

32ND

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Inferring Battery Current Interrupt Device Activation in an 18650 Cell under High C Discharge via Strain

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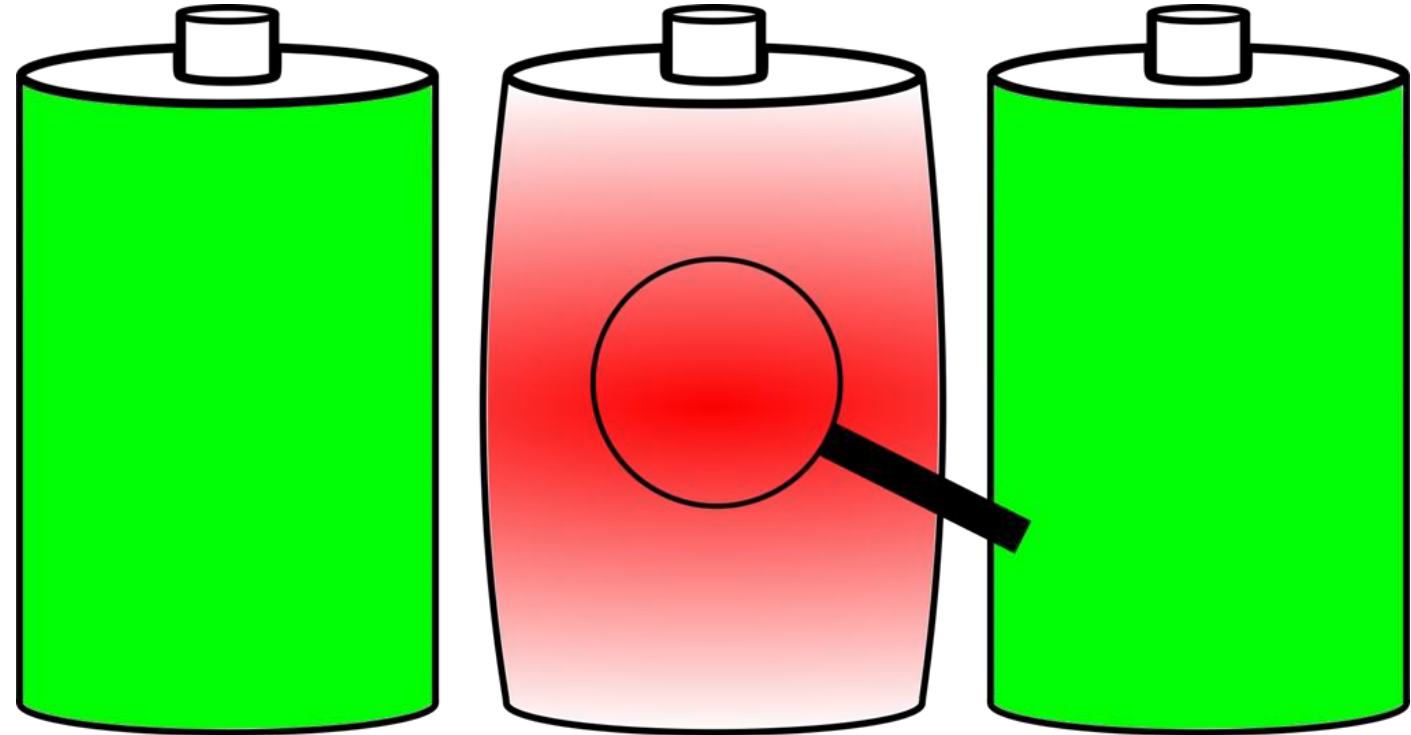
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Outline

