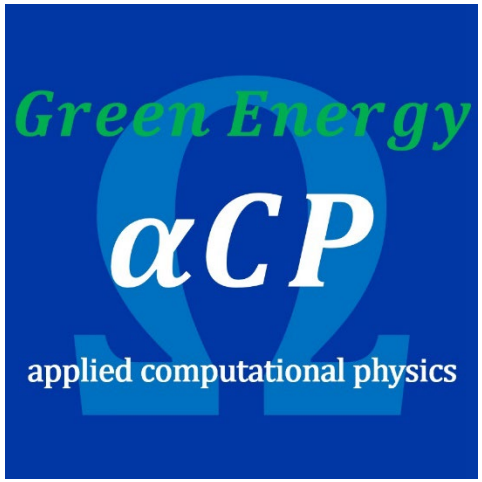
TECHNISCHE HOCHSCHULE NÜRNBERG
GEORG SIMON OHM



Numerical simulation of the coating process for organic photovoltaics

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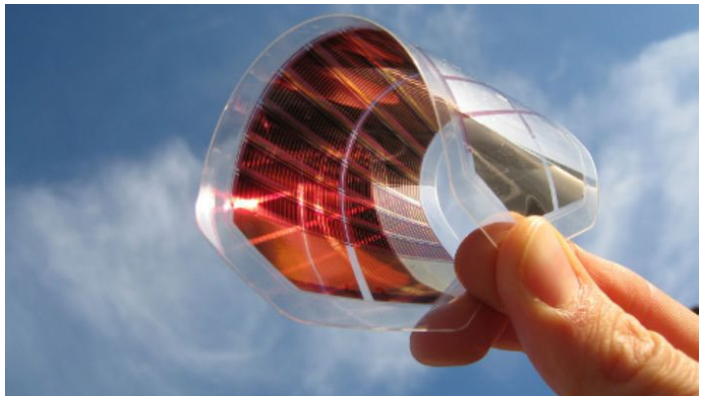
OPV enables new application fields



