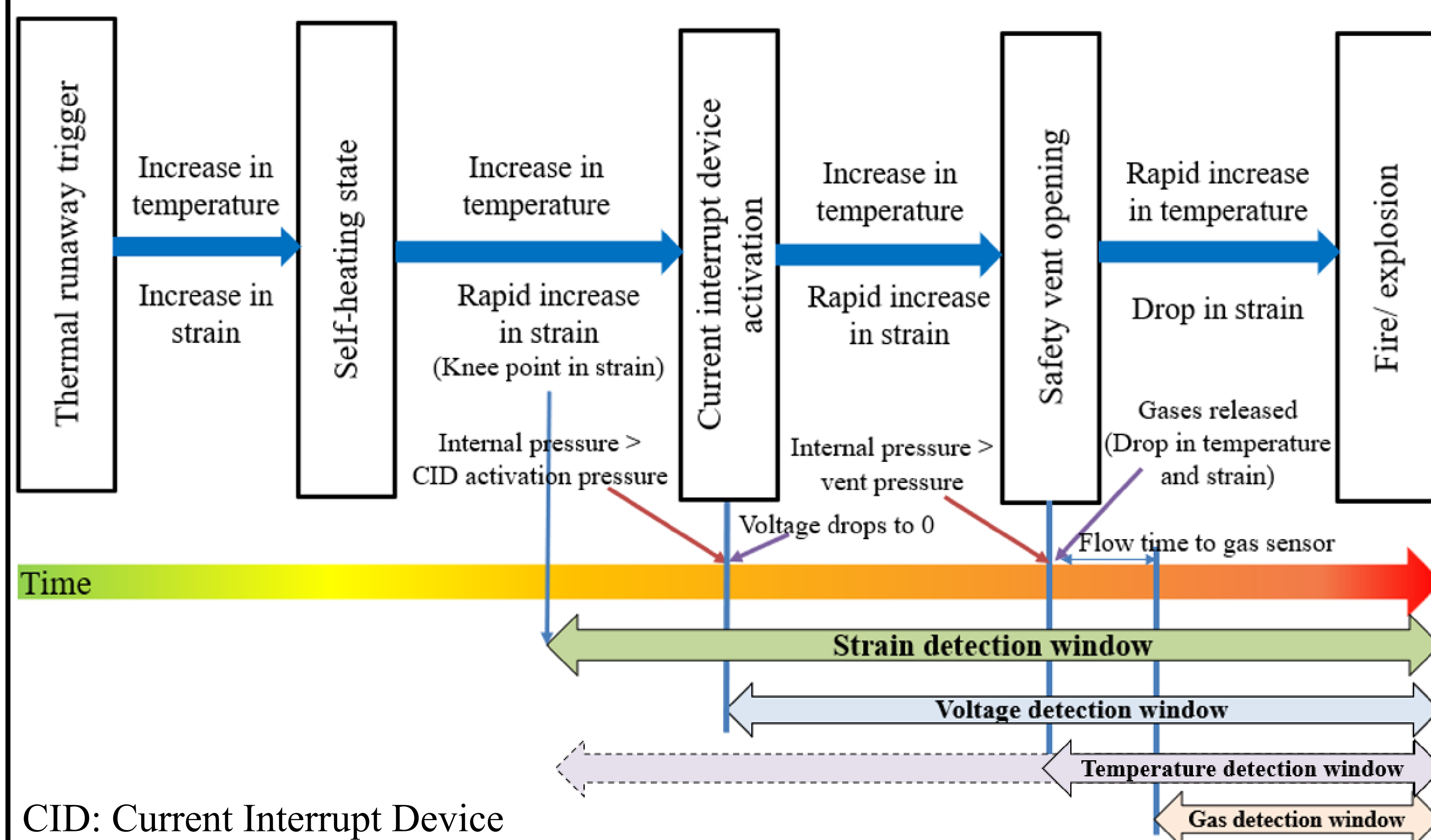


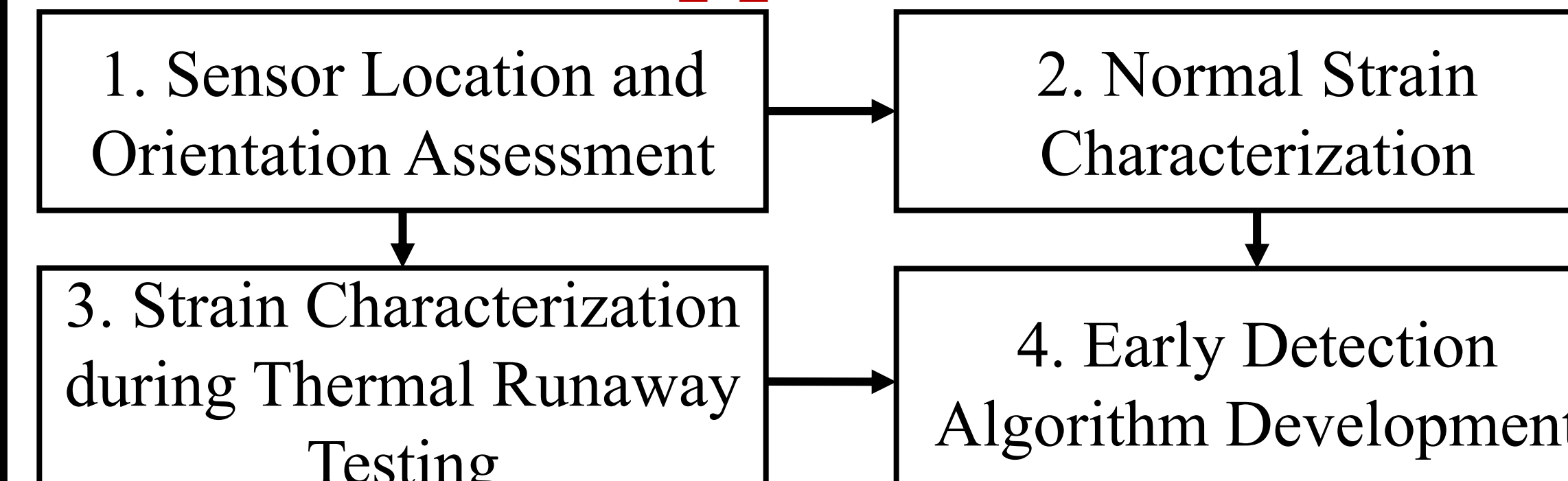


Problem Statement

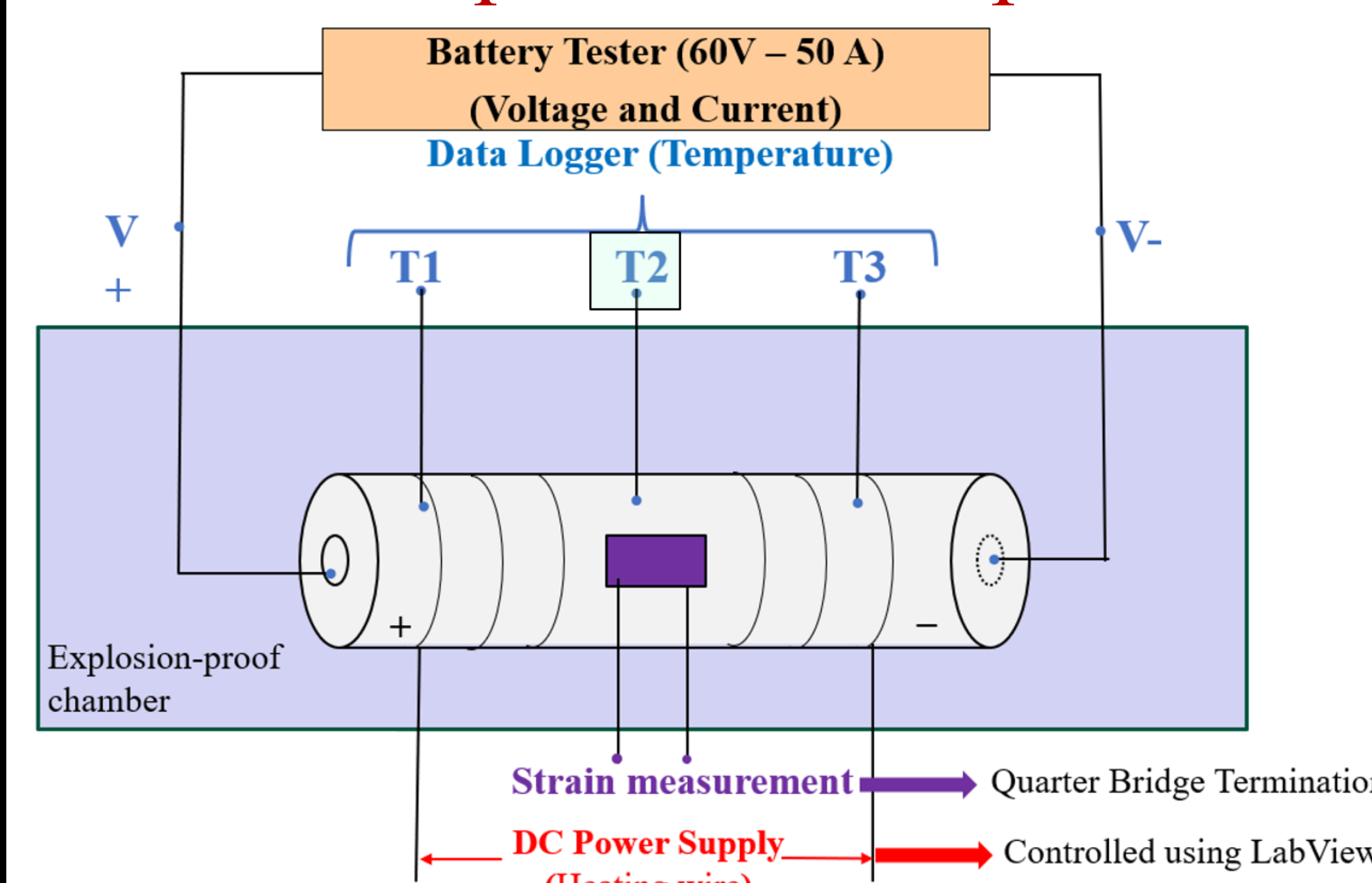
- Early detection of thermal runaway is critical for timely intervention and mitigation.
- During thermal runaway, gas generation increases internal cell pressure and causes swelling, making surface strain a promising non-invasive indicator for early detection.