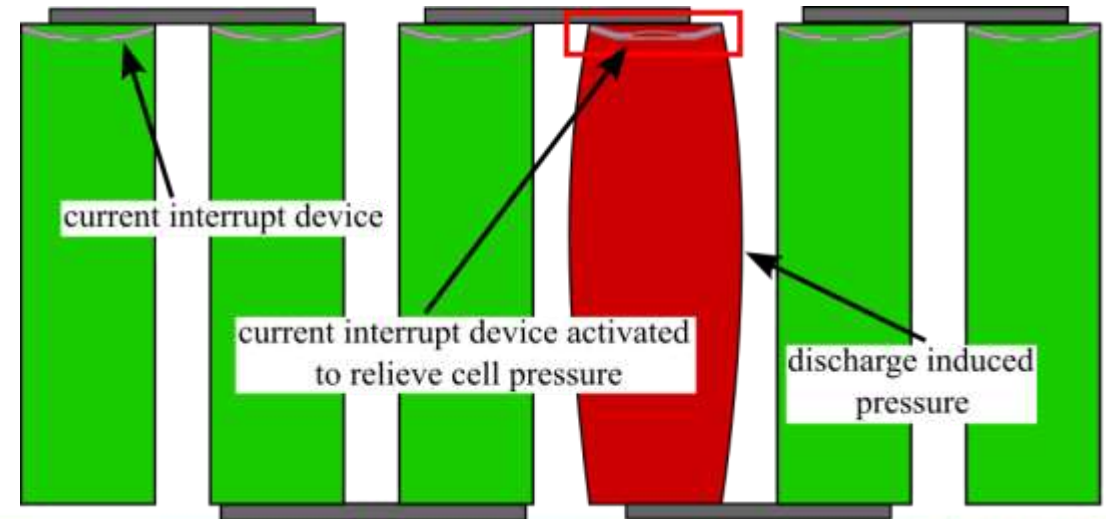
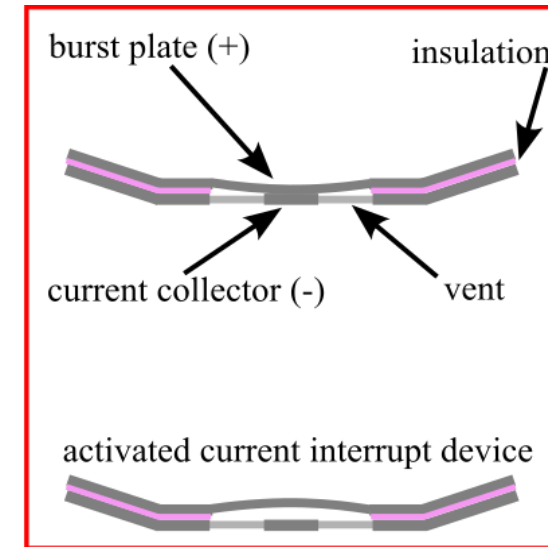
- Methodology and Challenges:
 - Digital Image Correlation
 - Foil Strain Gauges
- Results and Discussion:
 - Experimental outcomes
 - Findings and limitations
- Future work:
 - Model Development



The battery that experiences excessive strain should be identified to reduce the likelihood of failure

