

# Advanced characterization and digitalized design loops as catalysts for the efficient development of Lithium-SPAN Batteries for Aerospace Applications

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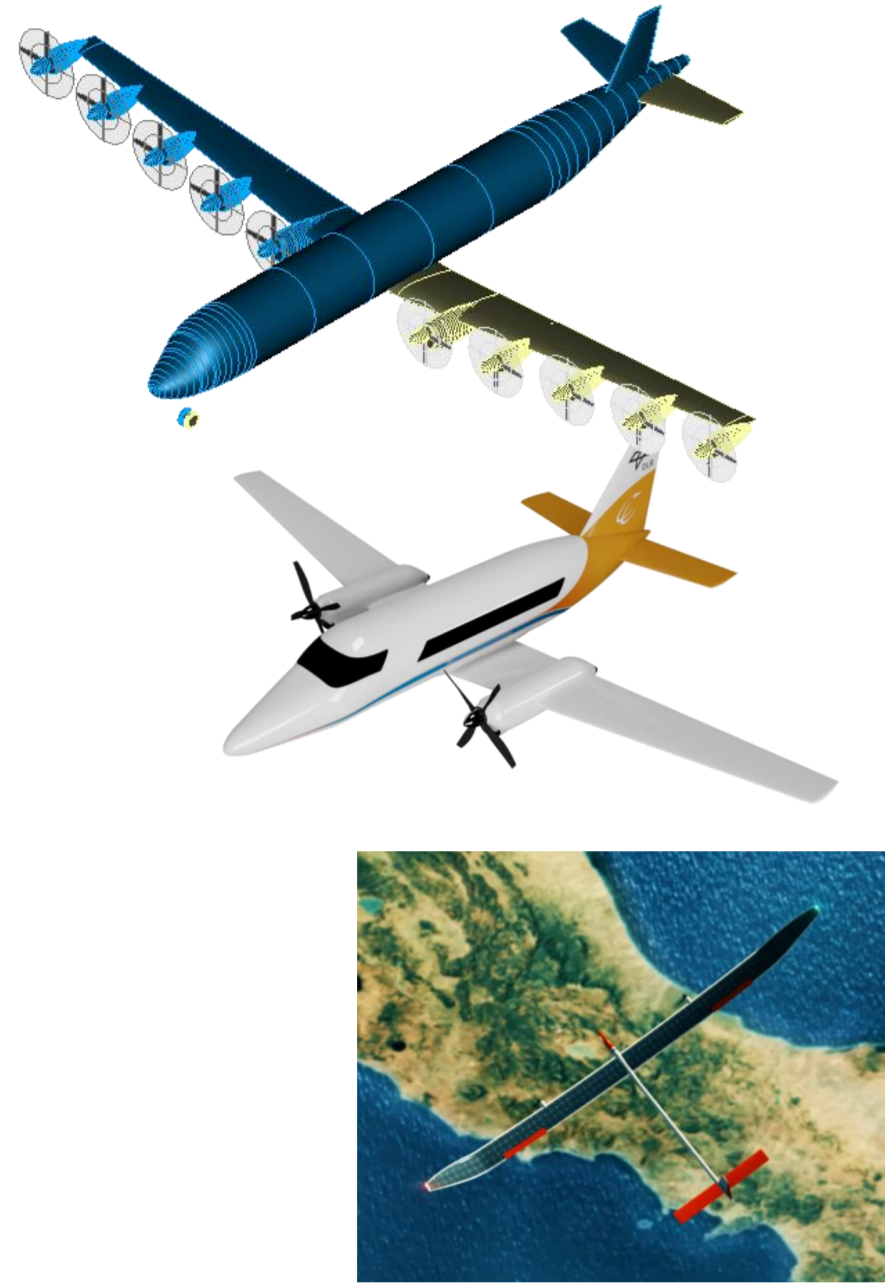
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## Motivation



Parameter	DLR D70 PHEA	DLR E19	LEO satellite	DLR HAP	eVTOL drone
Spec. Energy (Wh/kg)	450	>250	>250	>300	>250
Spec. Power (W/kg)	1200	>690	>65	>250	>1000
Charg. time (min)	40-50	>40-50	>60	>600	-
Cycle life	3000	>1000	>12000	>350	>400

Tap the full potential of a promising SPAN cell developed within the BMFTR funded project SulForFlight (No. 03XP0491)  
→ Better performance & aging to enable aerospace electrification!



