Characterization of Commercial Sodium-ion Battery Cells and their Performance metrics Compared to Lithium-ion Battery Cells

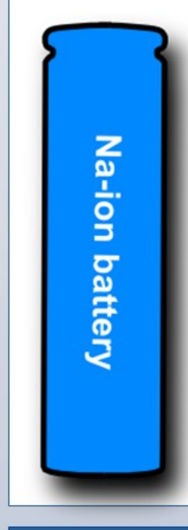
Katharina Bischof,*[,1] Vittorio Marangon,[2,3] Michael Kasper,[1] Aislim Aracil Regalado,[1]
Miriam Keppeler,[1] Margret Wohlfahrt-Mehrens,[1,2] Markus Hölzle,[1,4] Dominic Bresser,[2,3,4] Thomas Waldmann[1,2,4]

[1] Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Lise-Meitner-Straße 24, 89081 Ulm, Germany
[2] Helmholtz Institute Ulm for Electrochemical Energy Storage (HIU), Helmholtzstrasse 11, 89081 Ulm, Germany
[3] Karlsruhe Institute of Technology (KIT), P.O. Box 3640, 76021 Karlsruhe, Germany
[4] Ulm University (UUlm), 89069 Ulm, Germany

* e-mail: katharina.bischof@zsw-bw.de

Motivation

- **Sodium-ion batteries (SIBs)** are a more **sustainable**, **resource saving**, and **cost-effective** alternative to lithium-ion batteries (LIBs)
  → Can be built **without critical raw materials** (e.g. Co, Cu, Li, and graphite) [1,2]
- First **commercial SIB cells** available on the market
  → **Cell design?**
  → **Performance compared to LIB cells?**



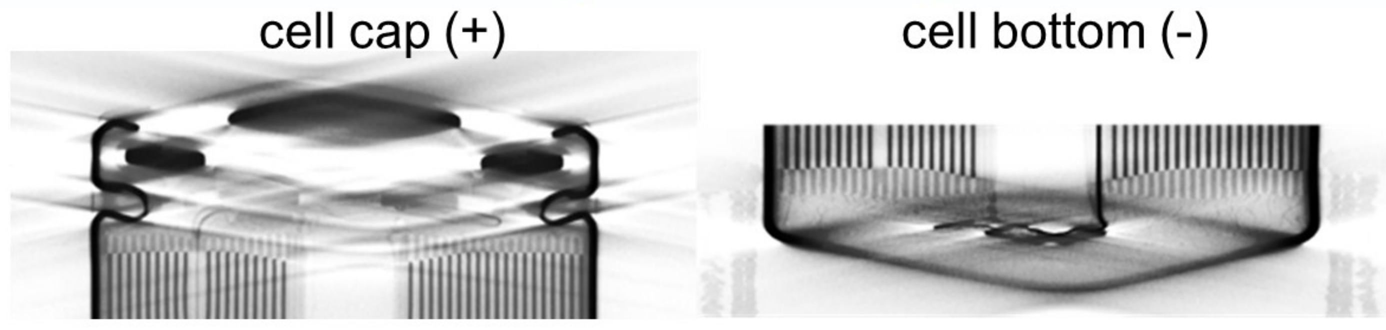
Investigation of two types of **commercially available cylindrical SIB cells** [3]:

- **1.5 Ah 18650** cells (cells from two different batches)
- **3.5 Ah 26700** cells

