Workshop »Coatings for Energy Technologies«

How to measure adhesion and mechanical properties of electrode coatings in lithium-ion batteries

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The goal of this work is to show new methods for adhesion measurement and characterization of mechanical properties of electrodes and their coatings in the lithium-ion batteries.

During the production and packaging of lithium-ion batteries (LIB) their components are subject to mechanical and thermo-mechanical loading (torsion, tension, compression, puncture, etc.). Such mechanical damage to the LIB cell can lead to short circuits which increase the risk of thermal runaways (fire) or decrease of its lifetime. For example, if the active layers on the electrodes have poor adhesion or if they are not sufficiently homogenous, the battery will have reduced capacity and thermal runaway is more likely to occur. The design of the LIB is also affected by the necessary trade-off between the capacity and mechanical strength: while high binder content in the electrode coating is needed for better adhesion of the electrode layer, high binder content will lead to lower capacity of the battery [1]. The determination of the adhesion of the active layers on electrodes is therefore important for the development of reliable high capacity batteries [2]. Several methods for adhesion measurement of electrode coatings are currently used, however their main drawback is subjective evaluation by the user. The scratch test method, based on sliding a sharp wedge blade-like tip with increasing load across the coated surface, can provide information about the adhesion of the active layers on electrodes in perfectly controlled and objective manner. It is therefore a more suitable test method for the adhesion as well as the scratch resistance of the electrode layers and its results can help in verifying the deposition process. In the present work the scratch test method was applied to various types of industrial electrode coating including calendered and not-calendered electrodes and electrodes with different levels of binder content. The results showed that the scratch test can be used for measurement of adhesion of electrode coatings with very good repeatability. The scratch test results allowed differentiation of adhesion on the calendered and not-calendered anodes as well as on anodes with different levels of binder content.

The adhesion measurements were completed with instrumented indentation (IIT) hardness measurement of the same electrode coatings. IIT is the only suitable method for characterization of mechanical properties of electrode coatings since the coatings have thickness between ~30 µm and ~60 µm. The measurement showed that the calendered coatings have hardness approximately two times (140 MPa compared to 64 MPa) higher than the not-calendered coatings. The coatings with different binder content exhibited very similar hardness (~78 MPa).
In a similar case the IIT was used to characterize the effects of addition of Zn to calendered and not-calendered anode coating, which was reflected in approximately two-fold increase of hardness (~30 MPa without Zn and ~55 MPa with Zn). IIT can also be used for hardness mapping of larger areas and thus reveal information about homogeneity of the coating which is crucial in avoiding premature lithiation. Finally, the IIT can be used for characterization of the crush resistance of slurry particles and thus estimate their behavior during slurry deposition.

[1] N. Billot, Investigation of the Adhesion Strength along the Electrode Manufacturing Process for Improved Lithium-Ion Anodes, (2020).

[2] W. Haselrieder, B. Westphal, H. Bockholt, A. Diener, S. Höft, A. Kwade, Measuring the coating adhesion strength of electrodes for lithium-ion batteries, Int. J. Adhes. Adhes. 60 (2015).