## Development of Li-SPAN batteries

1. Optimized Chemistry
  2. Optimized Processing
- Accelerated by advanced characterization and simulation



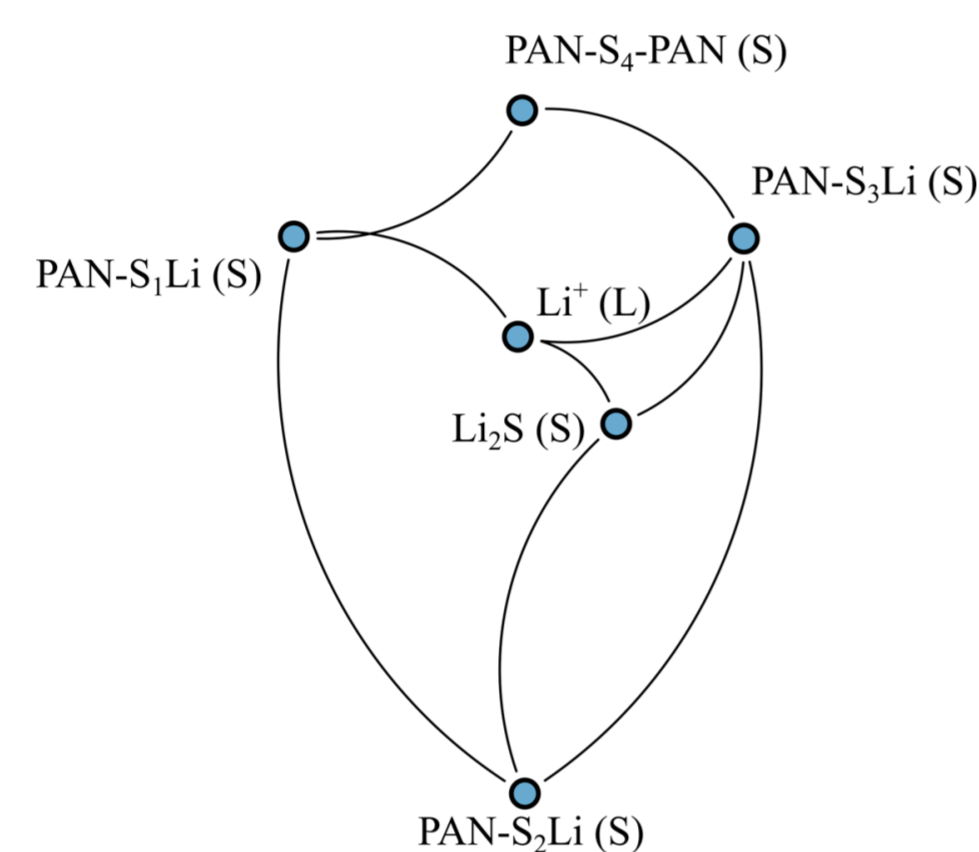
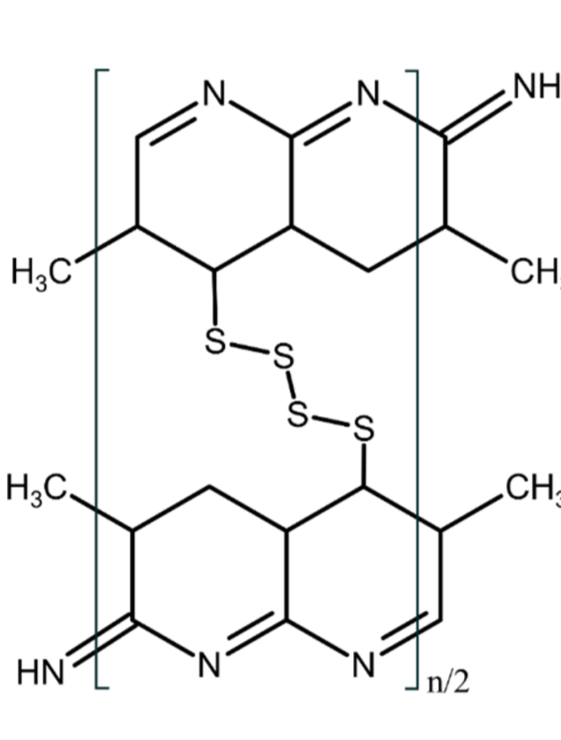
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## Methods & Results

