Patterns of Charge and Discharge: How they Influence the Homogeneity of Lithium Distribution in Cells with Silicon/Graphite Anodes and their Ageing

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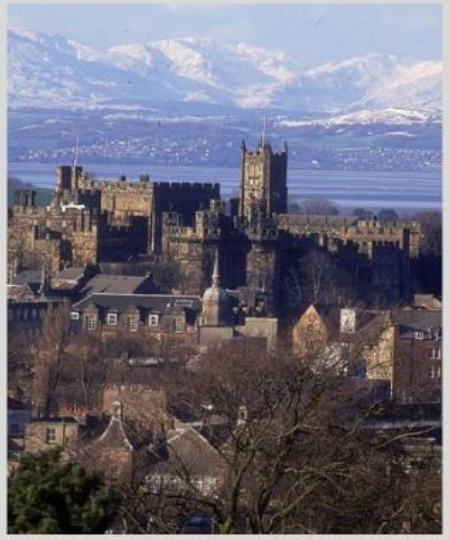
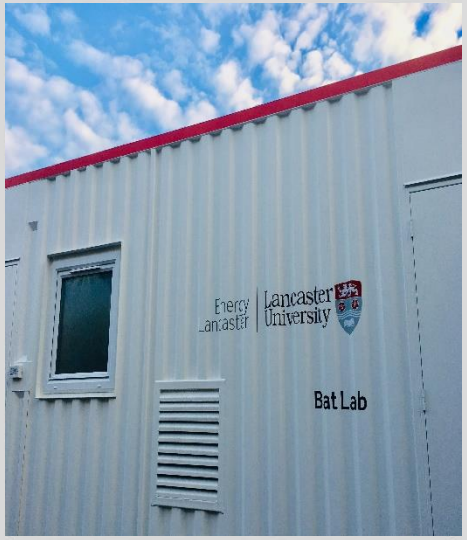
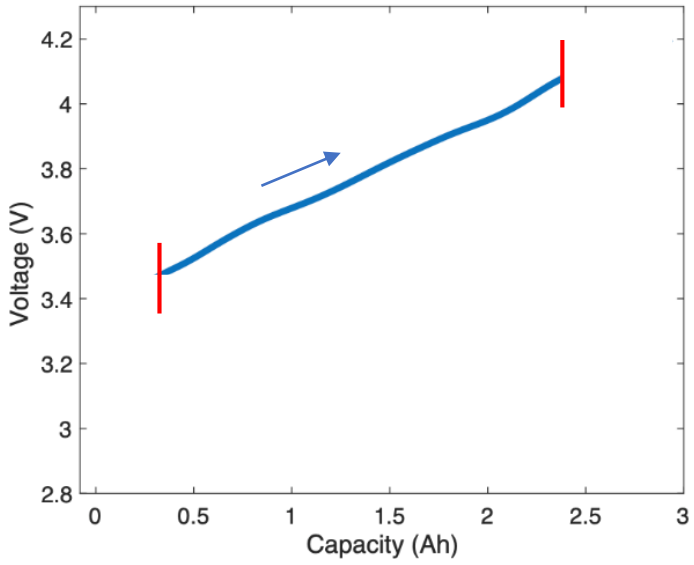




