Comparing Lithium and Sodium-Ion Battery Degradation Using Non-Destructive X-Ray Scans

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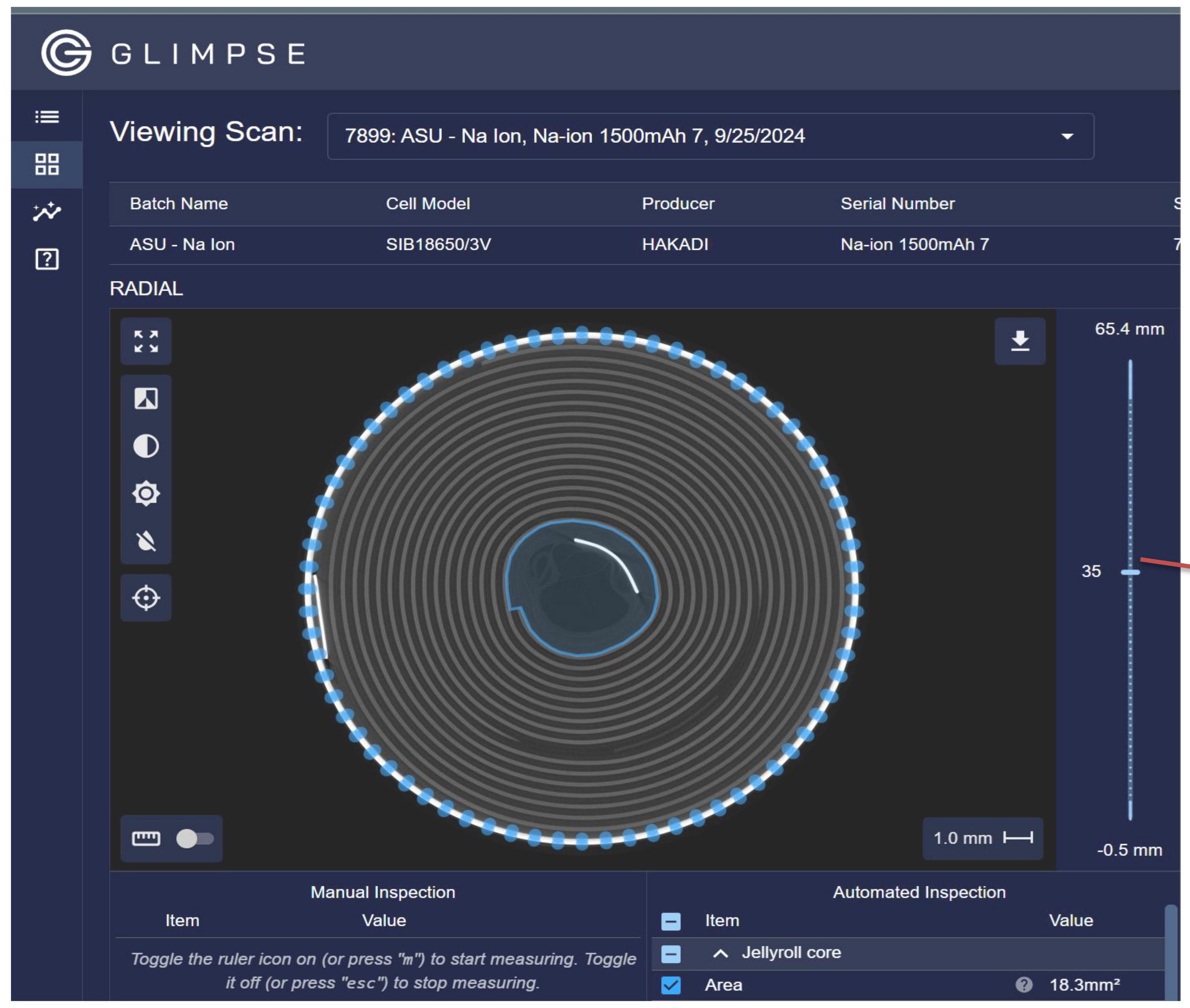
Special thanks to GLIMPSE: https://glimp.se/

Objective

The objective of this research is to analyze the behavior of lithium and sodium-ion cells cycled at slow rates in extreme temperatures, since cells tend to malfunction in said conditions. This has applications in repurposing obsolete batteries, comparing sodium-ion battery as a more sustainable alternative to lithium and finding how performance in extreme temperatures could be improved.

