Free Surface Microfluidics Based on Electrowetting

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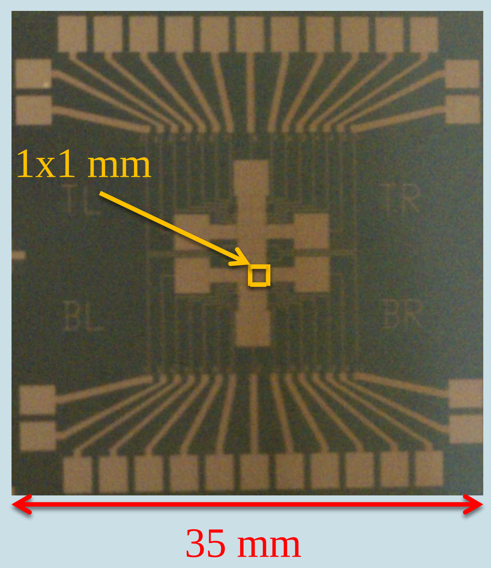
Introduction

Thanks to their portability and small sample needed, microfluidic devices have been developed for applications in biology and chemistry. Electrowetting has been used in such devices to allow movement of droplets by an applied electric potential.

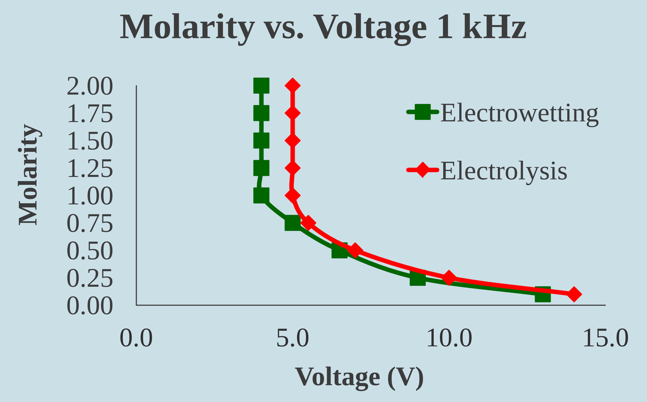


Mixing of droplets containing different chemicals to perform measurements and experiments, and evaporation of droplets on chips to increase reaction rate and eliminate solvent was intended.

Results

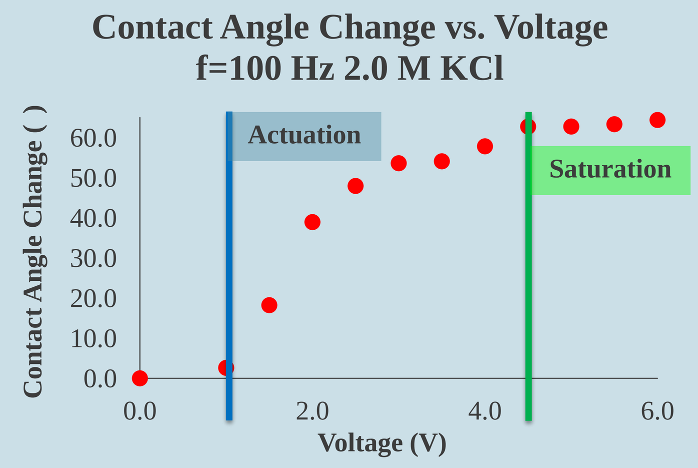
- Best electrowetting results seen with 1 M KCl solution at 4V with frequency of 300 Hz.

