Anonymized Cell Manufacturer – Two Parallel Development Tracks

Organization profile

The company is a vertically integrated lithium-battery manufacturer. It produces cells, modules, packs and energy-storage systems in-house, and has built a dedicated semi-solid-state cell line.

1 Semi-solid (hybrid solid–liquid) platform – company-demonstrated

- First-generation high-nickel prismatic cell at 270 Wh/kg – in small-scale production since December 2025, installed in a European passenger-vehicle model.
- Second generation at 342 Wh/kg, eVTOL*** flight-tested; a 360 Wh/kg pouch cell was sampled to a state-owned eVTOL program.
- Process: the cast electrolyte layer's clean release onto the electrode* rose from ≈20% to over 95%; insulation-test** yield +10%, safety +50%, runaway onset +5 °C.

2 All-solid-state sulfide program – company-demonstrated

- A 20 Ah sulfide all-solid cell sample reaches 380 Wh/kg, cycle life above 450 cycles (retention threshold, rate and temperature not disclosed).
- The all-solid-adapted cathode exceeds 220 mAh/g over 1,200 cycles; the sulfide electrolyte keeps over 93% of its conductivity after 4 h of high humidity.
- Nothing appears to be in production yet.

Patent portfolio analyzed

148 patent families related to semi-solid or solid-state Li-ion batteries.

PATENT LEVEL

110	1 · electrode & electrolyte
91	2 · cell chemistry & architecture
131	3C · reliability
39	3D · manufacturing
9	3A · pack / form factor
1	3B · application

SOLID ELECTROLYTE CATEGORIES

Sulfides	64 · 52%
Polymers / oligomers	24 · 19.5%
Halides / oxyhalides	23 · 18.7%
Oxide / polymer, liq.	6 · 4.9%
Oxides	3 · 2.5%
Oxide / polymer, no liq.	3 · 2.4%

* Clean release (the company's "electrolyte transfer rate") – the share of the cast solid-electrolyte layer that releases from the carrier film onto the electrode; 100% = complete release of the cast layer. ** Insulation test (HIPOT) – high-voltage insulation test on the finished cell. *** eVTOL – electric vertical take-off and landing aircraft. Category counts cover 123 of the 148 families. Full glossary on slide 6.

Links: underlined values are hyperlinked to the public statement they come from in the full version; patent-based items carry an EPO / Google pair to the patent family. Both are removed in this anonymized sample.

Semi-Solid Cell Development – Targets & Requirements

'Unique Capability Pathway' Performance & Energy Density ⟷ Reliability & Total Cost of Ownership

DESIRED OUTCOME (CELL LEVEL)

High Energy Density
270 Wh/kg demonstrated in first-gen high-nickel prismatic cells; 342 Wh/kg (second-gen) and a 360 Wh/kg pouch demonstrated.

Intrinsic Safety, No Added Cost
Cell-level safety with no added manufacturing cost; thermal-runaway onset +5 °C demonstrated.

High-Rate Discharge
5 C continuous / 8 C peak discharge for low-altitude aircraft cells; stated to meet DO-311A.

Next-Gen Energy Roadmap
Target: 400 Wh/kg (gen-2) and 450 Wh/kg (gen-3) by 2028, probably with a lithium-metal negative electrode based on patent filings; 245 Wh/kg mid-nickel mass production Oct 2026.

MATERIAL / ENGINEERING REQUIREMENTS

Transfer-Printed Cathode Interface
Uniform, ultra-thin solid-electrolyte coating transfer-printed onto the cathode; transfer rate lifted from ≈20% to over 95%.

Non-Flammable Electrolyte
Non-flammable, non-corrosive electrolyte as the basis for intrinsic cell safety.

Separator-Layer Properties
Higher ionic conductivity (+10%) and lower thermal shrinkage (–20% at 200 °C) vs. a conventional separator.

Line / Process Compatibility
Integrable on existing liquid-cell lines with no new equipment; the lithium-metal target still requires either lithium-metal handling or anode-free cells, seemingly not yet fully defined.

Concept 3 – non-flammable in-situ polymer electrolyte

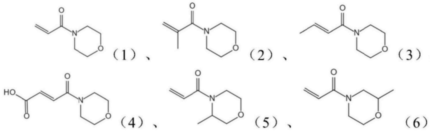

Figure X-4: acryloyl-morpholine Li-conducting monomer structures.

