# Jelly Roll Deformation as a Thermo-Mechanical Ageing Mechanism in Lithium-Ion-Batteries

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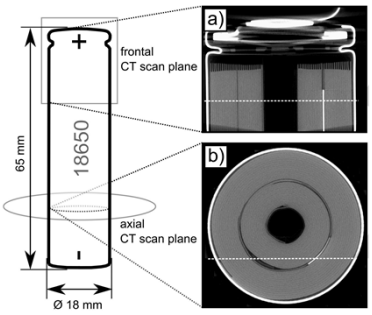
## Motivation

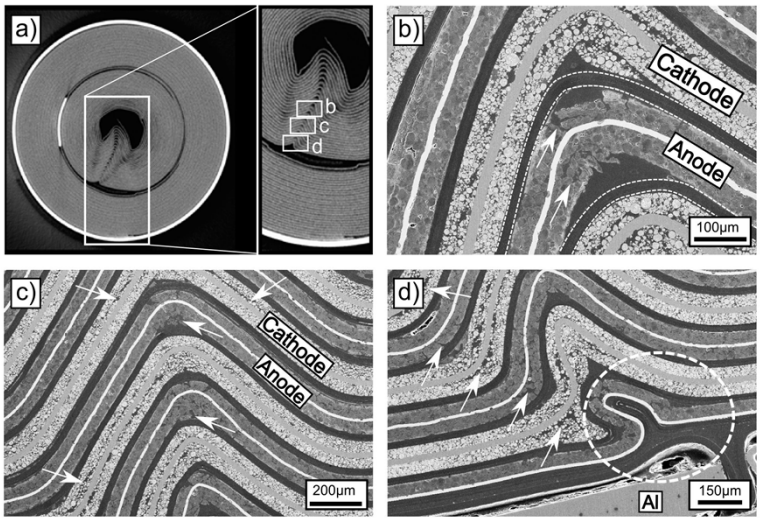
To gain a better understanding of the mechanisms that determine the lifetime of Li-ion-cells, macro- and microstructural information is needed. X-ray computed tomography (CT) is an excellent non-destructive method to monitor the interior of 18650 type cells. In the present study, commercially available cells have been subjected to different aging procedures while the jelly roll deformation was monitored and investigated post mortem by SEM-analysis. Additionally, the influence of a centre pin was analysed by comparing three different types of cells without centre pin and one cell with centre pin.



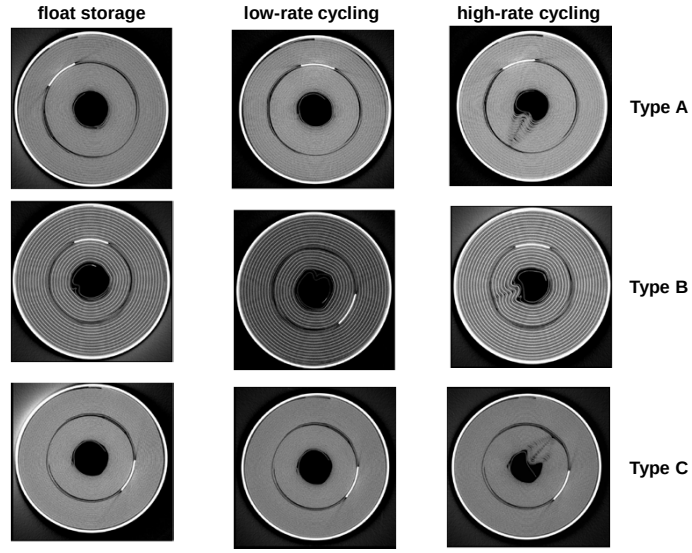

## Experimental

| | | Type A | Type B | Type C |
|---|---|---|---|---|
| Cell types | Activmaterial cathode | $LiMn_2O_4$ | $Li(Mn_{0,3}Ni_{0,5}Co_{0,2})O_2$ | $Li(Mn_{0,33}Ni_{0,33}Co_{0,33})O_2$/ $LiMn_2O_4$ |
| | Typical capacity | 1,2 Ah | 2,2 Ah | 1,5 Ah |
| Aging conditions | float storage | U=4.0V, T=70°C | U=4.0V, T=70°C | U=4.0V, T=70°C |
| | low rate cycling | 0.9C charge, 1C discharge, T=70°C | 1C charge, 1C discharge, T=25°C | 1C charge, 1C discharge, T=60°C |
| | high-rate cycling | 0.9C charge, 3.6C discharge, T=25°C | 4.33C charge, 16C discharge, T=50°C | 1C charge, 1C discharge, T=60°C |

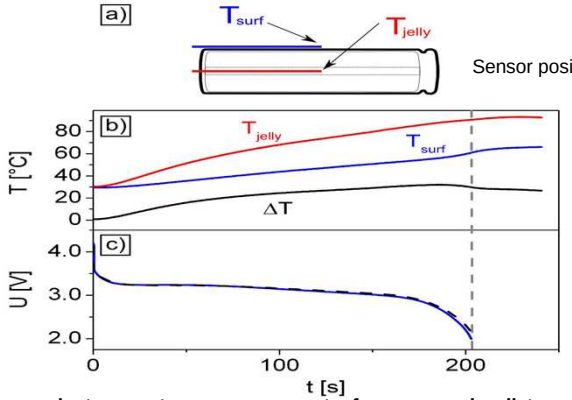
## Results



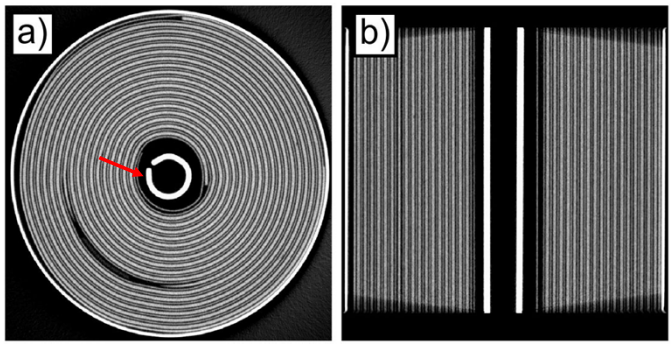

**a) Axial CT scan of a type C cell without centre pin at mid-height of the 18650 cylinders; b), c) and d) SEM images of the cross sections shows contact loss in the anode and cathode active material.**




**Comparison: Axial CT scans of cell type A, B and C without centre pin at different aging conditions. Especially during high-rate cycling, all cell types show jelly roll deformation.**




**In-operando temperature measurement of an un-aged cell type C during CC discharge of 16C (after CC charge to 4.2V). It shows a significant temperature difference between the cell surface and inside the jelly roll.**




**Axial (a) and tangential (b) CT scans of a type C cell with a centre pin after high rate cycling showing no jelly roll deformation**

## Conclusions

CT measurements show strong buckling of the inner part of the jelly rolls for the all 18650 cells without centre pin after cycling at discharge rates in the range of 3.6-16.6C. Most likely, the buckling is induced by thermo-mechanical stresses that arise during high-rate cycling. The jelly roll buckling can be significantly reduced by reducing the C-rates down to 1C. Cycling tests with cells including a centre pin indicate that the deformation may be suppressed by the centre pin that fills the hole of the jelly roll in cylindrical cells.

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