Fraunhofer ISIT

Fraunhofer Institute for Silicon Technology ISIT

10. Forum Elektromobilität Schleswig-Holstein/ Kiel/ 30.11.22

Jannes Ophey

FAB-SH: Das (neue) Zentrum für Batterieforschung in Schleswig-Holstein

Fraunhofer ISIT: A strong player in Battery Technology and Power Electronics

160 staff
(+ approx. 40 students)

Initial Investment: € 125 Mill.
- € 250 Mill. Industry
- € 42 Mill. Cleanroom II
- € 20 Mill. FMD

Annual Budget
€ 27 Mill.

Certified according to
ISO 9001:2015

Spin-Offs

Customcells
Leclanché

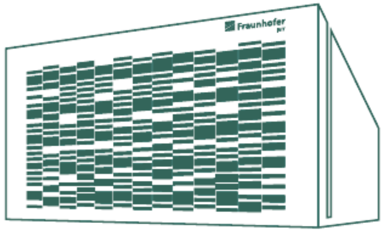
Partners & Cooperation

UniverCell
LIACON
ICMAB Institut de Ciència de Materials de Barcelona
Chalmers University of Technology
Uppsala Universitet
Universidad Complutense Madrid

CAMPTON Diagnostics
CONDIAS Conductive Diamond Products
VISHAY The DNA of tech.
OQmented
IZET Innovationszentrum Itzehoe
xfab

Boards & Memberships

- Advisory board battery research @ BMBF
- Scientific advisory board BVES
- Competence network lithium-ion batteries KLiB
- Competence cluster battery use “BattNutzung”
- Network of research pilot lines LiPlanet



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Battery Systems FAB-SH

- Manufacturing technology
- Cell development
- Battery analytics and systems

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Concentration and expansion strategy in new building - FAB-SH

2020	2021	2022	2023	2024	2025

Purchase building Fraunhoferstr. 2 ◆ ◆ Move in office Start Interior construction ◆ ◆ FAB-SH completely in operation

- Doubling of project and revenue development leads to bottlenecks at ISIT
- Industry partners seek facility space for joint projects
- FAB-SH enables project collaboration labs and incubator infrastructure for:
  - Joint development cooperation
  - Scaling of manufacturing processes
  - Cell construction and cell testing
  - Battery system construction
- Other potential partners:
  - Plant manufacturer
  - Cell manufacturer
  - Technical testing organizations

