

# BaMoS – The Battery Monitoring Solution by InnovationLab

## Revolution in battery understanding



29.09.2023

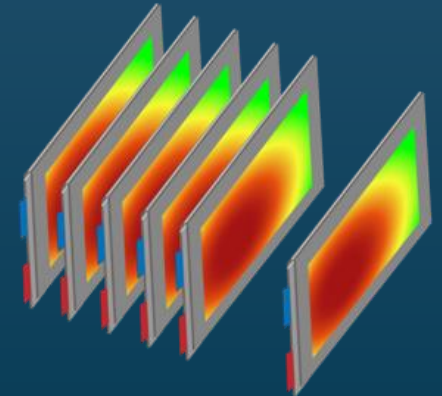
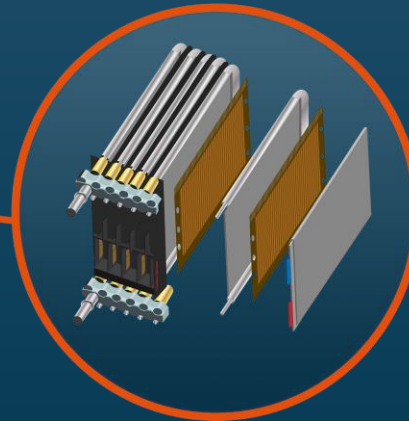
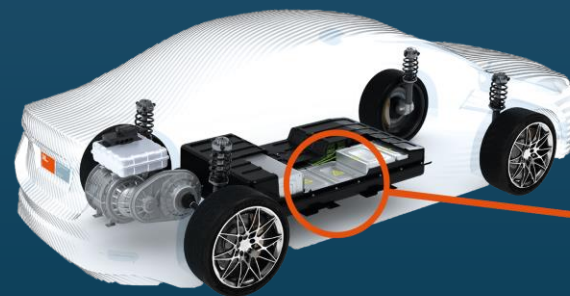
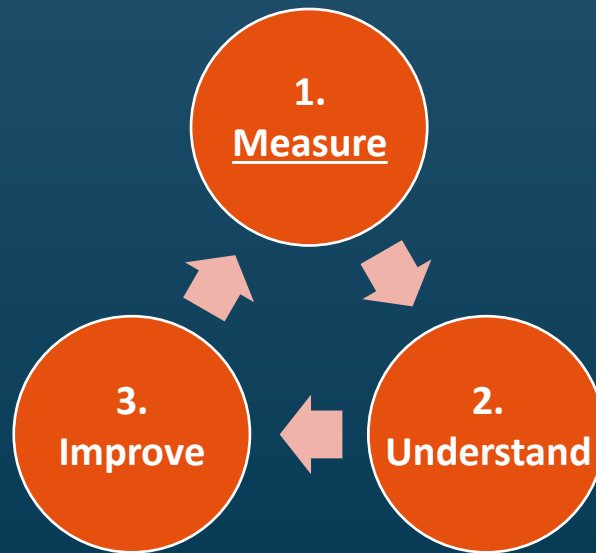


Acquiring meaningful data is the foundation for improvement. Often, however, this data is just not accessible.



This is the case for rechargeable batteries. We don't really know what is happening within a battery system during charging cycles and stress tests in terms of **pressure** and **temperature distribution**.

How can a measure of improvement be defined without properly understanding the system?



# How to Measure Inside a Battery System

## The solution: Foil sensors

Thin foil sensors can be placed between the cells and thus solve this issue.