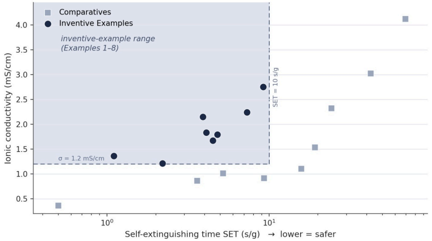

Figure X-5: ionic conductivity vs self-extinguishing time, Examples 1–8 and Comparatives 1–9; shaded region (SET ≲10 s/g) is an analyst demarcation.

Why it matters – conductivity and flame retardancy move against each other, so the electrolyte must sit inside a narrow composition window.

Ex. 2 – 2.75 mS/cm at 9.2 s/g, best balanced. **Control 9** – liquid carbonate: 4.12 mS/cm but 69.3 s/g.

Figure X-1 (top): multidimensional visualization of semi-solid Li-ion battery cell product development & up-scaling efforts. Boxes outlined in orange mark the 'Unique Capability Pathway'. Reproduced in full from the chapter.

Semi-Solid Cell Development – Key Materials & Scale-Up Challenges

'Unique Capability Pathway'   Performance & Energy Density ⟷ Reliability & Total Cost of Ownership

KEY MATERIALS

Transfer-Printed Composite Separator Coating
Concept 1

Pre-formed polymer-film / inorganic-particle / adhesive composite hot-pressed onto the electrode then peeled, leaving a layer at metered 0.52 mg/cm^2, ≈2 µm. Electrolyte-agnostic across oxide, sulfide and nanofiber fillers.

Non-Flammable In-Situ Polymerized Electrolyte
Concept 3

Acryloyl-morpholine Li-conducting monomer with a vinyl-phosphate flame retardant and a fluorinated sulfonylamide-anion ionic liquid; cures in-situ against a lithium-metal negative electrode at ≈2.75 mS/cm, self-extinguishing ≈9.2 s/g.

Epoxy-Silane Covalent Anchoring
Concept 2

Epoxy-silane-modified inorganic particles (LATP, LLTO, aluminum phosphates) co-polymerize with the gel to bond both electrodes and eliminate the polyolefin separator; 90.2% retention at 500 cycles, 180 °C hot-box.

UV In-Situ Cure & Low IL Fill
Concept 5

Acrylate monomers UV-cured in-situ (10–180 s) replace the multi-hour bake; fluorinated ionic-liquid fill ≈0.8 g/Ah, cell swelling force ≈1.37 kN vs ≈3.92 kN for a liquid control.

CRITICAL SCALE-UP CHALLENGES

Transferred-Layer Uniformity at Line Speed
Concept 1

Transferred ≈2 µm coating must keep uniform areal density and a continuous interface at production line speed.

Key KPI: coating areal-density uniformity (↑)

Safety Margin Under Electrolyte Substitution
Concept 1, Concept 3

Avoid losing the coating's inherent-safety benefit: disclosed cells pair the transferred interface with volatile carbonate; the benefit requires substitution by a non-flammable electrolyte against a lithium-metal anode.

Key KPI: thermal-runaway onset temperature (↑)

Conductivity–Flammability Trade-Off
Concept 3

Non-flammable electrolyte trades ionic conductivity against flame retardancy; both must hold within a narrow composition window for the targeted lithium-metal-anode cell.

Key KPI: ionic conductivity at 25 °C (↑)

High-Nickel Thermal-Runaway Class Risk
Concept 2

High-nickel ternary chemistry drives most EV thermal-runaway fires; mitigation routes (epoxy anchoring, dry-fibrillized ceramic, paired polyelectrolyte layers) are plural and probably not settled.

Key KPI: thermal-runaway propagation (↓)

How to read this figure

Four tiers, read downwards – the outcome targeted at cell level, the material or engineering requirement it implies, the key material (the patented concept) that delivers it, and the critical scale-up challenge that choice creates, with the KPI to watch.

'Unique Capability Pathway' – boxes outlined in orange trace the route this company appears to be taking. Boxes without the outline are capabilities it targets but that do not depend on that route.

The axis – columns are ordered from performance and energy density on the left to reliability and total cost of ownership on the right.

Concepts 1–5 named in the lower two tiers are set out in full on slide 4; the projected cell build they imply is on slide 5.