FAB-SH - Activities

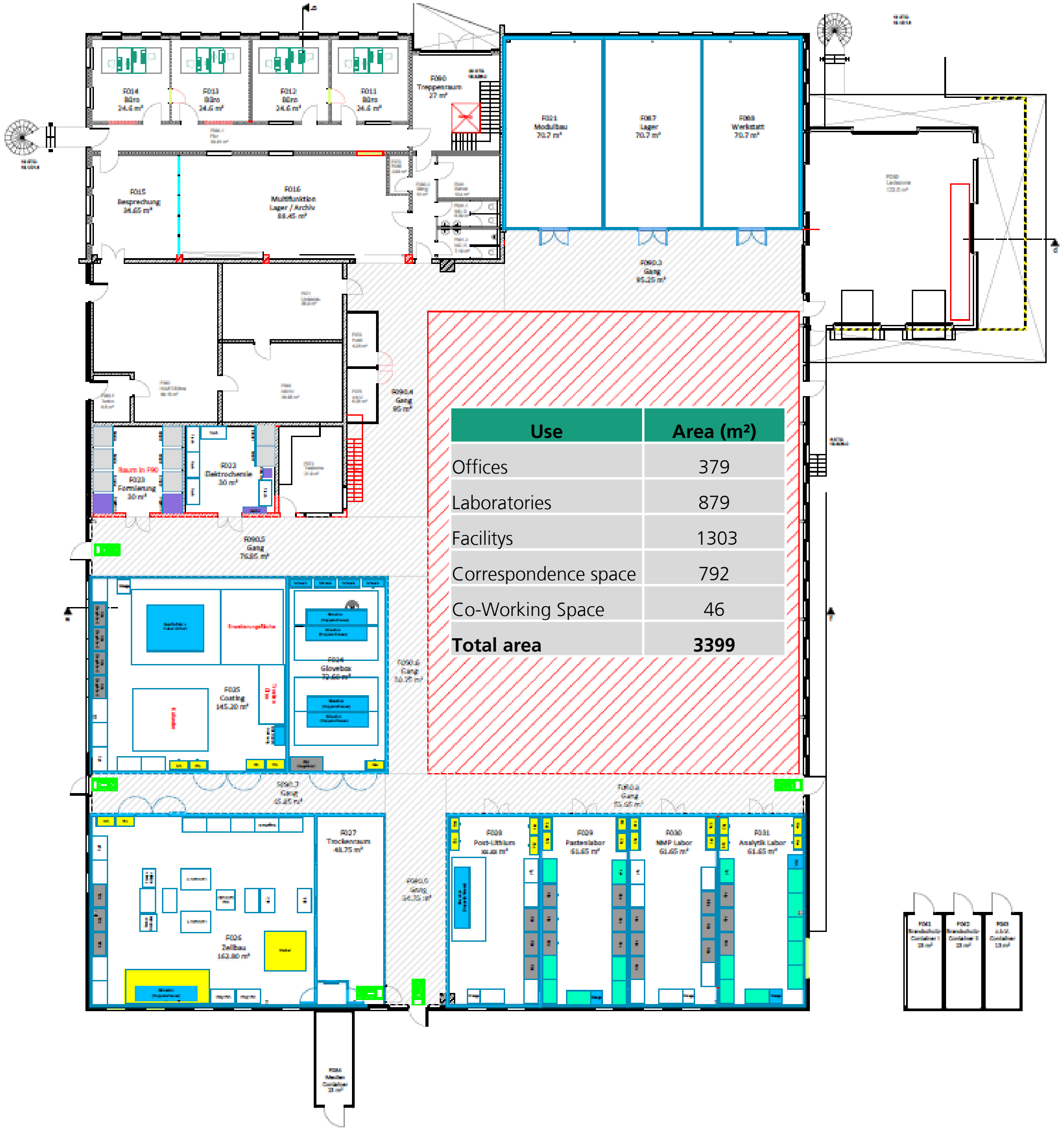
Current Topics

- Development of battery production technologies
- Lithium battery prototyping
- Tests on battery cells, modules and systems
- Development and optimization of battery system concepts
- Hands-on Training

Examples of battery cells realized at Fraunhofer ISIT

Technical Specifications	High Energy	High Power	Flexible	Robust
Voltage	3,7 V	2,5 V	3,7 / 2,5 V	2,5 V / 3,3 V
Energy Density	> 260 Wh/kg	> 90 - 160 Wh/kg	> 200 Wh/kg	> 75 - 210 Wh/kg
C-rate*	2C	18C / 60C	2C	8C
Cycle stability	> 1000 Cycles	> 2000 Cycles	> 2000 Cycles	> 15000 Cycles
Durability	8-10 years	Up to 20 years	8-10 years	Up to 20 years
Temperature range	0°C - 60°C	-10°C - 60°C	0°C - 60°C	-20°C - 150°C
Capacity	<65 Ah	<20 Ah	~150 mAh	1 Ah
Geometry	35 cm x 10 cm	35 cm x 10 cm	10 cm x 5 cm	6 cm x 5 cm
Use case example	Stationary energy storage	Starter battery	Wearables	Autoclavable medical devices

**Number of charge / discharge cycles per hour*



Use	Area (m²)
Offices	379
Laboratories	879
Facilitys	1303
Correspondence space	792
Co-Working Space	46
Total area	**3399**

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On-site training for battery technologists

Hands-on training on pilot production lines

- Electrode slurry mixing
- Electrode coating (2 coating lines)
- Calendaring
- Cell assembly (pouch and prismatic cells)
- Formation
- Analytics

Up to 900 persons per year

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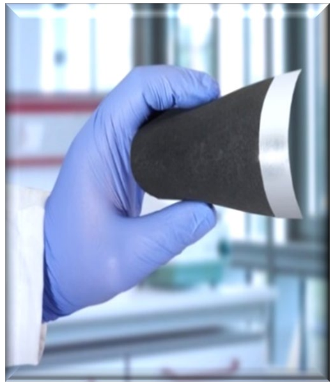
Battery research at Fraunhofer ISIT: Focus topics

Innovative **manufacturing technologies**

Dry coating

Sustainable manufacture of battery electrodes

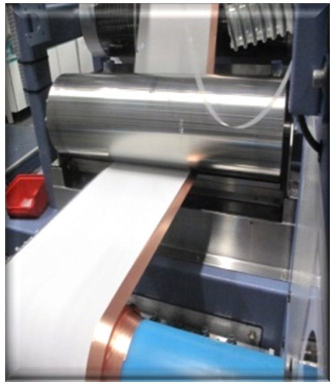
- Dry coating of electrodes
- Electrode design and up-scaling
- Polymer-ceramic all solid- state battery



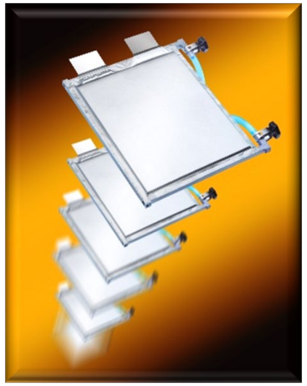
Separator technology

Simplification of the process chain

- High-Power Separator based on ISIT technology
- Ultra high-power batteries (60C)
- Direct coating of separators on electrodes



Accelerated **battery cell development**



Rapid prototyping

Fast battery cell development

- Time for development: 3 to 8 weeks
- Pouch cells in multiple form factors
- Cell adaptation to customer

