Willkommen
Welcome
Bienvenue

Strategic Focus Area
Advanced Manufacturing

SOL4BAT - Fabrication & diagnostics of stable solid-solid interfaces for next-generation Li-ion batteries

Project start: 1 July 2021

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Empa
Materials Science and Technology

ETH zürich

PAUL SCHERRER INSTITUT
PSI

Focus: Solid-state Li batteries (Gen4) (impact on Gen3, too)

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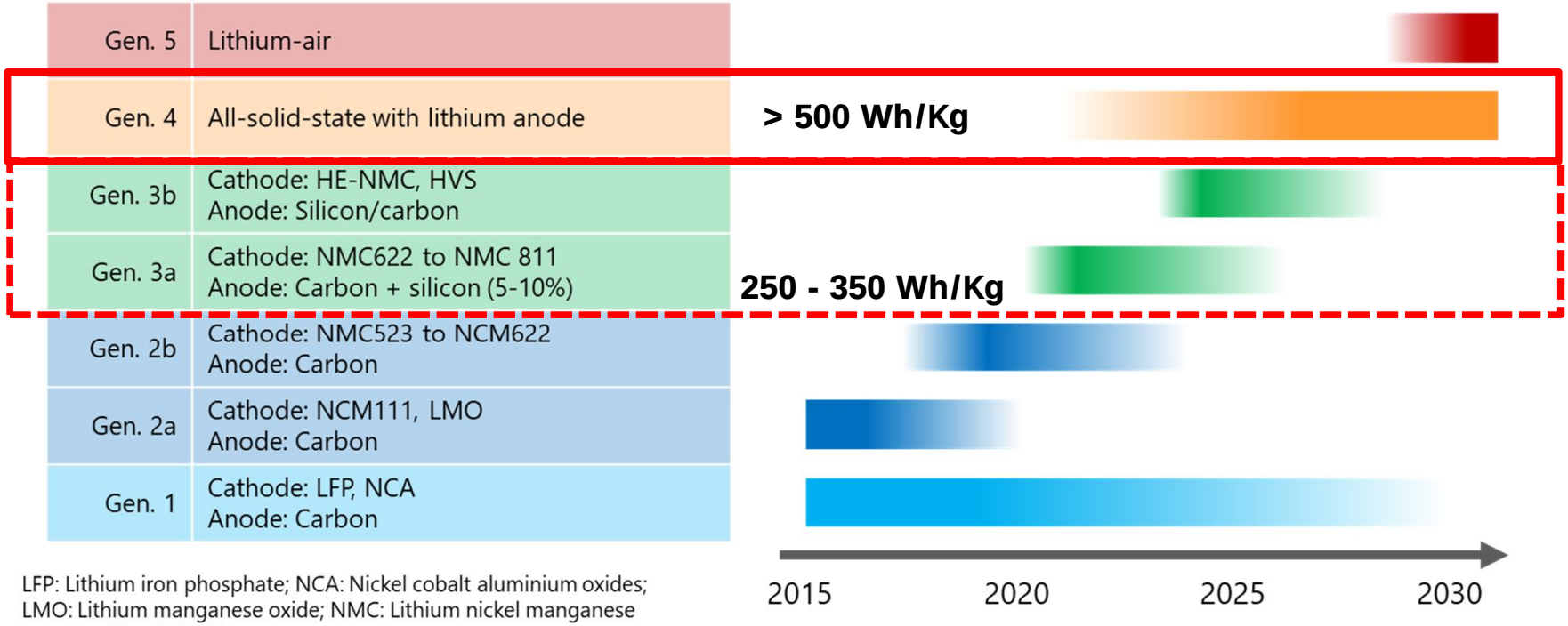
Gen. 5	Lithium-air
Gen. 4	All-solid-state with lithium anode
Gen. 3b	Cathode: HE-NMC, HVS Anode: Silicon/carbon
Gen. 3a	Cathode: NMC622 to NMC 811 Anode: Carbon + silicon (5-10%)
Gen. 2b	Cathode: NMC523 to NCM622 Anode: Carbon
Gen. 2a	Cathode: NCM111, LMO Anode: Carbon
Gen. 1	Cathode: LFP, NCA Anode: Carbon