http://summerschool.teiemt.gr

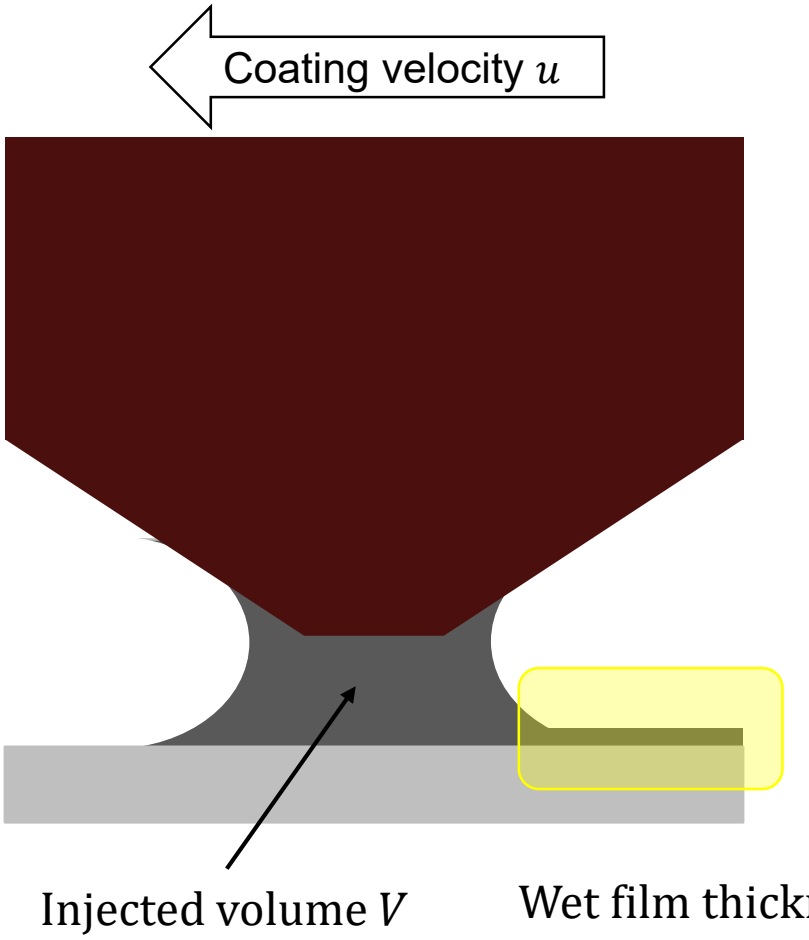
www.haustec.de

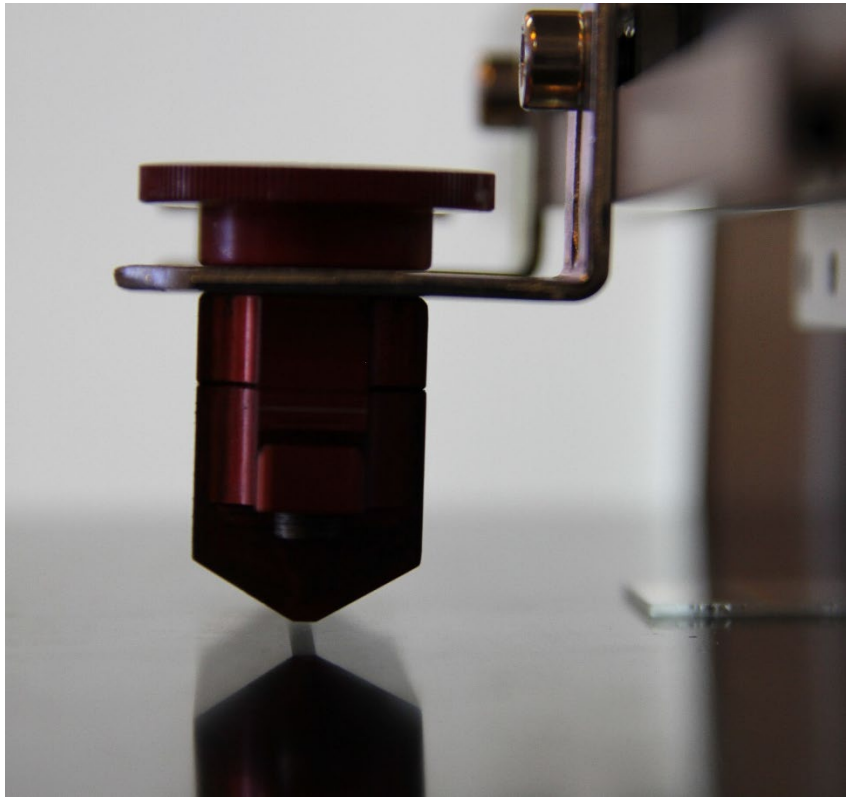
PV-Technologie	Rekordeffizienz Laborzelle[1] (~mm²)	Rekordeffizienz Modul[2] (>200 cm²)	Diskrepanz (Zelle → Modul)
Monokristallines Silizium (mono-Si)	26,1 %	22,8 %	- 13 %
Polykristallines Silizium (poly-Si)	23,3 %	20,4 %	- 12 %
Amorphes Silizium (a-Si)	14,0 %	12,3 %	- 12 %
Cadmiumtellurid (CdTe)	22,1 %	19,5 %	- 12 %
Kupfer-Indium-Gallium-Selenid (CIGS)	23,4 %	19,8 %	- 15 %
Galliumarsenid (GaAs)	29,1 %	25,1 %	- 14 %
Perowskit-Solarzellen (PSC)	25,7 %	17,9 %	- 30 %
Organische Photovoltaik (OPV)	18,2 %	**11,7 %**	- 36 %

[1] https://www.nrel.gov/pv/cell-efficiency.html
[2] https://www.nrel.gov/pv/module-efficiency.html

