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Safety of Aged Lithium-ion Batteries

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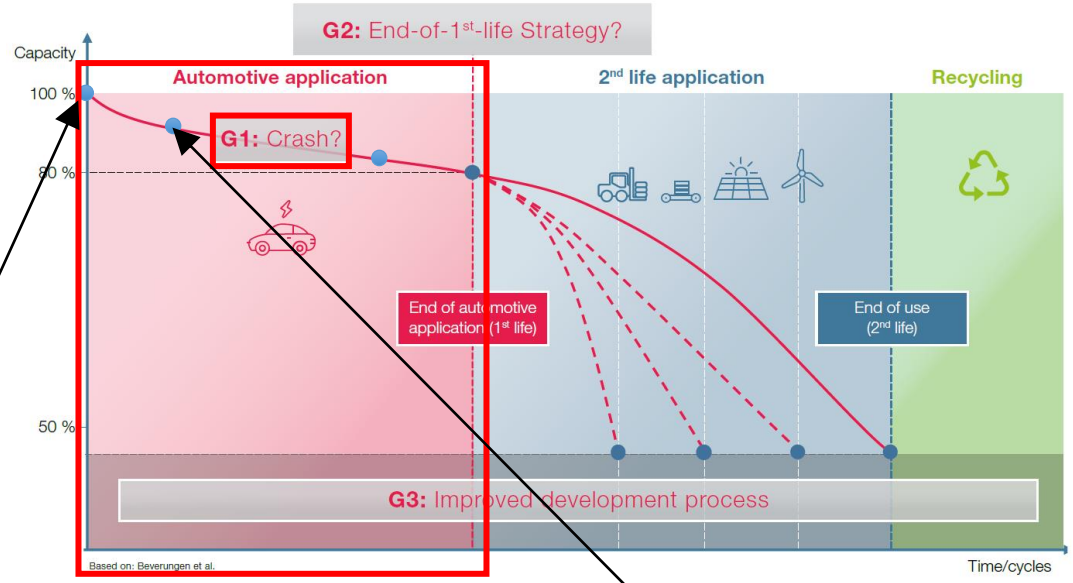
Safety of Aged Lithium-ion Batteries - Introduction

Is the battery of an EV still safe During the usage?

- Certification tests and safety assessment are done with new cars
- During usage battery is subject to electrochemical changes → Influence on safety?



Begin of Life:
Kilometers: 0km
Full charge cycles: 0
Age: 0

Current status:
Kilometers: 61.349km
Full charges cycles: ~195
Age:~ 3

Example: Car-Sharing Pool TU, Inffeldgasse

Safety of Aged Lithium-ion Batteries – Battery degradation

Known predominant ageing mechanisms:

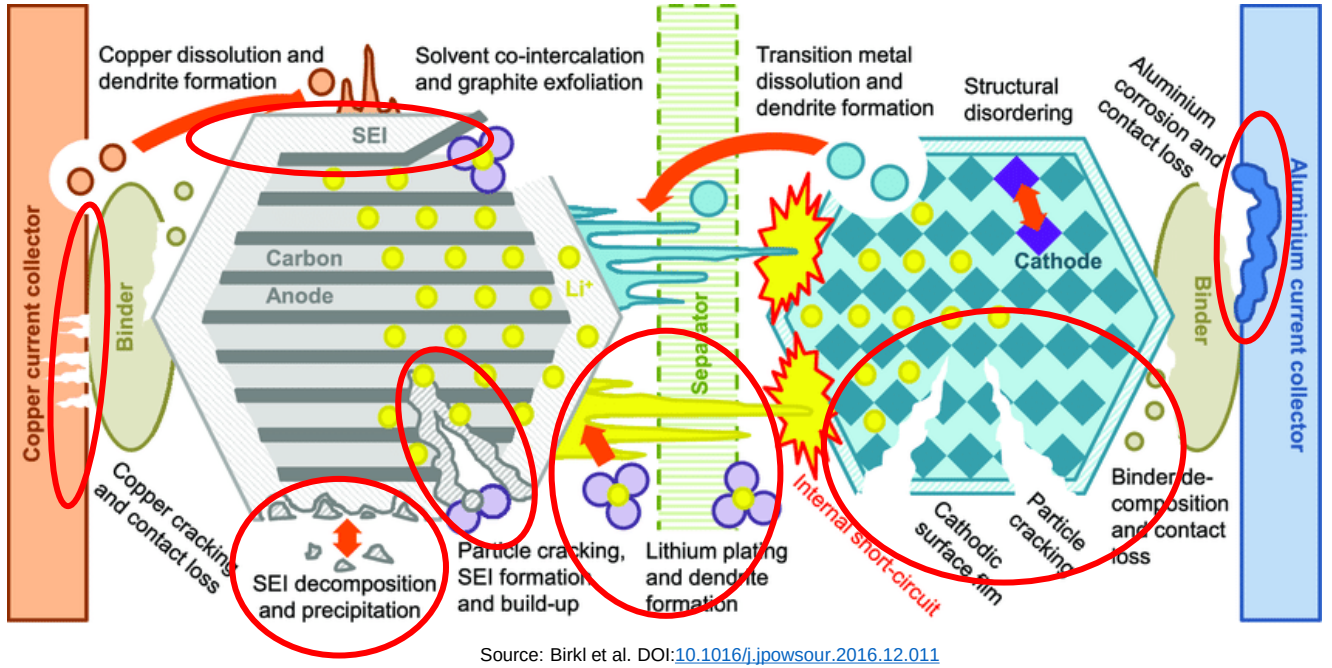
- Decomposition of electrolyte
- Electrode cracking and corrosion
- Lithium plating and dendrites formation

