

Anonymized Manufacturer – a process workflow, not a single electrolyte class

Assessed from 56 patent families, five lead patents and the public record: the company's cell-level evidence sits in the hybrid solid-liquid line, a coextruded electrolyte sheet defined by function rather than chemistry, laminated to lithium-alloy foil from its own upstream operations, while sulfide and oxide electrolytes are supplied to the industry as commercial products. The all-solid-state milestones in its public statements are not yet matched by cell-level patent evidence.

Organization profile

The company is a publicly listed, vertically integrated lithium producer and one of the largest lithium-metal producers worldwide. Solid-state development sits with a dedicated new-energy subsidiary, holder of 46 of the 56 families reviewed.

Sells refined lithium and lithium-metal foil, self-made lithium sulfide, sulfide and oxide electrolytes as commercial products (LGPS, LPSC, $\text{Li}_7\text{P}_3\text{S}_{11}$, Li_3PS_4 , LATP, LLZSO), and its own cells.

To whom the highest-energy cells go to aircraft and robotics programs, through aviation before passenger cars: the eVTOL cell flew in the manned flight test of December 2025 of an aircraft program. Vehicle application is stated. Electrolytes sell in volume to the industry.

56 patent families analyzed

Solid electrolyte categories



Benchmark

400 Wh/kg lithium-metal hybrid solid-liquid cell at 1,100 cycles (May 2026), protocol and temperature not reported, 650 Wh/kg in non-automotive service.

Patents: **1,320 cycles** to 80 % at 1 C / 60 °C, **30.7 mΩ**, 100 % nail-penetration pass for the coextruded sheet cell (slide 4): its proven edge is resistance and puncture safety, not cycle life.

Maturity

Hybrid solid-liquid: series production across graphite, silicon-carbon and lithium-metal anodes, highest-energy cells in small batches.

All-solid sulfide: sample stage in February 2026, small-batch 10 Ah, 500 Wh/kg cell by May 2026, no mass-production date identified. Electrolytes sell before cells do.

Design principle

Qualify process workflow and underlying equipment once, pursue both solid-liquid and all-solid electrolyte cells. The sheet is defined by what its layers do, not by what they are made of: garnet, oxyhalide or LZSP cores enter one line without requalifying it.

HF and Li-Al alloy, the connection: the injected fluorohydrogenate ionic liquid EMImF_{2.3}HF conducts near 100 mS/cm, ten times a TFSI-based liquid, behind the 30.7 mΩ internal resistance and the nail-penetration pass, but its (FH)_nF⁻ anion is a latent HF reservoir. The plasma-formed LiF / Li_3N / Li_xC_y film on the 50 μm Li-Al foil is the barrier against that HF, and the alloy's near-zero strain holds full-cell expansion to 3–5 % so the laminate needs no stack pressure. The HF fraction n is a dial between transport and corrosion, turned on scale-up without touching sheet, electrodes or line. Neither is in the company's public statements, and the alloy anode is a sparsely pursued field according to our patent analysis.

Links: underlined values are hyperlinked to the public statement they come from in the full version, EPO / Google pairs (slides 3 and 5) open the patent family. Publication numbers and links are removed in this anonymized sample. Level classification of all 56 families on slide 6.

Targets & requirements – what the route has to deliver

□ 'Unique Capability Pathway' – the route along which the company differentiates from the field (reading guide on slide 6)

Performance & Energy Density

Reliability & Total Cost of Ownership

DESIRED OUTCOME (CELL LEVEL)

Lithium-Metal Cell Energy Density

650 Wh/kg and 400 Wh/kg hybrid solid-liquid cells reported in service in non-automotive applications.

Series Production Across Anode Systems

Graphite systems at 240–280 Wh/kg and silicon-carbon at 320–480 Wh/kg reported in production.

Aviation & Non-Automotive Entry

eVTOL cell flown in the manned flight test of December 2025 of an aircraft program.

Cycle Life at High Energy

1,100 cycles reported for the 400 Wh/kg cell and 1,000 for the 320 Wh/kg silicon cell, test protocol not reported.