→ Huge potential for OPV modules

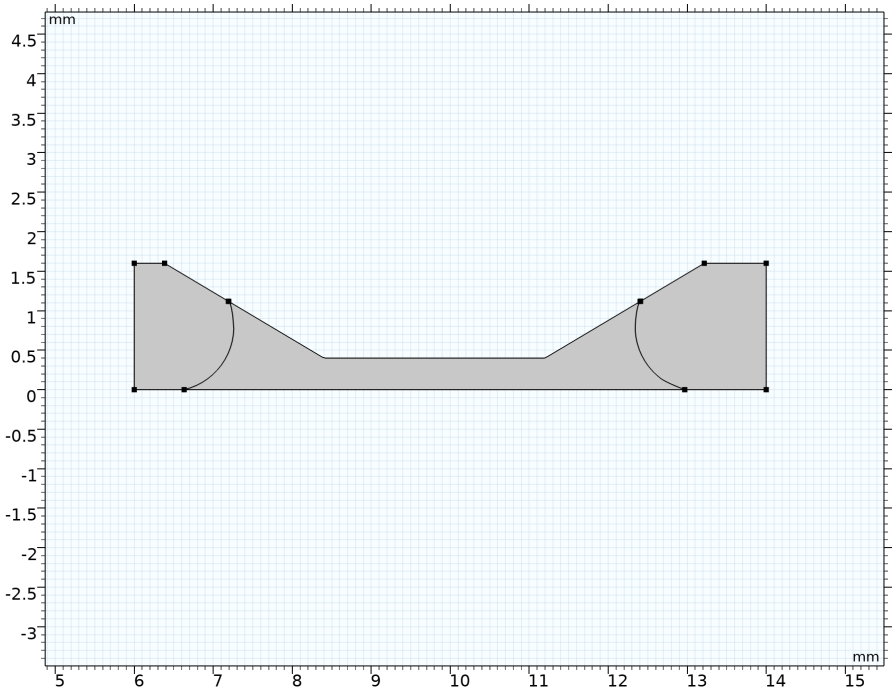
What is doctor blading? (experimental setup)





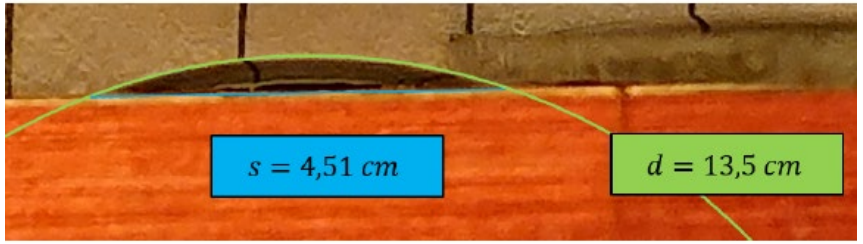
2-step method to initialize the geometry

1. Step:
Stationary study to model fluid-air interface



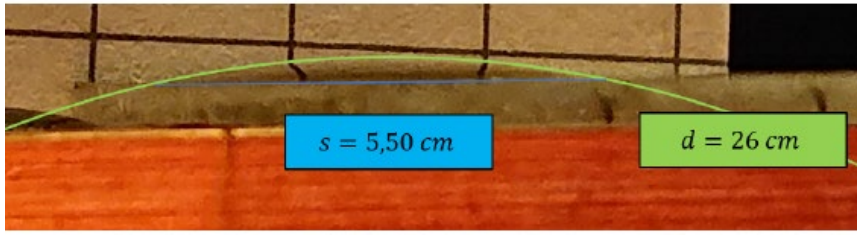
Experimental determination of contact angles Θ:

Applicator (stainless steel)