LFP: Lithium iron phosphate; NCA: Nickel cobalt aluminium oxides; LMO: Lithium manganese oxide; NMC: Lithium nickel manganese cobalt oxide; HVS: High-voltage spinel

Roadmap integrierte Zell-und Batterieproduktion Deutschland, 2016

Challenge: solid-solid interface

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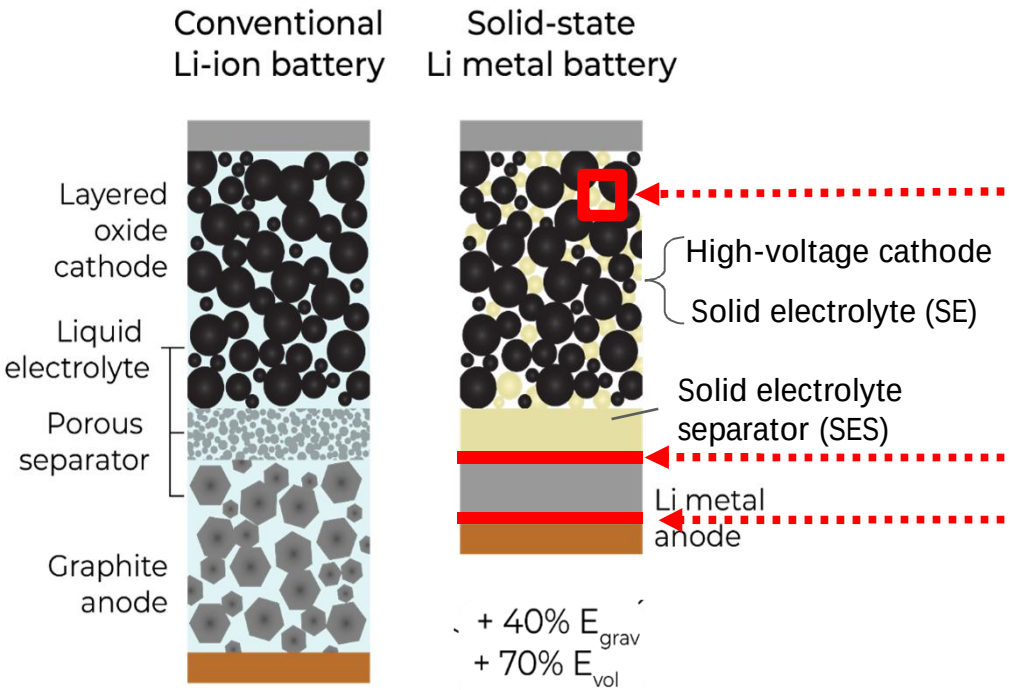

Challenges of solid-solid interfaces:

1. How to fabricate solid-solid interfaces with intimate contact?
2. How to maintain stable interface during operation (cycling)?

