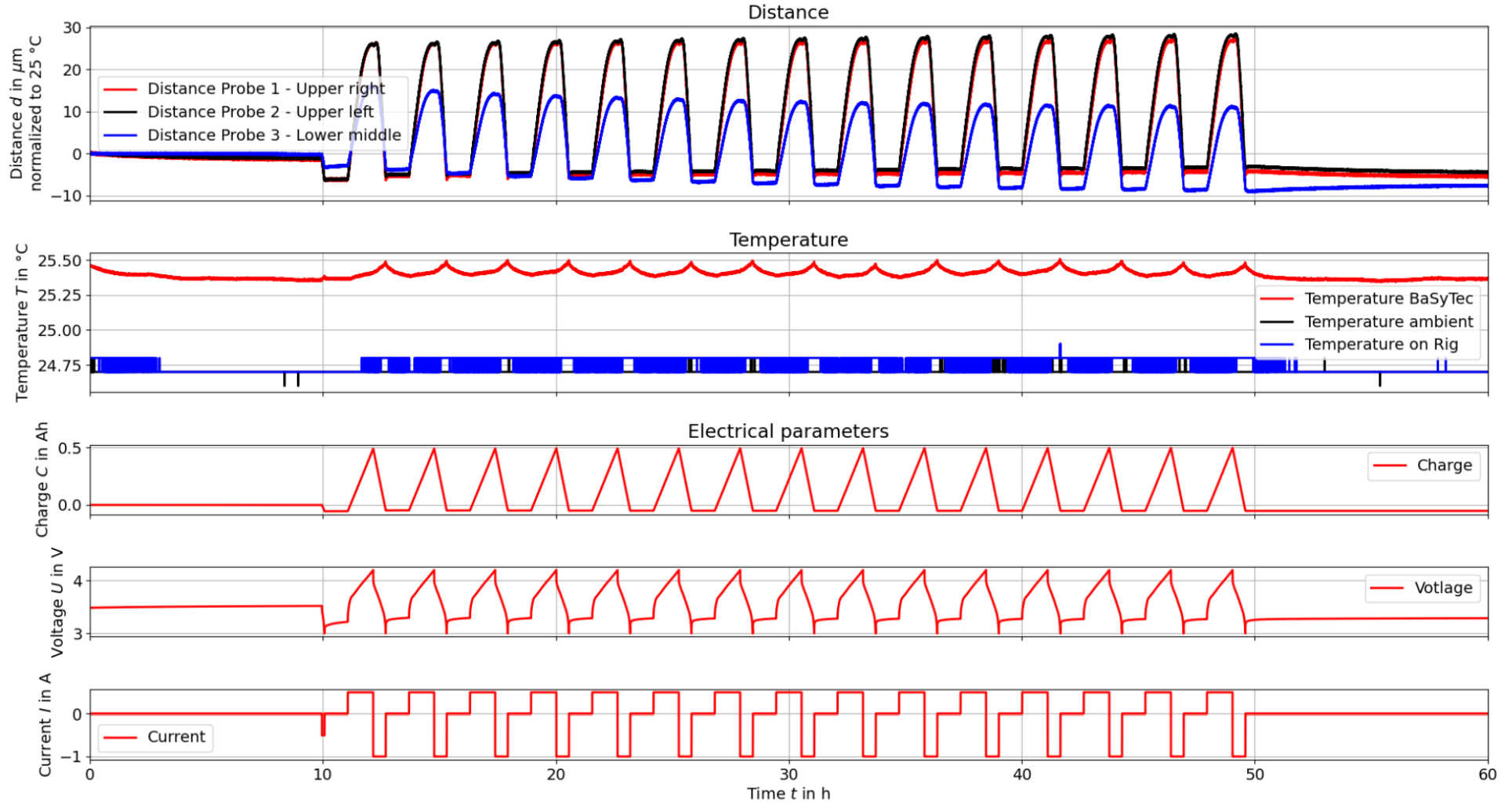
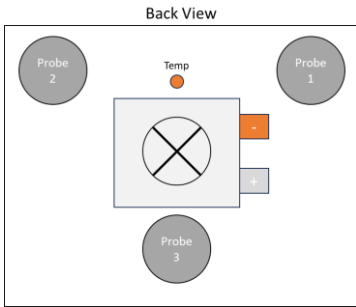


