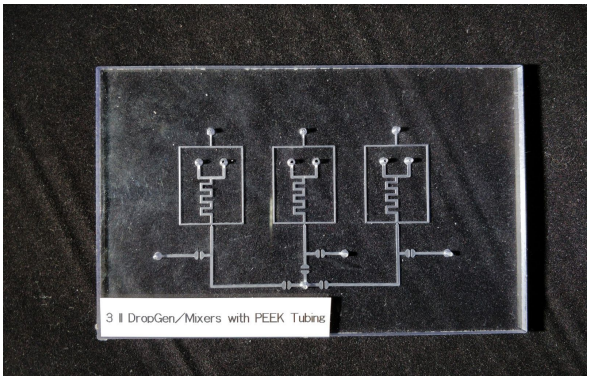
Cell Free Proof of Concept Chips

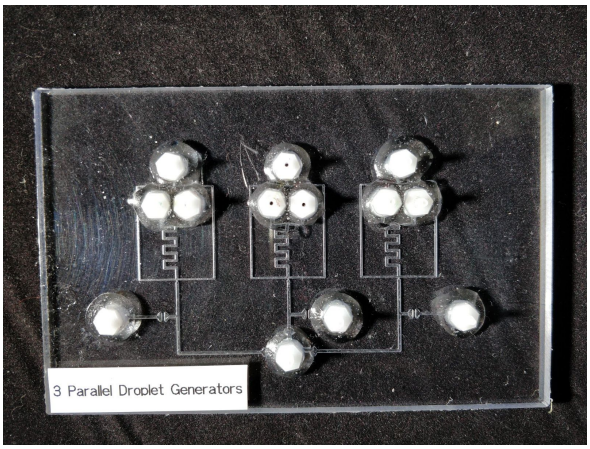
This microfluidic chip consists of three parallel systems, each designed to mix the TX-TL cell free solution and specific substrates needed to yield the desired colorimetric product. These three systems are combined by a series of valves that serve as a selection mechanism that directs the desired colored solution to the chip's output.

Initial Design



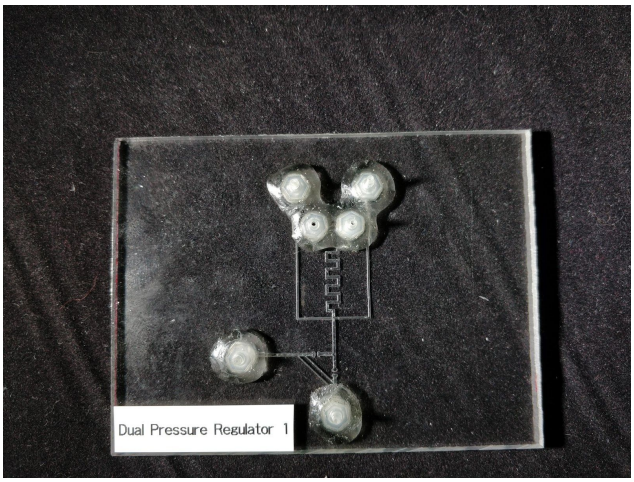
An initial idea was to use PEEK tubing for the input ports because their smaller volume would mean less reagent would be used during the course of the experiment. However, the amount of prep work post milling needed to accommodate the PEEK tubing was inefficient and so the chip was redesigned with our normal sized ports.

Version 2



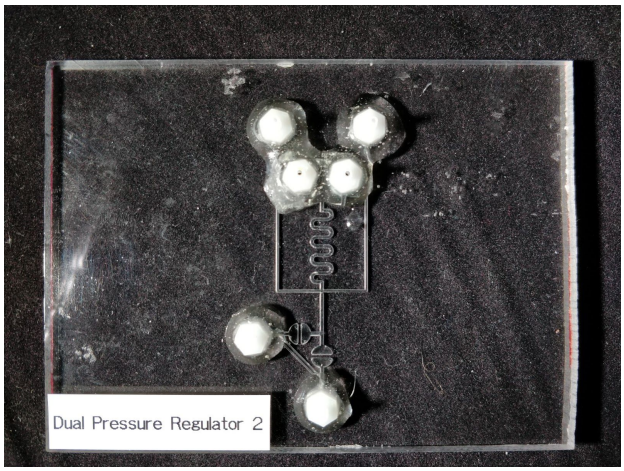
While the chip served its purpose and was capable of mixing fluids and creating droplets, when the output selection valves are actuated, the difference in pressure results in a series of deformed droplets for a couple seconds before the flow can restabilize. The new goal is to mitigate this pressure difference in an effort to significant decrease the number of deformed droplets and the time it takes for the chip to restabilize.