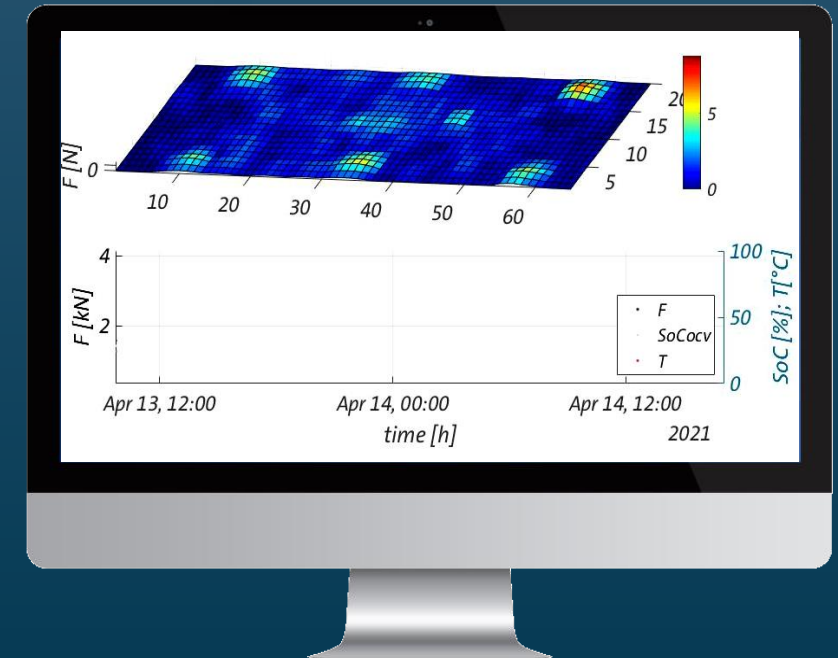
### An example:

During the charge/discharge cycle, batteries undergo continuous volume and temperature changes. These changes aren't uniform. The only way to capture them is by using foil sensors.

This allows to...

- ✓ measure the state of charge (SoC) directly,
- ✓ implement preload and cell balancing measures,
- ✓ detect irregular behavior,
- ✓ prevent overcharging,
- ✓ and gain information on state of health (SoH)

Foil sensors enable getting data from inside of the battery system.  
Both spatially & temporally resolved.

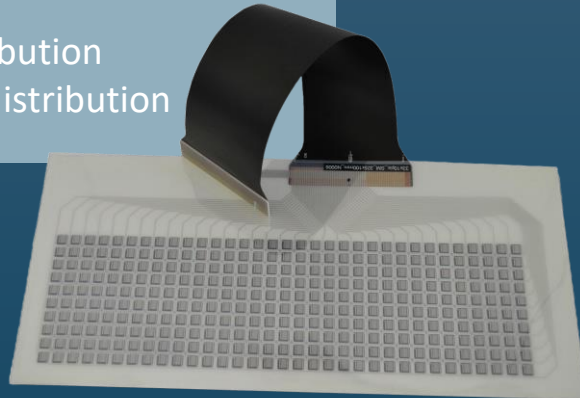




## Overview

### 1. Sensor Foils:

- Pressure distribution
- Temperature distribution



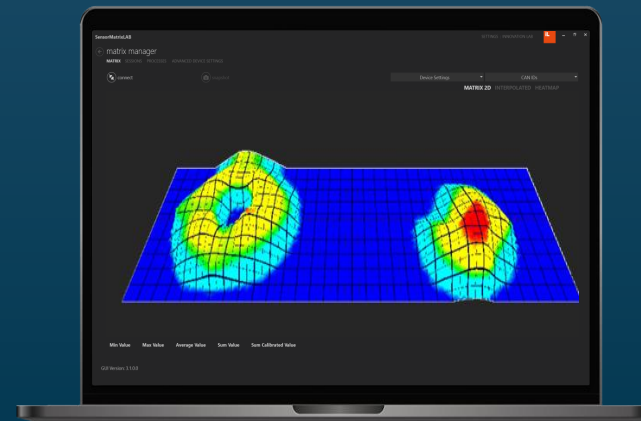
### 2. Read-out Electronics:

- State-of-the-art with reduced cross-talk
- 12-bit digital resolution
- Electro-magnetic interferences protection
- Several communication interfaces



### 3. Software:

- Live 3D/2D data visualization, storage and analysis
- Data filtering
- Real-time streaming via API
- Calibration option