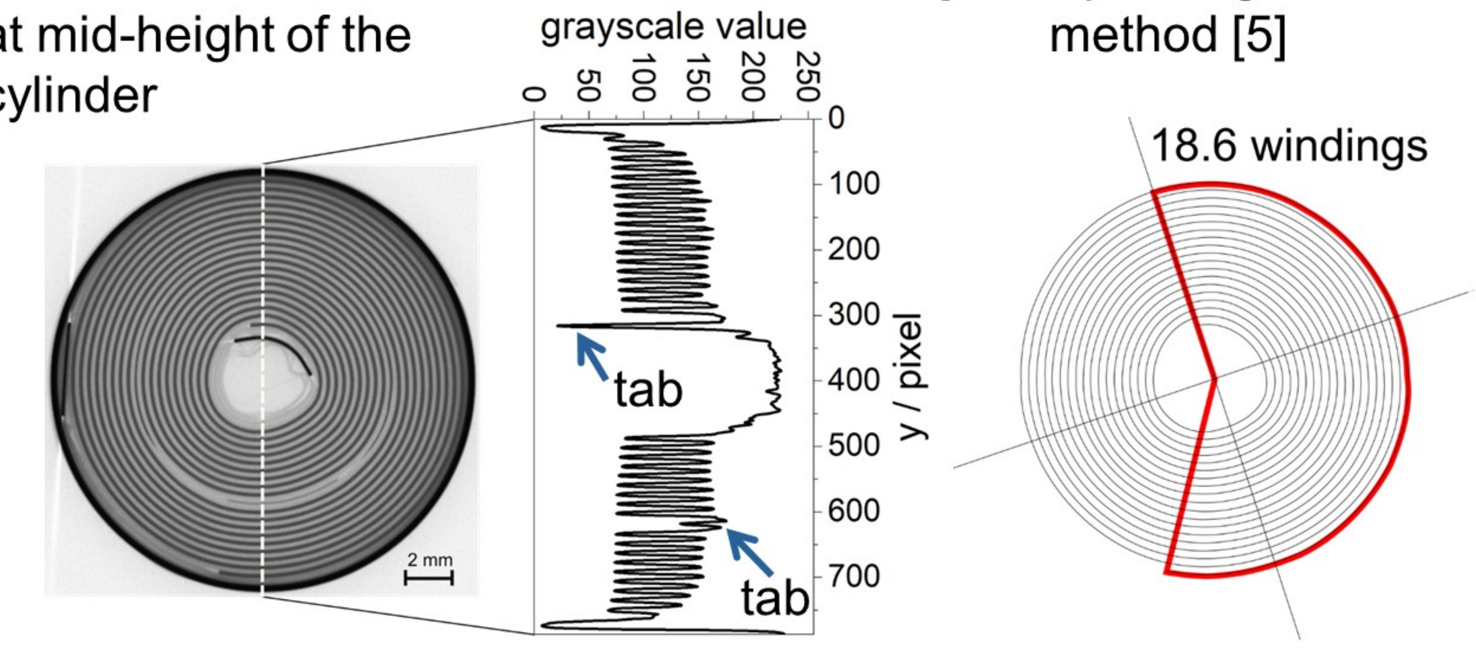
→ Cell chemistry: **hard carbon||$Na_xNi_yFe_zMn_{1-y-z}O_2$ (NFM)**
Operating voltage range: **1.5 V – 4.1 V**

X-ray CT analysis

18650 cells



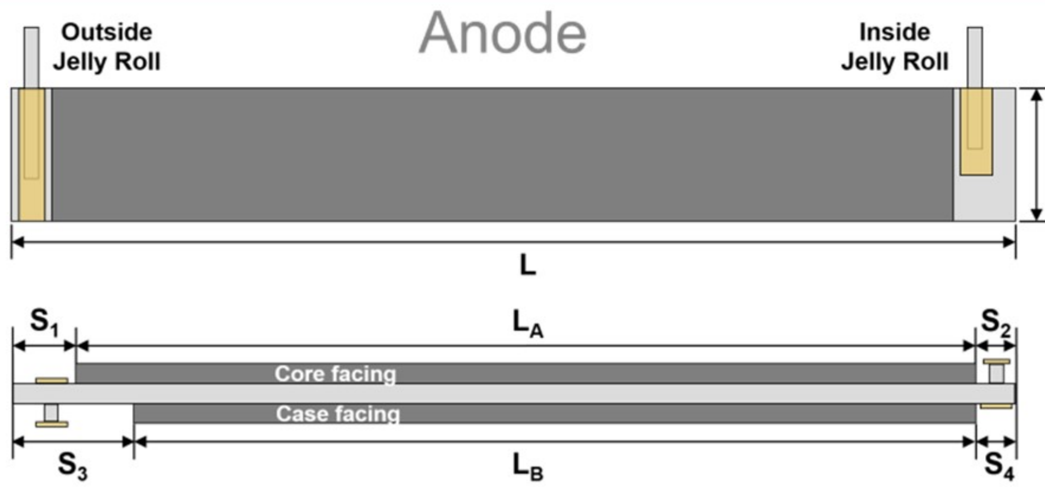
→ **No** manufacturing-related **defects**



X-ray CT analysis of a pristine 18650 SIB cell.

