

Developing ultralight batteries based on Lithium-Sulfur technology

Dr. Holger Althues | Fraunhofer IWS, Dresden, Germany

AERO Hydrogen & Battery Summit | April 21, 2026



Fraunhofer Battery Knowledge

We develop next generation batteries

Fraunhofer Battery Alliance

- 26 Fraunhofer Institutes with competences along the battery value chain
- Broad research and development skills in various battery technologies
- Your development and cooperation partner with extensive experience and technical equipment

Core competences



Material Research



Cells and Cell production



System and Integration



End-of-Life and Battery Recycling



Simulation and Modelling



Testing and Evaluation

Markets and applications



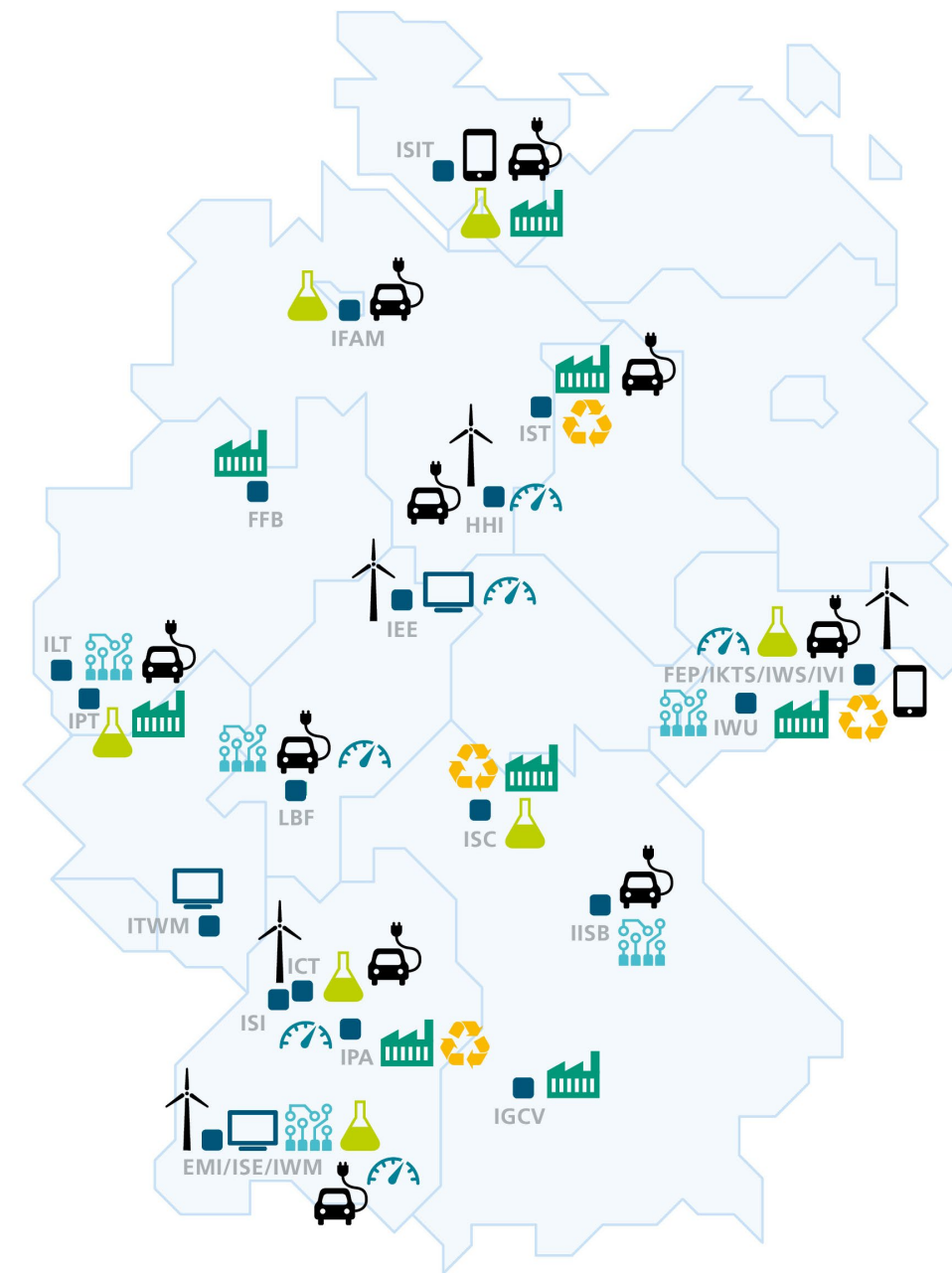
Energy Storage Devices
(Electromobility, Heavy Duty, Rail, Aviation)



