Mitigation of Failure Propagation in Multi-Cell Lithium Ion Batteries

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Traditionally, safety and impact of failure concerns of lithium ion batteries have dealt with the field failure of single cells. However, large and complex battery systems require the consideration of how a single cell failure will impact the system as a whole. Initial failure that leads to the thermal runaway of other cells within the system creates a much more severe condition than the failure of a single cell. Despite years of research in battery safety, there are still challenges associated with the complexity of system-level safety for large battery systems. There is a significant gap of safety knowledge at the module or pack level of the effects on adjacent cells in a large-scale battery pack as one cell experiences failure. After the impacts and consequences are identified, it is also essential to determine mechanisms to mitigate the effects of a single cell failure to the entire pack. In this study, we analyze the failure behavior of small battery packs with 5 stacked pouch cells (LiCoO2 cathode, 3Ah) after thermal runaway is induced to a single cell with nail penetration as the failure initiation method. The first part of the study was to determine the SOC in which full propagation was identified. Different states of charge were tested, including 50%, 75%, 80%, and 100% SOC. Complete propagation was observed for 80% and 100 % SOC. The second part of the investigation focused on identifying passive thermal management approaches to mitigate failure propagation. The results of this study could provide insightful information on the impacts of single battery failure in a pack and a base for future battery designs.

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