High power Battery cell

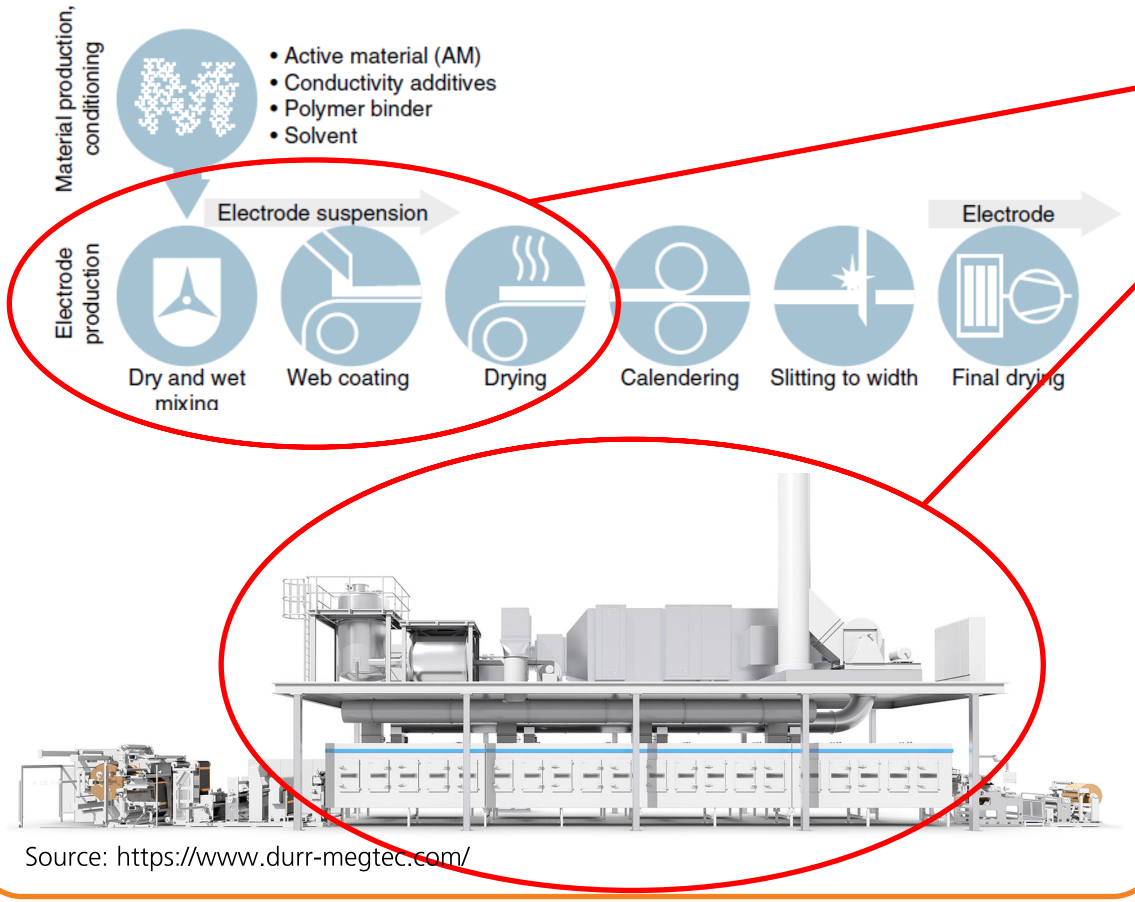
Ultra-high-performance batteries with ext. lifetime

- High-rate capability
- Cost efficiently
- Customized in shape

Dry Coating: Cost Reduction Potential through New Ideas

Life-Cycle Assessment, EU-Project

Electrode manufacturing processes

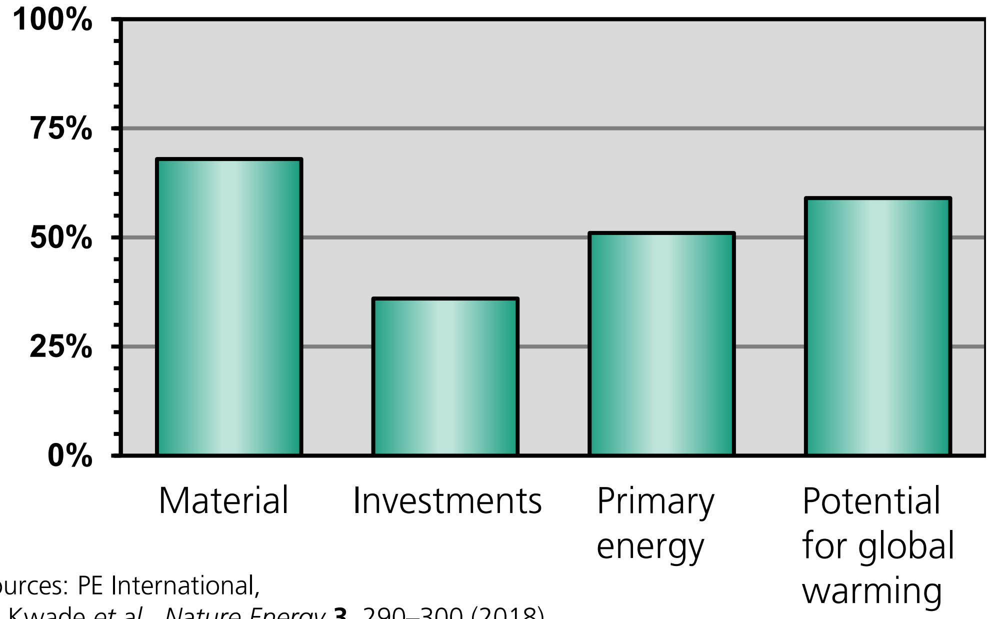


Source: https://www.durr-megtec.com/

Novel dry powder coating technology implies

- No solvent needed – significant material savings
- No drying needed – significant energy savings
- Significantly smaller footprint - reduced CAPEX