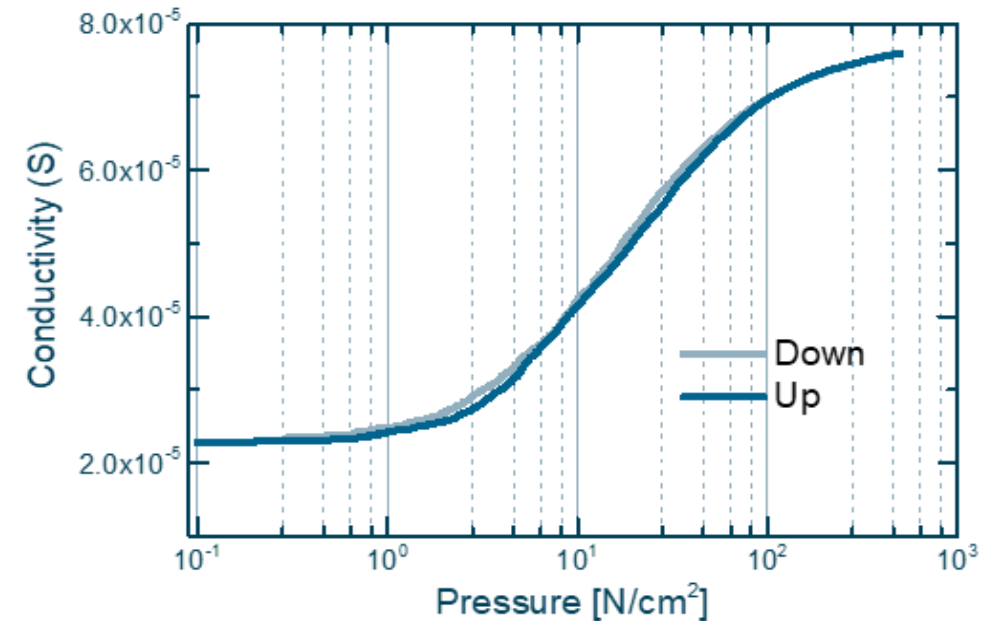
# Battery Monitoring Solution by InnovationLab

## Sensor foils for measuring the pressure distribution



Matrix of printed piezoresistive pixels on thin polyimide substrate.

### High Performance (Prime Mode):



### Strong performance: (General values)

- ✓ Huge measurement range: 0.1 – 500 N/cm<sup>2</sup>
- ✓ High repeatability: 0.2% - 5 % (repeatability error)
- ✓ High durability: < 5 % (loss after 1 Mio. Cycles of 150 N/cm<sup>2</sup> load)
- ✓ Overall thickness: 110 - 250 µm
- ✓ Operating Temperature: -20°C – 100°C

# Battery Monitoring Solution by InnovationLab

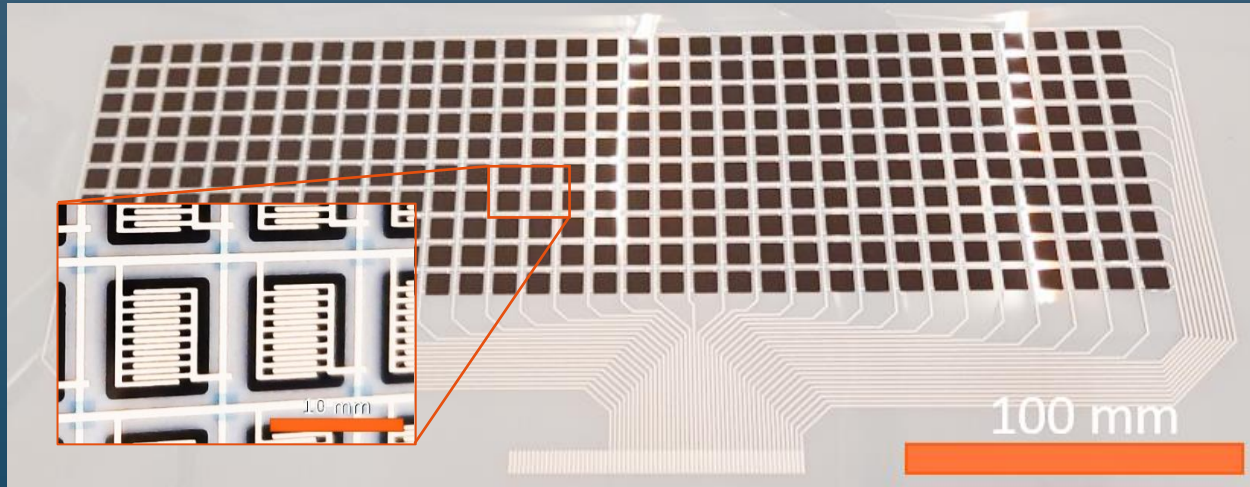
Sensor foils for measuring the pressure distribution

