# SURFACE TENSION FORCES FOR COMPACT MICROROBOTICS


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## INTRODUCTION

### Scaling laws: Forces at microscale

When we move from the macro (> $10^{-3}$ m) to the micro (< $10^{-3}$ m) world, the effects of different types of forces change, and capillary forces dominate in microsystems down to 100 nm − 1 µm [1].

This predominance of capillary forces in the microworld makes them attractive to use in micro-robotics applications.

Droplets of liquids resting in a surface shows this force and can be described by the contact angle between the droplet and the surface it rest on.

### Electrowetting

One way to modify capillary forces is by Electrowetting, which the change in wetting properties due to an electric field. This phenomena is usually described by using the contact angle and modeled by Lippmann's electrocapillary expression [2,3]:

$$cos(\theta) = cos(\theta_0) + \frac{cV^2}{2\gamma}$$

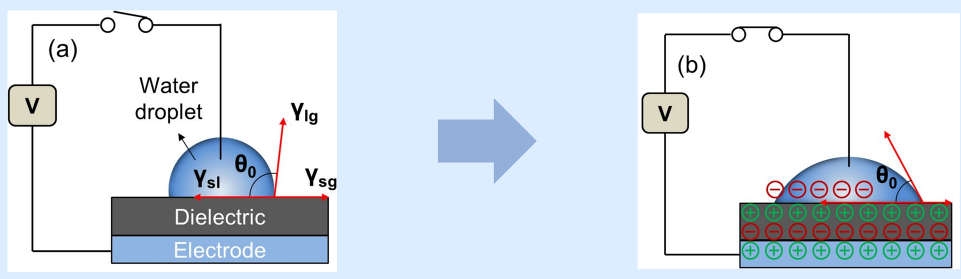


Figure 1: EWOD Principle. a) and b) without and with an applied voltage [4].

### Objectives

Use capillary forces and electrowetting as a compact actuator at microscale:

- Design, fabricate and characterize electrowetting actuator.
- Use this actuator in a complex structure (ex. Tripod platform).

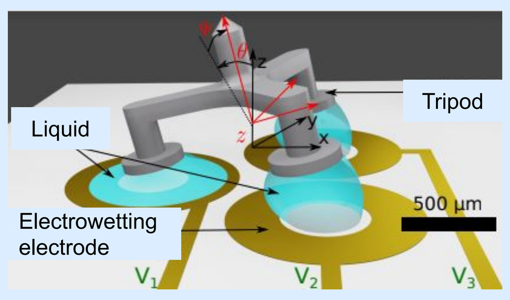


Figure 2: Schematic of electrowetting actuated orientated platform.

## MATERIALS AND METHODS

### Electrowetting actuator

It consists of an array of gold electrodes on a glass substrate to generate an electric field and covered by a hydrophobic layer.

- Three different shapes of electrodes.
- Electrodes fabricated in clean room.
- Liquids: **DI Water**, Oil, Ionic liquid, Saline solution.