### Advanced characterization

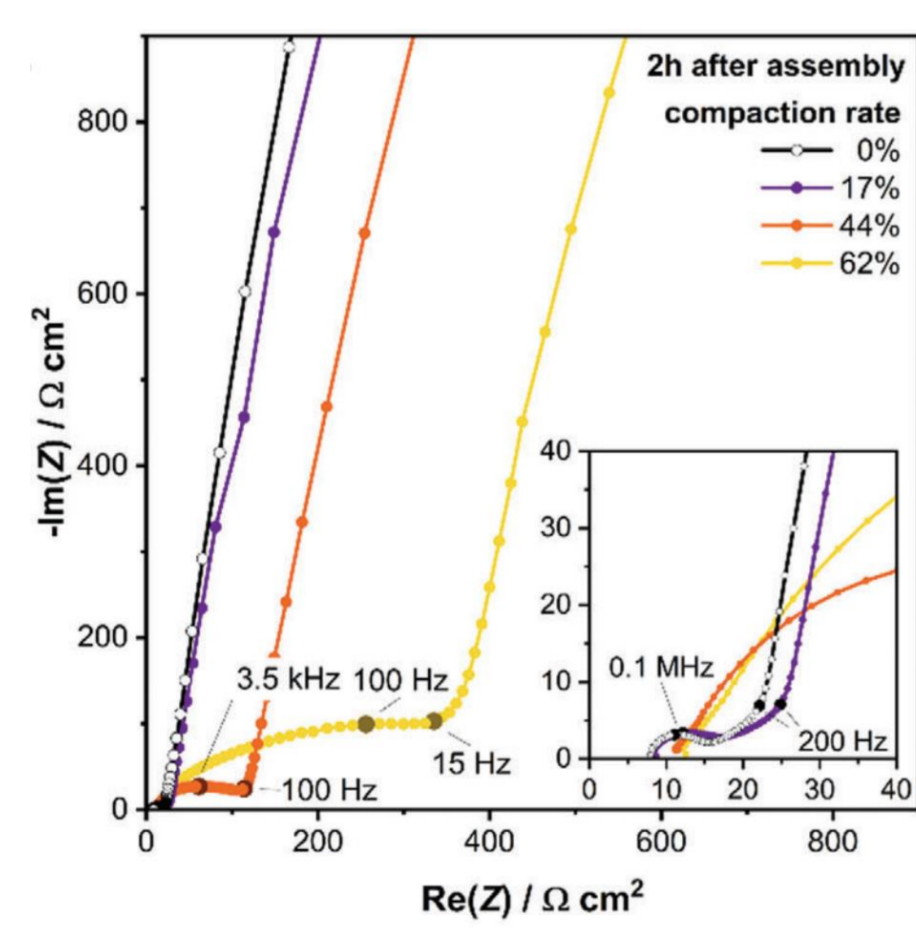
- Electrochemical characterization and operando analytics to understand mechanisms and limiting processes in Li-SPAN batteries
- SPAN reaction scheme adapted from Simanjuntak et al. (2024)