Main influencing factors:

- Application temperature
- Voltage limit used
- Charging (fast-charging) / discharging (driving)

Effects to battery:

- Capacity fade
- Power fade



Source: Birkl et al. DOI:10.1016/j.jpowsour.2016.12.011

Open questions:

- How is the safety of a cell affected during lifetime?
- Link between known ageing mechanisms and safety in crash?

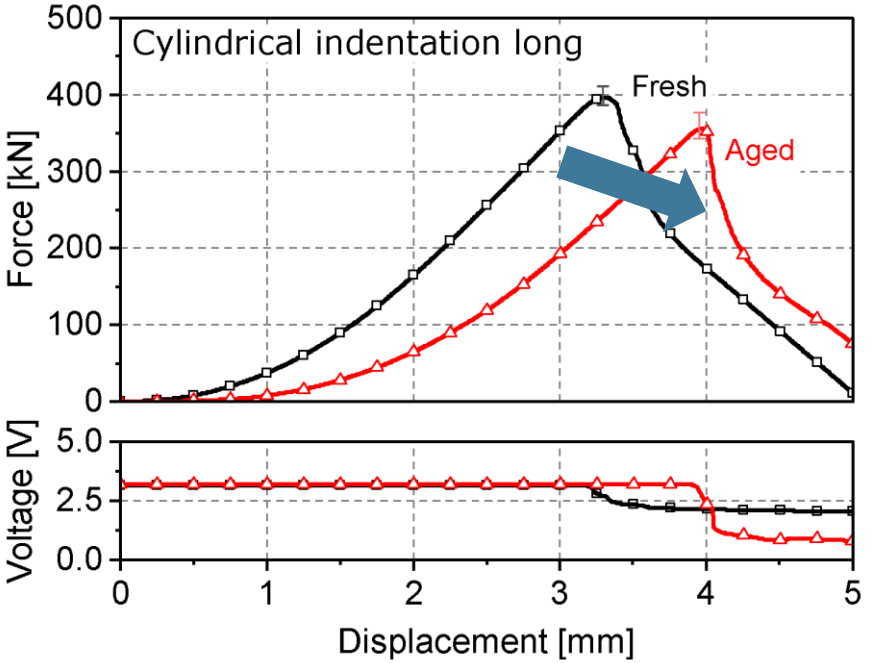
Safety of Aged Lithium-ion Batteries

What are safety relevant properties of a Li-Ion battery that can change over lifetime? Findings in SafeBattery and SafeLIB

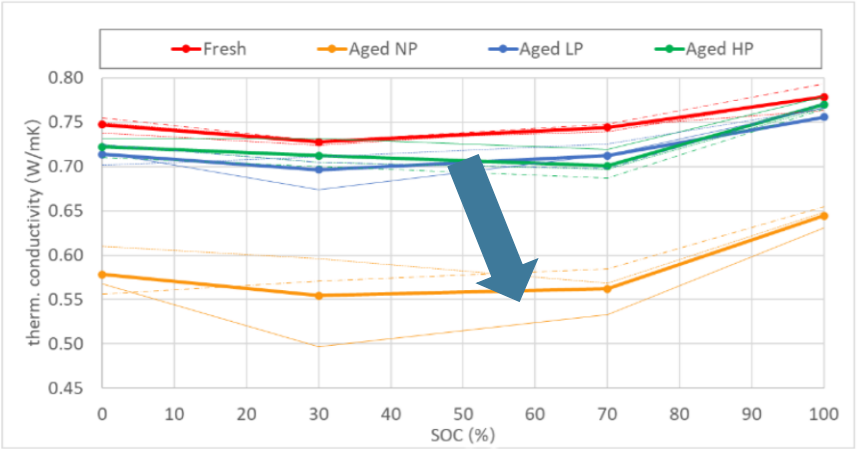
- Mechanical properties
- Thermal runaway behavior
- Electrical behavior
- Thermal conductivity