# Test facilities for the investigation of local expansion of battery cells



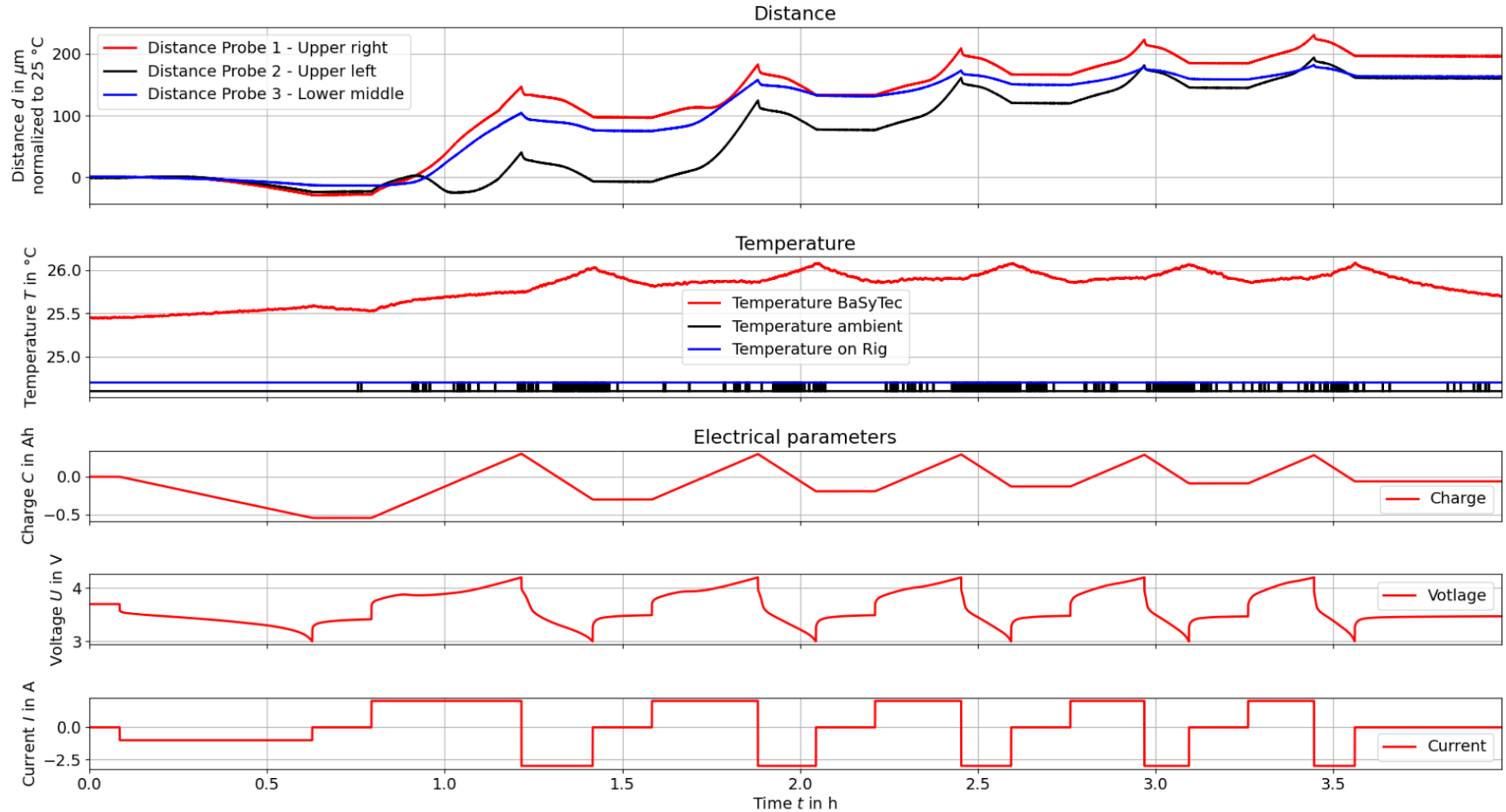
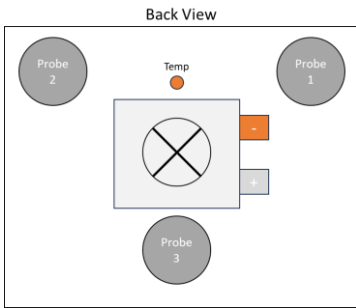
# First results

## Expansion measurement of pouch cell during cycling at 0,5C/1C (Charge/Discharge)



# First results

## Expansion measurement of pouch cell during cycling at 2C/3C (Charge/Discharge)

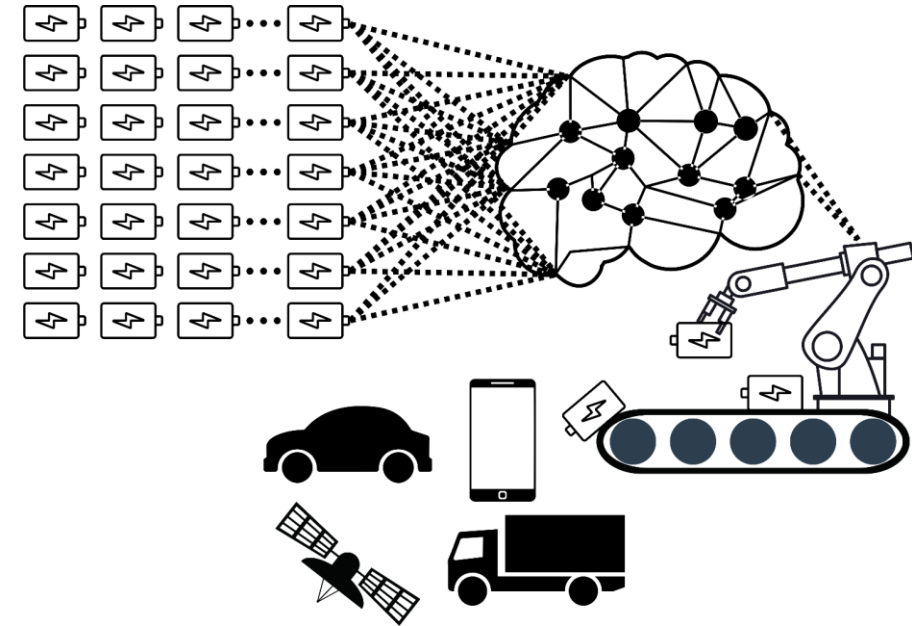


# AI-driven quality assurance

Measurements on Li-ion cells are used to train AI algorithms

These AI algorithms identify anomalous cells in production

Anomalous cells can then be removed and investigated further



# Conclusion

Improvement of end-of-line quality control in the production of battery cells

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**Rapid measurement to improve battery cell quality control**

**Local expansion measurement of compressed battery cells integrated with electrical measurements at the end of the production**

**AI training for unambiguous evaluation of battery cells**

# Next steps

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**Insertion of relevant defects in the jelly roll of battery cells**

**Measurement of the local expansion of the compressed battery cells with defects during formation and end-of-line tests**

**Investigation of correlation between expansion measurements, electrical parameters and type of defects**

# Thanks for the attention



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