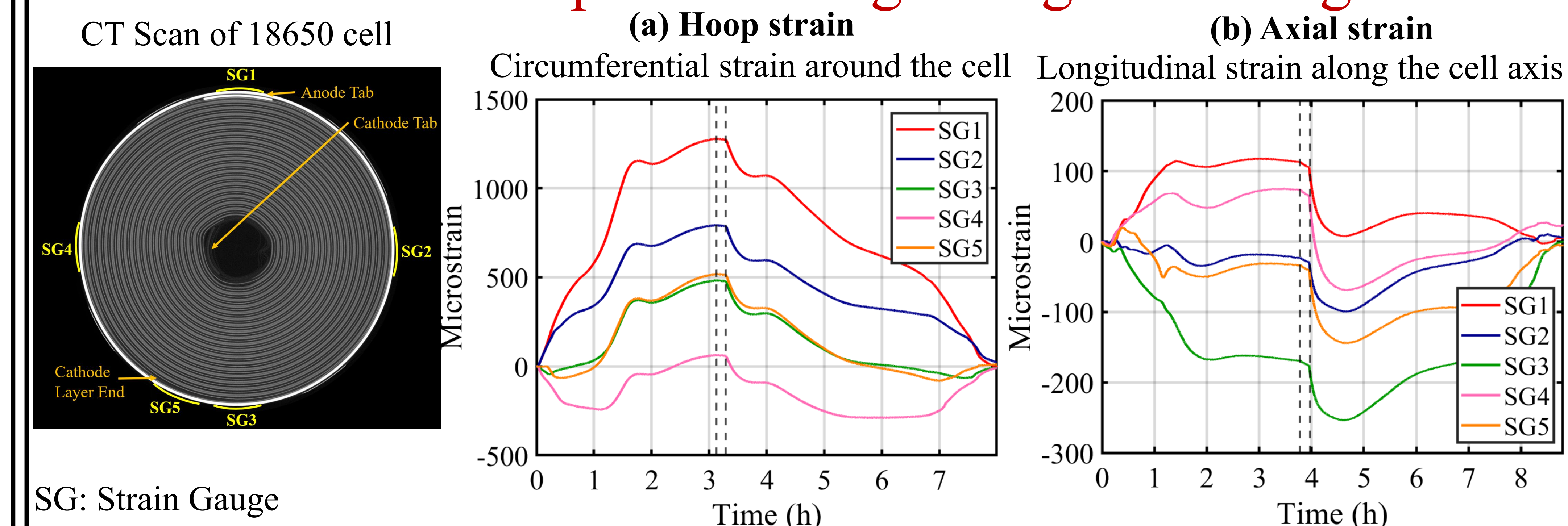
Approach



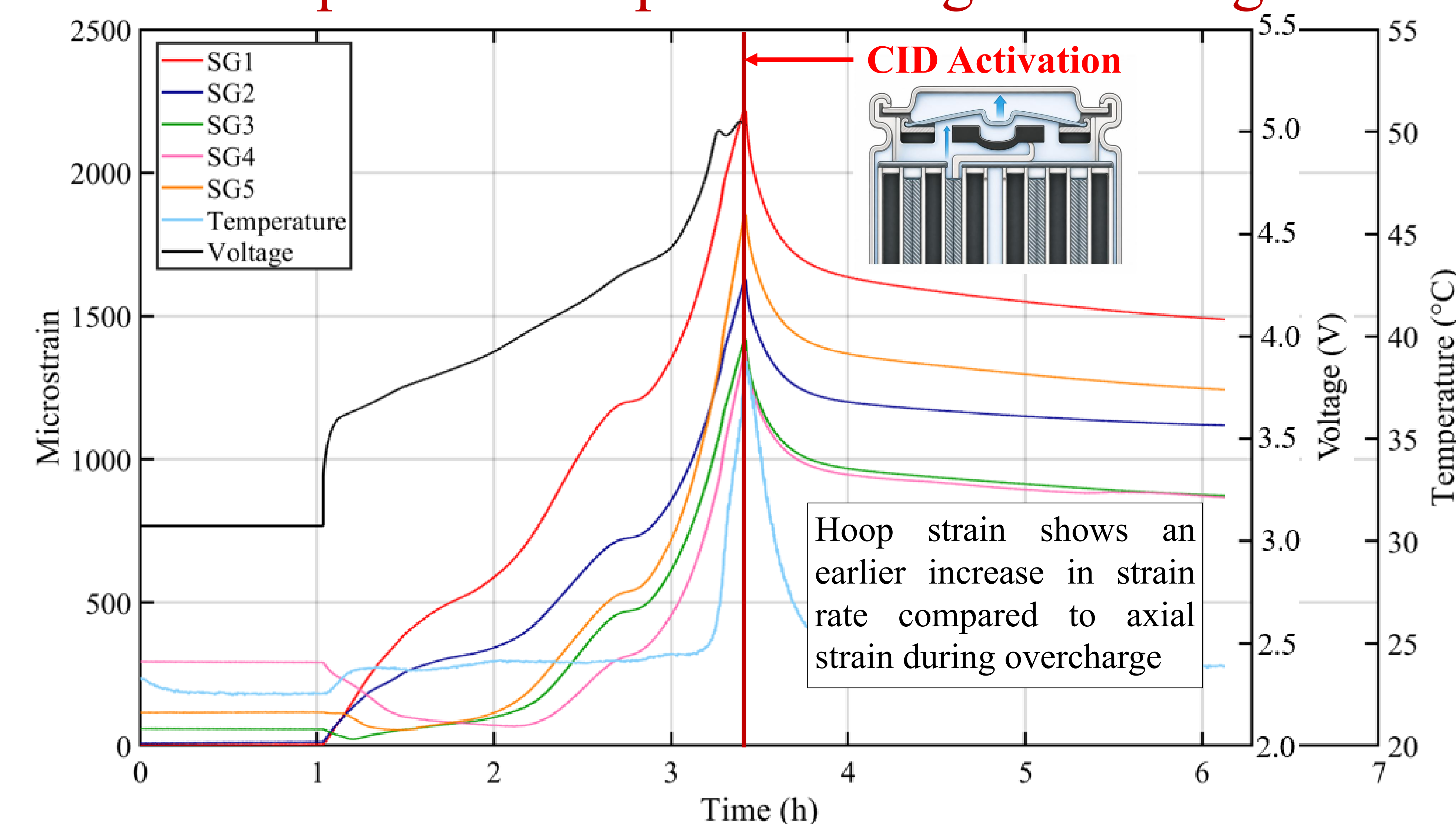
Experiment Setup



Strain Response during Charge-Discharge

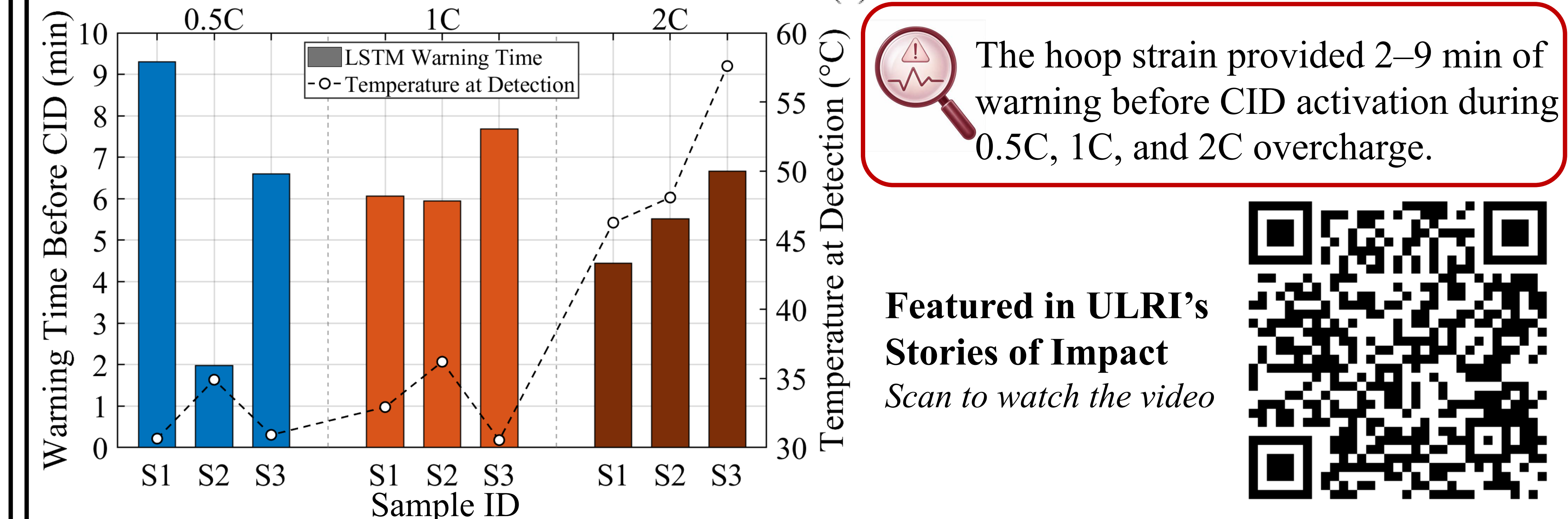