MATERIAL / ENGINEERING REQUIREMENTS

Dimensionally Stable Li-Al Alloy Anode

Zero-strain lithium-alloy negative electrode announced in February 2026.

Self-Made Flexible Electrolyte Membrane

Replaces the conventional separator in the hybrid solid-liquid cell.

Retained Liquid Electrolyte Phase

Liquid component kept alongside the solid membrane in the hybrid solid-liquid design.

In-House Oxide Electrolyte Supply

LATP above 0.6 mS/cm at hundreds of tonnes per year and LLZOXO (X = Ta or Nb) near 1 mS/cm at tens of tonnes.

Unique Capabilities

- **Track 1 (hybrid solid-liquid):** substitution rather than reinvention, a self-made flexible electrolyte membrane replaces the separator. Cells in series production across graphite, silicon-carbon and lithium-metal anodes, and 650 Wh/kg is extraordinarily high.
- **Track 2 (all-solid-state sulfide):** upstream position rather than a demonstrated cell. Self-made high-grade lithium sulfide, and LGPS, LPSC, $\text{Li}_7\text{P}_3\text{S}_{11}$ and Li_3PS_4 supplied as commercial products.

Technical Approach & Differentiation

- **Track 1:** a lithium-aluminum alloy anode where the field favors pure lithium, paired with a membrane that lets electrolyte and electrode chemistry change without changing the coextrusion line. Melting and rolling lithium foil is already the company's upstream business. The injected liquid does three jobs at once: it conducts, reflows into a puncture, and keeps contact without stack pressure.
- **Track 2:** sulfide electrolytes from lithium sulfide it produces itself turn the dominant electrolyte cost driver into an internal one. Low-cost Li_2S routes and dry jet milling sit in the portfolio.

Key materials & scale-up challenges – what is proven, what is not

□ 'Unique Capability Pathway'

Performance & Energy Density

Reliability & Total Cost of Ownership

KEY MATERIALS

Plasma-Treated Li-Al Alloy Foil

Concept 4

Room-temperature vacuum plasma forms a 2 nm–3 μm LiF/Li₃N/Li_xC_y artificial SEI. The best 50 μm Li-Al sample reaches 587 cycles to 80 % retention at 1C.

Coextruded Buffer | Core | Buffer Sheet

Concept 5

One-pass coextrusion after twin-screw compounding at a 20:60:20 thickness ratio. PEO/LiTFSI buffers hold internal resistance to 30.7 mΩ against 44.1 mΩ buffer-free.

EMImF-2.3HF Fluorohydrogenate Ionic Liquid

Concept 5

Injected after assembly, conducts ≈100 mS/cm at 25 °C, roughly ten times a TFSI-based liquid.

Spherical Garnet & Nanomilled LZSP

Concepts 1 & 3

Aqueous spray-drying yields single-phase cubic LLZO from 700 °C in free-flowing spherical particles. Nanomilled LZSP is a titanium- and germanium-free NASICON core.

CRITICAL SCALE-UP CHALLENGES

Continuous Plasma Treatment of Li-Al Foil

Concept 4

Throughput at cell-relevant Li-Al foil widths and speeds is unaddressed, as is folding a vacuum step into a dry-room electrode line.

Key KPI: treated Li-Al foil web speed (↑)

Core Interchangeability on One Line

Concept 5

Each new core chemistry might require its own compounding and coextrusion window rather than entering an established line.

Key KPI: requalification time per core chemistry (↓)

HF Release from the Injected Liquid

Concept 5

Avoid HF attack on the oxide core and the aluminum current collector. Gassing, corrosion and long-term impedance validation is not reported.

Key KPI: calendar-life impedance rise (↓)

Electrolyte Membrane Uniformity at Web Width

Concept 5

Uniformity and defect rate at production web widths and line speeds remain unproven.