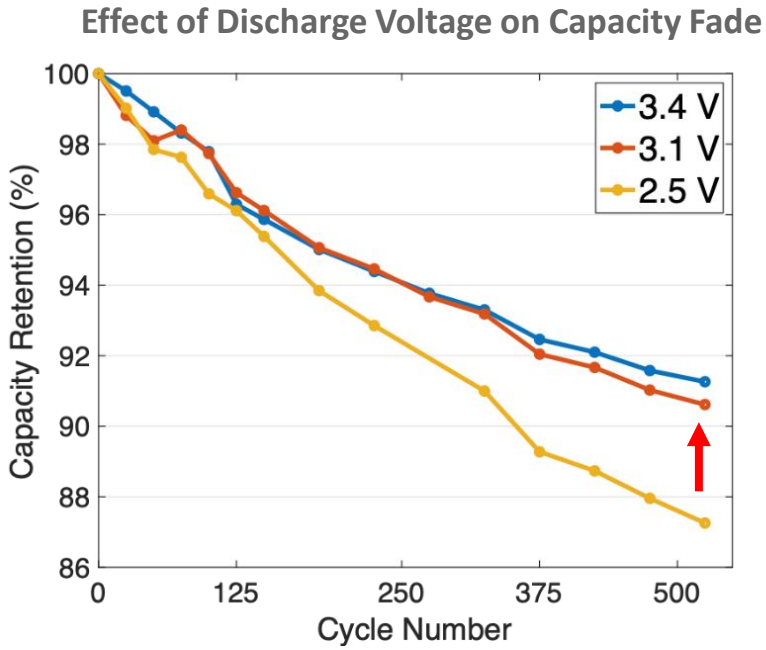
Research Motives

- Studying the effect of charge/discharge patterns on battery ageing
- Effect of relaxation periods on battery life-time
- Create usage strategies to improve cycle life

Charging Curve



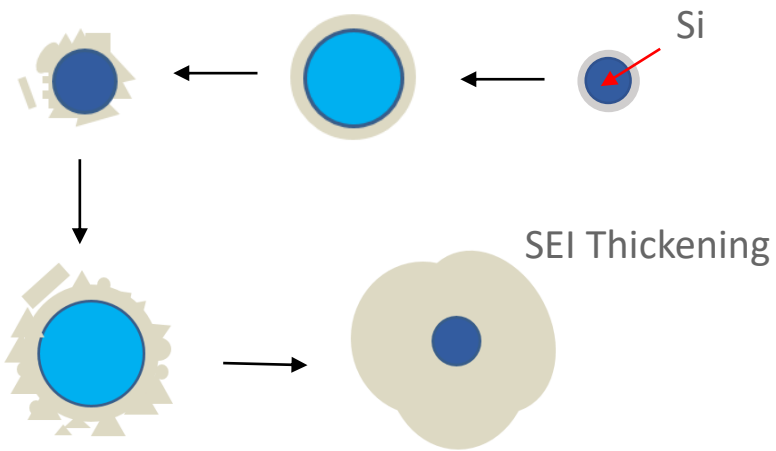
Smarter usage strategies

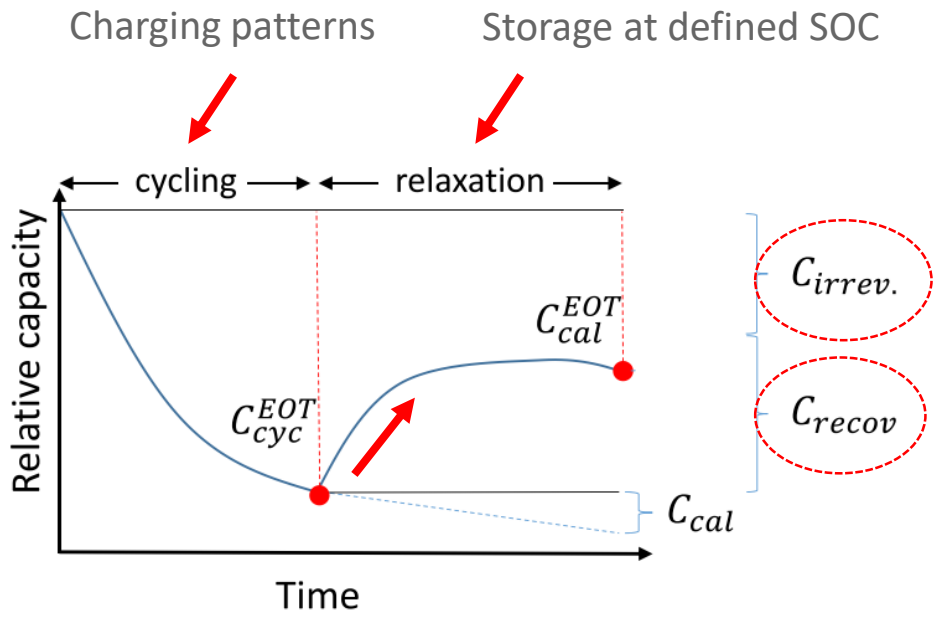


Our Research

Manufacturer	Samsung
Discharge Capacity	3.40 Ah
Maximum Voltage	4.2 V
Minimum Voltage	2.5 V
Charging Current	Standard: 1.7 A
	Maximum: 2.0 A