Stationary Energy Storage



Powertools/ Consumer

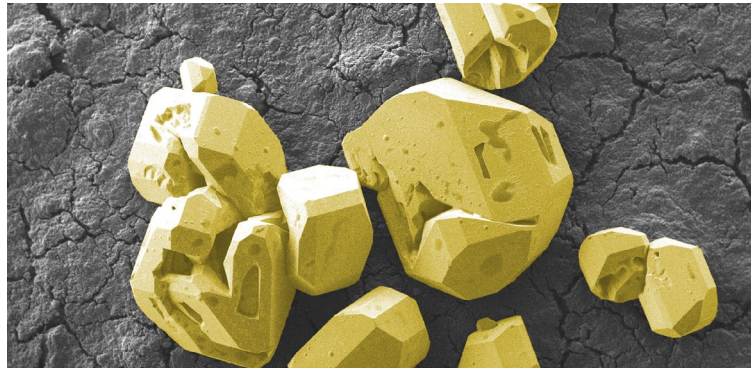


Fraunhofer IWS - Advanced Battery Technology Center

Innovations for future generation batteries



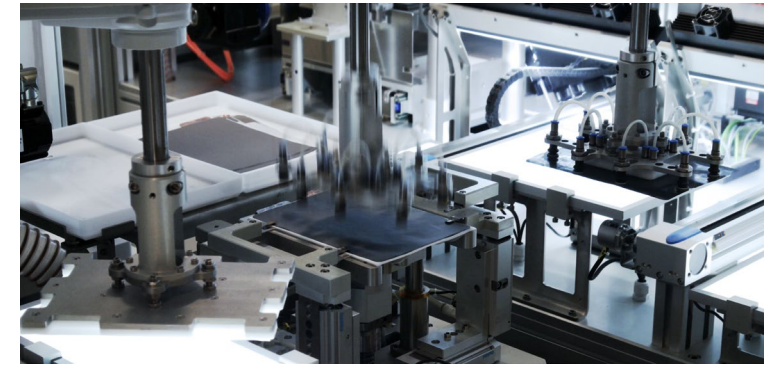
ABTC
Advanced Battery
Technology Center



**Expertise in
advanced cell chemistry**



**Innovations in
electrode processing**



**Cell manufacturing
and evaluation**



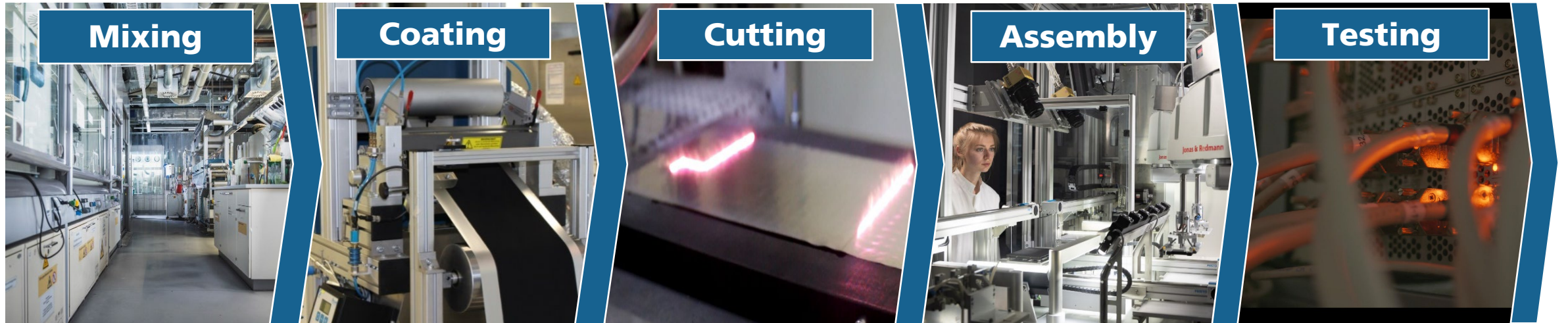
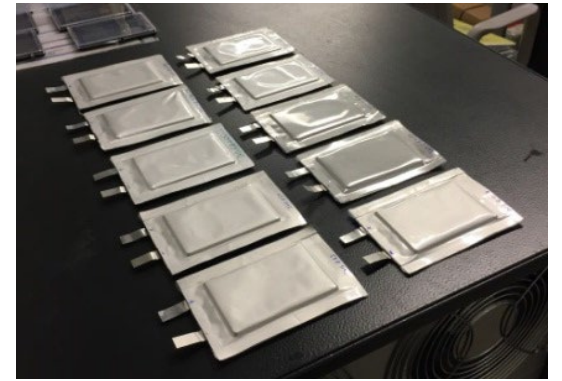
ABTC
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Cell manufacturing and evaluation

Process line for battery cell manufacturing

- Customized pouch cell manufacturing and testing
- Electrode manufacturing: Slot die slurry deposition and dry coating technologies
- Electrode laser cutting and cell assembly in local dry air environment



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Innovations for future generation batteries

Our motivation and objectives

Material research

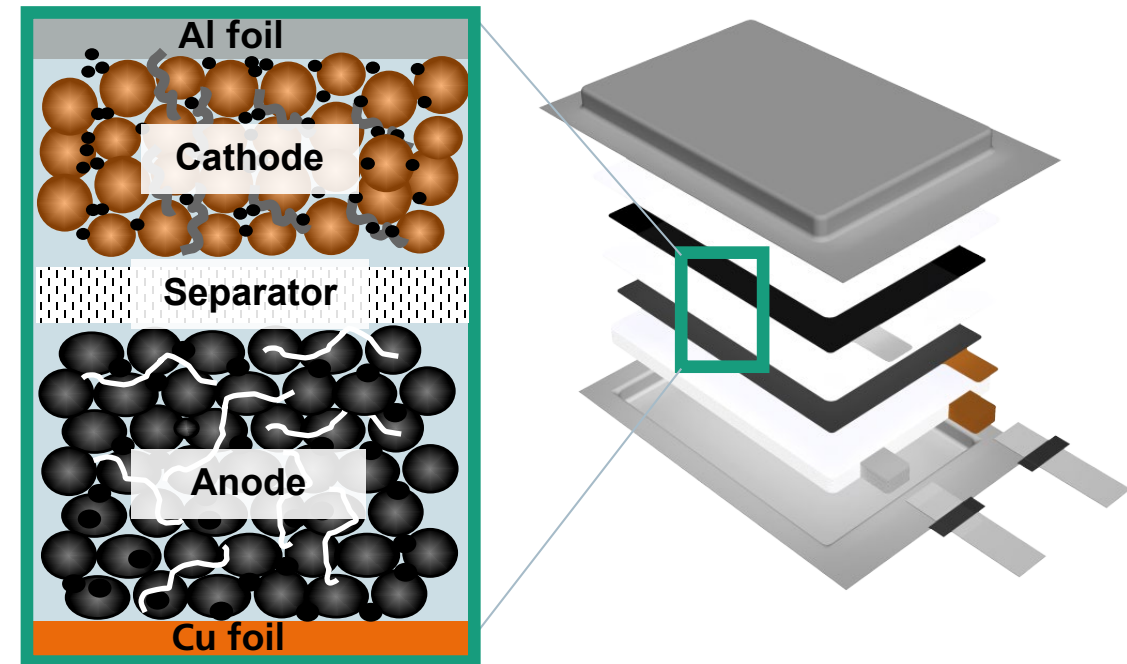
- Enhanced cell performance (Energy density, safety, power)
- Sustainability and resilience

Process development

- Reduced cell production costs
- Applicability towards next gen materials

Cell prototyping

- Application / client specific evaluation
- Demonstration / validation of new cell concepts



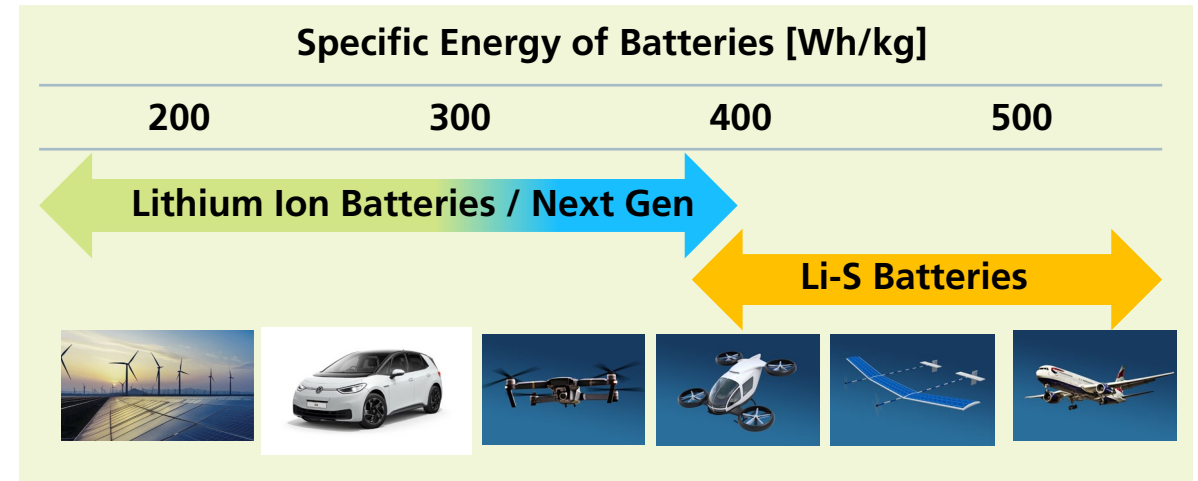
Scheme of a Lithium Ion Battery Cell

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Expertise in advanced cell chemistry

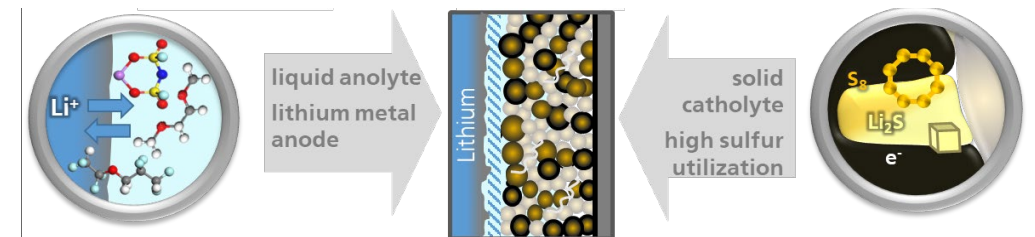
Light weight lithium sulfur batteries

- Li-S technology enables specific energy > 500 Wh/kg
- IWS contributes to Li-S development by
 - Cell design and liquid electrolytes [1-3]
 - Proprietary semi-solid concept [4]
 - Carbons and processes for all-solid-state Li-S-batteries [5, 6]



- [1] S. Doerfler, S. Walus *et al.*, Energy Technology **2020**, 2000694.
[2] S. Doerfler *et al.*, Joule **2020**, 4, 539.
[3] S. Kirchhoff *et al.* Batteries and Supercaps, 2024, 10.1002/batt.202400155
[4] S. Kirchhoff, M. Fiedler, *et al.* Adv. Energy Mater. 2024, 10.1002/aenm.202402204
[5] M. Fiedler *et al.* Adv. Sust. Systems 2023, 7, 2200439
[6] M. Fiedler *et al.* Carbon 2024, 227, 119252

