Cost Optimization for Lab-on-Chip Devices using Nano and Micro –Fluidics Technology

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***Abstract*: Now a days, in the field of science, technology, engineering and management, a lot of work has been carried out in the domain of Lab-on-Chip (LoC), Network-on-Chip (NoC), System-on-Chip (SoC) and Direct Write Assembly (DWA) and Three Dimensional Printing (3DP) Prototype etc. This kind of innovation technology not only used a less amount of engineering materials, it also optimized the production cost. Due to the advanced technology and mass production, the price at the user end, it also quite less. So with the literature survey from the past research and our experimental data, we are in the position to mention, we can optimized the cost of LoC, NoC, SoC, DWA and 3DP at very feasible price. We have performed the experimental work and used various kinds of simulators to optimize the cost of these devices at end user. Keywords: 3DP, DWA, LoC, NoC, SoC**

INTRODUCTION:

Since the invention of semiconductor devices, there is a tremendous growth in the area of miniaturization. As per Moore's law, numbers of chips are increasing exponentially on small packages while the package size is also decreasing on scale level. So there is a need of a technology, which make us move towards the sub micron (10^{-6} meter) size that will reaches towards nano (10^{-9} meter) and pico-meter (10^{-12} m). So as the size is decreased, there is problem of control the process [1-5]. To overcome this problem, advance hands-on-experience, in terms of sample picking, processing, releasing the devices on nano and micro size will come into the picture. We know the due to the osmosis process; water reaches the leaves and fruits/flowers, through the travelling via stem [4-9]. This kind of concept is well suited for flow of liquid at micron and nano level, that flow of liquid and the whole process with device, is jointly called as micro and nanofluidics [10-15].

1.1 Engineering Materials:

These are the basic things, which have to be used and process in the domain of microfluidics and nanofluidics. The main motivation behind the fabrication/development of the nano materials is their surface to volume ratio (SVR) as this is the most critical and important aspect at micro electronics and nanotechnology domain [16-18]. In the micron or nano level, the electrical, structural and morphological etc have significant value and importance [19-21].These materials are in the size of nano and micro.It may be summarize in following types:

Zero-dimensional (0D): These are the materials which have their all the dimensions in the range of nano or micro meter. The example of such material is Quantum Dots (QD or QDs) such as CdS, CdSe, and CdTe QDs [21-24] etc.

One-dimensional (1D): These are the materials which have at one of its dimensions (x, y or z) lies outside the range of nano or micron size. The best examples of such materials are Nano Particles (NP or NPs) {for example Gold (AuNPs) and Silver(AgNP)}[22-25]etc.

Two-dimensional (2D): The materials which have two dimensions outside the range of micro or nano meter. The example of such material is nano plates, nano prisms [24-27] etc.

Three-dimensional (3D): The materials which have all the dimensions outside the range of micro or nano meter. The example of such material is nano balls, nano cones [26-29] etc.

1.2 Technology Used:

After investigating the engineering materials, the next step is to find out the best technological terms, by virtue of that, the all kind of nano materials will justify their role in cost optimization in product line. Earlier in ELISA kits for determining the presence of virus or other harmful bio-micro/macro-molecules, the volume of sample was quite high. Also there is time bound problem, as it took long time to process in the lab. While there is still a chance of infection through the wrong hand handling or open atmosphere. So due the the diagnosed results were varies a lot[2-6, 8-11]. It also took a huge cost for full data collection, processing, execution and results.So these kinds of bottle necks are removed with the help of advanced role of STEM (science, engineering, technology and management) concept.

MICROFLUIDICS:

When the fluid move in a small track, i.e. in the range of micron level, is called as microfluidics. Due to the small channel of liquid flow, there is a chaotic, laminar or turbulent flow. These all kinds of flow depend on the following terms: rheological value of fluids, consist of nano or micro particles, viscosity of the fluid and sample size in the range of micro/nano/pico liters[8-12, 15-19]. One of the fabricated channels on some polymer is shown in figure 1.

