DEVELOPING A PROGRAMMABLE MICROFLUIDICS LAB-ON-A-CHIP (LOC) PLATFORM

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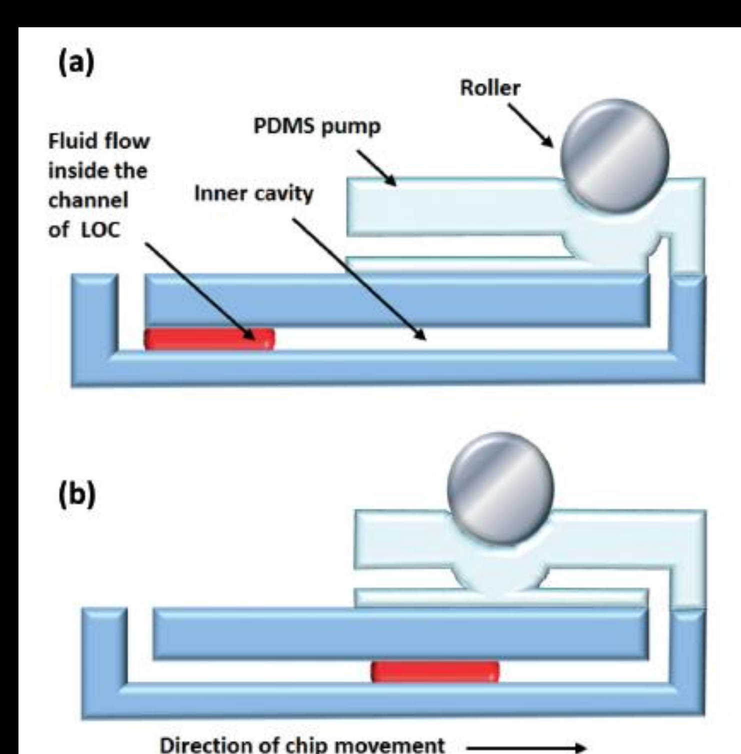
OBJECTIVES

- The objective of this research project is to fabricate a lab-on-a-chip (LOC) device, that will integrate serval labs into a single circuit.
- LOC is a miniaturized device that will integrate nanofabrication and microfluidics to conduct complex biochemical analyses (Sivilich, 2020).
- This microfluidics process of conducting labs can be useful in conserving reagents and causing shorter reaction time, which will enable multiplexed assaying.
- Through the utilization of various pneumatic, and hydraulic systems which will actuate the flow of the micro-fluids through the LOC device. The purpose of this research is also to eventually produce a reusable format.

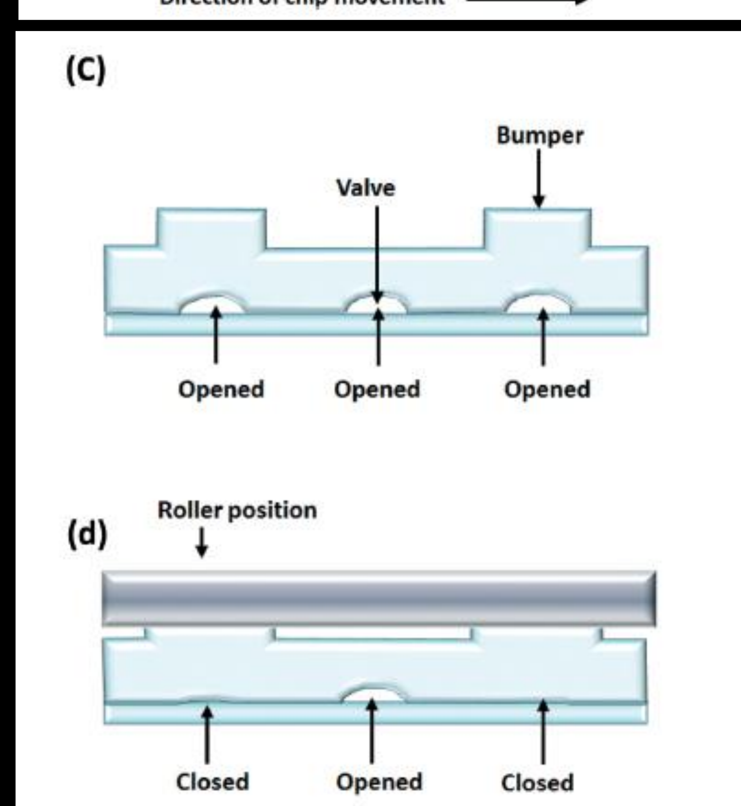
PRINCIPLE CONCEPTS

The fluidic flow actuation will be controlled by micro-pump and microvalve mechanisms, that will be constructed into the LOC device, which is made up of the polymer, Polydimethylsiloxane (PDMS).