Approach

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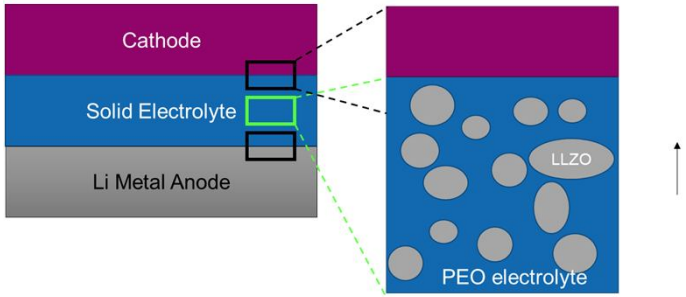
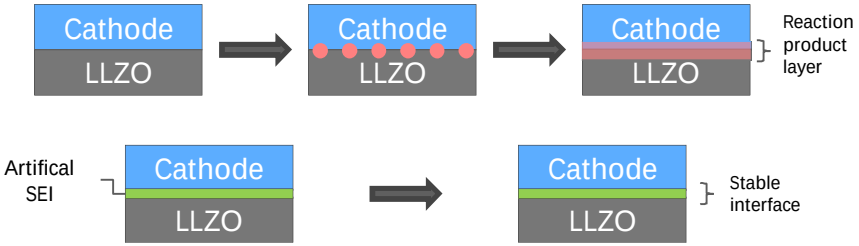
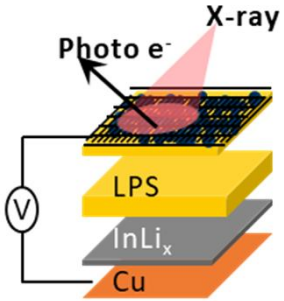
Strategy I: «soft» polymer interlayer

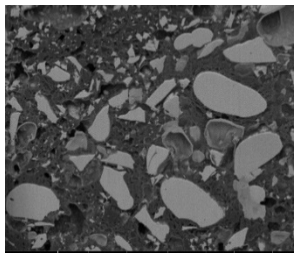


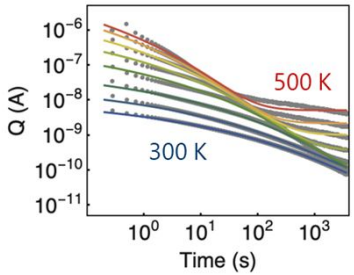
Strategy II: «hard» oxide interlayer



III. Advanced characterization to visualize internal interfaces and detect SSI degradation







«soft» polymer interlayers (ETH)

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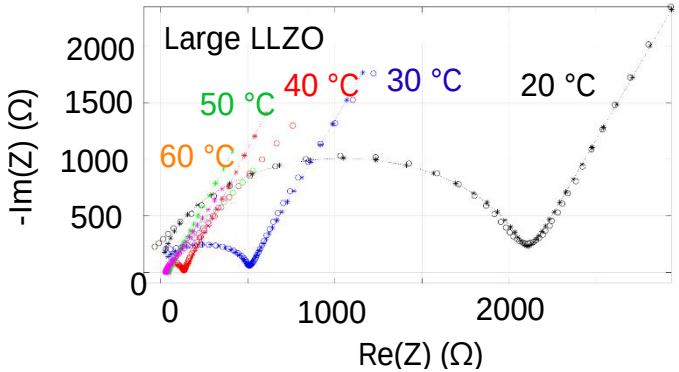
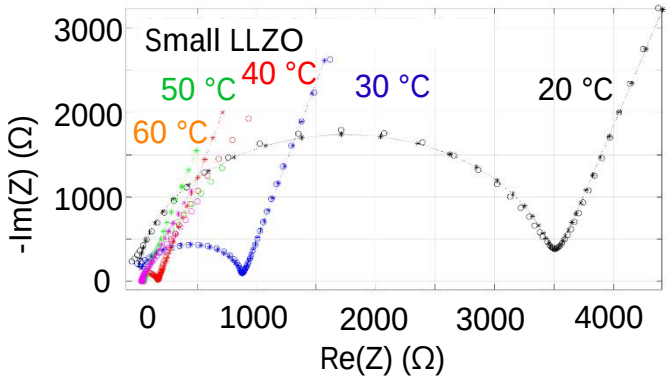
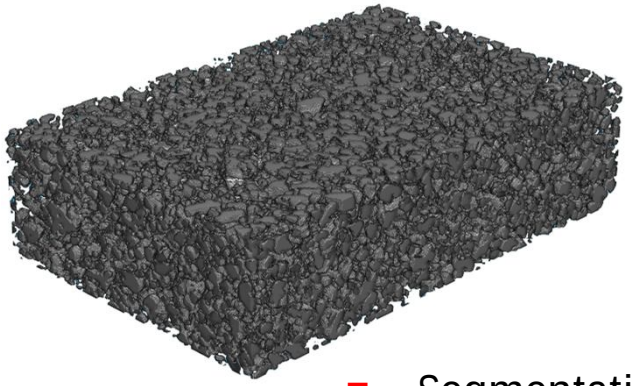
- Electrochemical characterization