Figure X-1 (bottom): multidimensional visualization of semi-solid Li-ion battery cell product development & up-scaling efforts. Boxes outlined in orange mark the 'Unique Capability Pathway'. Reproduced in full from the chapter.

Key Product Development Concepts – Five Patented Building Blocks

1

Transfer-Printed Solid Separator Coating

(EPO / Google)

Carrier-film lamination meters the composite separator layer onto the electrode independently of electrode roughness – **0.52 mg/cm^2, ≈2 µm**.

ARC* onset **1,200–1,315 min** vs 900 min; nail-penetration** tolerance **10–15** vs 6 layers.

2

Separator-Free Covalently-Anchored Gel

(EPO / Google)

Epoxy-silane inorganic layers on both electrodes crosslink with an in-situ gel, replacing the polyolefin separator.

90.2% at 500 cycles, hot-box*** **180 °C / 22 min**; controls 73.8% / 76.7%.

3

Non-Flammable In-Situ Polymer Electrolyte

(EPO / Google)

Flame-retardant monomers and an ionic liquid cure directly against a 20 µm lithium-metal anode.

2.75 mS/cm, self-extinguishing time† **9.2 s/g**, thermal-failure onset **160 °C**.

4

Multi-Coated Three-Dimensional Silicon Anode (EPO / Google)

Sequential oxide, carbon, sulfide electrolyte and polymer shells on porous silicon buffer volume change – **1,152 cycles to 80%**, 94.1% rate retention.

5

UV In-Situ Curing of Electrodes (EPO / Google)

A **10–180 s** UV cure replaces the 12–24 h bake and enables a low **0.8 g/Ah** fill; swelling force ≈1.37 kN vs ≈3.92 kN.

Potential synergies – one shared, electrolyte-agnostic platform

Concept 1 is the architectural hub, spanning inert oxide, Li-ion-conducting sulfide and nanofiber fillers, so it likely acts as a manufacturing platform rather than a fixed chemistry. Concepts 2, 3 and 5 serve it on a lithium-metal semi-solid stack – energy density and intrinsic safety, at higher curing and dry-room complexity – while Concept 4 opens a parallel silicon route for maximum anode capacity and all-solid-state cycle life.

* ARC – accelerating rate calorimetry, an adiabatic self-heating test; onset is the time to thermal runaway. ** Nail penetration – forced internal short-circuit test; tolerance = layers penetrated without runaway. *** Hot-box – oven test at the stated temperature. † Self-extinguishing time (s/g) – seconds to extinguish per gram of electrolyte; lower is safer. Full glossary on slide 6.

Links: in the full version each concept carries an EPO / Google pair opening the patent family on Espacenet and Google Patents. Publication numbers and links are removed in this anonymized sample.

Leap of Faith & Projected Cell Build – What the Patents Point To

Unique capabilities

- **Semi-solid:** process compatibility rather than new chemistry – the layer is transfer-printed* onto electrodes on existing liquid-cell lines.
- **All-solid sulfide:** full-stack in-house development; a thermal-composite stacking step already in volume replaces isostatic pressing**.

Leap of faith

- **Semi-solid:** that the safety margin shown with volatile carbonate still in the cell survives substitution by the non-flammable polymerized electrolyte against Li metal.
- **All-solid sulfide:** that the four-layer coating on porous silicon keeps the silicon–sulfide interface conducting through volume change, from the 20 Ah / 380 Wh/kg sample to a 60 Ah-plus, 400 Wh/kg cell.

Congruency – public statements vs patent portfolio

Broadly consistent. The safety case is publicly attributed to non-flammable, non-corrosive electrolytes, whereas the patent cells demonstrating it still contain carbonate – that electrolyte sits in a separate family, read as staged disclosure rather than contradiction.

Possible Material / Cell / Process Characteristics

Projection based on public information

Electrolyte

Facing the lithium-metal negative electrode: in-situ-polymerized non-flammable quasi-solid electrolyte from an acryloyl-morpholine Li-ion conducting monomer with a vinyl-phosphate flame-retardant monomer and a fluorinated sulfonylamide-anion ionic liquid (≈2.75 mS/cm, self-extinguishing ≈9.2 s/g, EPO / Google).

Separator layer: transfer-printed solid-electrolyte coating (≈2 µm, ≈0.52 mg/cm^2) of epoxy-silane polymer covalently anchored on LATP, replacing the polyolefin separator, possibly infused with ionic liquid (EPO / Google, EPO / Google).

