

HoliFab: Precise Flow Control using Photo Actuated Hydrogel Valves and PI Controlled LED Actuation for Microfluidic MEMS.



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FUNDED BY:



Adaptive Sensors Group



Principle Investigator: Prof. Dermot Diamond
Team Leader: Dr. Margaret McCaul

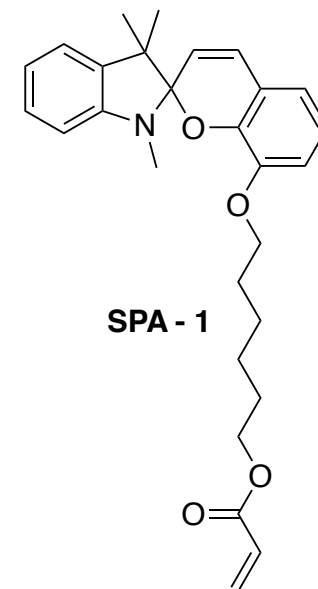
Multidisciplinary Team of Analytical Chemists,
Engineers, Material and Computer Scientists



**Wearable
Sensing**



**Environmental
Sensing**



**Material
Science**

Microfluidics

Microfluidics is the science of manipulating and controlling fluids, in a constrained network of channels. It is a multidisciplinary field with advantages including:

- Decreasing sample and reagent consumption
- Shortening runtime of experiments
- Reduces the overall cost of applications

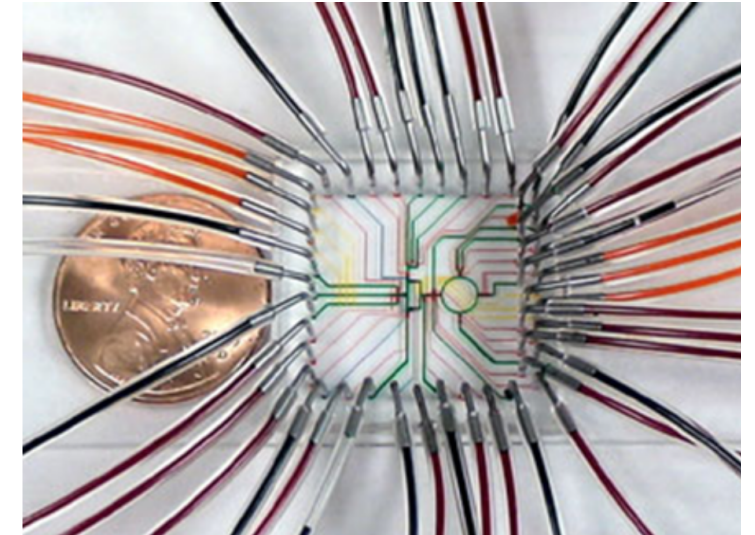
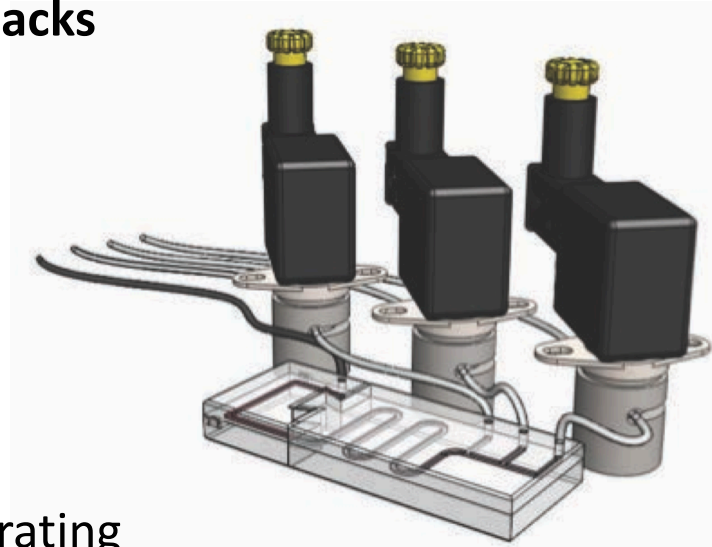
Applications in areas including Environmental Sensing, Medical Devices, On body Sensing, Biotechnology, Lab on a chip, Organ on a chip.