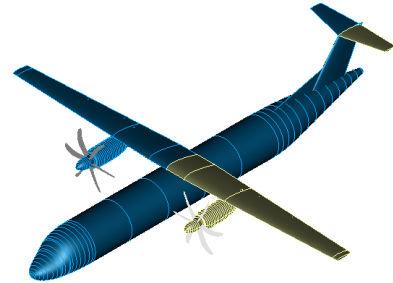
Semisolid cell concept [4]



Requirements for battery applications in aviation and aerospace

Specific energy as limiting factor

Examples for applications (BMFTR-Project Sulforflight)



Parameter	DLR D70-PHEA	DLR E19	Low Earth Orbit	DLR HAP	eVTOL Drone
Spec. Energy (Wh/kg)	>450	>250	>250	>300	>250
Spec. Power (W/kg)	1200	690	65	250	1000
Max. C-rate	3	3	0.34	1	4
Cycle life	(3000)	1000	12000	350	400

Advanced cell technologies enable new applications in aviation

Examples for applications of high energy battery cells

- EHang / Inx: 60 – 90 % extension of flight duration enabled by solid state battery achieving 480 Wh/kg [1]
- LG ES: HAPS Demonstration for 13 hour flight enabled by Li-S-Batteries achieving 410 Wh/kg [2]



[1] <https://ir.ehang.com/news-releases/news-release-details/ehang-and-inx-achieve-breakthrough-solid-state-battery/>

[2] <https://inside.lgensol.com/en/2022/07/lithium-sulfur-battery-the-soaring-next-gen-battery/>

Cell chemistries for ultralight batteries

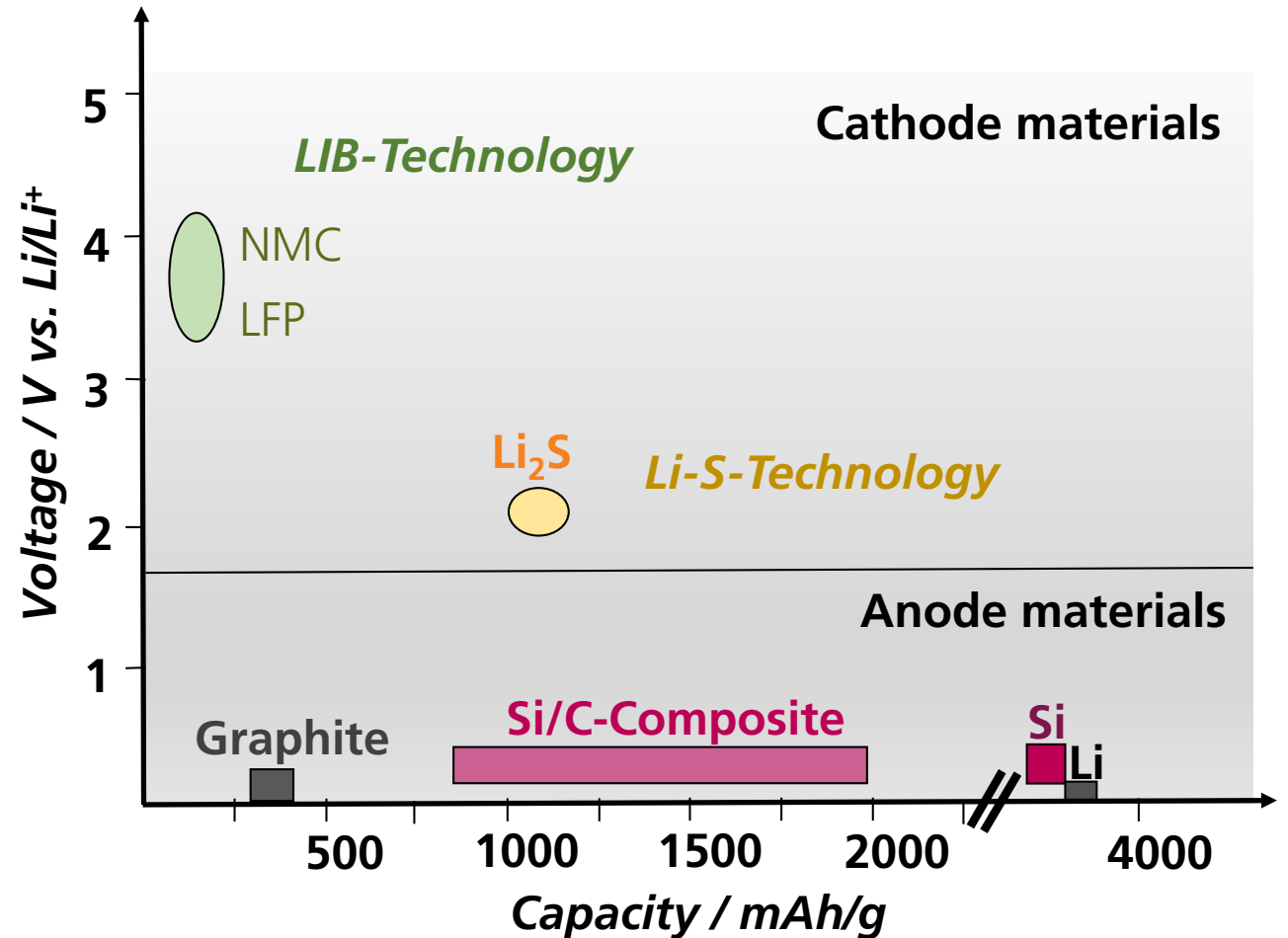
Active material selection

Specific energy on material level

Cathode	Anode	Theor. Spec. Energy*
NMC**	Graphite	484 Wh/kg
NMC	Silicon	664 Wh/kg
NMC	Lithium	760 Wh/kg
Li ₂ S	Lithium	2450 Wh/kg

* Related to mass of active material

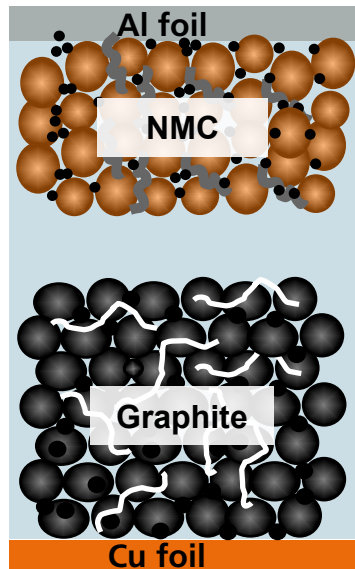
**assumption: NMC 811 with 200 mAh/g and 3,7 V



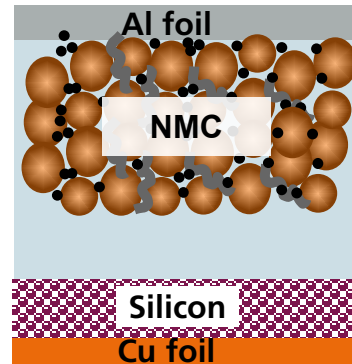
Cell chemistries for ultralight batteries