Version 3



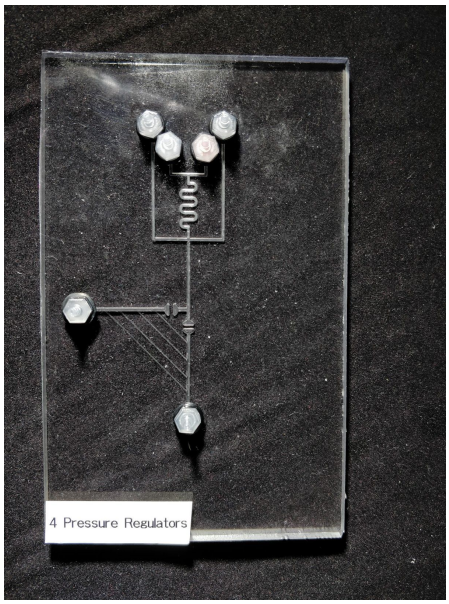
In order to save time on both fabrication and trouble-shooting, when testing the efficiency of a chip with pressure regulators, only one of the three pathways was used. While the results showed a slight decrease in restabilization time, there were still many deformed droplets. More pressingly, the pressure regulators were siphoning off some of the fluid from each droplet and the droplets themselves were merging when crossing through the valve. The valve problem would be solved when the diameter of the valve is increased. Switching to a curved mixer and making the output ports equidistance should help decrease the pressure difference. Finally, it was theorized that by increasing the difference in resistance between the output channels and the pressure regulator should help solve the problem of fluid being pulled from the droplets into the pressure regulators.

Version 4



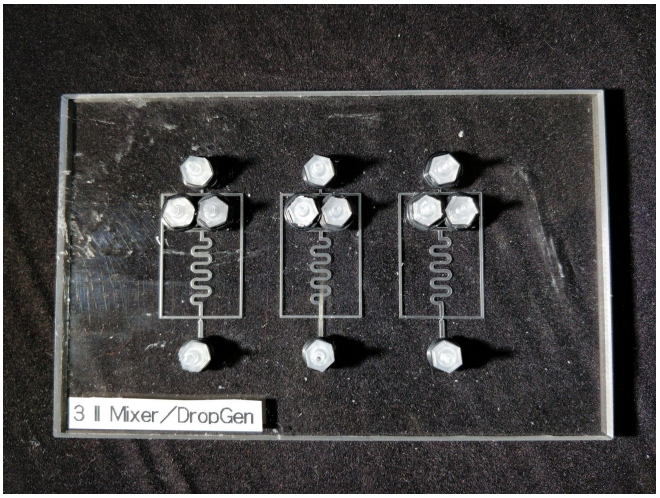
Once again, the restabilization time was decreased, but the fluid was still being pulled into the pressure regulators. In the next version, it was decided that the difference in resistance would be made even greater and that the number of pressure regulators would be increased. The resistance increase will be achieved by milling shallower, thinner pressure regulators, while simultaneously milling deeper, wider output channels.

Version 5



The four pressure regulators served their purpose and distributed the pressure evenly enough so that there is only one slightly deformed droplet per valve actuation, meaning there is a very fast restabilization period. This error holds true a variety of flow rates, both fast and slow. The respective resistance difference and number of pressure regulators used in this chip were successful and therefore used as the model for the branches of the droplet-based TERRA Adapters. The next step is to scale up the chip so that there are all three droplet generator systems and the output selection mechanism, or to combine a just the droplet generation systems with a three output TERRA Adapter.

Version 6



This version is designed to be used with TERRA Adapter. The design consists simply of three curved mixer, droplet generator units like those seen in the earlier versions of this chip. This chip will be tested with with colored water in preparation for our cell free experiments.