Towards on Device Integration

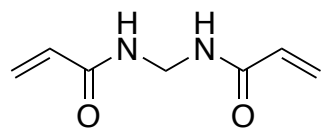
The use of conventional valves in microfluidics has a number of drawbacks including:

- Large power demand
- High Cost
- Has to be mounted externally
- Increased dead volume

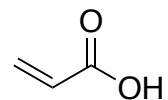


Drawbacks can be overcome by integrating fluidic control within the fluidic chip. Soft Polymer valves may hold solution to inline fluidic control

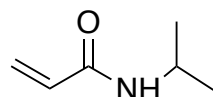
Soft Polymer Composition



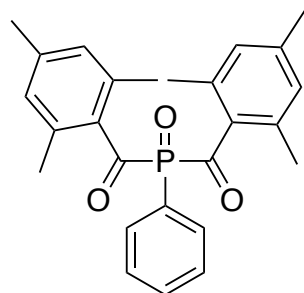
MBIS



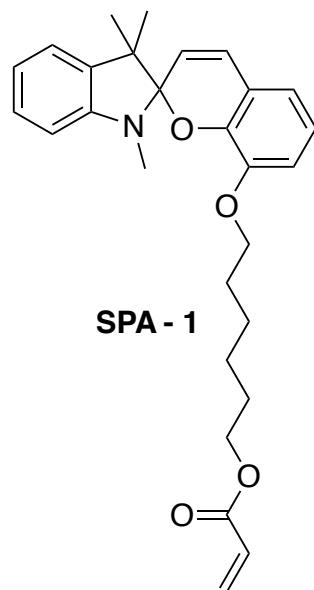
Acrylic Acid



NIPAAm



Irgacure 819



SPA - 1

Soft Polymers can be used to create valves in situ within Microfluidic channels

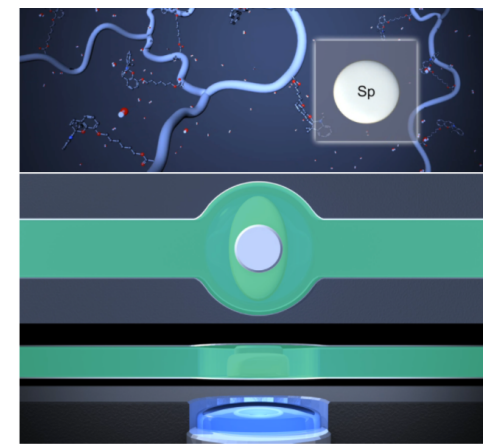
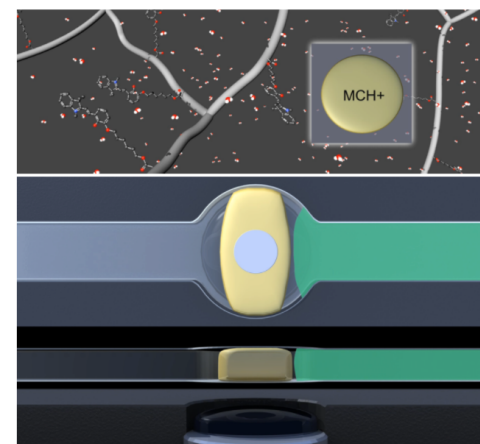
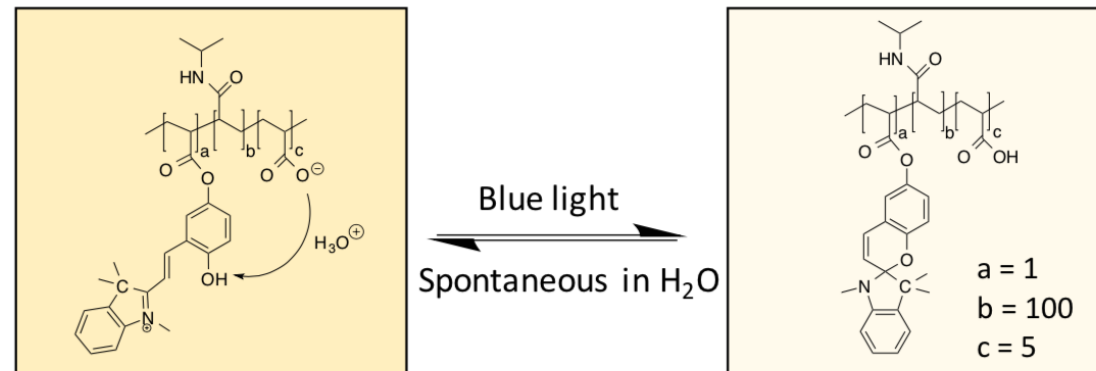
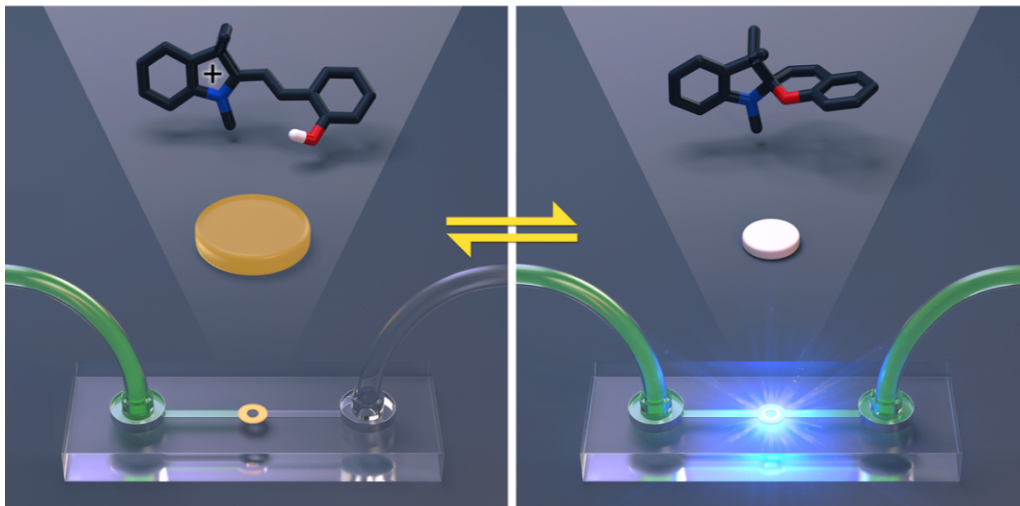
The Polymers can be actuated by pH, Light, Temperature.