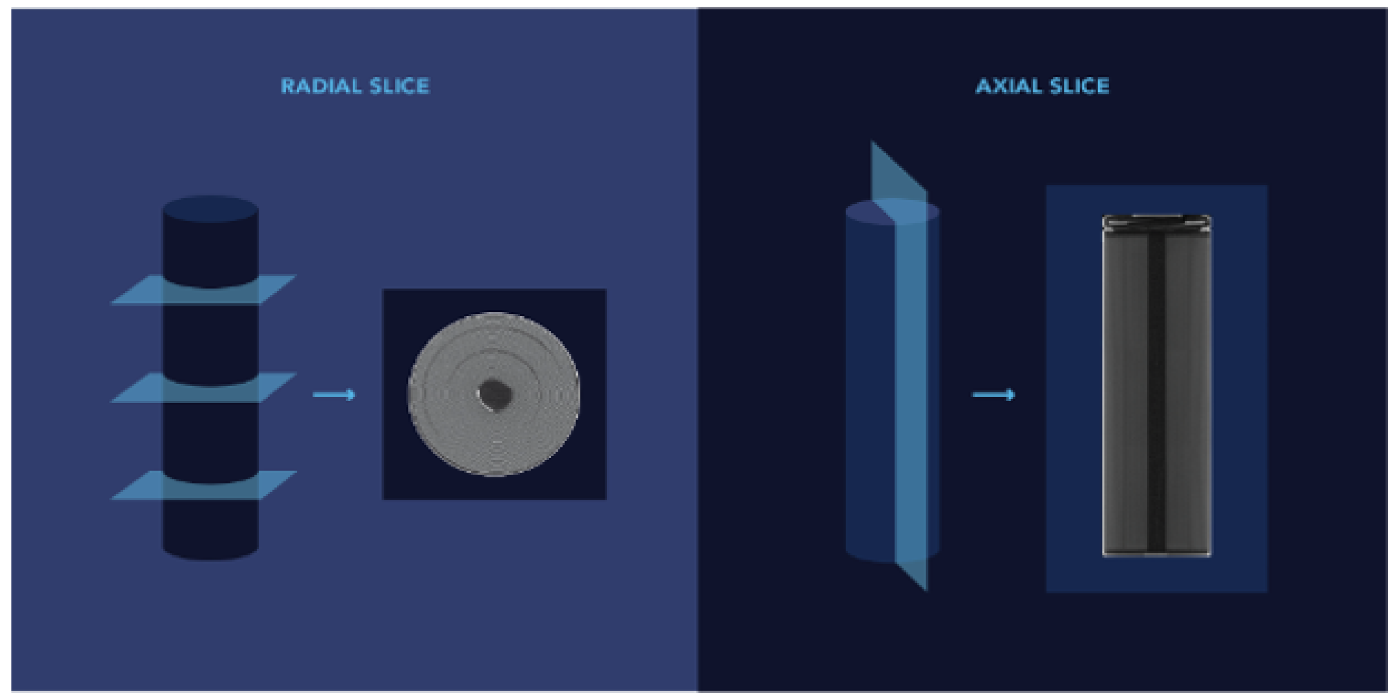
Methods and Results

Characterization process with the help of CT scans, which are non-destructive X-rays on the cells. The scans were taken after cycling approximately 60-100 times until failure (80% capacity).



