High energy- and high power density electrodes through immersion precipitation; towards cheaper, better and flexible batteries

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Li-ion batteries with high energy densities and sufficient power output are desired to meet the ever-growing demand for energy storage in modern society. To do so, considerable improvement is needed in both their cost and energy density. A general and very straightforward method to improve the energy density of a battery is to apply thicker electrodes. This increases the energy density on the cell level and lowers costs, as less inactive components such as current collectors and separators are required, and less layers need to be processed. Normally, however, increasing the electrode thickness is accompanied by increased electronic and ionic resistance, resulting in a lower power density. Additionally, with increasing electrode thickness the mechanical integrity of the layer becomes a major issue. This will even be of more concern for batteries that are required to be flexible during operation.

In this work we present immersion precipitation as a method for the fabrication of thick electrodes and asses the implications of the process for commercial batteries. It is a simple, low-cost and universal method to manufacture thick flexible (self-supporting) electrodes. The electrodes possess greater structural integrity than conventionally made electrodes, achieving flexibility and higher mass-loadings, without compromising the performance. Owing to their unique porosity and great interconnectivity of the particles, the electrodes show excellent electrochemical performance. Lithium titanate electrodes were tested with high mass-loadings (24 mg cm^{-2}), realizing a capacity of 4 mAh cm^{-2} at a rate of 1C. Furthermore a flexible full-cell was shown to be operational while in a fully folded state.

The ability to apply these thick, yet high performance, electrodes in a battery yields a higher energy density at the cell level and leads to lower costs due to the reduction of inactive materials. The large similarity of the presented method and the current industrial electrode fabrication process gives it a high commercial feasibility. The only difference is the application of a coagulation bath after slurry casting to solidify the binder, which is applied on a large scale in the field of commercial membrane manufacturing. In this stage the binder-solvent is replaced by a non-solvent (e.g. water), which in case of the commonly applied N-Methyl-2-Pyrrolidone based slurries, can be removed much easier from the electrode. This provides an additional cost reduction in the drying process.