$\Theta_{App} = 19.52°$

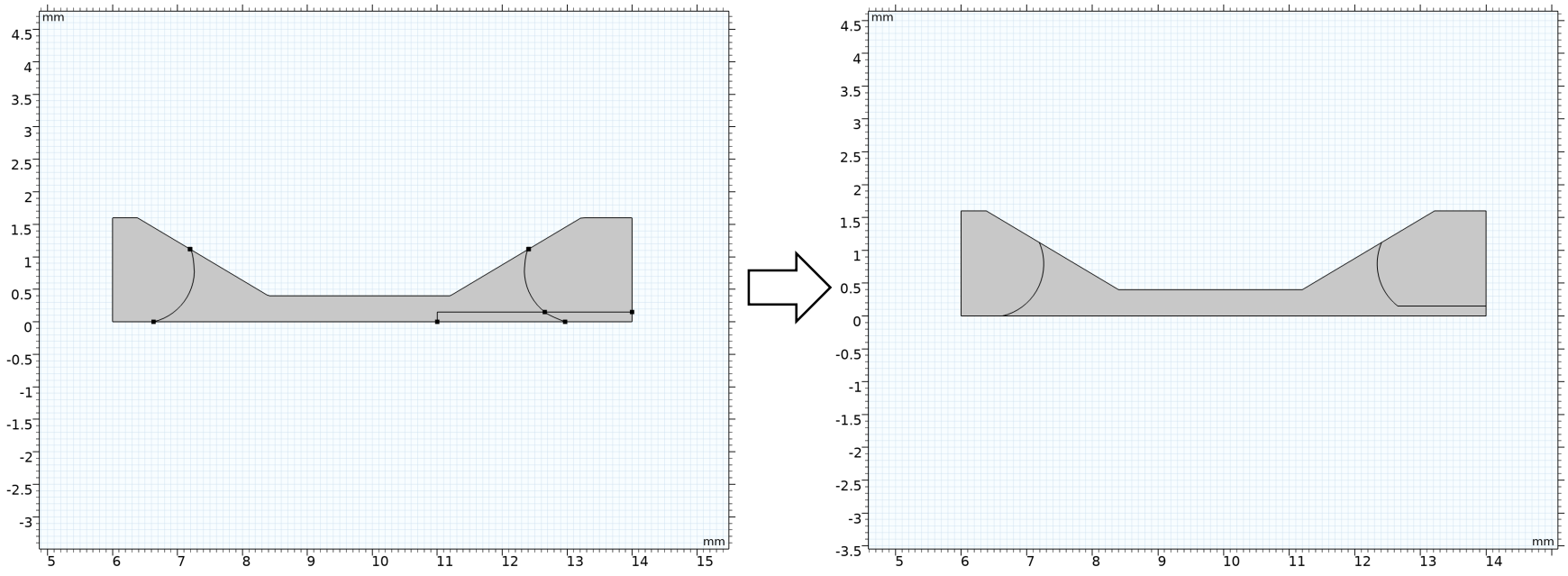
Substrate (glass)



