Advancing Low-Cost Manufacturing of Sulfide Solid Electrolytes for High Energy Density ASSBs

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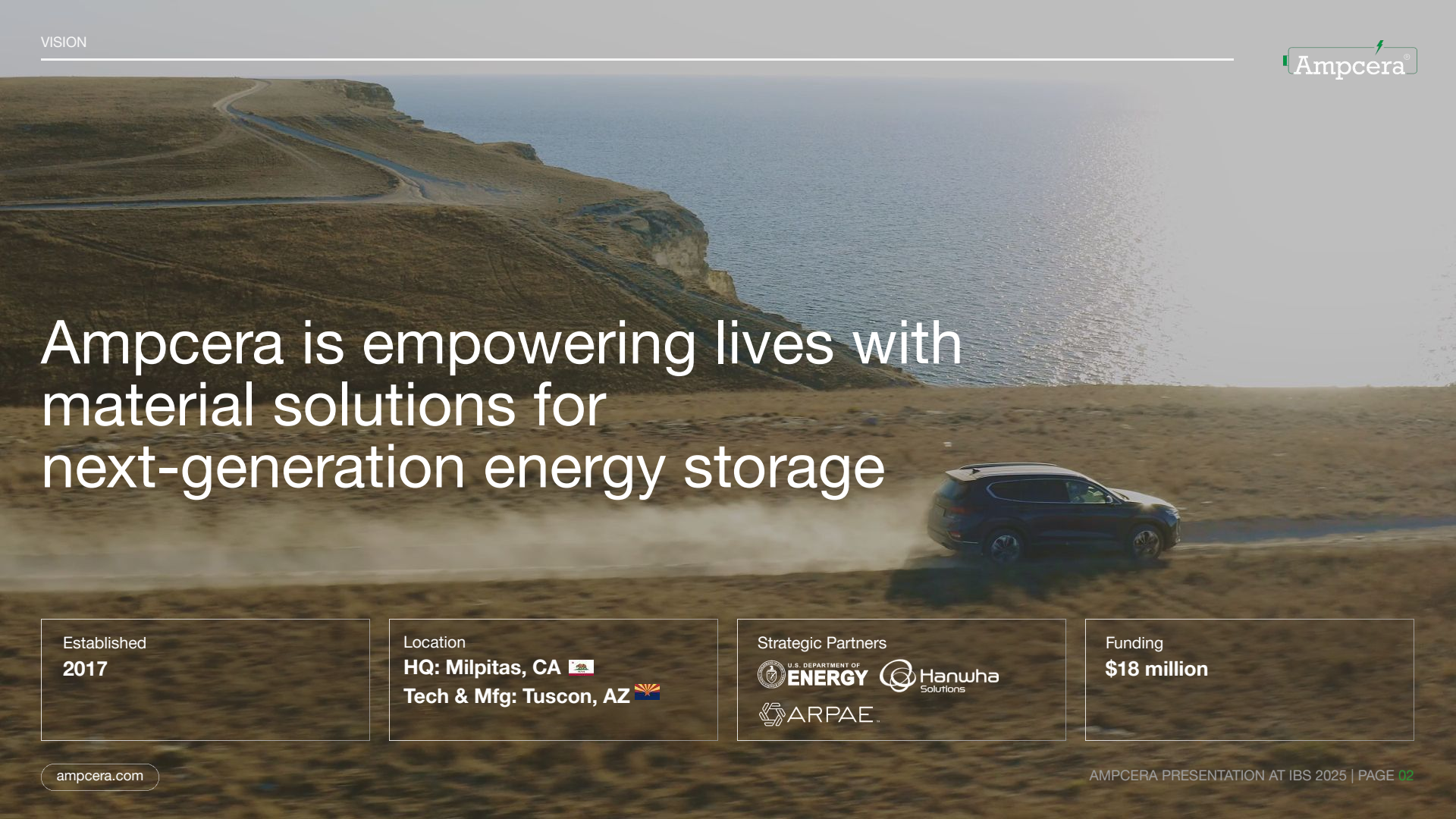
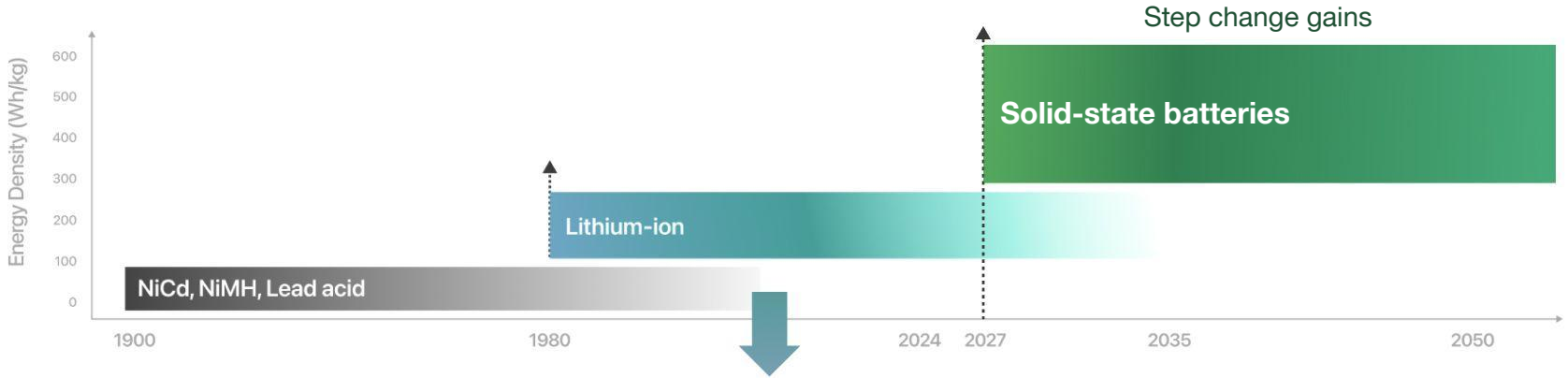
Ampcera



