A Microfluidic Device for Blood Separation and Cell Morphology Analysis using MicroVortex Technology

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Blood analysis is a primary test for disease diagnostics since blood is the most important biological fluid. Blood smears are the conventional method for blood analysis, but they are labor-intensive, time-consuming, and prone to human error. The objective of this project is to develop a fully integrated microfluidic device that can automatically separate human blood cells and perform cell morphology studies on a chip. The device design is based on acoustic microstreaming and hydrodynamic separation principles to separate Red Blood Cells (RBCs) from White Blood Cells (WBCs). 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. This device was tested with human blood samples. It was discovered that acoustic microstreaming not only served as a micropump to move fluids, but also generated micro-vortices that achieved highly efficient cell separation (89% rate) similar to that of conventional centrifugation technique. 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 11kHz, swirling fluidic vortices generated by acoustic microstreaming created a spinning effect to separate and concentrate WBCs close to the bubble surface. By utilizing different physical properties of blood cells in addition to the effects of acoustic microstreaming and hydrodynamic channels, the device successfully separated RBCs from WBCs based on differences of size, mass, and inertia and performed a blood cell morphology analysis to identify blood cells including RBCs (e.g., sickle cells), and various types of WBCs.

Awards Won:
Third Award of $1,000