Are Solid-State Batteries Ready For Mass-Adoption?

Center for Research in Extreme Batteries
University of Maryland

June 23, 2023

“The only commercially available all-solid-state battery. Powering vehicles every day, all over the world.”
Founded in 1822 as a paper manufacturer, the French company and family story successfully navigated through the 20th and 21st centuries with activities diversification in Transportation, Logistics, Energy distribution and storage as well as Media and Communications.

The group is publicly listed and chaired since 2019 by Cyrille Bolloré.
A global research & industrial footprint

France, HQ
Quimper & Grenoble
Production & Research

Canada
Boucherville, Quebec
Production & Research

United-States
Palo Alto, CA
Advanced research
500+ people with the experience of delivering 3 Million cells (>1 GWh) since 2011
Dedication to a decarbonized mobility

**Production**
- 600 MWh, 48,000m², 2 sites* in France, Canada & advanced research in the USA (CA).

**R&D**
- 400+ Technicians & Engineers

**Intellectual Property**
- 620 Patents.

**Innovation**
- Gen3 for Commercial vehicles to Gen4 for Passenger EVs.

**Sustainability**
- Innovations et developments in response to major environmental challenges, committed towards a long-term positive impact.

*Certified plants
ISO 14001 (environment),
ISO 9001 & IATF 16949 (quality)
World pioneer in solid-state cells

Lithium metal anode, highest energy density material

Solid polymer electrolyte replacing the flammable liquid found in lithium-ion batteries

High energy density

Safer: high temperature stability. Cells are intrinsically safe

Does not require a cooling system

Applications

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A long & solid story going back 40 years!

**Blue Solutions**

**Collaboration between CEA/CNRS & Hydro-Québec/IREQ**

- Creation of Batscap in France
- Creation of Avestor in Canada

**2007**

- Bolloré Group acquires Avestor and the merger with Batscap results in Blue Solutions

**2011**

- First electric car, with 250-km range thanks to its solid-state battery

**2019**

- Electric buses applications

**2026**

- Gen4 Designed for the EV mass market

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- Gen3
- Gen4

**3 Million units**

- # of cells produced

**500 Million km**

- Distance achieved
“Our Strengths”
At the heart of the cells lies chemistry

Blue Solutions is the all-solid-state battery pioneer with a unique expertise on: lithium metal and polymer-type solid electrolyte.

Unparalleled in-depth practical knowledge of interfaces management and ageing phenomena experienced in batteries.
Blue Solutions masters the full value chain of solid-state cells’ industrialization process

Blue Solutions is the only company in the world to have designed, developed and industrialised at scale for the last 11 years all-solid-state batteries: 3 million cells have been produced in cumulative.

Blue Solutions’ cells are larger (105 Ah, 610x175mm) than any lithium-ion ones in the market and without any match from the prototype cells developed by newcomers in the solid-state space.

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Cells are assembled in modules and packs with a simple pressure system, illustrating Blue Solutions abilities for system design and in-vehicle (buses, trucks, cars) and stationary integration.

Blue Solutions develops proprietary software solutions from cell monitoring tools (temperature, voltage) to overall system control and interfaces with vehicle ECUs.
Sustainability

Blue Solutions develops its own recycling solutions to **re-use all critical metals and to re-inject them in new cell manufacturing flows**, in compliance with European battery regulation.

Thanks to an unmatched experience with lithium metal, Blue Solutions has filed a new patent for an **innovative method to extract lithium metal from the heart of the cells**.

Key words: Recyclability, Re-use & Sustainability
“Next Objective”
Gen4 - passenger e-mobility needs

- Thinner Lithium metal
- Polymer electrolyte suited for a large range of operating temperatures
- Cathode: platform-design allowing automotive standard materials: NMC, LFP.