Ampcera is empowering lives with material solutions for next-generation energy storage

Established	Location	Strategic Partners	Funding
2017	**HQ: Milpitas, CA** **Tech & Mfg: Tuscon, AZ**	U.S. DEPARTMENT OF ENERGY Hanwha Solutions ARPAE	**$18 million**

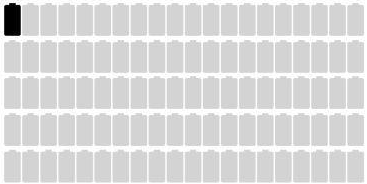
Build the future of energy storage



Supply chain problem

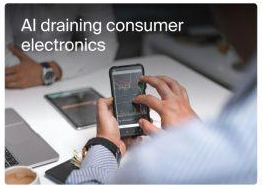
1%

Share of global lithium output that is mined and processed in the U.S.



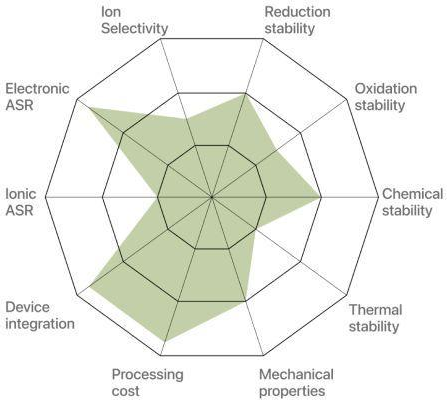
+

Technology problem

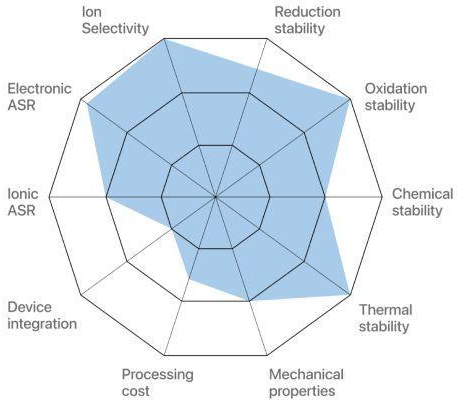


Strategic benefits of sulfide solid electrolytes

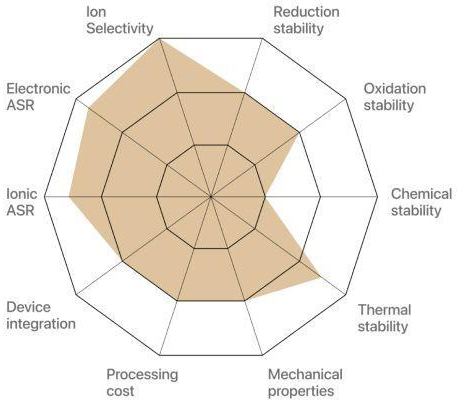
Polymer



Oxide



Sulfide



Sulfide ionic conductivity is on par with organic liquid electrolytes (1-10 mS/cm).

Device integration and processing cost are improving with manufacturing optimization.

Redox and chemical stability are improved with proper active material coatings as well as with proper solvent, binder, and electronic conductive additive selection.

SSB product launch scheduled for 2027

Japan's Idemitsu to build lithium sulphide plant to help support Toyota's EV plans

Automakers and battery suppliers worldwide are racing to develop solid-state batteries

BYD confirms plans for EVs with all-solid-state batteries to begin rolling out in 2027

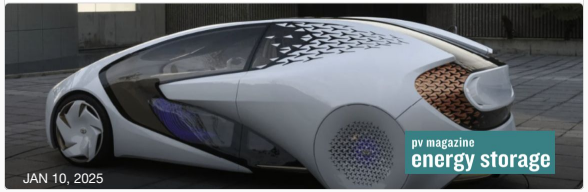
BYD's timeline: 2027 EV launch, 2027-29 demonstration.