Active material selection

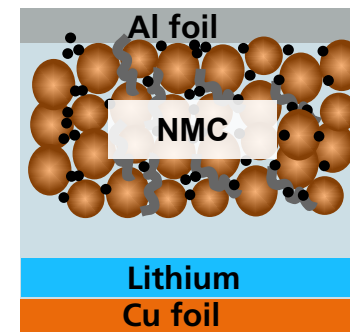
NMC / Graphite



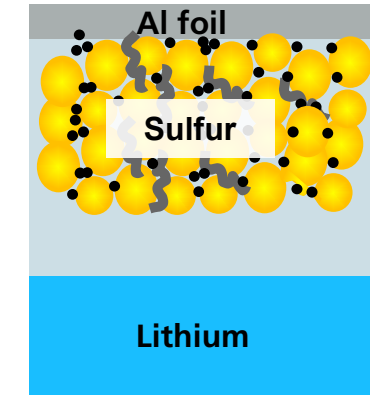
NMC / Silicon



NMC / Lithium



Sulfur / Lithium

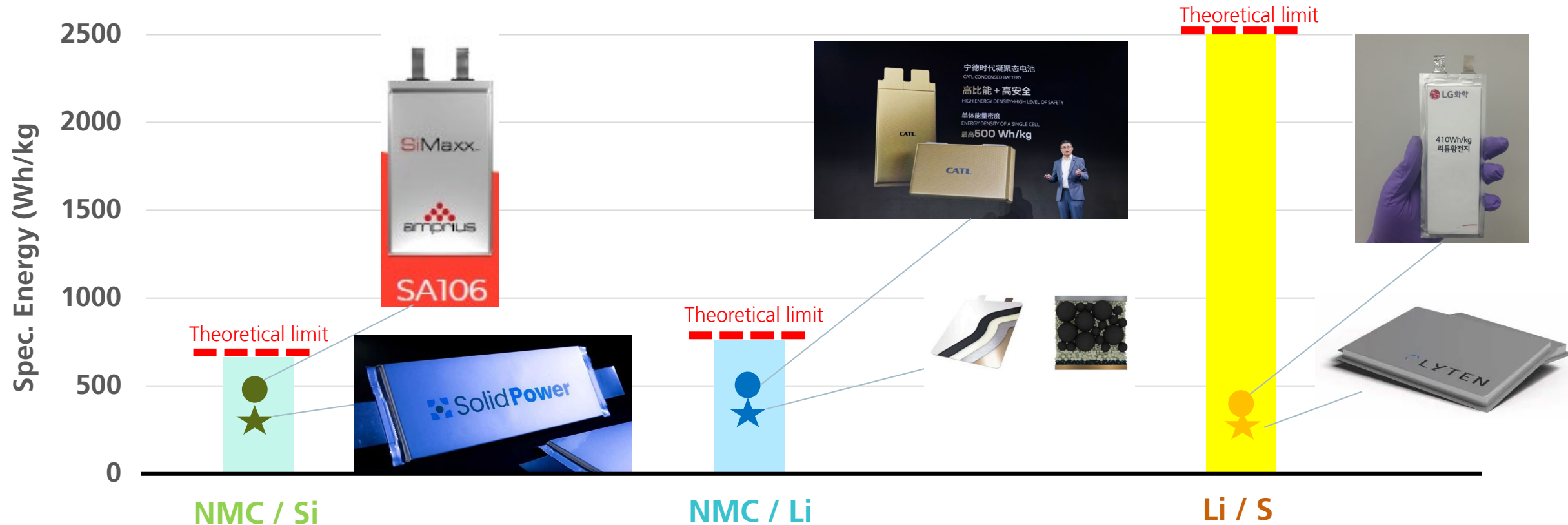


Variations

- NMC-Cathode: Ni-Content / Voltage range
- Silicon-Anode: Variations in Si-content and -Type
- Lithium-Anode: Reservoir-free / Lithium-Excess / Selfsupporting Li-Anode
- Sulfur-Cathode: Polysulfide-Chemistry / SPAN / Solid State
- Electrolyte: Liquid (Ether, Carbonate) / Solid (Oxide, Sulfide, Polymer)

Maximizing specific energy of battery cells

State of the art



● Amprius (AABC 2025)

● CATL „Condensed Battery“ / Nature Nanotechn. 20 (2025)

● LG ES (Li-S-Battery Workshop 2023)

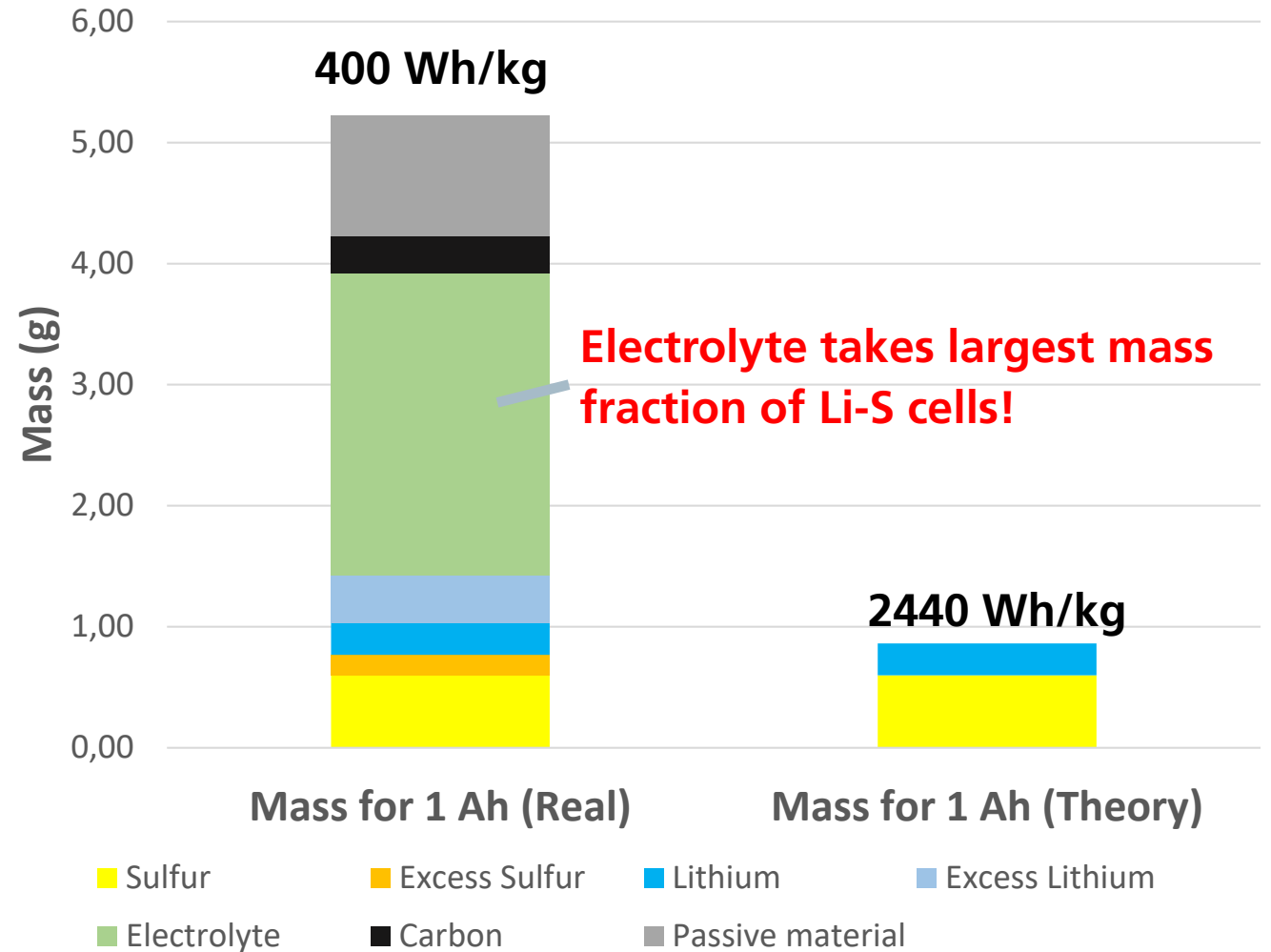
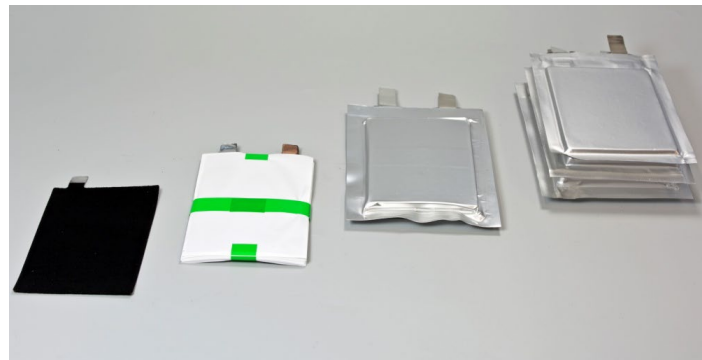
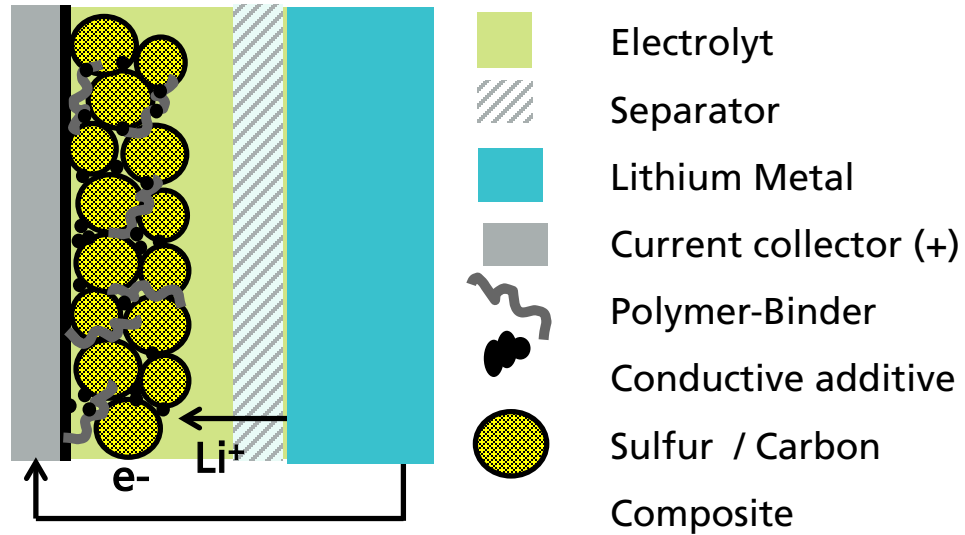
★ Solidpower (solidpowerbattery.com – 01/2026)