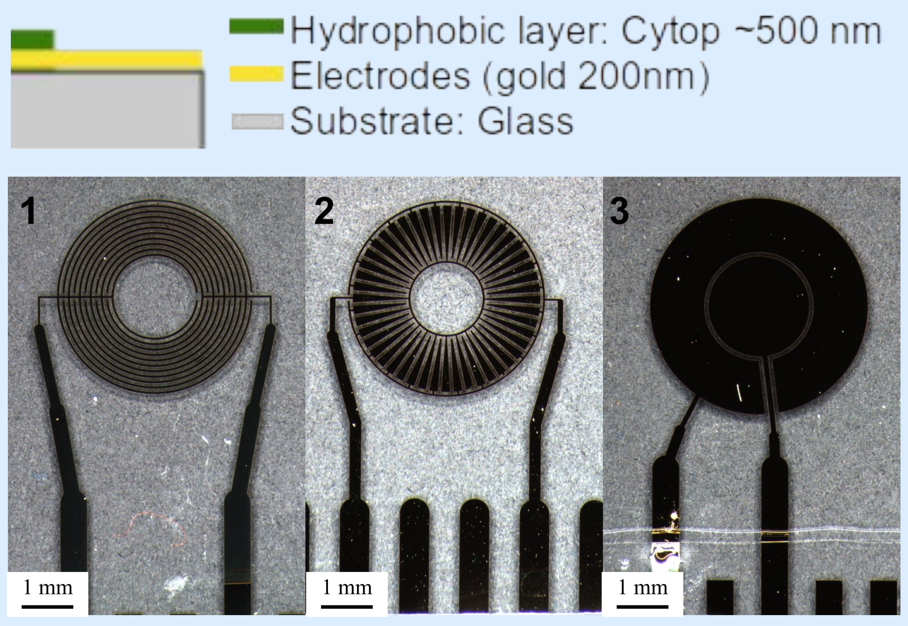


Figure 3: Electrode schematic and fabricated shapes.

### Experimental setup

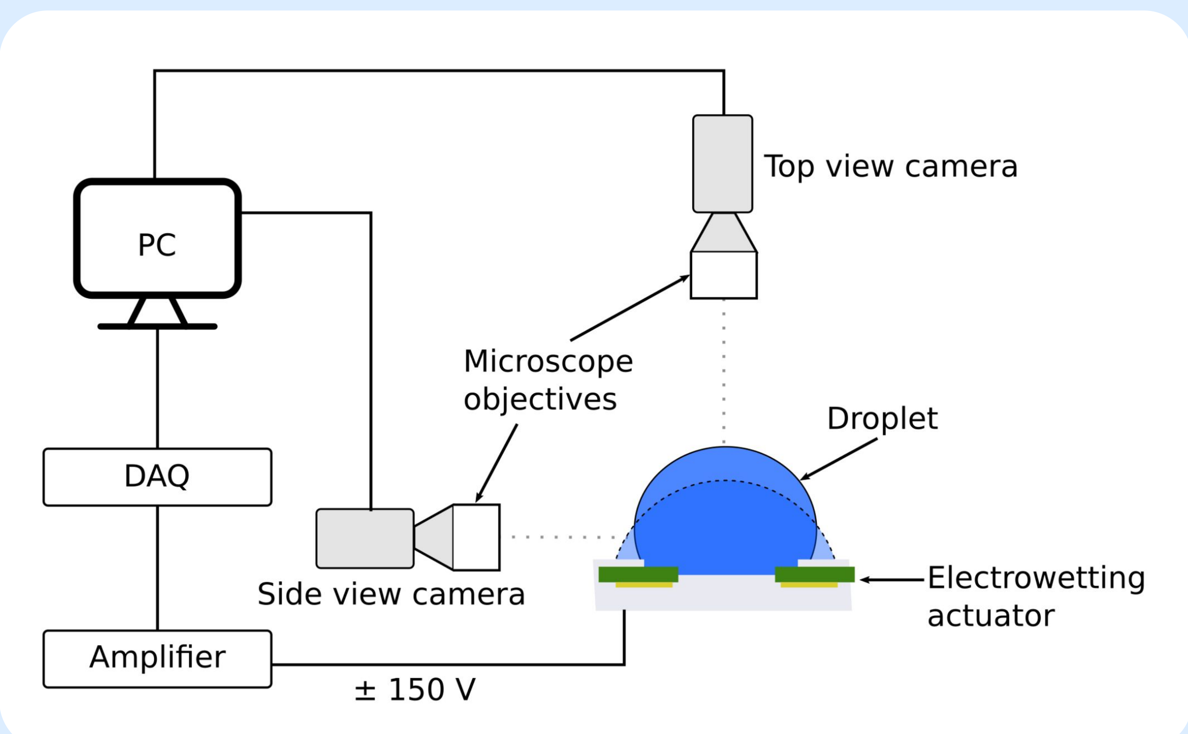


Figure 4: Experimental Setup.

## EXPERIMENTS

### Electrowetting actuation

We test the electrowetting actuation by placing a droplet on top of the electrodes and increasing and decreasing the voltage applied to the them. To quantify the deformation we use the side camera to measure the percentage change of the height of the droplet and we check the displacement of the droplet with the top view camera.

