The Impact of Thermal Gradients on the Aging Behavior of Lithium-Ion Batteries

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Abstract

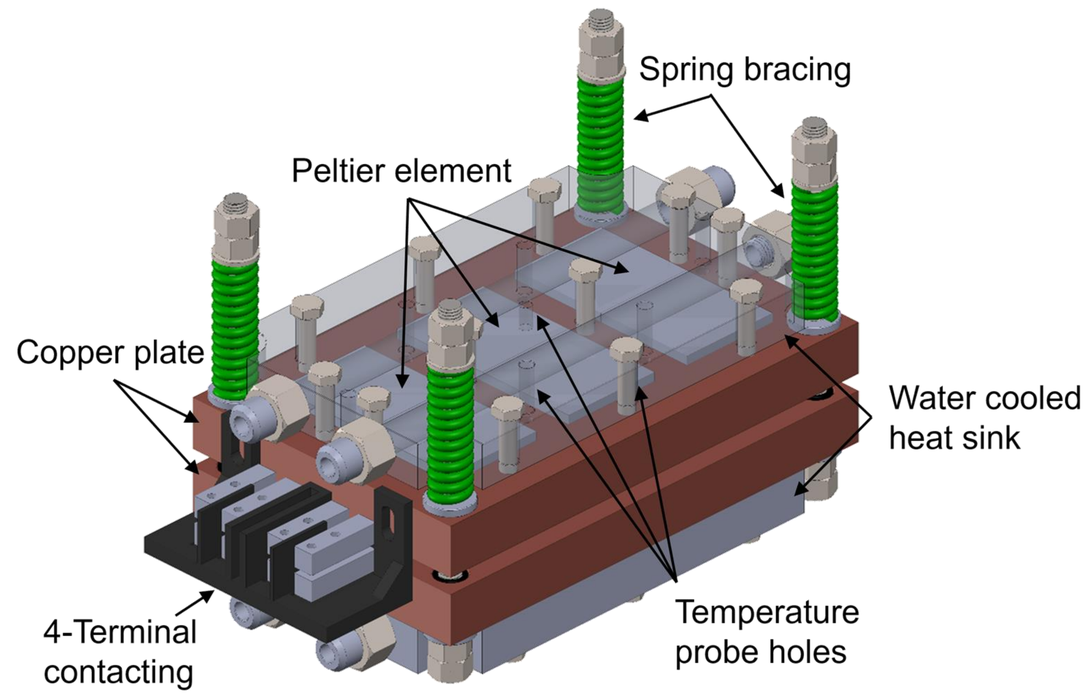
This work shows measurement results illustrating the effect of thermal through-plane gradients on the aging behavior of a commercial nickel-rich high energy lithium-ion battery. Using a carefully designed test bench, we aged multiple battery cells under different thermal through-plane gradient conditions which caused both globally and locally varying aging behavior.

Conclusion

The presented data shows that thermal through-plane gradients can drastically affect the ageing behavior of lithium-ion battery cells. Post-mortem analysis suggests that the main aging mechanism in the studied cells is plating combined with SEI growth. These local phenomena, however, are highly unusual and form different sizes of visible deposition clusters on all of the anodes' surfaces.

