In situ monitoring of Lithium-ion Battery Health Using Acoustic Emissions

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Lithium-ion batteries (LIBs) are essential for electric vehicles, consumer electronics, and large-scale energy storage systems. Reliable battery health monitoring is therefore critical for ensuring safe operation, optimizing performance, and supporting second-life applications. Conventional diagnostic methods, such as voltage and current profiling or electrochemical impedance spectroscopy, provide useful information but often require offline analysis, direct electrical connections, or controlled testing conditions, limiting their use for real-time monitoring.

Acoustic emission (AE) technology offers a promising non-destructive approach for in-situ detection of LIB degradation. By capturing mechanical waves generated during battery operation, AE can provide insight into internal structural changes, including electrode cracking, gas formation, and electrolyte leakage. In this study, AE was applied to investigate degradation mechanisms in graphite/Li and NMC/Li coin cells assembled with $LiPF_6$ in EC:DEC electrolyte. A differential wideband sensor was attached to the cell surface to record acoustic signals. Identical cells were aged under similar conditions for validation.

The results showed significant graphite exfoliation at the fully charged state, with AE amplitudes reaching approximately 65 dB. Incremental analysis indicated that the highest AE amplitude occurred near the phase transition point, suggesting a strong correlation between acoustic signals and electrode structural changes during cycling. Further experiments on commercial LIBs were performed using a specially designed foam enclosure to reduce background noise. Initial findings indicate that AE signals related to microcracking can serve as distinct markers of electrode degradation.

Overall, this study demonstrates the potential of AE as a real-time, non-invasive diagnostic tool for monitoring LIB health and aging mechanisms.