Comparison of a discontinuous and continuous slurry manufacturing process for silicon-containing anodes in lithium-ion batteries

T. Grenda, R. Jagau, A. Kwade
TU Braunschweig, Institute for Particle Technology, Volkmaroder Straße 5, D-38104 Braunschweig

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Lithium-ion batteries are the leading technology for energy storage devices such as hybrid, plug-in and all-electric vehicles [1]. Intensive efforts have been made to improve the energy density of lithium-ion batteries [2]. Particularly, it has been proven to be advantageous to use active materials containing silicon due to their high capacity [1]. For this reason, the processing of active materials containing silicon is becoming increasingly popular. In the future, continuous production of the required battery slurries, for example with an extrusion process, will also be preferred, since a constant product quality and a higher throughput can be realized [3].

In order to produce an electrode of the highest possible quality, it is necessary to distribute all powdered components homogeneously in the battery slurry during the dispersion step and to break up conductive carbon black agglomerates efficiently. However, this process leads to possible damages to the active material and to resulting capacity losses during battery operation. This is, because high stress on the active material during kneading could result in delamination of graphene layers of the graphite, affecting the structure and hindering lithiation. In addition, the volume change of the silicon during charging and discharging processes can lead to losses in stability [4]. For this reason, the main objective of this study is to test the stress limits of the silicon containing active material and to transfer them to the continuous process of extrusion. For this purpose, slurries are prepared in discontinuous and continuous (manufacturing) processes based on different process parameters and investigated with respect to their particle morphology and rheological properties. To have a closer look on the stressed slurries, the physical properties of electrodes are analyzed with methods like adhesion strength, electrical conductivity and mercury intrusion. The electrochemical performance of the manufactured Si-Anodes are represented with a surface area capacity of 8 mAh/cm^2 in full cells.

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