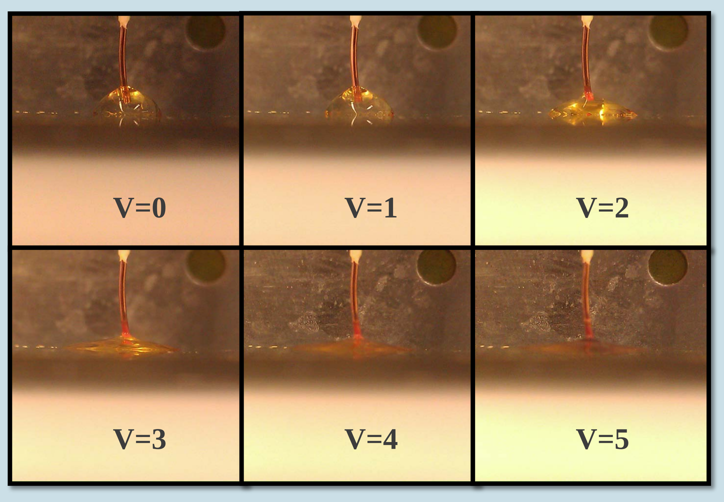
- Electrolysis increases as voltage increases or molarity and frequency decreases.



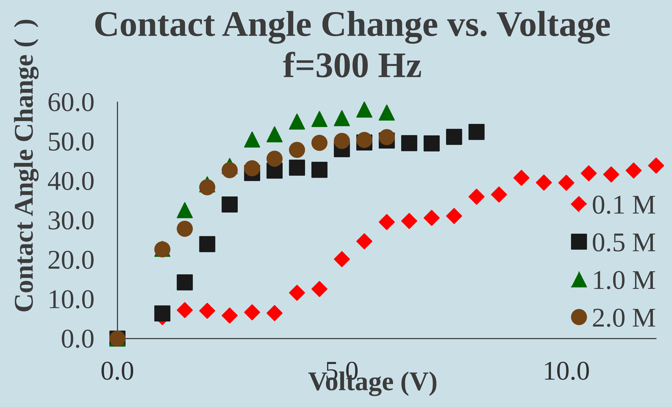
Factor	No Effect	Electrowetting	Electrolysis	Best Value
Voltage	< 3V	3V < V < 5V	> 5V	4V
Frequency	> 3 kHz	250 Hz < f < 3 kHz	< 250 Hz	300 Hz
Molarity	< 1M	1M	---	1M

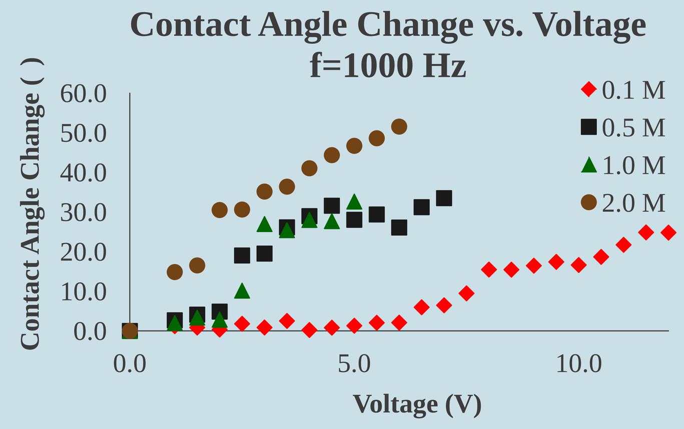
KCl solution on gold electrode with no dielectric.



