IN-OPERANDO CHARACTERISATION OF VOLUME CHANGES AND PRESSURE EVOLUTION IN POUCH CELLS

Quality Testing – Characterisation techniques for battery cells

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Smarter E Industry Days/ Qualitiy Testing

Live from Freiburg, 22.07.2021

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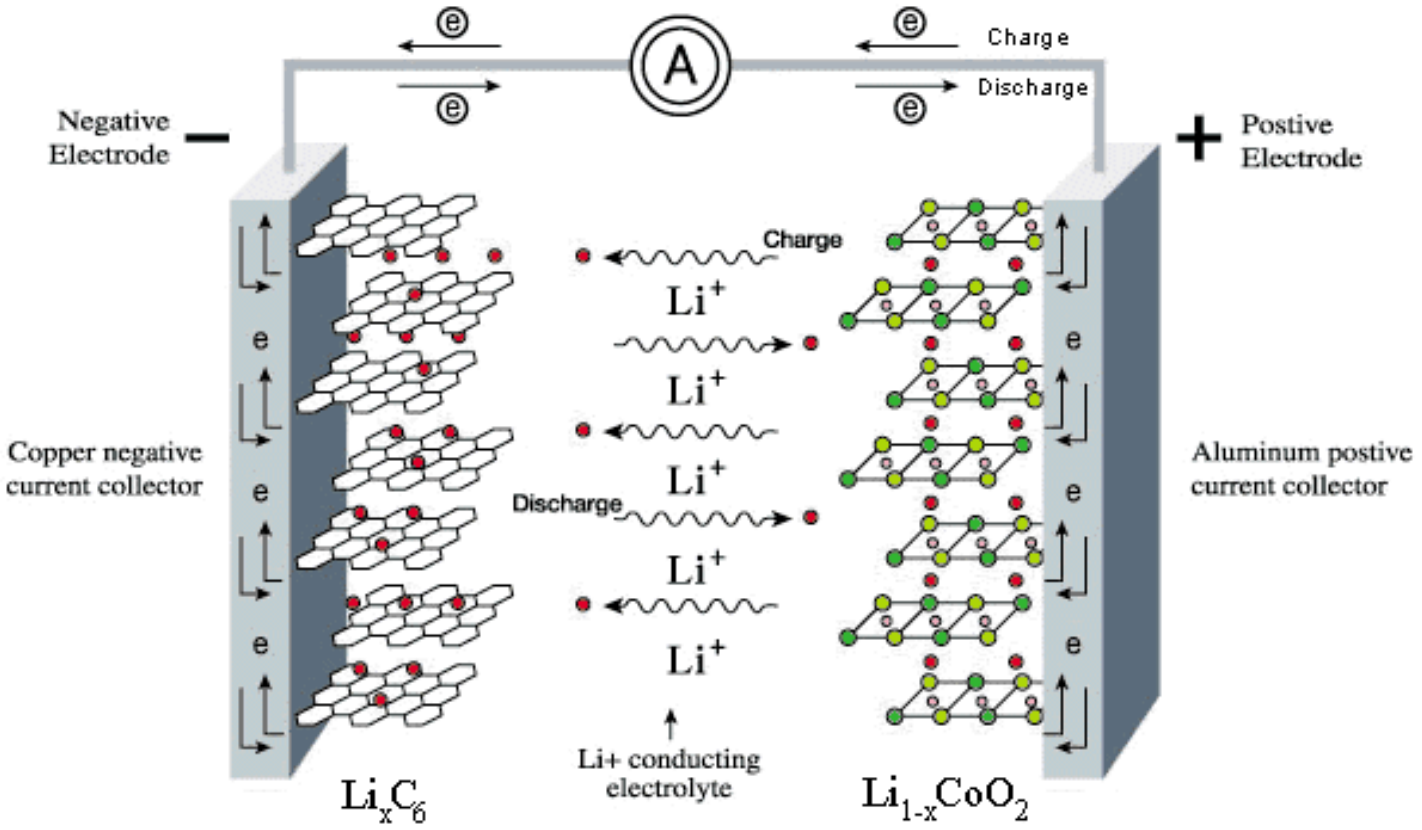
In-operando characterisation of volume changes and pressure evolution in pouch cells

