CUSTOMCELLS®
Ahead in cell innovation


CUSTOMCELLS

eMove360° - Munich, 15th Oct 2019
The challenge in Lithium ion cells at fast charging for long distance vehicles

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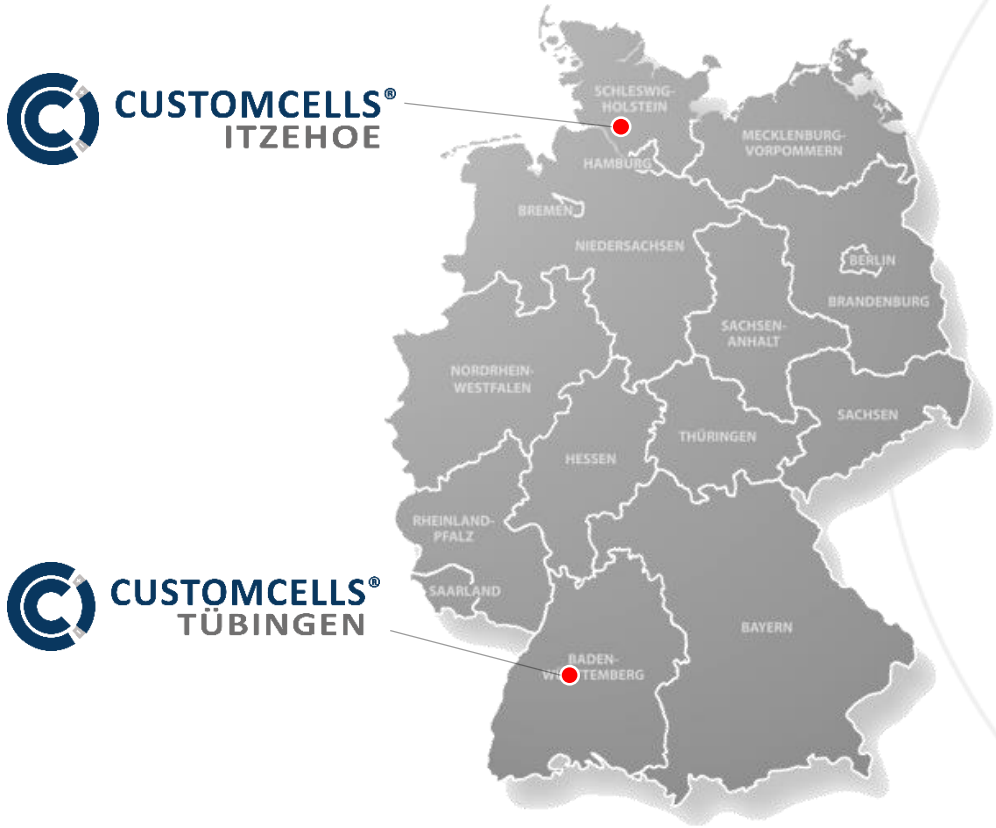
Head of Project Planning & Sales

COMPANY FACTS

- **2012** Foundation of **CUSTOMCELLS Itzehoe**
  Individualized lithium-ion cell prototypes
  Approx. 20 MWh, 24 h production
- **2018** 3.6 M Euro company turnover
  Positive EBIT
- **2019** 50 employees

  Foundation of **CUSTOMCELLS Tübingen**

  Low and mid volume cell production
  Approx. 100 MWh, series production



MANAGING DIRECTORS


Leopold König


Torge Thönnessen

INDUSTRIAL PROJECT EXPERIENCE

- CUSTOMCELLS collaborates as an industry partner with customers in the automotive, aviation, medical, security and niche markets.
- CUSTOMCELLS holds patents and know how over the whole area of lithium battery technology and battery production.
- Certified high quality cell development and production.
- Made in Germany.

