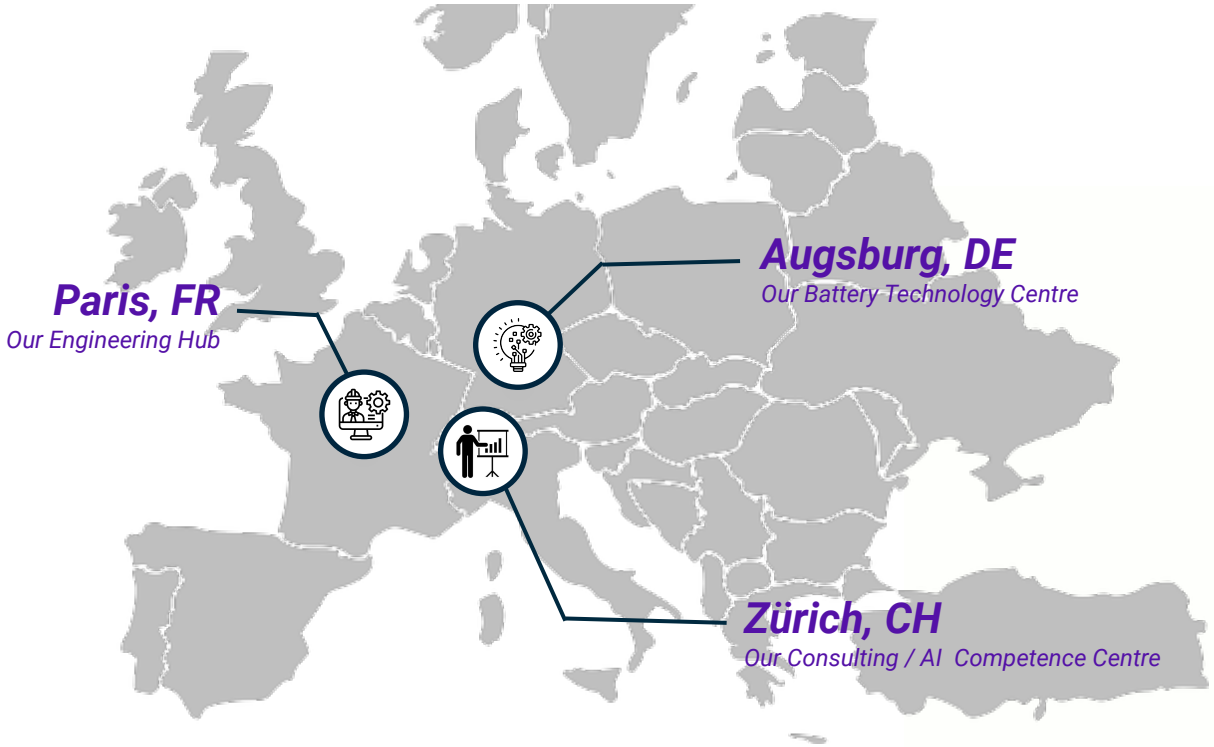
Navigating the Solid-State Battery Hype:
An Industry-Driven Assessment of Potential and Limitations

Introduction to Sphere-Energy

International team of battery and data experts.



We are a group of battery experts keen here to solve the toughest challenges in the battery value chain

- International team with 3 locations and a 500 m2 Technology Centre in Germany
- A team of 20 people with global experience in electrochemistry, **battery technology, data analytics & AI**
- We are **scientists, engineers and data experts** with more than 15 years of experience
- Industry thought leaders guide us along our growth trajectory as part of the **advisory board**

Leverage the battery to win!

Addressing the key challenges of the battery market

We accelerate the success of our clients and differentiate us through domain expertise & data.

Challenges of our clients

Our Services

Data & AI Services	Battery Data Management	Battery Performance Database	Battery Data Strategy
Technology Advisory	Innovation Scouting & Market Analysis	Competitor Analysis & Benchmarking	GTM strategy & Organizational transformation
Cell & Material testing	ASSB testing equipment	Battery Performance Testing	Technical Due Diligence & LCA assessment

Cell Testing & Engineering

And why do I have something to say about SSBs?

We are Boosting research on SSBs through practical setups - from lab-scale to prototypes.