#### Structural formula of SPAN

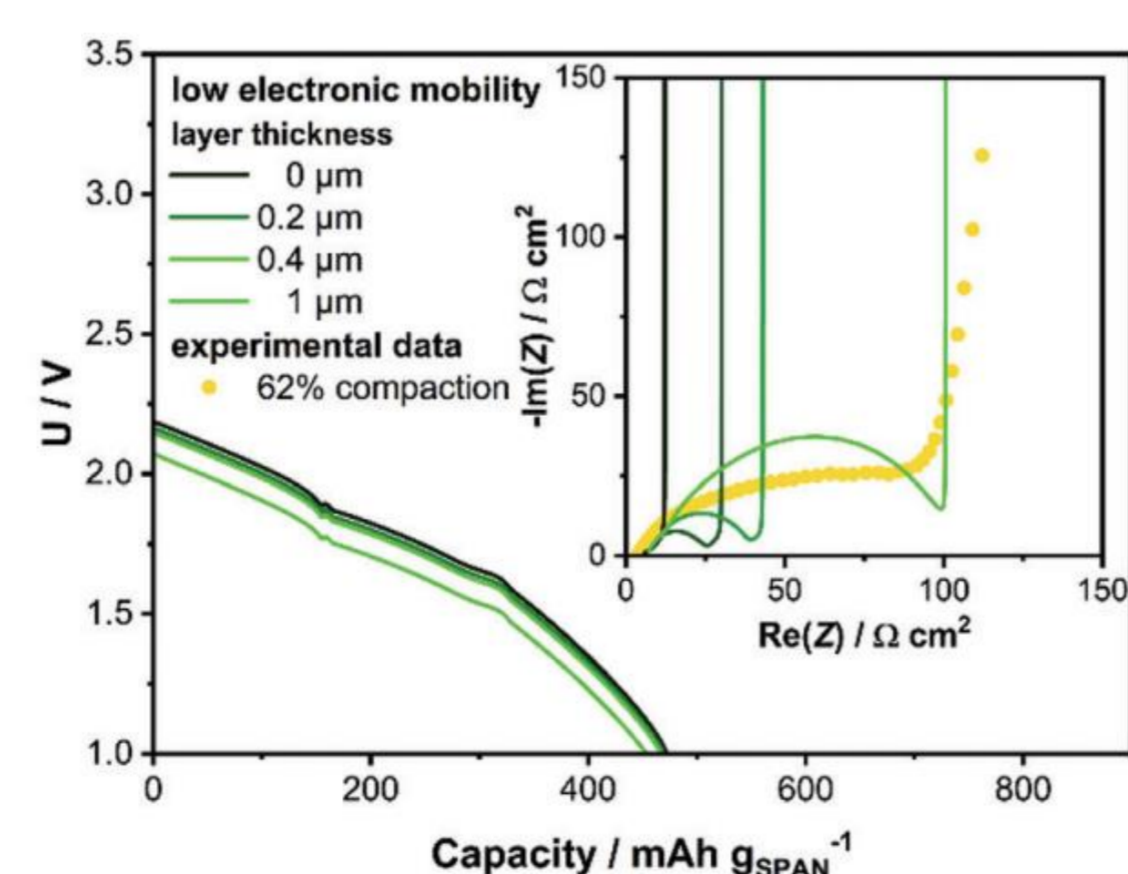
