Executive Summary: BME Design Excellence Award, BME 402

Microfluidic Cell Sorter

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Traditional cell sorting is conducted by tagging cells with molecules or RNA sequences which can be a difficult and time consuming task. The Skala lab has developed label-free optical signals to sort T cells by activation state. Through the use of optics techniques, cells can be excited, identified, and sorted based on their activation state. The lab is in need of a device that will allow for this process to be performed within a single device in order to speed up and improve their research techniques.

Previous microfluidic designs created by the lab have lacked in their ability to center the cells and slow them down enough to be individually read by the laser system. Current devices on the market are not suitable for the specific application as they do not achieve the focus or speed required. The goal of this project is to produce a microfluidic device that will allow for a controlled, reduced velocity flow of cells through an interrogation window to be analyzed by the lab's experimental set-up.

Work this semester included developing flow simulations and CAD drawings for two potential designs. The Funnel design consists of using a 0.18 mm diameter flat tip needle to introduce the cell solution while a sheath flow surrounds the needle until the end. The sides of the device begin to enclose the fluid into a smaller 0.4 mm diameter channel that carries the cells over the laser for reading. As the fluid moves through the funnel part of the design, the velocity will increase as the diameter decreases. The sheath fluid should confine the cells into the center as the sheath flow is on all sides of the cell flow. The final velocity of the fluid within the channel depends on the speed and the volume of fluid entering the system at the two inlets.

The second design, the Snake design, utilizes the principle of inertial lift. When laminar flow is made to pass through a channel that does not generate uniformly parallel streamlines, flow will seek out a path of least resistance. This displays itself in an outlet streamline which is uniformly centered towards the center of the channel. This design consists of a channel with a series of asymmetric serpentining turns resulting in an outlet of single-file cells.

Simulation testing has shown promising results with regard to the ability to center the cells in the microfluidic channel, and, upon further refinement, a prototype will be fabricated for testing in the lab. Results of the simulations have shown that the funnel design is capable of producing cells confined to a window of 0.4 mm and an outlet velocity suitable for imaging within the Skala Lab's system. Simulations of the Snake design have also shown sufficient outlet velocity and focusing of the cells with gradual separation upon increased dimensional and pressure adjustments.

The results of these simulations provide the user with a detailed understanding of the expected functionality of the device. As the simulations show results using the full range of pressures possible to provide the device with the current experimental set-up in the lab, the simulations will continue to be helpful if more precise or powerful imaging technologies are implemented.