Study of 3D focused droplet generation in a 2D flow focusing microfluidic geometry

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INTRODUCTION:

- We study the water in oil droplets formation inside a 2D microfluidic flow focusing geometry.
- Generation of monodisperse droplets of two immiscible fluids

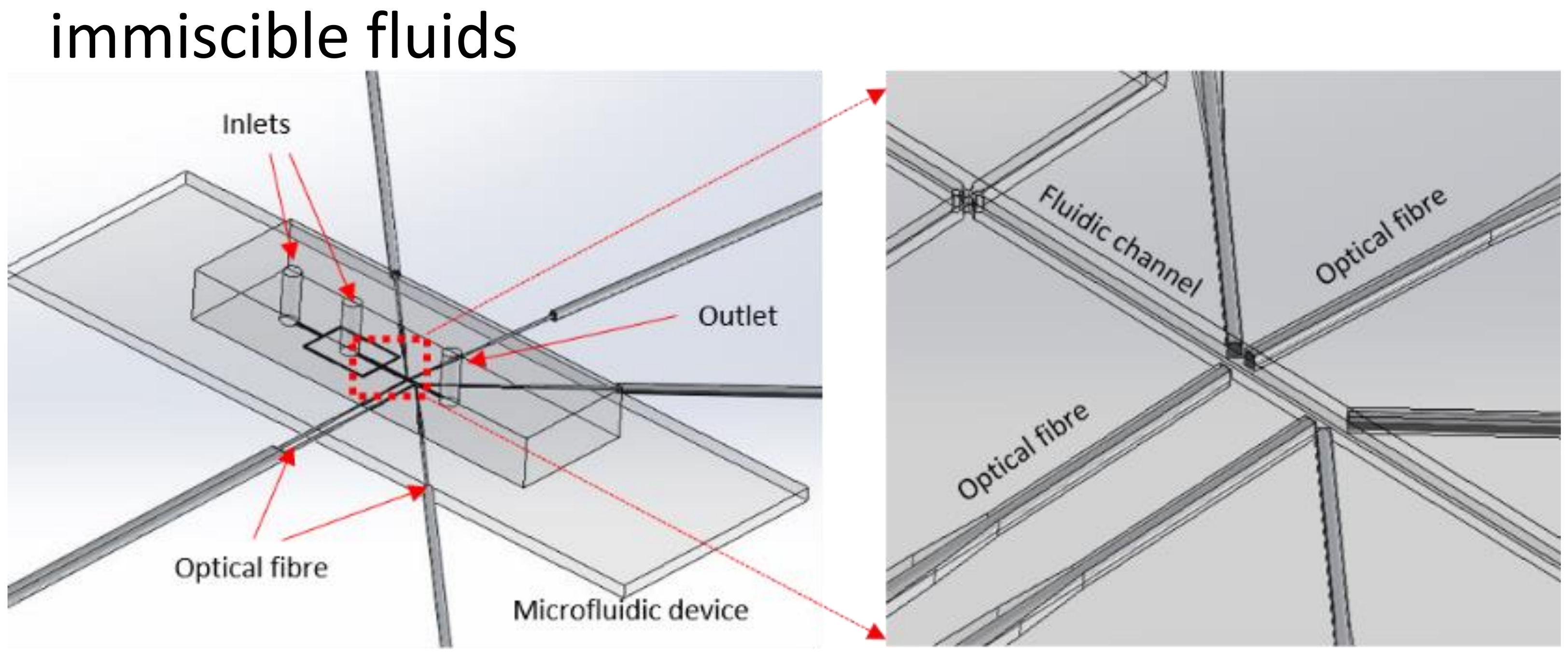

Figure 1. . Integrated optical fibres in microfluidic device for optical sensing of droplets

- The optical sensing by coupling fiber optics.
- Optical fiber diameter (130 µm) to match the microfluidic channel height.
- Reduced channel cross section improves the through put and efficiency of droplet.
- Height of the channel can be increased once the droplets are formed.