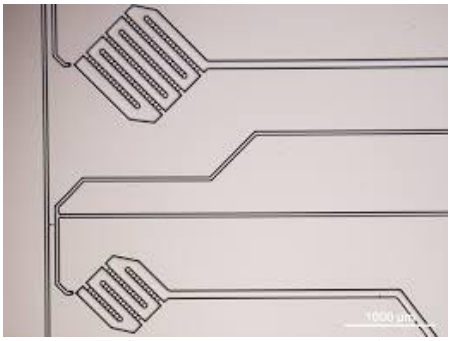

Figure 1: Microfluidic Channel in a Device of Polymer

NANOFLUIDICS:

When the fluid move in a small track, i.e. in the range of nano level, is called as nanofluidics. Due to the small channel of liquid flow, there is a chaotic, laminar or turbulent flow. These all kinds of flow depend on the following terms: rheological value of fluids, consist of nano particles, viscosity of the fluid and sample size in the range of micro/nano/pico liters [19-22. 25-26]. One of the fabricated channels on some polymer is shown in figure 2.

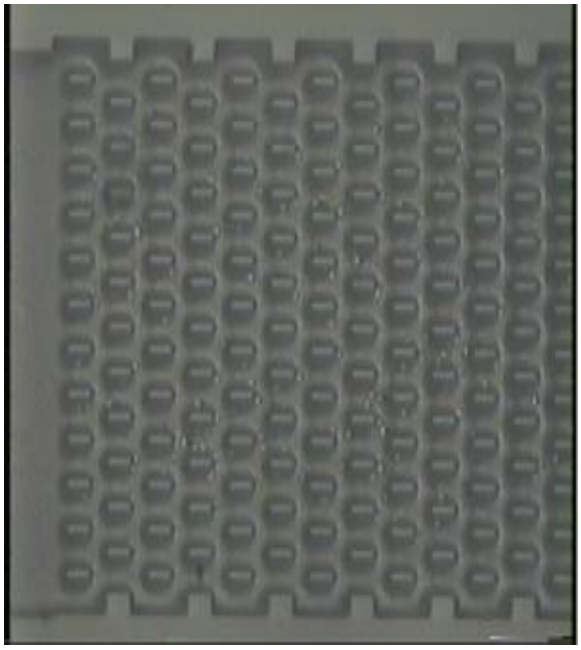

Figure 2: Nanofluidics Channel in a Device of Polymer

1.3 Conceptual Notes:

Lab-on-Chip:

When there is fabrication or mimic of some application on a single chip, that may take, process, show the result like laboratory atmosphere, is termed as Lab-on-Chip (LoC). Now days, there is huge cost of diagnostic kits and their uses for human being [2. 6. 14, 22, 28]. So by the implementation of small LoC, cost may be less for public. The one of the LoC is shown in figure 3 [citation is given in foot note of the image].

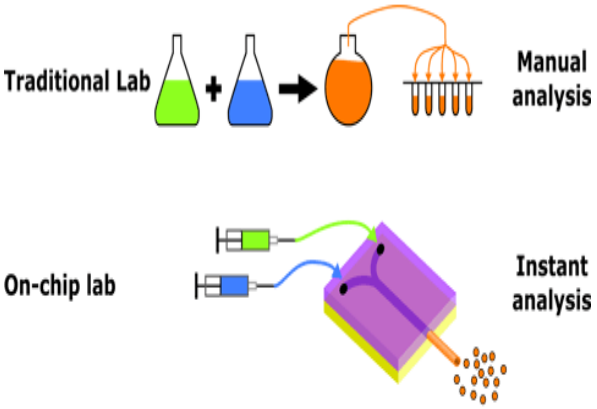

Figure 3: LoC Concept [Verboom et al, 2006]

2. REVIEW OF LITERATURE:

We may start from paper kind fluidic channel. Paper base technology a quite innovative kind of fabrication because of its minimum cost. Also its speed is fast and optimal. Various kinds of polymers are selected for the device fabrication. These polymers are having the best mechanical properties to carry out the base of device. Poly di methyl Siloxane (PDMS) and their compound with the other carbon or non carbon materials chain. Also the positive and negative resists are being used for the device fabrication [1, 4, 9, 16, 19, 25, 30]. The most widely used photo resist is SU-8. The all lithography (negative and positive method) must use proper way for Ultra Violet (UV) exposure on the fabricated part on PDMS, using SU-8.