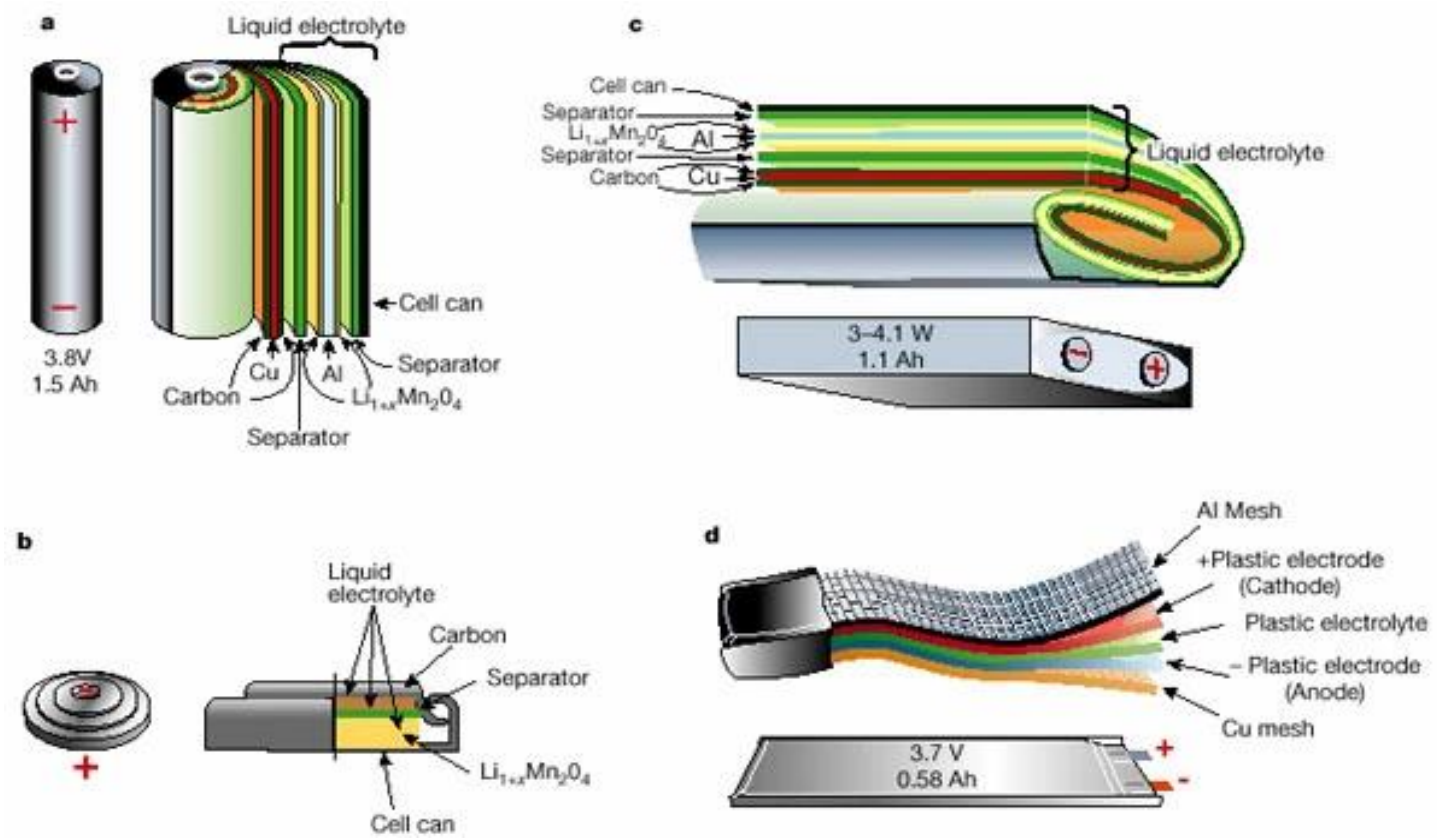
A first close-up – electrochemical Principle



Fraunhofer ICT: http://www1.ict.fraunhofer.de/deutsch/scope/ae/Libattery.gif (21/07/2021)

In-operando characterisation of volume changes and pressure evolution in pouch cells