Light was chosen by integrating a photo initiator for the work presented, however this can be changed to make the gels responsive to various stimuli

Monomer Cocktail Solution

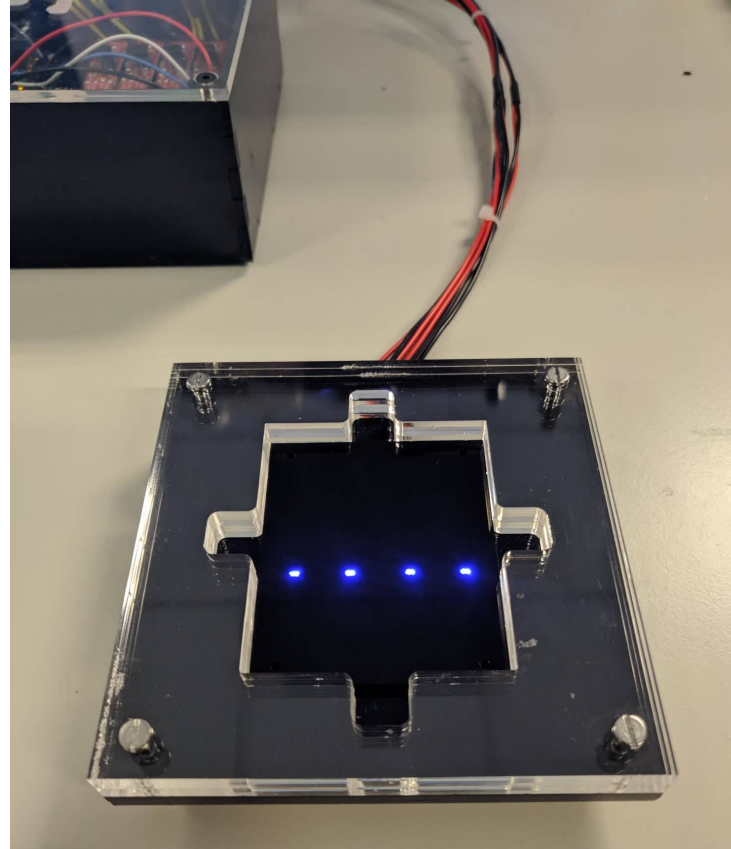
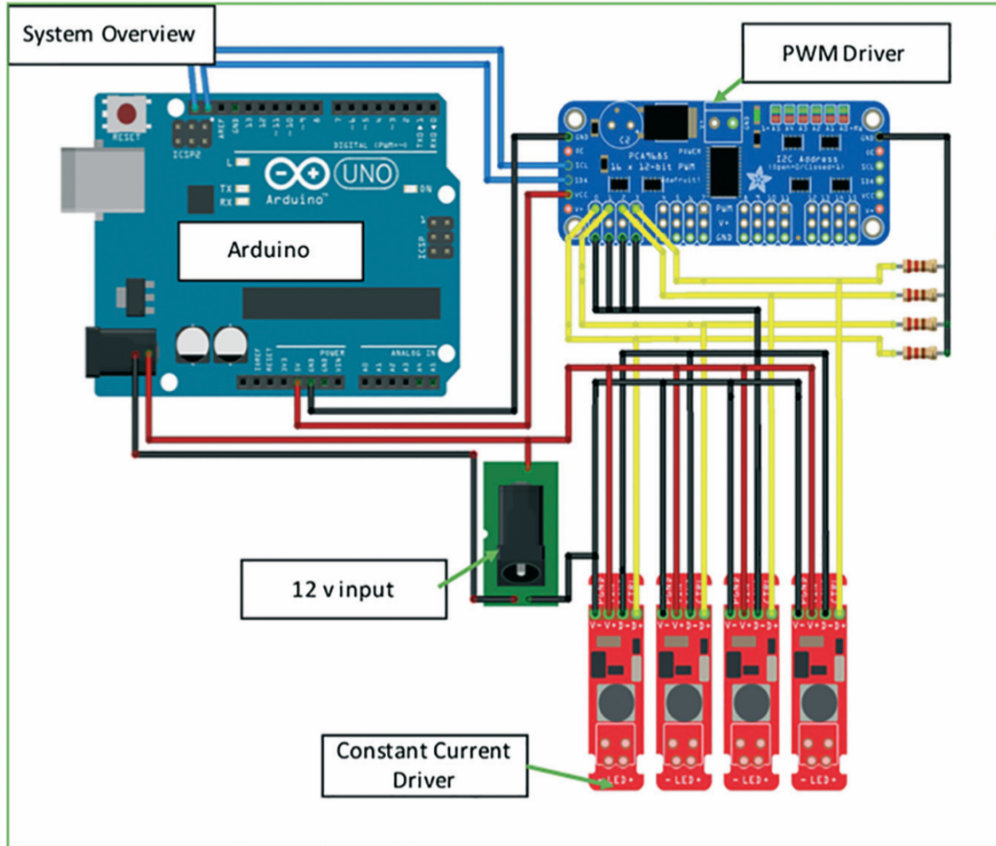
The photo responsive valves can be photo polymerised in situ using a monomeric cocktail containing 200 mg NIPAAm, 8.35 mg MBIS, 7.91 mg SPA-1, 7.42 mg PBPO and 6.05 μL Acrylic Acid (dissolved in 500 μL of the polymerisation solvent (2:1 v/v, THF:DI water) and an externally mounted LED.

