Building a Droplet Microfluidics Testing Platform

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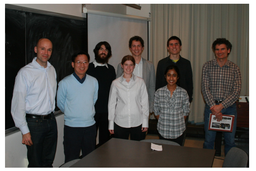
SCOPE
Senior Capstone Program in Engineering



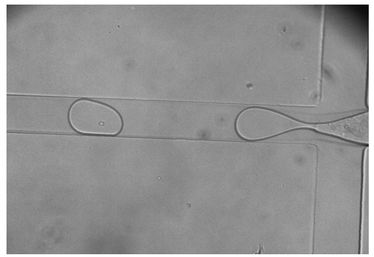
Project Statement

Microdrop microfluidics is an emerging technology for high throughput screening and processing of biological systems ranging from directed evolution to protein crystallization. Our team has implemented merging, interrogation, and sorting of droplets for the NSF Materials Research Science and Engineering Center at Brandeis. To do so, we developed a series of microfluidic chips and a test stand capable of actuating sorting in real time based on fluorescence levels, enabling Brandeis to pursue new directions of research.

Functions Implemented

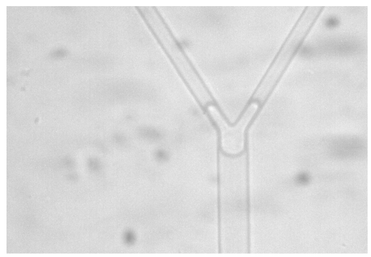
Formation

Droplet formation at a cross junction.

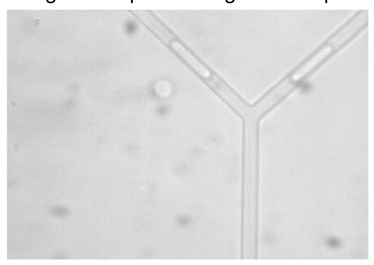


Splitting

Droplet splitting at a channel bifurcation.

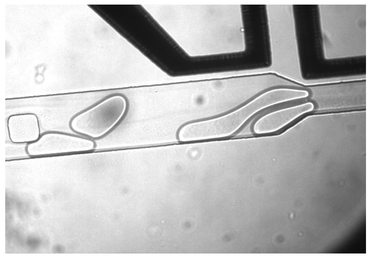


Daughter droplets taking different paths.



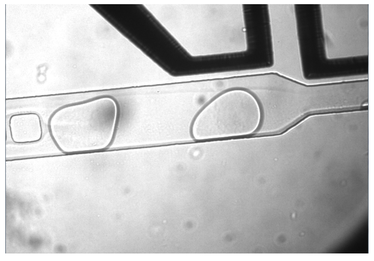
Merging

Chip with the electric field turned off.



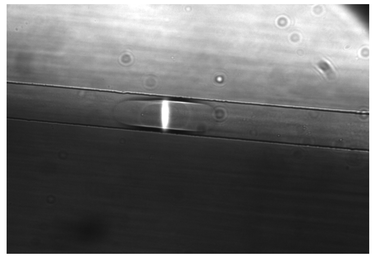
Two droplets prior to merging; 40VDC applied across the electrodes.

Droplets merged by electric field.



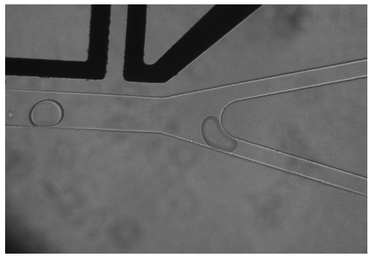
Interrogation

Fluorescence in a microfluidic droplet excited by a laser.

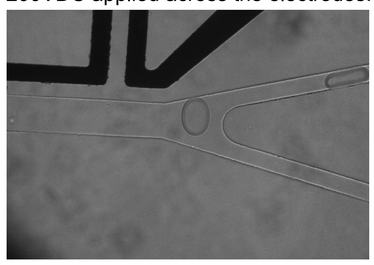


Sorting

Droplets taking the lower path absent an electric field.