Knowledge gap:

- Which are ageing mechanisms that lead to a relevant change in properties?
- Which ageing mechanism has the most safety relevance?
- What are measurement methods that can indicate critical changes in battery properties? -> Monitoring



Source: Sprenger et al. https://doi.org/10.3390/batteries9020067



Source: Kovachev et al. https://doi.org/10.3390/batteries7030042

Safety of Aged Lithium-ion Batteries – Example

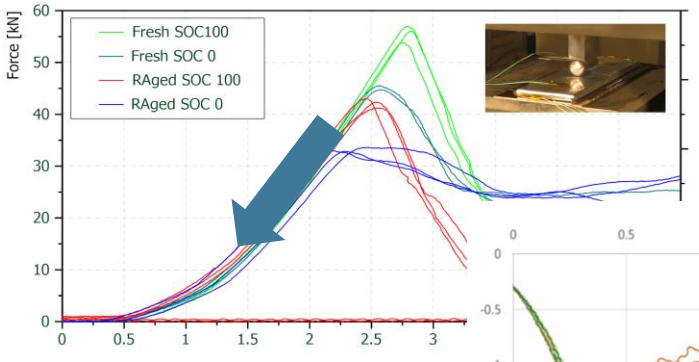
Approach for safety assessment based on <u>mechanical properties</u> of Li Ion cells

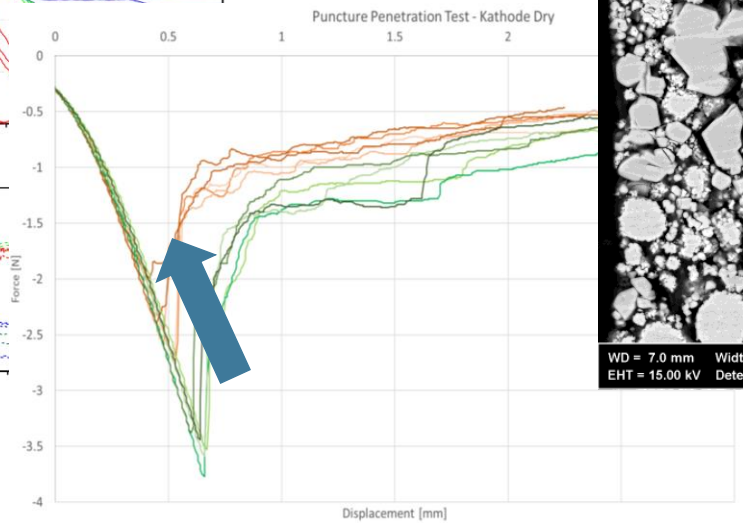
- Comparison of fresh and aged cell
- SoA EV Battery, 65Ah Pouch Cell
- 160.000km usage, 93% residual capacity

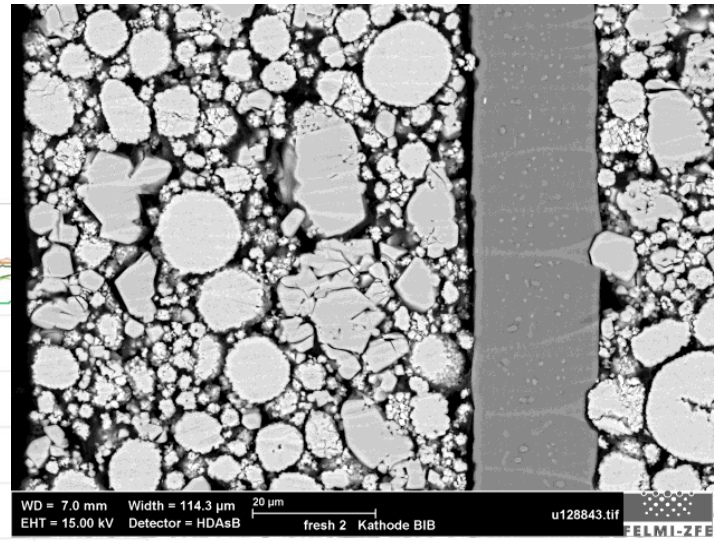
Cell level tests
- Quasi-static
- Dynamic

Component level tests
- Tensile
- Compression
- Puncture penetration

Microscopy and visual analysis
- SEM
- Micro CT







<u>Conclusion:</u>

- Safety changes with usage

<u>Outlook:</u>

- Further analysis needed
- Focus on specific degradation mechanisms
- Real vs. artificial aged cells

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