★ Samsung SDI / Nature Energy 5, 348 (2020)

★ Lyten (Li-S-Battery Workshop 2025)

Lithium-Sulfur Batteries

Specific energy and role of inactive materials

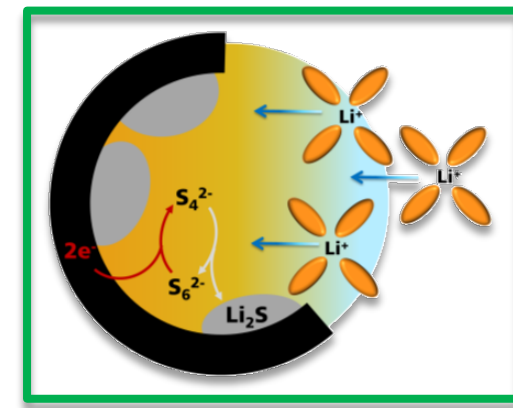
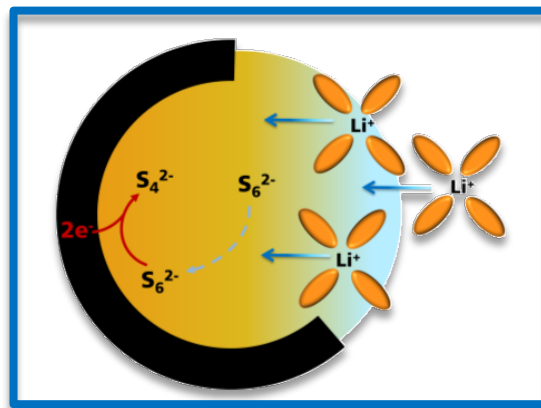
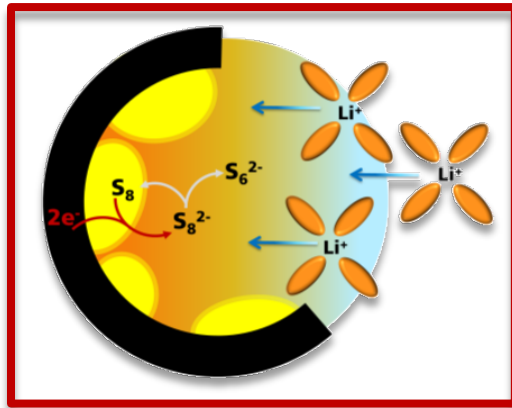
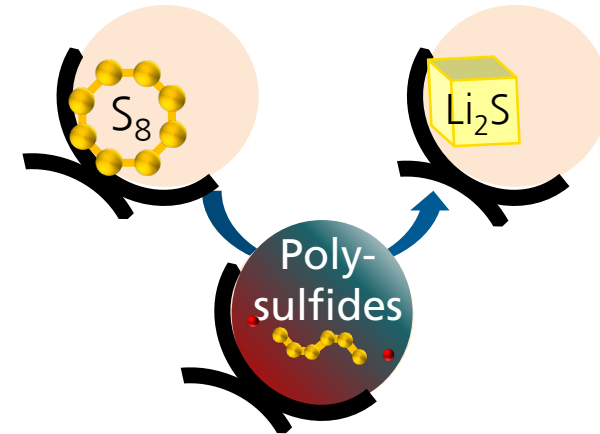
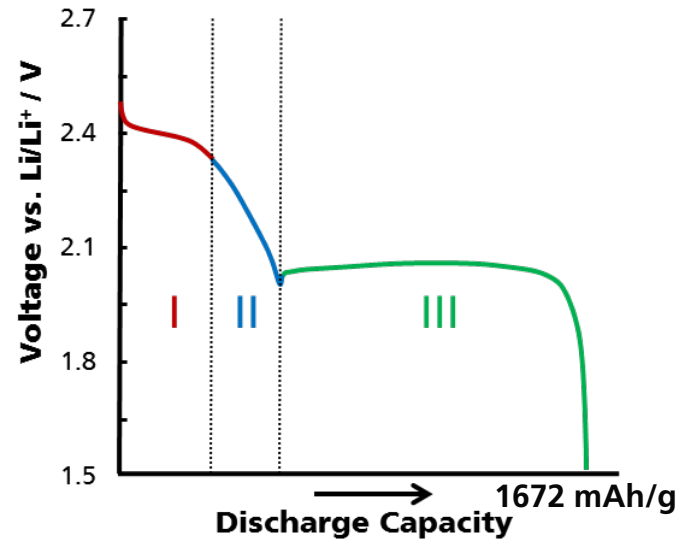