## Portfolio:

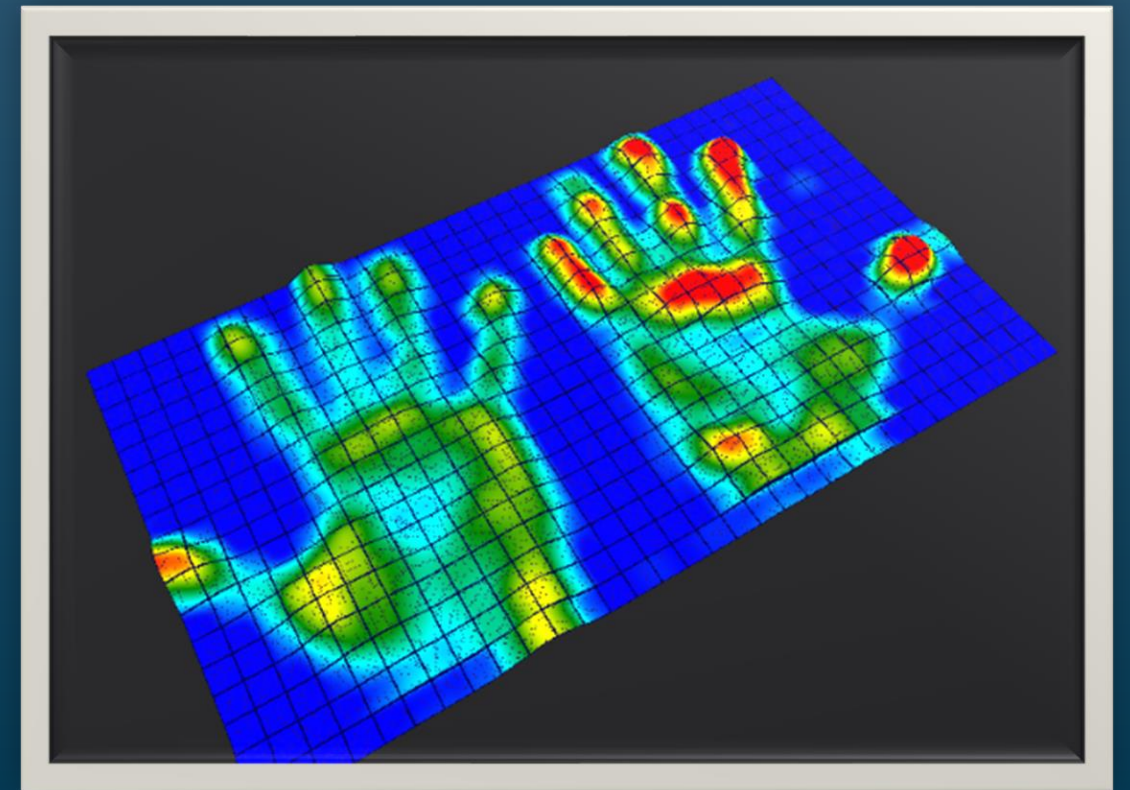
|                                       | Type 1  | Type 2   | Type 3  | Type 4  | Type 5  | Custom   |
|---------------------------------------|---|--|---|---|---|--|
|                                       |  |  |  |  |  |  |
| <b>Measurement Mode</b>               | Thru  | Thru   | Thru  | Shunt   | Prime   |  |
| <b>Resolution</b><br>(# of pixels)    | 29 x 17   | 64 x 20  | 64 x 20   | 32 x 10   | 32 x 10   | up to 96 x 96  |
| <b>Active area</b> (cm <sup>2</sup> ) | 15 x 9  | 33 x 10  | 53 x 11   | 32 x 10   | 32 x 10   | up to 40 x 60  |
| <b>Pixel size</b> (cm <sup>2</sup> )  | 0.32 x 0.32   | 0.30 x 0.30  | 0.50 x 0.32   | 0.62 x 0.57   | 0.5 x 0.5   | down to 0.01 (Thru)<br>down to 0.2 (Shunt)<br>down to 0.25 (Prime) |
| <b>Foil material</b>                  | PI (2 x 50 µm)  | PI (2 x 50 µm)   | PI (2 x 50 µm)  | PET (2 x 75 µm)   | PET (2 x 100 µm)  | PI, PET, PEN,...   |
| <b>Suitability for</b>                |   |  |   |   |   |  |
| • low pressure                        | +   | +  | +   | ++  | ++  |  |
| • high pressure                       | +   | +  | +   | +   | ++  |  |

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## Sensor foils for measuring the temperature distribution



Temperature-sensitive resistors printed on interdigitated electrode structures enable **spatially resolved temperature measurements** on very thin foils ( $< 80 \mu\text{m}$ ).