Hyundai starts solid-state battery production in March

The inauguration of the Dream battery pilot plant is not far away.

China, South Korea, Europe, & the US continue active development of all-solid-state batteries

Japan keeps lead in solid state battery development



Lotte Energy Materials sets sights beyond copper foil: CEO Kim

Battery makers and automakers are striving to develop all-solid-state batteries (ASSBs)

Materials that deliver significantly higher performance for wearable devices

Apple supplier TDK announces solidstate battery breakthrough

Overview of Ampcera solutions

Ampcera's robust electrolyte technology platform is driving commercialization

Solid electrolytes

("component")

ENGINEERED ARCHITECTURE

Cell integration

("tailor-made")

CELL ECOSYSTEM DESIGN

Battery cell

("system")

HIGH ENERGY DENSITY & FAST CHARGING

Process technologies

("manufacturing")

SCALABILITY AND REPRODUCABILITY

50+ patents and **90+ trade secrets** covering materials, manufacturing, and cell designs

Journey: Synergized material design with system-level understanding

Pre-2023

"Has been"

Matured SSE materials architecture

Targeting physical attributes: particle size, surface area, mechanical strength, porosity, ionic conductivity

Manufacturing proven to be reproducible at lab-scale

2023-24

"Is"

Refine SSE architecture for superior electrochemical performance

Used system-level data to guide granular material design (design for electrochemical performance)

Advanced materials with multiple variants

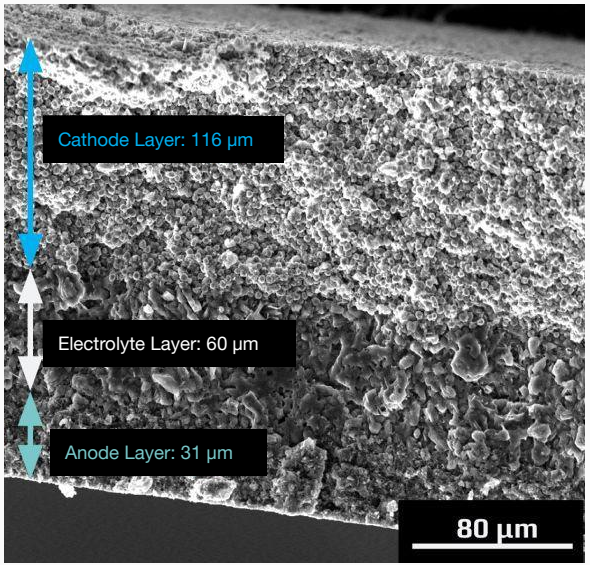
2025-

"To be"

Product development with dedicated cell/auto partner

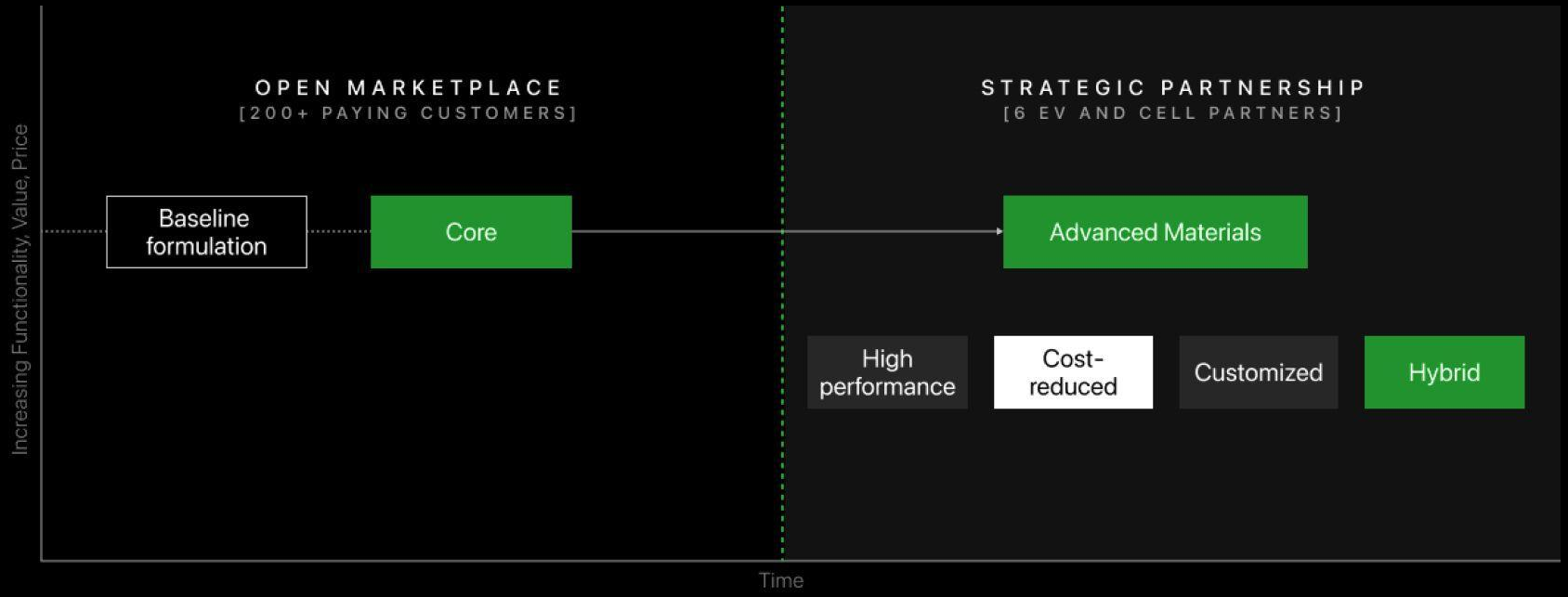
Incorporate all the positive aspects of SSE material architecture to create a "super-particle".