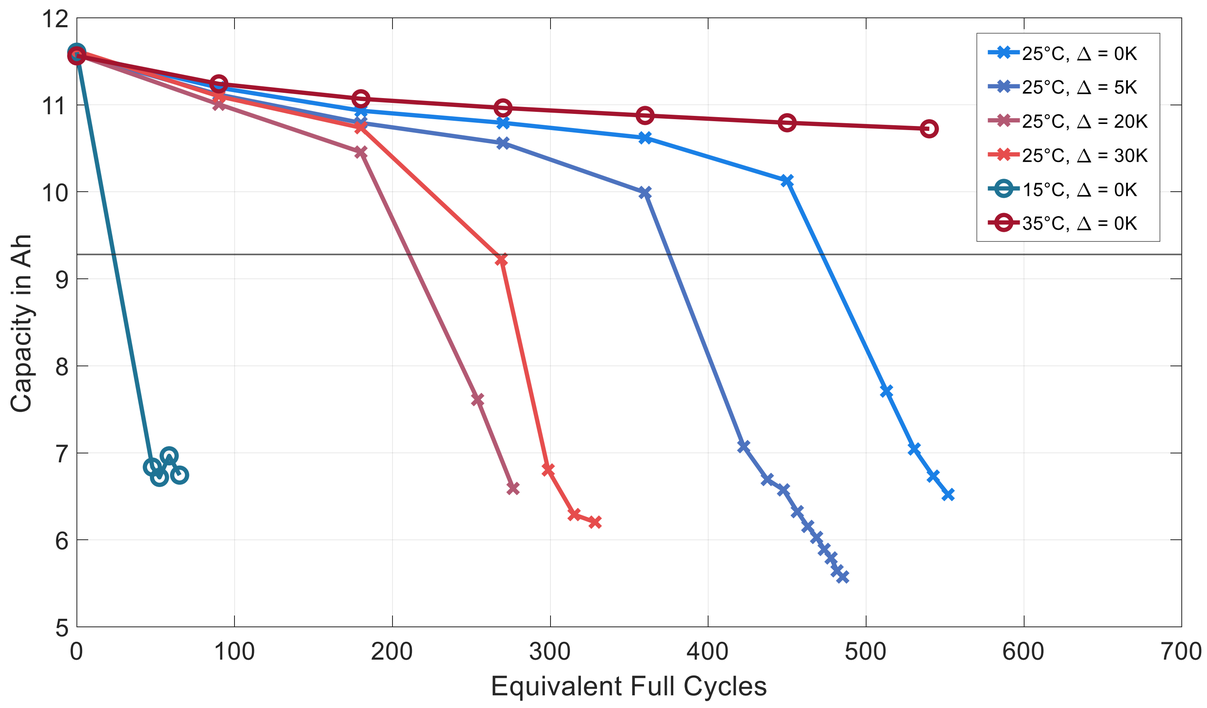
Experimental Setup

- Battery Cell: Kokam nickel-rich high energy lithium-ion pouch cell, 11.6 Ah, 246 Wh/kg.
- Mechanical Setup: Cell is clamped in a spring setup with 0.5 bar between two 20 mm copper plates.
- Thermal Setup: Peltier elements impose thermal boundary conditions using copper plates to ensure a homogeneous temperature distribution.
- Electrical conditions: 1C CC charge/discharge of 7 Ah between 4.2 V and a varying lower voltage.
- Check-up conditions: One Check-up every 150 charge/discharge cycles at homogeneous 25 °C

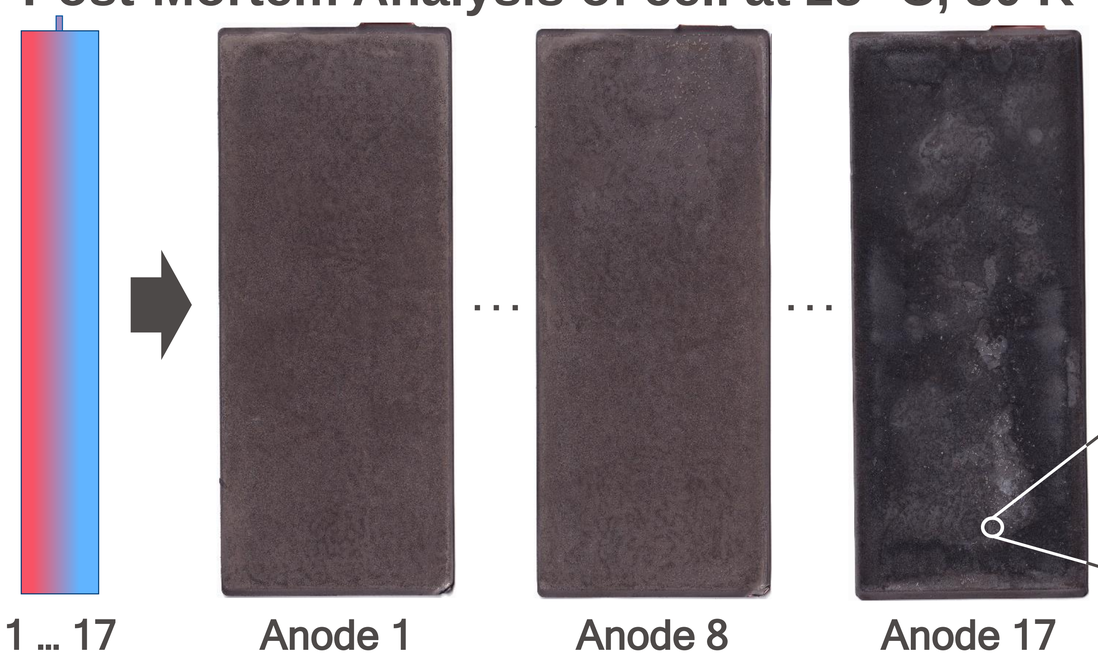


Aging Results

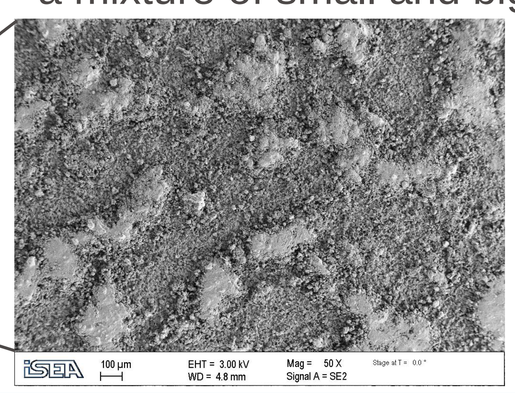
- Legend gives average aging temperature in °C and maximum through-plane temperature difference in K.
- Battery cell aged at homogeneous 25 °C reached end of life (black horizontal line) earlier than cell at homogeneous 35 °C (test still running). Cell at homogeneous 15 °C suffered from heavy plating.
- Thermal gradients negatively affect the batteries' aging behavior.
- All cells at average 25 °C reached end of life much earlier than 3,000 cycles specified in the cells' data sheet.

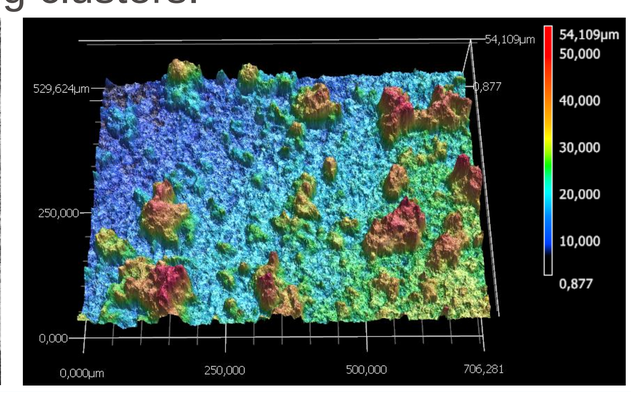


Post-Mortem Analysis of cell at 25 °C, 30 K



- Cathodes showed no aging.
- Anodes all covered with clustered filament-like depositions.
- From warm to cold anodes the deposition cluster size distribution changes from lots of visible small clusters to a mixture of small and big clusters.





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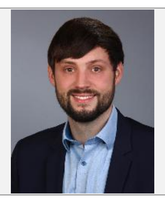

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