PARTNER & COOPERATION

- CUSTOMCELLS uses a strong partner network to offer high quality products and services. Examples:

p3 group — Shareholder

ELYTE INNOVATIONS — Electrolyte production

manz — Plant manufacturer

coperion confidence through partnership — Slurry mixing technology

Fraunhofer — R&D partner

CUSTOMERS HIGHLIGHTS

- 7 of TOP 10 worldwide automotive companies
- 3 of TOP 10 globale chemical companies
- 6 of TOP 10 German automotive suppliers
- 7 of TOP 10 German defense companies

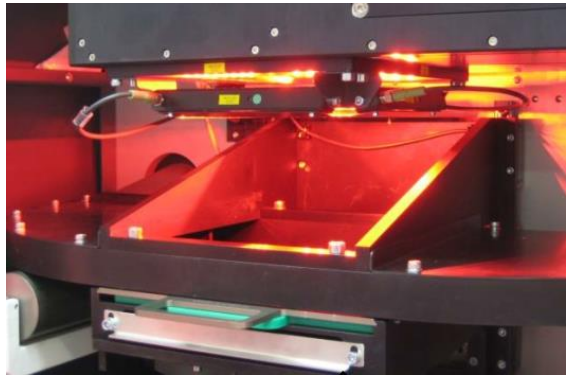
- > 580 companies are customer base
- > 1.400 projects team experience
- 14 electrode technologies industrialized
- 4 customers supported to set up own facility

High quality cell production: VARIOUS FORMATS AND SHAPES

EUROPE`S CUTTING EDGE CELL PRODUCTION

- Cells in individual formats and shapes (3D-cells) including tailored chemistry.
- Unmatched cell quality and performance.
- Outstanding high-quality production processes.
- End-to-end traceability.
- Annual production from 10K up to 1.2 M cells.
- Cell Dimensions: 20 x 30 mm² - 200 x 200 mm².
- Low volume production possible.
- Made in Germany.

A NEW LEVEL OF CELL MANUFACTURING



Series production plant CUSTOMCELLS Tübingen GmbH

Agenda

1. Technological challenges of lithium ion cells at fast charging
2. Charging process and cell impact
3. Influences of cell sizes and materials
4. Summary and key messages

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1. **Technological challenges of lithium ion cells at fast charging**
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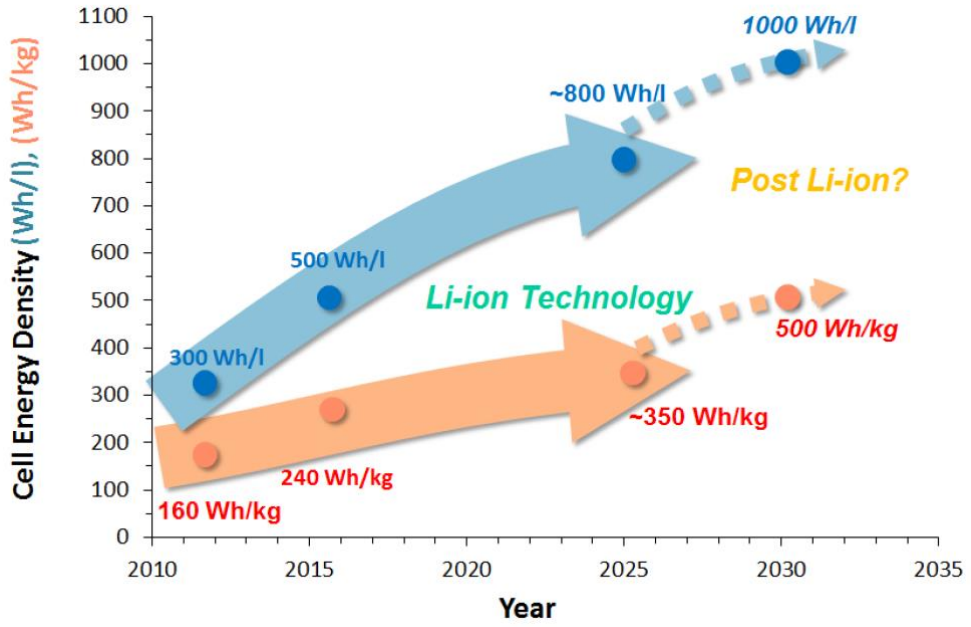
LITHIUM ION CELLS AT FAST CHARGING FOR LONG DISTANCE VEHICLES

Technology roadmap OEMs – examples



Current OEM cell development roadmaps

- Energy density increases to >350 Wh/kg in the next years
- Cathode material with high nickel contents (NCA, NMC) with high calander grades.
- Development on anode with SiC content.