Building commercial samples



Investment from Hanwha Solutions and Grant from ARPA-E

Product development and commercial traction



All-solid sulfide electrolyte materials

High ionic conductivity, high purity and engineered particle sizes.

1 ton annual capacity

Manufacturing

~$1M revenue/year

R&D sales

200+ paying customers

Major automotive OEMs, cell manufacturers, and consumer electronics hardware companies.

IP-protected processing for high-phase purity and modular scaling

PRE-PILOT JAN 2023	INDUSTRIAL PILOT JUN 2025	LARGE SCALE COMMERCIAL PLANT 2026
1 ton per annum	20 tons per annum	1000 tons per annum

STAGE 1

Precursor procurement & quality validation

Ensuring supply chain security and the highest level of material quality

STAGE 2

Material preparation and homogenization

Scalable processing approach for achieving high phase purity

STAGE 3

Material processing

IP-protected processing method that enables modular scaling to thousands of tons

STAGE 4

Post-processing and particle size classification

Confidential processing approach for achieving small particle size distribution

STAGE 5

Material packaging and distribution

Patented packaging technology to protect against moisture contamination

Collaboration with Tier 1 partners has enabled Ampcera to achieve larger batch size, high-quality powder, and consistent production.

Ampcera’s dry manufacturing process

Dry manufacturing

High energy density

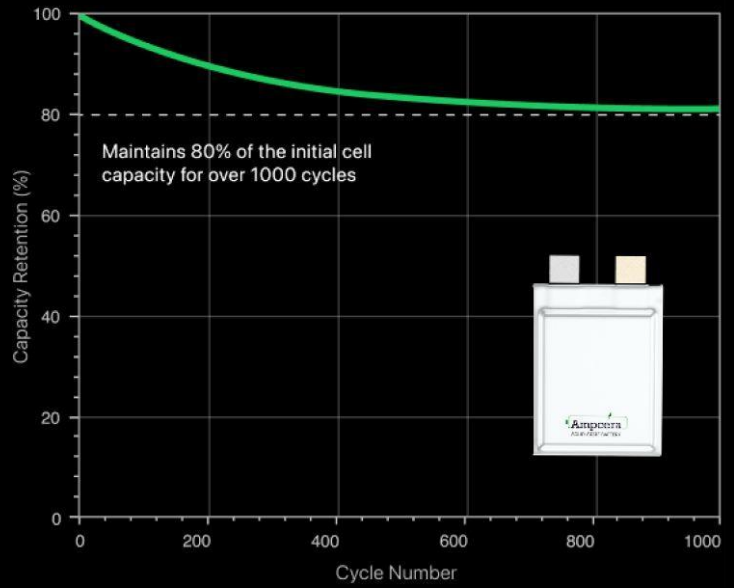
+

Lower manufacturing cost

+

Lower emissions

Cycle life performance



Ampcera's dry electrode manufacturing process for solid-state batteries eliminates electrode drying steps, reducing costs and CO_2 emissions by over 60%.