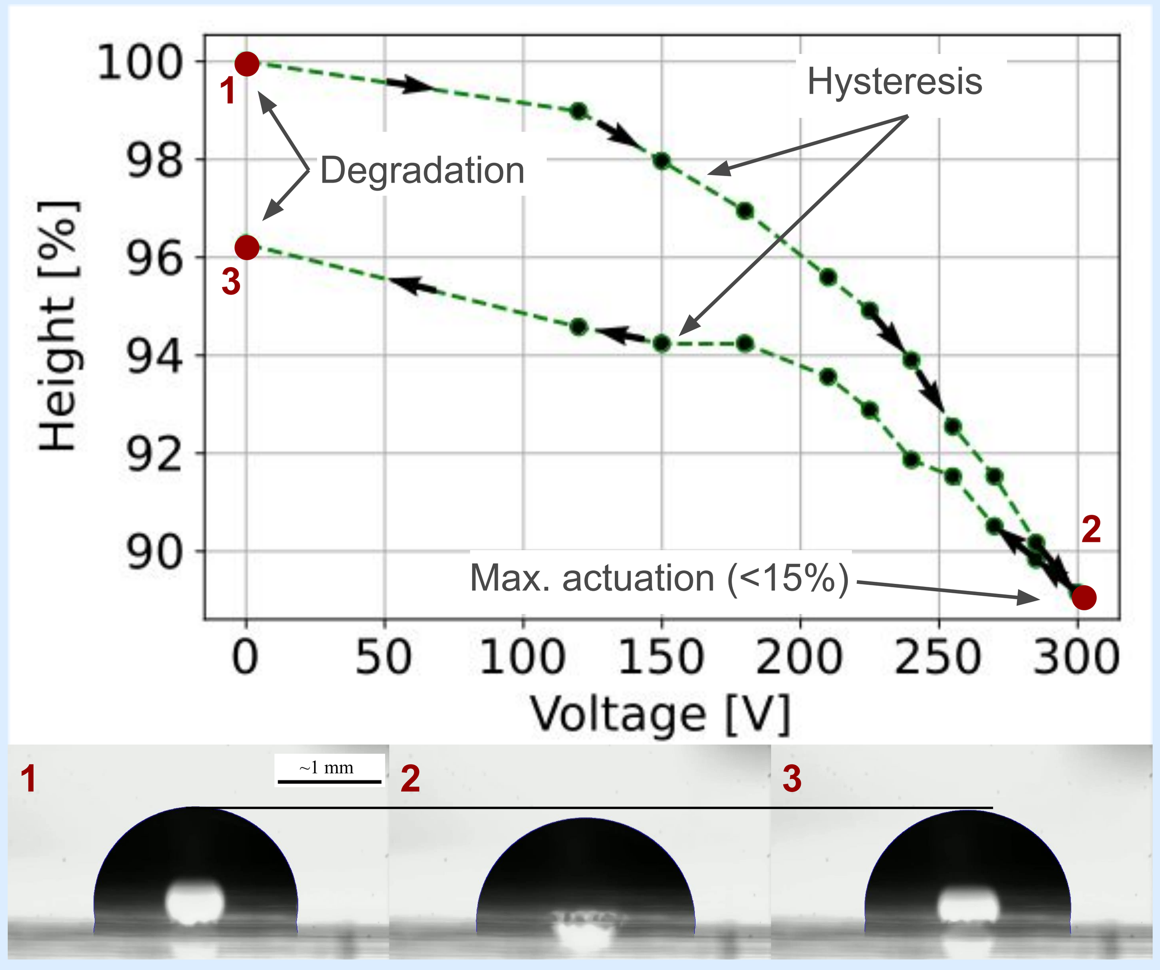


Figure 5: Percentage change in height for different voltages 0-300Vpp (Elect No. 2 - DI Water) and side view of the droplet.