Source: AABC2019 Europe, Renault, Bruno Delobel, 30th Jan 2019

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Cell design – high energy vs. high power cell layout

High energy cell

Cathode Material	Anode Material	Substrate	Slurry Solvent	Binder	Additive	Coating thickness	Drying Process	Calander Parameter
						mAh/cm²		
LCO		Al 20µ						high pressure
LMO	C	Al 12µ			carbon black	1	IR	high temp.
LFP	Si/C	Al 15µ prim	NMP	PVDF	graphite	2	hot air	medium pressure
NMC 111	LTO	Cu 12µ	NMP mix	SBR/CMC	CNT	3	fast	medium temp.
NMC 622	Li	Cu 8µ	water		Graphene	4	slow	low pressure
LMNO		Cu 12µ prim						low temp
NCA		Al 20µ prim						
S								

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Cell design – high energy vs. high power cell layout

High power cell

Cathode Material	Anode Material	Substrate	Slurry Solvent	Binder	Additive	Coating thickness	Drying Process	Calander Parameter
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LMO	C	Al 12µ			Carbon black	1	IR	high temp.
LFP	Si/C	Al 15µ prim	NMP	PVDF	graphite	2	hot air	Medium Pressure
NMC 111	LTO	Cu 12µ	NMP mix	SBR/CMC	CNT	3	fast	medium temp.
NMC 622	Li	Cu 8µ	water		Graphene	4	slow	low pressure
LMNO		Cu 12µ prim						low temp
NCA		Al 20µ prim						
S								

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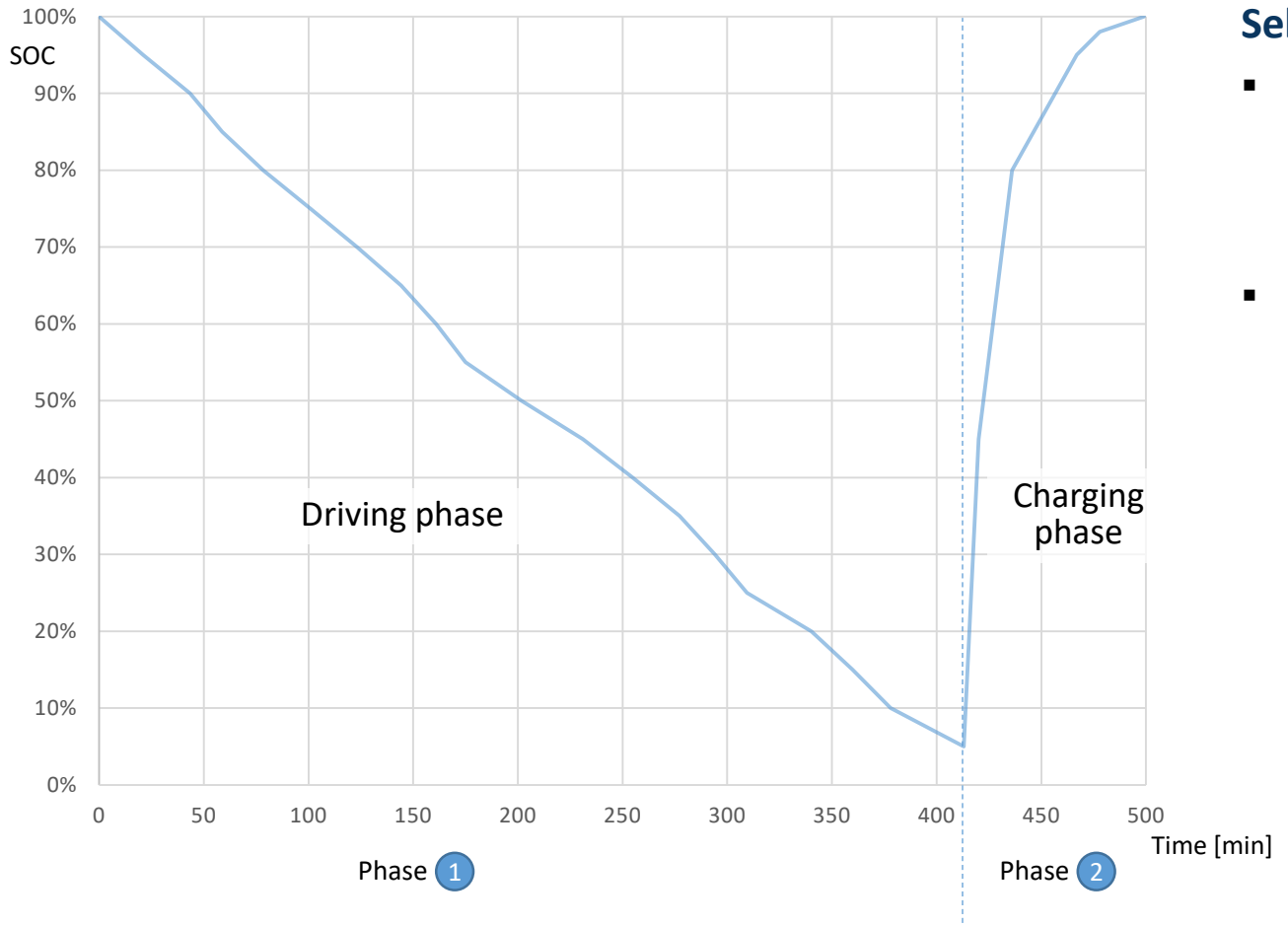
Exemplary usage of a long distance EV: driving and charging phase