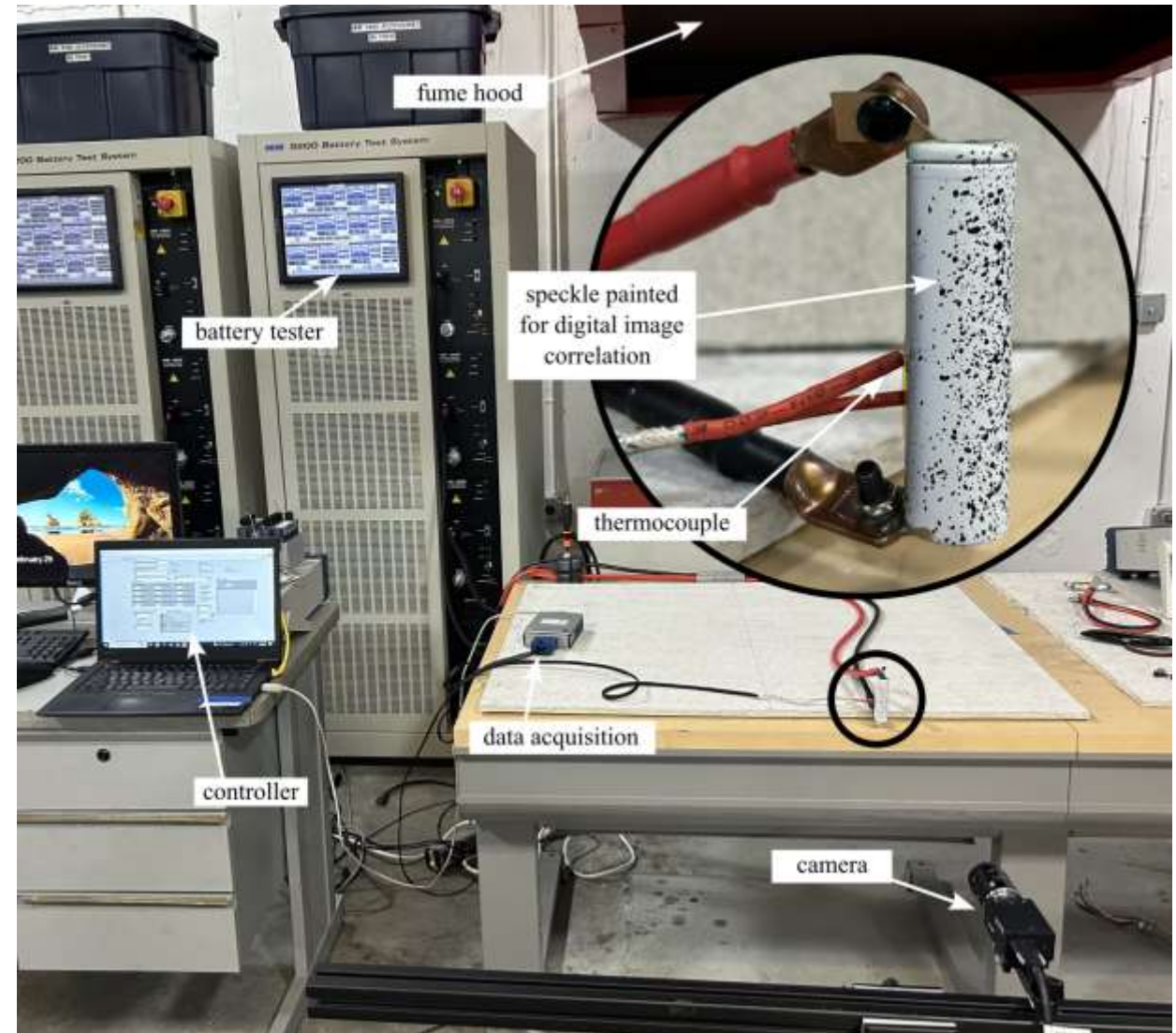
Introduction

- Due to high energy capacity of batteries:
 - safety measures are put in place to open the internal circuit before it enters thermal runaway
- Problem statement:
 - Gas expansion within the battery causes Current Interrupt Device(CID) activation
 - Relies on irreversible changes to the structure of the cell
 - Prevents future use of the battery
- Proposed approach:
 - Pressure sensing through external strain measurement
 - Digital Image Correlation or Strain Gauge to monitor the cell during discharge



