SBD Explores: EV Battery Technology

Are semi-solid-state and solid-state batteries the next big thing for EVs?

10-minute Insight

Automakers are carefully observing the development of new battery chemistries. Existing lithium-ion batteries are likely to dominate the battery market for the next decade due to their high energy density, long cycle life and decreasing costs, but the ultimate theoretical performance has a ceiling.

The performance of lithium-ion batteries can be enhanced with more complex cathode or anode materials (e.g. niobium, silicon). Solid- and semi-solid-state batteries are an alternative and offer performance benefits.

In this edition of SBD Explores, we dive into these two emerging battery technologies and discuss their potential impact on the automotive industry.

Target audience

Product planning Strategy Engineering Investing

Focus market(s)

Global

Industry Buzz:

IM Motors launches new electric sedan IM L6, starting at $30,400 with semi-solid-state battery option

Nio Becomes The First EV Maker To Bring Semi Solid-state Batteries To The Mass Market

Chinese vehicle maker Nio has just announced its solid-state EV batteries, and it will be equipped in the new ES6 SUV.

BY NOAH STAATS
UPDATED MAY 11, 2024

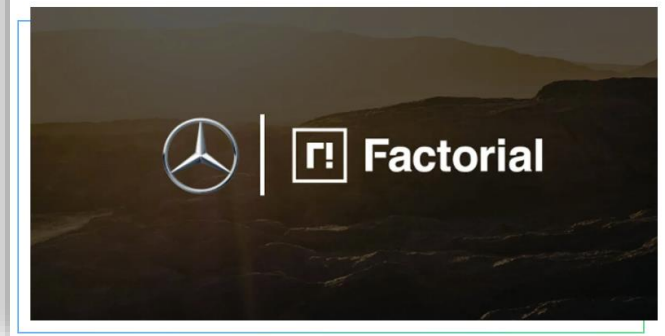
Toyota Lays Out Its EV Battery Road Map, Including a Solid-State Battery (Eventually)

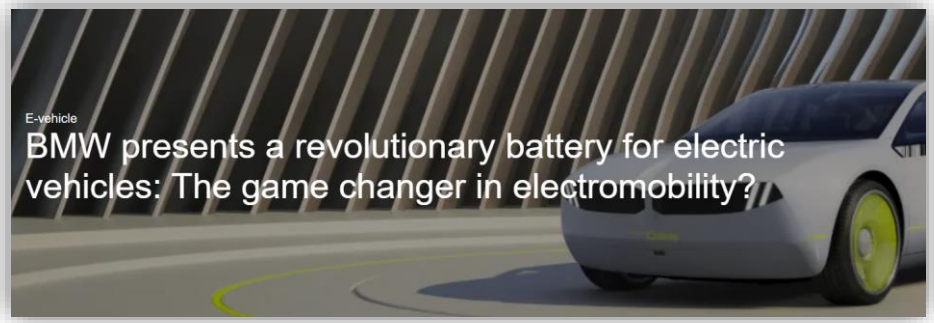
Toyota has been very late to the EV party, but now the automaker is unmistakably looking to dominate.

Ford CEO Jim Farley says semi-solid state batteries are 'promising for production'

Factorial delivers 106+ amp-hour solid-state cells to Mercedes-Benz to validate for EV use

Scooter Doll | Jun 5 2024 - 9:09 am PT | 23 Comments





Key takeaways

OEMs are looking for new technology to boost EV range. Current traditional lithium-ion batteries utilize a liquid electrolyte to transfer lithium ions across electrodes. Now, OEMs are investing in new forms of lithium-ion batteries with solid electrolyte interfaces.

- Two different cell designs are being developed by OEMs and suppliers. Semi-solid-state and solid-state batteries replace some or all the liquid electrolyte with a solid interface.
- Semi-solid-state batteries contain a mix of solid conductive material and liquid electrolyte to conduct ions across the electrodes. These have significantly less liquid electrolyte than traditional lithium-ion batteries.
- Solid-state batteries have a have no liquid at all and use a pure solid material as the electrolyte.