Saving potentials:

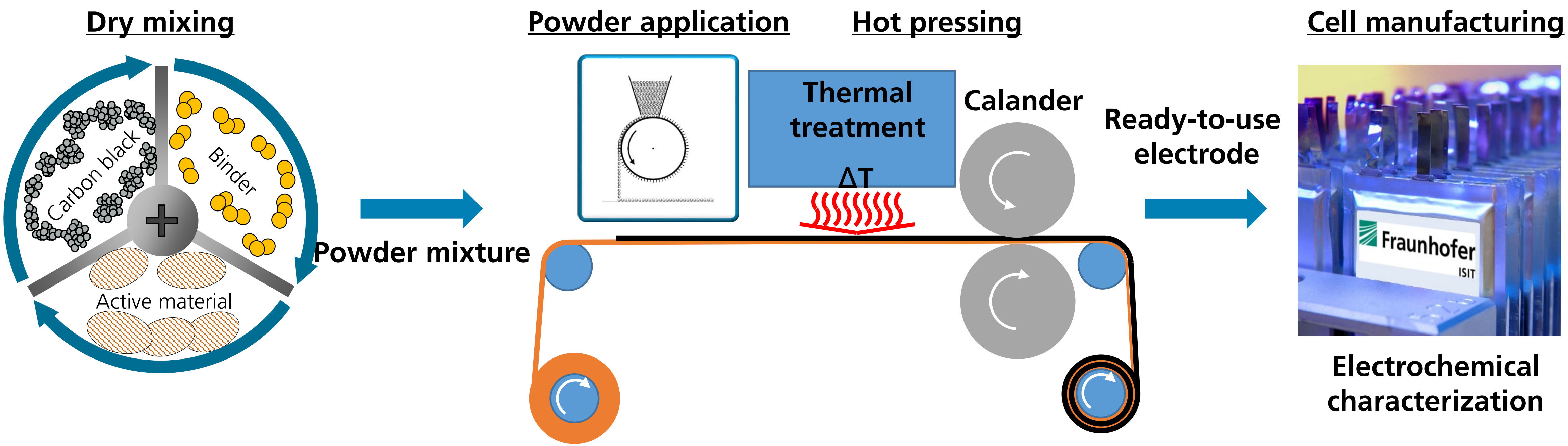


Sources: PE International,
A. Kwade *et al.*, *Nature Energy* **3**, 290–300 (2018)

Dry coating: Process for Electrodes

Environmentally friendly, cost efficient, space and energy saving

Process chain



„The technological approach of "dry coating" allows the energy-intensive drying step to be eliminated for significant energy and cost savings. "

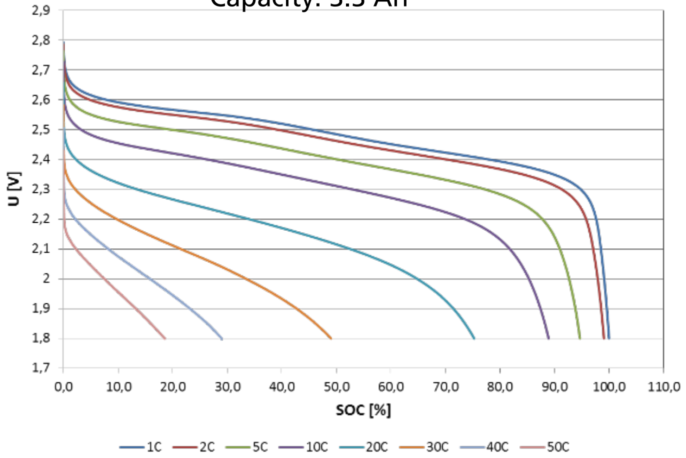
F. Degen and O. Krätzig, "Future in Battery Production: An Extensive Benchmarking of Novel Production Technologies as Guidance for Decision Making in Engineering," in *IEEE Transactions on Engineering Management*, doi: 10.1109/TEM.2022.3144882.

