# A reliable large-scale implementation of water-based slurry technology for production of high-performance lithium-ion batteries

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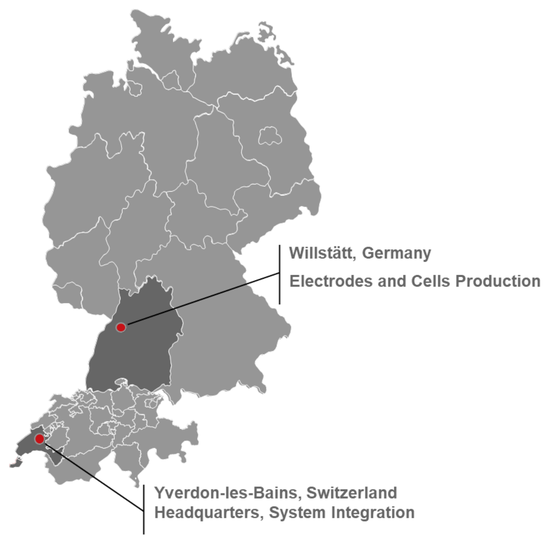
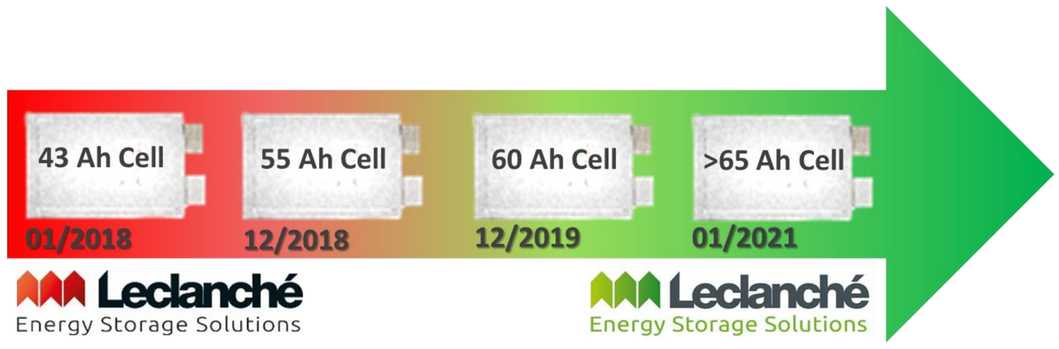
- Leclanché offers to the energy storage market two kind of rechargeable lithium-ion cells: graphite/NMC cells for energy intensive applications, and titanate/NCA for leading performance in long-life and rapid charge applications.
- Both cell types in pouch format are produced entirely in Willstätt, in Germany, and assembled in battery modules in Yverdon-les-Bains, in Switzerland. Such cells are manufactured on the same line function of the customer requirements for energy solutions.



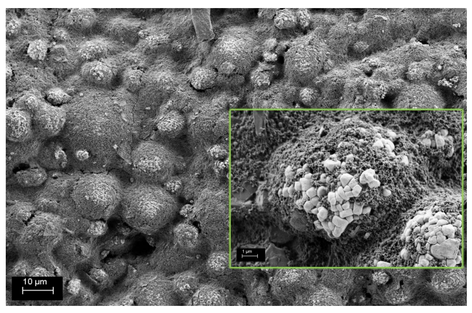

- The cell assembly starts with the electrode manufacturing exclusively using a water-based binder (WBB) process. This is a simplified process in comparison to the organic solvent-based process, leading to a minimum environmental impact, reduced end cost of the cell manufacturing and as well improved cell performance. While the technology used for anode fabrication is worldwide rather common, the cathode water-based technology is not well-known or understood.
- This makes Leclanché one of the global leaders of the WBB technology.

**Fabrication steps: a part of coating line, electrode notching and cell assembly machines**

- Our main focus lies on the development of the G/NMC cells containing NMC cathodes with high Ni content (NMC622) for an improved cell energy density and cell capacity (>60 Ah) required for e-transportation energy storage solutions.