Micro-pump - Pressurizing PDMS bumper by roller bar deforms the PDMS structure and sealing the cavity. The roller bar moves in the direction that increase the volume of the inner cavity, generating a negative pressure, pulling the fluids further into the microfluidic channel and to the reaction chamber. Roller motion in the opposite direction, causes positive pressure to extract fluid from the chamber.



Microvalve - Microfluidic slides are covered with bump patterns, when the roller sits on the bumper it presses down on the PDMS bumper which closes out channel cavity causing high fluidic resistivity. However, channel without the bumper opens up, allowing an influx of fluidic flow into the channel. Therefore operation of the microvalve mechanism is dependent on the position of the roller on the microchannel.



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PHOTOLITHOGRAPHY

1. COATING

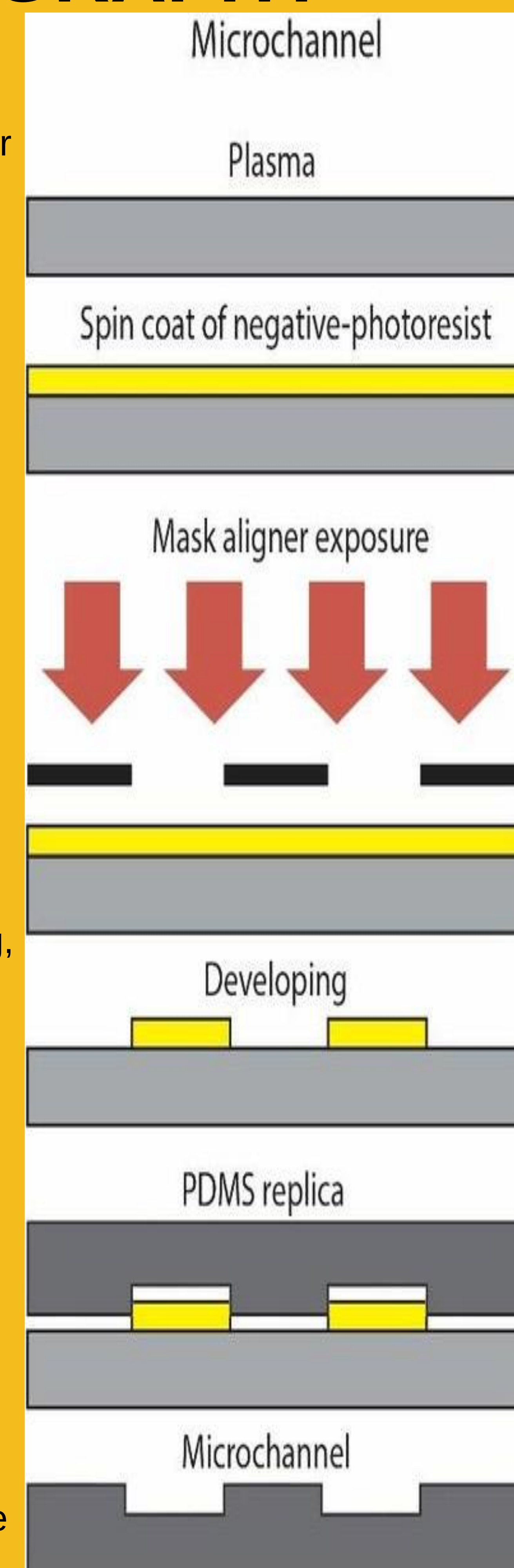
- The fabrication of the LOC starts with cleaning and preparing the wafer surface for spin coating by conducting Hexamethyldisilizane (HMDS) priming to boost chemical adhesion of the photoresist onto the wafer.
- Spin coating the silicon wafer with photoresist to produce an uniform coat of approximately 30µm, which will determine the depth of the micro-channels of the LOC device.

