Deformation of thin liquid films by static surface charge distributions

Christian W.J. Berendsen, Kees (C.J.) Kuijpers, Jos C.H. Zeegers and Anton A. Darhuber

Mesoscopic Transport Phenomena Group, Department of Applied Physics,
Eindhoven University of Technology, The Netherlands
Corresponding author: a.a.darhuber@tue.nl

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In high speed roll-to-roll coating processes, static electricity is a topic of concern [1] due to for example dust attraction and risk of spark generation. On the other hand, static charges can be employed to promote wetting in the deposition of coatings [2].

Our investigation focuses on the dielectrophoretic deformation [3] of thin liquid coatings due to non-homogeneous charge distributions on the liquid-solid interface.

In our experiments, we deposited patterns of static charges by dragging an electrified water droplet in a pre-defined trajectory over a dielectric substrate. We performed two-dimensional characterization of the deposited charge distributions by scanning the substrate with a high-resolution electrostatic voltmeter.

After charge deposition, we applied a thin dielectric liquid film and quantified the deformation of the liquid film due to the electrical forces using interference microscopy. We studied the dielectrophoretic thin film deformation as a function of time and static charge density.

We also performed numerical simulations based on the lubrication approximation [4] and achieve good agreement with the experimental results. Numerically, we also investigated the effect of the width of the static charge distribution patterns and the initial film thickness.

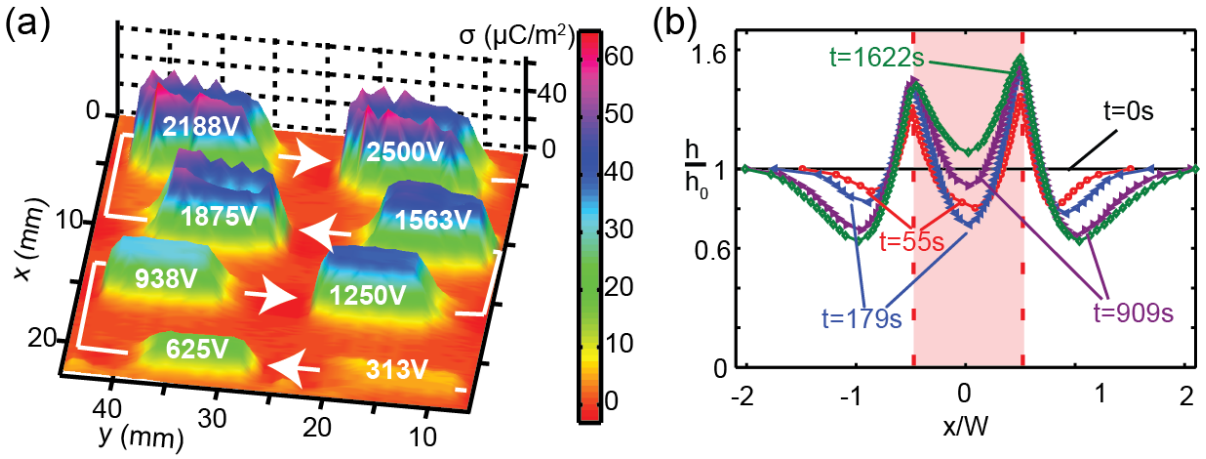

Fig. 1: (a) Surface charge density distributions on a dielectric substrate generated by dragging water droplets that were kept at different voltages [3]. (b) Deformation of a thin dielectric liquid film on a polymer substrate with a non-homogeneous charge distribution (indicated by the red zone).

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References

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