Cell development - High Power Cells
LTO based

Lithium-Polymer Accumulators

- **USPs**
  Flexible format, scalable, resilient, durable, safe, wide temperature range
- **Know-how**
  Conception, development and optimization of individual samples up to small series
- Value chain from electrode foil production to the battery module
- **Measurement technology**
  Charging/discharging processes, electrical characterization (impedance measurement, etc.), cycle tests, load tests, temperature change and humidity tests, post-mortem analyses

High-performance single cell
Average voltage: 2.5 V
Capacity: 3.3 Ah



Discharge process at different C-rates

Application: 50C high-performance storage system

- Very high C-rate for fastest charging and discharging up to 50 C
- High intrinsic safety through LTO anode material
- Extended temperature range (-10 °C ... 60°C, also for charging)
- Very high cycle stability
- Maximum power of the 2.5 V / 3.3 Ah single cell of 412W
- High-performance battery storage system with 1 kWh/300 V and nominal/peak power of 30/50 kW consisting of 11 modules with 12 cells per module

Cell development - High Power Cells

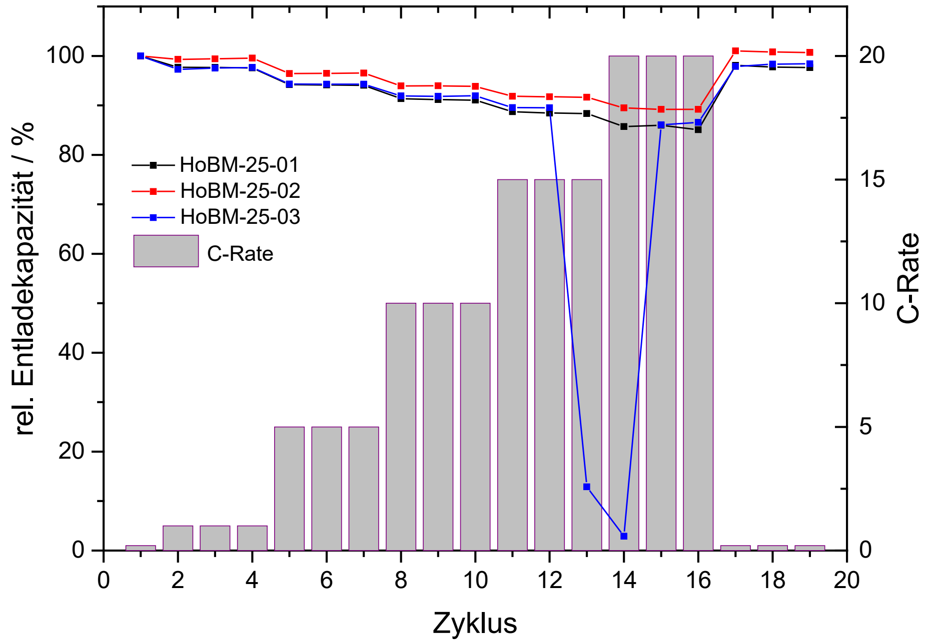
Graphite based

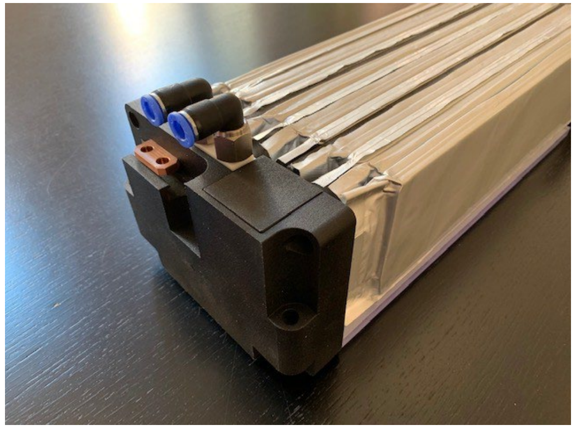
Results:

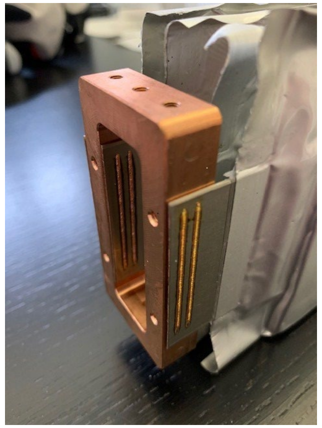
- **High discharge current of more than 20 C**
- **Energy density of at least 150 Wh/kg**
- Space-saving design with optimal heat dissipation
  - Long lifetime
  - High performance

Technical parameters of the cells

- Cell voltage: 3,7 V
- Energy density: >150 Wh/kg / > 400 Wh/l
- Peak power: > 3.750 W/kg (25 C) 10s
- DT @ cell: < 2 K @ 10 C (DC)
- Cycle stability: > 300 cycles @ 100% DOD