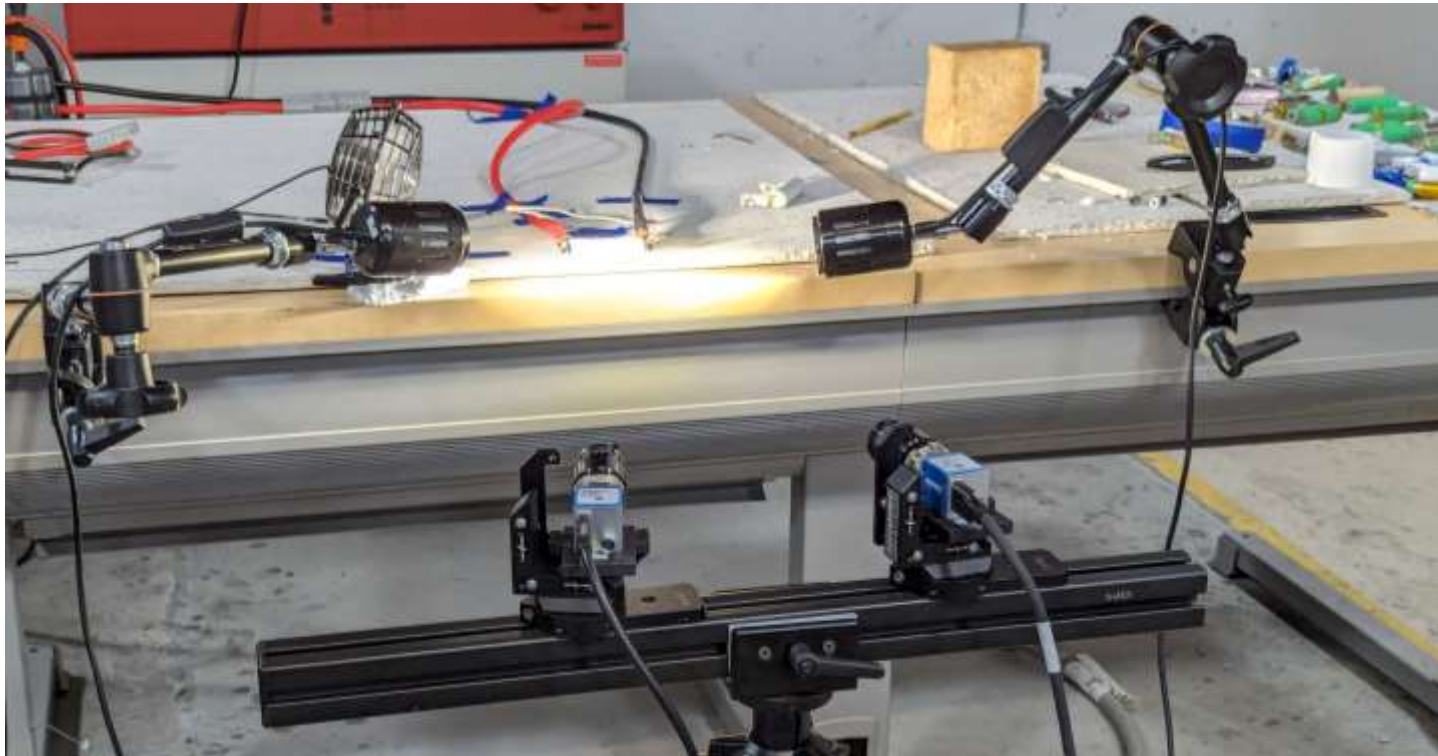
Digital Image Correlation Setup

- 3 module battery tester to allow for high-C discharge
- Battery is speckle painted for digital image correlation nodes
- Controller for:
 - digital image correlation cameras
 - battery tester
 - thermal data acquisition