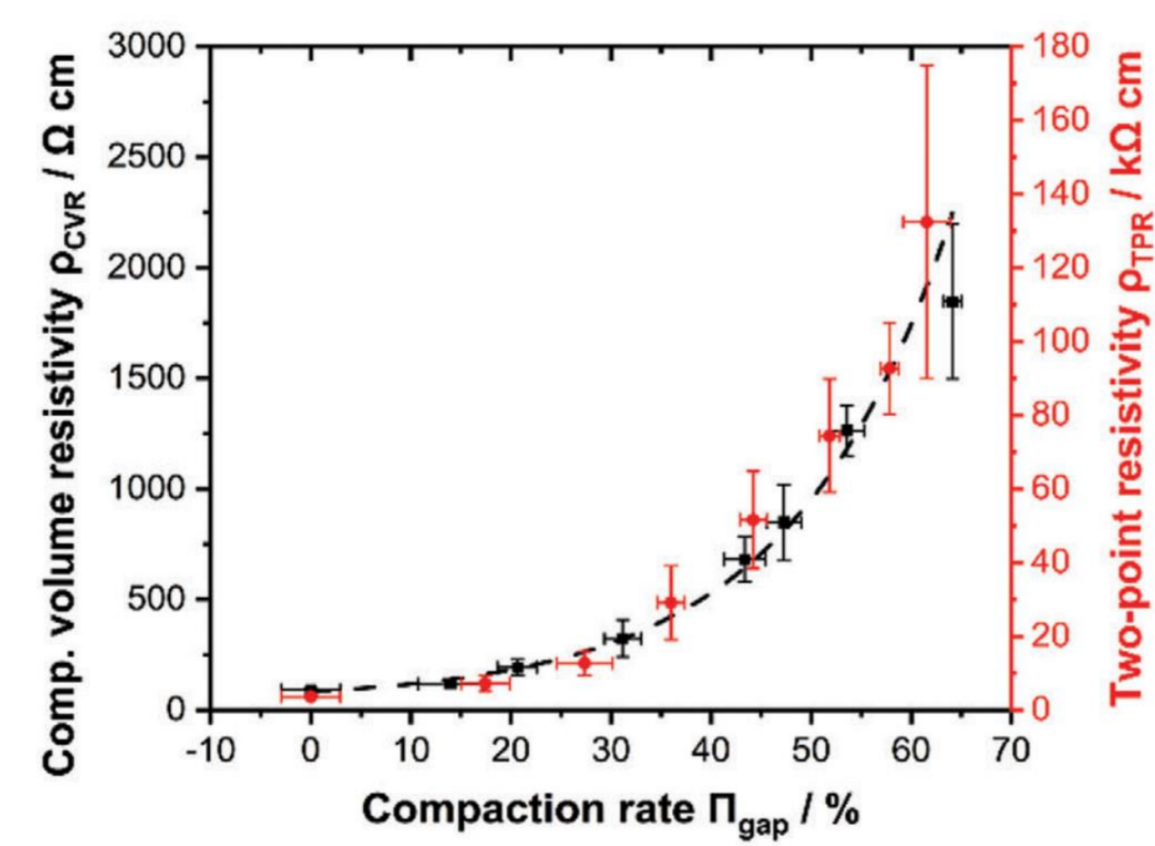