Microfluidic Concept – Integrated Polymer Valves



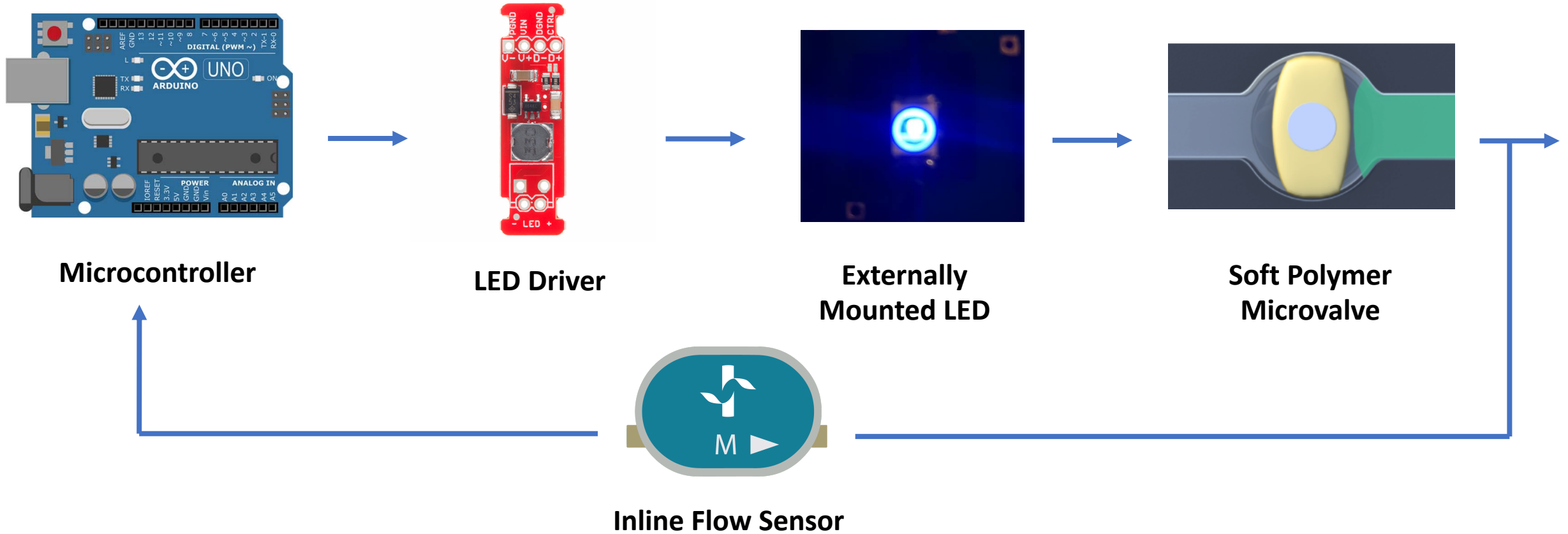
Conceptual model showing integrated soft polymer valve within microfluidic channel being controllable by externally mounted LEDs

Actuation and Control



PI control using an inline flow sensor is implemented to accurately control the brightness of the LEDs which in turn can control the flow.

