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Thin Film Technology

Development of a New Dryer Concept for Agile Drying of Battery Electrodes

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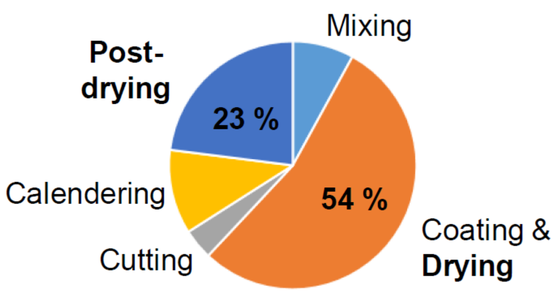
Motivation

Production cost of electrodes



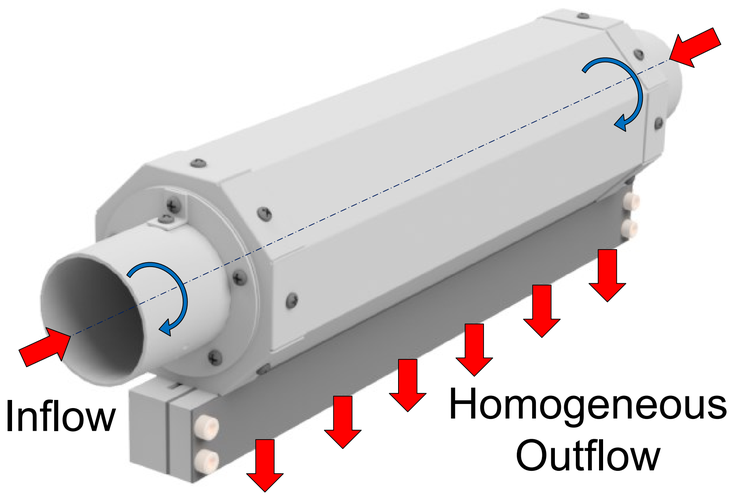
[1] Bosten Consulting Group, 2018

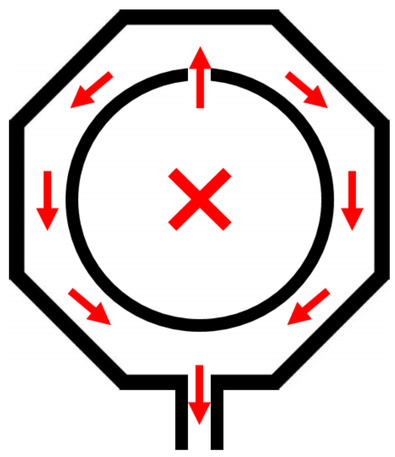
Drying of electrodes

- Cost intensive
- Energy intensive
- High impact on properties & performance
- Error prone (high risk of waste)

New dryer concept for agile drying of battery electrodes

Drying Nozzle Concepts



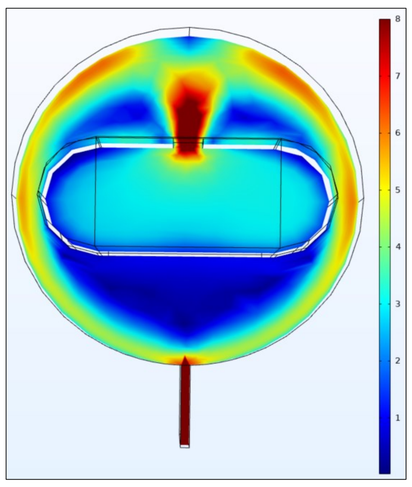


- Nozzles mounted pivotable & vertically adjustable
  - → **Adaptation of outflow angle**
  - → **Adaption of HTC distribution**
- Volume flow controlled individually for every single nozzle
- Air path: high local pressure loss
  - → **Homogeneous velocity distribution**

Homogeneous Heat Transfer Coefficients

Nozzle concepts developed & optimized:

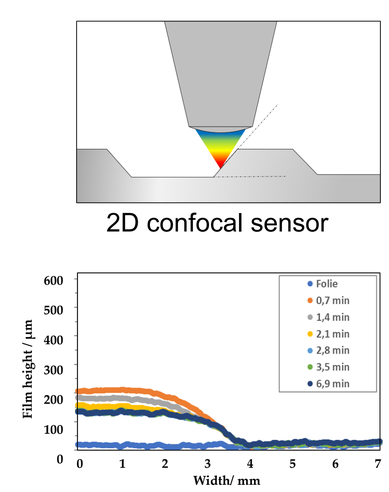
Simulations (CFD)