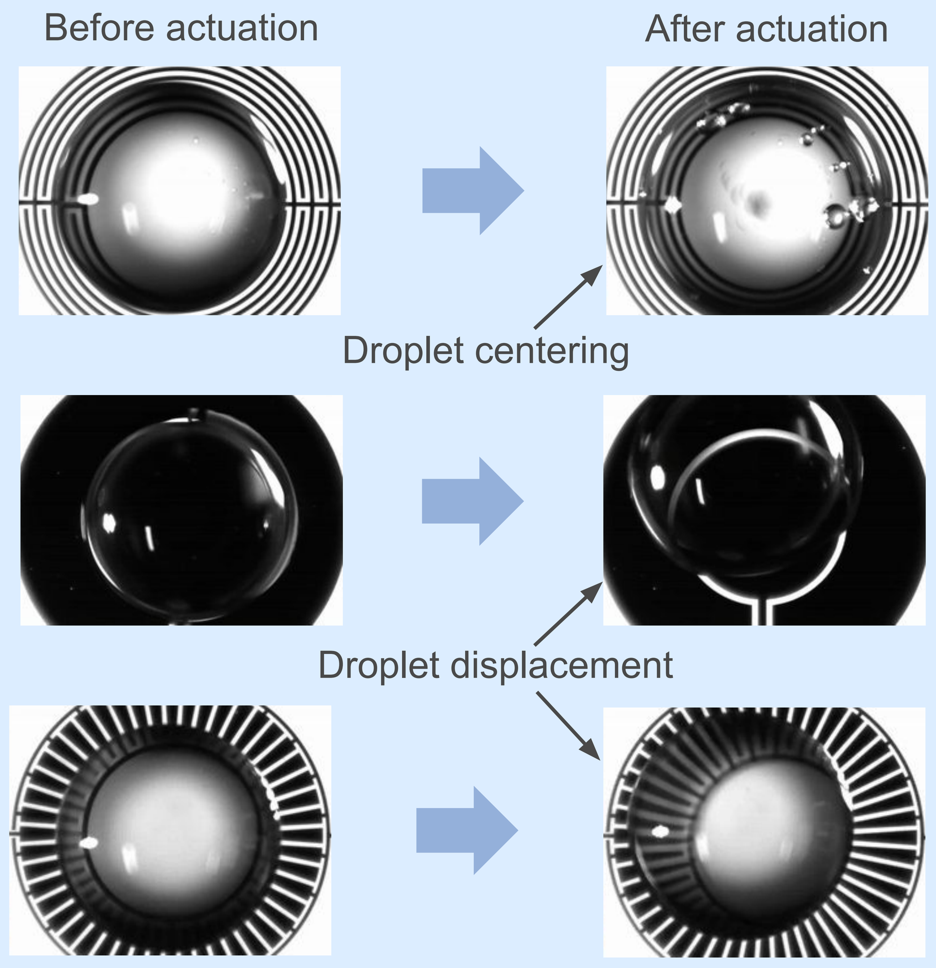


Figure 6: Top view of the droplet at the beginning and end of the test.

### Tripod platform:

The stability of a object placed in three droplets is an challenge by itself. To test the stability of the floating platform, we place a tripod platform in three droplets of water resting in silicon wafer covered by a patterned hydrophobic.

