Flexibility in Battery Cell Design for Innovations and Scale-Up within the Battery Industry

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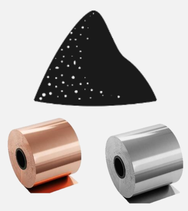
Current situation - Innovations in Battery Cell Design

The race for the perfect battery cell design regarding high energy and power applications is very vital and in recent years none of the three main battery cell types (cylindrical, prismatic hardcase and pouch) is dominating the market. A general trend of increased cell dimensions, hence capacity per cell can be observed and predominantly an improved engineering of cells led to massive increase regarding gravimetric and volumetric energy density. Due to improvements on material and electrode level (e.g., the use of next generation lithium ion battery (LIB) materials, development of solid-state battery materials) energy and power densities can and will be further enhanced in the coming years. Each innovation needs to be validated in terms of its scalability on an industrial level.[1]

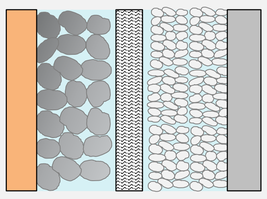
Innovation Pool*

Material Level



- Ni-rich cathode material
- Silicon anode material
- Sodium ion cathode
- Lithium metal anode
- Solid electrolytes

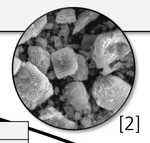
Electrode Level



- Thin current collectors
- High areal capacity electrodes
- 3D structured coatings
- Ceramic edge coatings on cathode
- Electrode lamination (mono cells)

Cell Level

- Cell dimensions (cell-2-pack)
- Jelly roll / stack design
- Tab-design (e.g., tabless)
- Thermal management
- Sensor integration
- Safety elements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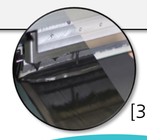
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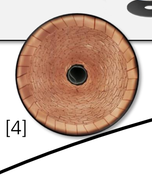
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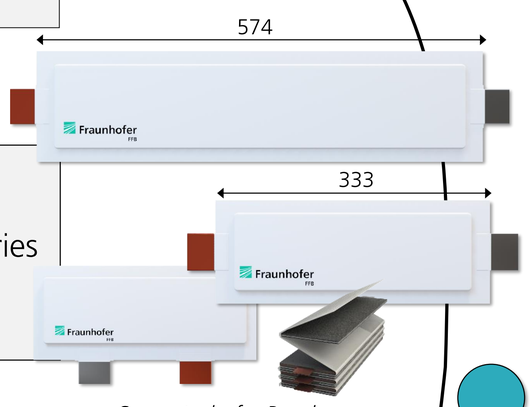
Active Materials

Cathode			Anode
NMC622 *180 mAh/g*	High Power Application	Graphite *360 mAh/g*	
NMC811 *200 mAh/g* NCA *200 mAh/g*	High Energy Application	Graphite/SiO_x *500 mAh/g*	
LFP *150 mAh/g*	Long Life Application	Graphite *360 mAh/g*	

Further chemistries possible.
Next generations: NMC955, LMFP, Sodium-Ion, Silicon, Li-Metal, ASSB, …

Pouch Cells

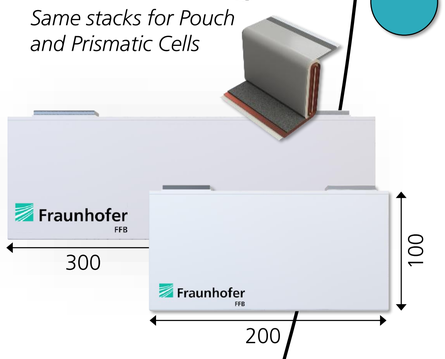
- Flexible & customizable (shape, dimension, thickness)
- Different tab positions and geometries
- Integration of sensors
- Ideal for prototyping



Same stacks for Pouch and Prismatic Cells

Prismatic Hardcase Cells

- Stacks and windings possible
- Changes in cell housing and lids feasible
- Testing of new safety elements
- Integration of sensors



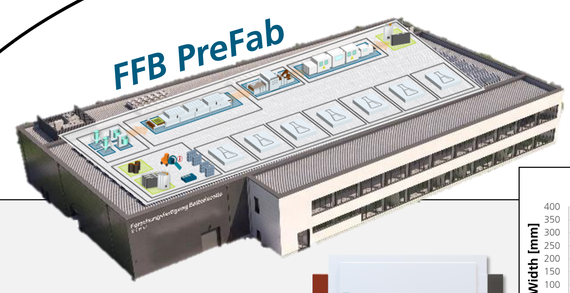
Cylindrical Cells

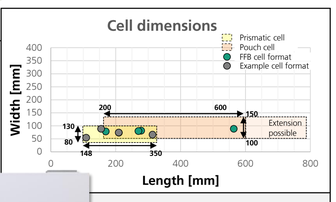
- Flexibility on materials and electrode level
- Very high production speed (30 ppm)
- Traceability over all production processes

Promising new Technologies

TRL 5 6 7 8 — *Technology readiness level*

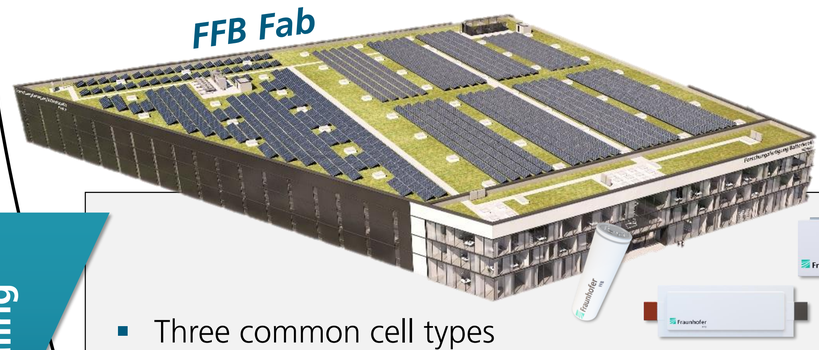
Prototyping





- Pilot line for pouch cells
- Prismatic cells manufacturing
- Stack forming by Z-folding or single-sheet-stacking
- Innovation rooms (e.g., dry-coating and laser cutting)
- Innovation labs for solid state batteries

Upscaling



- Three common cell types
- Scale-up in giga factory production environment
- Prismatic cell assembly: Stacking and winding possible
- Dry-rooms and mini-environments
- Flexible for design and process innovations

Successful Innovation

Conclusion

The Fraunhofer FFB focuses on a high flexibility in the dimensions of all three cell types and the tab position within the cell designs. This allows the implementation of latest trends from research and industry. Furthermore, synergies between different cell formats can be used to link the production lines. This enables the integration of the same electrode stack into pouch and prismatic hard case cells. The high flexibility of battery cell design and cell chemistry enables a wide range of opportunities, e.g. the development of recycling-friendly cells or the possibility of using sodium-ion battery production as drop-in technology. Solid-state battery strategies are under evaluation. The upscaling of promising new technologies and innovations can be achieved in collaboration with the Fraunhofer FFB on different production levels from pilot lines to industrial production with high throughput.

* Examples for possible innovations

[1] Neef, C. et al.; 2022; Development perspectives for lithium-ion battery cell formats
[2] E-Magy; 2024; Si-Anodes; https://e-magy.com/
[3] Fraunhofer IFAM; 2024; Printed batteries; https://www.ifam.fraunhofer.de/en/magazine/printed-batteries.html
[4] Tesla; 2020; Tabless, Battery Day

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