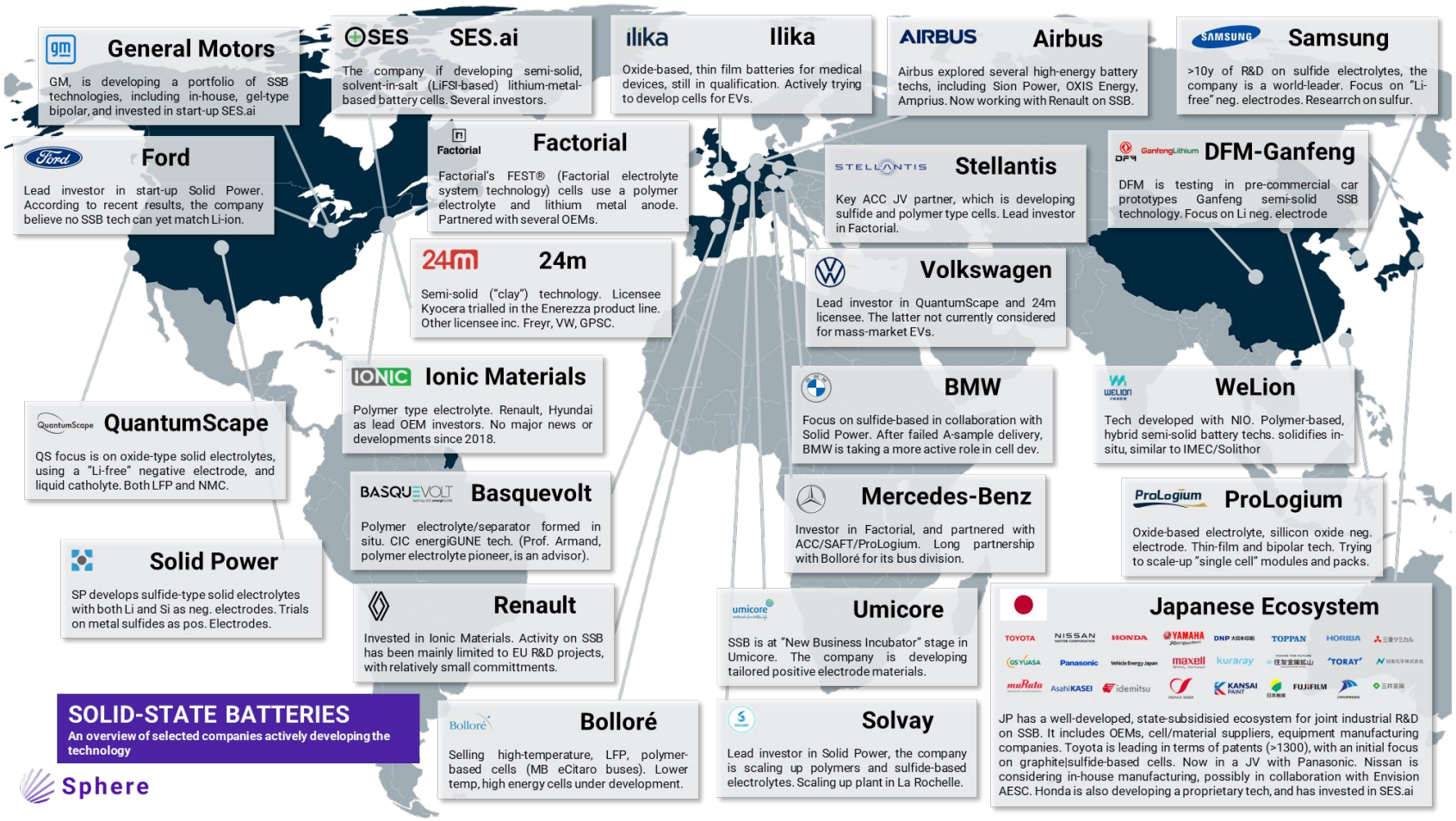
ASC test setups for solid-state batteries

Providing essential features for R&D

- High-pressure sample densification
- Pressure monitoring
- Swelling monitoring
- Fixed thickness or fixed force test configurations
- Ionic conductivity
- Surface resistance
- Coupling with gas analysis

Solid State Batteries… where do we start

Significant commitments and robust momentum within this market.

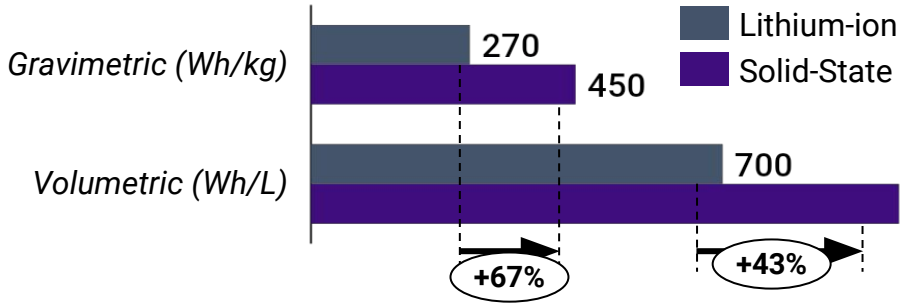


Refs:
Prologium
https://pubs.acs.org/doi/10.1021/acsami.1c07952
https://caneparesearch.org/research/

Solid-State technology, big potential, still to be proven on all levels!

Three claims that still need to be validated!

1 Beating Li-Ion energy density by using lithium metal



A competitive solid-state cell would require:

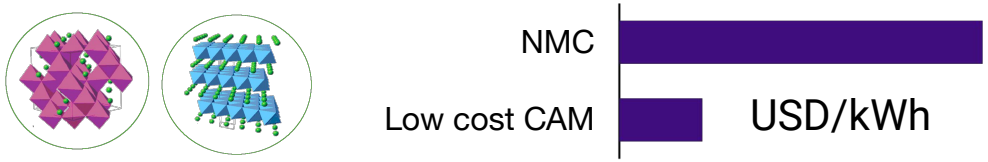
- *Next-gen. Li-ion cells (e.g., SiOx-C || NMCA) > 300 Wh/kg*
- <20 um separator
- >4 mAh/cm^2 CAM areal capacity
- Low solid catholyte (e.g., 10%)
- N/P of 1.1 at most
- Operate at room temperature and pressure

2 Improved safety and wider stability range

Safety Challenges:

- Electrolytes can undergo combustion (inc. ceramic, S and P oxidation) and/or hydrolyze (e.g., H_2S generation)
- Release energy in the form of heat (e.g., due to short circuit)