Color-coded image of the temperature distribution induced by a hand.

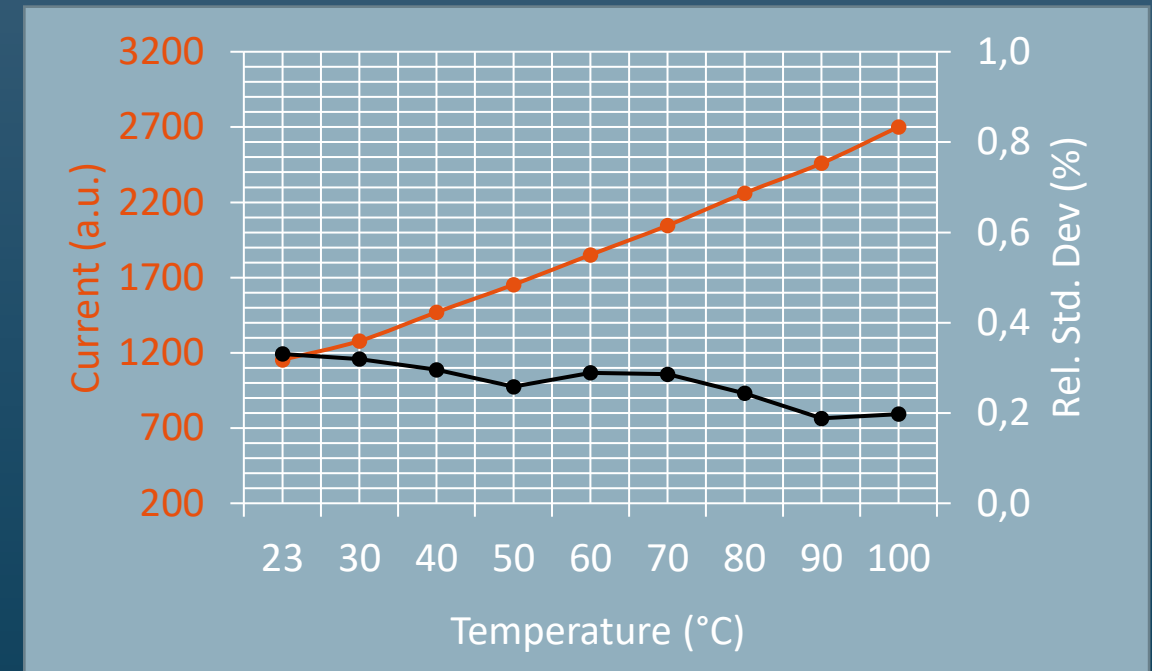
# Battery Monitoring Solution by InnovationLab

Sensor foils for measuring the temperature distribution

## Portfolio:

|                                       | Standard        | Custom        |
|---------------------------------------|-----------------|---------------|
| <b>Resolution</b> (# of pixels)       | 32 x 10         | up to 96 x 96 |
| <b>Active Area</b> (cm <sup>2</sup> ) | 32 x 10         | up to 35 x 55 |
| <b>Pixel size</b> (cm <sup>2</sup> )  | 0.62 x 0.57     | down to 0.2   |
| <b>Foil material</b>                  | PET (2 x 75 µm) | PI, PET, PEN  |

- Typical performance:**
- ✓ Highly linear behavior
  - ✓ Accuracy: < 1 °C
  - ✓ Range: 10 - 100 °C and beyond
  - ✓ Pressure independent