Selection in phases:

- Phase 1: Discharging by driving
  - Low C rate (except short time acceleration).
  - High energy density needed for long driving phase.
  - Focus on energy density (Wh/kg and Wh/kg).
- Phase 2: Charging @HPC:
  - High C rates charging.
  - Optional: Starting at low SoC (cell impact!)
  - Focus on power density.

Phase 1 — High energy cell

Phase 2 — High power cell

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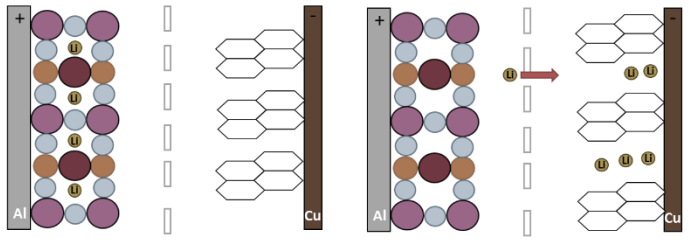
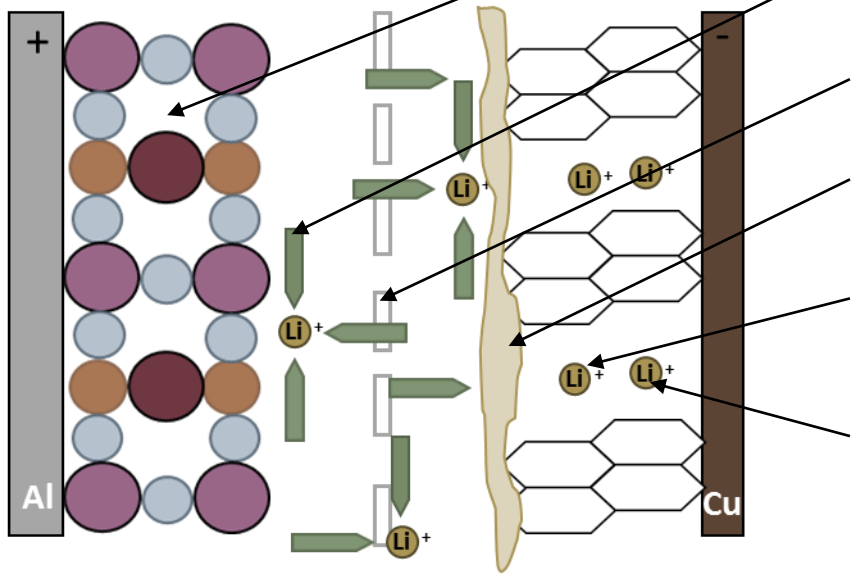
Charging process