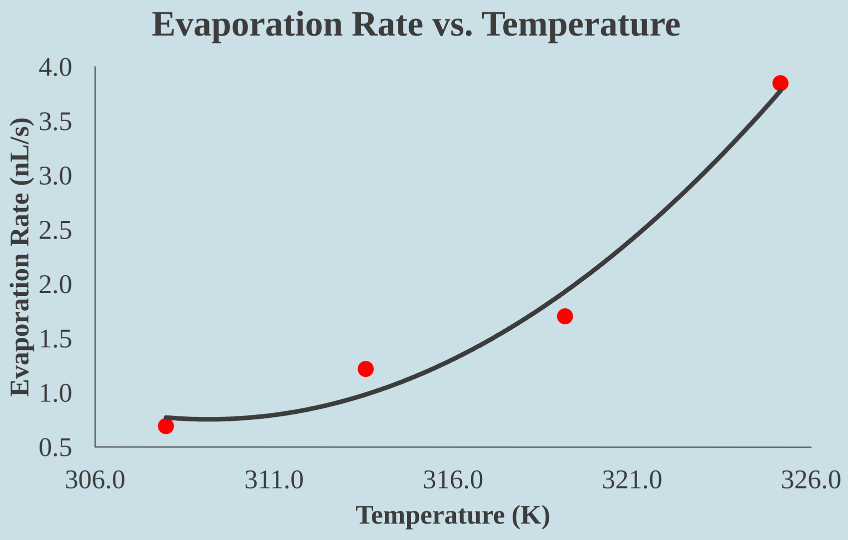


- Saturation of contact angle is reached sooner by the higher molarity solutions



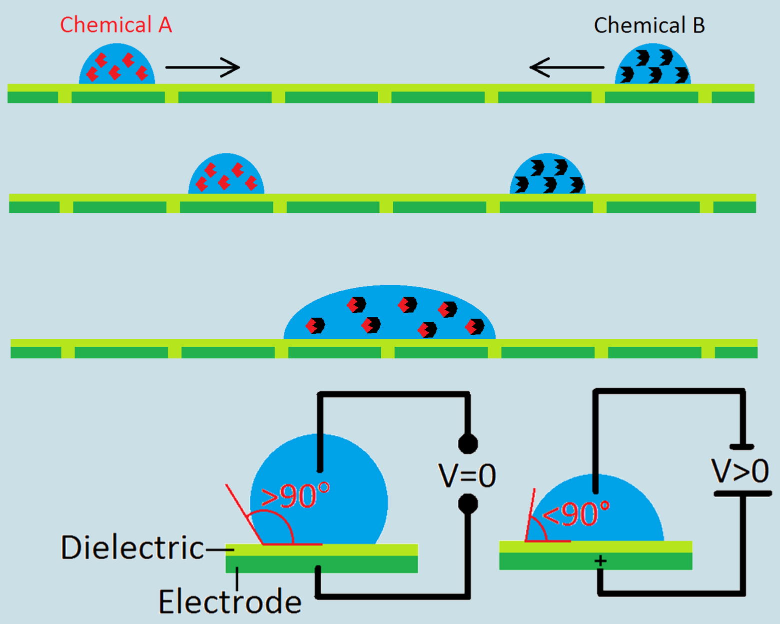


- Evaporation rate of the solvent was plotted against surface temperature.
- Evaporation rate increases as temperature raises.