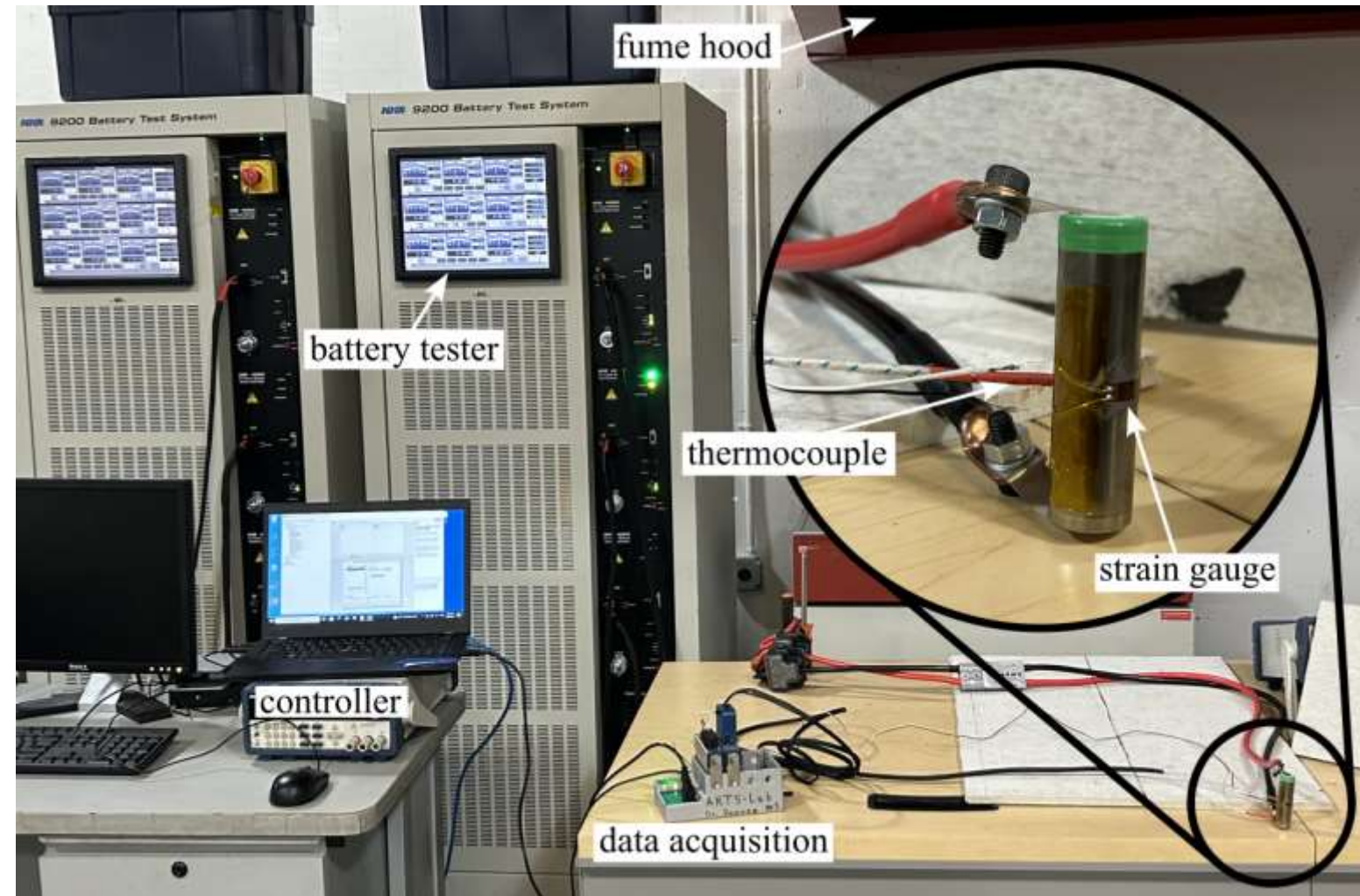
Digital Image Correlation Setup

- Improved speckle painting methods
- Added better lighting for speckle detection
- Added fan to mitigate heat waves