A first close-up – Cell designs



J.-M. Tarascon & M. Armand (2001): https://doi.org/10.1038/35104644, Figure 4

In-operando characterisation of volume changes and pressure evolution in pouch cells

Volume changes in pouch cells

- **Formation** – Solid electrolyte interface (SEI)
- **Reversibel** expansion – Intercalation
- **Irreversible** expansion – Aging

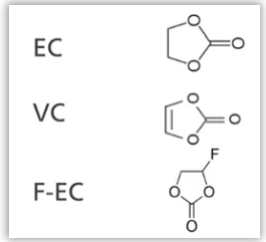
In-operando characterisation of volume changes and pressure evolution in pouch cells

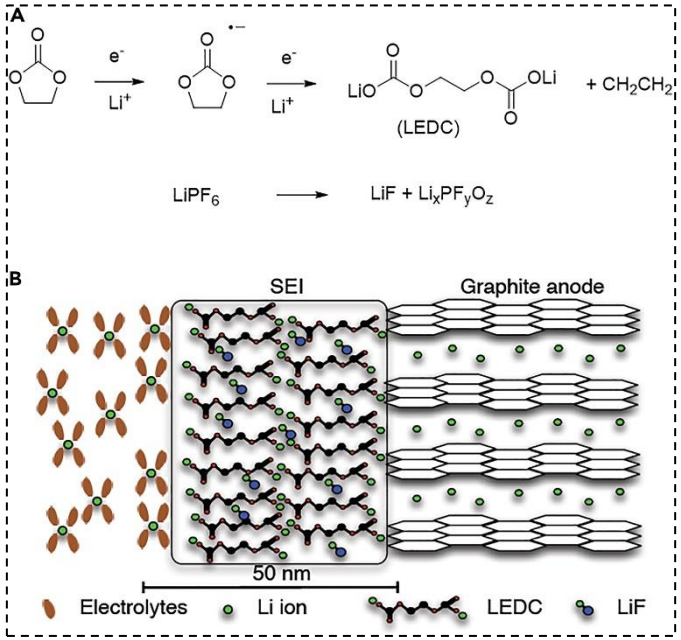
Volume changes in pouch cells

- **Formation – Solid electrolyte interface**
- Reversibel expansion – intercalation
- Irreversible expansion – aging

1,5 – 2 µm

SEI forming additives in electrolyte:





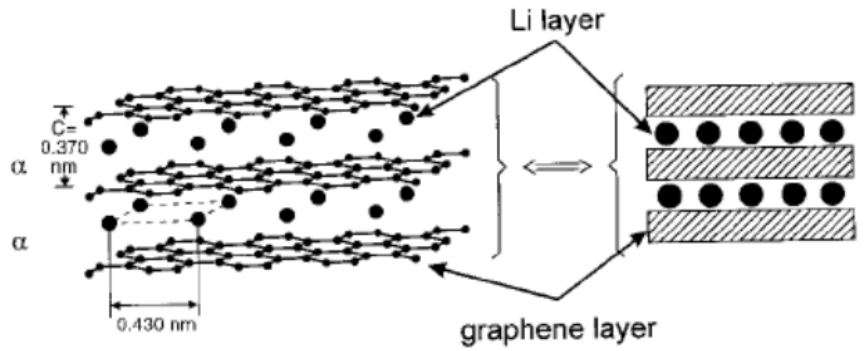
Heiskanen et al. (2019): https://ars.els-cdn.com/content/image/1-s2.0-S2542435119304210-gr1_lrg.jpg, Figure 1

In-operando characterisation of volume changes and pressure evolution in pouch cells

Volume changes in pouch cells

- Formation – Solid electrolyte interface
- **Reversibel expansion – intercalation**
- Irreversible expansion – aging