Charging steps:

1. Delithiation of cathode material.
2. Coordination of Solvent molecules to Li-Ion
3. Passing of Li Ion trough separator
4. Removing of Solvent molecules by SEI
5. Intercalation of Li Ions into Graphite Particles – from sides
6. Movement of Li inside the Graphite layers

Cell impact:

Low resistance active materials – special coatings.

Balance between strong and weak coordinating solvents.

Poor size optimizing.

Balance between strong and weak coordinating Solvents – SEI needs to be formed homogeneous.

Large particles are unfavorable due to Lithium only intercalating trough edge planes and long diffusion paths.

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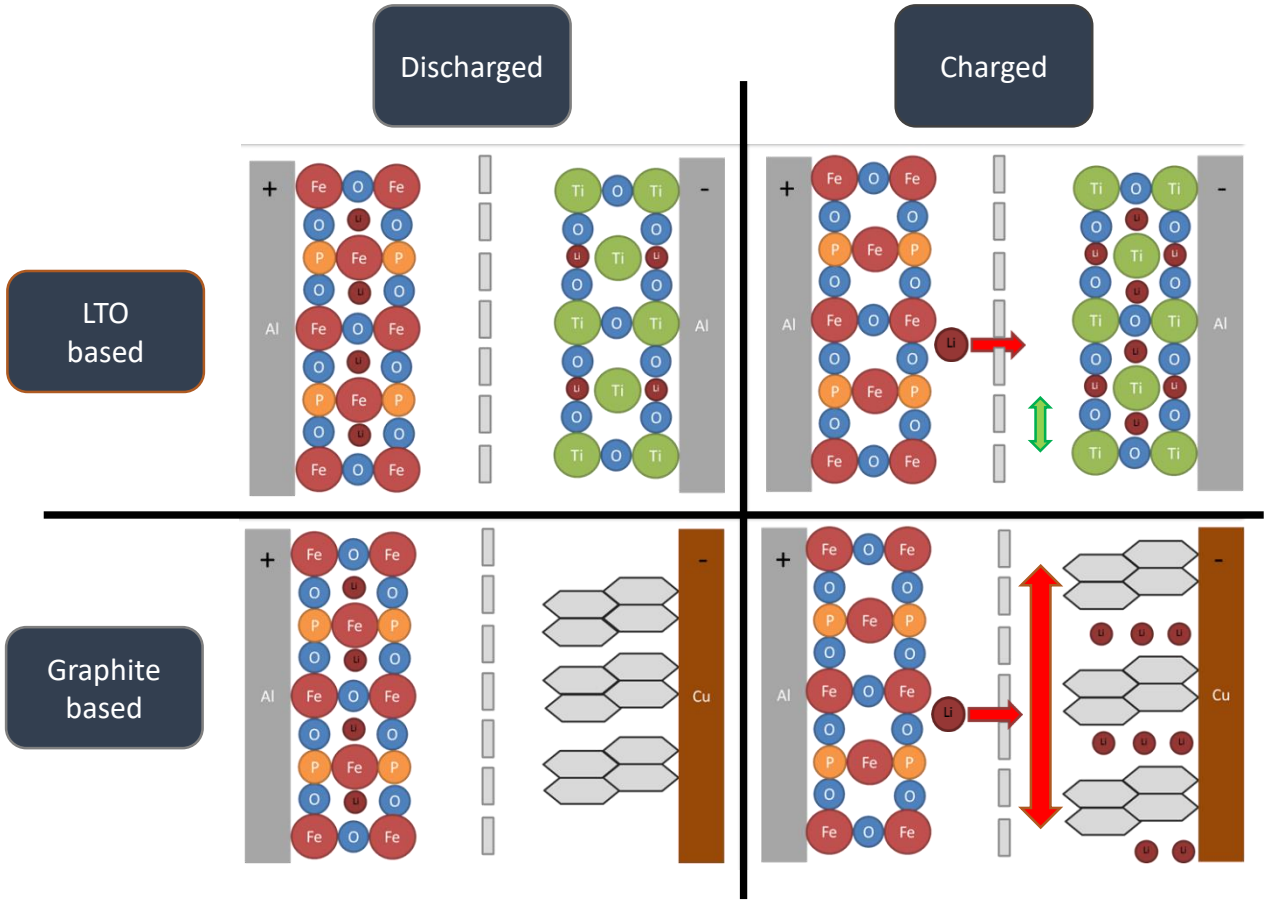
Charging process



