Possibilities and methods of Calorimetry to investigate the heat generation of silicon anodes for Li-Ion-Batteries

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The utilization of silicon-based anodes presents a promising solution to address the increasing demand for high energy density lithium-ion batteries. However, a major challenge associated with this type of anode is its volume expansion, which can reach up to 400%, leading to rapid capacity deterioration of the battery. To mitigate this issue, one strategy is to develop anodes that combine carbon and silicon nanoparticles, which has been shown to enhance the cycling stability of the anode. Despite its crucial role in ensuring safety, the thermal characteristics of such anodes remain poorly understood and require further investigation.

The calorimetry offers a variety of methods to tackle this lack of information. The decomposition of battery materials and the investigation of the thermal runaway allow the determination of the critical temperatures and the developed heat during this process. Moreover, the heat generation during charging and discharging and the cell performance depending on temperature can be determined without a destruction of the cells.

In this work, a comparison of crystalline and amorphous silicon anodes is conducted. Our inhouse battery production enables the manufacturing of 2032 coin cells consisting of a GF/A separator (260 µm), EC/DEC (50:50, 1M $LiPF_6$) electrolyte, Si/C- and Li-electrodes. We can customize the silicon structure, the coating thickness, additives and particle size to create a variety of testing scenarios.

In this study, a DSC-like method using a multi-module calorimeter from NETZSCH (Germany), equipped with a coin-cell module, was employed to measure heat flow in-situ during the formation and cycling of silicon-based anodes. Furthermore, changes in the signal resulting from the aging of the anodes were determined.

The goal of this research is to investigate the material properties of heat generation during formation and cycling. Additionally, the study aims to identify any differences between crystalline and amorphous starting materials in terms of their SEI-formation, cyclical or thermal stability. The data generated from this study is used to illustrate the effect of the anode structure on the thermal performance and stability of silicon-based Li-Ion batteries.

This research is part of the BMBF-NanoMatFutur research group Kems4Bats, which combines established and novel experimental methods to comprehend heat and gas evolution in terms of materials properties. (Visit www.kems4bats.de for more information on the research group.)