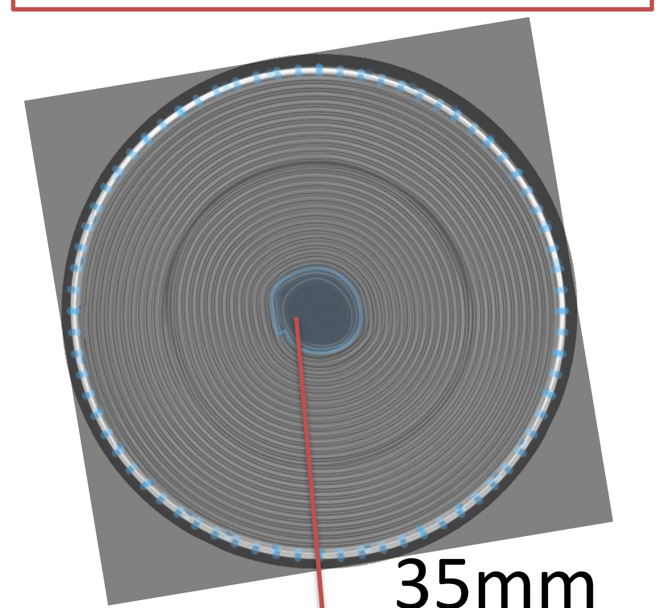
GLIMPSE scans allow for slicing at different heights of the battery.