- Silicon-graphite (**Si-Gr**) anode
  - ✓ Higher **gravimetric capacity** and **energy density** than graphite
  - ✗ Large **volume expansion** upon lithiation (~300%)





M. Lewerenz and D. Sauer, *Journal of Energy Storage*, 2018, 18, 421-434.

Homogeneity of Lithium Distribution (HLD)

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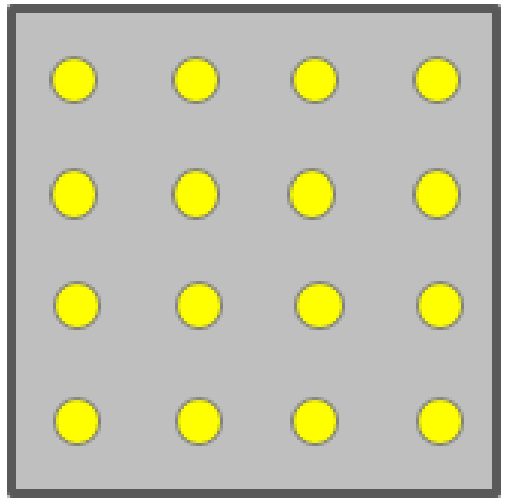
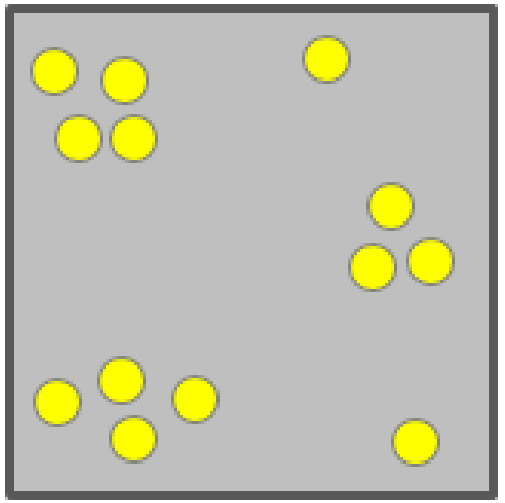
High HLD