Cell design

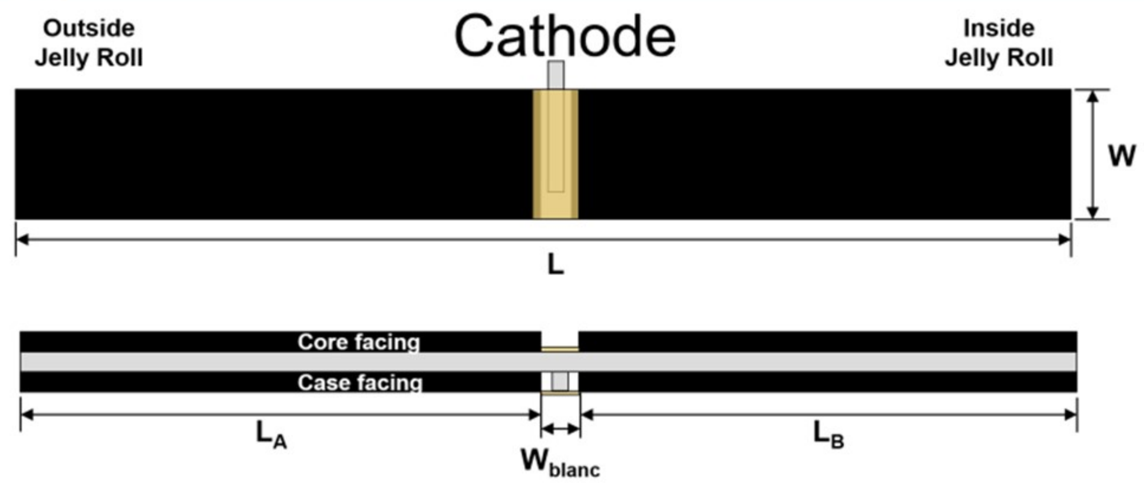
18650 cells



mean values for 3 cells from batch 2

L: 651 ± 2 mm	W: 59 ± 1 mm
L_A: 628 ± 1 mm	L_B: 572 ± 6 mm
S_1: 13 ± 1 mm	S_2: 11 ± 2 mm
S_3: 68 ± 6 mm	S_4: 11 ± 2 mm

Comparison:
batch 1: L: 709 mm



mean values for 3 cells from batch 2

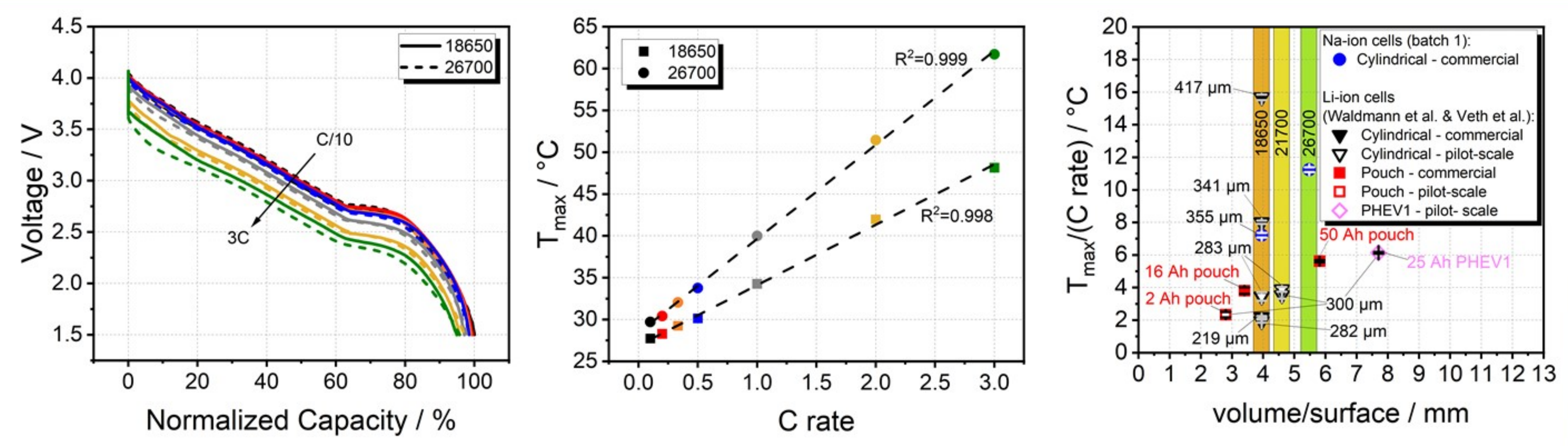
L: 573 ± 2 mm	W: 57 ± 1 mm
L_A: 332 ± 3 mm	L_B: 232 ± 2mm
W_{blanc}: 9 ± 1 mm	

Comparison:
batch 1: L: 633 mm

Schematic representation of the cell design of the 18650 SIB cell.