- Calendering impacts conductive networks and cycle life of Li-SPAN batteries. Coating and calendaring studies for SPAN electrode with 3.5 mAh/cm<sup>2</sup> performed at iPAT TU Braunschweig (Gerle et al. 2025)

### Spring-Back effect during calendaring impacts conductive networks

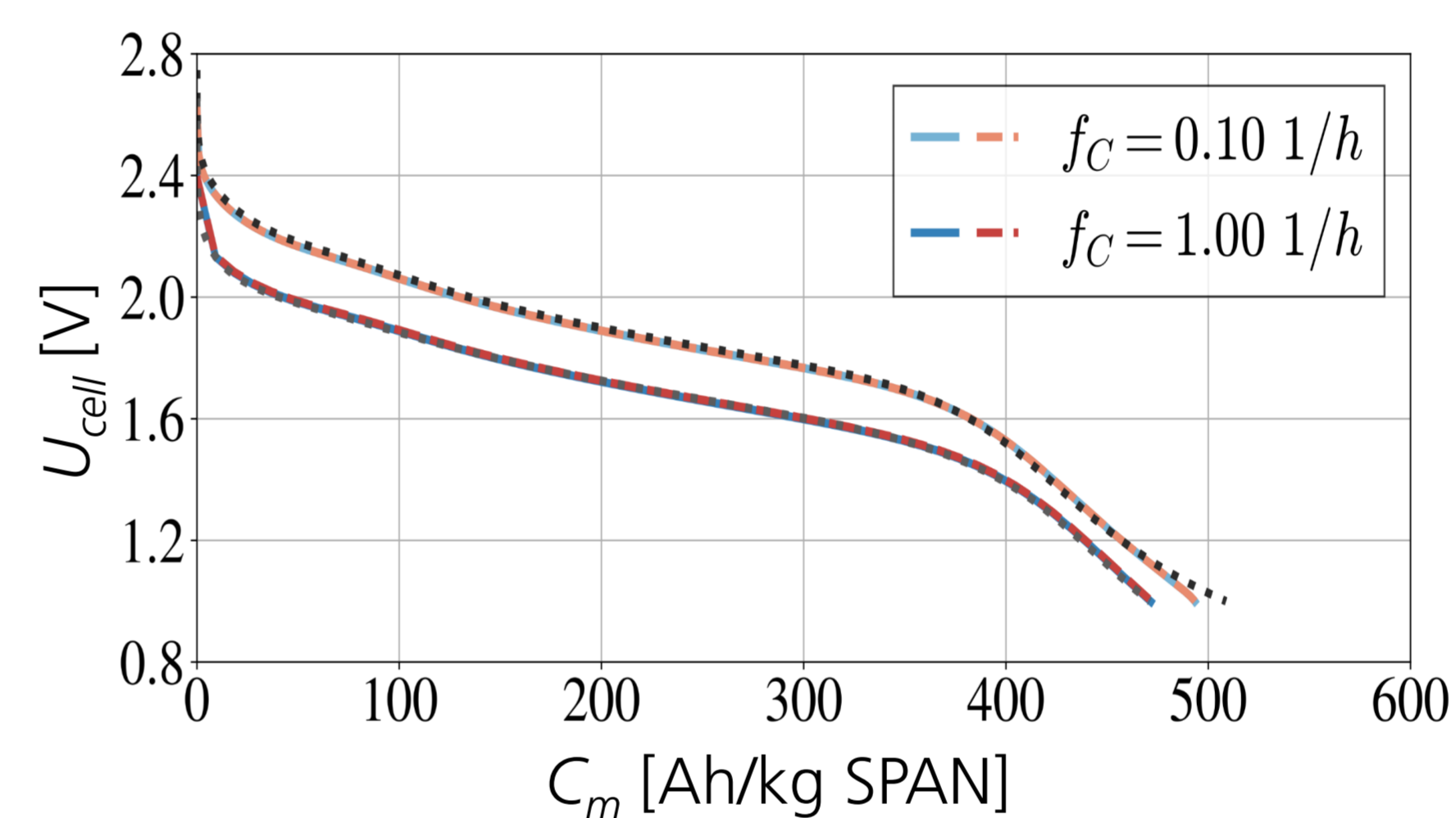


Effect detectable in symmetric impedance spectra and reproduced by simulations



### Model development

- Model calibration based on experimental pouch cell data provided by Fraunhofer IWS (grey) and a fully homogenized 1D model (red) assuming species diffusion dominant scaling conditions