- Lithium intercalation as Li+ (reduction of titanate).
- Usage of aluminum as collector foil possible.
- No volume changes.

- Lithium intercalation as Li+ (metal-like).
- Usage of copper as collector foil.
- Volume changes ~13 % (anode).
  Silicone: >300 %. Additional effect: delithiation at low SoC.

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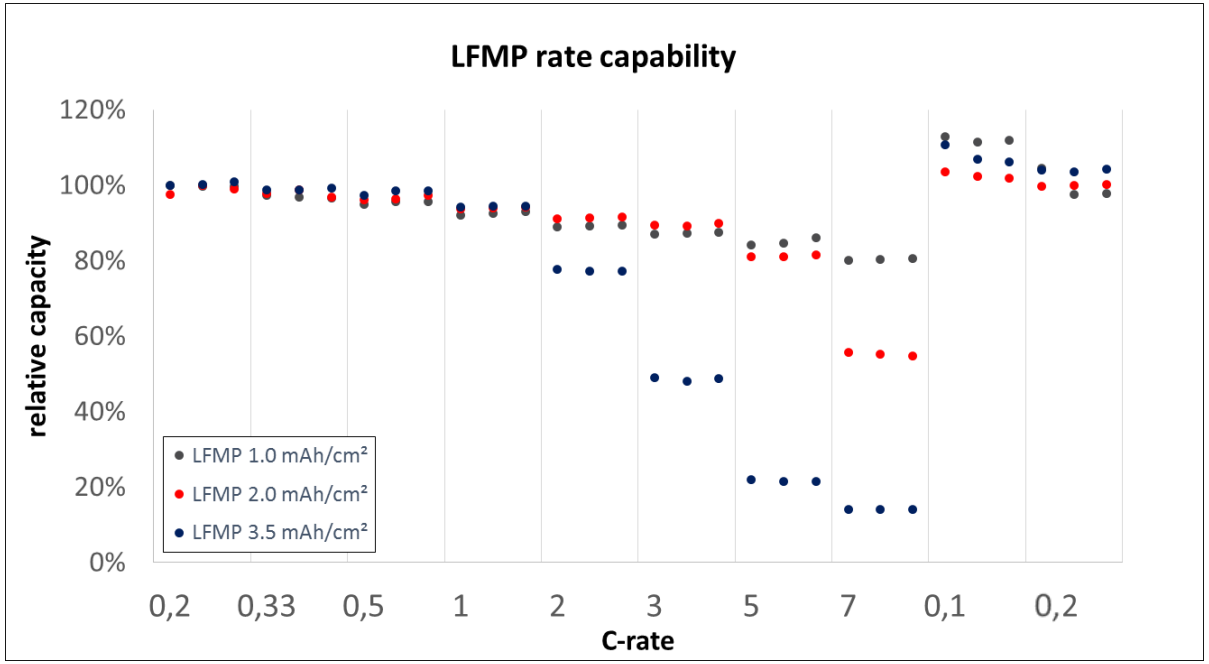
CUSTOMCELLS – Industrial project experience



Rate capability high power vs high energy:

- Small deviation for low C rates.
- Specific loading of electrodes between 1.0 mAh/cm² and 2.0 mAh/cm².
- Higher deviation for higher C rates between high power and high energy capacity.

High specific energy:

- Large active material particles – high active material content.
- High coating thickness (area capacity) – low binder content.
- Low conductive additive content.
- Low porosity.