Key KPI: membrane defect rate (↓)

Leap of Faith

- **Track 1:** that one coextruded sheet carries garnet, oxyhalide or LZSP cores on one line without requalifying per chemistry, that the Li-Al anode holds full-cell expansion to 3–5 %, and that the ionic liquid's HF fraction does not drive excessive parasitic reactions.
- **Track 2:** that the cathode-side interface gains demonstrated with mixed-conductor argyrodite are anode-agnostic (EPO / Google).

Underlying Scientific Hypothesis

- **Track 1:** ionic transport is governed by the sheet's layer architecture and the injected liquid, not by core chemistry, so similar performance is achievable with various electrolyte combinations, while a near-zero-strain Li-Al anode keeps interfacial contact at low stack pressure and a reduced HF fraction keeps conductivity high.
- **Track 2:** the mixed-conductor network acts on the oxide-cathode space-charge layer, a mechanism independent of the negative electrode, so its retention gain should survive a change of anode.

Five patented building blocks – and the cell they add up to

One coextrusion line, a chemistry-agnostic core: the sheet is the hub, the three electrolyte patents are its feedstock, and the treated Li-Al foil is the anode it laminates to. Its proven gain is resistance and puncture safety, not cycle life.

1

Spray-Dried Spherical Garnet Powder

Aqueous spray-drying forms spherical single-phase garnet particles, improving conductivity and easing kiln scale-up

$1.26\text{--}1.64 \times 10^{-3} \text{ S/cm}$ Ga-doped

2

Rapid-Synthesis LiTaOCl_4 Oxyhalide

Short milling plus a low-temperature anneal crystallizes an air-tolerant oxyhalide with high oxidative stability

$1.05 \times 10^{-2} \text{ S/cm}$ at room temperature

3

LZSP Core-Shell Nanofiber Membrane

Electrospun polyimide-core fibers in a fluoropolymer shell, pore-filled with NASICON nanoparticles, combine conduction with thermal stability

$3.0 \times 10^{-3} \text{ S/cm}$ at room temperature

4

Plasma-Formed Surface Film on Li-Al Foil

Room-temperature plasma builds a fluoride- and nitride-rich film on lithium-aluminum foil, improving cycle life and ambient handling

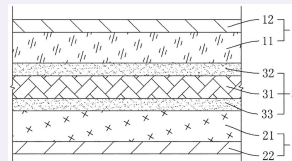
587 cycles to 80 % at 1C vs 429 untreated

5

Coextruded Self-Healing Three-Layer Membrane

One-pass buffer | core | buffer sheet restores electrical isolation after puncture. The injected ionic liquid's HF content can be reduced if upscaling reveals corrosion

1,320 cycles to 80 % at 60 °C / 1C, 30.7 mΩ, 100 % nail pass vs 1,280 cycles, 45.0 mΩ and 72.9 % for a conventional polyolefin-separator cell



The cell the five concepts feed into: the composite electrolyte sheet (3) leaves one coextrusion line whatever fills its core (31) and buffers (32, 33), and the injected liquid can change too, so the chemistry varies where the drawing shows it while the line stays. It is laminated between the positive plate (1: active layer 11, collector 12) and the negative plate (2: 21, 22).

Concept 5 · HF management and ionic-liquid flexibility

EMImF-2.3HF conducts near 100 mS/cm, ten times a TFSI-based liquid, but its anion is a latent HF reservoir threatening the oxide core, the aluminum collector and calendar-life impedance. Not architecture-defining: the same patent injects PF_6^- and TFSI-type liquids, an FSI-based liquid is an HF-free fallback, and the HF fraction n can be dialed down on upscaling, a lever between transport and corrosion that can follow pilot data.

Concept 4 · Lithium-alloy versus lithium-metal anode

A sparsely pursued field, the company's plasma patent does not settle alloy against pure lithium (587 against 536 cycles), so the case rests on the February 2026 cell claims and stack-pressure logic. A lithium-rich foil keeps the intermetallic a minor skeleton, so the pulverization that discredited aluminum-rich alloys does not arise, and rolling Li-Al foil is the company's upstream business, the treated foil sellable on its own.