OR

Low HLD



Active material

Lithium

- Inhomogeneous ageing
- Reduction in immediate capacity

Effect of Restricted Voltage Windows

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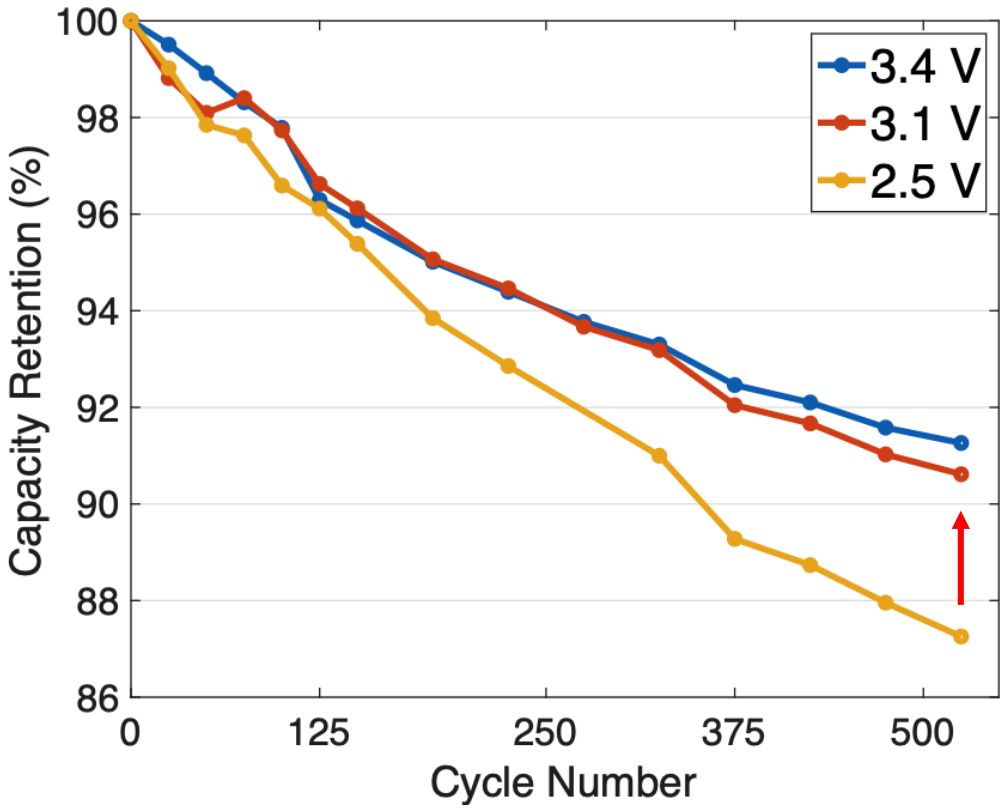
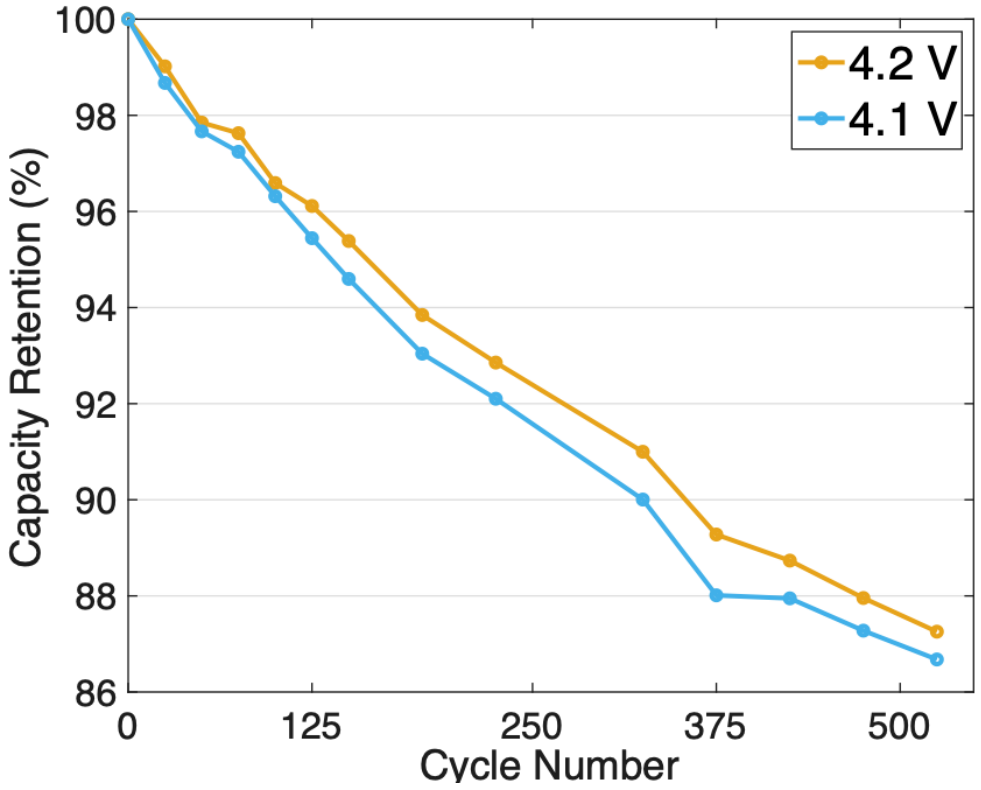
Discharging voltage