COMPUTATIONAL METHODS:

- Computational Fluid Dynamics (CFD) simulation using the Laminar Two-Phase Flow, Phase Field method in COMSOL Multiphysics®.

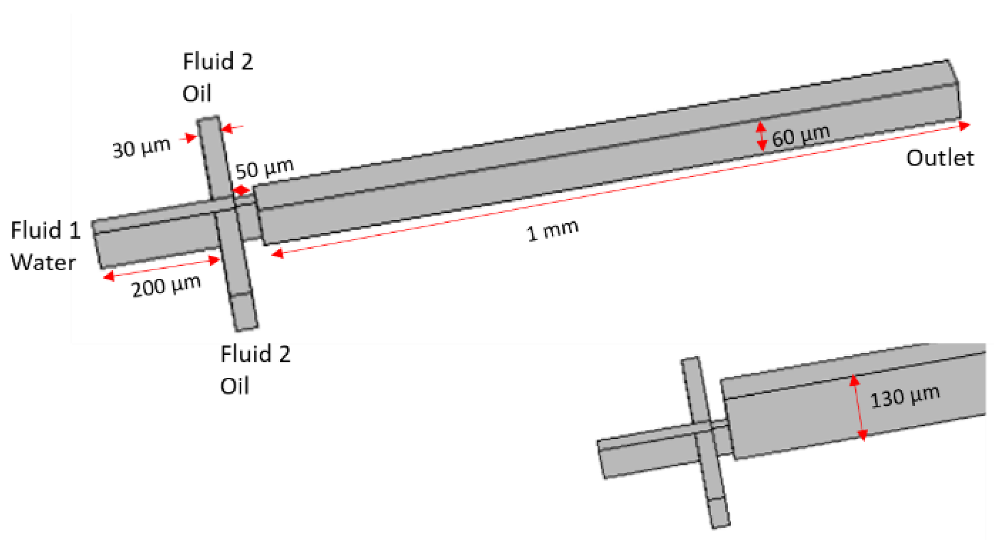

Figure 2. Flow focusing micro channel geometry designed for droplet generation modelled in 3D. (a)Device geometry with lower channel cross sections (b) Height of the fluidic channel increased from 60 µm to 130 µm.

- the Laminar Two-Phase Flow, Phase Field module was selected to perform the simulation.
- Phase field method to study the interfacial motion of the multiphase flow.
- To observe the geometric evolution of the fluidic interface.
- Also considered the a laminar flow behaviour in the micro channels

RESULTS:

- Material properties of oil and water were given as shown in table

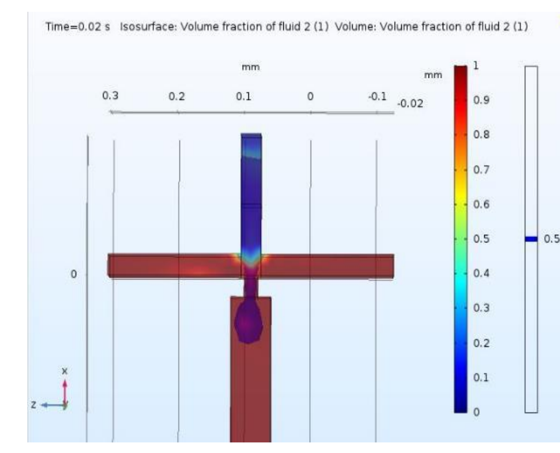

Figure 3. Droplet breakup

Fluid	Dynamic Viscosity (Pa·s)	Density (kg/m³)
Water	1.05e-3	1000
Oil	6.71e-3	900

Table 1. Fluid properties used

- First the disperse phase meets the continuous phase and forms a convex shape governed by the surface tension of the fluid.