2. EXPOSE

- The maskless aligner aids in rapid prototyping, and unlike the commonly used Mask Aligner does not require a mask to expose the micropatterns onto the wafer surface.
- Once the photoresist has been allowed sufficient time to softbake, post spin coating, the wafer will be placed into the maskless aligner, which will expose the computer-aided design of the micropatterns directly onto the photoresist surface.

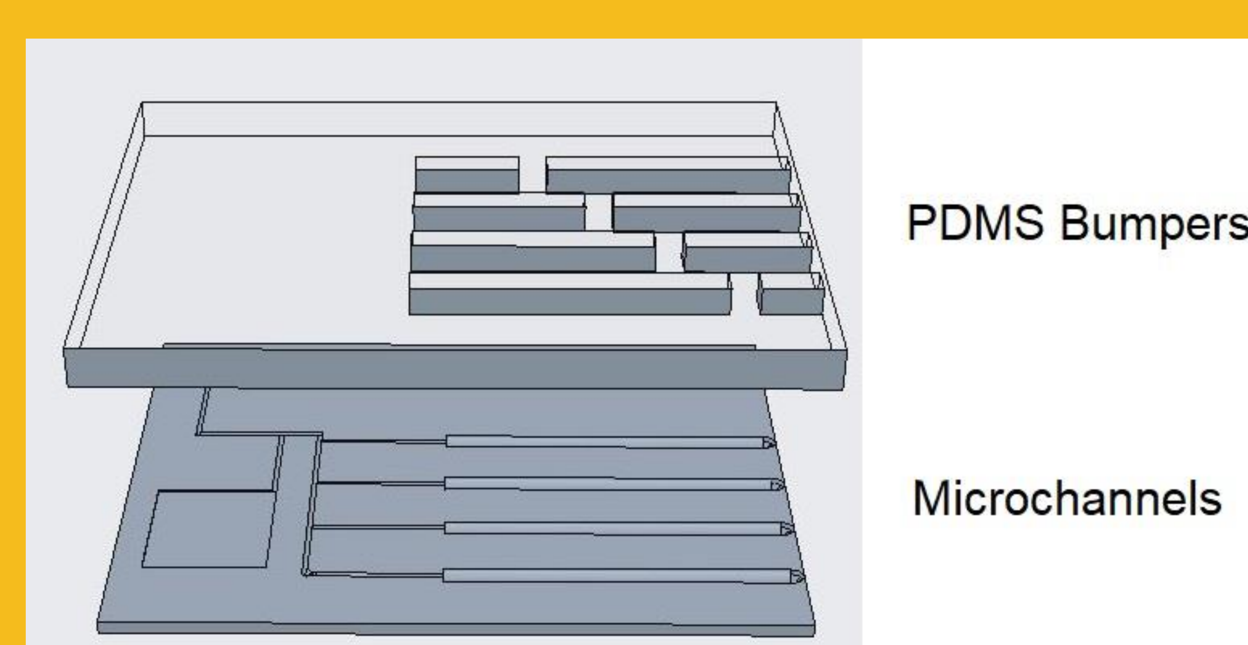
3. DEVELOP

- The exposed regions of the photoresist are dissolved in the chemical developer.
- Achieving a successful negative resist, will prepare the wafer to behave as a mold for the PDMS substrate.
- The developing process is followed by a hardbake to harden the photoresist after the developing.



LOC FLUID ACTUATION

The LOC Device will be controlled to actuate the micro-fluids that are present by the motion of a roller. Whose motion will be dictated by an Arduino microcontroller. The Arduino board will actuate the micro linear actuator according to the analog button inputs given. The forward and backward displacement of the linear actuator along the LOC surface will control the amount of fluid dispensed.