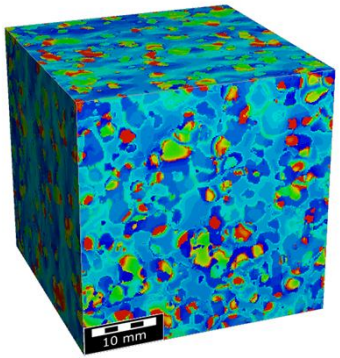




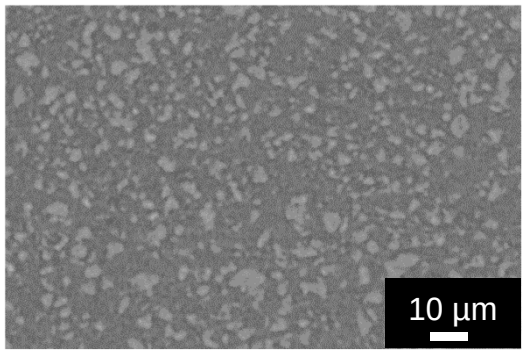
- X-ray tomography

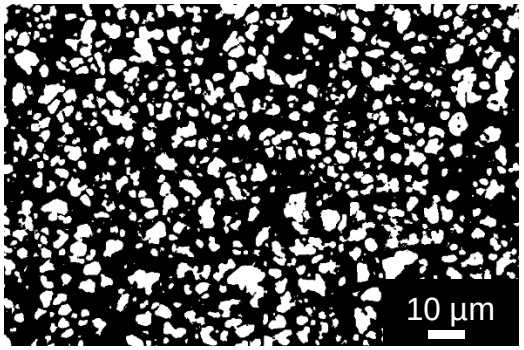


- Transport simulation



- Segmentation





«hard» oxide interlayers (Empa)

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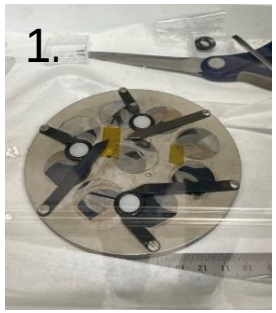
1. Coating @ cathode/electrolyte interface
2. Deposition of $LiCoO_2$
3. Co-sintering of the stack
4. Evaporation of Li metall as anode
5. Testing the battery in custom setup

1.



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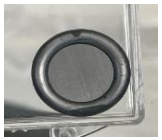


3.

4.

5.

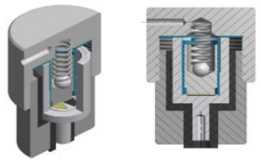
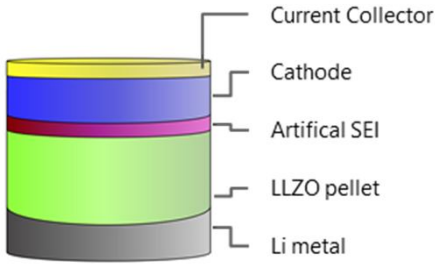
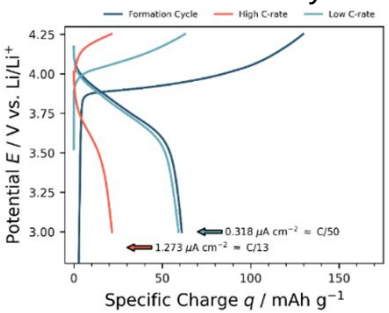


Figure 5.1.: Representation of a PSI standard cell.