Ampcera material products

Coarse

RT Ionic Conductivity:
7.5+/-0.5 mS/cm

D50: **10 – 20 µm**, **D99 <100 µm**

DIY particle size processing and applied or basic research

Fine

RT Ionic Conductivity:
6.5+/-0.5 mS/cm

D50: **5 – 8 µm**, **D99 15 – 20 µm**

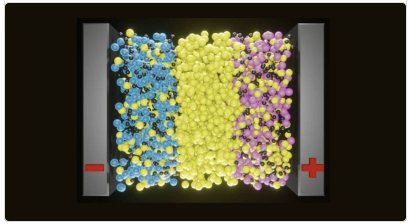
SSE membrane separator – lower binder requirement

Ultra-fine

RT Ionic Conductivity:
5.5+/-0.5 mS/cm

D50: **1 – 3 µm**, **D99 5 – 8 µm**

Catholyte, Anolyte, SSE separator – higher binder requirement

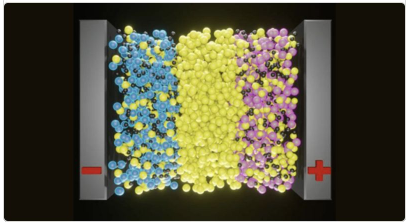


Nano

RT Ionic Conductivity:
4.5+/-0.5 mS/cm

D50: **0.4 - 0.8 µm**, **D99 2-3 µm**

Catholyte and Anolyte



RT @ 25 °C

Ampcera's proprietary sulfide-based solid-state electrolyte is IP-protected and engineered to reduce stack pressure, achieve fast-charging and long cycle life.

Sulfide-based solid electrolyte is available in four standard particle size ranges.

Ampcera material products

Ampcera offers a variety of sulfide solid electrolyte products along with customization options in a wide range of particles sizes to fit customers needs.

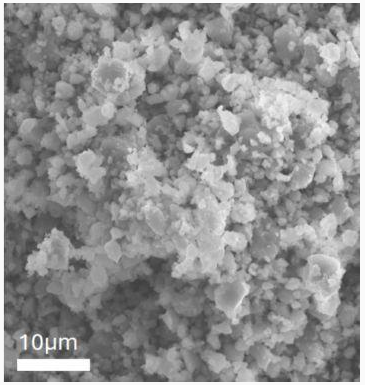
Argyrodite Solid Electrolyte

- Li_6PS_5CL
- $Li_{5.5}PS_{4.5}Cl_{1.5}$
- Li_6PS_5Br
- $Li_{5.5}PS_{4.5}Br_{1.5}$
- $Li_6PS_5Cl_{0.5}Br_{0.5}$
- $Li_{5.5}PS_{4.5}Cl_{0.75}Br_{0.75}$
- $Li_6PS_{4.5}O_{0.5}Cl$
- $Li_{5.5}PS_4O_{0.5}Cl_{1.5}$
- $Li_6PS_5Cl_{0.75}F_{0.25}$

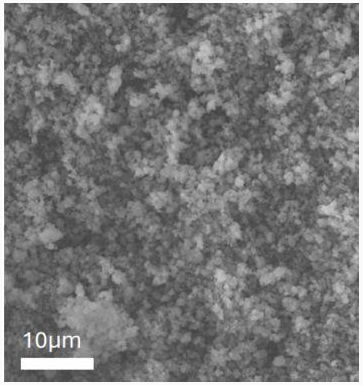
Sulfide Solid Electrolyte

- $Li_{10}GeP_2S_{12}$ (LGPS)
- $Li_{10}SnP_2S_{12}$ (LSPS)
- Li_3PS_4 (Crystal LPS)
- $Li_7P_3S_{11}$ (Crystal LPS)
- $75Li_2S\text{-}25P_2S_5$ (Glassy)
- $70Li_2S\text{-}30P_2S_5$ (Glassy)
- SS7 (Proprietary Formulation)
- $Li_7P_2S_8Br_{0.5}Cl_{0.5}$
- $Li_7P_2S_8Br_{0.5}I_{0.5}$

Ultra-Fine



Nano SSE



BET measurements of the Nano powder put the average particle size in the range of 400 - 800 nm.

Realizing <$100/kWh for ASSB cells

In partnership with Hanwha Solutions, U.S. Department of Energy, ARPA-E

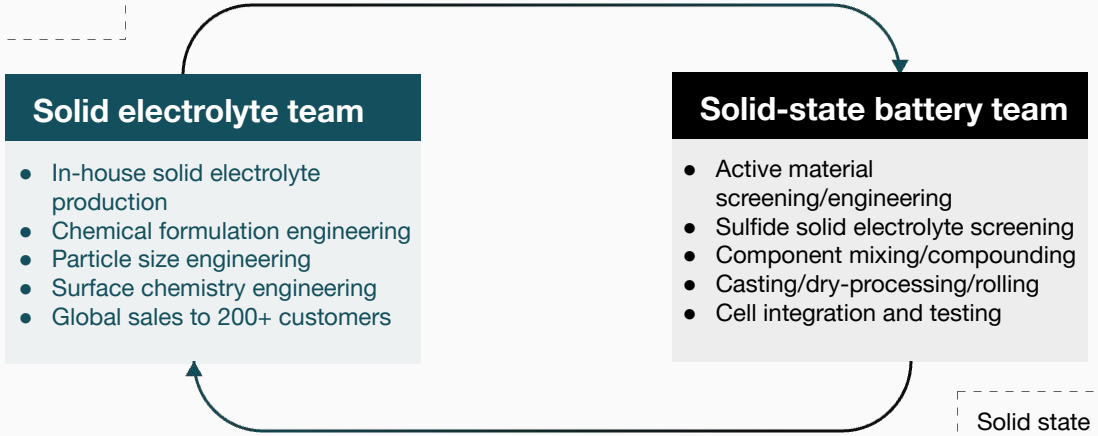
Precursor	Electrolyte	Battery
Lithium Sulfide (Li_2S)	Sulfide Solid Electrolyte	All-Solid-State-Battery
<$45/kg	<$50/kg <$25/kWh	<$100/kWh

