MS13 Structural Characterization of Functional Materials

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Insights into battery materials by electron microscopy

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Abstract

Scanning transmission electron microscopy (STEM), especially when aberration-correction is used, can be applied to investigate all kind of functional materials at an atomic level. When compared to image simulations, the information on the sample structure and composition can be quantitative. Combining STEM with a fast, pixelated detector allows for the acquisition of a full diffraction pattern at each scan point. From this, four-dimensional STEM (4D-STEM) data sets are available, which can be used to generate different data, e.g. annular dark field (ADF) as well as (annular) bright field ((A)BF) images, angular resolved STEM (ARSTEM) or differential phase contrast (DPC) data.

We use a double aberration corrected JEOL 2200FS, equipped with an in-column energy filter and a pnCCD detector to acquire 4D-STEM data sets.

With the example of cathode materials for battery applications (e.g. LiNi0.85Co0.10Mn0.05O2), we track the formation of different phases of and defects within the oxide in dependence on cycling conditions of the material and derive ABF as well as BF images from 4D data sets. These are used to also obtain difference images (ABF-BF). It will be shown that the composition of the materials and especially the Lithium content can be derived from the contrast of the different atomic columns in the structure, which has a characteristic specimen thickness dependence for the different data sets. This is possible by comparing the experimental data sets to state of the art multi-slice simulations.

Moreover, we will investigate the co-sintering of the cathode material with several solid electrolytes as well as the influence of electrochemical cycling on (nano)structure of the battery materials.

This contribution will hence summarize the material science aspects of the energy materials investigated but also elucidate the potential of quantitative 4D-STEM to investigate materials.

References

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