Development of Li-ion Battery Models from Electrochemical Impedance Spectroscopy Data

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The reliable electrical testing and diagnostic evaluation of battery cells, modules, and packs is currently an important task in industrial automotive manufacturing and in battery field tests. Here we present how calibrated and accurate experimental data acquisition is combined with electrochemical modeling for robust data interpretation. The combined electrochemical impedance spectroscopy (EIS) measurement hardware, calibration procedure, and modeling software allows for the analysis of different cell form factors and power levels. We show how EIS output data is used as input data to modeling algorithms to extract the equivalent electrical circuit parameters of the cell. The resulting model is amenable to electro-chemical interpretation and provides a compact representation of the detailed performance characteristics of the cell, relevant for evaluating the SoH (State of Health) and second life applications of cells, modules, and packs. A standard operating procedure (SOP) is provided for EIS focusing on metrological evaluation of accuracy and error sources for low impedance battery measurements. This is developed in ongoing EU research projects (e.g. NanoBat) and evaluated in round-robin tests together with OEMs and national metrology institutes. Accurate experimental workflows, metrological measurements, and modeling are brought together for robust industrial use cases, for instance in battery manufacturing Gigafactories.