Cost target will be achieved by 2028, through vertical integration, low-cost manufacturing technologies, and scale.

Ampcera SSB development: In-house synergy

Solid electrolyte team provides high performance sulfide powders for large scale screening/testing.

Next-gen solid electrolyte powders



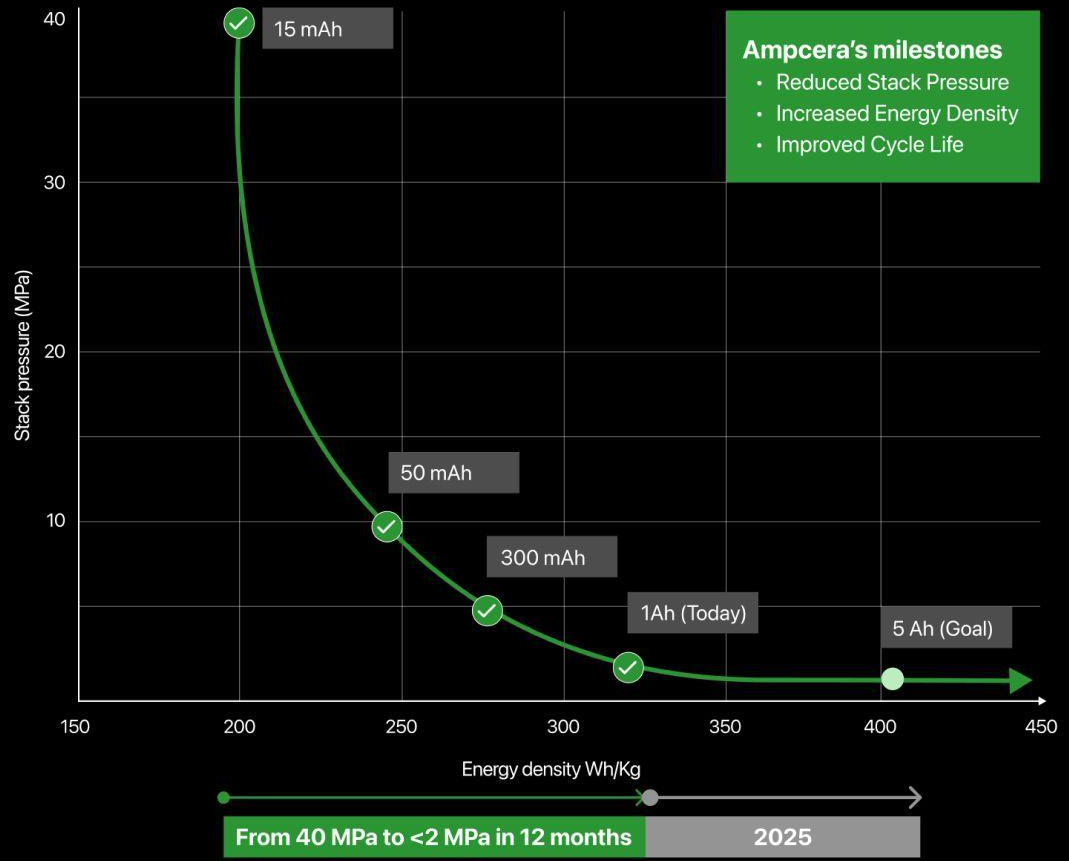
Technical feedback for performance improvement

Solid state battery team serves as an internal validation customer, providing rapid feedback for next gen sulfide solid electrolyte powder development.

