Design and Fabrication of Multichannel PDMS Microfluidic

M N Afnan Uda¹, U Hashim¹, M N A Uda¹, ², N A Parmin¹ and V Thivina¹

¹Institute of Nano Electronic Engineering, Universiti Malaysia Perlis, 01000 Kangar, Perlis, Malaysia.
²Faculty of Chemical Engineering Technology, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia.

Email: azizahparmin@unimap.edu.my

Abstract. Microfluidic delivers miniaturized fluidic networks for processing liquids in the microliter range. In the recent years, lab-on-chip (LOC) is become a main tool for point-of-care (POC) diagnostic especially in the medical field. In this paper, we presented a design and fabrication on multi disease analysis using single chip via delivery of fluid with the multiple transducers is the pathway of multi-channel microfluidic based LOC’s. 3 in 1 nano biosensor kit was attached with the microfluidic to produce nano-biolab-on-chip (NBLOC). The multi channels microfluidic chip was designed including the micro channels, one inlet, three outlet and sensor contact area. The microfluidic chip was designed to include multiplex detection for pathogen that consists of multiple channels of simultaneous results. The LOC system was designed using Design Spark Mechanical software and PDMS was used as a medium of the microfluidic. The microfluidic mold and PDMS microfluidic morphological properties have been characterized by using low power microscope (LPM), high power microscope (HPM) and surface profiler. The LOC system physical was experimental by dropping food coloring through the inlet and collecting at the sensor contact area outlet.

1. Introduction

Microfluidic is a device that can play out a perplexing coordination capacities incorporated onto a solitary chip with just a few centimetres in size [1–3]. Microfluidic device consists of several components such as microchannel, microchamber and micromixer [4–6]. This part is configuration to empower these devices to deal with a little measure of liquids and can computerize and play out the compound alone just by dropping a couple drop of testing liquid [7–9]. Lab-on-chip device are usually consist of microfluidic channels that provide paths for biomolecules to flow to individual biosensors [10–12]. It is often used as an analysing tool for small and low concentration samples to attain a complex laboratory functions in biomedical applications [13–16].

Microfluidic devices comprise of a few points of interest for example, diminish the pollution odds of tests on the grounds that the devices are totally fixed. Low volume of liquids utilization implies less waste, bring down reagents cost and less example volume indicative [17–21]. A part from that, microfluidic devices has better process control and ready to give exact estimation since the framework can react quicker. The investigation is quickened and reaction time is diminished in light of the fact that short dispersion remove, quick warming, high surface to volume proportions and little warmth limits [22–24]. The material to manufacture lab on chip is artificially latent, so the devices can be cleaned effortlessly. It is additionally a protected stage to run synthetic radioactive or organic reviews as a result of joining of usefulness, littler liquid volumes and put away energies.
The fabrication cost of lab on chip devices is lower, which makes it a practical expendable chips and ready to manufacture in large scale manufacturing [25–27].

In this paper, we present the fabrication of nano-biolab-on-chip (NBLOC) system for medical diagnostic. The multichannel microfluidic design is done using Design Spark Mechanical software. The microfluidic mold is made from aluminium and microfluidic is fabricated using PDMS. Lastly, aluminium interdigitated electrode (Al IDE) based multi biosensor kit is coupled with the microfluidic to form NBLOC.

2. Materials and Methods

2.1. LOC Layout Design

Figure 1 shows the LOC design with specific dimensions and 3D view of the LOC device. The process was start by designing the whole device layout plan. The Design Spark Mechanical software was used to design the layout of the LOC device including basement and microfluidic which were in millimetre units. After that, the design being transferred to vendor to fabricate the aluminium microfluidic mold.

![Figure 1. Schematic of LOC design using Design Spark Mechanical software: (a) top microfluidic view and (b) basement microfluidic view.](image)

2.2. Microfluidic Mold

Design Spark Mechanical software was used to design the aluminium microfluidic mold. As shown in Figure 2, the dimension on the microfluidic outlet are optimized according to the biosensor active area size. The depth of aluminium microfluidic mold for top and basement are 2.8 mm and 2.0 mm.
2.3. Fabrication Procedure of PDMS Microfluidic

Figure 2. Aluminium microfluidic mold.