3 Enabling new cathode chemistries

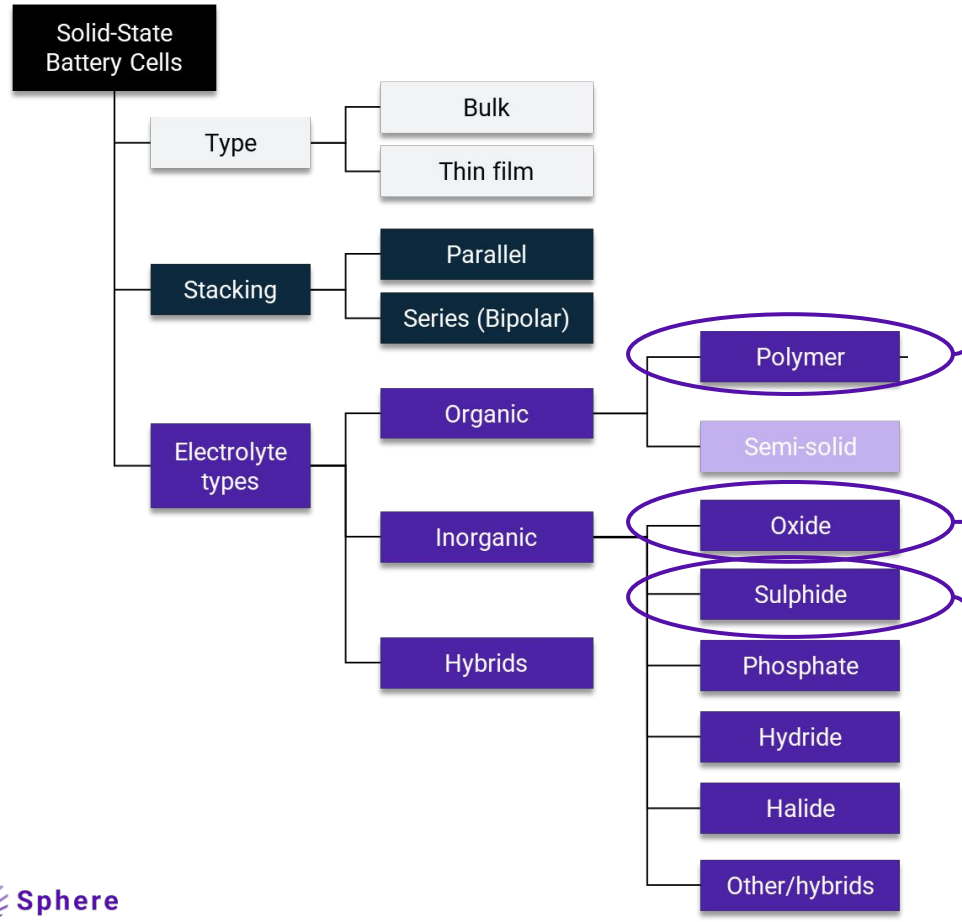


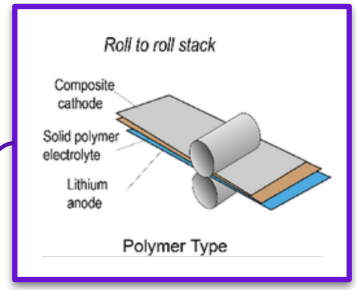
High voltage stability:

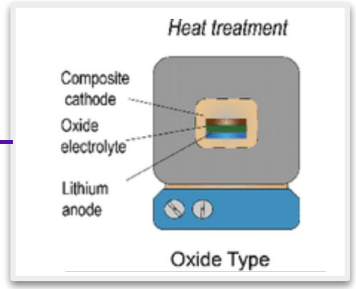
- High voltage stabilities
- No liquid catholyte

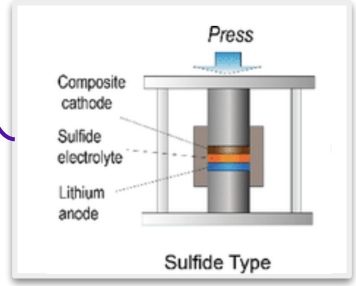
One step back - what are actually Solid State Batteries?

Which technology do we refer to?









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- ➔ **Manufacturability**
- ➔ **Processablibilty**

−

- ➔ **Operating temperature**
- ➔ **Dendrite protection**

+

- ➔ **High voltage compatibility**
- ➔ **Safety**

−

- ➔ **Mechanical properties**
- ➔ **Manufacturability**

+

- ➔ **High ionic conductivity**
- ➔ **Electrode compatibility**

−

- ➔ **High cost**
- ➔ **Sensitive production**

Sphere

Sources: https://pubs.acs.org/doi/10.1021/acs.chemrev.9b00268

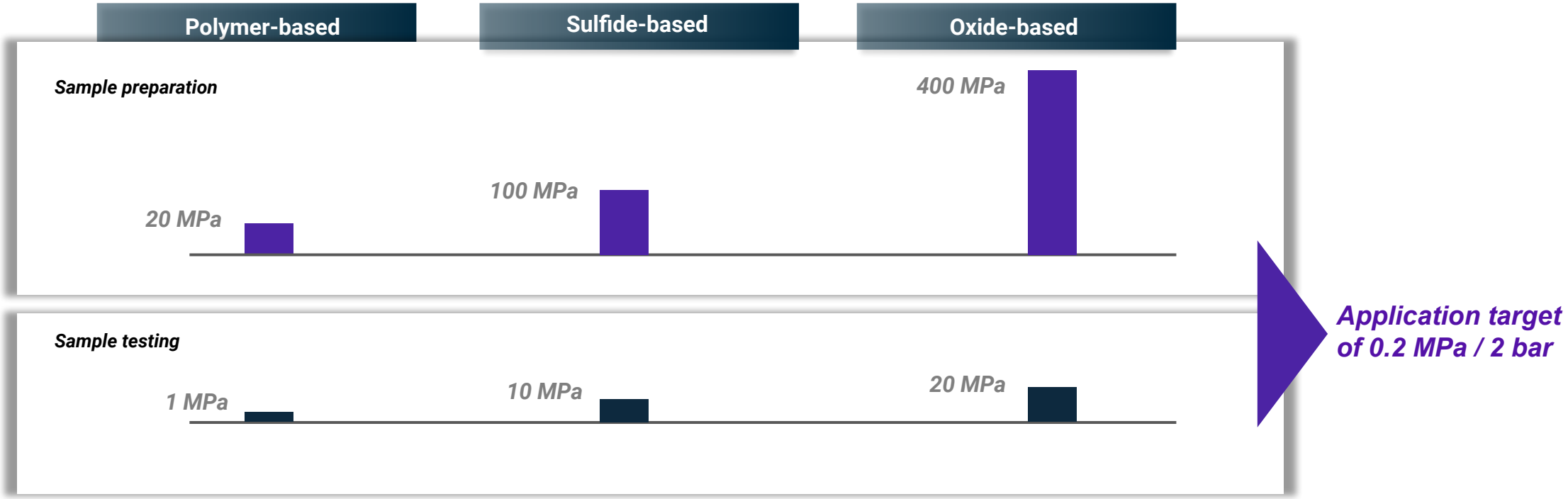
It’s currently hard to judge where we stand

Available data is inconclusive - battery manufacturers are in a difficult position.

