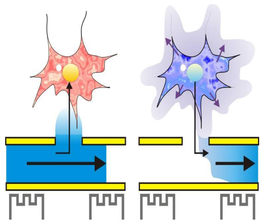
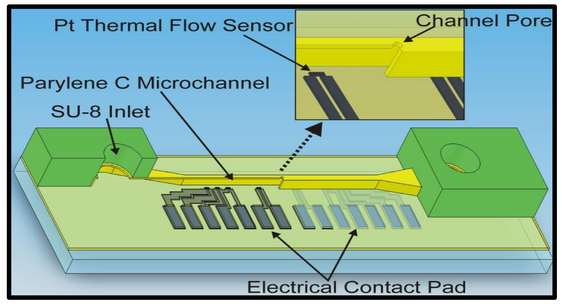
A Microfluidic Platform for the Focal Stimulation

Aye Yin Thu and Ellis Meng
Department of Biomedical Engineering, Viterbi School of Engineering,
University of Southern California, Los Angeles, CA

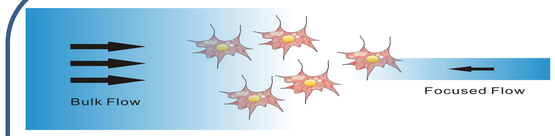
Abstract

Biological systems communicate via exchange of both electrical and chemical signals. Chemical gradients formed in cell signaling, nutrient uptake, waste disposal, and gas exchange influence cell functions. Active polymer-based microfluidic systems previously fabricated in the lab were characterized with a flow rate of 1µL/min. The flow out of the pore is characterized as a function of input flow to the microchannel by measuring the dimensions of a cloud of a Rhodamine B solution ejected into water as a function of time.





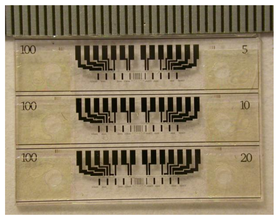
Schematic of the microfluidic platform for focal stimulation



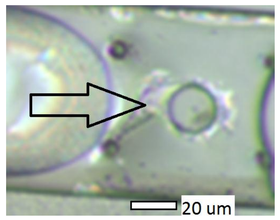
Background

The conventional method of bulk fluid flow delivered by hand-pipetting or other forms of perfusion can only stimulate a large cell population. The microfluidic platform presented here allows for precise and repeatable modulation a targeted cell or small cell group within a population.

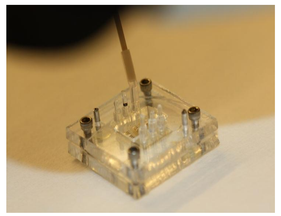
Methods



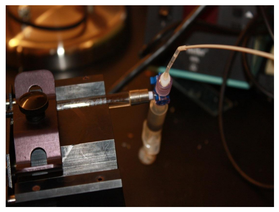
A microfluidic chip (1.5x1 cm) designed with 3 microfluidic channels (4x100µm) each with a pore in the middle of the channel.



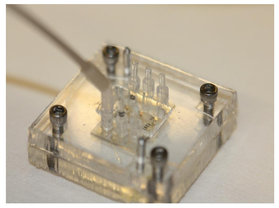
A pore in a microchannel (3 different pore sizes – 5, 10 and 20 µm.



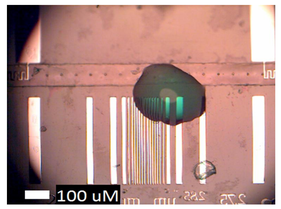
A microfluidic platform is packaged with a custom made acrylic jig and glass capillary tubes are inserted through the PDMS gaskets, carefully aligned to match inlet and outlet ports of the device.



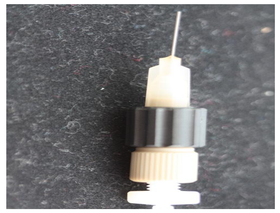
A 3-way valve connecting a glass syringe, a plastic syringe and PEEK tubing is connected to a precision glass syringe driven by a syringe pump.



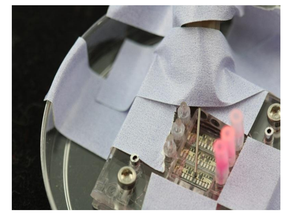
The other end of the PEEK tubing is connected to the assembled microfluidic platform.



