Electrowetting on dielectric: history effects on rupture voltage

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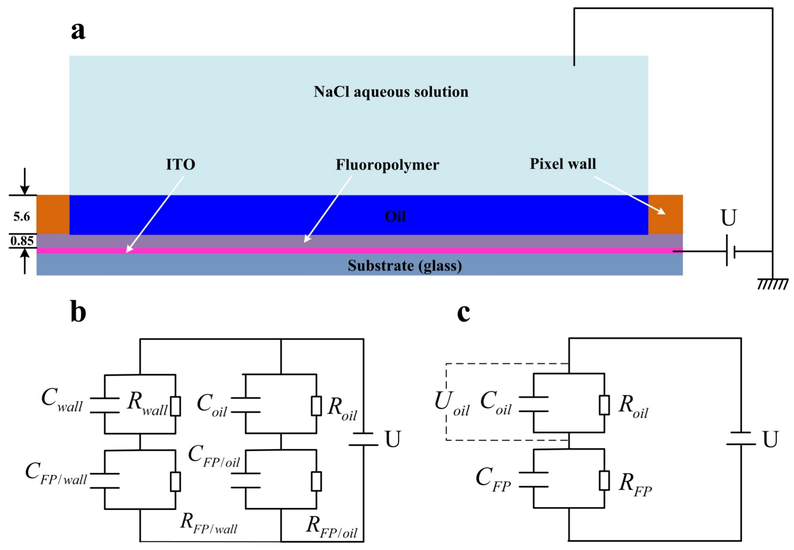
Introduction

For a classical EWOD based two-phase microfluidic system, such as an Electrofluidic displays[1] (EFD) device, the conducting fluid (NaCl aqueous solution) and the isolating fluid (oil) are assumed to be in direct contact.

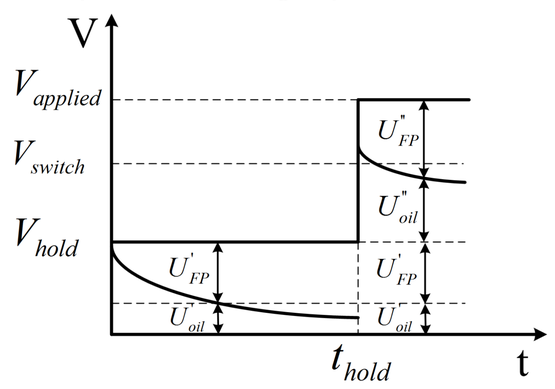


Here, we investigate a problem in the operation of electrowetting on dielectric caused by a finite conductivity of the oil[2].

Model

Equivalent circuit model :

We find that the voltage at which the oil film ruptures is sensitive to the application of relatively low DC voltages prior to switching.



Equations

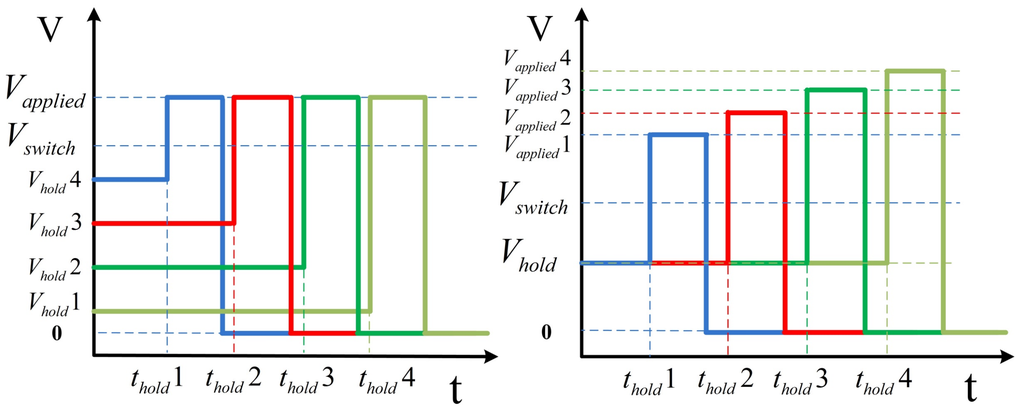
$$\tau_{RC} = \frac{\frac{\varepsilon_{oil}}{d_{oil}} + \frac{\varepsilon_{FP}}{d_{FP}}}{\frac{\sigma_{oil}}{d_{oil}} + \frac{\sigma_{FP}}{d_{FP}}}$$

$$t_{hold}^{\max} = -\tau_{RC} \ln\left(1 - \frac{V_{applied} - V_{switch}}{\chi V_{hold}}\right)$$