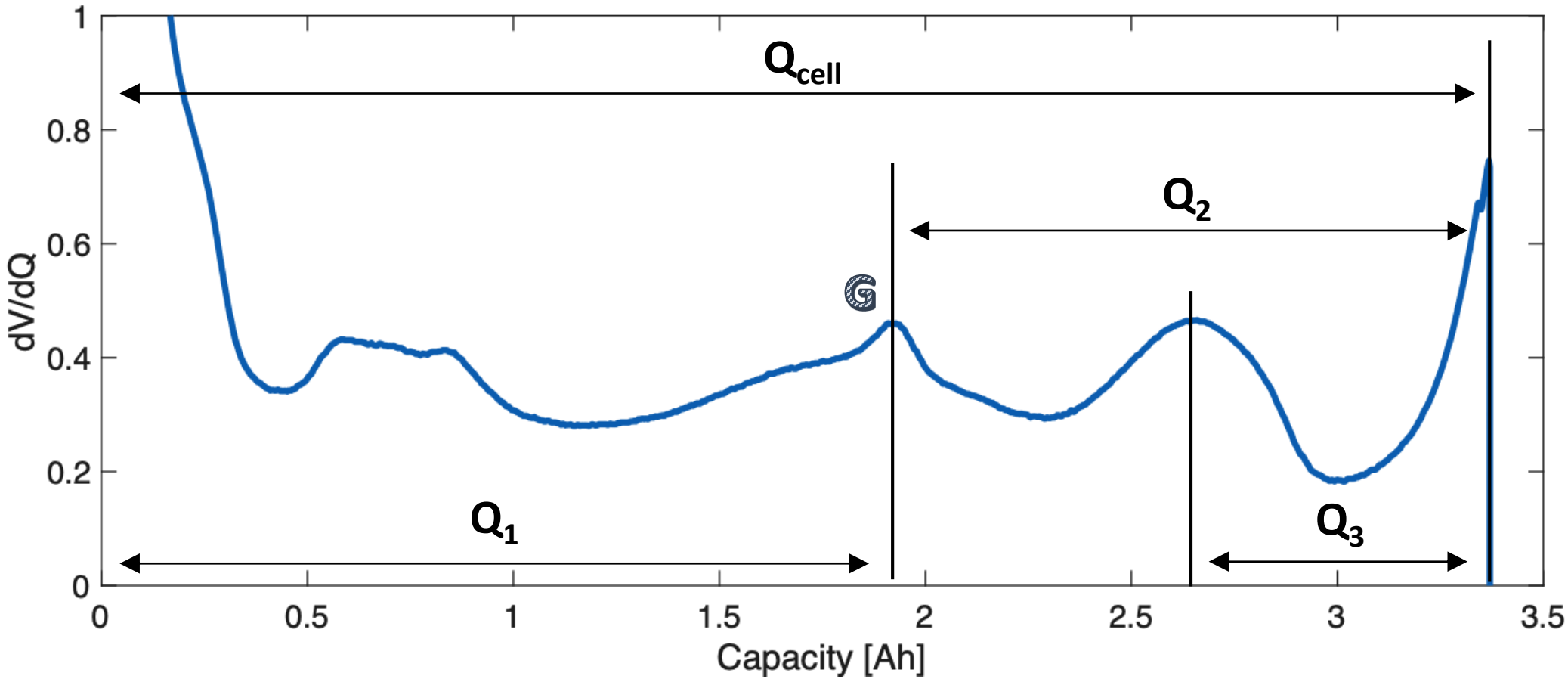


Charging voltage



Charging - C/2 & C/3
Discharging- C/3

Differential Voltage analysis (DVA)