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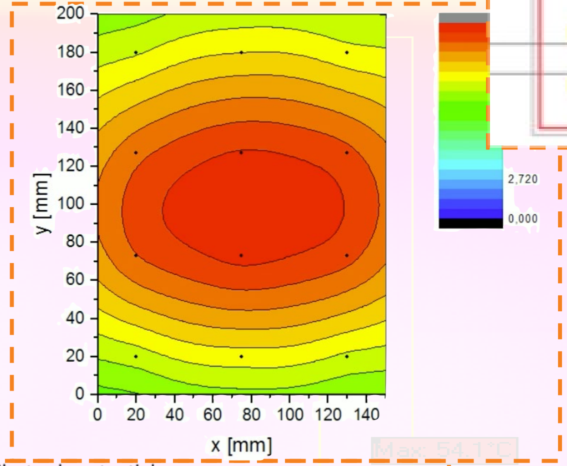
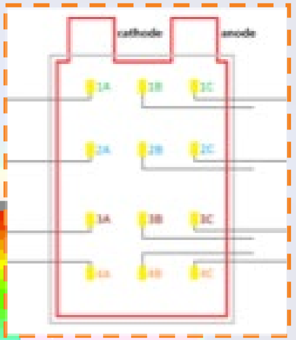
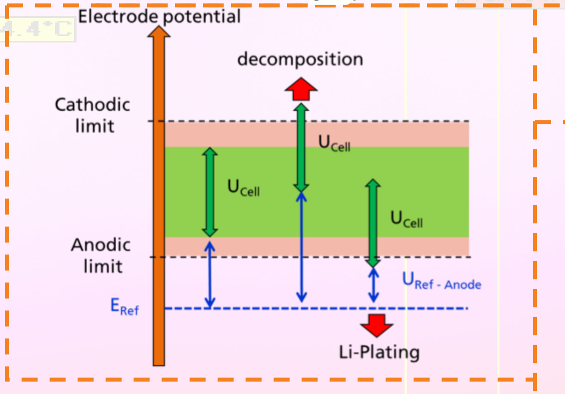
Cell Testing

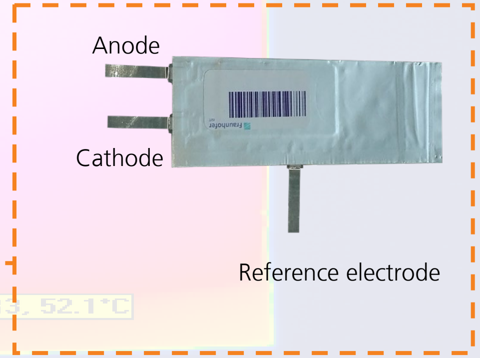
Advanced Test Procedures

- Instrumentation with third electrode and in-situ measurement
- Instrumentation fibre optics and in-situ measurement
- Instrumentation thermal sensors and in-situ measurement
- Instrumentation strain gauges and in-situ measurement
- Abuse tests with observation of electrode parameters during failure
- Volume expansion measurement in static condition as well as under cycles or C-rates
- Thermography - in standard operation or under extreme stress of the cells
- Evaluation of all critical cell parameters









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Battery Analytics & System Integration

Development and simulation of intelligent module and system design

Smart Cells

- Reference electrodes
- Light sensors
- Pressure & temperature sensors

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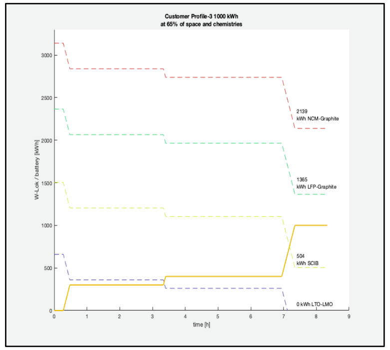
Profiling & optimisation



- Analyzing driving profiles
- Selecting cell technology
- Estimating characteristic values

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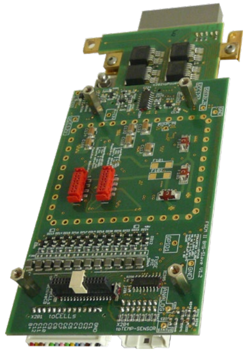
Algorithmic & AI-design



- Building of AI - algorithms
- Creation of HW / SW
- Simulation of behavior

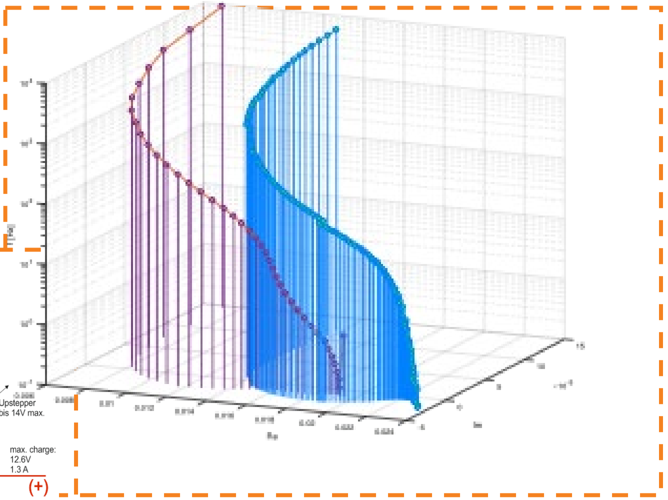
System and BMS in application

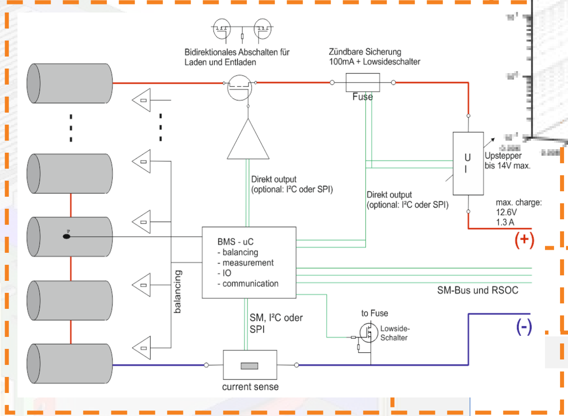
- System simulation
- Installation space optimization
- Implementation in application