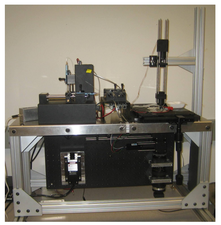


Droplets being steered to the upper path; 200VDC applied across the electrodes.

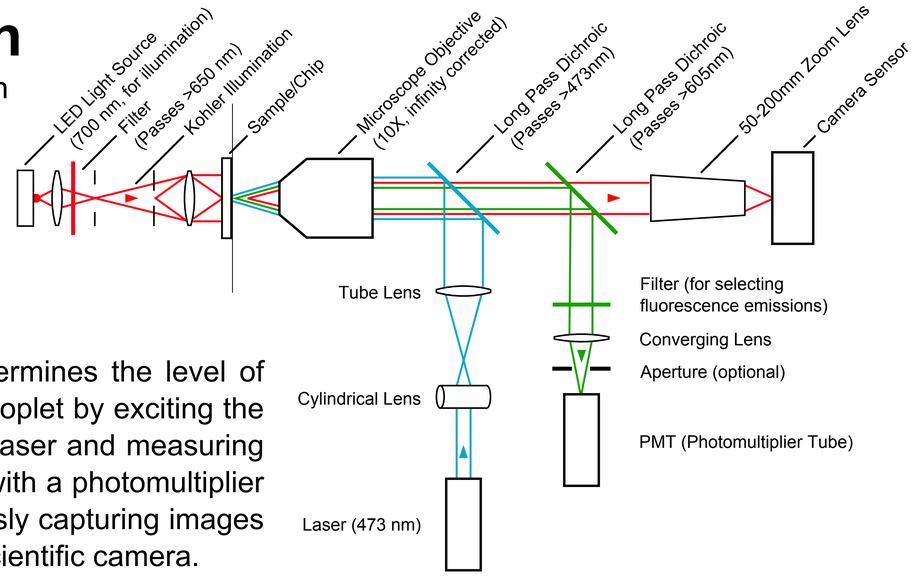


Optics Train

for droplet interrogation



The optics system determines the level of fluorescence in each droplet by exciting the fluorescent dye with a laser and measuring the emission intensity with a photomultiplier tube while simultaneously capturing images of the droplets with a scientific camera.



Hardware

for data collection

The hardware subsystem serves as an interface between the software and the physical world and houses the mechanical assembly. It consists of a real-time computer, analog input and output modules, and a standard Windows PC, and interfaces with the PMT and scientific imaging camera.

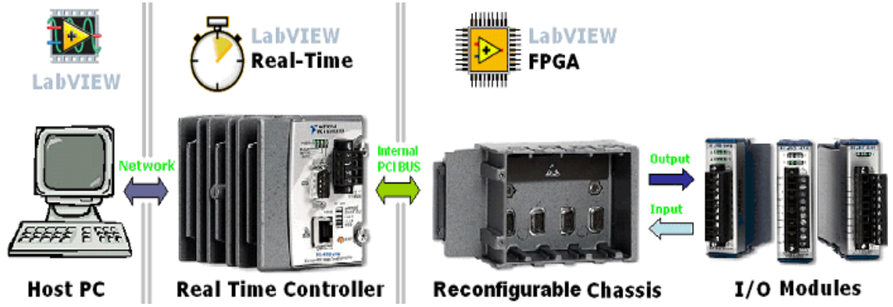


Image retrieved from *FPGA Design, Development and Programming Tutorial*, NI, http://zone.ni.com/devzone/cda/tut/p/id/3358.

Software

for data processing

The software subsystem collects data from the PMT, analyzes it, and makes decisions about whether or not to actuate the droplet by sending the appropriate signals to the hardware subsystem. The software also provides a graphical user interface (GUI) for reading the input waveform generated by the droplets, extracting statistics about device operation (e.g., droplet frequency, stability, etc.), and logging both raw data and statistical information.

Time Trace

of actual droplet data