CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Vick C. Liu

Project Number
S1208

Project Title
A Microfluidic Device for Blood Separation and Cell Morphology Analysis Using Acoustic Microstreaming

Abstract

Objectives/Goals
The objective of this project is to develop a fully integrated microfluidic device that can be used to automatically separate human blood cells and perform cell morphology studies on a chip.

Methods/Materials
The device was designed based on acoustic microstreaming and hydrodynamic separation principles to separate Red Blood Cells from White Blood Cells. The device was fabricated using soft lithography technology and consists of PDMS microchannels with widths of 10~30 µm. It also consists of pockets that are used to store air bubbles to generate acoustic microstreaming under an acoustic field created by a PZT disk. This device was tested with human blood samples.

Results
It was discovered that acoustic microstreaming not only served as a micropump to move fluids, but also as a method to achieve highly efficient blood cell separation (89% rate) similar to that of conventional centrifugation techniques. At higher frequencies (12kHz), acoustic microstreaming served as a micropump to move the blood solution at a flow velocity of 0.25 mm/sec. However, at lower frequencies (11kHz), the swirling fluidic vortices generated by acoustic microstreaming created a spinning effect, similar to conventional centrifugation. By utilizing different physical properties of blood cells in addition to the effects of acoustic microstreaming and hydrodynamic channels, I was able to successfully separate RBCs from WBCs based on their size difference, mass, and inertia and perform a blood cell morphology analysis to identify various blood cells including RBCs (e.g., sickle cells), and WBCs (lymphocytes, neutrophils, eosinophil).

Conclusions/Discussion
An integrated microfluidic device has been successfully developed to separate blood cells and to perform blood morphology analysis. Three onchip cell separation techniques (hydrodynamic, particle retention filter, and acoustic microstreaming) were investigated. While all achieved good cell separation, the former two suffered from a cell clogging issue. However, acoustic microstreaming showed superior advantages over the other techniques: 1) no cell clogging issues; 2) no moving parts; 3) simplicity; 4) easy to integrate and fabricate; 5) low cost; 6) high WBC separation efficiency. It is the first time this concept of MicroCentrifugation based on acoustic microstreaming has been demonstrated for blood separation and analysis.

Summary Statement
A fully integrated microfluidic device, which can be used to automatically separate human blood cells and perform cell morphology studies on a chip, was successfully developed.

Help Received
Used lab equipment at University of California, Irvine under the supervision of Prof. Lee.