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Deformation of thin liquid films by non-homogeneous static surface charge

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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.
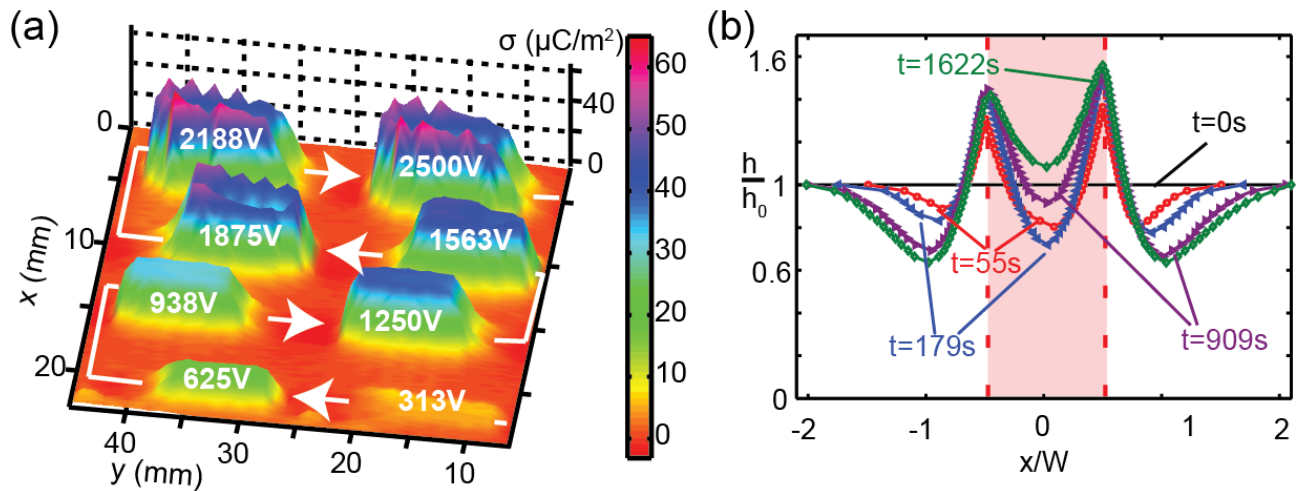

Fig. 1: (a) Surface charge density distributions on a dielectric substrate generated by dragging water droplets that were kept at different voltages [3]. (b) Deformation of a thin dielectric liquid film on a polymer substrate with a non-homogeneous charge distribution (indicated by the red zone).

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