WET FILM CHARACTERIZATION OF SLOT DIE COATED MULTILAYER BATTERY ELECTRODES

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Introduction

Due to their high energy- and power-density, lithium-ion batteries are suitable for automotive applications, where mobile energy supplies are needed [1, 2]. Besides the material science aspect, there is a high potential in the manufacturing process for increasing the efficiency of the battery cells [3]. A specifically desired distribution of the electrode components could be realized by dividing the electrode into several layers with different compositions and properties.

Experimental Methods and Results

As one of the most used coating methods for lithium-ion battery electrodes, slot-die coating gives the opportunity to apply uniform layers of highly viscous electrode slurries [3]. Furthermore, coating more than one layer simultaneously is easy to implement within this process by the application of more than one feed slot (*Figure 1*).

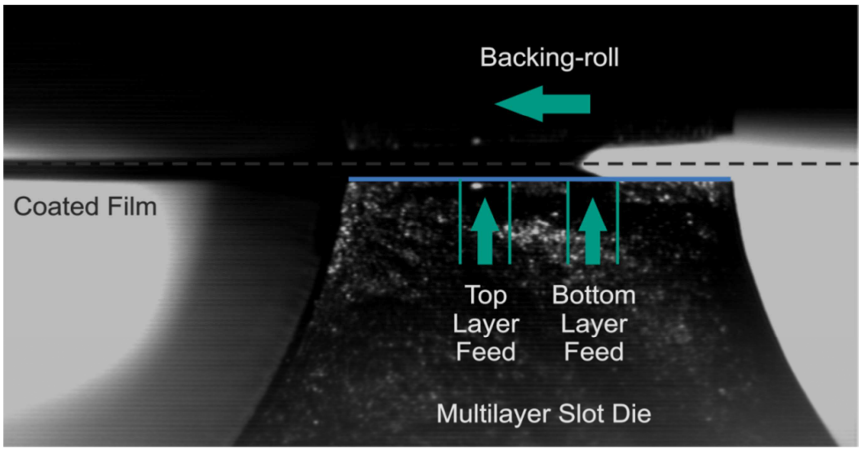

Figure 1: Coating bead of a two-layer lithium-ion battery anode film, applied versus a backing roll.

Related to rising production capacities, battery slurries are coated at continuously increasing velocities. Facing these higher web speeds, extended coating windows and relevant limiting mechanisms of coating defects are to define.

In a first step, we investigated single-layer coating of various anode slurries consisting of large graphite particles, a polymeric stabilizer and a polymeric binder with water or NMP as solvent and applied different models for coating-stability to calculate the coating windows. These theoretical limits for stable coating conditions were compared to experimental results, obtained by systematically detecting conditions for which coating defects occur.