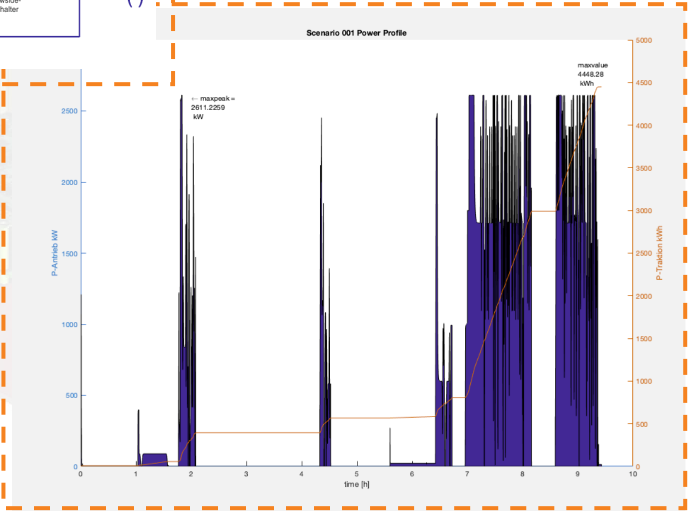
System Level

Advanced considerations and tools

- Testing of novel algorithms in existing systems to improve SOC/SOH calculation
- Test of the system in the user profile and derivation of statistical properties - lifetime estimation for the customer
- Integration of machine-learning algorithms to be able to react to changes in the profiles - regarding 2nd life requirements
- Comparison of customer profiles (such as ancillary services or driving cycles) against different geometries or cell chemistries
- Computational design and test whether the selected configurations meet all criteria of the requirement.
- Lifetime estimation regarding 1st and 2nd use