Company	Key Performance Indicators								
	Cell Size	Safety Testing	Energy (cell)	Energy (System)	Cycle Life	Current/Power (Peak)*	Current/Power (Prolonged)*	Temperature	Pressure
GanfengLithium	Up to 120 Ah (Gen1)	Passed GB38031-2020	240 Wh/kg, 500 Wh/L (Gen.1)	160 Wh/kg (Pack)	1500	3C, 150 kW (pack)	1C, 50 kW (pack)	-20 to 60 °C	N/A (standard expected)
SES	Up to 102 Ah (untested) 50 Ah (Preliminary test)	Only for transport (UN38.3, IATF)	Up to 300-350 Wh/kg (initial), ca. 700 Wh/L	N/A	200	3C (unclear power)	C/3, ca. 60-70 W	-10 to 45 °C	N/A (likely above standard, i.e., likely 3-10 atm based on 3rd parties)
24m	N/A (5-10Ah estimated)	N/A	N/A (150-170 Wh/kg, 250-350 Wh/L estimated based on patents)	N/A	N/A (2-10k expected)	N/A (Likely low)	N/A (Likely low)	-20 to 40 °C	N/A
ProLogium	50 Ah	N/A	Depends on SiOx percentage. From 240 Wh/kg, 600 Wh/L to 300 Wh/kg, 700 Wh/L	180 Wh/kg, 370 Wh/L	500-700	5C (format unclear)	C/3	-20 to 45 °C	Undisclosed (above the standard expected)
QuantumScape	1-5Ah	N/A	N/A	N/A	800	5C (small format only)	1C	-10 to 45 °C	1-5 atm
Bolloré	105 Ah	Passed	255 Wh/kg, 380 Wh/L	255 Wh/L (Module)	3500 (70% DOD)	N/A	C/4 (charge) 1C (discharge)	≥ 60 to 105 °C (heating always required)	N/A (standard expected)
WELION	30 Ah	Passed	270 Wh/kg, 600 Wh/L	250 Wh/lg, 490 Wh/L (Module)	1200-1500	N/A	2C (charge), 5C (discharge)	0 to 45 °C (Charge) -20 to 55 °C (Discharge)	N/A (standard expected)
Factorial	40 Ah (graphite) 20-100 Ah (Li)	N/A	N/A	N/A	1500 (graphite) N/A (Li)	N/A	0.5C	Room temperature	N/A
BASQUEVOLT	1 Ah (multilayer)	N/A	460 Wh/kg, 960 Wh/L	N/A	N/A	N/A	C/5	25 to 40 °C	2 to 3 atm
TOYOTA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SAMSUNG	>5-15 Ah	N/A	420 Wh/kg, 900 Wh/L	N/A	> 1000	N/A	0.5C	≥ 45-60°C	Undisclosed (above the standard expected)
	20 Ah	N/A	390 Wh/kg, 900 Wh/L (Roadmap, Si Cell)	N/A	200-1000 (Coin cell, mAh)	2C (Coin cell, mAh)	C/5	≥ 29-60°C	Undisclosed (5-20 atm expected)

Every technology needs its own conditions - its hard to compare!

Detailed reporting, especially of pressures is essential to draw conclusions.

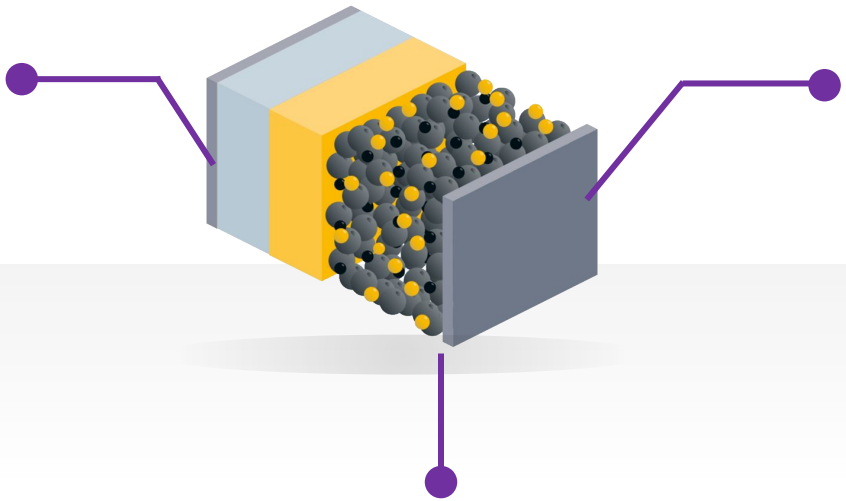


Three major challenges for the commercialization of SSB's

Let's look outside of interface challenges and electrolyte scale-up.

The issue with Lithium

Lithium in the electrolyte and excess at the anode makes it not hard to compete



"Just drop it in"

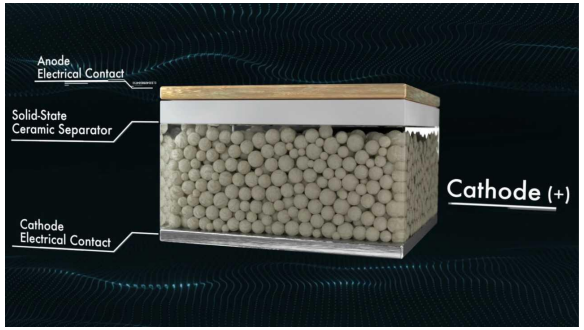
Battery production is super sensitive and dropping in a new component only works on paper.