80 – 150 µm



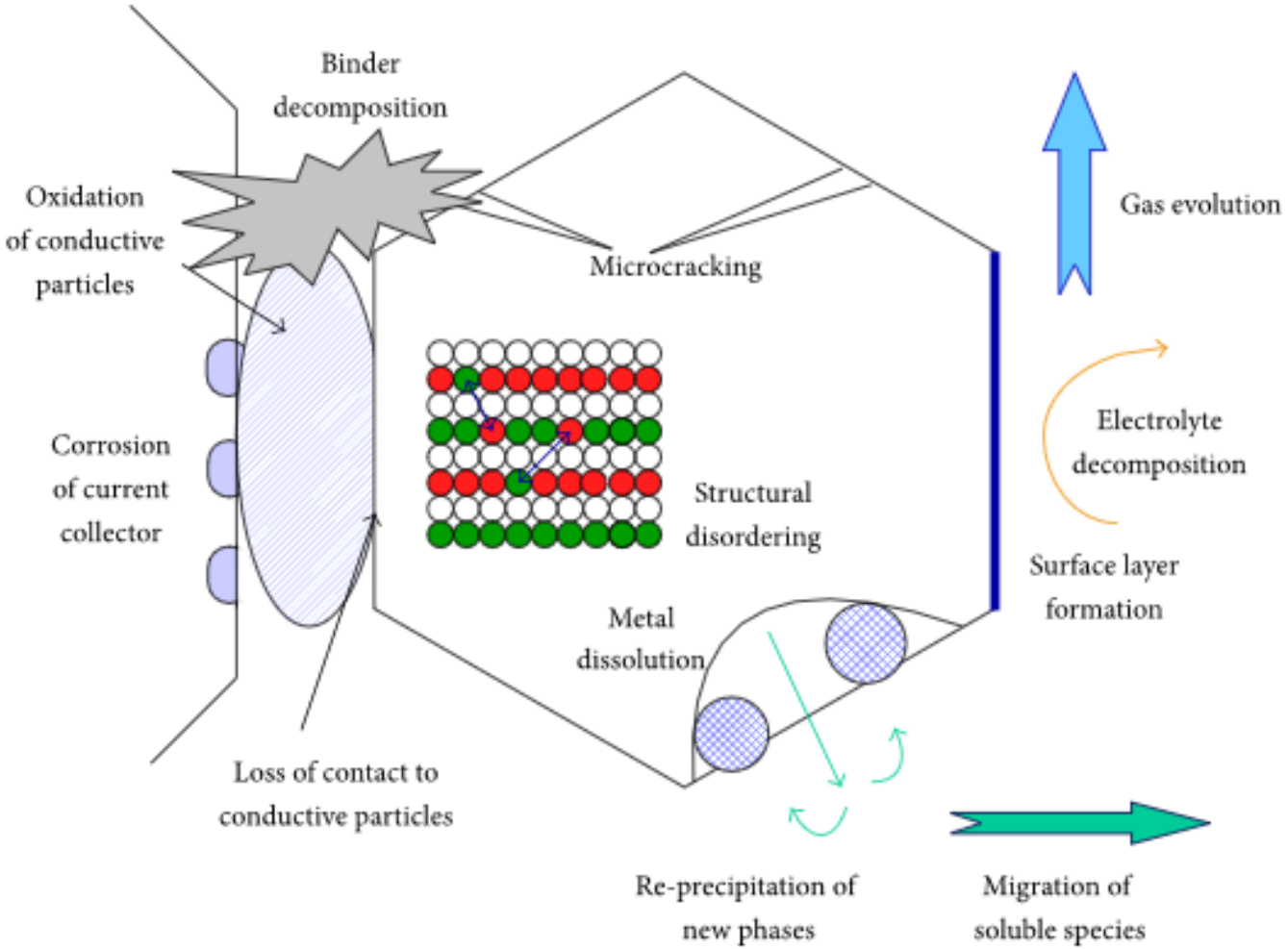
Winter et al. (1998): https://doi.org/10.1002/(SICI)1521-4095(199807)10:10<725::AID-ADMA725>3.0.CO;2-Z, Figure 6

In-operando characterisation of volume changes and pressure evolution in pouch cells

Volume changes in pouch cells

- Formation – Solid electrolyte interface
- Reversibel expansion – intercalation
- **Irreversible expansion – aging**

5 – 500 µm



Lin et al. (2015): https://doi.org/10.1155/2015/104673, Figure 1

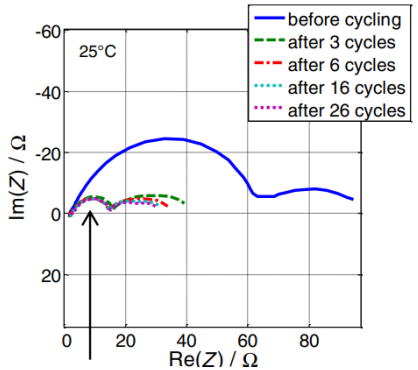
In-operando characterisation of volume changes and pressure evolution in pouch cells

