Simulation of a Parallelizable Flow-Focusing Constant-Volume Droplet Generator

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Abstract

Microfluidic droplet generators offer distinctive advantages to create emulsions that cannot be matched by conventional methods such as membrane or batch emulsification[1]. Since microfluidic droplets are created in a confined and controlled space in a chip, they can be used as micro-reactors to perform delicate chemical reactions that take advantage of the scaling laws associated with miniaturization[2].

On of the main challenges that this technology has in order to be widely adopted in the industry is related with their scale-up and consequently volume production. A single chip can generate up to 10ml/hour of product. This can be enough for research settings but is far from being sustainable for industrial applications. [3], [4]

Common microfluidic droplet generators, especially those known as flow-focusing generator, are very sensitive to the flowing rates of the continuous and disperse phases[5], [6]. Due to this strong dependence, parallelization of such devices is very challenging because one must ensure uniform flow distribution in a chip and minimize crosstalk and other interactions between them.[3]

For this reason, other geometries that are less sensitive to the flowing rates have been proposed based on a common microfluidic T-juntion. [7]

In this work, we have proposed a new constant-volume droplet generator based on a flow-focusing droplet generator instead. This new configuration has distinctive advantages over the classic T-juntion because the disperse phase is in lesser contact with the channels walls and therefore has lower probability of wetting these walls.

We used the Laminar two-phase flow interface, from COMSOL Multiphysics software, to model this multiphase flow. Our simulations allowed us to simulate different geometries, and identify the key dimensions affecting the constant-droplet formation.

Our results show a successful integration of a flow-focusing droplet generator with a geometrically set constant-volume generator. This integration will allow us to take the advantages of both types of devices into one.

Reference

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Figures used in the abstract

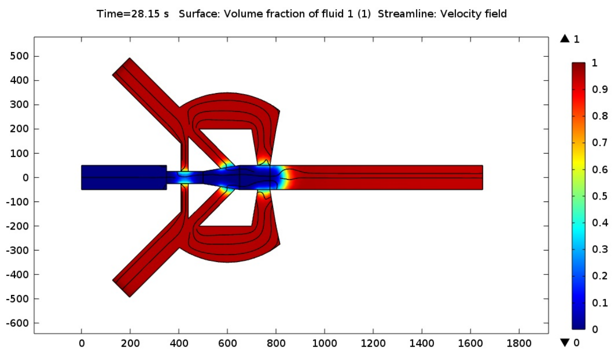

Figure 1: Simulation of a Flow-Focusing microfluidic device for constant volume droplet generation

Figure 2

Figure 3

Figure 4