Lithium-Sulfur Batteries

Polysulfide-based conversion chemistry

Challenges

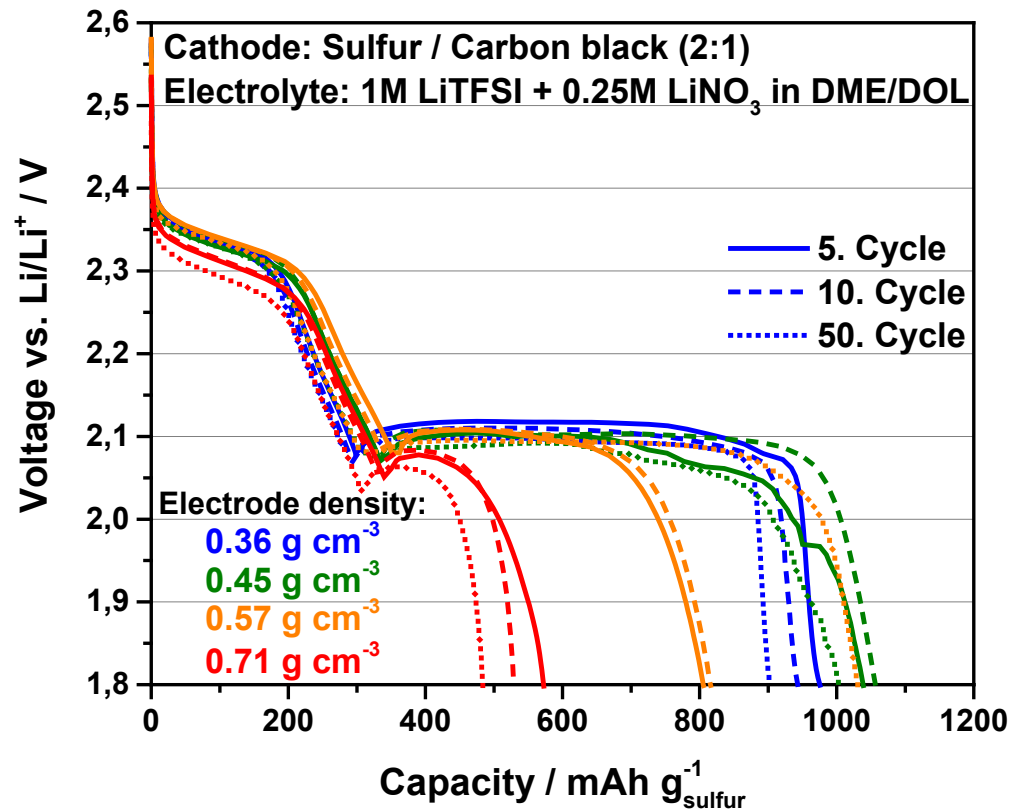
- Complex (electro-) chemical reactions during conversion of sulfur
- Dissolved polysulfides lead to side reactions and self-discharge



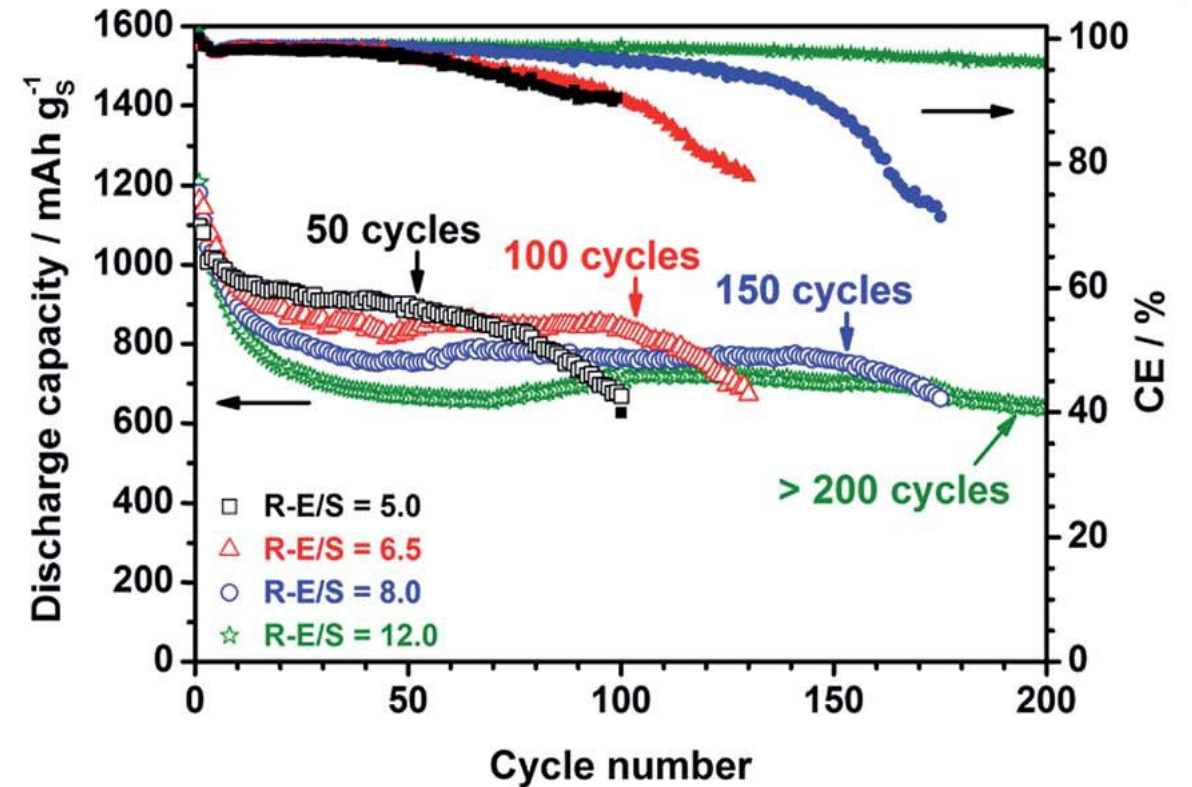
Lithium-Sulfur Batteries

Polysulfide-based conversion chemistry

Impact electrode density



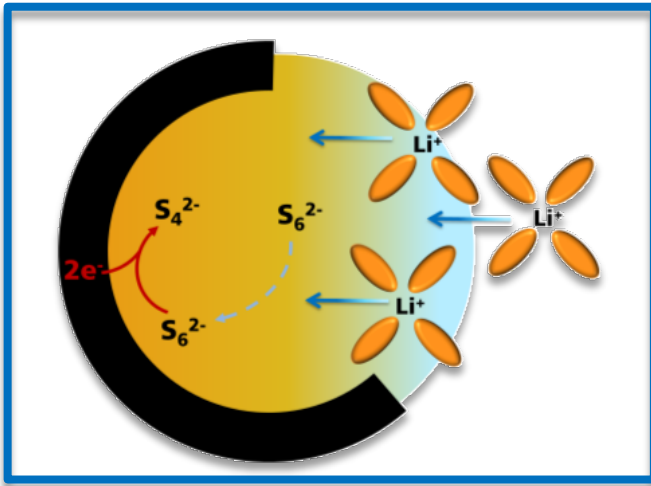
Impact electrolyte content



Lithium-Sulfur Batteries

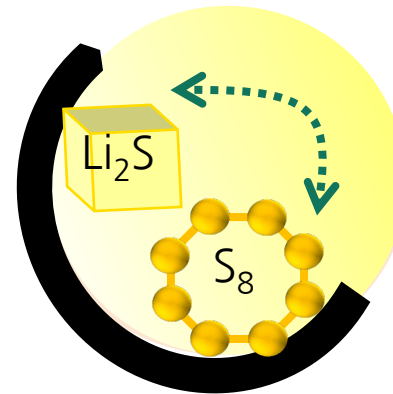
Alternative Li-S cell systems

Polysulfide-based conversion



- Many concepts have been evaluated to enhance cycle life and energy density
- **However: required electrolyte content for solvation is limiting the spec. energy**

