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4D imaging of abuse mechanisms in Li-ion Batteries

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Higher energy density materials are being pushed by the research community to make lithium ion batteries a better competitor of chemical fossil fuels for transport applications. This increases potential risk of lithium ion batteries and therefore safety investigations are highly important for application purposes. Operando Computer Tomography provides a non-destructive investigation method of different abuse mechanisms.
Application of X-ray computed tomography (XCT) for studying lithium-ion batteries has gained interest among the research community especially in the past decade [1]. This technique is widely used for ex-situ samples to measure porosity and tortuosity [2], particle size and volume distribution [3] in the graphite anode as well as different cathode materials such as LiCoOx and NiMnCoOx. [4]. In situ measurements of commercial batteries are also often carried out to detect defects induced in a cell by a safety abuse test or manufacturing process [5]. Operando CT of large cells (for example 18650 form factor) is conducted at synchrotron facilities with high flux of high energy photons, however at a cost of details due to the large field of view [6].

Thanks to their high brilliance, synchrotron beam facilitates us to do a full Computed Tomography in a short time. This enables us to measure batteries while being cycled with a reasonable time resolution to record morphological changes. In this poster we illustrate how one can utilize this ability to investigate abuse mechanisms on an actual commercially available lithium ion battery as well as a home made micro cell.

In this work, synchrotron X-ray computed tomography is applied to commercial lithium-ion batteries. It is shown how to find most suitable imaging settings to study available lithium-ion batteries on different size scales, from cell level to particle level. We also demonstrate how to optimize contrast as well as both temporal and spatial resolutions to study in-situ and operando processes in a commercial battery using attenuation and phase contrast SXCT. Manufacturing defects and inconsistencies on cell level as well as the electrode and microstructure on material level are shown in our study.
Using the presented methodic, some abuse conditions are induced and imaged in operando on a commercially available li-ion battery. In this work, deep discharge mechanism is visualized and quantified in detail for the first time in 4 dimensions.

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