Potential Synergies for Well-Rounded Cells

Concept 1

Reduction-Tolerant Oxide Electrolyte

Concept 2

Oxidatively Stable Catholyte

Concept 3

Thermally Stable Conductive Separator Core

Concept 4

Li-Al Alloy Anode Passivation

Concept 5

Tuned Interfaces & Process Upscaling Efficiency

Scale-up risks, timeline & projected cell build – what the patents point to

The route is already commercial at the lower energy densities. The patents extend it, and the build on the right is what they point to.

Scale-Up Risk Factors

- Track 1:** core interchangeability may prove narrower in production than in the examples. The fluorohydrogenate liquid is a latent HF reservoir, its mitigations are in the same patent. The powder step is validated at hundreds of tonnes per year, membrane uniformity and defect rate at web width are not.
- Track 2:** holding the cathode-interface gain once the cell is closed with a lithium-metal anode at 10 Ah. H₂S evolution on moisture contact sets dry-room requirements across the line, addressed by an ultrafine powder route ([EPO](#) / [Google](#)). Cell-level yield at format is unproven.

Timeline Feasibility

- Track 1:** already commercial. Vehicle application is stated, graphite, silicon-carbon and lithium-metal systems were in production by February 2026, and the high-energy variants reach the market through aviation first. Cell-volume dates follow customer qualification.
- Track 2:** sample stage in February 2026, small-batch 10 Ah, 500 Wh/kg cell by May 2026, no mass-production date identified. Material-first: electrolytes sell before cells do.

Possible Material / Cell / Process Characteristics Projection based on public information

MATERIALS & CELL DESIGN

Electrolyte	Coextruded buffer core buffer sheet at a 20:60:20 thickness ratio. The core disperses nanomilled LZSP ($\text{Li}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$, D50 $\approx 0.15 \mu\text{m}$, $3.59 \times 10^{-3} \text{ S/cm}$) in PVDF with dibutyl phthalate at 80:10:10 by weight, the buffers pairing spherical garnet with LiTFSI in PEO. An injected fluorohydrogenate ionic liquid (EMImF-2.3HF) completes the ionic path. EPO / Google EPO / Google EPO / Google
Negative electrode	$\leq 50 \mu\text{m}$ lithium-aluminum (Li-Al) alloy foil on copper under a 2 nm–3 μm plasma-formed artificial SEI of LiF, Li ₃ N and Li _x C _y . EPO / Google
Positive electrode	NMC811 with the LiTaOCl ₄ oxyhalide as catholyte and a conductive carbon at 50:45:5 by volume on aluminum foil. EPO / Google
Design	Laminated single-cell pouch, hot-pressed interfaces with the ionic liquid injected after assembly, operating at 25–60 °C. The liquid phase probably allows comparably low external stack pressure (such as <1 MPa). EPO / Google

PROCESS

- 1 Spray-dry an aqueous slurry of LiOH·H₂O, ZrO₂, La₂O₃ and an aluminum dopant (inlet 130–300 °C, outlet 80–170 °C) and sinter at 700 °C in a rotary or roller-hearth kiln to porous spherical garnet. [EPO](#) / [Google](#)
- 2 Mill LiOH with TaCl₅ at 1:1 molar in a nitrogen glovebox for 10 h and anneal at 300 °C for 5 h to the crystalline oxyhalide. Nanomill the LZSP at 1,000–2,000 rpm. [EPO](#) / [Google](#) [EPO](#) / [Google](#)
- 3 Twin-screw compound the core and buffer formulations separately, then coextrude them in one pass as a buffer | core | buffer sheet. [EPO](#) / [Google](#)
- 4 Coat the cathode onto aluminum in a dry room, and treat the lithium-alloy foil in a room-temperature vacuum plasma at 13.56 MHz and 500 W in CF₄/N₂ 4:6 at 35 Pa for 120 s. [EPO](#) / [Google](#) [EPO](#) / [Google](#)
- 5 Hot-press laminate the sheet between the electrodes, inject the ionic liquid, and seal. [EPO](#) / [Google](#)

Links: in the full version each entry carries its publication number and an EPO / Google pair opening the patent family on Espacenet and Google Patents via b-science.net. Publication numbers and links are removed in this anonymized sample.