Actuation and Control

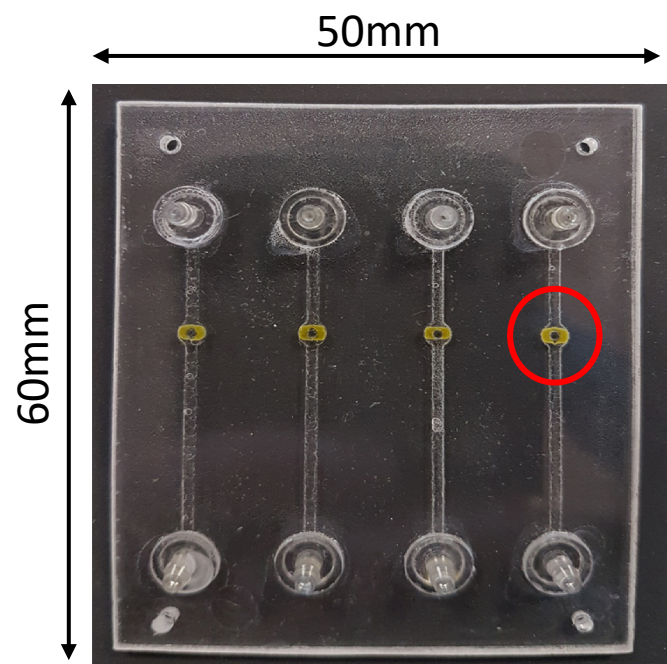


<https://www.fluigent.com/product/microfluidic-components-3/#packs>

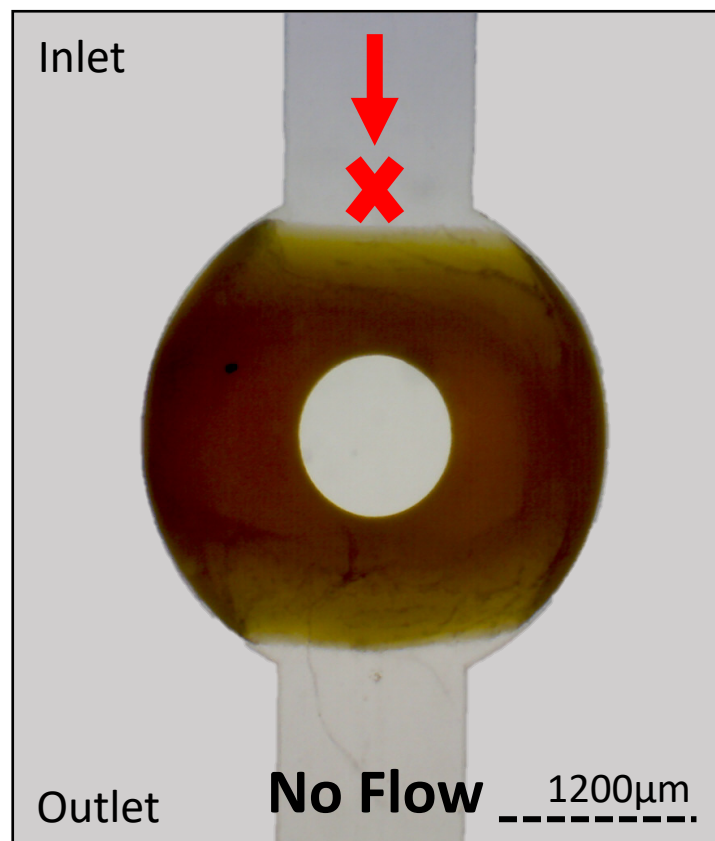
<https://www.digikey.com/-/media/MakerIO/Images/blogs/2018/How%20to%20Add%20a%20Simple%20Circuit%20to%20Your%20Arduino/Fig-1.jpg?ts=4e2d9e7a-2725-4247-921b-57bd6d02c4f5&la=en-US>

Soft Polymer Valve Actuation

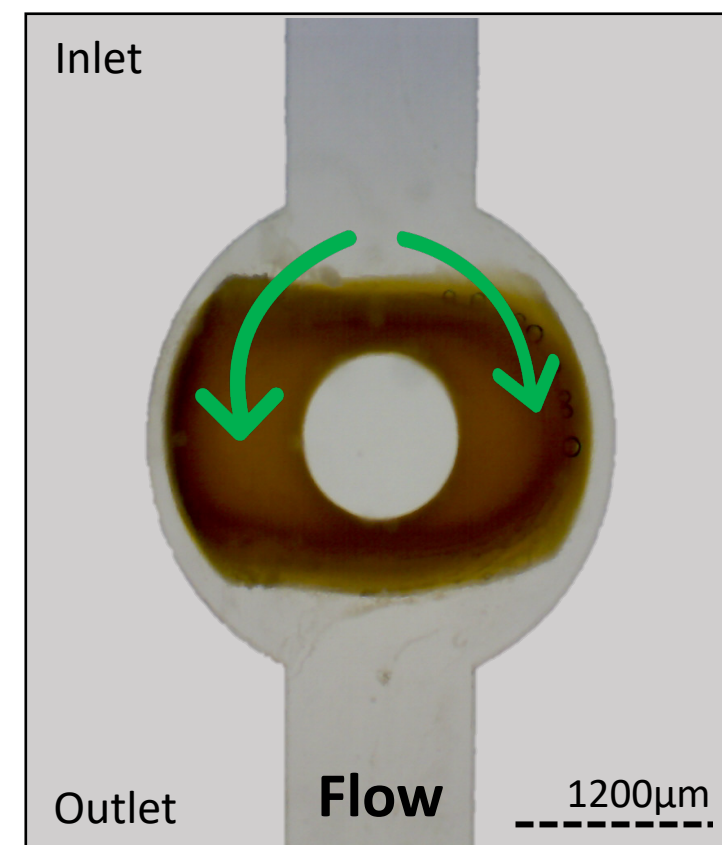
Actuation of Soft Polymer Valves Carried out using LED actuation (450nm)



