Non-contacting interferometric distance measurements of pouch cells during cycling

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Abstract:

Lithium-ion cells gain increasingly interest in e-mobility applications. During charging and discharging, these batteries experience reversible thickness changes and inhomogeneous temperature distribution causing a space-dependent aging. Additionally, irreversible expansion and temperature driven defects occur during operation, such as gassing, particle cracking and SEI growth. These aging effects occur inhomogeneously. As a result, the useful life of commercial lithium-ion batteries can be significantly shorter than the life estimation for a theoretical cell considering homogeneous aging. It is common knowledge that the battery cells swell over the course of their service life. So far, the industry is not further considering local swelling discrepancies. The optimization of the swelling distribution, and thus the aging distribution, has been counteracted by compressing battery cells and modules. Compression has shown an impact on the reduction of electrode delamination, gas evolution and SEI growth. However, the local distribution and detailed expansion has not been studied in detail until now. The current research is mostly focused on global cell expansion over cyclic and calendric lifespan.

Our goal was to fill the missing research gap by examining local volume changes in detail using an interferometric distance sensor. The sensors have a lateral resolution of 1 µm. In this work, two commercial Ni-rich lithium-ion pouch cells were investigated during cycling. The main focus was on measuring the local expansion through the strategic positioning of the sensors above the pouch cells. In this way, the inhomogeneity could be confirmed. In a next step, the C-rate was varied and temperature influences were evaluated. Finally, Raman spectroscopy and Scanning Electron Microscope were used for post-mortem analysis, in order to clarify the aging processes occurred on different areas of the pouch cell.

This research reveals detailed local expansion behavior of lithium-ion pouch cells and their correlations to geometric and manufacturing factors. We can gain information for ideal compression strategies in order to approach homogeneous aging and a longer cell service life. In addition, this work leads to new insights into inhomogeneous aging of pouch cells.

Keywords: lithium-ion battery, pouch cell, in situ dilation, intercalation expansion, cell thickness growth, battery swelling, battery expansion, thickness distribution, local thickness changes, battery compression.