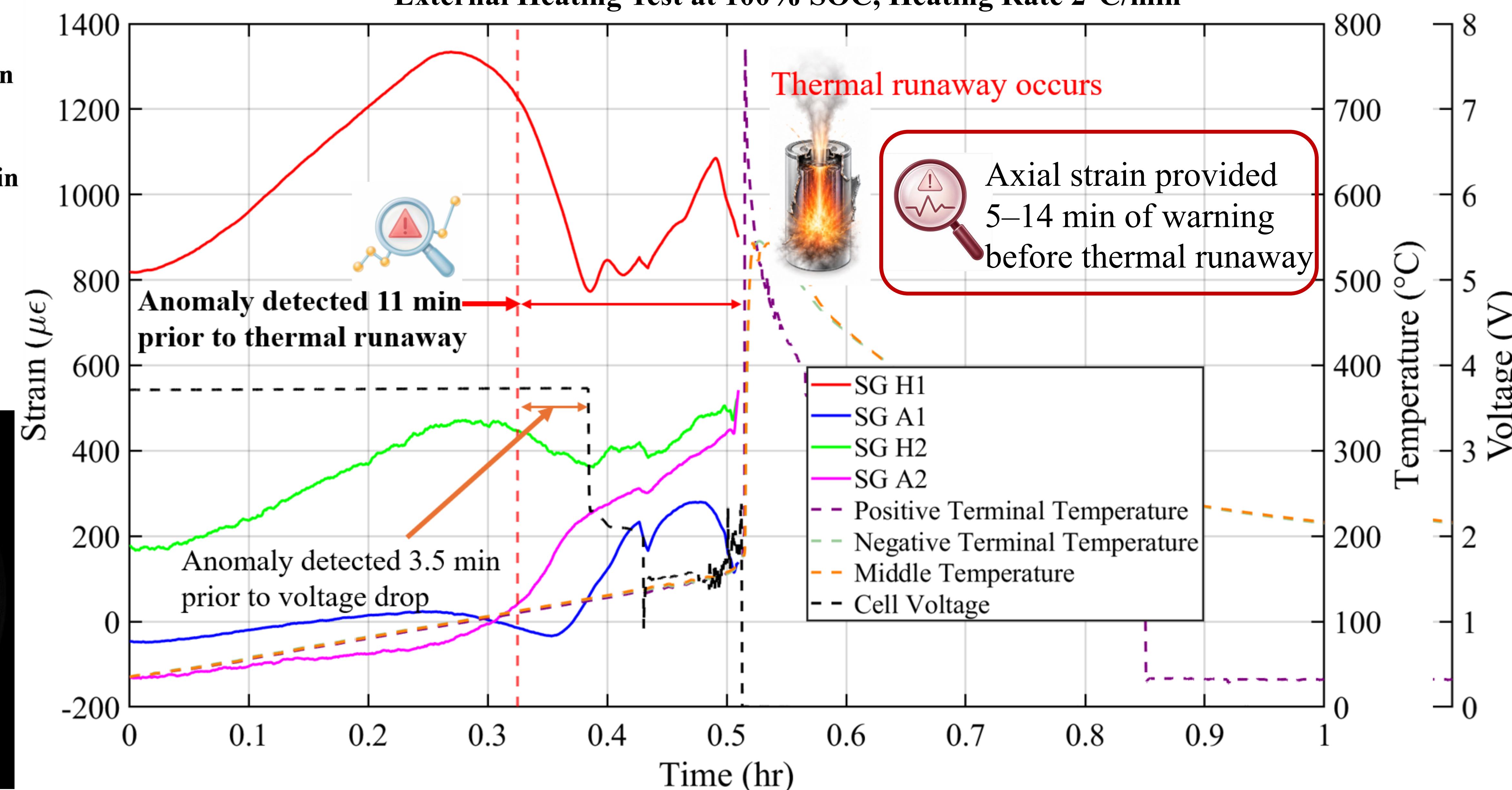


Hoop Strain Response during Overcharge



Strain Response during External Heating

External Heating Test at 100% SOC, Heating Rate 2°C/min



The hoop strain provided 2–9 min of warning before CID activation during 0.5C, 1C, and 2C overcharge.

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