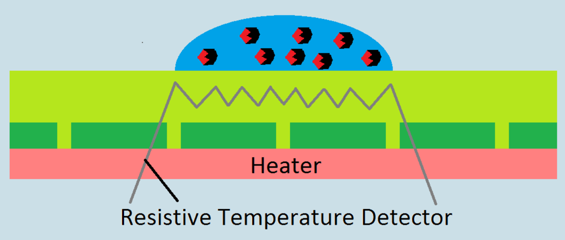


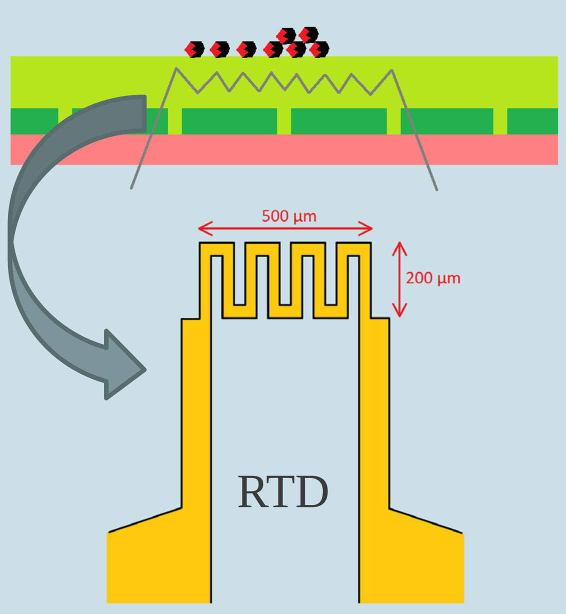
Methods

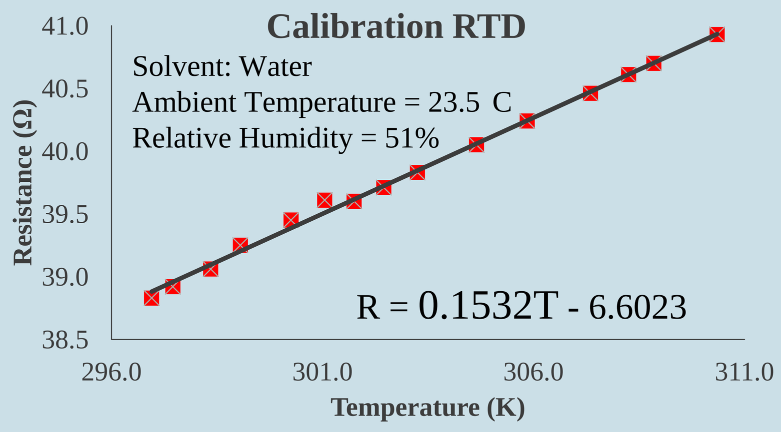
- **Mixing of chemicals**
  - Apply voltage to droplet on chips to obtain electrowetting without electrolysis.
  - Try different solution concentrations, voltages, frequencies, and dielectrics.



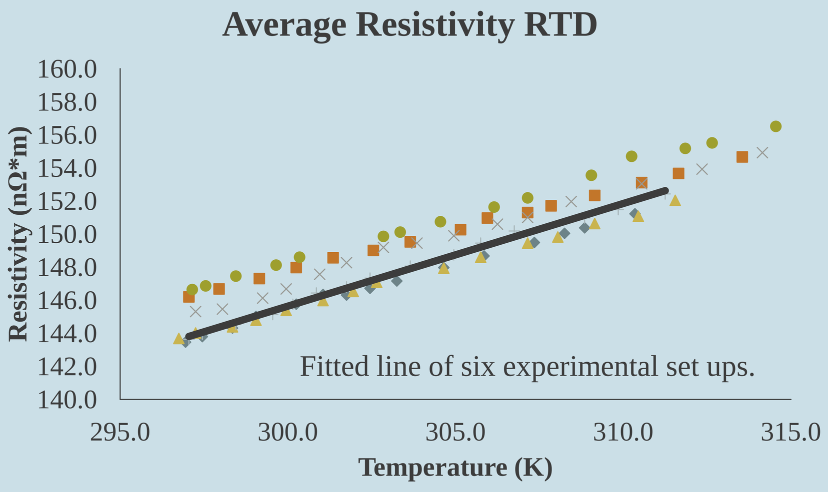
- **Evaporation of solvent**
  - Chip placed on Peltier heater to increase the temperature.
  - Measure resistance of Resistive Temperature Detector (RTD) to control surface temperature of chip.
  - Made of two layers: Ti/Pt (200/2500Å)
  - Resistance of RTD is measured and related to temperature linearly.
  - Evaporation rate curve vs. temperature was obtained.







The equation to relate temperature to resistance is obtained from a graph of resistance vs. temperature



$$\rho = \rho_{ref}\left[1 + \alpha\left(T - T_{ref}\right)\right]$$

Experimental Value

$\rho = 144 n\Omega * m$

$\alpha = 0.00395 K^{-1}$

$T = 25°C$

Conclusions

- Best electrowetting seen with 1 M KCl solution with applied potential of 4V at 300 Hz.
- Manual movement of droplets has been achieved using EW.
- Pt RTD used to measure the temperature according to linear relationship between resistance and temperature.

Future Plans

- Find dielectric that decreases voltage needed for electrowetting and prevents electrolysis.
- Find way to de-wet a droplet after electrowetting occurs.
- Control the evaporation rate of the droplet using a Peltier heater and the reading of the resistance of the RTD.
- Combination of electrowetting and evaporation devices.

References

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