Effect of Discharging Voltage on HLD

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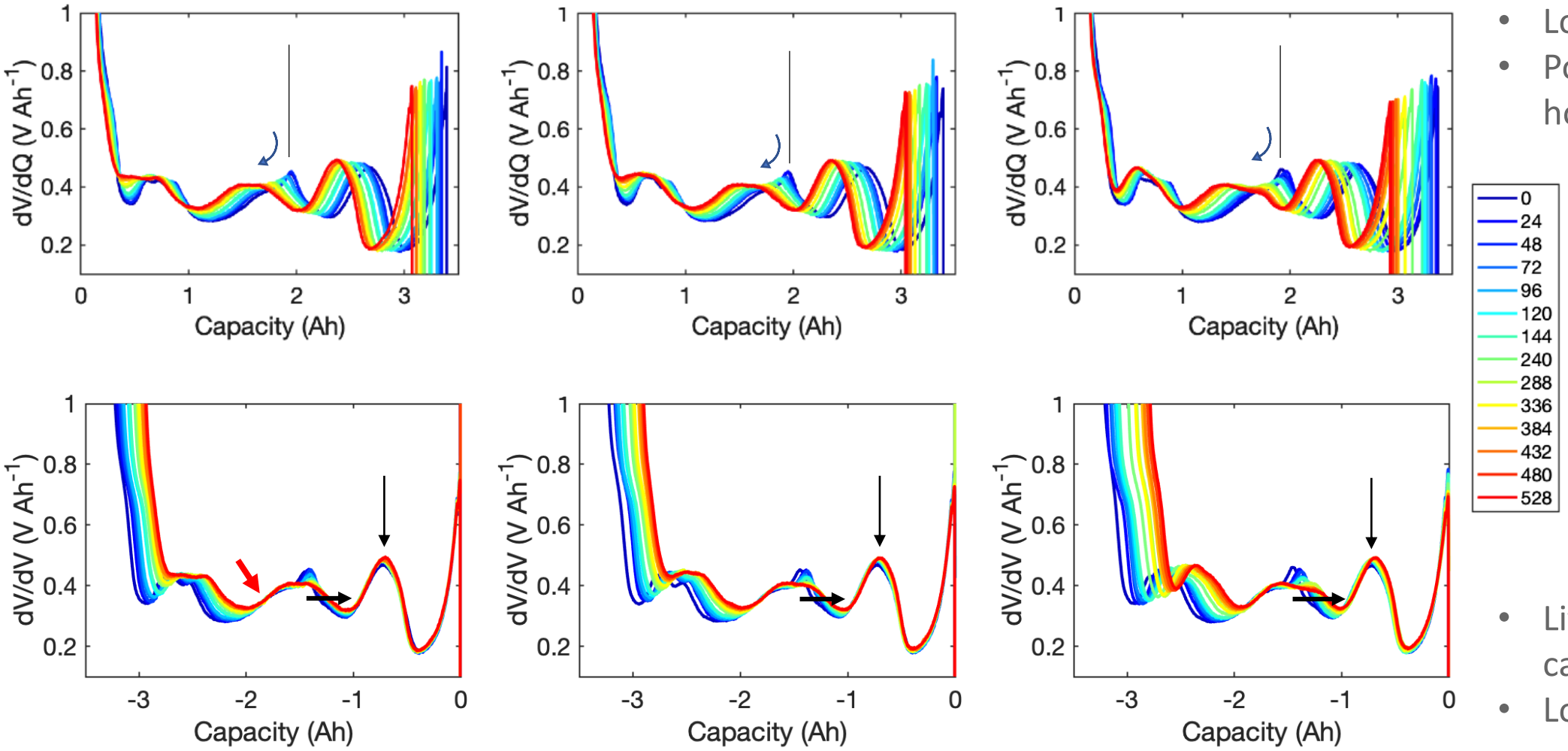
4.2 - 3.4 V | **4.2 - 3.1 V** | **4.2 - 2.5 V**