Characterisation methods – quality testing

measuring overlapping effects

calorimetry

EIS

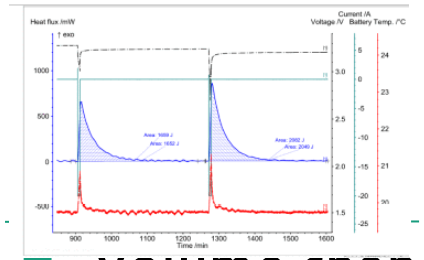


Ecker et al. (2015): https://doi.org/10.1149/2.0551509jes, Figure A1 (b)

mainly **electrical** quality testing

ohmic resistance

pulse response methods



Millet et al. (2017): 10.1109/EVER.2017.7935932, Figure 5

- **volume change** investigations
- **Pressure evolution** investigations

physical quality testing

measuring local effects

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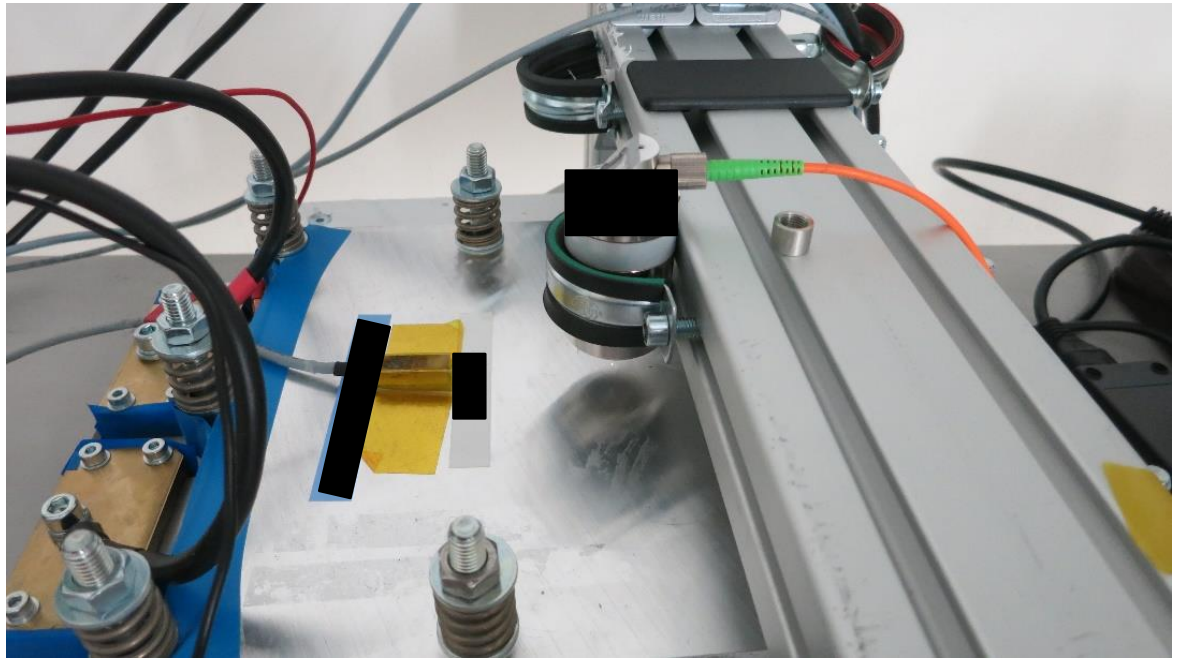
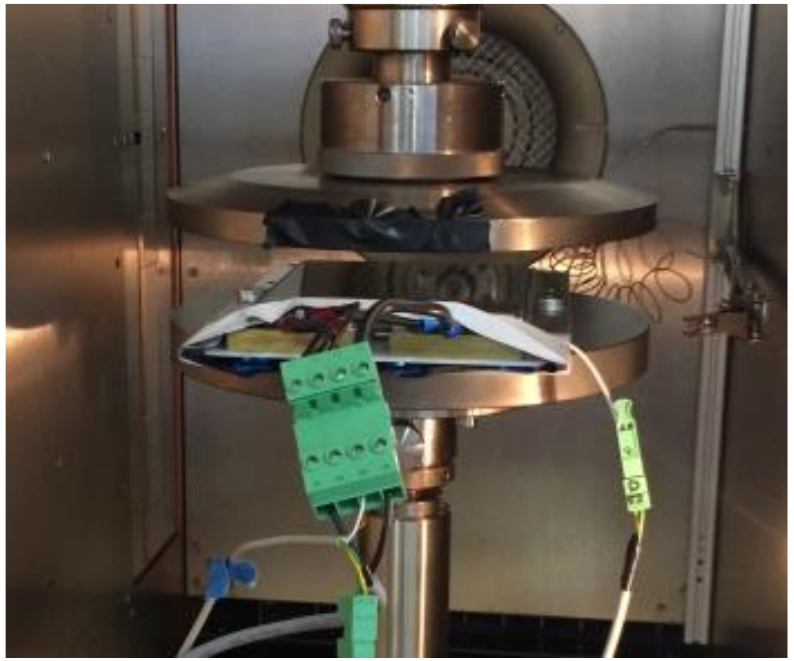
In-operando characterisation of volume changes and pressure evolution in pouch cells