Solid state conversion



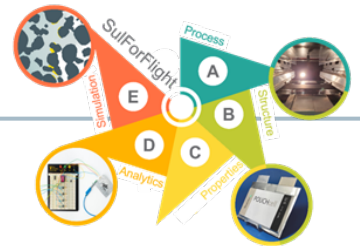
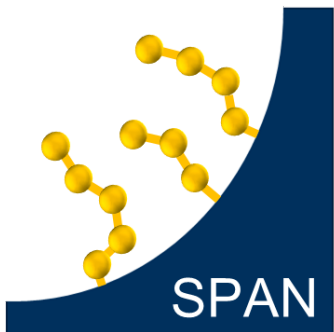
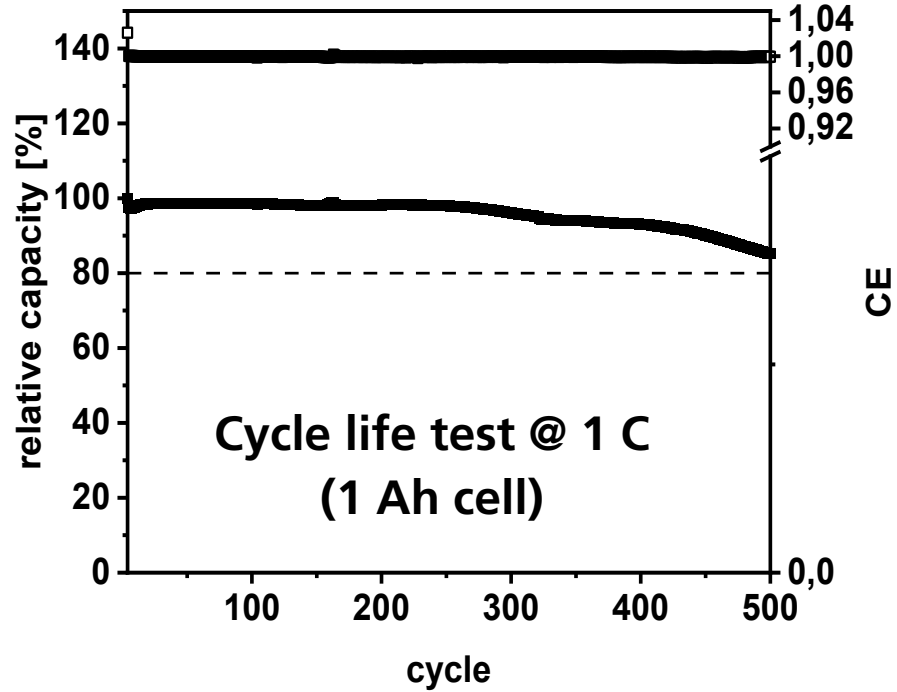
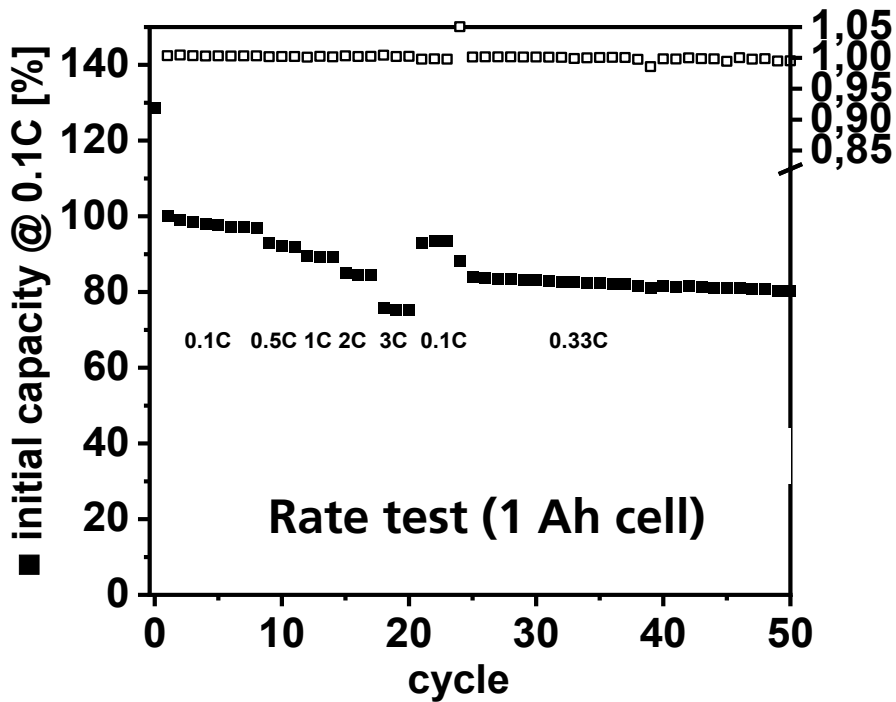
- Direct conversion of sulfur to Lithium sulfide without solvation of polysulfides

- **Opportunity to overcome limitations on cycle life and specific energy**

Lithium-Sulfur Batteries

Solid-solid conversion in SPAN-based cells

Solid state conversion can be very fast and reversible!

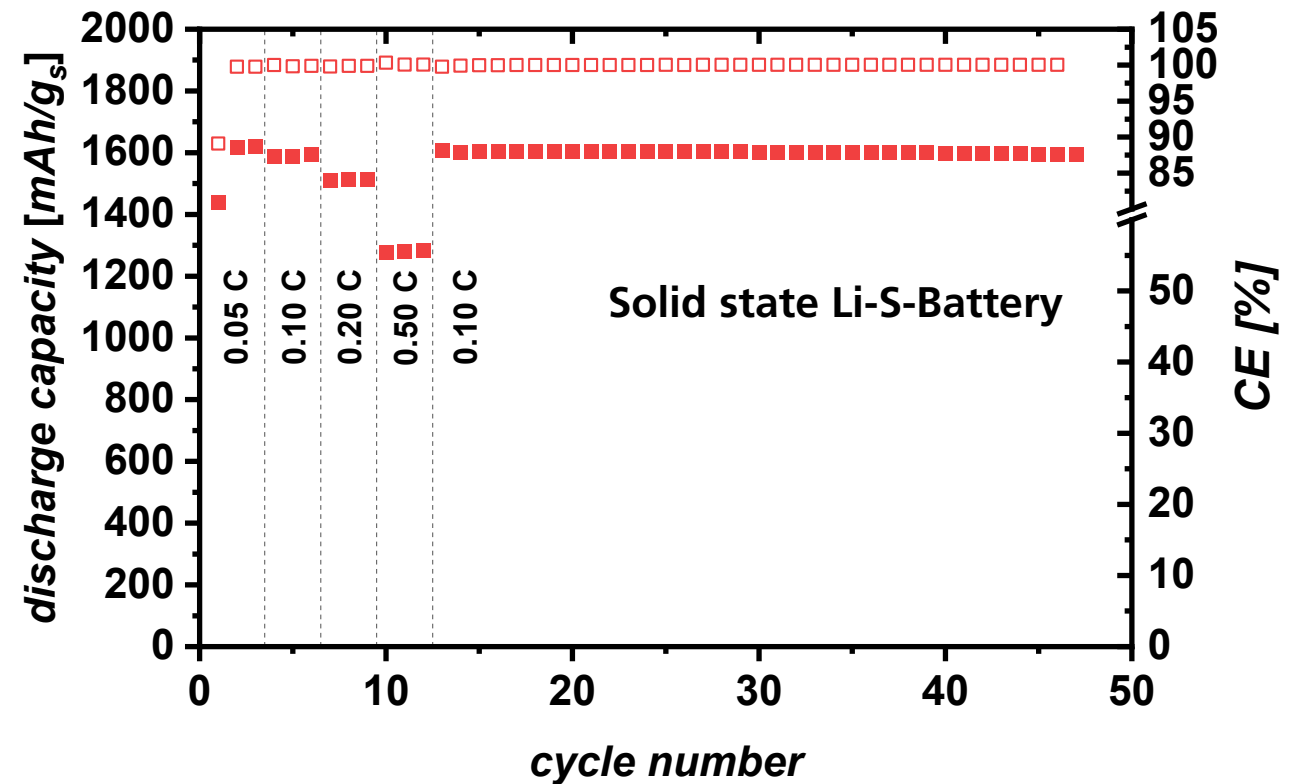
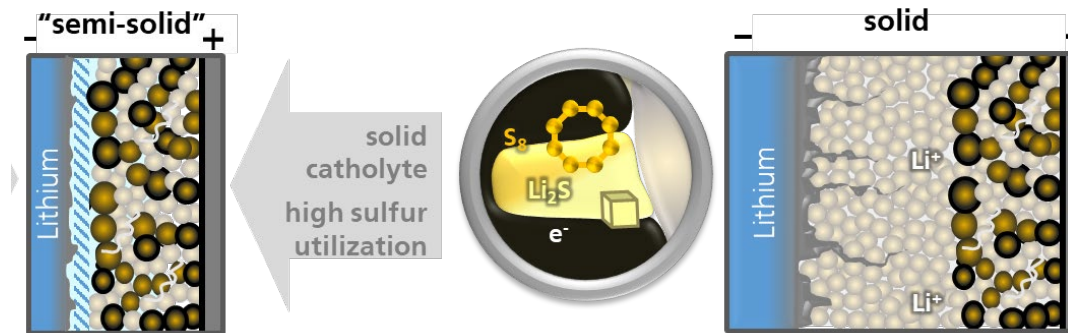