- Loss active material
- Potentially lower homogeneity

- Little change of cathode
- Loss of lithium

DVA Peak Analysis

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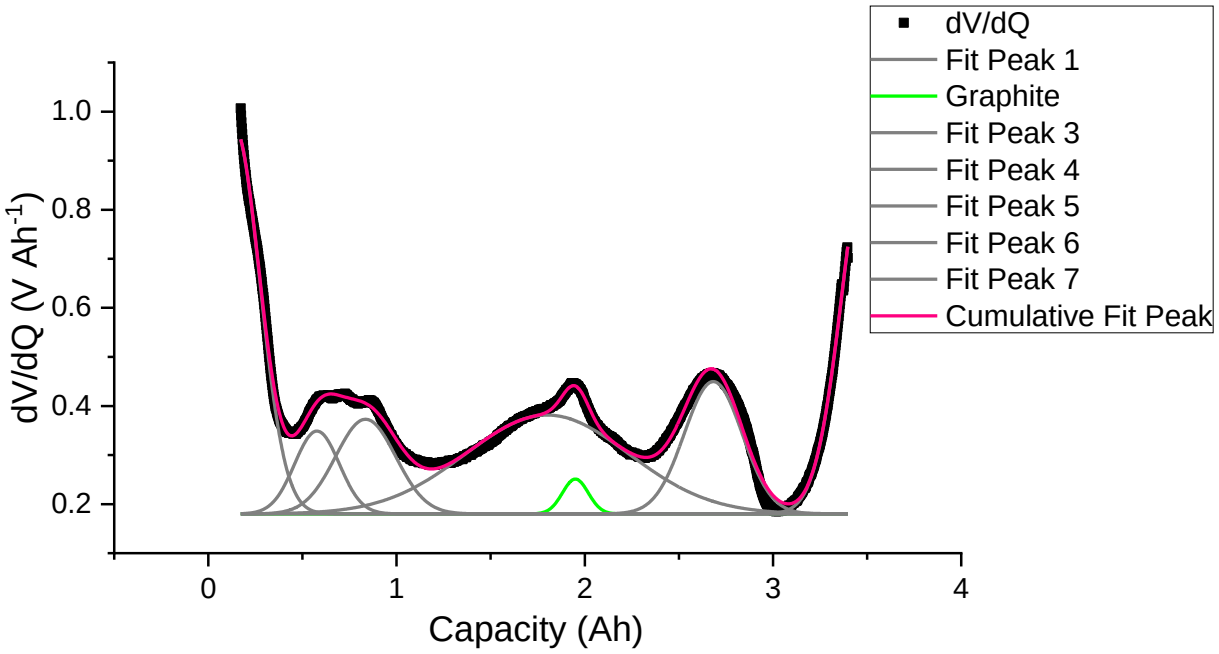
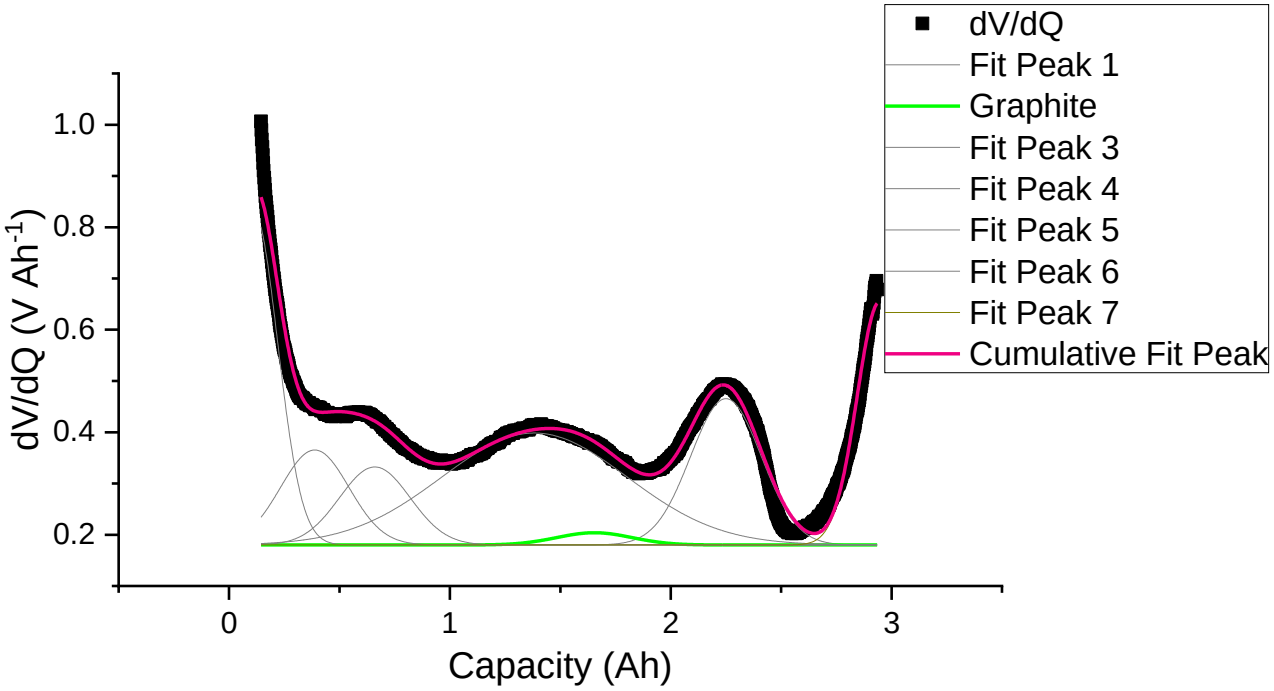
Fresh