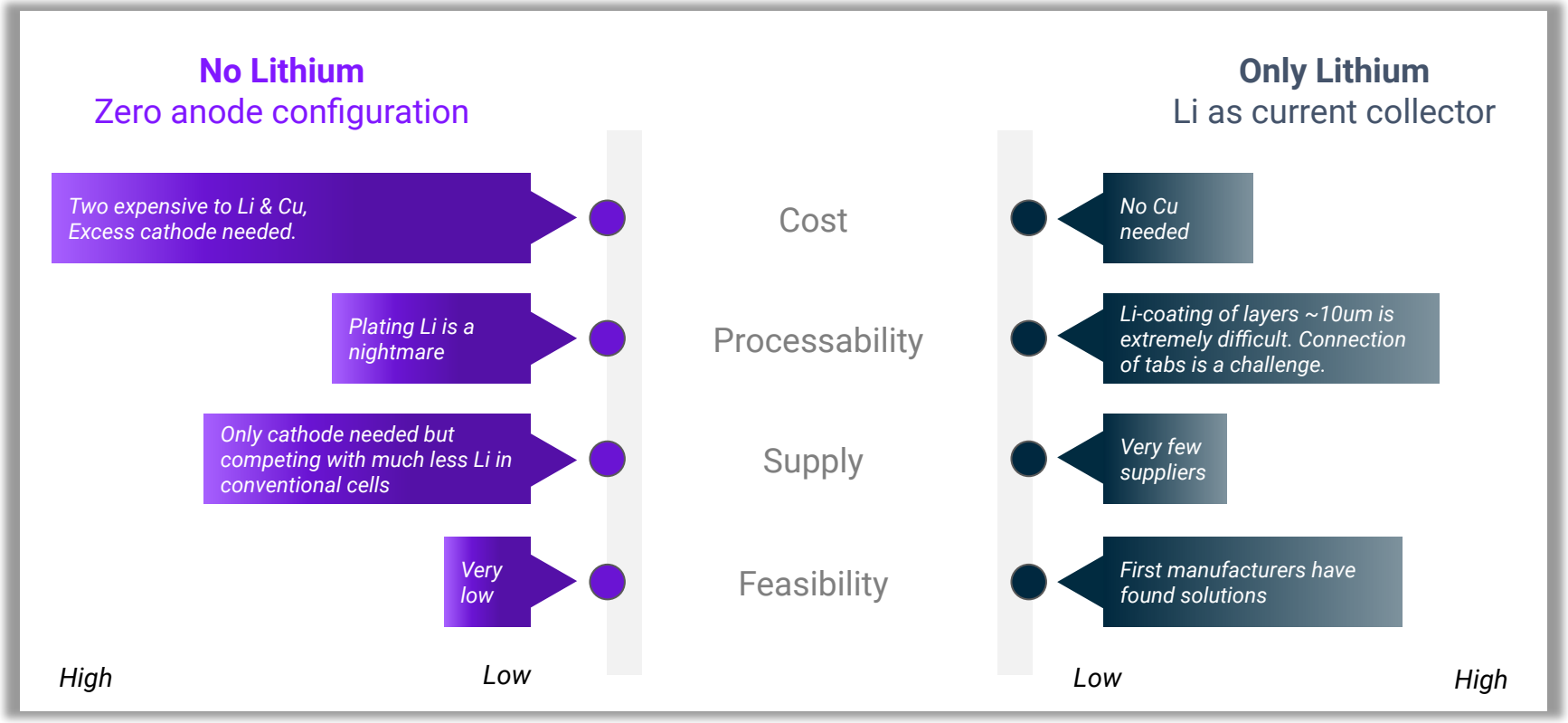
Competition isn't sleeping

Si-anodes, or tables designs bring massive improvements to classical Li-ion technology.

The issue with metallic lithium anodes

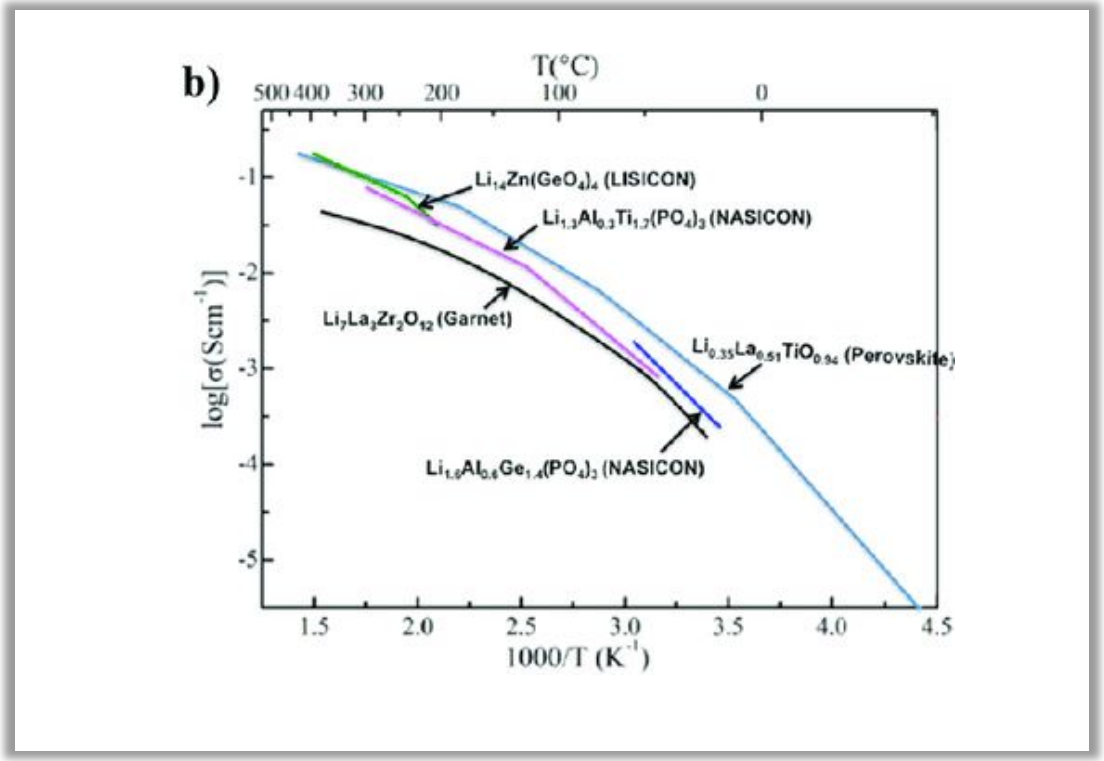
A metallic Li-anode sounds amazing, but is really challenging!





