Numerical simulation of two-phase flows in dip coating

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In a dip coating process, a substrate is dipped into a liquid pool including the functional materials and then pulled up with an entrained liquid layer. It is dried or evaporated to recover the funtional materials on the substrate. This coating process has received attention as an efficient particle deposition process for fabrication of micro patterns [1,2].

Despite a number of experimental studies, a general predictive model of dip coating has not yet been developed due to the complexity of the process involving the liquid-gas interface motion with phase change. In this work, a numerical method is presented for computing liquid film formation and evaporation on a moving substrate. A level-set interface tracking method is employed to solve the conservation equations of mass, momentum, and energy in each phase, the vapor mass fraction in the gas phase, and the particle concentration in the liquid phase.

Fig. 1 shows the evolution of liquid film on a moving plate with T_w =70°C and V=10cm/s. When the plate is pulled up from the liquid pool, a meniscus climbs the plate to satisfy the no-slip condition and the liquid-gas-solid contact line is formed at the plate surface. As the plate velocity inceases, the film thickness increases as seen in Fig. 2. When the plate velocity is reduced to 3cm/s and is balanced with the liquid evaporation rate, the liquid film reaches a quasi-steady state and the contact line is not moved as plotted in Fig. 3. The film height decreases with the plate velocity.

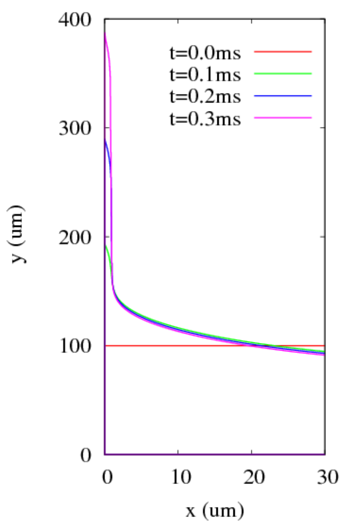

Fig. 1: Evolution of the liquid-gas interface.

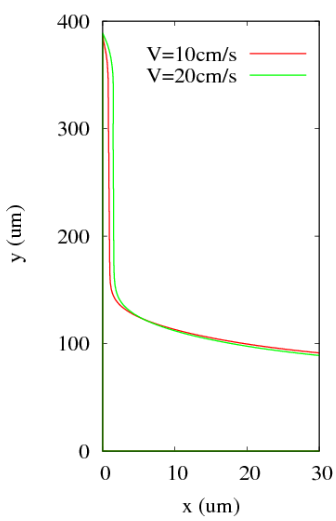

Fig. 2: Effect of plate velocity on the liquid film thickness.

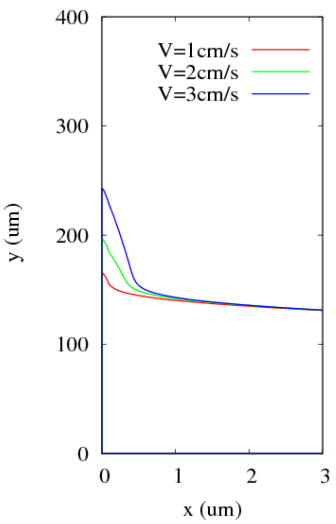

Fig. 3: Effect of plate velocity on the liquid film height.

References

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