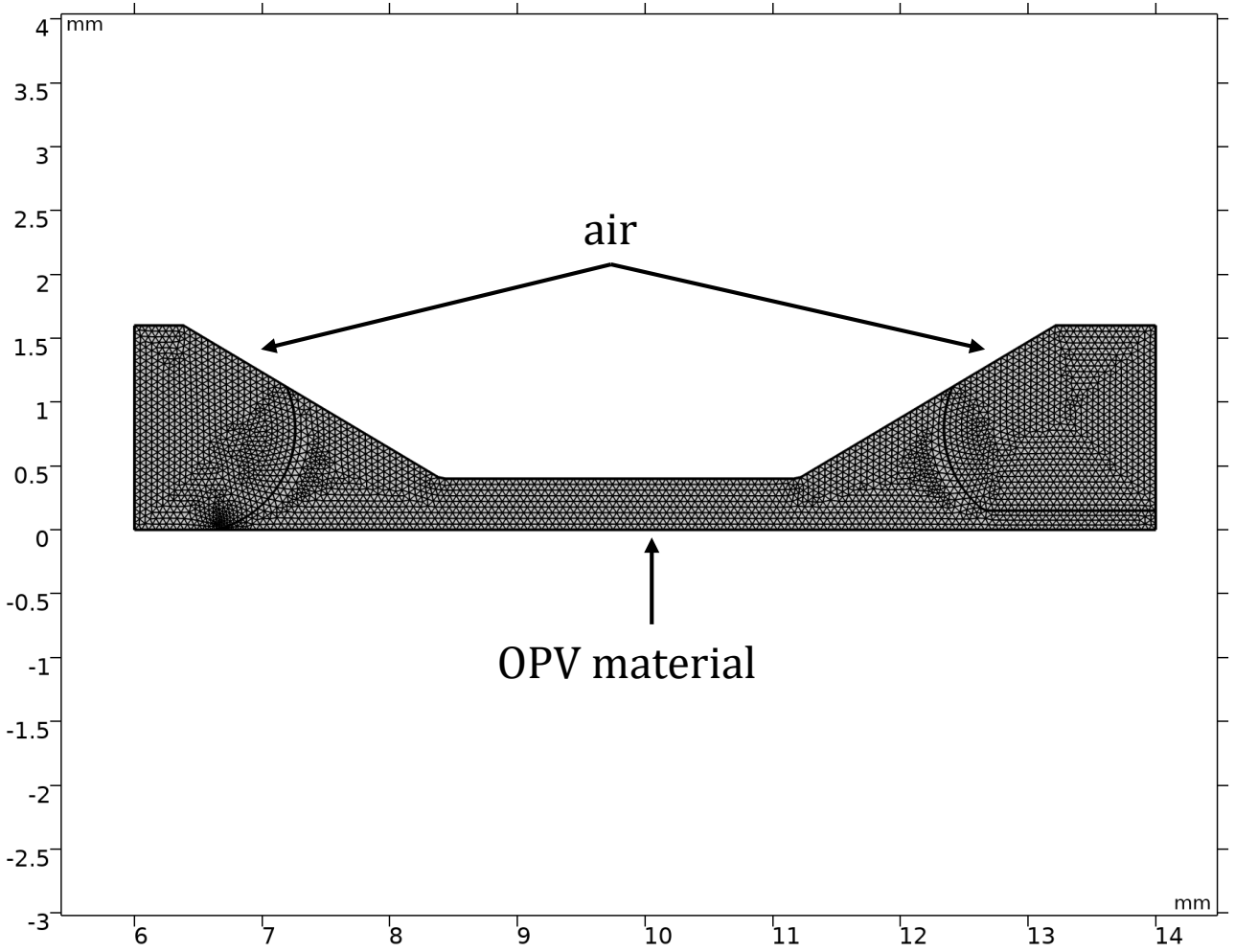
$\Theta_{Sub} = 12.21°$

2-step method to initialize the geometry

2. Step:
Supplement geometry to avoid topology changes

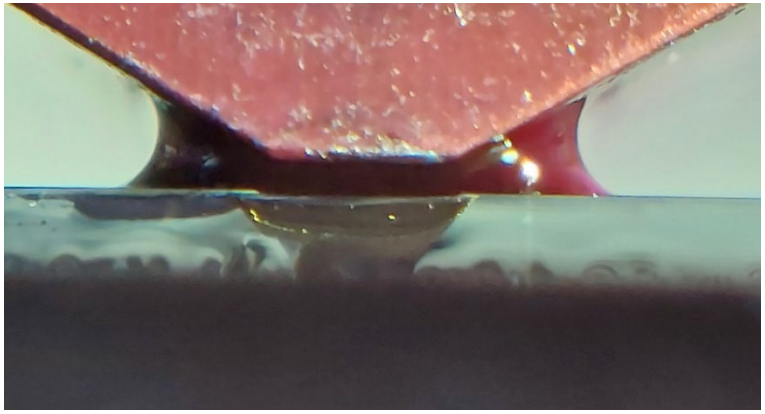


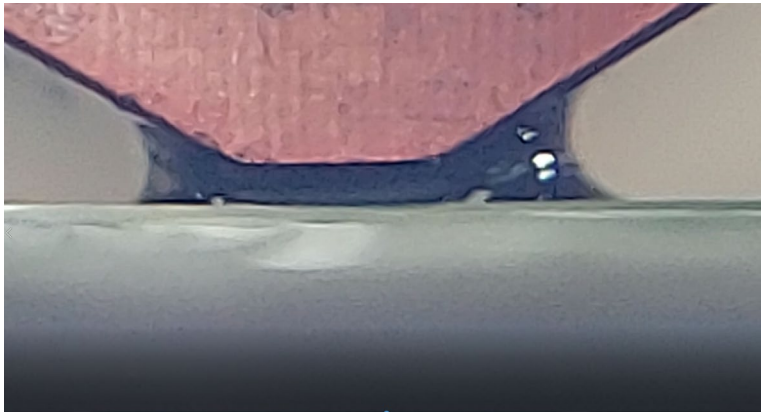
CFD model to investigate the wet film thickness