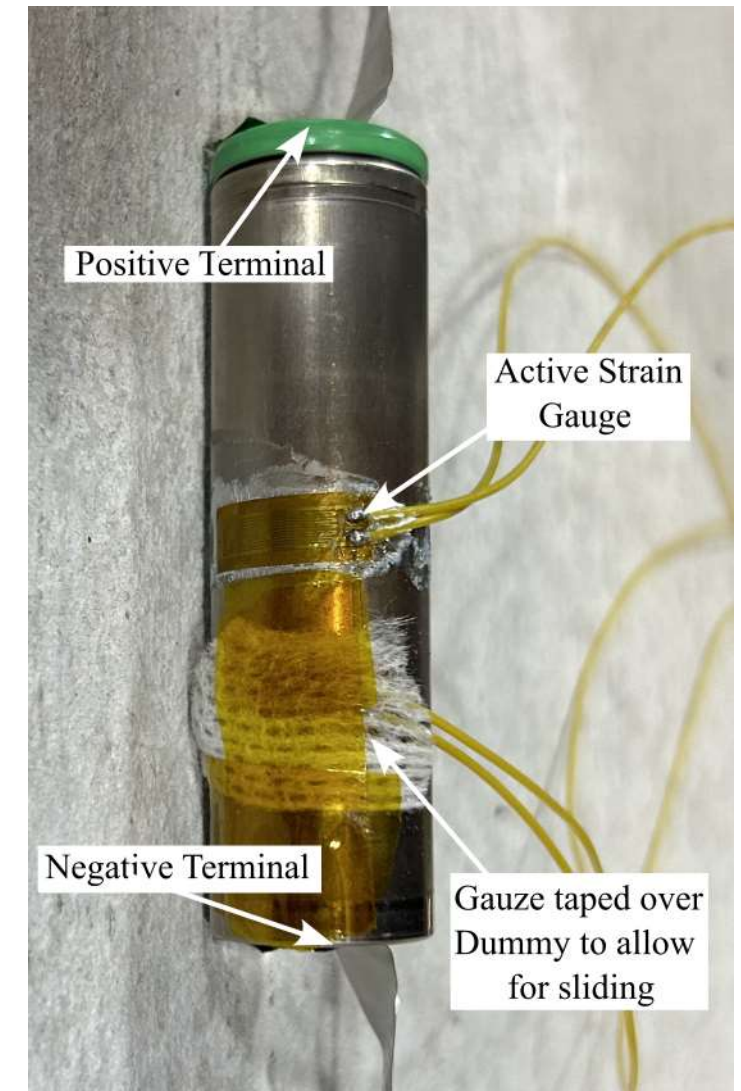
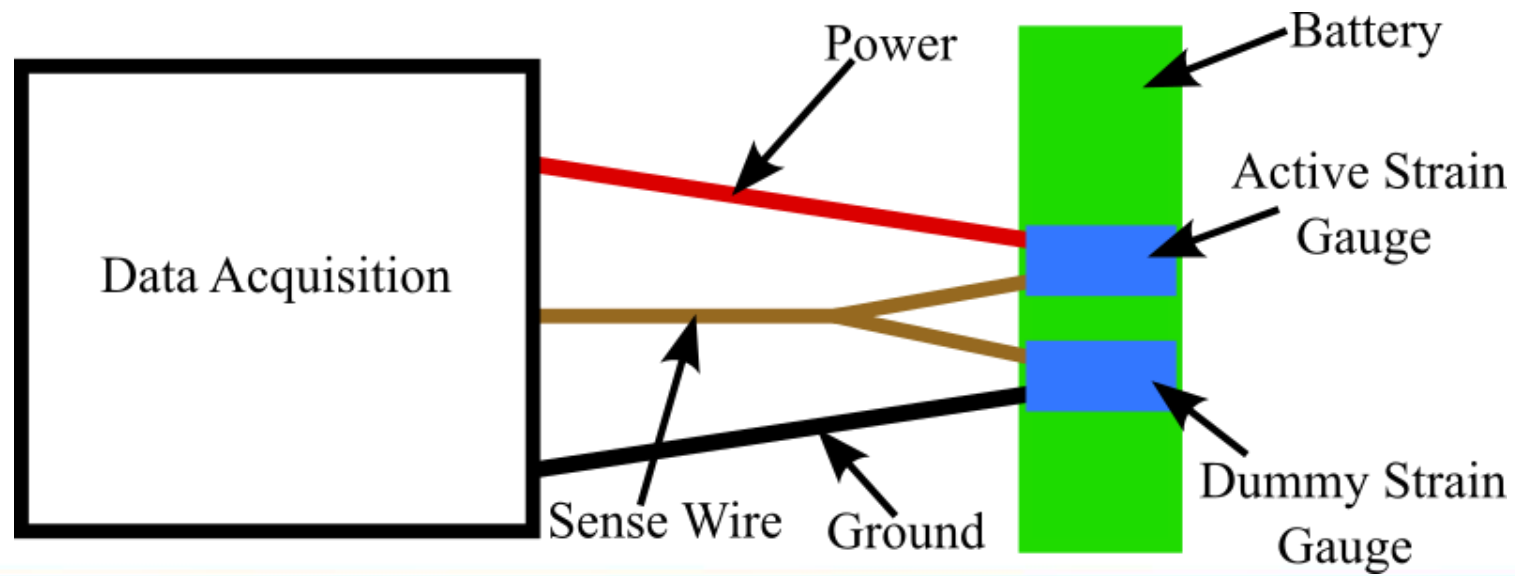
Strain Gauge Setup

