Side-Coupled Microfluidics for Biosensor

CNF Project Number: 2465-16

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Primary Source of Research Funding: Moore Foundation

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Primary CNF Tools Used: Heidelberg mask writer DWL2000, edge bead removal system, ABM contact aligner, SÜSS SB8e substrate bonder, DISCO dicing saw

Abstract:

A side coupled microfluidic device was designed and manufactured using standard photolithography and wafer bonding technique. Devices formed from bonding two wafers using AZ 125 nXT showed satisfactory integrity, neither breaking from the dicing step or from fluid flow that was supplied using a pulled glass capillary connected to a syringe pump.

Summary of Research:

We previously designed and fabricated an iteration of a novel biosensor combining optical and microfluidic components. While the optical components displayed satisfactory performance, the previous design's microfluidic components suffered from certain critical problems that rendered it useless, including a lack of fluid perfusability and difficulty in coupling the microchannels to an external fluid supply (i.e. syringe pump). Specifically, we had previously etched microchannels into silicon dioxide and capped the microchannels using a slab of PDMS with pre-punched through holes. However, the PDMS slab was poorly bonded to the SiO_2 and the pre-punched through-holes were not properly aligned to allow fluid perfusion.

In order to overcome these limitations in the microfluidic components, we conceptualized a different approach that utilized a photoresist adhesive bonding and side-coupled microchannels (in contrast to the top-coupled microchannels from before). Before combining the optical and microfluidic components to form a complete biosensor, we created a separate standalone microfluidic device test the effectiveness of this new approach.

The process flow for fabricating the standalone device is shown in Figure 1. Essentially, AZ 125 nXT is spun on a fused silica wafer to a thickness of approximately 20 μm and patterned using the ABM contact aligner, leaving behind the microchannel pattern. AZ 125 nXT was chosen because it could be spun to large thicknesses, but only one paper has extensively documented its use for micromachining [1]. We then spun and exposed AZ 125 nXT on a second wafer made of borosilicate glass. AZ 125 nXT is broadband sensitive, which

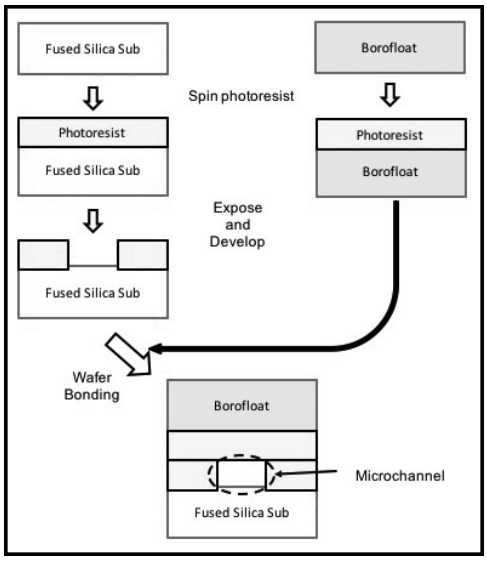

Figure 1: Process flow of fabricating side-coupled microfluidic devices.

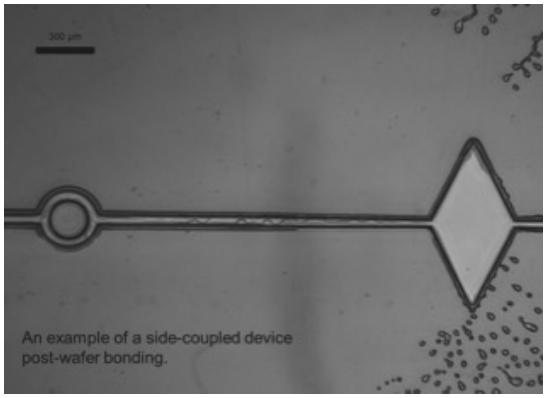

Figure 2: Micrograph showing side-coupled microfluidic device after wafer bonding.