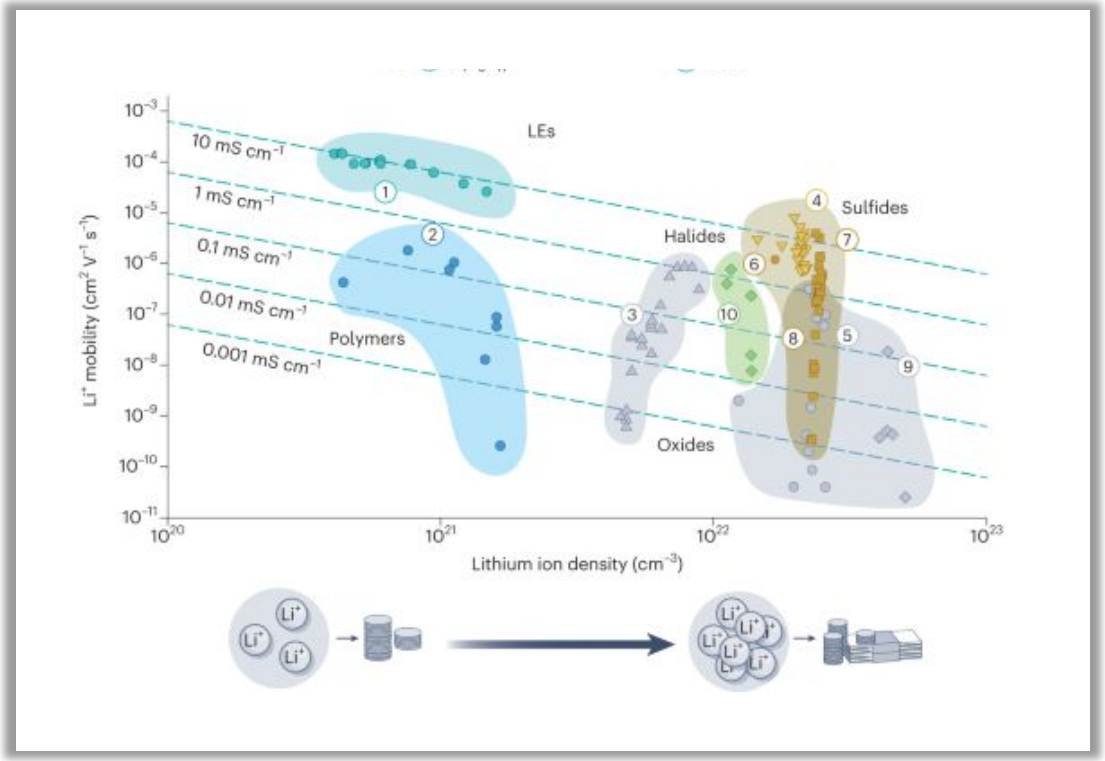
The issue with high Lithium contents in the electrolyte

We often forget that most of the solid electrolytes also contain Lithium.



Almost every SSB contains large amounts of Lithium…

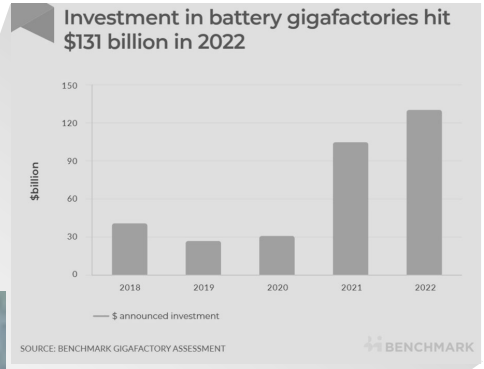
Ref: Recent Advancements in Li-Ion Conductors for All-Solid-State Li-Ion Batteries, ACS Energy Letters 2(12)



…more Lithium = higher cost!

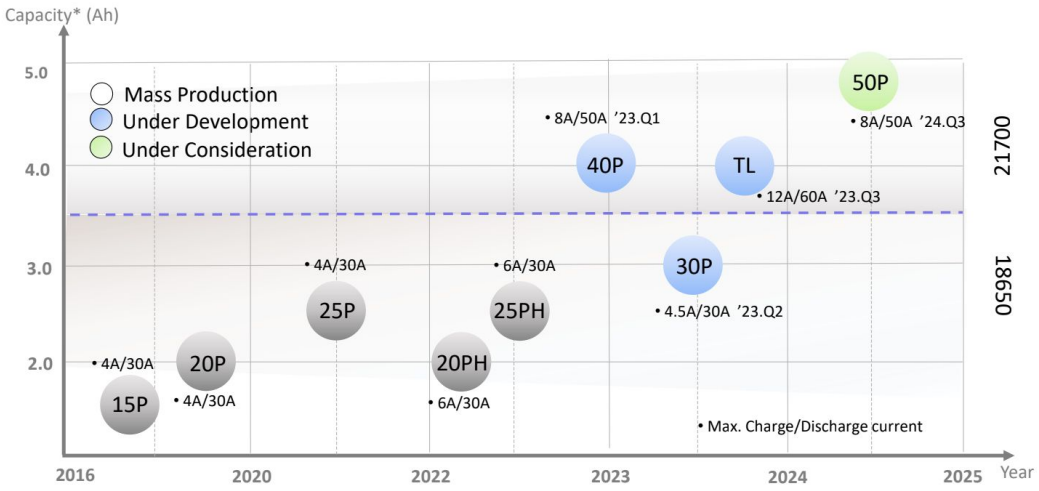
Ref: Challenges in speeding up solid-state battery development, Nature Energy, 8, pages230–240 (2023)

“Just drop it in.”
It is not that easy with our complex battery production processes!



