# Design and fabrication of a microfluidic system for compact portable flow cytometry

**Robert R. Real, Dao Y. Lim, Alek D. Jerauld, and Nastaran Hashemi**
Department of Mechanical Engineering, Iowa State University, Ames, IA, 50011

## Introduction

In order to better understand the effects of global warming on marine life, a common practice is to use a flow cytometer to measure the size and light responses of microscopic organisms in the water.
Our goal in this project was to develop a compact, cheap and portable device that could be used for on site analysis of microorganisms in the ocean, and interface with a simple laptop requiring little other equipment . To do this we developed a microfluidic system that could be cheaply manufactured, and easily produced.

## Flow Cytometry

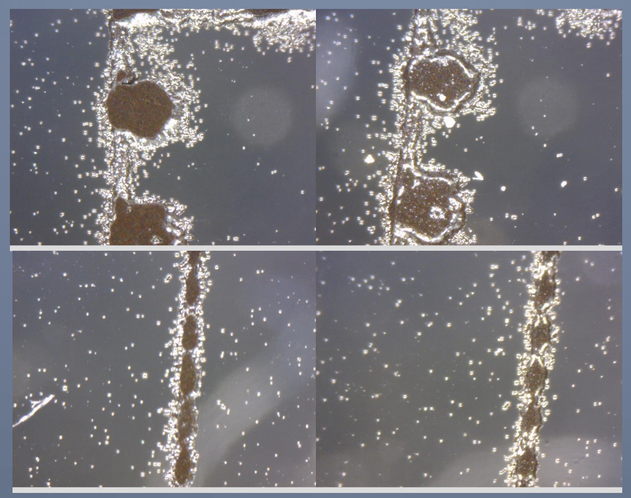
Flow cytometry uses a light source aimed at a sample stream of a fluid. The excitation light is filtered to a specific wavelength, and excites the particles. On the output side of the channel, another filter of a different wavelength filters out all the light that isn't emitted by the particle. The emitted light is then picked up by a photo multiplying device and recorded for analysis.
From the frequency and number of emitted photons you can determine the number of particles per fluid volume. Additionally by seeing which spectrums the particles absorb and emit the best, you can determine some properties of the test materials.

## Design

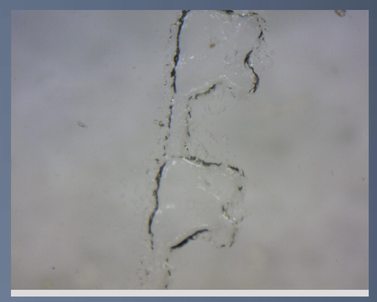
The chip was designed with the main principle being a cheap and compact design. For this reason a design similar to that by Kettlitz et al. was used, with a polydimethylsiloxane (PDMS) microchannel. A white LED was used in place of a laser for excitation light, with a filter of 532nm to reduce ambient light and narrow the wavelength to the excitation frequency. The light emitted by the sample was passed through a 575nm filter and collected by an avalanche photo diode (ADP). The signal passed through several electronic noise filter circuits, and was analyzed.

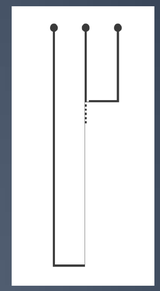
## Fabrication

A fabrication method was employed using shrinking thermoplastic or "Shrinky Dink" as had been demonstrated by Grimes et al. A scale model of the microchannel was constructed in Solid Works, and the image was printed onto the thermoplastic at 1200dpi. The image was baked at 163°C for 5 minutes on a petri dish until shrunk. The shrunk mold was put in to bake for a second time for 7 minutes to smooth out the ink. The resulting mold was used as a negative for the PDMS lab chip.
A sheathing technique was used that employed vortex zones to wrap a sample flow in a sheath using only single height geometry which simplified the fabrication process allowing for only one pass of the printer which kept the geometry precise.



Above are images of the printed microchannel mold elements at different phases in the process. To the left we have the channel after only the initial bake to shrink the plastic, and to the right we have the same channel after it has gone through a second baking cycle to smooth out the ink features. The top row is a close up of the focusing element, and the bottom shows the main channel where the analysis takes place.





To the left: a picture of the finished PDMS microchannel fabricated and sealed. Shown is the focusing element, the part of the microchannel requiring the most precision.
To the right: the image of the complete microchannel that was printed onto the Shrinky Dink. The waste comes out the left circle, the sheath fluid goes in the middle and the sample goes in the right.

## Conclusions

It was found that the Shrinky Dink fabrication technique was unable to produce a channel of the required depth. Instead of having a main channel of the target depth of 50 microns, only 20 microns was reached. It was found the the wider elements had a greater print height, however we were unable to scale up the geometry to achieve the necessary depth while maintaining the small elements.

## Acknowledgments

We gratefully acknowledge the Iowa State University Foundation and Honors Program for their support of our research, as well as the mechanical engineering department for allowing us to use their equipment.

## References

1. Siegfried W. K.; Sebastian V.; Wibke S.; Uli L. Flexible Planar Microfluidic chip emplowing a light emitting diode and a PIN Photodiode for Protable Flow Cytometers. *Lab Chip* [online] **2012**, 12, 197-203.
2. Anthony G.; David N. B.; Maureen L.; Jonathon P.; Luke P. L.; Michaelle K. Shrinky-Dink Microfluidics: Rapid Generation of Deep and Rounded Patterns. *Lab Chip* [online] **2008**, 8, 170-172.
3. Myung G. L.; Sungyoung C.; Je-Kyun P. Three-Dimensional Hydrodynamic Focusing With a Single Sheath Flow in a Single-Layer Microfluidic Device. *Lab Chip* [Online] **2009**. 9, 3155-3160.