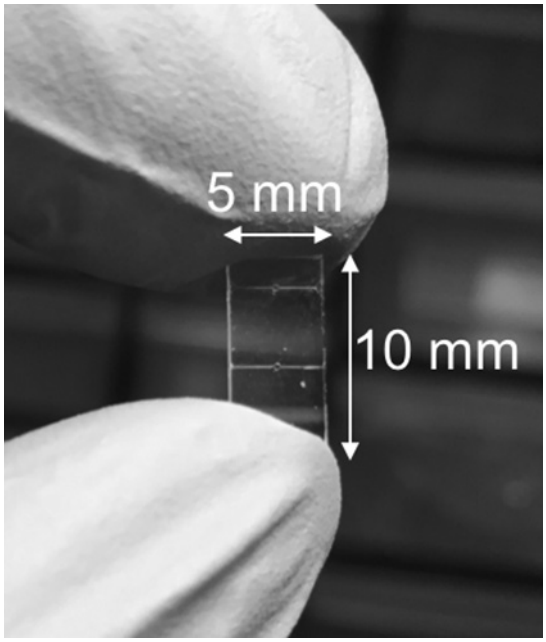

Figure 3: Snapshots of the completed side-coupled microfluidic device.

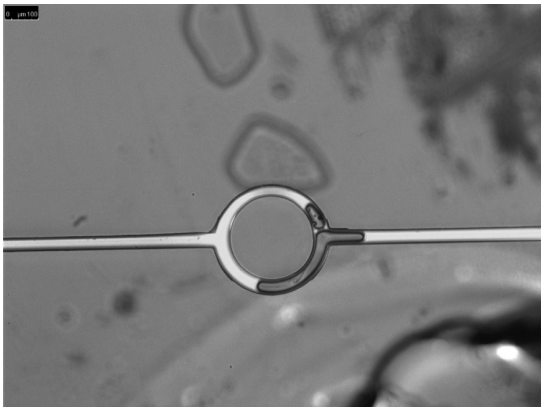

Figure 4; Snapshots of fluid perfusion through microchannels.

effectively cut the necessary exposure from the ABM contact aligner by a factor of 3. The two wafers were then bonded together using the SÜSS substrate bonder. Specifically, the two wafers were heated to 100°C and pressed against each other with a force of 1000 N to form the final device wafer. Upon bonding, the patterned photoresist showed minimal deformation, leaving the microchannels clearly defined (shown in Figure 2). Finally, using the DISCO dicing saw, the device wafer was diced into individual devices (shown in Figure 3). The wafers did not separate during the dicing step, which indicated good bonding between the wafers.

The resulting devices were then subjected to fluidic tests to investigate the perfusability of the device and the feasibility of side-coupled microfluidics. To couple the microchannels to an external syringe pump, 1 mm glass capillaries were pulled using a glass pulling machine to achieve a tip with a diameter that could fit into the microchannel inlet/outlet. In addition to being able to fit the tips into the inlet/outlet, the tip could also perfuse fluid supplied from a syringe pump (shown in Figure 4).

Pumping fluid from the syringe pump revealed that the microchannels were capable of perfusing fluid up to flows of 250 μL/hr. Therefore, we have successfully designed and fabricated a side-coupled microfluidic device that can effectively perfuse fluid.

Although side-coupled microfluidic devices have already been reported in the literature (mostly for mass spectroscopy purposes [2-3]), these experiments nonetheless demonstrated that side-coupling may be a viable strategy for realizing the microfluidic components on our proposed biosensor.

References:

[1] T. Knoll, A. Bergmann, and D. Nussbaum, "Fabrication of microfluidic chips using lithographic patterning and adhesive bonding of the thick negative photoresist AZ 125 nXT", Proc. of SPIE, vol. 9517, 2015.

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[3] Z. L. Fang, and Q. Fang, "Development of low-cost microfluidic capillary-electrophoresis system coupled with flow-injection and sequential-injection sample introduction", Fresenius J. Anal. Chem., vol. 370, pp.978, 2001.