- Thermocouple attached opposite 120 Ω Strain Gauge



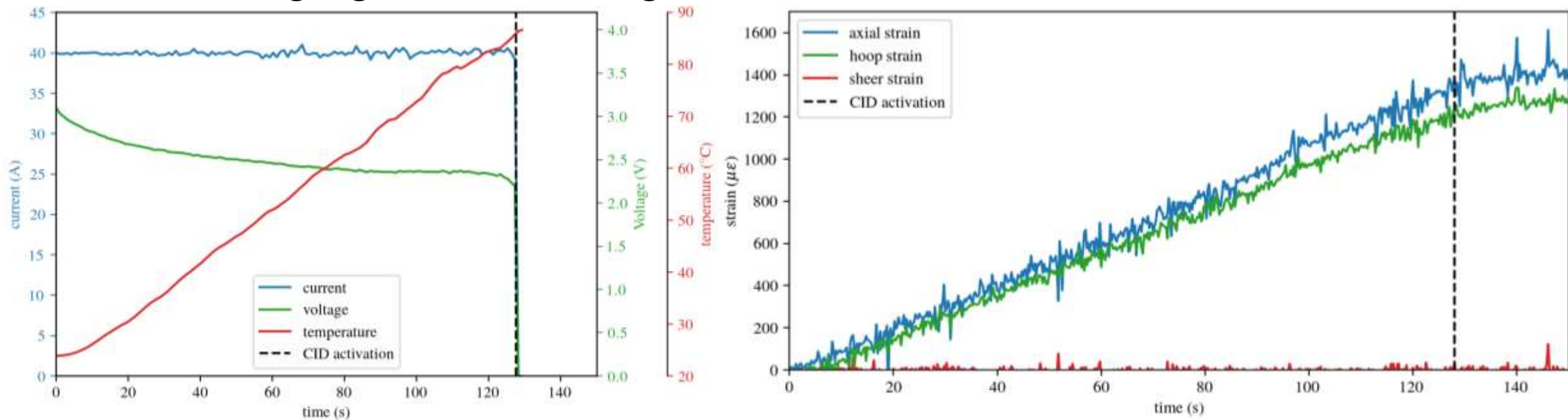
Strain Gauge Setup

- Can be improved with temperature compensation from dummy gauge
- 350 Ω resistors can be employed for more accurate readings at higher temperature
- Dummy gauge should be across the cell at the same height due to the cell temperature gradient



Experimental outcomes: Digital Image Correlation

- Strain increase from temperature should be isotropic and we see that for the first minute
- As the test progresses divergence of axial and hoop strain can be observed
- Evidence of a force besides the temperature expansion
- could be the gas generation leading to CID failure

