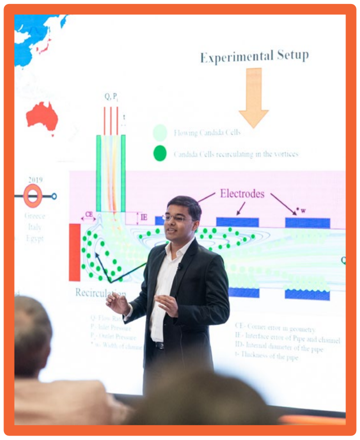
Graduate Student Research Seminar
Fall 2023

Understanding and Mitigating Recirculation, Dead Volume Zones, and Biomass Loss in Microchannels for Cell Manipulation

Shivam Yadav (PhD student)
Advisor: Dr. Rodrigo Martinez-Duarte

Monday, September 11th
3:00 pm (EST) – 132 Fluor Daniel Building



Abstract

Microfluidic devices featuring integrated electrodes have become valuable tools for applications such as cell sorting and electroporation in the realm of biology. Nevertheless, these devices often face challenges related to the creation of recirculation zones and dead volumes, resulting in the loss of biomass and suboptimal performance. This loss of biomass directly diminishes the overall efficiency of these microfluidic devices. In this study, our primary aim is to investigate the underlying factors contributing to the formation of recirculation in microfluidic devices.

Typically, microfluidic devices exhibit a high surface area-to-volume ratio, and their flow characteristics adhere to low Reynolds number laminar flow. However, sharp variations in geometry, often stemming from microfabrication errors, introduce step-like features that induce recirculation in the corners of these devices. Furthermore, the interplay between channel geometry and flow rate significantly influences the emergence of these recirculation zones within the microchannels. Consequently, biomass introduced into these microfluidic devices becomes trapped within these zones, leading to decreased efficiency and throughput during various processes conducted within the microchannel. These processes include cell sorting, cell capture, single-cell sequencing, single-cell proteomics, single-cell imaging, point-of-care testing, cell lysis, electroporation, and more.

This research delves into the causative factors of recirculation within microfluidic devices and presents an in-depth analysis of strategies to mitigate their occurrence. Our objectives encompass establishing correlations between channel length and fluid flow stability, optimizing microchannel dimensions to ensure table flow while increasing flow rates without encountering recirculation, fine-tuning process parameters using simulation results to prevent biomass losses, establishing a connection between biomass loss and recirculation in the microchannel, and expanding the biomass processing capacity without losses within the microchannel.

This study holds the potential to enhance the efficiency of biomass handling within microfluidic devices by effectively addressing the issue of biomass loss caused by recirculation.

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