- Long diffusion path, low ionic and electric conductivity.
- Sophisticated processing – low specific power.

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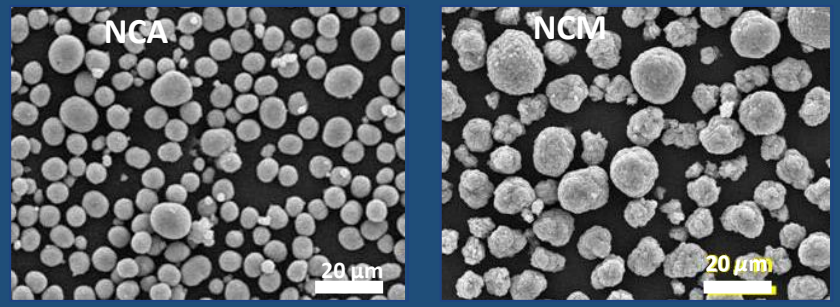
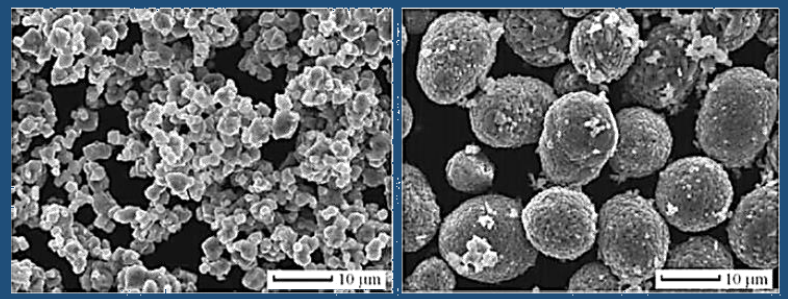
Particle size and morphology has great influence on battery characteristics

Size



Morphology



- Smaller particles → shorter diffusion length → higher rate capability
- Smaller particles → larger surface → more side reactions → faster aging

Masaki Yoshio; Ralph J. Brodd; Akiya Kozawa; *Lithium-Ion Batteries Science and Technologies;* Springer Science+Business Media, LLC 2009

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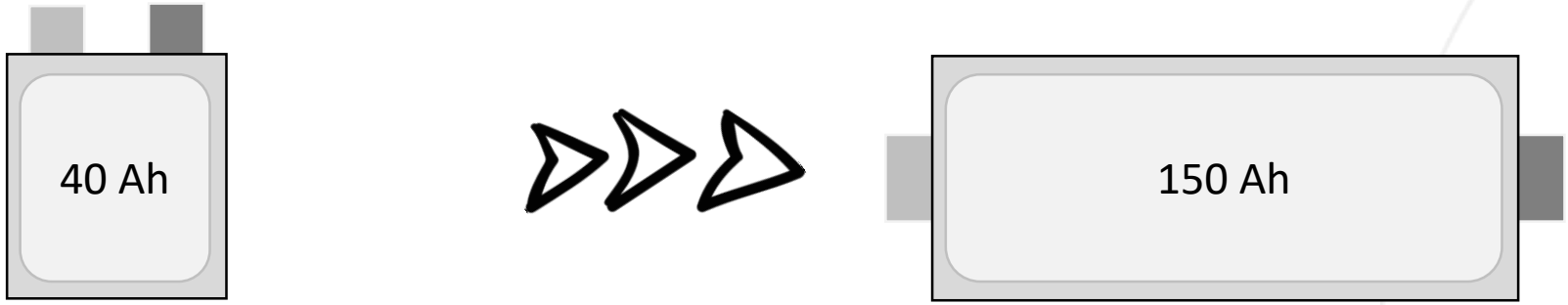
Influence of the cell size on the battery and charging behavior of the EV



Pro

- Higher energy density due to lower inactive material.
- Less cells needed to reach a certain system capacity (less parallel lines).

Con

- Higher quality demanded due to higher m² of every material in one cell.
- Higher energy content per cell leads to higher risk in assembly process.
- Higher costs per cell – higher loss in case of cell failure during production process.