GLIMPSE cell scanning configuration



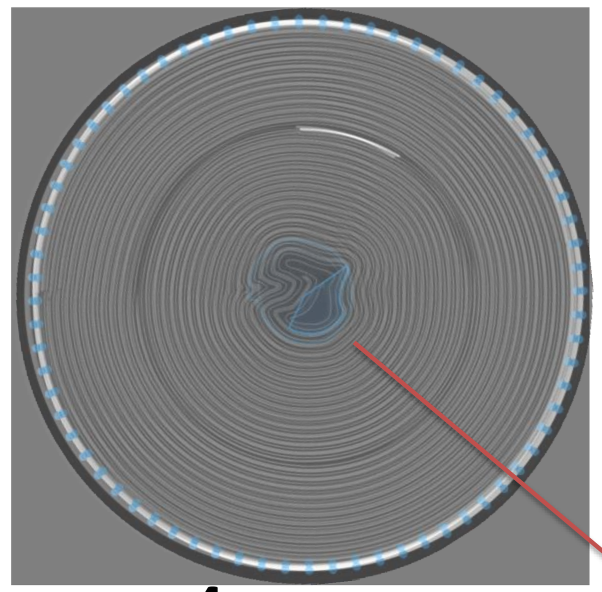
Li-ion at 0° Celsius

Standard Cycling



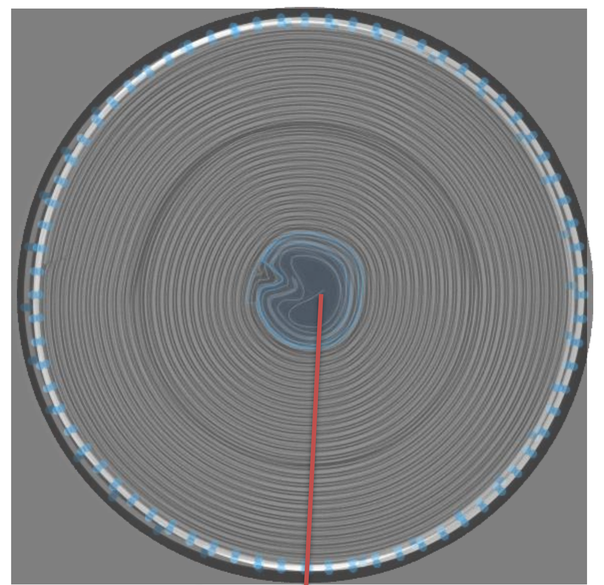
35mm

Fast charge



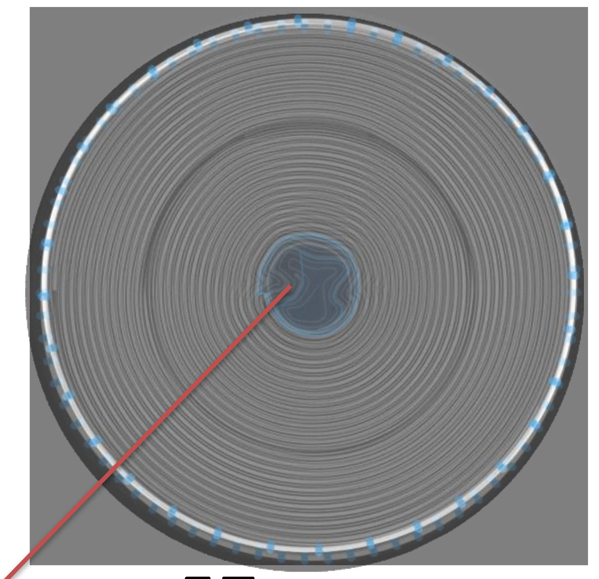
4mm

Fast charge



35mm

Fast charge



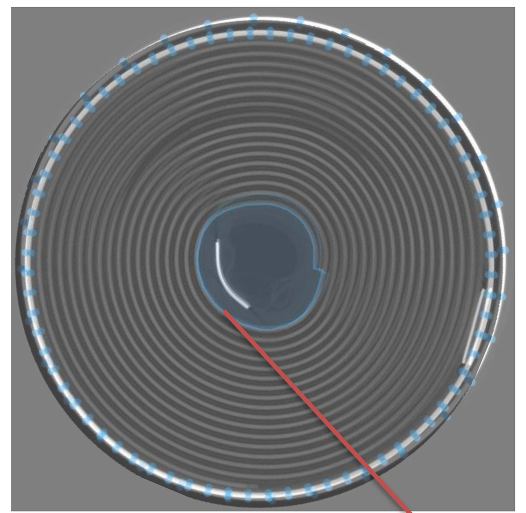
57mm

Stable cell core

Collapsed core, where inner coils deform inward, caused by mechanical stress of cycling.

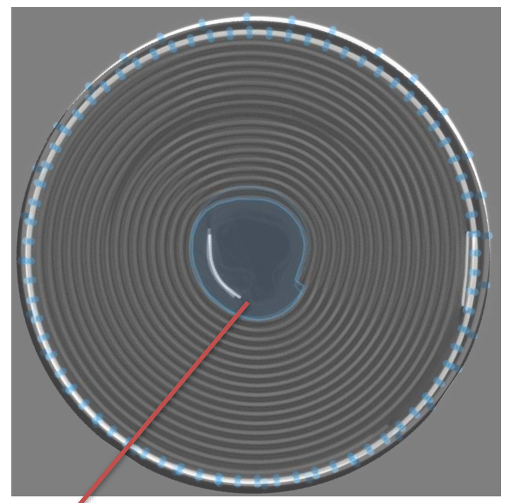
Na-ion at 0° Celsius

Standard Cycling



35mm

Fast charge



35mm

Minimally collapsed core

Analysis

At standard conditions, batteries seemed to maintain relatively stable core areas, especially Na-ion cells. Fast charging demonstrates more abnormal behavior in core conditions. These cycling rates accelerate core collapse. It is observable that Li-ion cells showed a more extreme core collapse at all heights when being fast charged. This can be due to the extreme cycling, or the cell design with more layers. Na-ion cells were more stable than Li-ion in terms of core area. In general, the cells with the most changes in the mechanical state also show the most capacity fade.

Next steps

Understanding how cycling rate and temperature affect core collapse for batteries by doing virtual unrolling of core areas and analyzing DV/DQ plots to understand the electrochemical processes of batteries at extreme temperatures. Another interesting alternative is the research into solid state battery design that could bring more stability at low temperatures. This research could prove useful for the electric vehicle industry and in second life applications for batteries.

Battery Type	Standard Cycling Rate	Fast Charge Cycling Rate
Li-ion Samsung (2170)	C/2 charge and discharge	C/1.6 charge and C/2 discharge
Na-ion Hakadi (18650)	C/1 charge and discharge	1.25C charge and C/1 discharge

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