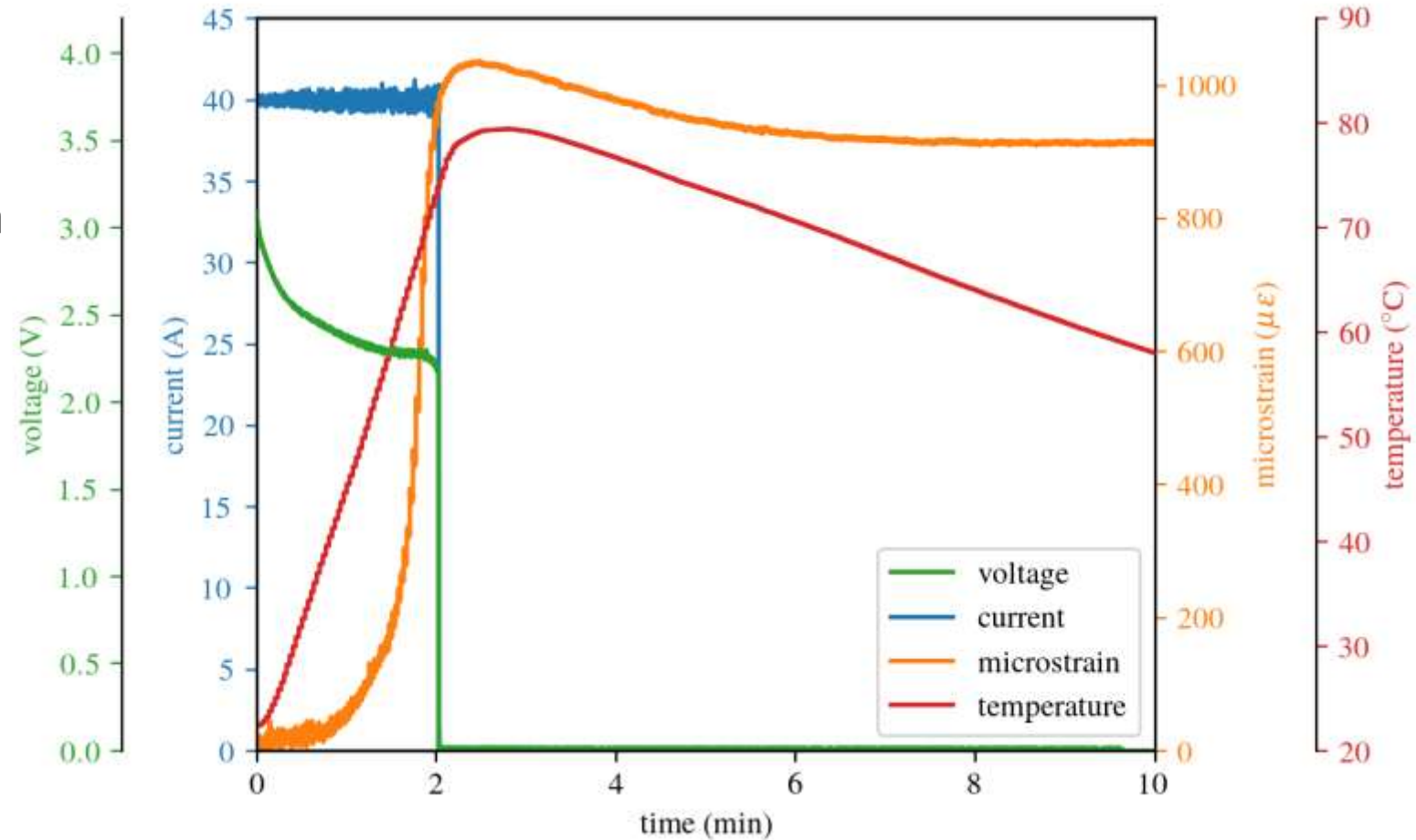


Experimental outcomes: Digital Image Correlation

- Improved Digital Image Correlation setup
- Less noise likely due to new speckle method

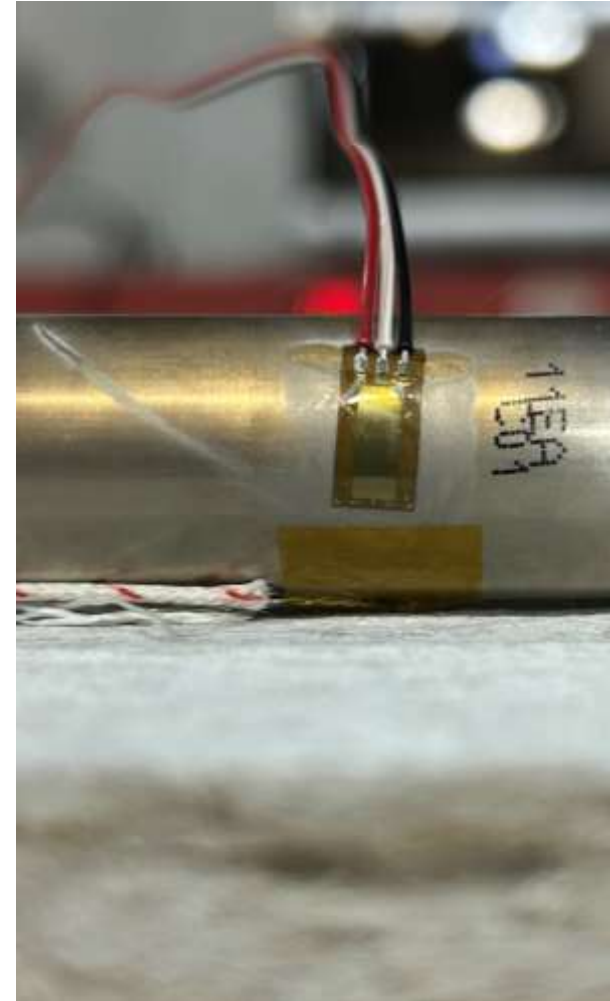
Experimental outcomes: Strain Gauges

- Could be incorporated into a battery pack, on an active cell unlike Digital Image Correlation
- Current Interrupt Device activation is more pronounced



Conclusions and Overview

- Potential for using battery deformation as a method of detecting CID failure is evident
- Integration of non-destructive strain evaluation methods into a pack or battery monitoring systems would require accurate strain gauge measurements
- Future work will seek to build a model that can estimate failure from current interrupt device as well as refine current methods



Future Work

- Model will be built with a Bayesian framework to based on known relationships between pressure strain and temperature
- Will require significant sample size to predict likelihood of current interrupt device activation from current, strain, and temperature.

$$P(\Theta|D) = \frac{P(D|\Theta) \cdot P(\Theta)}{P(D)}$$



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Thank you

Questions?

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- [2] Li, W., Crompton, K., Hacker, C., and Ostanek, J. K., “Comparison of current interrupt device and vent design for 18650 format lithium-ion battery caps,” Journal of Energy Storage 32, 101890 (Dec. 2020).
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