Lithium-Sulfur Batteries

Solid-solid conversion enabled by sulfide solid electrolytes

Lithium-sulfur solid state batteries

- Sulfidic solid electrolytes enable solid conversion
- Very high specific capacity (1.600 mAh/g) observed at low electrolyte content
- Projected specific energy: > **600 Wh/kg**



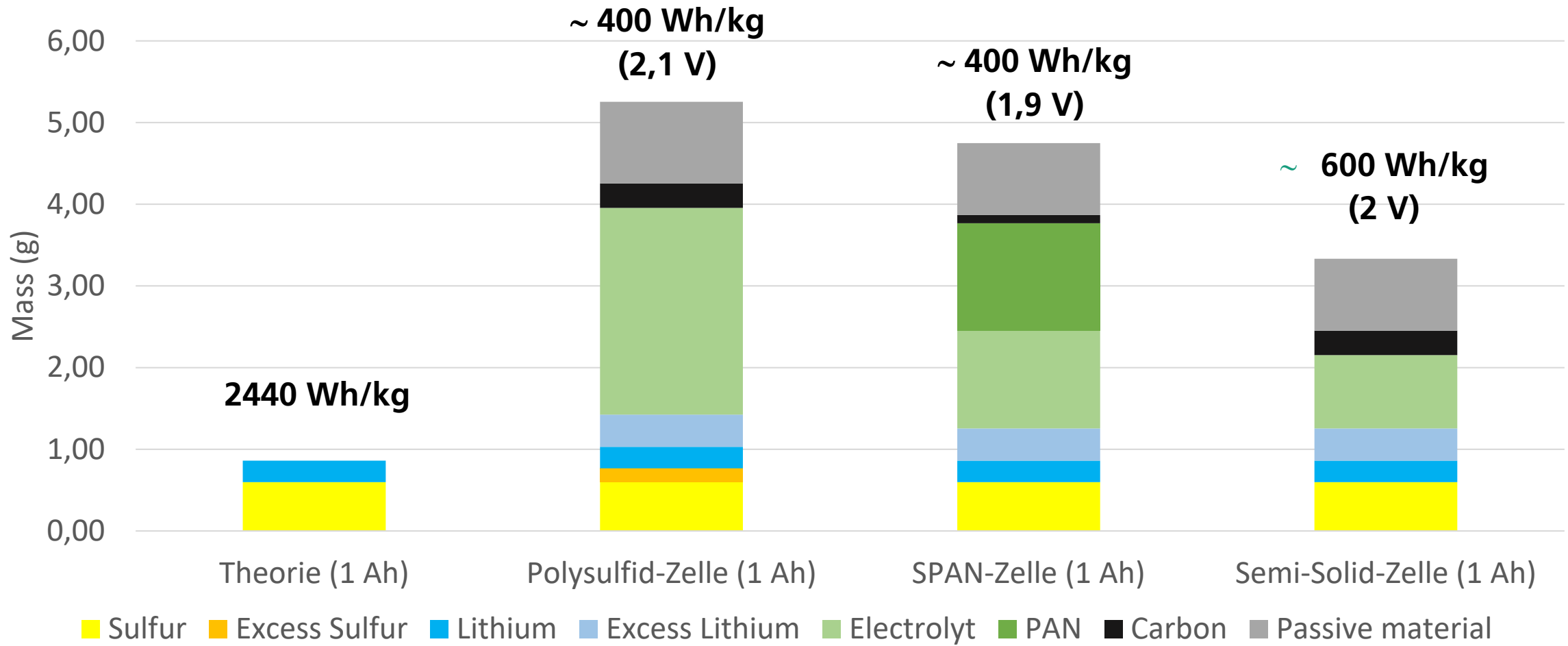
[1] M. Fiedler et al. Adv. Sust. Systems 2023, 7, 2200439

[2] M. Fiedler et al. Carbon 2024, 227, 119252

[3] S. Kirchhoff, M. Fiedler, et al. Adv. Energy Mater. 2024, 10.1002/aenm.202402204

Lithium-Sulfur Batteries

Comparing specific energy for different cell concepts

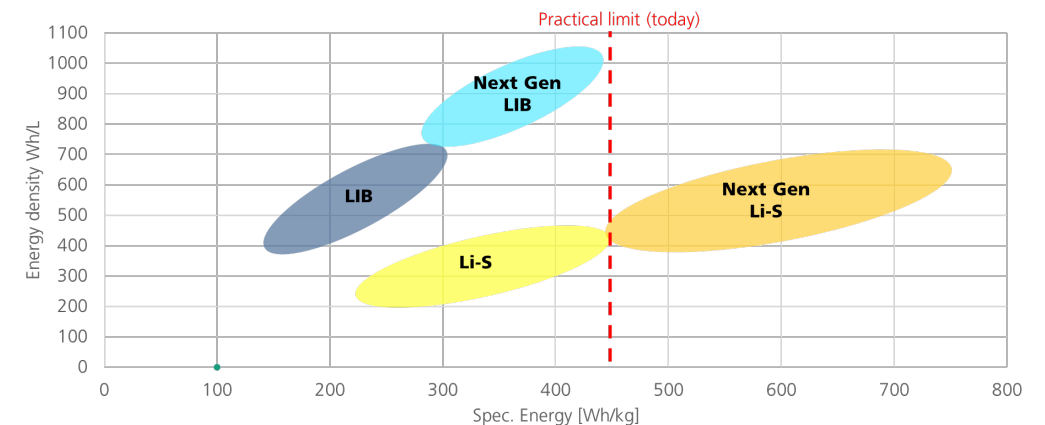
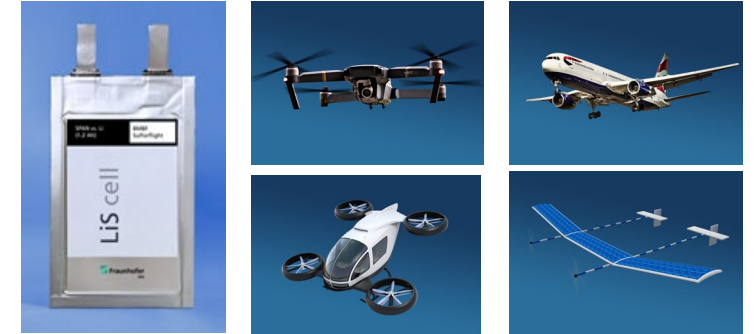


Developing ultralight batteries based on lithium-sulfur technology

Conclusions

Light weight batteries are a key component for enabling electric aviation

- New cell generations achieve 350 – 500 Wh/kg
 - NMC-based technologies are approaching their theoretical limit
 - Li-S-batteries are still far from their theoretical limit (e.g. due to high passive material weight)
- Sulfide solid state electrolytes enable direct (solid-solid) conversion of sulfur at low electrolyte content and thus enhanced specific energy
- **Projected specific energy > 600 Wh/kg**



Save the Date

13th Workshop Lithium-Sulfur Batteries

November 10–11, 2026
Fraunhofer IWS | Dresden



Contact

Dr. Holger Althues
Advanced Battery Technology Center
Telefon +49 351 83391-3476
Fax +49 351 83391-3300
Holger.althues@iws.fraunhofer.de

Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS
Winterbergstraße 28
DE-01277 Dresden
www.iws.fraunhofer.de



www.drytraec.de
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