Why does it matter?

	Traditional lithium-ion batteries	Semi-solid-state batteries	Solid-state batteries
Current cost	Traditional lithium-ion battery costs vary. Much of the cost depends on the cathode active material.	Price per kWh is still unclear. Cost is likely to be between lithium-ion and solid-state.	There are large costs involved with the development and production of solid-state batteries.
Current development	Technology is already developed and in production. Advancements in chemistry are being made.	NIO has released a 150-kWh semi-solid-state battery for mass production. Other OEMs are likely to follow soon.	Developments have been slow and anticipated mass production dates have been pushed back to 2027.
Charge time	Current best charging times - from ~15-85% - take about 20 minutes.	Capable of faster charging times than lithium-ion batteries. Some estimates indicate up to 40% faster.	Researchers are looking to achieve charging times - for 0-100% - of 10-15 minutes.
Range	Lithium-ion battery chemistries can achieve ranges of up to 500-700 km (310-434 miles).	NIO's new ES6 with a 150-kWh semi-solid-state battery has a reported range of 930 km (578 miles).	Research shows range could exceed 950 km (590 miles), but this has not been demonstrated in a vehicle.
Weather resilience	In cold temperatures there is reduced battery performance.	With less liquid electrolyte, cold weather effects are less pronounced than with standard lithium-ion batteries.	Lack of liquid electrolyte reduces negative cold weather effects on the battery.
Cycle count	Cycle counts vary depending on the chemistry. LFP has shown promise, offering up to up to 5,000 cycles.	Research is still ongoing, but initial results show cycle life in the region of 2,000.	Current research suggests solid-state batteries can retain close to 80% of their capacity after 6,000-10,000 cycles.

Key takeaways

There are some key advantages that give semi-solid-state and solid-state batteries an advantage over traditional lithium-ion batteries. The advantages arise from the reduced amount, or lack of, liquid electrolyte.

- Having a liquid electrolyte can cause performance issues in cold temperatures as it does not allow ions to flow between electrodes as easily.
- Safety issues arise when flammable liquid electrolyte is present. Semi-solid-state batteries reduce this risk, and solid-state batteries remove this risk.
- Generally speaking, semi-solid-state batteries offer better performance than lithium-ion batteries, but not as good as the expected performance of solid-state batteries.
- The increased performance and expected reliability of solid-state batteries comes at a large investment cost into new manufacturing.

Who to watch out for?