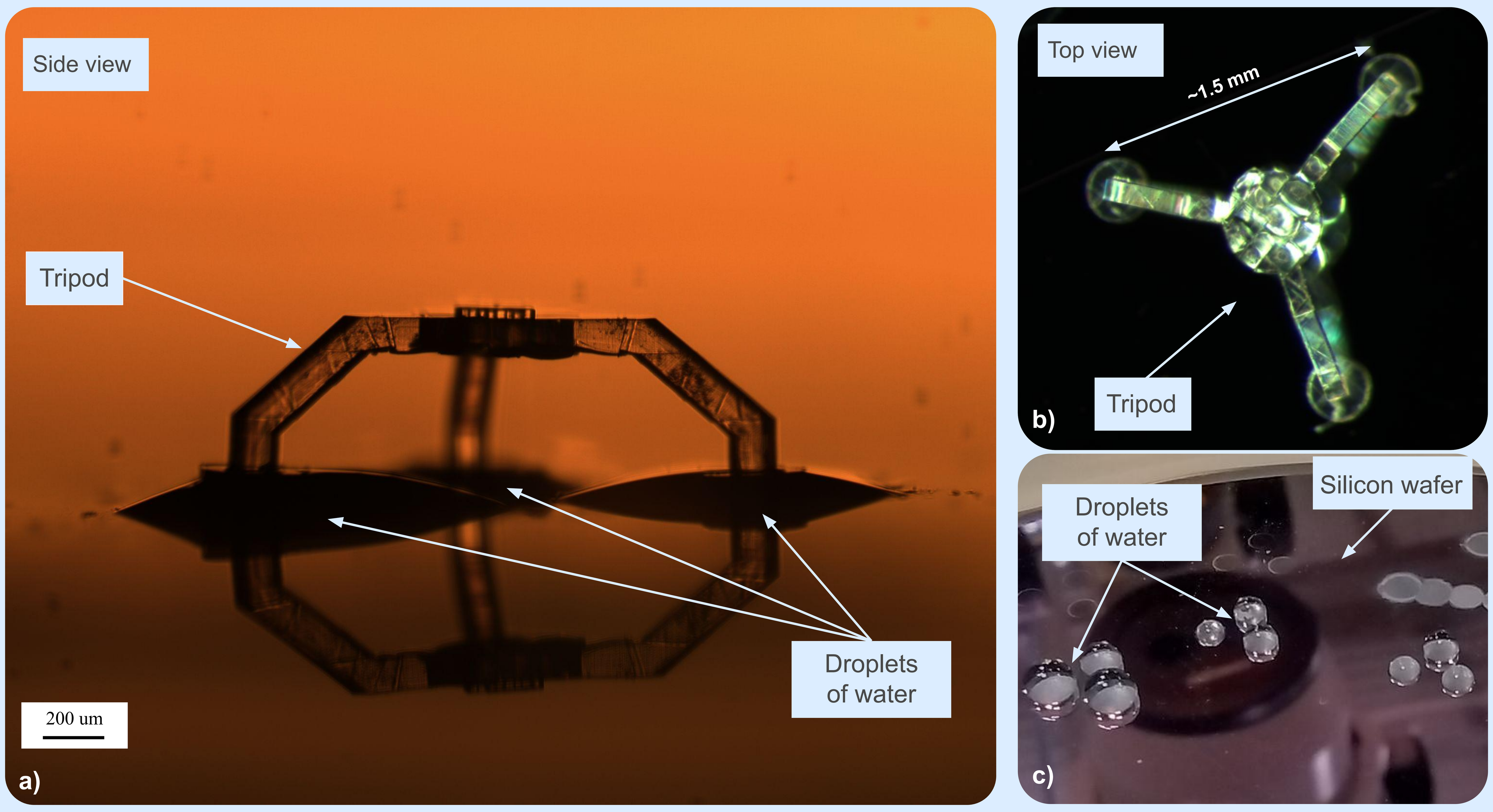


Figure 7: a) Tripod placed in three droplets of water. b) Tripod Top view and c) Droplets of water in silicon wafer and laser etching top view.`

## CONCLUSIONS

- Electrodes designed, fabricated and tested showed electrowetting effect.
- Issues: Hysteresis, droplet displacement, unstable position in the center.
- Tripod platform successfully placed in top of three droplets.

### Perspectives

- Enhance droplet behavior: New electrodes design.
- Control height in close loop.
- Actuated tripod platform.

## REFERENCES


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## ACKNOWLEDGEMENT


This work was supported in part by the ROBOTEX network and its Micro and Nanorobotics center under Grant ANR-10-EQPX-44-0, in part by the french RENATECH network and its FEMTO-ST technological facility, and by ANER and ANR EwetBot project.
Extreme gratitude to my directors, Aude Bolopion and Antoine Barbot, for all their guidance, and Joel Agnus and Gwenn Ulliac for the technical contributions.
Special thanks to my partner for all her support.



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