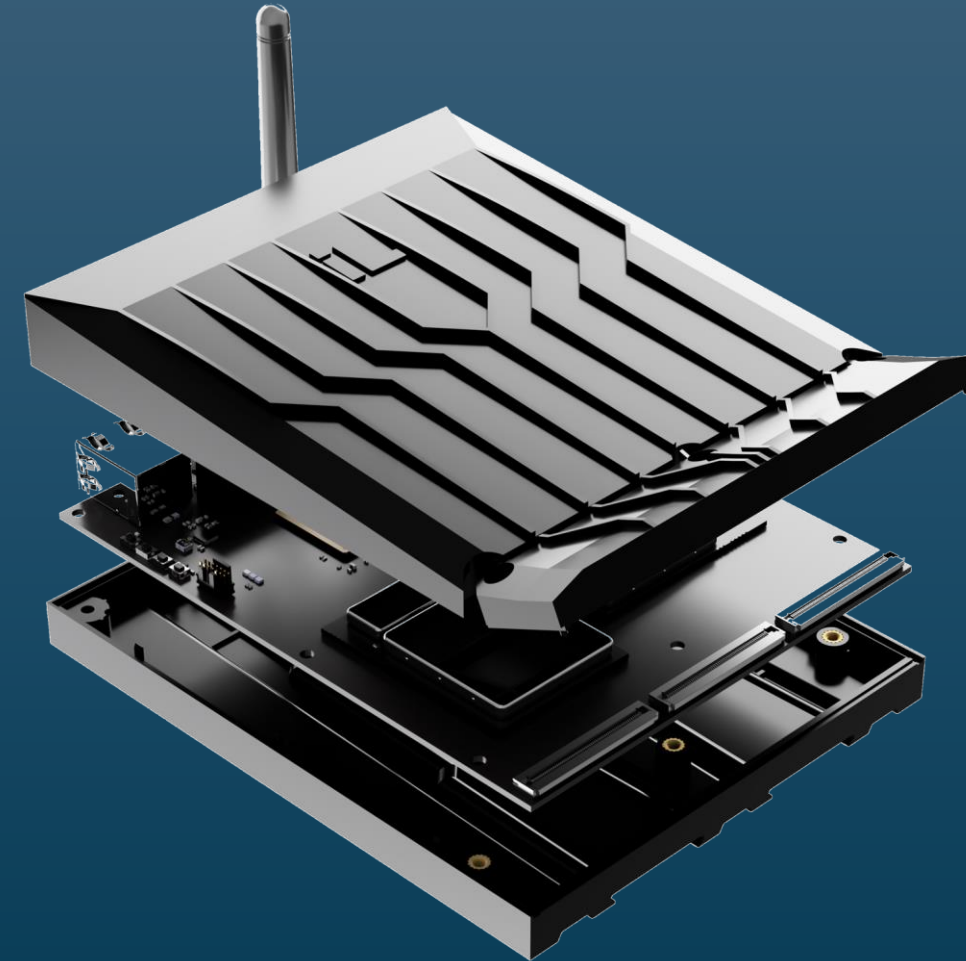
Dependency of the measured current on the temperature. A clear linear behavior is observed.



