Evaporation of complex fluids in a Hele-Shaw cell

Ching Hsueh,[1] Frédéric Doumenc,[2] and Béatrice Guerrier[3]

[1]*Université Pierre et marie Curie, Lab. FAST, Bât 502, Campus Universitaire, Orsay, F-91405, France,* ching@fast.u-psud.fr

[2]*Université Pierre et marie Curie, Lab. FAST, Bât 502, Campus Universitaire, Orsay, F-91405, France,* doumenc@fast.u-psud.fr

[3]*CNRS, Lab. FAST, Bât 502, Campus Universitaire, Orsay, F-91405, France,* guerrier@fast.u-psud.fr

We study self-assembly of drying complex fluids (colloidal suspensions or polymer solutions) induced by solvent evaporation in a meniscus. A Hele-Shaw cell made of two paralleled glass plates separated by 1mm spacers is vertically immersed into a reservoir which contains the colloidal suspension or polymer solution. Due to the 1mm-thin gap, there is a spontaneous capillary rise. The setup principle is then similar to classical dip-coating. Indeed, in dip-coating the substrate is withdrawn from a reservoir which contains coating materials, while in our set up the substrate is motionless and the solution is pumped out from the reservoir. The flow rate of the pumping system controls the contact line velocity V. The set-up is put inside a chamber of volume 50.4L, where temperature and humidity are regulated by a PID system. A fan blows an air flow to the meniscus through a vertical channel set above the two plates. Deposit morphology is studied as a function of the process parameters (substrate velocity and evaporation rate) and the solution properties (polymer solution or colloidal suspension, initial concentration, viscosity).

A model has been developed to describe the flow induced in the bulk by solvent evaporation at the free surface. Concentration and velocity fields are obtained by solving the Navier-Stokes equations and Fick law. At the upper boundary (meniscus) a known but non uniform evaporation flux is imposed. The description of the tip of the meniscus is achieved by introducing an a priori cut-off where boundary conditions result from a small scale description using lubrication approximation. An iterative procedure is used to define these boundary conditions. The concentration and velocity fields are analyzed as a function of the process parameters. Deposit thicknesses are compared to experimental results.

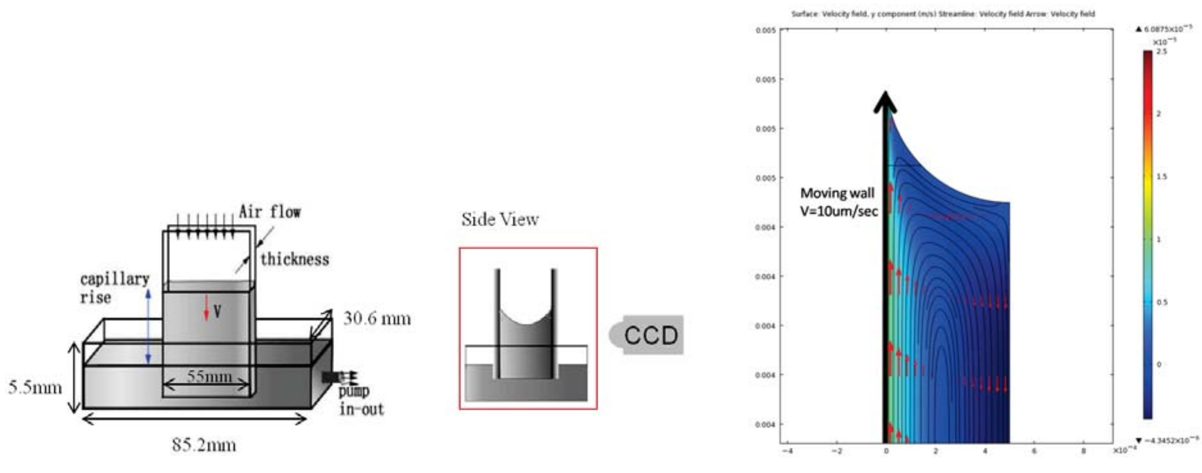

FIG. 1: Left: experimental set-up - Right: Simulation results: Flow field for a polymer solution drying on a moving substrate.