An Integrated Microfluidic Device for Onsite Particle Detection

Patrick Kalgren and Nastaran Hashemi

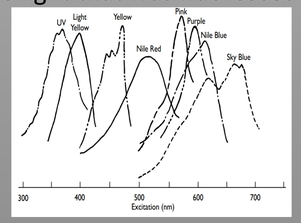
Department of Mechanical Engineering, Iowa State University, Ames, IA, 50011

Introduction

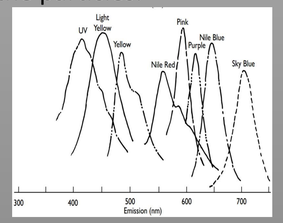
Flow cytometry is the use of light to analyze particles in a liquid solution. Some common applications of this technology include counting and sorting white blood cells, or analyzing microorganisms in the ocean. Cytobuoy was a recent invention that was completely autonomous and employed a flow cytometer to analyzed marine microorganisms. Most flow cytometers are very big and expensive. Our goal was to create a portable device that was small, used cheap materials, and was capable of plugging into a USB port on a computer.

Optics

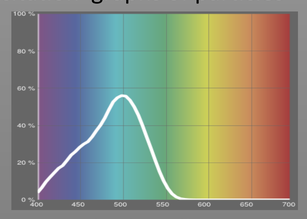
There are four main parts to the optical part of the device. There is an excitation filter, a microfluidic channel, a shadow mask, and an emissions filter. The excitation filter is used to only allow light of the correct wave length to go into the microfluidic channel. The correct wave length is between 475nm and 540nm, which is the correct range to cause the particles that we use to fluoresce. The excitation filters is placed directly on top of the microfluidic channel. Our microfluidic channel was made out of PDMS (Polydimethylsiloxane) and was a long and straight channel. The shadow mask was placed underneath the channel and consisted of tinfoil covered in photo tape with a 0.5 mm hole punched in it. The emissions filter was placed underneath the shadow mask and allowed light of wavelength 575 nm and above which contains the wavelength of the light that was fluoresced off of the particles.



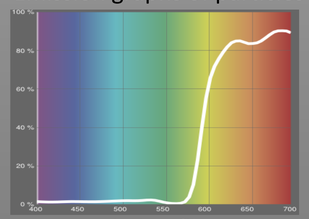
Excitation graphs of particles



Emission graphs of particles



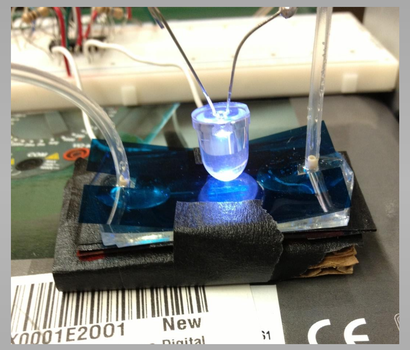
Excitation Filter



Emission filter

Electronics

The electronic components of the device include an LED, a USB sound card, a photodiode, and a circuit to amplify the current of the photodiode. The circuit was connected to the soundcard which then converted the signal into a form that the computer could read. The LED (Radio Shack 276-005) was used as a stable supply of light that would then be used to excite particles. The proper resistor that was used in series with the LED was calculated using the formula $R = (V_s - V_f)/I_f$.



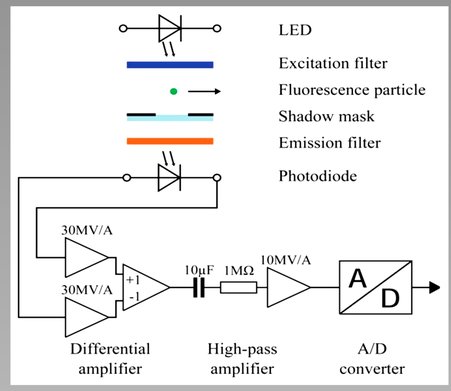
Electronics Testing

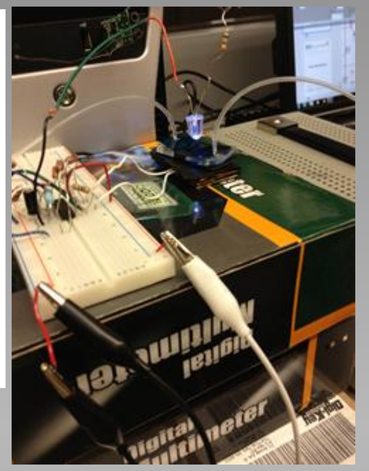
Originally the circuit was found to not be functioning. The output voltage wasn't changing when the photodiode was put into different light conditions. A resistor was found to be out of position and after it was fixed the circuit worked.

Experiment Setup

When the experiment is run, the LED is positioned directly over the channel and the photodiode is placed directly under the opening in the shadow mask. The circuit is connected to the sound card, which is plugged into a USB port. The program on the computer that we are using is Labview. The code that we are running in Labview is called WaveIO, which allows us to see a real time graph of the intensity of light that the photodiode is seeing. For our experiment we would want to see a spike in the intensity when a particle goes through the channel. In order to get the particles (nile red 6µm, Spherotech) to pass through the channel, they are diluted in a saline-Tween solution at a ratio of 100µl per 1 ml of solution.

The particles are then forced into the channel using a syringe pump which flows at a constant rate of 3000 µl/h.





Conclusions

The experiment hasn't been run yet, there is a problem with the circuit and the soundcard. If we wanted to make the device more practical we could transfer the circuit to a chip that would be more permanent. We could also use a microfluidic channel design that would focus the particles in the center of the channel in a straight line. The idea of using cheap, small materials in flow cytometry was a big step in the field because it allows the technology to be used in a wider set of applications.

Acknowledgements

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References

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2. Dao Yan Lim, Alek D. Jerauld, and Nastaran Hashemi, "Designing a Low cost Data Acquisition Device for a Portable Flow Cytometer", Iowa EPSCoR All Hands Meeting, Iowa City, IA, July 31, 2012.