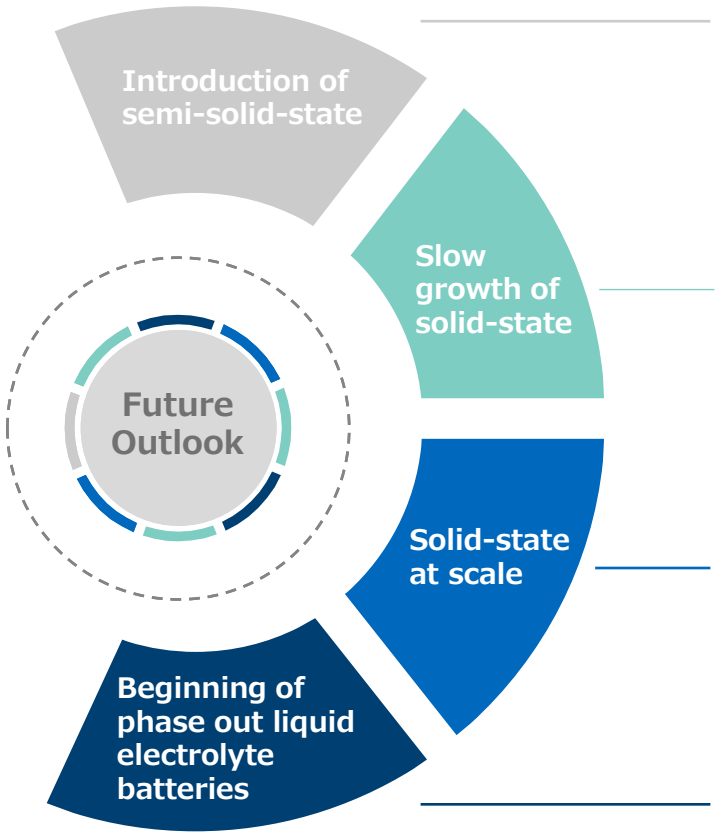
Semi-solid-state		Solid-state	
NIO	NIO is the first automaker to mass produce semi-solid-state batteries.	Factorial	Factorial supplied samples of solid-state batteries to Mercedes-Benz for EV validation and testing.
ZENDURE	Zendure produces semi-solid-state batteries with NMC chemistry for energy storage solutions.	QuantumScape	QuantumScape are working to develop an anode-less solid-state battery. They have delivered some samples to OEMs.
IM	IM Motors is planning to release a variant of their new L6 model in September that uses a semi-solid-state battery.	Solid Power	Solid Power is working to develop solid-state batteries with different types of electrodes and electrolytes. This includes silicon-based electrodes.
GREPOW RECHARGEABLE BATTERY	Grepow highlights aerospace as an industry that can benefit from their semi-solid-state battery pouches.	SAMSUNG SDI SAMSUNG	Samsung have noted that solid-state batteries are an important trend for the future, and they are working to develop the technology.

Key takeaways

Both semi-solid-state and solid-state batteries are being developed in tandem, with semi-solid-state being more mature than solid-state batteries for automotive and non-automotive applications. Solid-state batteries have been, “5 years away” for a long time due to continuous difficulties (both technical and commercial) in the design and validation processes.

- Energy storage solutions and batteries for non-automotive applications are being actively deployed. Learnings from the field will support refinement of the technology for the technically-demanding automotive space.
- Semi-solid-state batteries are being installed in vehicles in China. More are expected to follow before solid-state hits the market. NIO’s swapping technology supports in-field testing and sampling of new chemistries.
- Solid-state batteries are still some way from being ready for production vehicles.

Where Next?



1
- NMC and LFP are the dominant chemistries for automotive EV batteries.
- NIO is the first to release semi-solid-state batteries for mass production.

2
- More OEMs consider using semi-solid-state batteries in their vehicle line-up.
- Semi-solid-state battery vehicles will be more expensive than those with lithium-ion batteries, justified by increased range.

3
- Solid-state batteries finally adopted at scale, starting with premium vehicles.
- Traditional lithium-ion batteries remain in use for low-cost EVs.

4
- Semi-solid-state batteries become used in low-cost EVs.
- Solid-state batteries become more widespread.

Now | 2-6 yrs. | 6-8 yrs. | 8+ yrs.

Key takeaways

Several automakers see value in semi-solid-state and solid-state batteries. Production of semi-solid-state batteries will likely occur sooner than solid-state batteries for most OEMs.

Key factors contribute to the market adoption of semi-solid-state and solid-state batteries:

- If consumers continue to demand electric vehicles with more range, this will drive OEMs and suppliers to further develop the technology.
- However, while consumers want vehicles with more range, this will come at a cost. Vehicles with new battery technologies will likely be expensive as manufacturing processes develop.
- Further development of manufacturing processes can help drive costs down, allowing more vehicles to be equipped with this battery technology.

How should you react?

1 Continue to **build** alliances and joint ventures with OEMs and battery suppliers to develop new scalable models.

2 **Understand** how different battery technologies will impact now/near/far EV prices and plan your model specifications and price-point accordingly.

3 If you want to be a leader in the EV space, **invest** in new forms of battery technology, not limited to semi-solid-state and solid-state batteries. Alternative anode and cathode materials are also worthy.

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