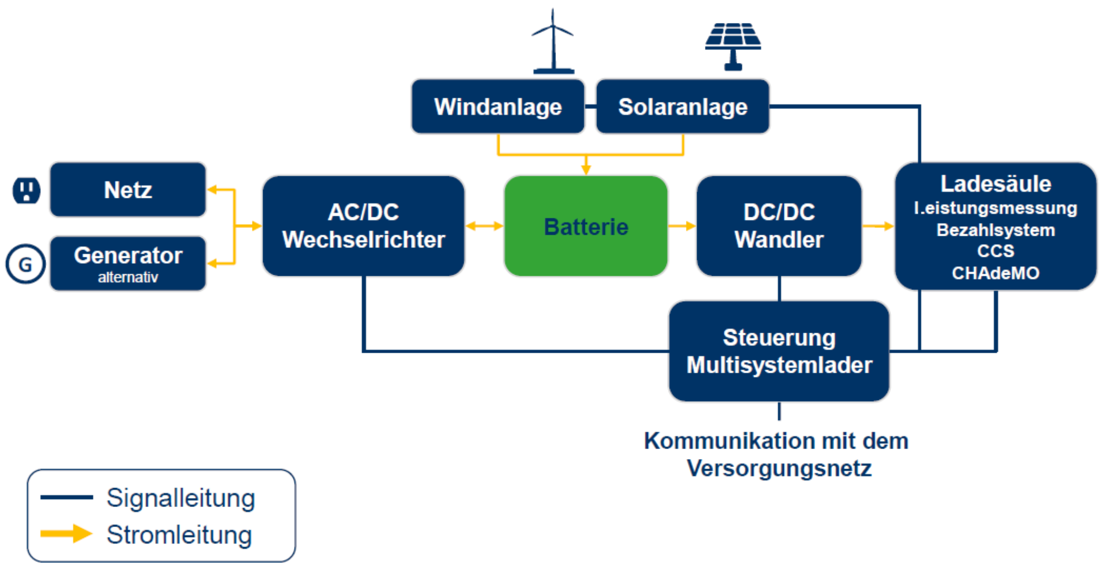
Power 400

Project Idea and System Design

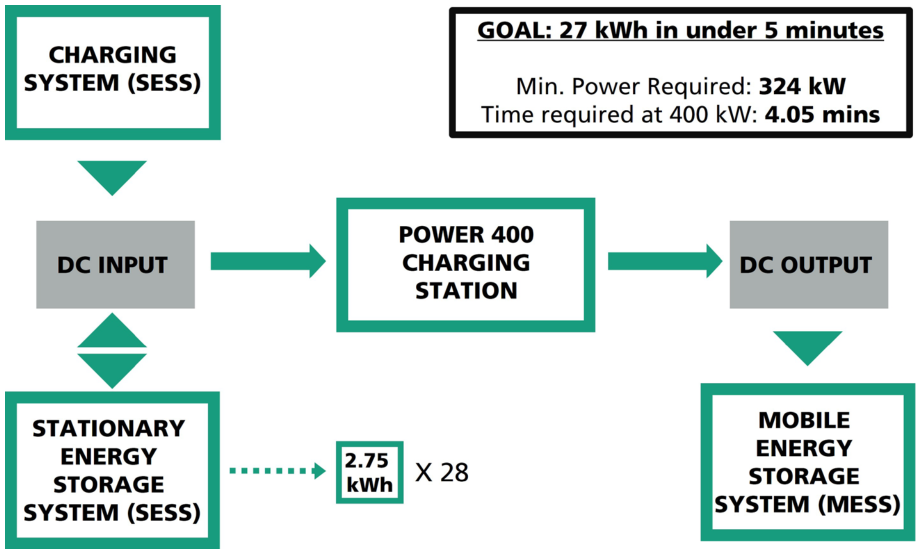
Wir fördern Wirtschaft
Landesprogramm Wirtschaft: Gefördert durch die Europäische Union - Europäischer Fonds für regionale Entwicklung (EFRE), den Bund und das Land Schleswig-Holstein

Idea:

- **Charging station with buffer storage**
- Fast charging independent of infrastructure
- Relief and stabilization of the grids



System design:



Charging system requirements and specification

	DC Input	DC Output
Voltage range	540-890 V	0-1283 V
Max. current	1600 A	0-794 A

Power 400 - Prospectives

Bundling the Competences of FAB-SH and CAU@ISIT

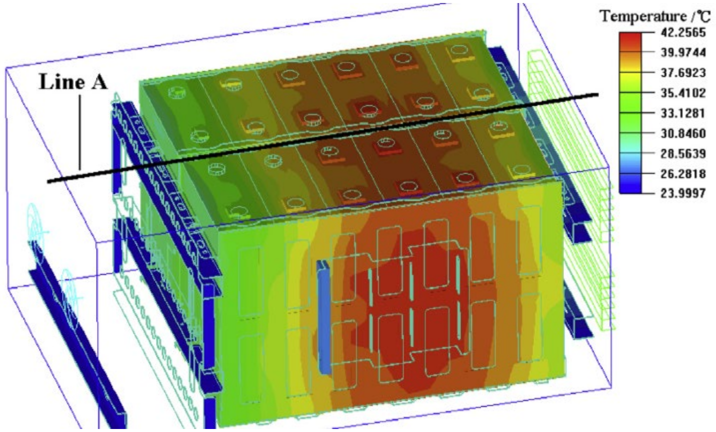
Wir fördern Wirtschaft

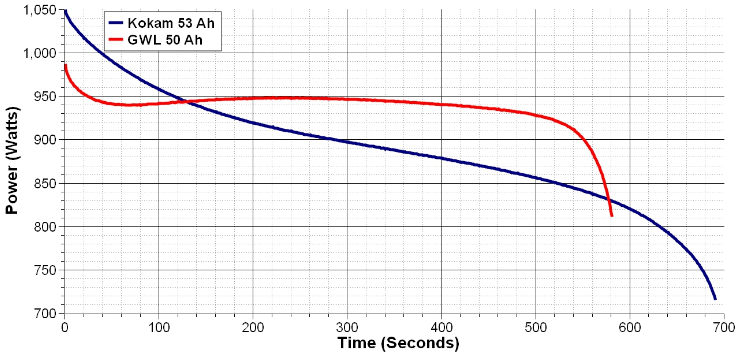
EU.SH

Landesprogramm Wirtschaft: Gefördert durch die Europäische Union - Europäischer Fonds für regionale Entwicklung (EFRE), den Bund und das Land Schleswig-Holstein

FAB-SH:

- **Buffer storage**
- Design and development
- Cell production and module construction





ISIT@CAU:

- **System design**
- Charging system
- Grid integration
- Analysis

What else we can do for you?

Dry Coating	High-Power Cell	High Temperature Cell	Smart-Cell
Solvent free	18C discharge/charge rate	Up to 150°C operation temperature	Sensor integration in cells
Space saving	160 Wh/kg	Autoclavable	Safety monitoring
Energy saving	Graphite technology	High intrinsic safety	Ageing prediction

ISIT-Separator	Ultra-High-Power Cell	High Pressure Cell	Cell Test
High flexibility	60C discharge/charge rate	600 bar pressure resistant	>400 measurement channels
Low resistance	190 Wh/kg	Flexible geometry	Cycle stability, C-Rate capability
Direct coating on electrodes	LTO technology	Good low temperature performance	CV, HPLC, Impedance

Solid State Batt. (ASSB)	Si-High-Energy Cell	Flexible Cell	Module Test
Polymer-Ceramic Hybrid	100% Si Anode	Resistant to alternating bending	5 Channels
Dry coated	>300 Wh/kg	High intrinsic safety	Up to 60 V, 150 A

Thank you for your attention!

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