# Battery Monitoring Solution by InnovationLab

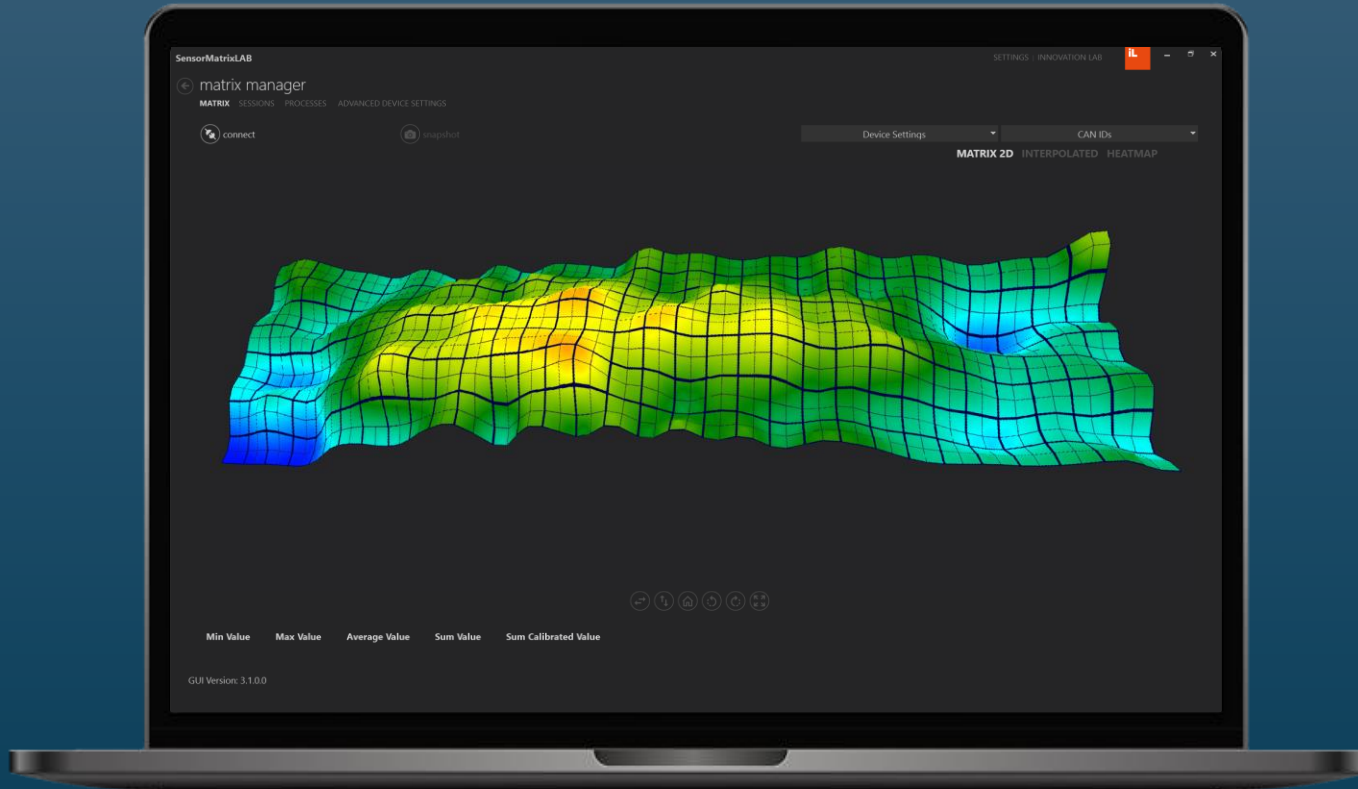
## Read-out electronics

- High-resolution for matrices with up to 96x96 sensor pixels
- Low noise 12-bit ADC signal
- Protected from electro-magnetic interference
- Strongly reduced crosstalk between pixels
- Typical read-out frequencies of about 100 fps
- Usable for pressure- and temperature-sensitive matrices
- Communication via serial USB, CAN, Ethernet or Wi-Fi



# Battery Monitoring Solution by InnovationLab

Software: SensorMatrixLAB v5.x



Advanced 2D & 3D  
data visualization



Data recording and  
replaying



Real-time streaming  
via API



Supports different  
communication Interfaces



Multi-matrix real-time  
readout possibilities



Support of customized  
printed sensor matrices



HDR function: adjustment of  
measuring range via  $V_{ref}$



Sensor calibration  
option

More information at: [www.innovationlab.de/en/products/sensormatrixlab/](http://www.innovationlab.de/en/products/sensormatrixlab/)

# Who we are

InnovationLab – The One-Stop Shop for Printed and Organic Electronics

- Highly-skilled engineers and scientists
- Unique R&D, upscaling and production infrastructure
- Connected to internationally acclaimed Universities, research institutes and material provider
- Innovation partner of world-leading companies in Automotive, Healthcare, Logistics and Retail industries



## Shareholders:



# References



## InnovationLab customers:



## BaMoS in media (click to open link):





## Summary

Our **Battery Monitoring solution** in your **R&D test stands** supports you to...

- ✓ acquire **spatially resolved** live data on **cell level**
- ✓ make your battery research **more effective**
- ✓ **optimize** cycling conditions and increase **battery health**
- ✓ **validate simulation** data with physical data
- ✓ and finally get **the most out of your battery**.

Web



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**Dr. Florian Ullrich**  
Head of  
Business Development

The solution is **customizable** to your specific requirements and **approved by OEMs!**

**Contact us or place your order at:**

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