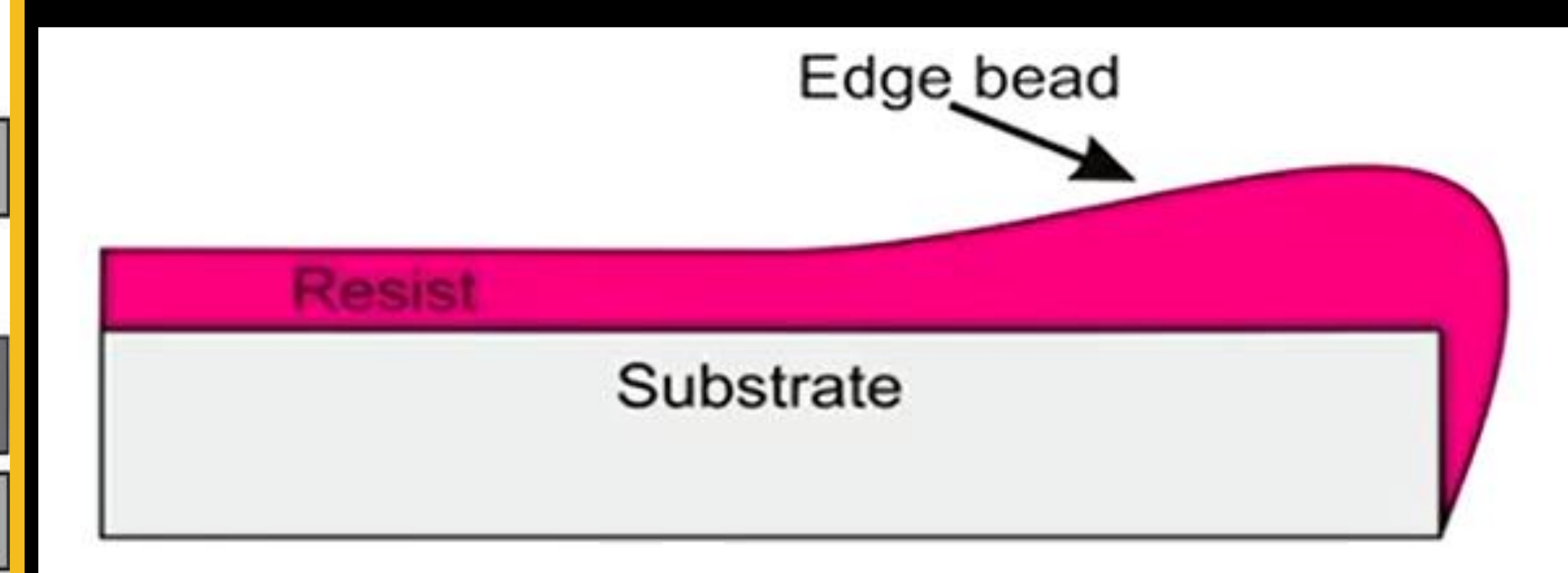


PDMS PREPARATION

- Mix curing agent for PDMS solution preparation
- Placed in a desiccator to remove air-bubbles
- Then poured into molds and cured for 30 mins at 80 ° C
- After curing the fabricated layers bonded via atmospheric plasma treatment for 1 min, using a corona generator
- Annealed for 10 mins in a hot press to fix bonding

ERROR ANALYSIS

- While spin coating one of recurring errors in fabrication are due to Edge Bead formation on the edges of the coated wafer. Edge bead formation is due to low spin speeds or high viscosity of the photoresists, this produces higher surface friction which restricts the centrifugal forces to accelerate in a uniform manner across the surface of the wafer, producing a "bulge" at the wafer edge. Manual edge bead removal solvent application process are followed to avoid this kind of discontinuities



CONCLUSION

By utilizing the PDMS microstructures that make up the micro-pump and micro-valve mechanisms, precisely dispense the reagents, and can control the volumetric supply of the solutions into the testing region.

This LOC platform can open up many different approaches to conducting polymerase chain reactions (PCR), microarray analysis, and protein separation.

BIBLIOGRAPHY

1. **Sivilich, S. (2020, December 11). Microfluidics Lab-On-A-Chip Technology. Chemyx Inc.**
2. **Im SB, Uddin MJ, Jin GJ, Shim JS. A disposable on-chip microvalve and pump for programmable microfluidics. Lab Chip. 2018 May 1;18(9):1310-1319. doi: 10.1039/c8lc00003d. PMID: 29619470.**