- DOF: 17k
- Computation time: 2 ½ minutes (transient study)

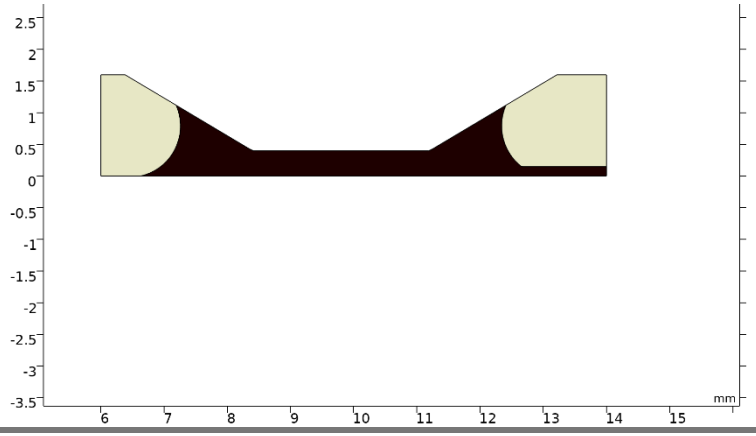
Position of applicator

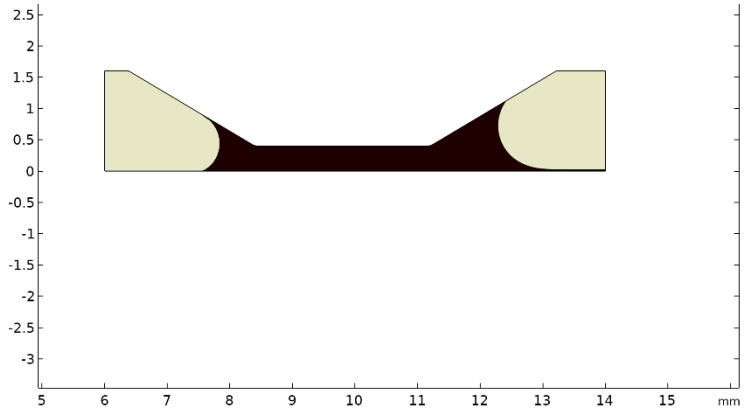




