Microtechnology / Microsystems 2016
Lab session: Micro-droplet dispensing
Report due Wednesday, April 27

1 Overview

Droplets are found everywhere, from the Mayonnaise poured on your fries to the ink printed on the document you are reading. In inkjet printing, tiny droplets have to be released on demand at a well-defined location. Drop-on-demand (DOD) devices rely on either thermal or piezoelectric actuation. The former consists in a strong local heating of the ink in a small chamber. Vaporization creates a small bubble that considerably increases the pressure in the chamber and expels a droplet of ink towards the paper. In the latter (piezoelectric) technique, the volume of the chamber is temporarily reduced by the deflection of a piezoelectric membrane. Piezoelectric dispensing is not only used in printing devices, but also in many other robotic applications where the controlled delivery of tiny amounts of liquid is required. It covers several markets, including biomedical applications where the liquid samples do usually not tolerate heating.

This lab session focuses on the piezoelectric dispensing of small droplets. You are asked to fabricate a piezo droplet dispenser (lets say a very basic inkjet printer), and characterize its capabilities in terms of droplet dimensions.

Suggested additional reading: Harris, D. M., Liu, T. and Bush, J. W. M., *A lowcost, precise piezoelectric droplet-on-demand generator*, **Experiments in Fluids, 56**, 83 (2015).

2 The session

The lab session is organized from 2pm to 6pm in the Microfluidics Lab (B52 / -2). Loïc Tadrist (loic.tadrist@ulg.ac.be) will be your teaching assistant; please do not hesitate to contact him if any questions.
PLEASE READ THESE INSTRUCTIONS BEFORE COMING TO THE LAB.

2.1 Fabrication

First, you have to assemble five piezoelectric devices (each has a different hole diameter). For each,

1. Glue the circular chamber at the center of a plastic plate. Pay attention to leave the inlet and outlet out of the plate, so you can later connect the tubings. Cure it for 180 s in the UV chamber.

2. Glue the piezo actuator on top of the chamber. Cure it on both sides (180 s again).

3. Cut two tubes of 20 cm each. Connect and glue them to the inlet and outlet of the chamber. Cure the assembly for 180 s again.

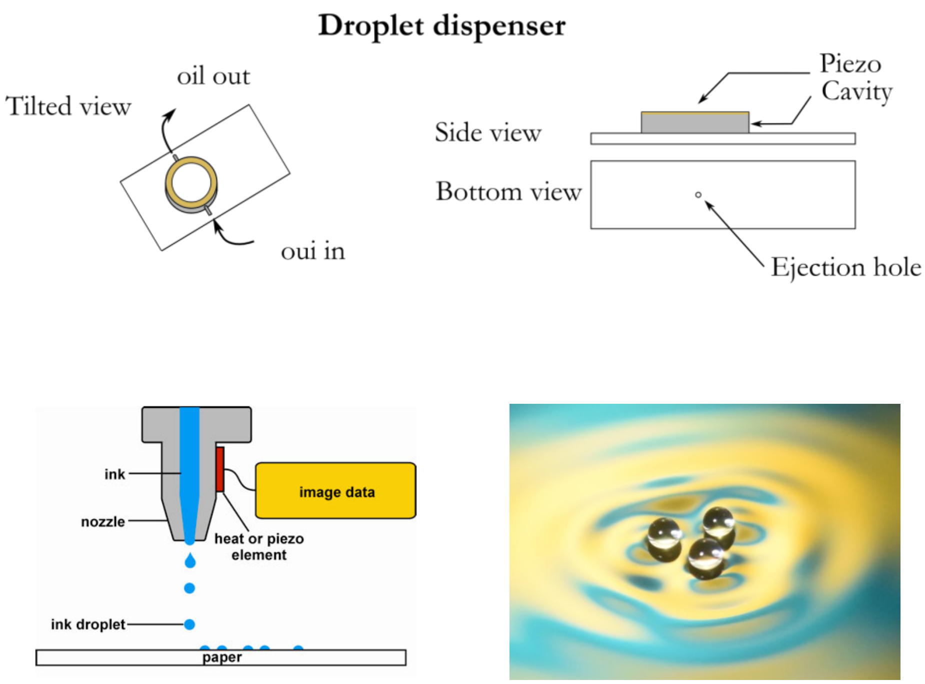

Figure 1: Schematics of a piezoelectric droplet dispenser.

4. Glue the connectors and cure again.

The piezo dispensers are not ready to use yet. They still need to be filled with liquid.

1. Connect a large syringe to 40 cm of tubing, then to a valve, then to the chamber inlet. Connect a little reservoir (for the outlet flow) to again 40 cm of tubing, then to a valve, then to the chamber outlet.

2. Set-up the experimental bench (one droplet dispenser at a time) with the lab construction kit that is given to you.

3. Close the hole of the droplet dispenser with blue putty.

4. Pour some oil into the inlet syringe. Open the valve and fill the droplet dispenser until the oil reaches the outlet tank. Great care must be taken to avoid any air bubble in the chamber.

5. Close the outlet valve and adjust the hydrostatic pressure close to 0 (by moving the syringe up and down).

6. Remove the blue putty. If the hydrostatic pressure is properly adjusted, you should observe neither oil leakage nor air bubbles forming in the chamber.

7. Connect (electrically) the piezoelectric element to the pulse generator.

2.2 Testing

In order to characterize your device, you have to identify the range of voltage for which it creates single calibrated droplets. Indeed, you may observe that depending on hole size, surface defects and input voltage, it may also form satellite droplets or jets.

1. Mount the high speed camera on a tripod and check the image on the computer. Please be very careful with lights and optical elements.
2. Try different pulse intensities and observe the resulting ejection. Which voltage does generate satellite droplets or jets ? What is their main drawback, for both industrial and lab use?
3. Characterize the droplet size as a function of the voltage applied by the pulse generator.
4. What is the effect of hydrostatic pressure on droplet size?
5. Characterize the range of droplet dimension as a function of the hole diameter.
6. Wash thoroughly the droplet generators and try to dispense another liquid (e.g. water). Which physical parameters are different ? What do you expect to observe?
7. Plot a single diagram on which you can report all your observations.
8. Give the limitations of such system for industrial use. What improvements do you suggest?

3 The lab report

The lab report synthesizes the work accomplished during this lab session. It is worth 15% of the final mark. It has to be written in English and structured as follows:

1. Introduction (./1): Context and main goal of the lab.
2. Design and microfabrication (./5): Design strategy. Additional details about the microfabrication operations (not already present in the lab instructions). Also describe what has gone wrong and why. What is the theoretical accuracy of the technique ? How much accuracy did you get ?
3. Experimental testing (./3): Accurate description of the experimental setup and manipulations.
4. Results (./6): Description of the phenomenology (illustrated with representative snapshots or schematics). Identification of relevant parameters (time, position, displacement, speed, liquid properties). Motion characterization by image processing. Presentation of the data. Interpretation, discussion and conclusions.

Additional comments

- Do not forget to criticize your results, i.e. to say how much you are confident in them.
- Make sure that your figure captions are sufficiently detailed (incl. relevant parameters and symbol description) and that every figure is called at least once in the main text.
- Do not forget to cite your sources.