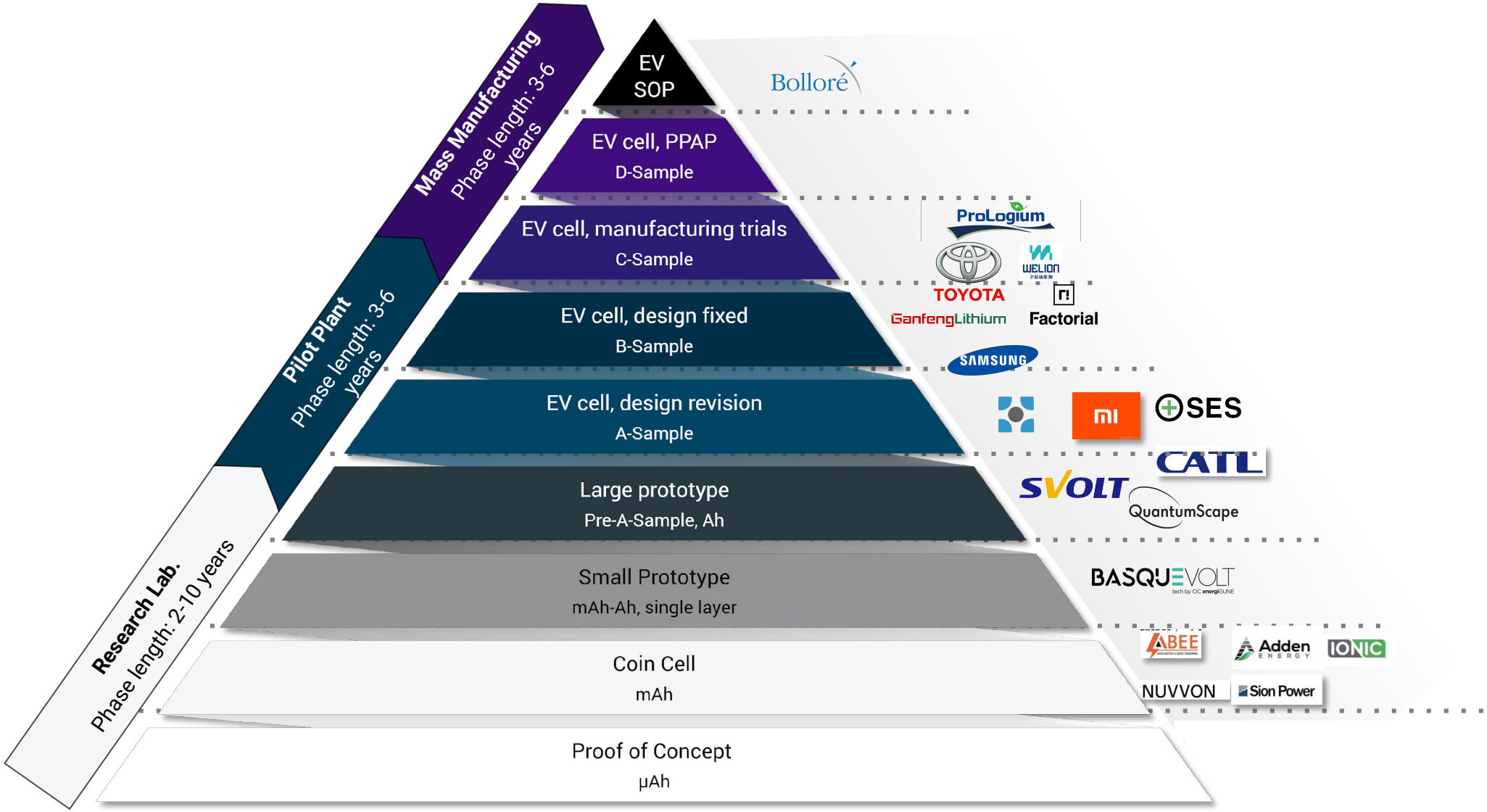
Competition isn’t sleeping!

Classical Li-Ion cells undergo massive improvements in terms of power and energy density!



Most of the industry is still in the R&D phase - and it simply takes time!

Keep in mind that most news have to be looked at through the “R&D glasses”.



5 winning criteria that need to be met for SSB to take over!

Key challenges for SSB to compete in the battery market.

Key takeaways

Performance & safety are measured on pack level!

Beneficial thermal properties can lead to a significant advantage - eliminating the need for sophisticated BTMS

True sustainability can be a large asset!

Design the batteries for sustainability is a key driver for the success of this technology in the EU and US.

Request a demo
Sphere's LCA assessment

Fast charging 3C is a must!

Fast charging is essential for the adoption of customers in the current markets.

Meeting the price point of LIBs is key!

