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Stroboscopic neutron diffraction applied to fast time-resolved operando studies on Li-ion battery

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High penetration ability of neutrons and dramatic character of crystal structure modifications occurring in the battery materials during electrochemical cycling make neutron powder diffraction an obvious method to study the reaction mechanisms in rechargeable cells. While basic chemical reactions occurring in batteries upon charge/discharge are mainly understood, the specific processes leading to faster battery degradation upon increasing the charge/discharge rates are under question. We are presenting a practical implementation of the stroboscopic operando neutron diffraction to allow studying the structural and chemical changes occurring in batteries with industrially relevant dimensions and compositions, also at incredibly fast cycling rates. We demonstrate that the graphite lithiation mechanisms at fast and reasonable cycling rates are different, and discuss the possible reasoning for sooner performance fading upon faster charge/discharge. Our stroboscopic method allows to investigate the crystallography of rather short-living states in materials, provided these are possible to be periodically reproduced. The temporal resolution achieved is hereby well below a minute. This stroboscopic mode of collecting the neutron diffraction data is essentially binning the partial low-intensity data from various repetitions of a process into enhanced intensity patterns representing the statistics over many cycles. It offers new possibilities for research into the reproducible changes occurring in solid diffracting materials during the rather short times, otherwise hardly accessible by regular neutron diffraction.

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