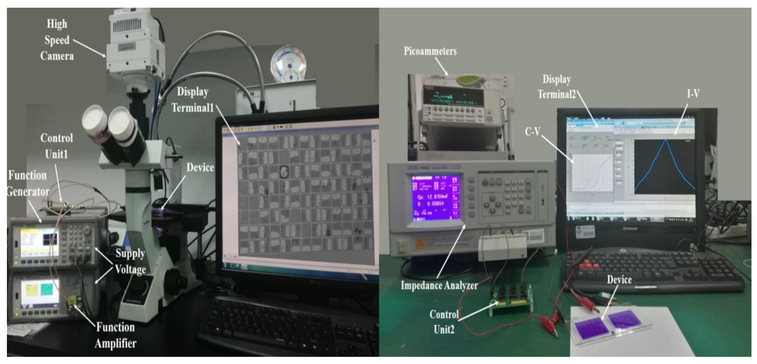
$$\chi = \frac{\left(\frac{\sigma_{oil}}{\sigma_{FP}} - \frac{\varepsilon_{oil}}{\varepsilon_{FP}}\right)\frac{d_{FP}}{d_{oil}}}{1 + \frac{\sigma_{oil}}{\sigma_{FP}}\frac{d_{FP}}{d_{oil}}}$$

Experiments

a. driving schemes

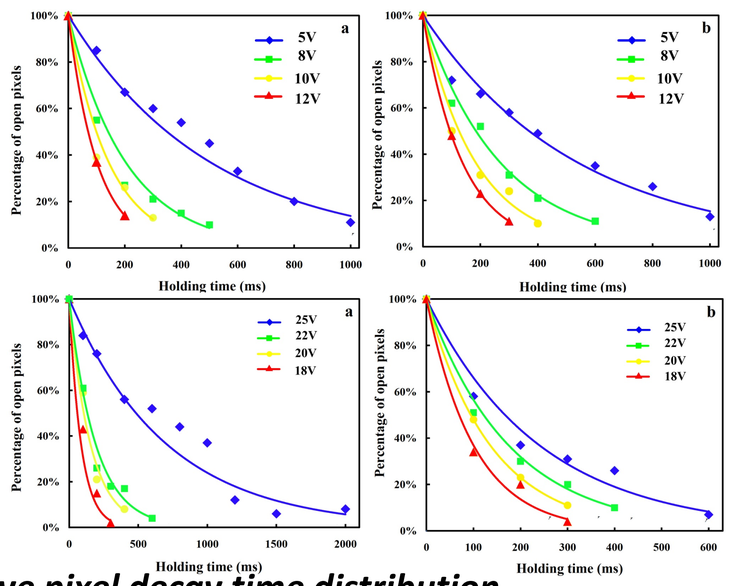


b. Optical Performance Test System

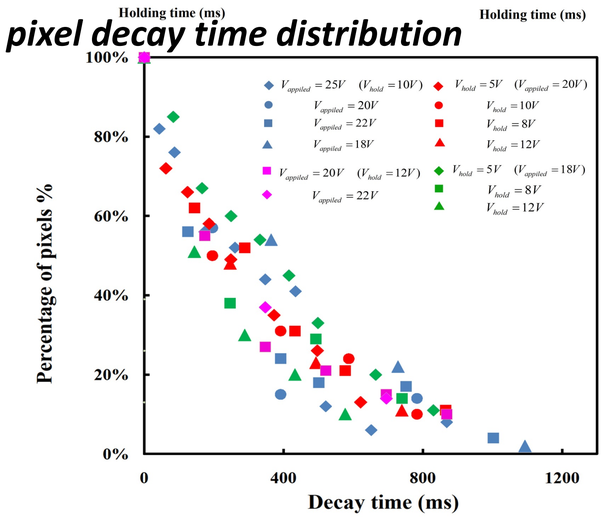


Results

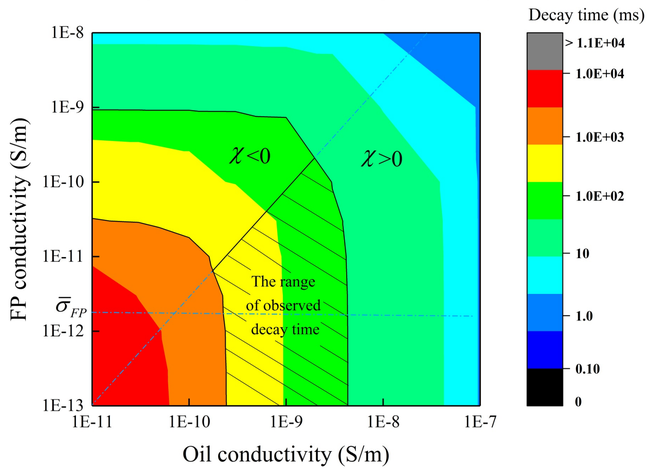
Holding time statistics with varying holding voltage and applied voltage



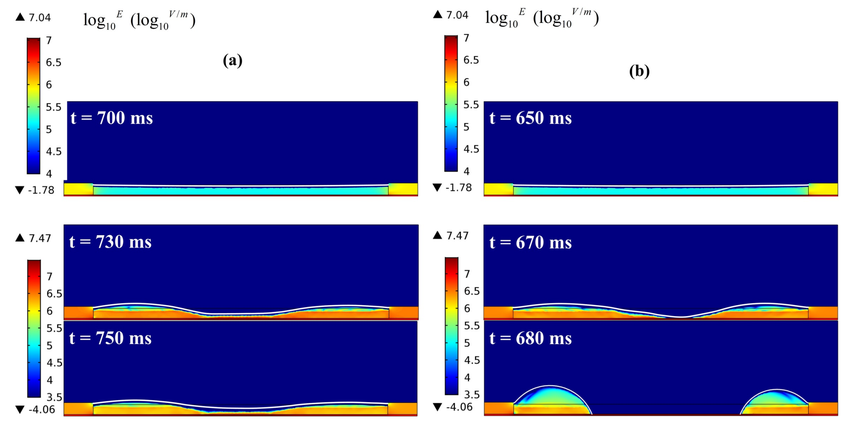
Mastercurve pixel decay time distribution



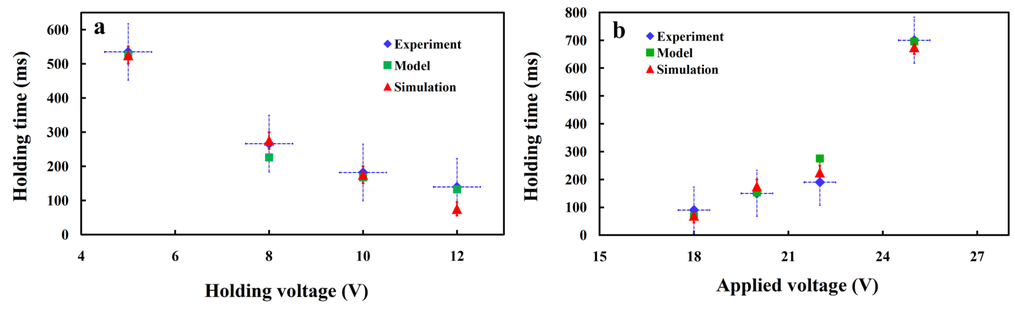
Pixel-to-pixel variability analysis using an equivalent circuit model



Simulation



Comparison of experimental, simulation and model results



Conclusion

1) We developed an equivalent circuit to model the effective voltage across the oil film. 2) We can only explain the pixel-to-pixel variation well by variations in the oil conductivity. 3)Experiments and models, simulation results are very consistent.

References:

1. R. A. Hayes and B. J. Feenstra., *Nature*, **425**, 383 (2003).
2. 2. Jones T B, Fowler J D, Chang Y S, et al. Frequency-based relationship of electrowetting and dielectrophoretic liquid microactuation. Langmuir, 2003, 19(18):7646-7651.

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