2.1 Background of different technological indexed terms (3DP, DWA, LoC, NoC, SoC):

With the invention of rapid prototype machine and technology, there is a demand of fabrication of costly and unavailable body part of various devices. So by the control of x, y and z-all three axes in a pulley control motor, we may able to developed a new kind of printing machine. This machine is called as three dimensional printers (3DP). Aha3D, India and Ensemble, USA are few of the manufacturers of such devices. This whole concept is term as direct write assembly (DWA). LoC is nothing but a laboratory on a single chip such as pregnancy kit (PregaNews) etc. NoC is a device which comprises of a whole network (any kind of network, electrical or mechanical or information technology etc) [2, 8, 12, 21, 28]. A single and small chip that consists of whole systems on a single chip is termed as system-on-chip (SoC).

2.2 Applications of the covered terms:

Aerospace, biotechnology, Computer science, deference industry, electrical, electronics, food technology, house held appliances, hematology, information technology, mechanical, mechatronics, nanotechnology, optoelectronics, personal device applications, real time systems and security industries are the main application based part of the 3DP, LoC, NoC, SoC and DWA [1-9, 12-16, 22-28].

Advantages and disadvantages of covered terms:

The main advantages are: low cost, less sample, less time, high accuracy etc.The main disadvantages are: handling must be accurate, clean atmosphere needed etc.

3. RESEARCH METHODOLOGY USED BY EARLIER RESEARCH GROUP:

This will cover the methodology used by earlier research groups. This evolves all about micro fabrication and nanofabrication etc.

3.1 Research Design:

The proper selection of nano or micro particles for fabricating the proper devices such as LoC/NoC/SoC is main motive behind the research design.

3.2 Materials used:

0D, 1D, 2D, 3D nano structured materials (NSM), polymers (PDMS) and photo resist (SU-8) are the main materials which have been used in past work, being used in current research, and will contribute in the future engineering work.

3.3 Bottle neck of the design:

Handling must be accurate and the clean atmosphere needed-is the summary of main problems in this work.

4. COMPARISON OF THE COVERED WORK:

5.

By the presence of various kinds of NSM and polymers/resist, the all work varies from one point to other point. It also depends on the end use product.

5.1 Compare in terms of basis:

The main base for the differentiation is the used of NSM and Technology being used.

5.2 Compare in terms of end product:

This may treated as advance appliances such as electrical or mechanical products.

5.3 Contrast in covered work:

The main similarity between the all concepts is the use of lithography process, which plays an important role.

6. APPROACH TOWARDS NEW DESIGN:

The main thing is to minimize the samples being used, low waste of processed sample and recycling of the end sample if possible (in case of invasive/in vivo/in vitro technology).

6.1 Removal of problem:

With the particular and perfect selection of the requirement in terms of NSM and polymers, we may be in the position of removal of such bottle neck of the proposed and covered research work.

6.2 Technology used:

The main technology which has been used in the past, being used now a days are basically positive and negative lithography process.

6.3 Applications:

The main application varies from various horizontal and vertical domains, already discuss in point 2.2.

7. COST OPTIMIZATION

Due to the less volume of sample, the cost is being optimized [29-30]. While scale up on the mass production, the cost of clean room technology and materials price will be optimized properly. The main four pillars of the cost optimization is given in figure 4.

Figure 4: The Four Pillars of Cost Optimization [Allan Knudsen, AWS 2015]

8. CONCLUSION:

With the use of proper NSM and proper selection polymer with resist, we may device proper device. This kind of devices has found its role in various aspects of life. The cost is also optimized by the proper simulation, experimental and modeling.

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