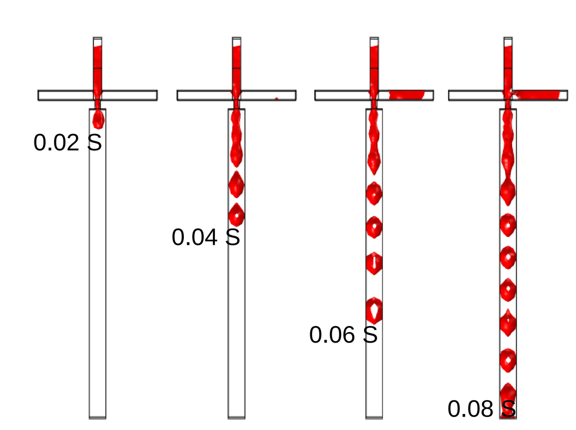

Figure 5. Droplet evolution with time

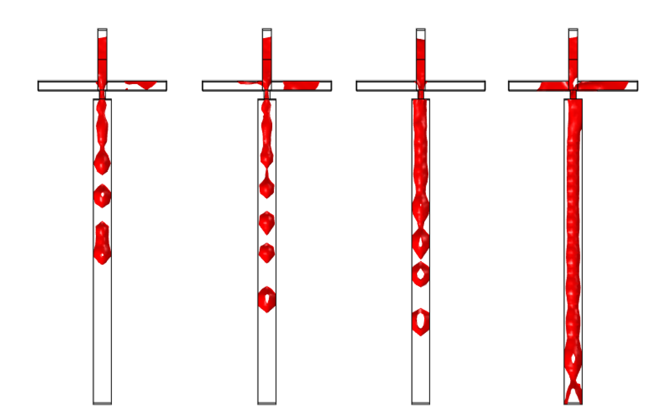

Figure 5. Increasing sheath flow rate by keeping the sample flowrate at 0.5 s

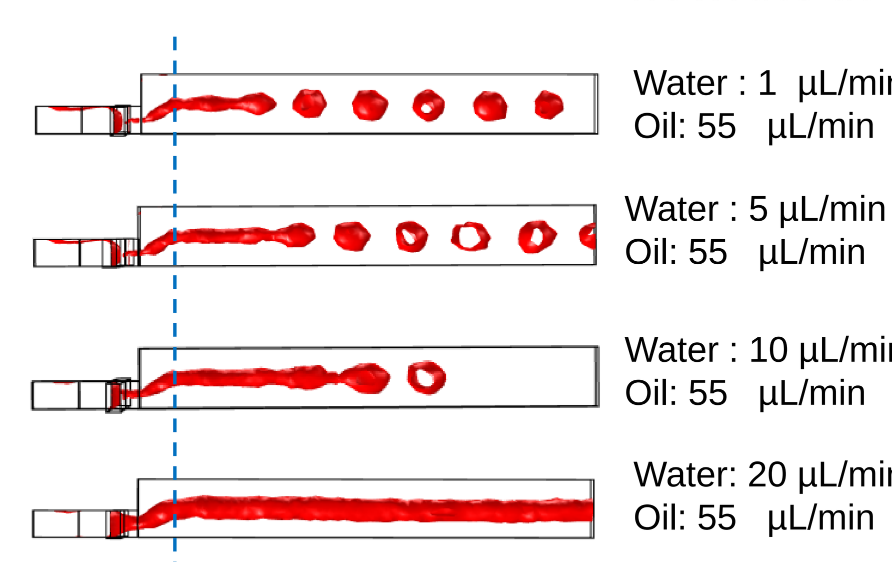

Figure 5. Propagation of generated droplets in the fluid channel with increased height (from 60 µm to 130 µm)

- Lower water flow rate brings the droplet breakup close to the flow focussing region.
- Droplets starts aligning to the centre within a distance of 100 µm from the flow focussing point.
- Not much variation observed in this distance across different sample(water) flowrates.

CONCLUSIONS:

- Successfully simulated a micro fluidic droplet generator.
- Analysed the formation and evolution of the successive droplets.
- Understood the dependence of flow rate ratio of the two phases.
- Finally the droplets observed to be getting aligned to the centre of the fluidic channel within a distance of 100 µm.