SSBs need to meet the performance and come closer in cost to LIBs - especially in the OEM market

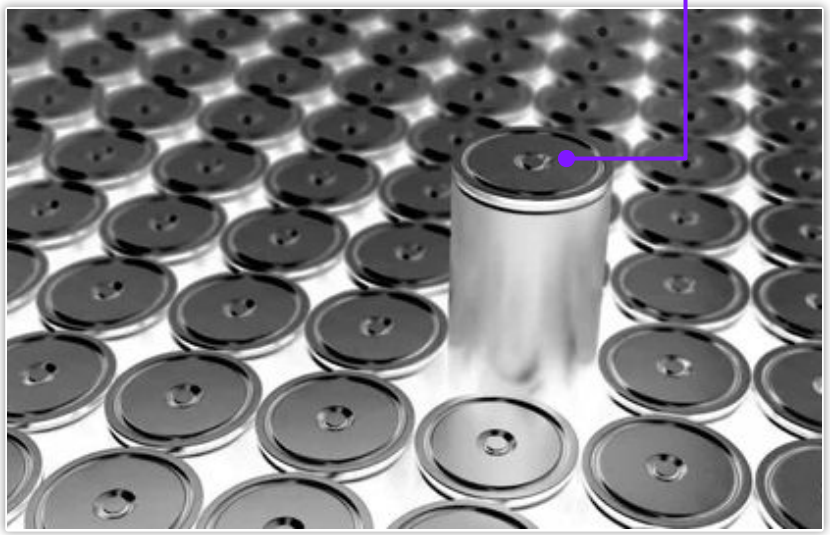
Leverage all the existing data properly!

We have so much info lying around in data centres - let's build the right architecture and leverage AI to become more efficient!

Request a demo
Sphere's Data Mgmt & AI Services

What does industry really care about?

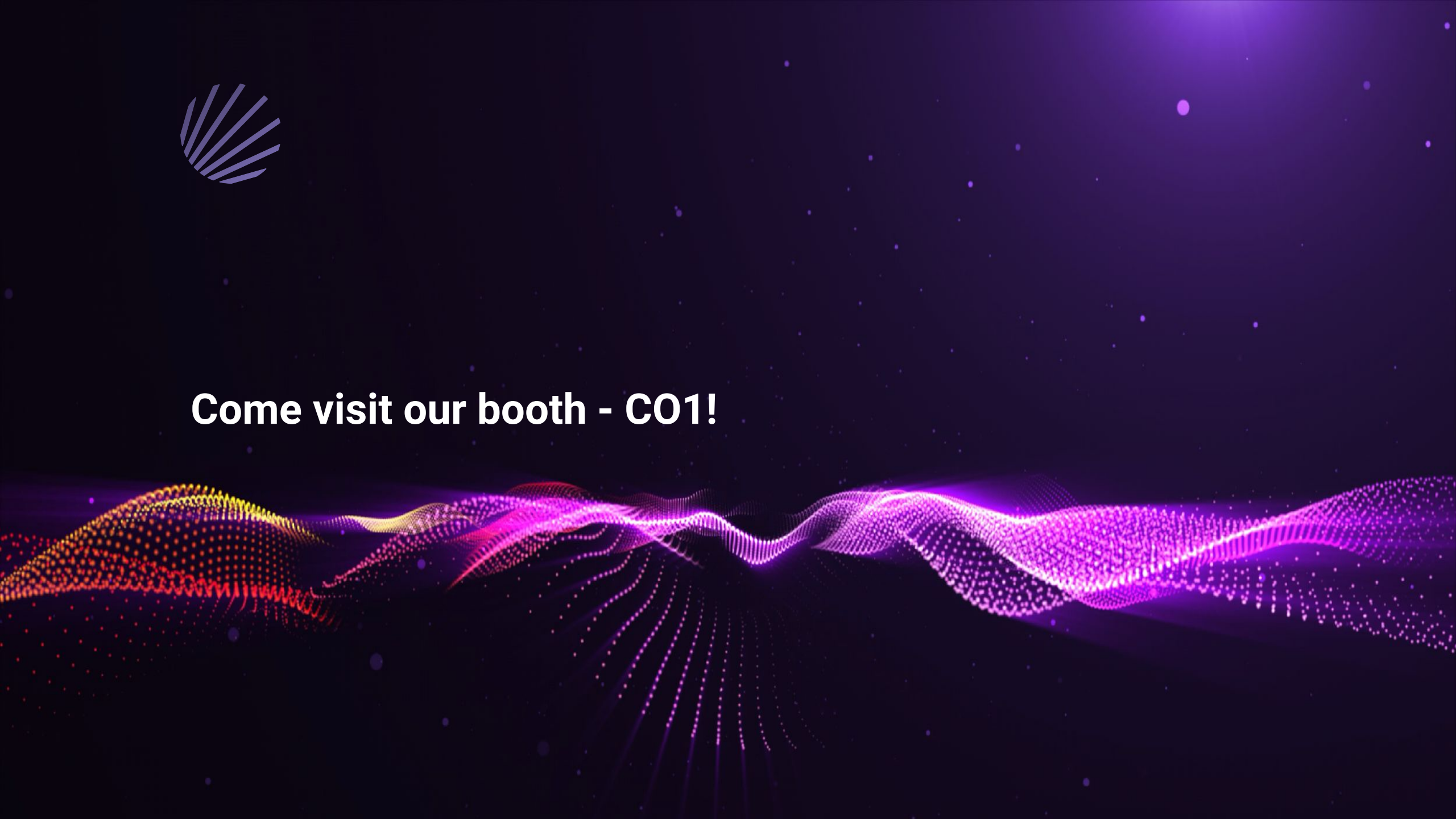
From a business perspective new technologies have it really hard to challenge Li-Ion cells.



What makes a battery tech successful?

- **Solid value proposition:** no body cares whats inside a battery - it simply has to do the job!
- **Attractive cost**: be ready to beat Li-Ion
- **Good manufacturability**: Can I manufacture it in my line - Billions of dollars need to be amortized

We love science but the battery has become a business! We have to play by the rules!


Come visit our booth - CO1!