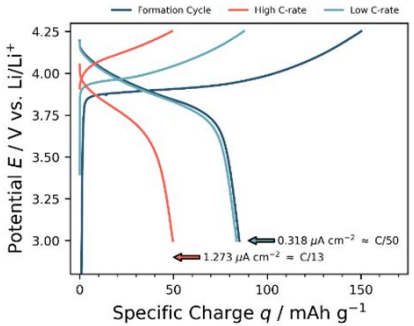


without interlayer



Improvement o battery discharge profiles by applying an artificial SEI

With Li-Nb-O interlayers at the LCO/LLZO interface



XPS, XAS, and XPEEM *operando* spectroscopy

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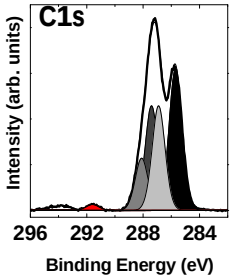
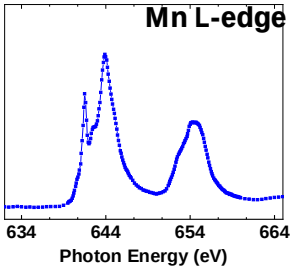
In house

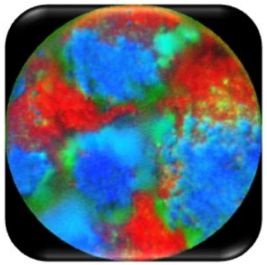
XPS

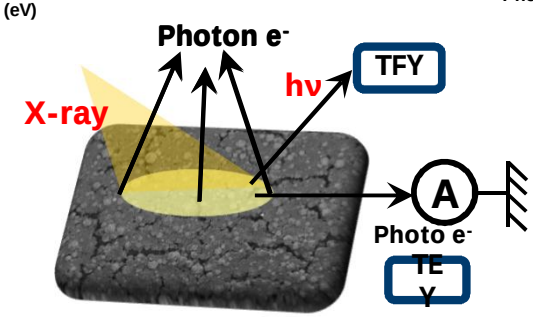


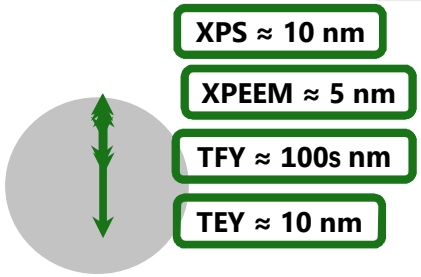
Synchrotron Swiss Light Source (SLS)