Characterisation methods – quality testing

- **Volume change** investigations
  - Local measurements possible
  - Contactless



- **Pressure evolution** investigations
  - Distinct material strain
  - Closer to applications



In-operando characterisation of volume changes and pressure evolution in pouch cells

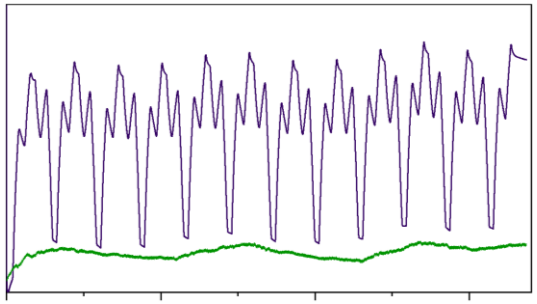
Volume change investigation

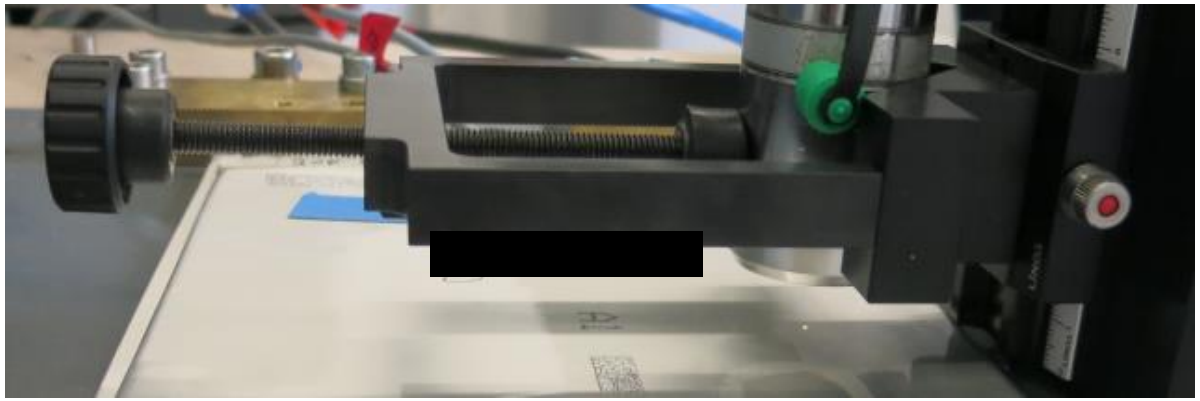
Techniques:

- Light/ laser-based sensors

- Scanning vs. global measurements
- Local measurements

} During cycling





Characteristics:

- Local electrode characteristics
- Temperature dependency

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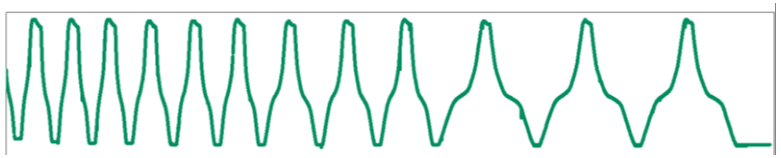
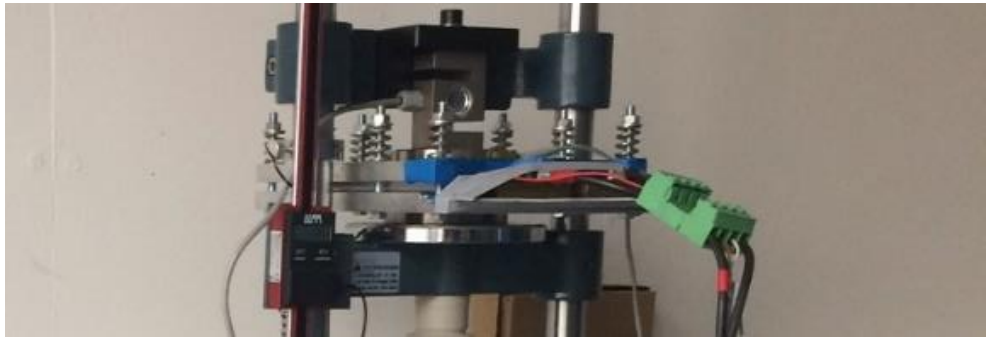
Pressure evolution investigation

Techniques:

- Mechanical press / matrix pressure sensors



- Global *and* local measurements simultaneously
- Locally limited measurements



Characteristics:

- global electrode material characteristics
- Detailed intercalation mechanism

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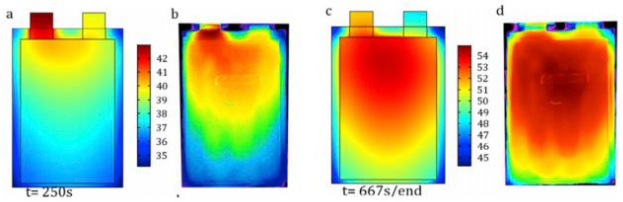
Goals of research – value for industry

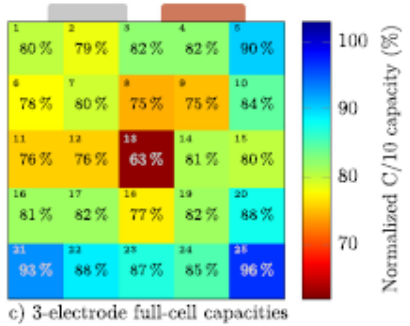
- **Volume change** investigations
- **Pressure evolution** investigations

Knowledge gain of aging and aging distribution



Tomaszewska et al. (2019): https://doi.org/10.1016/j.etran.2019.100011, Figure 3

Knowledge transfer to applications



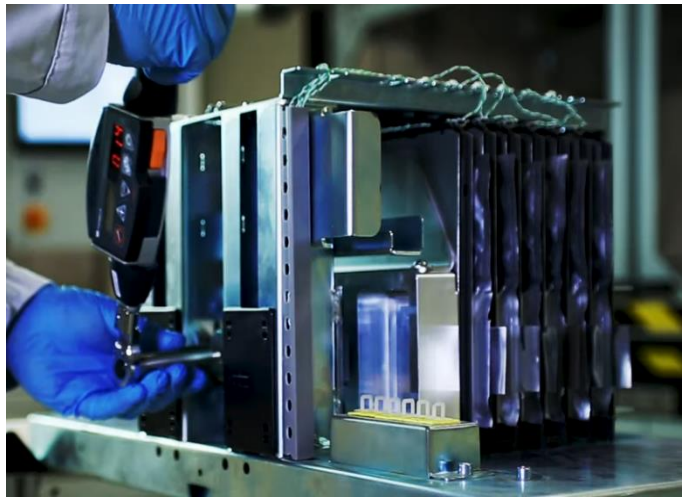
Sieg et al. (2020): https://doi.org/10.1016/j.est.2020.101582, Figure 5c)