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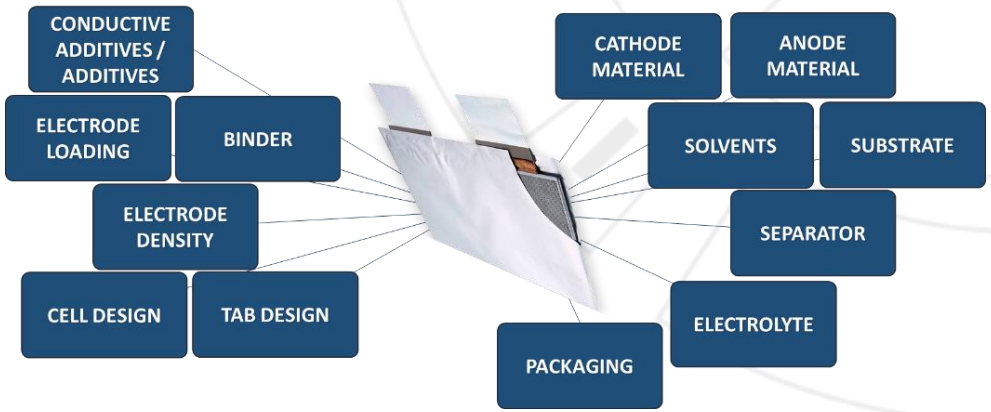
Summary and key messages

The trade-off between long-distance EV and high power charging is based on the physical principles of cell architecture. Further developments to increase reach will intensify the challenges.

- Roadmaps from OEMs are focused on energy densities >350 Wh/kg in the next decade.
- The use of silicon on the anode side will increase the challenge after very good material with less volume change and stability for fast charging at low SoCs.
- The geometrical upscaling the cells to larger formats and capacities will be unavoidable for future battery concepts.
- The improvement of the internal cell resistance and the thermal behavior of the cell can result in an increase in the fast-charge capacity.

Parameter which influence the performance of the cell



Thank you!

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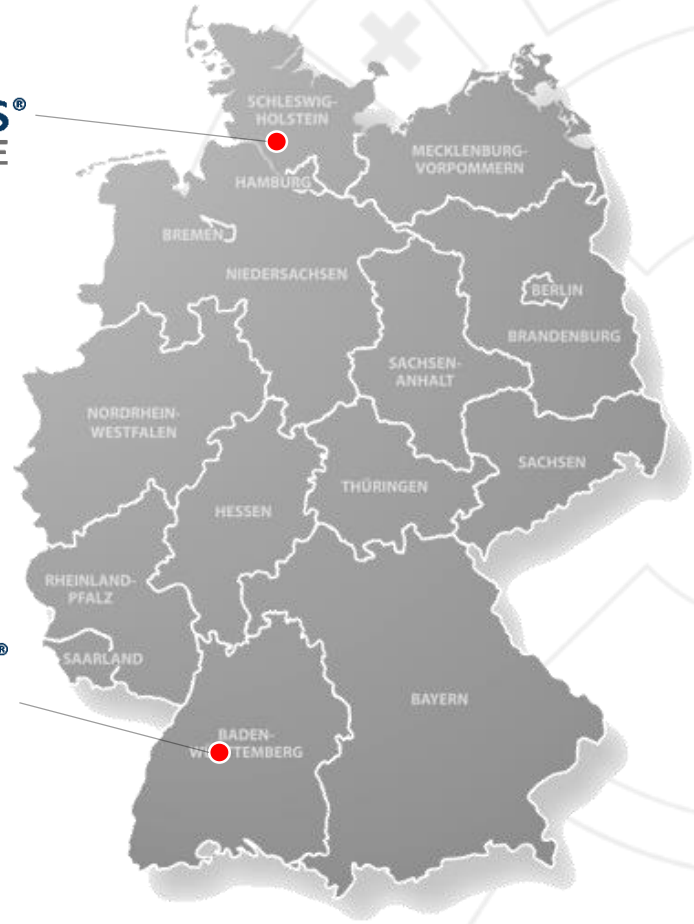

www.customcells.de