XAS - TEY | XAS - TFY | XPEEM









***Operando* XPS & XAS cell**

***Operando* XPEEM cell**

Operando characterization – Bulk & thin ASSB

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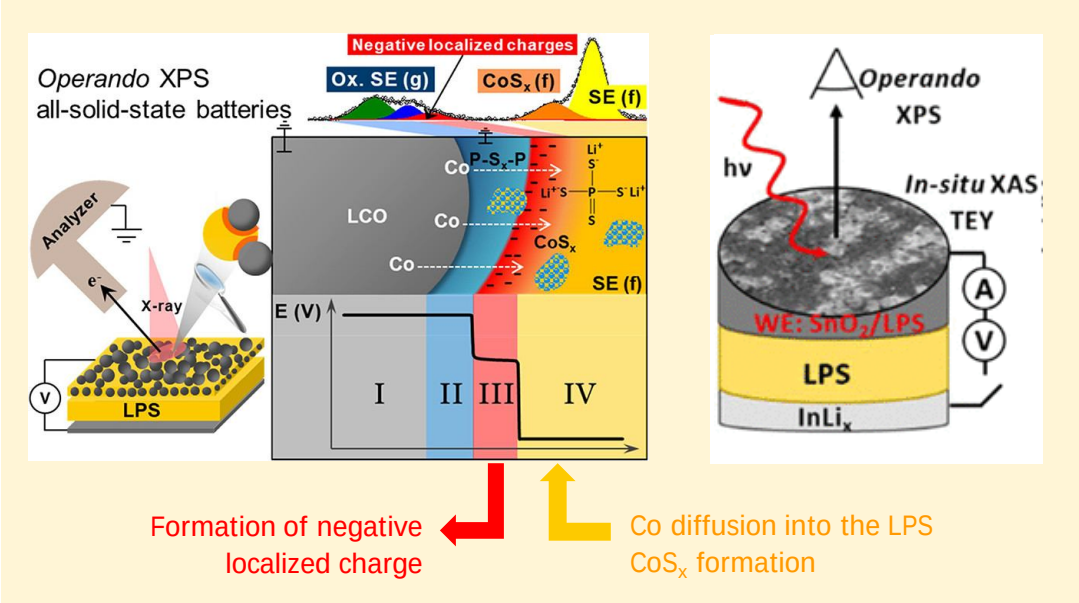
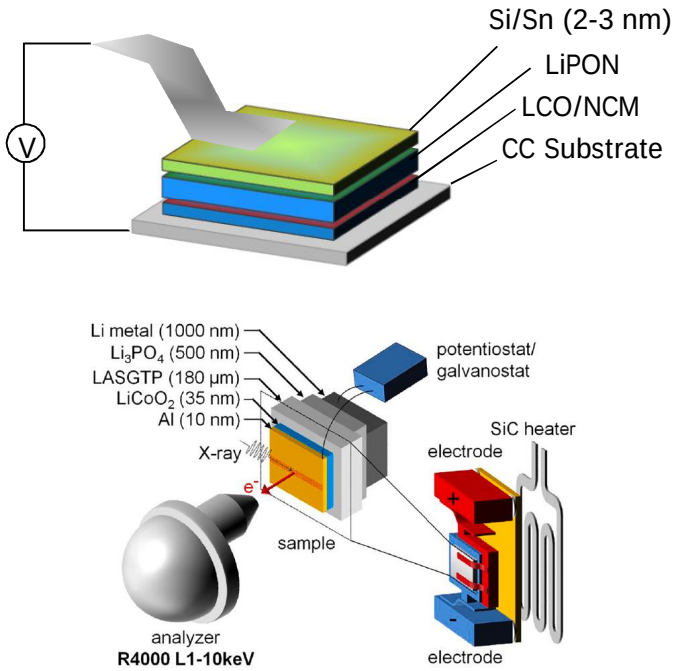
Bulk type ASSB



Thin films ASSB



Electrochemistry Communications 118 (2020) 106790

Outlook

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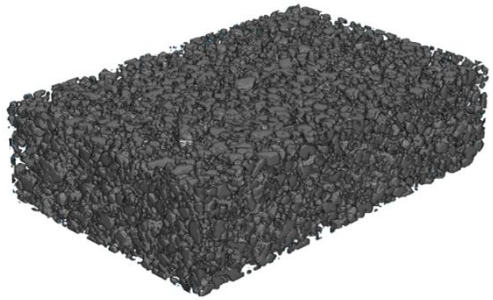
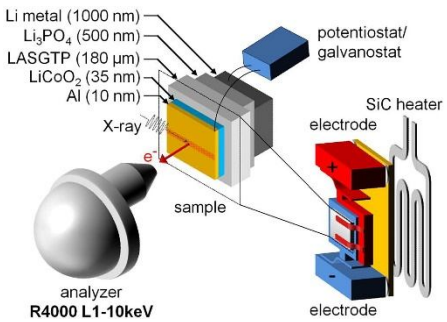
- **“Soft” interlayers:** LLZO:PEO composite electrolyte 3D structural analysis and ion charge transfer simulations



- **“Hard” interlayer:** identify the most promising Li-Me-oxide interlayers as artificial SEI to LLZO electrolyte using Electrochemical Impedance Spectroscopy

- **Advanced characterization:** identify decomposition products at the interface using XAS at synchrotron (beamtime)



People

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