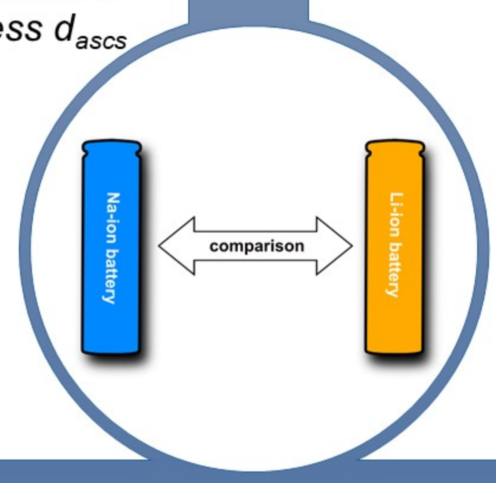
→ **Aluminum current collectors** at anode and cathode side
→ Significant **dimensional differences** between the cells of the **two batches** investigated – no standard visible

Thermal properties upon discharge

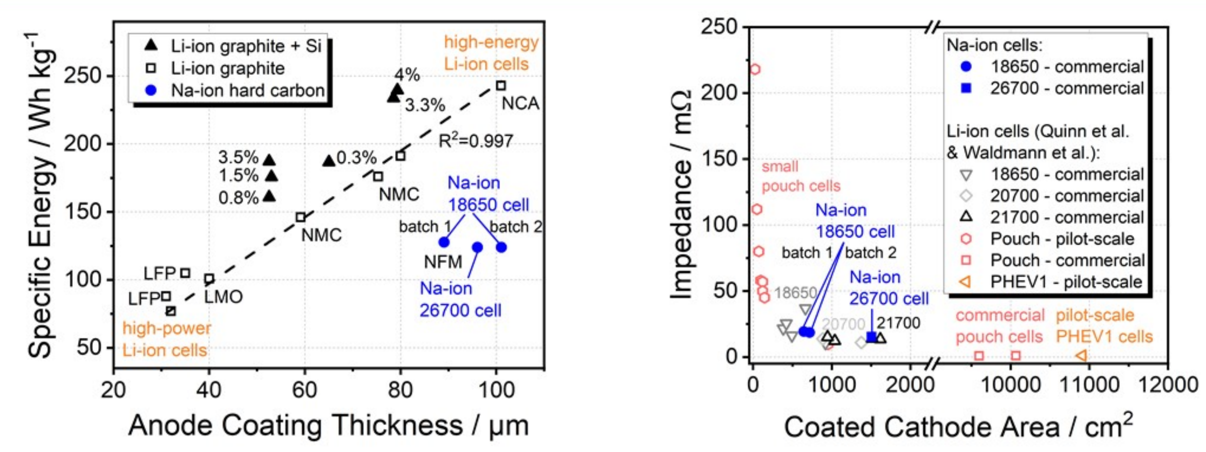


Voltage curves of the 18650 and 26700 SIB cells during discharge, associated maximum temperature reached on the cell surface (mid-height of cell cylinders), and comparison of the heating behavior of the SIB cells with data from commercial and pilot-line built LIB cells of different cell types reported in [5-8]. The given values in µm correspond to the thickness d_{ascs} (sum of thicknesses of anode, cathode, and the two separators).

- Higher C rates → Stronger temperature rise
- T_{max} correlates **linearly** with C rate
  → Trend **consistent** with LIB cells [6,7]
- T_{max}/(C rate) values of **SIB** cells **in similar range** as values for **LIB** cells



Specific energy and cell impedance



Comparison of specific energy and cell impedance of the two batches of the 18650 SIB cells and the 26700 SIB cell with data reported for commercial and pilot-line built LIB cells in [4,7,9].

- 18650 and 26700 **SIB** cells provide **higher specific energies than** high-power LIB cells with **$LiFePO_4$ (LFP)** cathode, despite **thicker anode coatings** for **SIB** cells
- Impedance of SIB cells: 18650 → **18.6 mΩ** (batch 1)
  19.2 mΩ (batch 2)
  26700 → **15.4 mΩ**
  → **Similar range** as for cylindrical LIB cells [4,7]

Conclusion

- First evaluation results for **commercial SIB cells**
  → Similar cell design to LIB cells suggests **drop-in production technology**
  → Remarkable differences in cell design between the two batches of 18650 cells investigated
- **SIB** cells provide **comparable performance metrics** to commercial **LIB** cells in terms of
  - Specific energy (higher to high-power graphite||LFP cells)
  - Cell impedance
  - Heating behavior

References

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