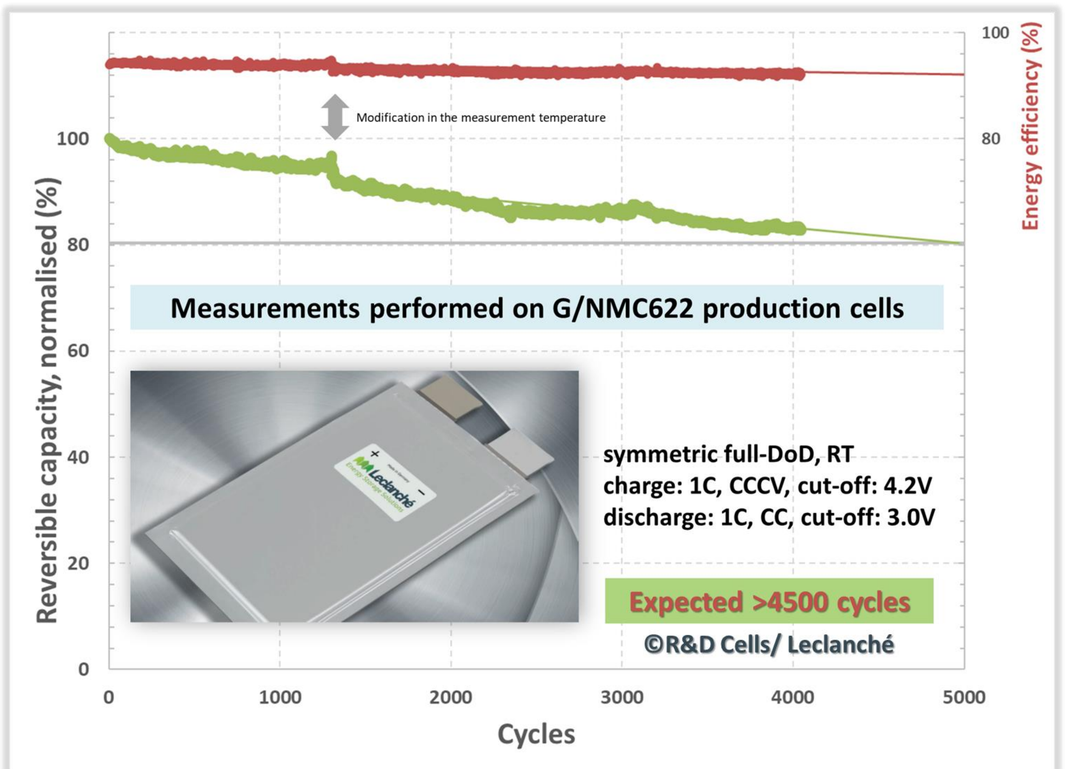



- The manufacturing of these electrodes is however more difficult in general, due to complications of active material chemical and physical properties, e.g. higher intermixing rate of Li-ions with Ni-ions in the NMC lattice, due to similar ionic radius, yielding to irreversible structural changes during intercalation/deintercalation processes (charging/discharging of a cell).




**SEM picture of a NMC622 WBB cathode**

- In particular, the problematics of the WBB slurry development is its stability with time due to variation in physical-chemical properties.
- Its instability could lead to a lower electrode quality, adhesion and cohesion issues, current collector foil affected by corrosion, etc.
- Currently we achieved the development of a reliable large-scale implementation process from the lab towards all production steps by transferring the R&D know-how to the industrial scale towards a safe and performant cell with high energy density and/ or for high power applications. The lifetime tests on this cell at ca. 1C/1C continuous for a 100% DoD validate over 4000 cycles at room temperature conditions.




| Measurement Step | 1C Discharge | | ... | 5C Discharge | | Power capability |
|---|---|---|---|---|---|---|
| cell type | Ah-Step | Wh-Step | | Ah-Step | Wh-Step | % Capacity at 5C |
| 55 Ah cell | 54.2 | 196.8 | ... | 43.0 | 148.5 | 79.4 |
| prototype 60 Ah cell | 57.9 | 210.1 | | 45.8 | 157.6 | 79.1 |
| 60 Ah cell | 59.1 | 213.8 | | 48.2 | 165.1 | 81.7 |

**Increase of cell capacity correlates to increase of power capability**
**Power capability at 5C: >40 Ah (over 80% capacity)**

| Measurement Step | 1C Discharge | | ... | 5C Discharge | | Power capability |
|---|---|---|---|---|---|---|
| Cell type (60 Ah) | Ah-Step | Wh-Step | | Ah-Step | Wh-Step | % Capacity at 5C |
| Standard Electrolyte | 59.1 | 213.8 | ... | 48.2 | 165.1 | 81.7 |
| Electrolyte 1 | 58.8 | 213.3 | | 51.8 | 177.8 | 88.0 |
| Electrolyte 2 | 59.3 | 211.4 | | 57.1 | 195.7 | 96.1 |

**Increase of power capability with further cell development (electrolyte type)**
**Power capability at 5C: over 95% capacity**

- Development of slurry formulations containing NMC811 and higher Ni content is in progress: very good lab results;
- Compatible anode materials (Si-based, $SiO_x$/graphite) for NMC622/ 811 cathodes in large-format cells: ongoing;
- Implementation of new WBB formulations for high energy density G/NMC (>65 Ah) and titanate (>34 Ah) cells.

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