Ampcera®

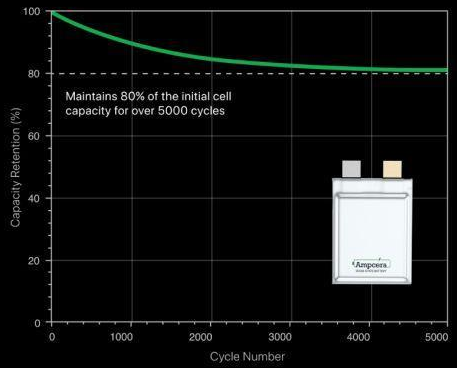
Achieved <2 MPa stack pressure for ASSB cells

Ampcera is at 1 MPa currently under development and aims to achieve 0.5 MPa in H1 of 2025

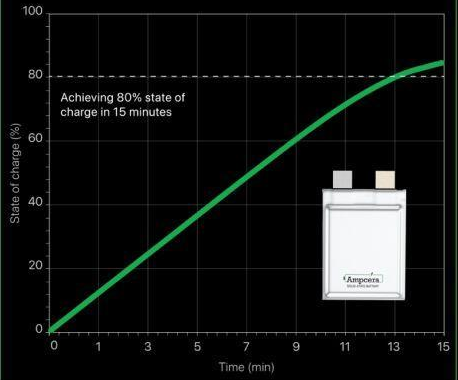


Partners delivered performance results for Ampcera's ASSB cell (100 mAh to 1 Ah)

Cycle life



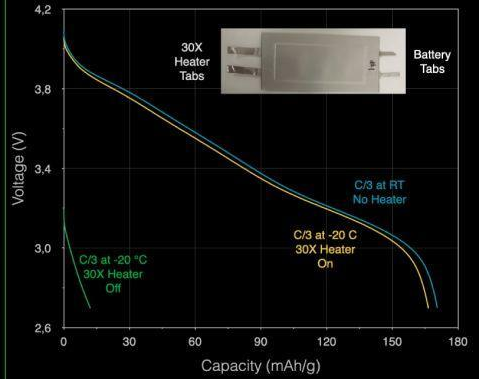
Fast charging



Increased safety

Safety demonstration: [1] Scissor cutting test, [2] Nail penetration test

All-climate



Ampcera's approach to addressing cell size increase challenges

Challenges

Stack pressure requirement
Larger area requires larger load at fixed pressure

Pressure field uniformity
With cell size increase, pressure field needs better control/regulation

Performance drop with stack pressure
Solid/solid interfacial contact resistance increases with reducing stack pressure

Addressed by optimization at material, electrode, cell, and system level

→

Develop materials/components that require less/no stack pressure

Ampcera's approach

Solid Electrolyte Development
- Size, formula
- Crystallinity
- (Surface)chemistry
- Conductivity
- Ductility

Active material selection/design
- Size, morphology
- (Surface)chemistry

Electrode formulation
- Mixing method/sequence
- Mixing ratio
- Binder selection

Pressure regulation
- Pad/gasket
- Cell fixture design

Business model for the commercialization of safe, all-climate, fast-charging ASSB

Sale of engineered materials to battery and OEM manufacturers and licensing of battery design and process technology

SOLID-STATE ELECTROLYTE

Technology Solution

1

SALE

Electrolyte Material

Material characteristics
Design and specifications
Manufacturing know-how

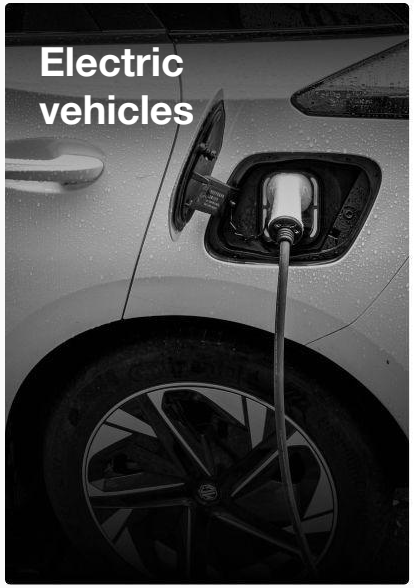
2

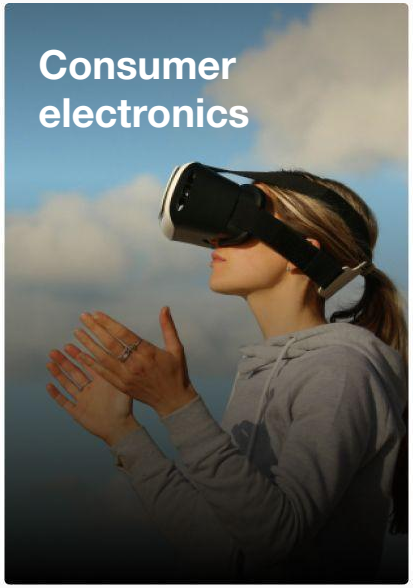
LICENSING

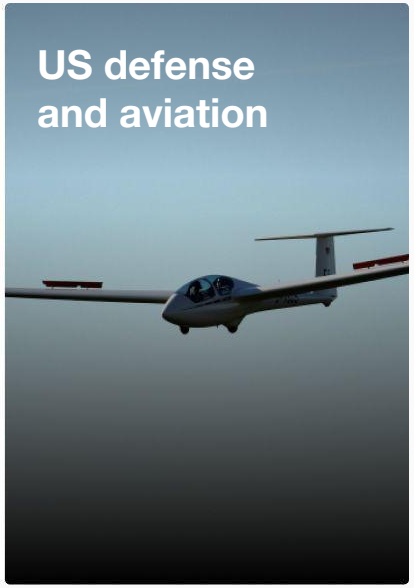
SSB Cell Technology

Structured dataset
Cell design & specifications
Component supply chain

Partnerships across multiple markets to accelerate the commercialization of ASSBs







3-fold business development strategy blends production at scale with premium margins by targeting EV, high-end consumer electronics, and U.S. defense sectors.