Valve Closed / Gel Swollen



Valve Open / Gel Contracted

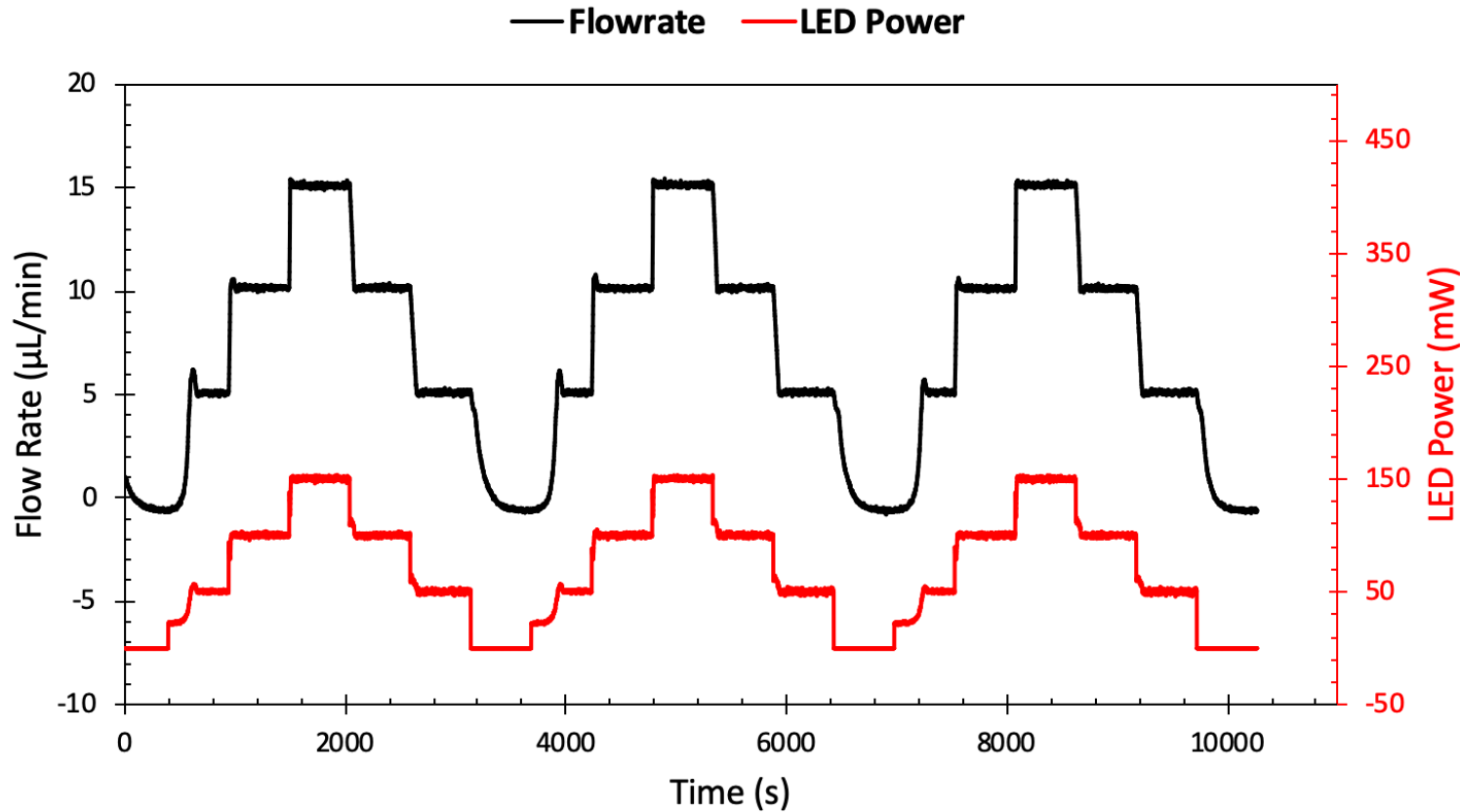


Blue Light
($h\nu$)



Relaxation
(H^+)

Microfluidic Flow Control



Flow rate control obtained using Photo responsive Polymer Valve and PI control.

Cycles of (5.0, 10.0, 15.0, 10.0, 5.0 $\mu\text{L}/\text{min}$) shown in black (KP = 5 at 5 $\mu\text{L}/\text{min}$, KP = 8.0 at 10.0 $\mu\text{L}/\text{min}$ and 15.0 $\mu\text{L}/\text{min}$; KI = 0.1), overlaid with power supplied to the LED to achieve actuation in red.

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