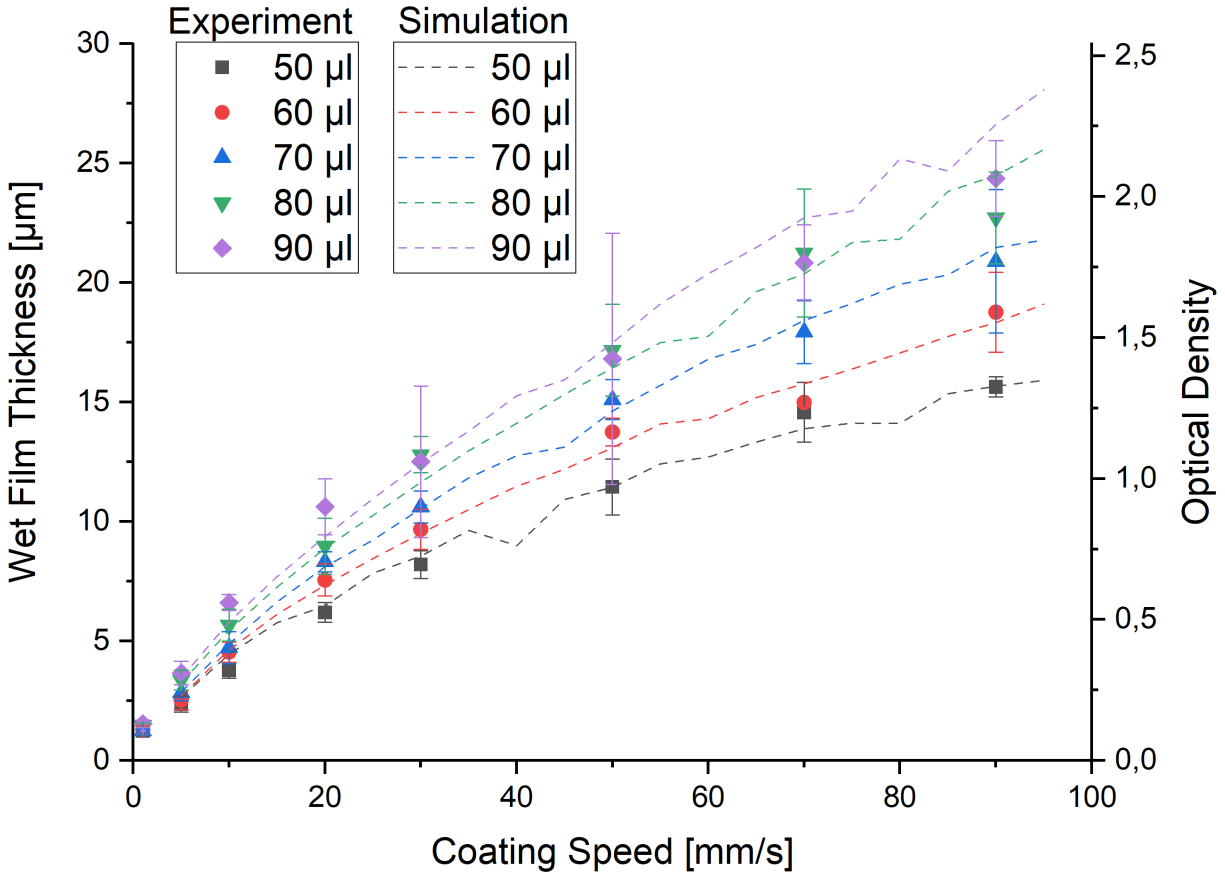
At rest

In motion





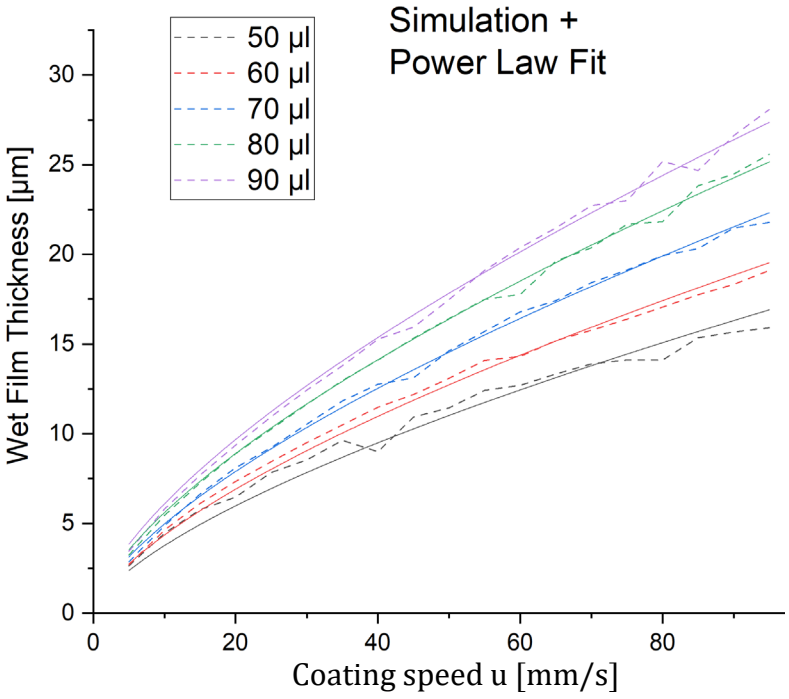
Comparison: simulation and experimental data