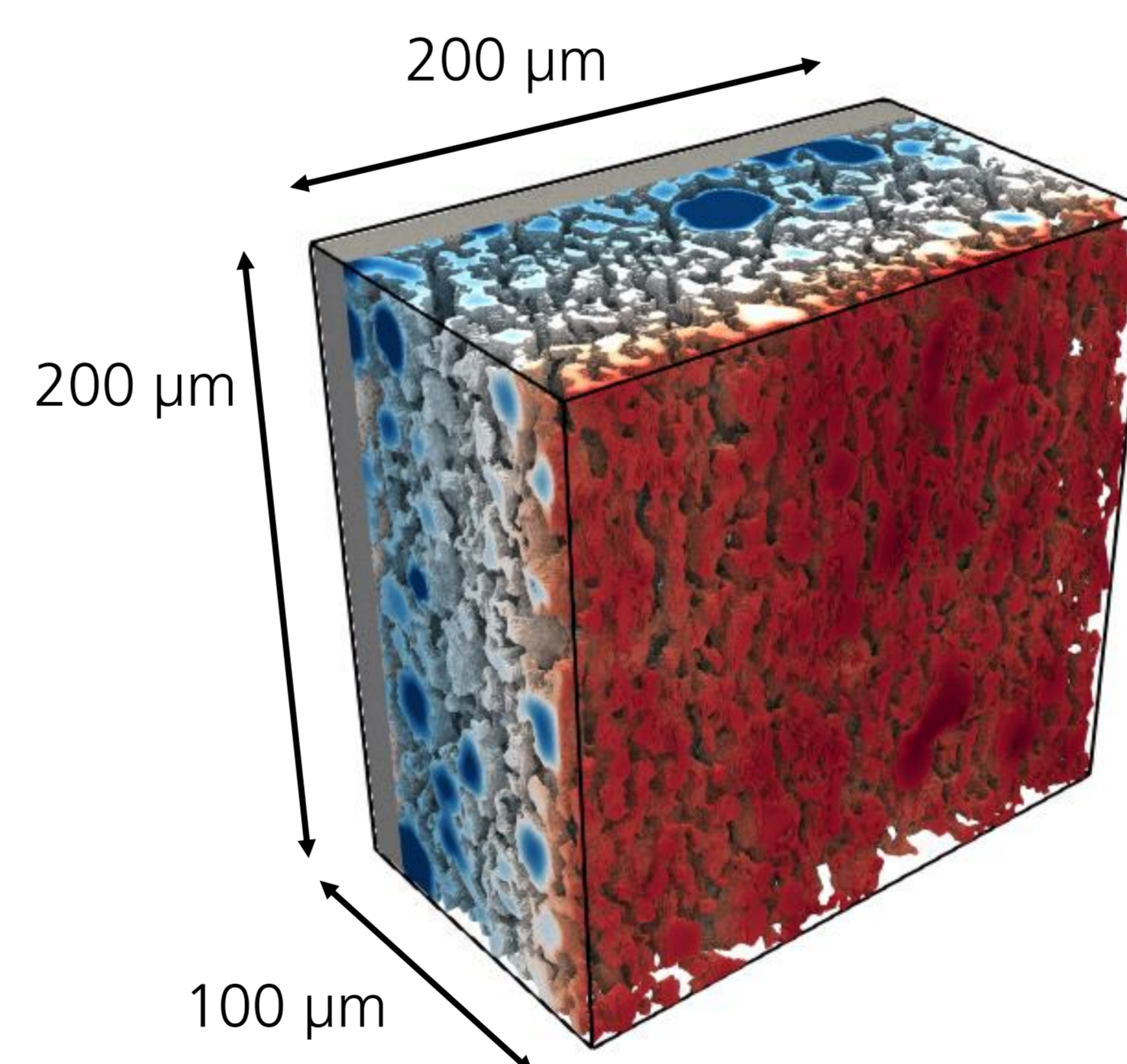


Firedrake



arXiv Preprint

- Simulations were repeated with a 3D scale-resolved model (blue) using structural information from a CT scan with resolution of 0.6 μm  
→ Relevant for global deviations at higher currents and aging effects!
- A full discharge simulation with a large 3D scale-resolved model (120 Mio. degrees of freedom) was performed at  $f_c = 1$  1/h using 1536 cores



Tomography data courtesy of Steffen Rehse (DLR - Oldenburg)

End of Discharge

Normalized Lithium Concentration  
0.85 1.00 1.15

## Perspective

- Li-SPAN batteries promise specific energies > 350 Wh/kg, C-rates exceeding 3C for >1500 cycles
- Operando analytics enable detection of volume changes and temperature evolution during operation
- 3D simulations to accelerate electrode design for high-performance applications

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