Figure 3. Fabrication procedure.

Al IDE LOC comprises of two main parts as microfluidic fabrication and Al IDE electrode fabrication. The fabrication and characterization of the Al IDE had been done previously. Firstly, a solution of PDMS and curing agent are mixed together in weight boats as shown in Figure 3 (a and b). It is prescribed to set the proportion of PDMS and curing agent at 8:1.5. After that, the PDMS mixture is stirring together for 30 minutes continuously in order for the mixture to dissolve completely as shown in Figure 3 (c). PDMS is cured through the organometallic crosslinking process during the stirring of PDMS and curing agent. Apart from that, if large amount curing agent used, the PDMS elastomer will become harder, poor versatility and easily to be damage. After completed stirring, the solution was poured onto the aluminium microfluidic mold as shown in Figure 3 (d and e). This method is to get the coveted in square shape as measurement of PDMS microfluidic device. Next, the aluminium microfluidic mold was kept into the plasma preen system within 3 minute for vacuum process to evacuate the air bubbles inside the solution as shown in Figure 3 (f). After that, the mold was dried in the room temperature within 12 hours. Lastly, the dry microfluidic was pull out from the mold.
2.4. Development of Lab-on-chip

The multi-channel microfluidic is integrate with multiplex Al IDE biosensor to fabricate LOC device. Two Perspex layer was used as top and basement to hold the sensor and microfluidic. The fabrication of Al IDE and functionalization steps based DNA biosensor was discussed in our previous papers.

3. Result and Discussion

The developed aluminium microfluidic mold and PDMS microfluidic were characterized using LPM, HPM and surface profiler. After that, PDMS microfluidic and Al IDE sensor kit were integrated to make LOC device. Lastly, the leakage test was done using food coloring.

3.1. Morphological Characterization

Figure 4 (a) shows the microfluidic design from aluminium mold. Figure 4 (b and c) shows the microfluidic image using low power microscope and high power microscope. Based on the image, it shows clearly the micro channels, one inlet, three outlet and sensor contact area. The channel width is 500 µm, diameter of fluid inlet is nearly 1 mm and the width of the fluid outlet nearly 2.1 mm which have negligible differences compared to Design Spark Mechanical software design dimensions.

![Figure 4. (a) Microfluidic design, (b) LPM image and (c) HPM image.](image)

Based on the surface profiler image as shown in Figure 5, the channel width of the microfluidic channel height and flow path is approximately 150 µm and 500 µm respectively. From the result, it shows some defect on the edges of the channels because of improper pull out the microfluidic from the aluminium mold.

![Figure 5. Surface profiler of the microfluidic channel.](image)
3.2. Leakage Test

Figure 6 shows the LOC leakage test based on path flow of liquid through the inlet, channels and outlets. The blue food coloring was used in the process. Based on the result, it clearly shows that the liquid can flow very smoothly after it gives some pressure from the micropipette through the inlet. The total volume that used for this process to reach until the Al IDE biosensor outlet was only 50 μl. Hence, this LOC design required low volume of liquid sample for validation and to avoid waste of the target sample.

![Figure 6. LOC leakage test using blue food coloring.](image)

4 Conclusion

In this paper, we exploited to develop multichannel microfluidic LOC devices. The microfluidic mold was designed using Design Spark Mechanical software which has been completely transferred to the aluminium microfluidic mold. Moreover, the aluminium microfluidic mold pattern successfully transferred to PDMS microfluidic. The characterization and inspection of the fabricated devices were performed using LPM, HPM and surface profiler. Based on the morphological analysis, the dimensions of the microfluidic and aluminium microfluidic mold are nearly the same. Al IDE based nano biosensor is successfully integrate with microfluidic to develop NBLOC. The leakage test was confirmed that LOC can be commercialized for medical diagnostic in the real detection.

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