Graphite peak:
Height – 0.07
Width – 0.13
Area – 0.012

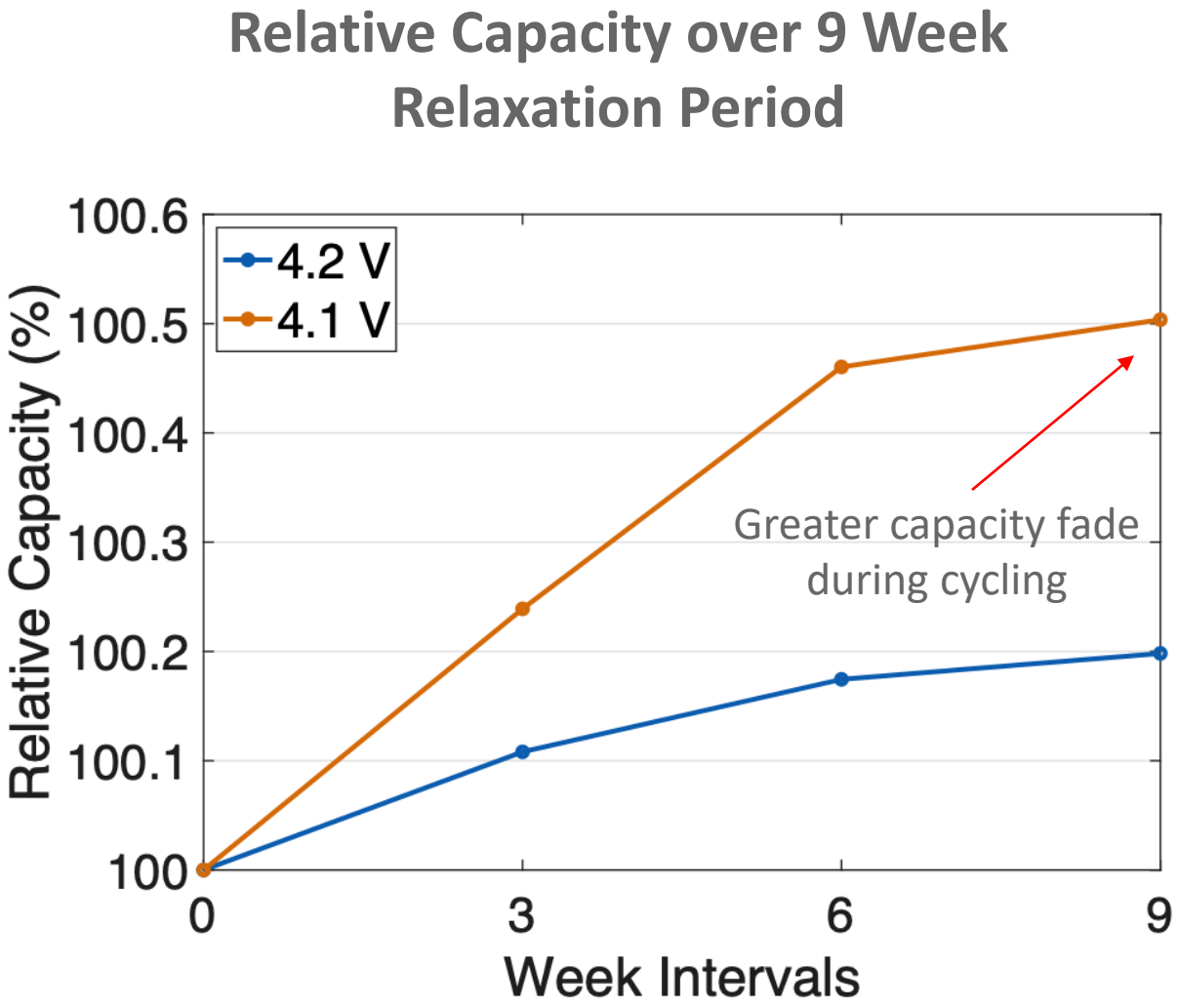
Aged



Graphite peak:
Height – 0.02
Width – 0.34
Area – 0.010

~0.3 Ah shift

Effect of Relaxation Periods



Storage conditions:

Storage SOC - **50% SOC**
Temperature - **25°C**

Conclusions and Future Work

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Conclusions

- A shallower depth of discharge (DOD) → less capacity fade
- Raising the upper charging voltage → less capacity fade

- Loss of active material and loss of lithium during cycling
- Little change in storage capabilities of cathode
- Potential reduction in homogeneity

- Lowering the charging voltage increases capacity recovery during storage

Future Work

- Storage at **low SOC** to determine contributions from **anode overhang**
- **Continued cycling** after storage periods to determine **long-term effects** of relaxation periods
- Post mortem analysis – validation with half cells

Acknowledgements

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