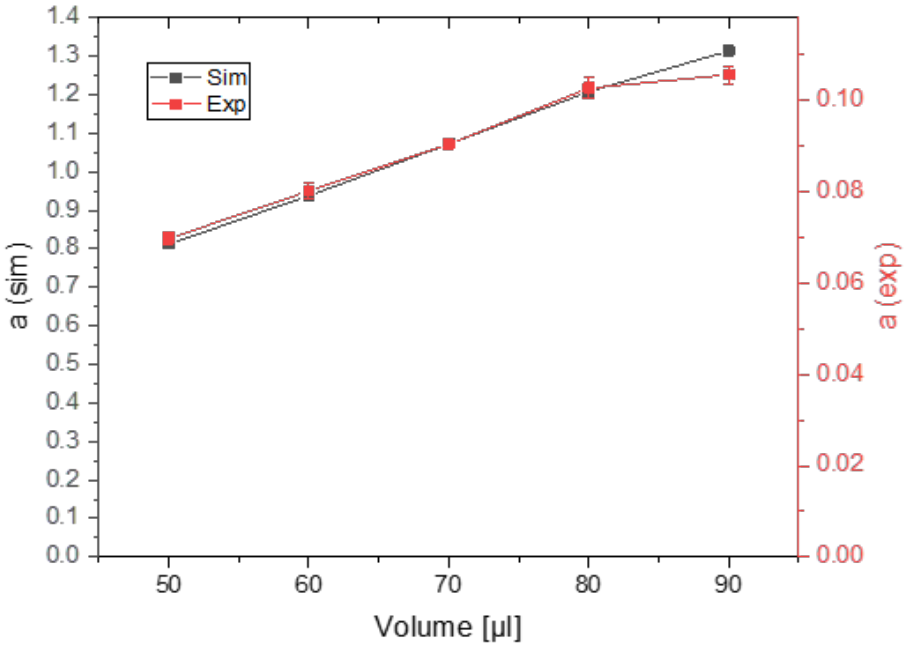


→ Very good agreement of simulation and experimental data

Theoretical considerations

$$h(u,V) = a(V) \cdot u^{\frac{2}{3}}$$ [3]



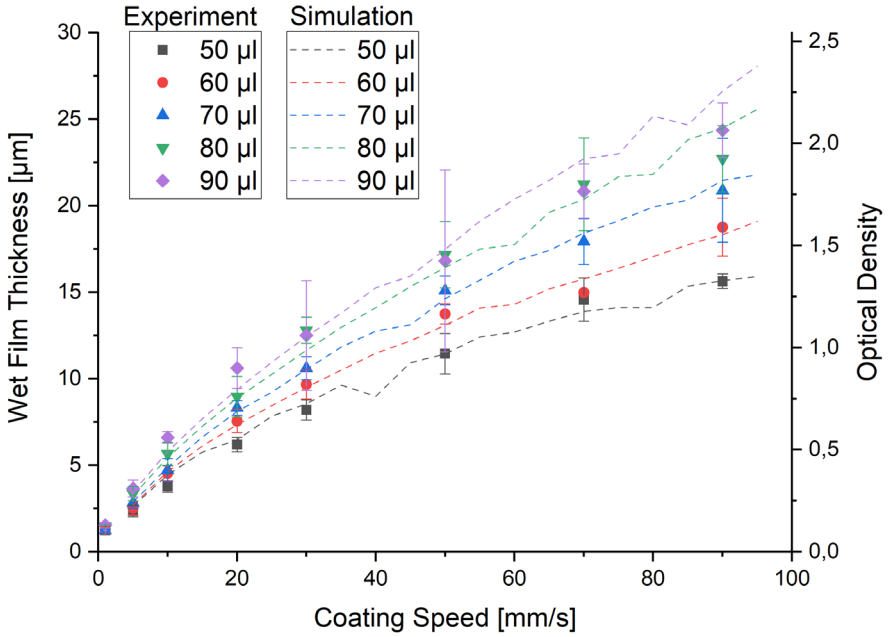


[3] L.D. Landau, V.G. Levich, Dragging of a liquid by a moving plate, Acta Physicochimica 17

→ Good agreement with theory

Conclusion

CFD simulation and experiment are in very good agreement



Outlook

- Start of joint project „AWESOME“:
  - Modelling of further printing strategies
    (e.g. accelerated printing, spatial homogeneity of wet film thickness)
  - Consideration of world-record materials

Thank you for your attention!

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www.th-nuernberg.de/cp4x

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Additional slides

Is laminar flow a valid approximation?

$$Re = \frac{\rho U L}{\mu}$$

$$L \approx 6mm$$
$$Re = 332 << 2000$$

Maximal cell Re number over time