Negative electrode – ≈20 µm lithium-metal foil on a copper current collector (EPO / Google).

Positive electrode – high-nickel NCM811 with a PVDF binder and carbon black, carrying the transfer-printed composite separator interfacial coating (EPO / Google).

Design – stacked (Z-folded) pouch cell operating at room temperature under low external stack pressure (such as <2 MPa), with a comparably low fluorinated ionic-liquid fill coefficient (≈0.8 g/Ah, EPO / Google, EPO / Google).

Process

1) Cast and press the high-nickel NCM811 cathode with its acrylate monomer and UV in-situ cure it under inert atmosphere (10–180 s), replacing the multi-hour thermal bake (EPO / Google).
2) Coat both electrode surfaces with the epoxy-silane-modified inorganic functional layer (2–20 µm) that will replace the separator (EPO / Google).
3) Transfer-print the composite separator layer onto the positive electrode by hot-press lamination of the pre-cast polymer-film, coating and adhesive composite (60–500 °C), then peel the carrier film (EPO / Google).
4) Stack the printed cathode and the lithium-metal anode separator-free, inject the non-flammable precursor of acryloyl-morpholine monomer, vinyl-phosphate flame retardant and fluorinated sulfonylamide-anion ionic liquid, and cure in-situ (≈60 °C) so the epoxy layers and gel co-polymerize into a covalently anchored quasi-solid electrolyte (EPO / Google, EPO / Google).
5) Package and complete cell formation.

Supporting inventions listed in Figure X-3 might additionally be employed in this context.

* Transfer printing – the layer is cast on a carrier film at metered areal density, laminated to the electrode, then the film is peeled off. ** Isostatic pressing – uniform high-pressure densification of the stack (≈300 MPa). Full glossary on slide 6.

Links: underlined items are hyperlinked to their source in the full version; EPO / Google pairs open the patent family on Espacenet and Google Patents. Publication numbers and links are removed in this anonymized sample.

Addendum – Abbreviations, Units & Test Methods

Units & performance metrics

Wh/kg – gravimetric energy density; cell level unless stated as pack level.

Ah – ampere-hour, the capacity of a cell.

mAh/g – specific capacity of an active material.

mS/cm – ionic conductivity of an electrolyte.

mg/cm^2 – areal density, coating mass per unit area.

µm – micrometer (0.001 mm), layer thickness.

g/Ah – electrolyte fill coefficient, grams of electrolyte per Ah; lower means a drier cell.

s/g – self-extinguishing time per gram of electrolyte; lower is safer.

kN – kilonewton, the swelling force a cell exerts in a fixture.

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

Rate retention – capacity at a high discharge rate relative to a low one (1C vs 0.1C).

Test methods & safety terms

ARC – accelerating rate calorimetry; an adiabatic test tracking cell self-heating. Onset (Δt_1) is the time to thermal runaway.

Hot-box – oven test; the cell is held at a set temperature for a set time.

Nail penetration – forced internal short-circuit test; tolerance is the number of electrode layers penetrated without runaway.

HIPOT – high-voltage insulation (high-potential) test on the finished cell; yield is the share that passes.

Thermal runaway – self-sustaining exothermic cell failure; onset is the temperature or time at which it starts.

Capacity retention – share of initial capacity left after a stated number of cycles.

H_2S – hydrogen sulfide, a toxic gas formed when sulfide electrolytes meet moisture.

Process & technology terms

Semi-solid (hybrid solid–liquid) – a cell pairing a solid or gel electrolyte layer with a residual liquid electrolyte.

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

Transfer printing – the layer is cast on a flat carrier film at metered areal density, laminated to the electrode, then the film is peeled off.

Transfer yield – share of that cast layer released onto the electrode; 100% = complete release.

In-situ polymerization – a liquid precursor is injected into the assembled cell, then cured.

Dry-fibrillized – solvent-free process in which PTFE is sheared into fibers that bind the particles.

Isostatic pressing – uniform high-pressure densification of the stack (≈300 MPa).

eVTOL – electric vertical take-off and landing aircraft.

b-science.net patent classification

Level 1 – electrode & electrolyte patents	**Level 2** – cell chemistry & architecture	**Level 3A** – pack / form factor / packaging	**Level 3B** – application patents	**Level 3C** – reliability (short circuits, heat & gas)	**Level 3D** – manufacturing (electrolytes, electrodes, cells)

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 148 analyzed.