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In-operando neutron reflectometry studies on Li incorporation and volume modification of silicon electrodes in Li-ion batteries

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The rapid development of renewable energies, portable electronics and electric vehicles has encouraged the development of energy storage devices, such as Li-ion batteries, toward longer lifespan, higher energy density and power density. This necessitates the exploration of new materials for use in current Li-ion battery technology [1]. The lithium-ion battery storage technology has also the potential to play an important role in the off-grid renewable energy sector [2].

Due to its high theoretical specific capacity of about 4200 mAh/g amorphous silicon has become a promising anode material for future Li-ion battery applications and is on the way to replace graphite as dominating anode material in commercial batteries [3].

The objective of our work is to study Li incorporation into the electrode as well as the accompanying tremendous volume changes occurring during cycling. These phenomena are important to improve battery performance and to reduce irreversibility effects. For our experiments, we applied the non-destructive analysis technique of neutron reflectomrety. This method allows to study processes and interface phenomena on nanometer length scales during cell operation in-operando.

The experiments were done using a self-constructed three electrode electrochemical half-cell setup. The working electrode consists of a nanometer-sized amorphous silicon thin film deposited by magnetron sputtering on a quartz block covered by a current collector. Counter and reference electrode are made of pure lithium metal foil. As an electrolyte, propylene carbonate with 1 M LiClO4 is used [4].

Our experiments reveal that it is possible to monitor volume changes and Li content during
cyclic voltammetry and galvanostatic experiments in-operando. Recent results are presented and discussed in the framework of literature data.

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