A Soft-Polymer Piezoelectric Bimorph Cantilever-Actuated Peristaltic Micropump

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For this work, a peristaltic micropump was fabricated. Actuation of the micropump was accomplished with piezoelectric cantilevers. To date, a minimal number of soft polymer-based micropump designs, have explored the use of piezoelectric materials as actuators. The fluidic channel for the micropump was fabricated using PDMS and soft lithography. A novel and very simple template fabrication process was employed, where the use of a mask and clean room facilities was not required. Replica molding to the template produces both, a channel measuring 95 μm in height, and a rounded cross-sectional geometry, the latter of which is known to be favorable for complete valve shut-off. Clamps were adhered to the tips of the cantilevers, and used to secure in place aluminum valves. The valves had finely machined tips [3 mm × 200 μm (L × W)] on one surface. These tips served as contact points for the valve making contact with the PDMS membrane surface, and were used for the purpose of opening and closing the channels. The cantilevers were secured in place with in-house manufactured micropositioners, which were used to position the valves directly over the PDMS channel. The micropump was thoroughly tested where the variables characterized were maximum attainable backpressure, flow rate, valve open/close characteristics, and valve leakage. The effect of the phase difference (60°, 90°, and 120°) between the square wave signals delivered to each of the three cantilevers was investigated for flow rate and maximum attainable backpressure. Of the three signal phases, the 120° signal demonstrated the largest flow rate range of 52–575 nL/min (0.1–25 Hz), as well as the highest attainable backpressure value of 36,800 Pa (5.34 psi). The valve shutoff characteristics for this micropump was also examined. Fluorescein was trapped inside the microchannel, where the fluorescent signal was monitored throughout the valves open/close cycle with the aid of an epifluorescent microscope. It was found that the fluorescent signal went to zero with the valve fully closed, supporting the conclusion that the valve completely closes off the channel. Further evidence of this claim was demonstrated by observing the valve leakage characteristics. An electronic pressure sensor was used to collect data for this experiment, where it was found the valve was able to hold off 36,800 Pa (5.34 psi), only losing 2% of this pressure over 10 minutes. In conclusion, it has been shown this micropump outperforms many existing micropump designs, and is suitable for integration into a variety of both macro, and microdevice platforms. Experiments are currently underway to examine how the flow and valving characteristics change for valves with different tip dimensions. A discussion will also be given for improved fabrication techniques, where injection molding is currently being used as the fabrication method to examine the performance changes associated with different cross-sectional PDMS channel geometries. The end goal for use of this micropump is twofold: 1) integration into a micro-free flow separation device, and 2) integration into a capillary electrophoresis instrument for use in direct-sampling neuroscience experiments.