The flow rate from the pore is observed and measured as a function of time for a given input flow rate and pore size.



A 30 gauge syringe with 10-32 female to male Luer adapter.



The adapter is placed between the assembled chip and the glass slide to Rhodamine cloud coming out of the pore periodically.

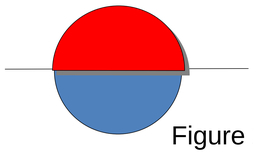


Figure 1.

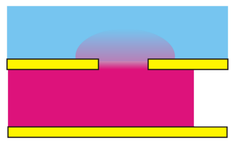


Figure 2.

Results

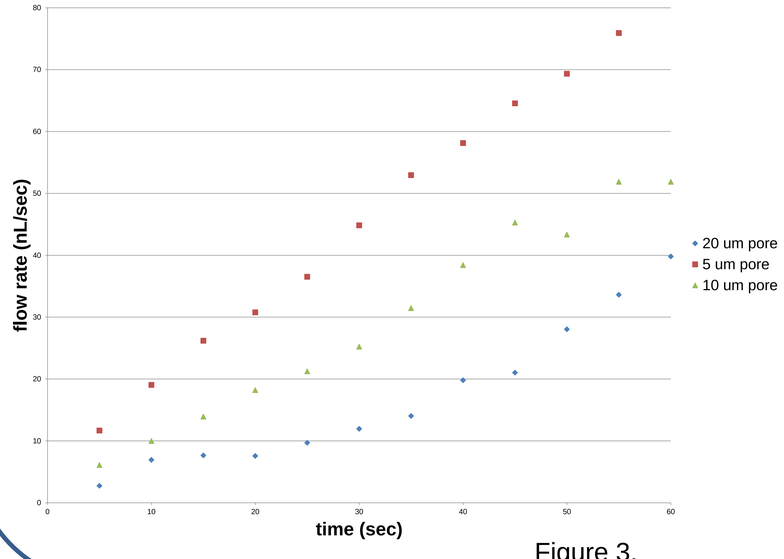
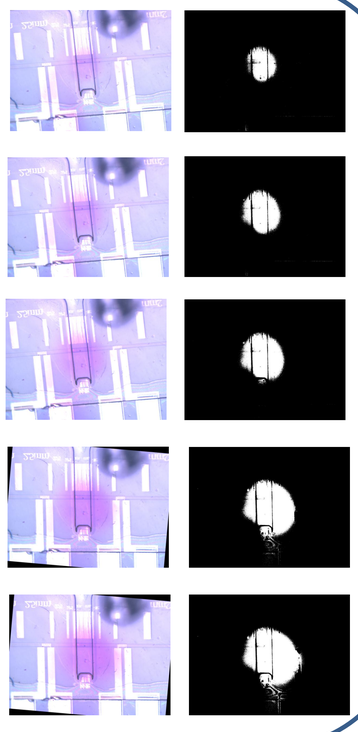


Figure 3.

Flow out of the pore as a function of input flow to the microchannel was estimated by measuring the dimensions of a cloud of a Rhodamine B solution ejected into water as a function of time (Fig.1,2 & 3). Experiments were conducted for all three pore sizes and one input flow rate (1 uL/min) while a glass plate was placed on the device. Volumes were estimated by assuming that the ejected Rhodamine cloud had the shape of a hemisphere(Fig. 1 & 2). Images were taken and processed with ImageJ software (Pictures on the right). To systematically measure the volume of dye ejected from the pore of a microfluidic channel and minimize operator subjectivity, based on the known length on the object, scale was set and images were changed to binary. ImageJ software analyzed particles and calculated the area. Radii of the ejected Rhodamine B were computed and volumes were further calculated ($V = \frac{2}{3}\pi r^3$).



Future Work

The microfluidic channels developed will be used with different cell lines for localized ejection of chemicals at the pore. The biological response of the cells to focal chemical gradients will be evaluated to further develop and fabricate improved microfluidic platforms.

Reference

Kuo, Jonathan T.W., Li-Yuan Chang, Po-Ying Li, Tuan Hoang, and Ellis Meng. "A Microfluidic Platform with Integrated Flow Sensing for Focal Chemical Stimulation of Cells and Tissue." *Sensors and Actuators B: Chemical* 152.2 (2011): 267-76.

Acknowledgements

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