Modeling laser-based drying of battery electrodes

When lithium-ion battery electrodes are manufactured, a liquid mixture of ceramic, binder and solvent has to dry, a process that plays an important role as it can save energy and significantly impact the performance of the cell. Indeed, the temperature, speed, and time of drying influence the distribution of the binder, with uneven distribution leading to reduced adhesion between the electrode and current collector, increased electrical resistance, and reduced cell capacity. Experimental diagnostics and numerical simulation can be used to analyze the influence of drying parameters on binder dispersion.

Definition of a suitable simulation model

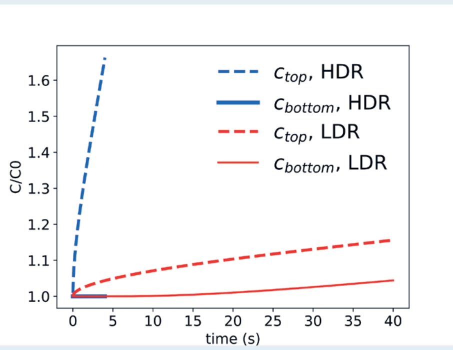
In the project »Laser-based Drying of Battery Components« Fraunhofer ILT, Instruction and Research Department NLD of RWTH Aachen University and industrial partners are exchanging their know-how on process simulation and experimental tests to define a suitable reduced model by phenomenological model reduction approach. The model predicts the distribution of the binder and thus the adhesion force of the anode.

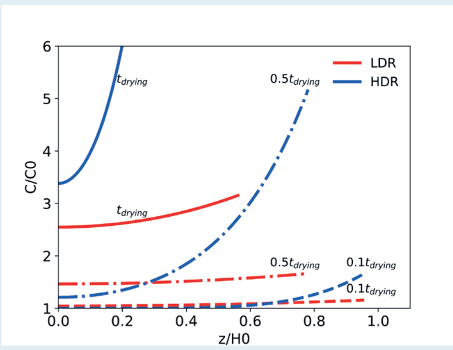
Modeling and optimization of the drying process

Two main phases of the drying process have been identified. In phase 1 the liquid mixture shrinks, whereby a homogeneous distribution of the binder should be targeted. Phase 2 includes pore emptying, final drying, but also cracking, which should be avoided. The analysis shows that the thermal relaxation time is short compared to the drying time, and the temperature is almost constant while the solvent evaporates. At a low drying rate, the binder concentration increases gradually and remains almost homogeneously distributed, but the required drying time is undesirably long. At a high drying rate, the short drying time leads to a large concentration gradient and the binder accumulating near the surface of the film. Much better results are obtained with multiple drying steps, e.g. two layers with increased adhesion and reduced drying time.

The developed physical modeling can be used to improve the laser-based drying process of electrode slurries and ceramic coatings.

Author: Zahra Kheirandish M. Sc., zahra.kheirandish@nld.rwth-aachen.de





1 Temporal variation of binder concentration at film surface.
2 Spatial variation of binder concentration at low and high drying rate.