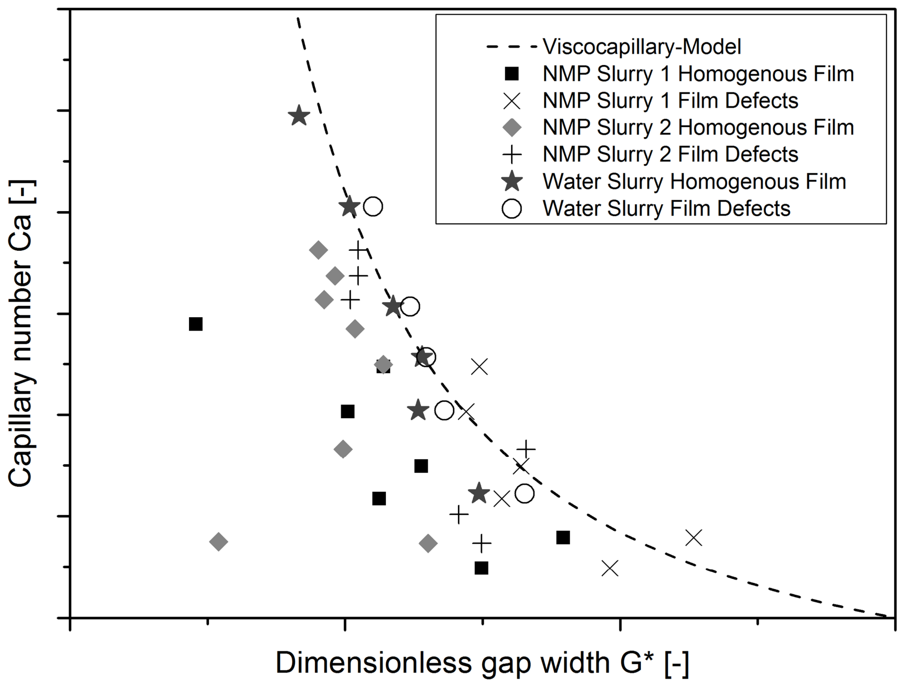

Figure 2: Coating window for different anode slurries with the viscocapillary model [4] as theoretical limit.

The experimental results show, that even though high capillary numbers and non-newtonian fluids are used, the viscocapillary model [4] can be applied to single-layer slot-die coating of lithium-ion battery electrodes with some minor limitations. Agglomerations and disturbances may provoke a film break-up at small film thicknesses, regardless of the coating speed (see *Figure 2*).

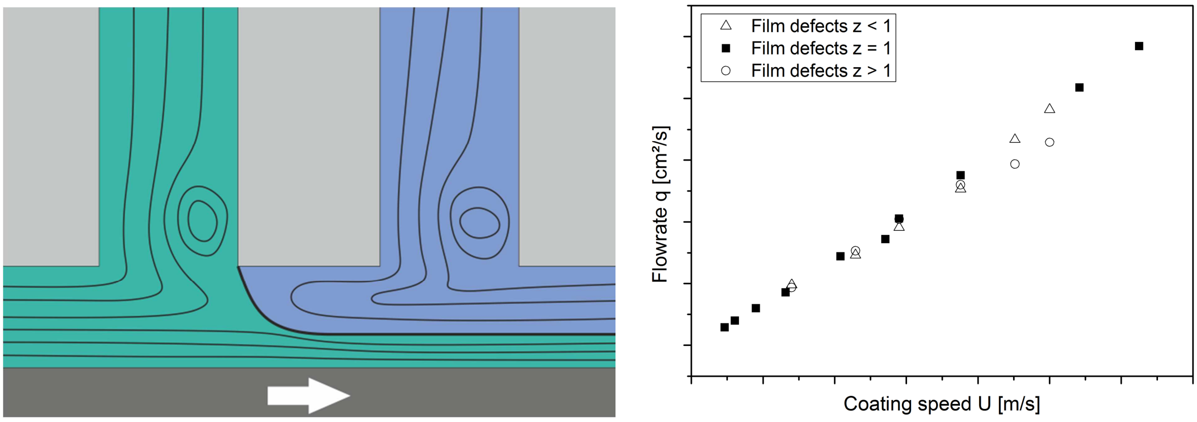

Figure 3: Left: *Schematic flow situation with possible vortex creations in the feed slots of a two-layer slot-die.*

Right: *In the investigated range the variation of the feed-ratio z shows no influence on the minimal flow-rate.*

In a second step special aspects of multi-layer coating-stability, like vortex creation inside the feed-slots and inside the gap, were investigated and combined with flow phenomena known from single-layer coatings. Variation of the feed-ratio z showed no influence on the low-flow film thickness, as shown in *Figure 3*. Whereas an effect of different viscosities, gap and slot widths on the break-up line were found and will be discussed.

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References

1. Thielmann, A., et al., *Produkt-Roadmap Lithium-Ionen-Batterien 2030*, in *Technologie-Roadmapping am Fraunhofer ISI: Konzepte – Methoden – Praxisbeispiele*, F.-I.f.S.-u.I. ISI, Editor. 2012, Fraunhofer-Institut für System- und Innovationsforschung ISI: Karlsruhe.
2. *Zweiter Bericht der Nationalen Pattform Elektromobilität*, G.G.E.d. Bundesregierung, Editor. 2011, Nationale Plattform Elektromobilität: Berlin.
3. Yoshio, M., R.J. Brodd, and A. Kozawa, *Lithium-ion batteries: science and technologies*. 2009: Springer.
4. Kistler, S.F. and P.M. Schweizer, *Liquid film coating: scientific principles and their technological implications*. 1997: Chapman & Hall.