CFD-calculated air velocity field inside a nozzle

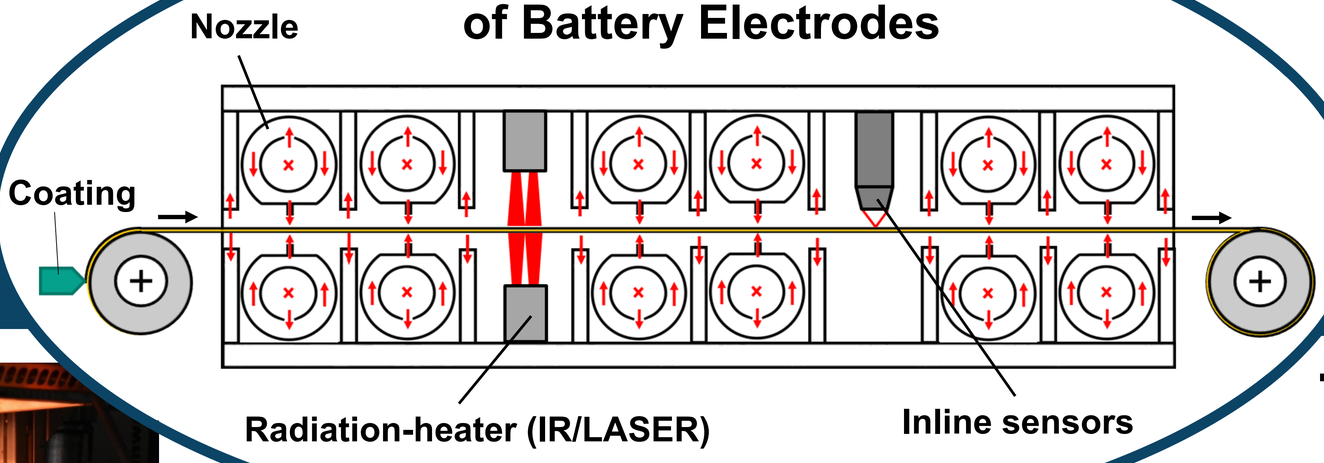
Experiments (TLC)

- Experiments based on **thermo-chromatic liquid crystals (TLC):**
  - → Detailed analyzing of HTC-distribution for different nozzles
  - → Validation of CFD-simulations
  - → Optimizing nozzle geometries

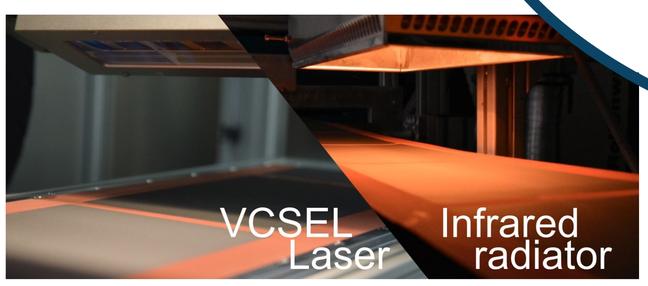


Measured HTC distribution

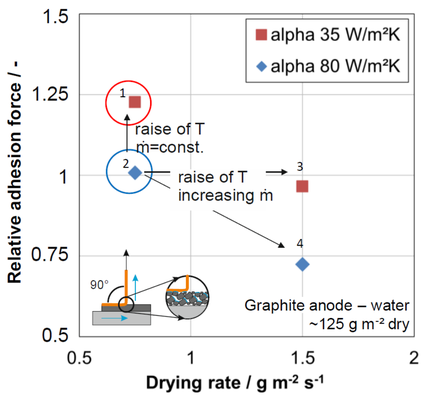
Agile Drying of Battery Electrodes



Radiation Drying



Integration of radiation-heater (Infrared or LASER): additional heat input



Delamination of electrode at too high drying rates

- Positive effect of high **film temperature** shown in convective drying experiments
- High drying rates lead to low adhesion force/ delamination due to **binder migration**

→ **Higher energy efficiency**

→ **Higher drying temperatures: Reduction of drying time** (Increase of production capacity, decrease of costs)

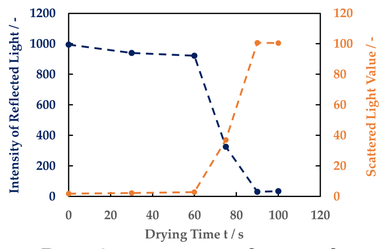
→ **Additional degree of freedom to react on changing production conditions**

Inline Measurements

- Integration of inline **measurement sensors:** real time monitoring of the drying process
- Applied inline sensors: **scattered light sensor, 2D confocal sensor, heat flux sensors, thermographic camera, infrared sensors**

Monitoring of drying status

Scattered light sensor



Development of surface reflection intensity and surface roughness

→ Detection of **characteristic drying points** (e.g. **beginning of pore emptying**)

Monitoring of film height distribution

2D confocal sensor

Development of layer thickness distribution during the drying process

- Definition of Quality Gates: early waste detection
- Track und Trace: collected data related to single sheets/cells

→ **Goal: less waste (less costs), higher electrode quality despite altering conditions**

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