Fabrication of Microfluidic Devices with Integrated Transducers for Fluid Pumping

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Abstract:

The ability to fabricate miniaturized channels for the handling of biofluids helps to advance biomedical research. To further develop the use of these channels, we incorporate transducers to be used for the pumping of fluids throughout the system. We have etched the anisotropic channels into a double-side polished silicon wafer and at present the wafer is being bonded between two quartz wafers. Once this is completed, transducers will be added on top of the quartz wafer.

Transducers convert electrical energy into radiation pressure which is used to push the liquid in a desired direction. We are testing the use of sound radiation to facilitate the movement of fluids through the channels. Our group has already used transducers in such channels. To create a better device for pumping applications, we used a more complex geometric layout. Once fabricated, we will be monitoring the movement of fluid in the channels by taking pictures with a charge coupled device camera. Through use of these developed channels and transducers, advancements in the field of microfluidics will be possible.

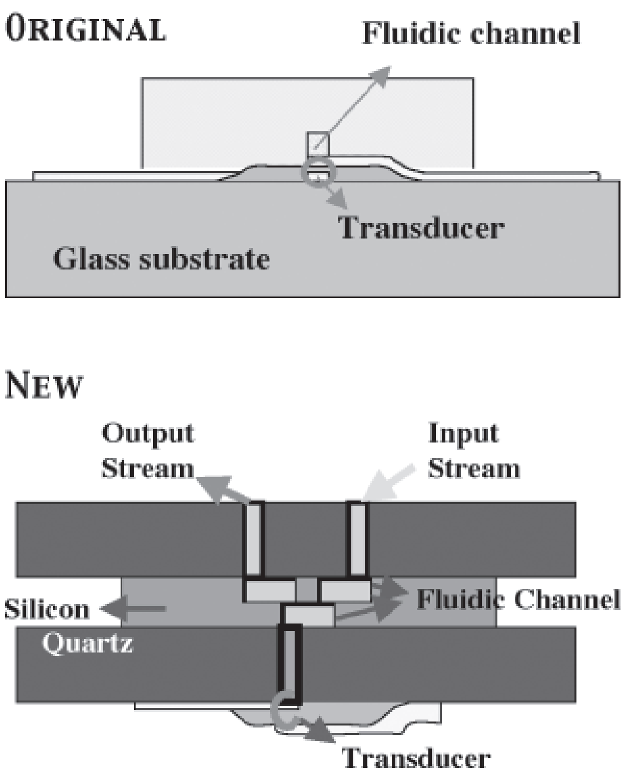

Figure 1: Comparison of old design with our new design.

Introduction:

Microfluidics is essentially the study of the movement of liquids in channels built on the micro or nano scale [1]. Advancements are being made in this field by testing the ability to move and direct liquids or certain particles as they move throughout the channel [2]. We need to detect the presence of certain materials and locate their positions in order to better understand the interactions of these microscopic substances.

This research group works to integrate transducers into microfluidic channels, and use ultrasound for detection and fluid actuation purposes [3, 4]. Our group's previous designs used single level channels, while our new design involves bi-level channels. Figure 1 shows the simpler one channel design next to our new more complex tri-channel design. While the previous research focused on using transducers for mixing liquids or switching channels to open or closed, our project is now testing the pumping capability of transducers.

Transducers work in the following way: the transducer is hooked up to a RF voltage source. This source excites the transducer, allowing it to emit sound wave propagation through the channel. The sound propagation has a corresponding radiation pressure, which actuates fluid in the channel. This pressure is used to move either the fluid or a specific particle in the stream. Figure 2 shows the positioning of the transducer in our design. We position the transducer so the pressure is applied precisely at the location and in the necessary direction to pump the liquid back up to the higher level, as shown in the picture of the complex bi-level design in Figure 2.

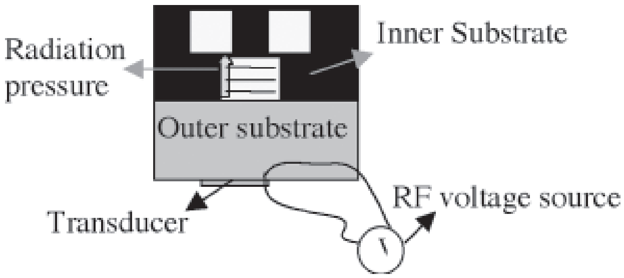

Figure 2: How the transducer works.

The Fabrication Process:

We started out with a bare silicon double-side polished wafer and deposited 1500Å of oxide and 1500Å of silicon nitride on both sides. We then worked on the topside and spun 1.6 µm of photoresist atop the nitride, exposed a mask on the wafer and developed the wafer, making its design visible. Then we dry etched the nitride and oxide along the pattern exposed on the wafer and rinsed off the remaining photoresist with a Piranha mix of sulfuric acid and hydrogen peroxide. We then repeated the process of exposing and developing on the bottom side. After the final dry etch, the channels were anisotropically etched through the pure silicon with KOH. We then did a final rinse on the wafer with plasma to dissolve the remaining nitride, and with dilute hydrofluoric acid to dissolve the remaining oxide, leaving behind only the silicon wafer. Figure 3 shows a picture of our etched channel.

We are now bonding quartz wafers on each side of the silicon to create a platform on which to place the transducer. Once completed, we will deposit a layer of gold, covering an area we do not want dissolved with resist and then do a gold etch, leaving only a small area behind. On top of the gold, we will deposit a layer of zinc oxide and add the top electrode, successfully constructing a microfluidic device with an integrated transducer.

Results:

Due to complications in bonding the quartz wafers, we have not yet been able to add the transducer. Once the transducer is added, testing will commence. Our test will consist of seeing if liquid can flow through the new design.

Conclusions:

If liquid flows through our device, this research will have created a better device for pumping applications. Pumping is important to move liquids or particles into desirable positions in order to monitor and better understand the movement and interactions of liquids on this scale. Pumping pushes the substances into a position beneath a microscope to be monitored. Better understanding of these substances can eventually lead to improvements in the field of medicine.

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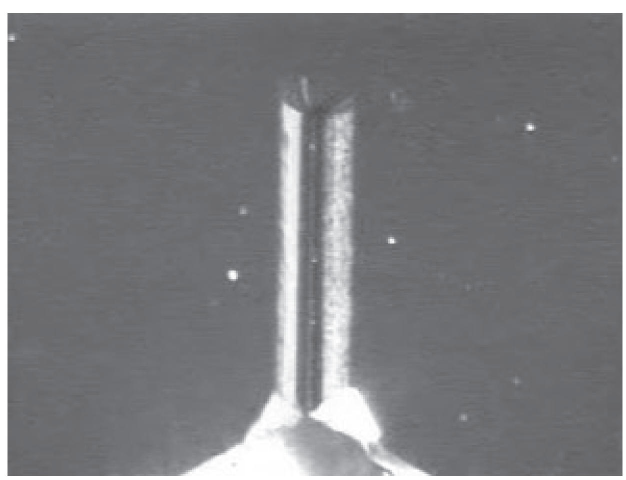

Figure 3: A channel in our device.