Homogeneous, reduced battery aging

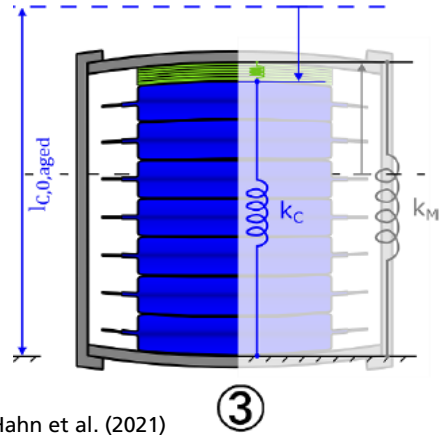
In-operando characterisation of volume changes and pressure evolution in pouch cells

Application transfer for all battery systems

- **Pack** installation → initial pressure
- **Silicon** – volume changes of up to 300%
- **All-Solid-State Batteries** – pressure for reduction of ohmic resistance and contact preservation

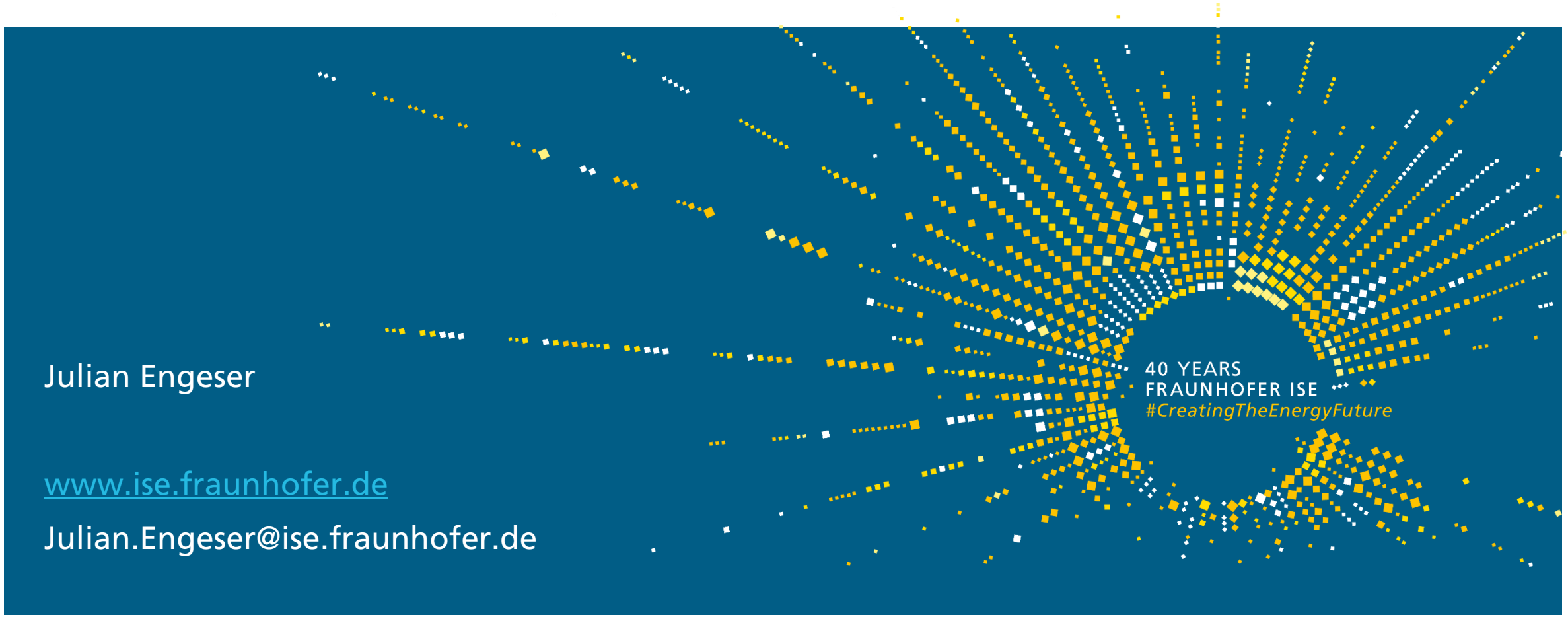


VOLKSWAGEN AG: https://www.youtube.com/watch?v=AE2Yogxgwb8 (2:04), (21/07/2021)



Hahn et al. (2021)
https://doi.org/10.1016/j.est.2021.102517, Figure 5a)

Thank You for Your Attention!



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