Reading guide, glossary – and the b-science.net patent classification

b-science.net patent classification – the company and its subsidiaries

Level 1 · 47
electrode & electrolyte

Level 2 · 21
cell chemistry & architecture

Level 3A · 1
pack / form factor

Level 3B · 7
application

Level 3C · 43
reliability

Level 3D · 21
manufacturing

Patent family – one invention and its filings in several countries, counted once. Levels are not mutually exclusive: one family can carry several, so the level counts add up to more than the 56 families analyzed.

How to read Figure X-1 (slides 2 and 3)

Four rows, read downwards – the chapter's Figure X-1 split over slides 2 (upper two rows) and 3 (lower two rows): the outcome targeted at cell level, the material or engineering requirement it implies, the key material (the patented concept) that delivers it, and the scale-up challenge that choice creates. **'Unique Capability Pathway'** – boxes outlined in orange trace the route along which the company differentiates from the field. Aviation entry and cycle life at high energy carry no outline because they are targeted outcomes that do not depend on that route. **The axis** runs from performance and energy density (left) to reliability and total cost of ownership (right). **Key KPI** – the production metric that decides a scale-up challenge, with the direction that counts as progress (↑ higher, ↓ lower). **Concept N** in a box points to the patented building block of slide 4 and of the chapter's Figure X-3. **Assessment panels** on slides 2, 3 and 5 condense the chapter's assessment sections under their chapter headings, for **Track 1** (hybrid solid-liquid cells) and **Track 2** (all-solid-state sulfide cells). The chapter section of the same name holds the full argument.

Units, metrics & general terms

Wh/kg – gravimetric energy density, cell level unless stated otherwise.

mS/cm, S/cm – ionic conductivity of an electrolyte.

mΩ – milliohm, the internal resistance of a cell.

1 C – a rate that fully charges or discharges the cell in one hour.

D50 – particle size below which half of the powder lies.

Cycle life to 80 % – cycles until capacity falls to 80 % of its initial value.

Nail penetration – forced internal short-circuit test, pass rate = share of cells surviving.

SEI – solid electrolyte interphase between electrode and electrolyte.

Zero-strain anode – volume barely changes on cycling, so stack pressure stays low.

Web width – the working width of a continuous roll-to-roll production line.

eVTOL – electric vertical take-off and landing aircraft.

Materials & chemistry

LLZO – $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$ garnet solid electrolyte. LLZXO is its Ta- or Nb-doped form.

LATP – $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ oxide solid electrolyte.

LZSP – $\text{Li}_3\text{Zr}_2\text{Si}_2\text{PO}_{12}$, a titanium- and germanium-free NASICON conductor.

NASICON – a sodium-super-ionic-conductor crystal structure, also used for Li conductors.

Oxyhalide – a halide electrolyte containing oxygen, here LiTaOCl_4 .

Argyrodite – the $\text{Li}_6\text{PS}_5\text{X}$ sulfide electrolyte family. A mixed conductor carries both ions and electrons.

LGPS, LPSC – sulfide solid electrolytes sold by the company as commercial products.

NMC811 – $\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$ cathode material.

Catholyte – electrolyte blended into the positive electrode.

Process & cell terms

Hybrid solid-liquid electrolyte – a solid or gel electrolyte layer with a residual liquid electrolyte.

All-solid-state – no liquid electrolyte in the cell.

Coextrusion – core and buffer melts extruded together in one pass, forming the sheet without separate lamination.

Buffer | core | buffer – the three-layer sheet: a solid-electrolyte core between two ion-supplying buffer layers.

EMImF-2.3HF – a fluorohydrogenate ionic liquid injected after assembly, ≈ 100 mS/cm.

PEO, LITFSI, PVDF – conducting polymer, lithium salt and binder in the sheet.

Space-charge layer – the resistive zone that forms where an oxide cathode meets a sulfide electrolyte.