

Pressure as Lifetime Extender for Lithium-Ion Batteries Potentials and Challenges

How do machines from ZwickRoell support the research?

10/17/2023 Hendrik Laufen

Center for Ageing, Reliability and Lifetime Prediction of Electrochemical and Power Electronic Systems (CARL) CARL CARL CARL CARL CARL Center for Ageing, Reliability and Lifetime Prediction of Electrochemical and Power Electronic Systems



Agenda







Fundamentals Batteries & Pressure









→ Consequently, the electrode and thus the cell change its volume





Influence of pressure on Lithium-Ion Batteries & Pressure













Which pressure is the optimum in terms of performance and lifetime?





How to Determine the Optimum Pressure Optimum Pressure

Batteries & Pressure

Pressure as Optimum Pressure

Lifetime

Extender

Potentials & Challenges





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How to Determine the Optimum Pressure **Optimum Pressure**

Batteries & Pressure

Pressure as Optimum Pressure **Extender**

Lifetime

Potentials & Challenges







Test Bench Pressure as Lifetime Extender

Cell (Kokam 11.6Ah SLPB065070180) is centered between aluminum (2618-T61) plates

□ Maximum expansion:

1.72µm (0.1MPa) - 17.2µm (1MPa)

- Two compression pads (CPD) are used as buffer layers
 - □ BISCO® HT-840 Silicone Foam 4.8mm

Pressure sensors (Tekscan FlexiForce A201) are embedded in lower aluminum plate

Electronics for sensor data reading





Compression Pad in zwickiLine Pressure as Lifetime Extender

Batteries &
PressureOptimum
PressurePressure as
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ExtenderPotentials &
Challenges

Minimum rest phase of 14 h @100 kPa

Criteria:

■ Drift ≤ 20 µm/h

- Maximum expected irreversible cell swelling until end of life of 1 mm
 Tested with 5 µm/min
- Resulting stiffness of < 0.06 MPa mm⁻¹
 - Less than 15% of lowest module stiffness in Deich et al.^[1]

[1] Deich et al. ; doi: <u>10.1016/j.jpowsour.2021.230163</u>



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Compression Procedure in zwickiLine

Pressure as Lifetime Extender

Batteries & Optimum Pressure Pressure Ex	etime ender Potentials & Challenges
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Cyclic Lifetime Extension by Pressure Pressure as Lifetime Extender

- The cycle lifetime (1C/1C 100% DOD, 25°C) can be prolonged by more than 120%
- Capacity fade can be subdivided into 3 phases
 - Initial aging phase
 - Linear Degradation
 - Transition into sudden death in terms of remaining capacity
- Quasi-static pressure (100 kPa) extends phase II by more than 250%
- Quasi-static pressure prevents transition to phase III in the SOH region of the nonpressure-loaded cell (0 kPa)
- Possible shift of phase III towards lower SOH



Optimum

Pressure

Batteries &

Pressure



Pressure as

Lifetime

Extender



Potentials &

Challenges

100 kPa

0 kPa

Challenges Potentials & Challenges

 Every chemistry within a battery cell and its properties on electrode level can have an impact on the optimum pressure range





Testing for each chemistry, temperature and cell format is required to understand its correlation with pressure



Potentials Potentials & Challenges

Optimum Pressure Pressure as Lifetime Extender

Potentials & Challenges

Kappa 50 DS in combination with battery cycler and EIS-device

Available at ISEA in CARL beginning from January 2024

[1] https://www.zwickroell.com/de/

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- Parallel testing of up to 5 cells at one temperature
 - Reducing required time for identifying optimal pressure range for different chemistries and cell formats

Looking for industry project partners to acquire BMBF funding

Interested?







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Thank you for your attention



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