High performance products through cross-market development

Faster technology development and time-to-market

Diversity sector risk

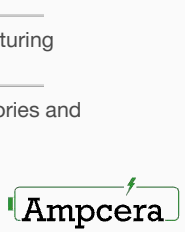
Full-stack cell solution that integrates Ampcera's electrolyte technology

Strategic Benefits

Ability to scale-up the development with the understanding of mass-production requirements and limitations

Enjoy the economy of scale and EV-grade manufacturing know-how learning curve

Provides validation and comfort to battery gigafactories and EV OEMs to embrace solid electrolytes



ELECTRIC VEHICLES

UPSTREAM: RAW MATERIAL SOURCING

Confidential | Confidential | Confidential | Confidential

Securing raw materials supply chain for Li_2S, P_2S_5 and other critical materials

MIDSTREAM: EQUIPMENT AND PROCESS DEVELOPMENT CELL AND MANUFACTURING PARTNERS

Confidential | Confidential

Equipment and process development and scale-up
Sulfide solid electrolyte manufacturing
Establishing strong capabilities in building battery cells via partners

DOWNSTREAM: JOINT DEVELOPMENT PARTNER AND CUSTOMER

Confidential | Confidential | Confidential

Ford* | gm**

EV-grade mass production manufacturing partner helps in swift validation, qualification, and commercialization

* EVs4ALL ARPA-E program
** DOE Grant, VTO in collaboration with Shirley Meng

CONSUMER ELECTRONICS

MIDSTREAM: CELL PARTNERS

Confidential

Strong capabilities in building pouch cells for CE

DOWNSTREAM: JOINT DEVELOPMENT PARTNER AND CUSTOMER

Confidential

Helps Ampcera achieve premium pricing for its SSE-based products

Foundational building blocks and areas of synergy

Solid electrolytes

(“component”)

MATERIAL ARCHITECTURE ENGINEERING: Precisely control material properties to customize physical attributes and characteristics, thereby meeting electrochemical performance requirements.

BENCHMARKING: Systematic integration of a diversity of electrolyte materials variants or other next-generation materials in cell systems that meet end user needs.

INNOVATION STRATEGY: Drives innovation through close collaboration, key stakeholder in-licensing, and strategic partner out-licensing.

ENGINEERED ARCHITECTURE

Cell integration

(“tailor-made”)

SYNERGIZING MATERIAL DESIGN: System-level understanding to reach customers required battery performance

DESIGN: Optimize cell structure via material screening for peak electrochemical performance.

ECOSYSTEM TAILORABILITY STRATEGIES: Development of information packages for integrating new solid electrolytes and other next-generation materials into customer-specified cell systems.

MATERIAL ENGINEERING: Solid electrolytes and other next-generation materials for diverse cell chemistries, sizes, and formats.

CELL ECOSYSTEM DESIGN

Battery cell

(“system”)

SYSTEMATIC ENGINEERING: Optimized cell architecture for best-in-class energy density and fast charging.

BATTERY SOLUTIONS INFRASTRUCTURE: Ampcera provides leading cell design, prototyping, and electrolyte solutions, leveraging in-house development and strategic partnerships.

CUSTOMIZED TURN-KEY SOLUTIONS: Next-generation batteries and building structured datasets with performance metrics that meet customer needs.

DRY MANUFACTURING: Strategy to enhance energy density and lower production cost.

HIGH ENERGY DENSITY & FAST CHARGING

Process technologies

(“manufacturing”)

DESIGN: Manufacturing line for safety, scale, and capital efficiency

ADVANCED ENGINEERING OF MATERIALS AND CELLS: Process optimization, process integration, process development, and equipment customization.

SCALE-UP: Engineering strategies to meet current and future demand.

EQUIPMENT SELECTION: Development strategies to meet manufacturing requirements.

D-FMEA AND P-FMEA: Achieve commercial ready cell solutions.

SCALABILITY AND REPRODUCABILITY

Ampcera's commitment to commercializing ASSB through innovation, cost reduction, and strategic partnerships

Ampcera

Let’s connect for building a sustainable future

Sumin Zhu

Co-Founder & CEO

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