The effect of viscosity on dynamics of Electrowetting droplet

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Introduction

Among various approaches to control the droplet motion, electro-wetting (EW) is particularly convenient and versatile for its ability to tune the surface wetting property with an external electric field. With EW, it is now possible to design digitized active and reconfigurable cooling devices for high-flux thermal management of compact microsystems.

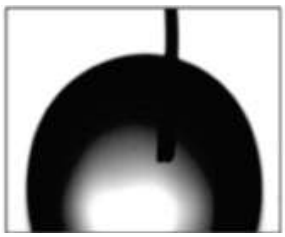

Fig 1. Droplet system for transient droplet spreading under electrical actuation

Governing equations

$$\rho\left(\frac{\partial \mathbf{u}}{\partial t}+\mathbf{u}\nabla\mathbf{u}\right)=-\nabla p+\nabla\left(\mu\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^{T}\right)\right)+\rho\mathbf{g}+\mathbf{F}_{st}$$

$$\theta_D=\cos^{-1}\left[\cos\theta_S-\left[\varsigma U+c_{pin}\,\mathrm{sgn}(U)-\frac{c_{pin}}{\pi/2}\tan^{-1}\left(\frac{\varsigma U}{c_{pin}/(\pi/2)}\right)\right]/\gamma_{LV}+\frac{1}{2}\frac{\varepsilon_0\varepsilon_r}{d\gamma_{LV}}V^2\right]$$

Numerical model

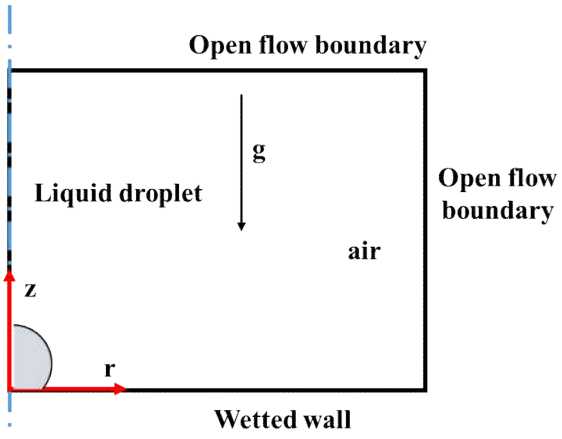

Fig 2. Schematic of computational domain

Results

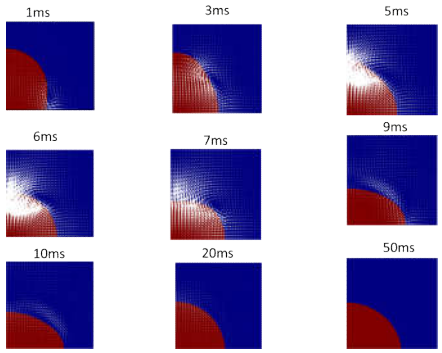

Fig 3. Electro-wetting process of droplet on the substrate

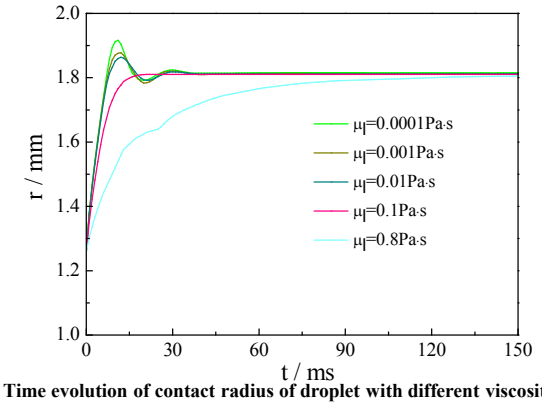

Fig 4. Time evolution of contact radius of droplet with different viscosity (V=120V)

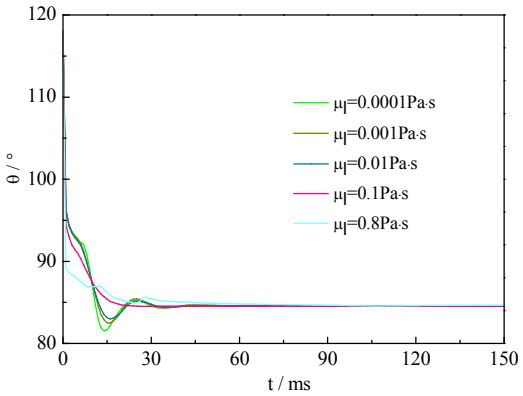

Fig 5. Time evolution of contact angle of droplet with different viscosity (V=120V)

Conclusions

(1)In this regard, an MKT based model that considers the contact line friction and the pinning force at the moving contact line was successfully implemented.

(2) When droplet's viscosity is low, it recoils and undergoes damped oscillations under DC Electro-wetting. When droplet's viscosity is high, oscillations don't occurs.