Higher energy density: 900 Wh/L - 450 Wh/Kg

Operating at room Temperature

Enabling Fast charging

Development with the support and collaboration of global industry & ecosystem partners
## Gen 4 - EV Market Specifications

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Gen4 targeted properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrolyte</td>
<td>Polymer-based</td>
</tr>
<tr>
<td>Cathode</td>
<td>High Voltage Cathode NMC / LMFP - LFP</td>
</tr>
<tr>
<td>Anode</td>
<td>Lithium Metal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety</th>
<th>Gen4 targeted properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire hazard</td>
<td>Thermally stable electrolyte up to 300°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
<th>Gen4 targeted properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature</td>
<td>Ambient, system operation from -20°C to 60°C</td>
</tr>
<tr>
<td>Fast charging rate</td>
<td>3C</td>
</tr>
<tr>
<td>Cycle life</td>
<td>1000 +/-</td>
</tr>
<tr>
<td>Volumetric density</td>
<td>&gt;900 Wh/L</td>
</tr>
<tr>
<td>Gravimetric density</td>
<td>&gt;450 Wh/kg</td>
</tr>
<tr>
<td>Pressure</td>
<td>&lt;2 bars</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Packaging</th>
<th>Gen4 targeted properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format</td>
<td>Cell designed for integration (cell to pack/chassis)</td>
</tr>
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</table>

Polymer, lithium metal processing, low stack pressure, modules & packs, scale-up experience

Know-How

Manufacturability

Maturity

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Blue Solutions: Polymer path as the best choice for SSB

SSB Technology Comparison

Multiple industrialization and integration roadblocks are expected for Oxide and Sulfide technologies: process in inert environment and high levels of cell stack pressure required detrimental to pack-level energy density.

Polymer technology is the most polyvalent solution, already industrialized today with major ramp-up experience and quality control.
Comparing a set of 6 SSB players value propositions illustrate similar level of targeted performances, despite various actual cell sizes, number of layers and test conditions. Blue Solutions’ SSB is expected to be highly competitive on density level vs. start-ups.
**GEN4 concept**

GEN4 will enable the use of HV materials at room temperature with a Li metal anode

**NEW CONCEPT**

**GEN4 strategy**

Ongoing development of 3 cells with GEN4 chemistry

**Our philosophy**

Use only representative conditions: dry rooms, pouch cells, manufacturing processes as closed as possible to the pilot line, cells configurations moving forward to the targets...

<table>
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<tr>
<th>LFP based</th>
<th>LFMP based</th>
<th>Ni-rich NCM based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cost</td>
<td>Medium Performance</td>
<td>High Performance</td>
</tr>
<tr>
<td>Cobalt &amp; Nickel free</td>
<td>Medium energy density</td>
<td>High energy density (&gt;1000 Wh/L)</td>
</tr>
<tr>
<td>=&gt; Secured supply chain</td>
<td>Cobalt &amp; Nickel free</td>
<td>High power performances</td>
</tr>
<tr>
<td>Reinforced stability of phosphate chemistry</td>
<td>=&gt; Secured supply chain</td>
<td>PREMIUM</td>
</tr>
<tr>
<td>Low sensitivity to high Temperatures</td>
<td>Reinforced stability of phosphate chemistry</td>
<td></td>
</tr>
</tbody>
</table>
Where do we stand?

**Cyclability**

**Power performances**

New generation cycling capability demonstrated at 20°C with HV cathode material. Charging performances show promising results by achieving 35% SOC at 3C and 70% SOC at 2C!

Charging:
- 35% SOC at 3C
- 70% SOC at 2C
**Industrial Roadmap**

**Ambition**
145 M€ in R&D effort till 2025 and 70+ additional research engineers to pave the way towards breakthrough performances for passenger cars.

**Gigafactories**
Launching production capacity in accordance to the expanding EV market.

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**Energy Density**
- 380 Wh/L → 900 Wh/L

**Production Capacity**
- 600 MWh → 20 GWh

- **2022**
- **2025**
- **2028**
Thank you

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