PDMS Based Air Pollution Detection Sensor Using Microfluidics Technology

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***Abstract*: Microfluidics designs are the rapid growing technology in various aspects. We have work on design on channel fabrication which are having dimension in several microns. Such kind of channels is main reason to control the flow of particular sized molecules through it. By using lithographic process, which follows substrate selection, CAD (Computer Aided Design) modeling, UV (Ultra Violet) radiation uses and etching, we are able to fabricate micron level channel. These designs are well suited for air pollutant checks and their control thereafter. Poly Di Methyl Siloxane (PDMS) are used in this design and glass substrate of 75mm*25mm is being used. SU8 from sigma Aldrich are used as developer during these processes.**

Keywords: CAD, Microfludics, PDMS, SU8

I. INTRODUCTION

In this work we proposed and design an innovative way to fabricate and/or design a sensor. This kind of sensor may find its application in air pollution detection. Poly dimetheyl Siloxane is chosen for this sensor. Through the literature survey done by us, we reached a position where various kinds of such sensors have been reported such as spider kit for some kind of gas detection [1-4]. Beside this fact spontaneous way for gas detection are also come into the picture. Brief information of last 40 years has been used and cited throughout this research work. Various sensing method has been made the backbone of our work. Such as lux detection for various organic and inorganic gases [5-9]. The over view diagram of PDMS channel is shown in fig.1.

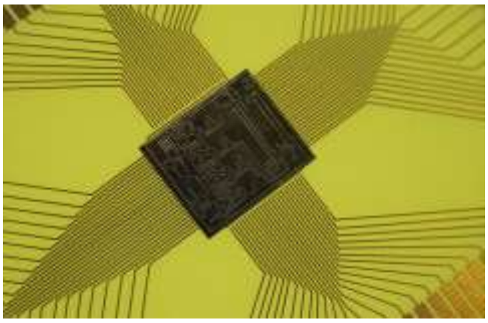

Fig. 1 PDMS channel (source MIT Nano lab)

A. PDMS – a brief info

1) Background and Research

PDMS is the abbreviation of Poly Di Methyl Siloxane. This is a compound which can be suited as backbone of Microfluidics design. SU8 is a photo resist which can be well suited for design work and proper adhesion [10].

2) Microfluidics Design

Micron or micro is nothing but 10^{-6} of meter. The science, technology, engineering and mathematics at this dimension are called a Microfluidics technology. The design, control and applications of materials show a tremendous unexpected behavior under this domain [11-14]. Fig.2 shows one micron channel made up of PDMS and SU8.

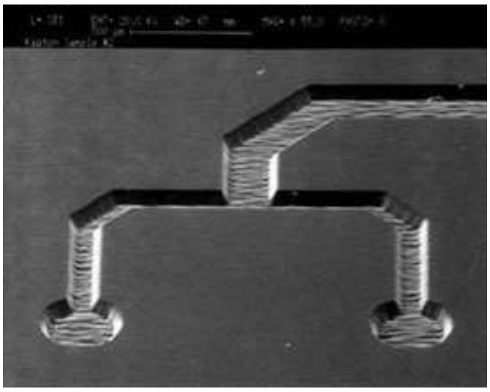

Fig. 2 Micron channel (source MIT Nano lab)

3) Gap of Research Work

Various sensors has been placed in the market such as O_2, NO_2, NO and CeO_2 gases. The main design for all kind of gas sensor is by using highly sophisticated instruments and clean room technology. Also patterning, vertical aligned and horizontal design already used. Beside this innovation, few of the correction also embedded in this research work. For example various acoustic and physical sensors are used [15]. Fig. 3 is chemical formula of – $[C_2H_2F_2]_n$-.

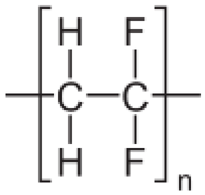

Fig. 3 $C_2H_2F_2$ molecule (polymer)

For oxygen gas and other one, the sensor based on specific gases are being manufactured and redesigned. Pattern based design also included in this flow of research [16].

Micro TAS (Total Analysis System) is a system which automates and includes all necessary steps for chemical analysis for many fields such as an electronics, mechanical etc. The designed sensor also comprises TAS kind of sensing and processing application. In this TAS, tomography is selected. Hydrolysis and condensation method is chosen for detection of chemical compounds. Various cell biology is also utilized for this work [17].

CMOS (Complementary Metal Oxide Semiconductor), PMOS (P-type Metal Oxide Semiconductor) and NMOS (N-type Metal Oxide Semiconductor) are chosen for Point of Care diagnostic tools [18]. In the CMOS sensor, complementary MOS is chosen, while under the heading of PMOS and NMOS, p-type and n-type of materials are chosen for sensor design respectively. Wearable kits are also in trends due to the following features:

Well suited for miniaturized design.

Will use less volume of sample.

Can be well optimized.

Controlling is very easy.

Fabrication can be done at room temperature only etc.

One innovative materials Barium Titanate ($BaTiO_3$), having dimensions 1-100nm (1nm=10^{-9} meter). This will work as backbone for this kind of sensor work [19]. The filler used for these experiments, various conducting and non conducting polymers has been chosen and selected in literature review done so far by writers of various research groups across the globe. These polymers are PVDF (Poly Vinylidene Di Fluoride), PVC (Poly Vinyl Chloride), PE (Poly Ethylene), and PMMA {Poly (Methyl Methacrylate)} etc. Apart from these experimental products, various s and f-block elements i.e. metal and non metal oxide has been resourced. TiO_2, Fe_2O_3, Al_2O_3 and $CsNO_3$ have been utilized.

Thermopile i.e. 35Juction thermopile is new sensing devices under the rail of air pollutant detection. CeO_2 is being trapped and detected via new and innovative sensor by using chemical Microfluidics technology.

The frequency relation:

$$F = \{1 / (2\pi)\} * (k / m)^{1/2} \text{ Hz}$$

$$C = (K \text{€}_0 A) / d \text{ Farad}$$

Where F = frequency of oscillation in Hz, k = spring constant (Newton / m), m = mass in kg, C = capacitance in farad, K = constant, €o = permittivity of vacuum, d = diameter in mm and l = length in mm.

a) Nano composites

By using simple chemical bath deposition, we have developed composites structure of Barium titanate, Titanium oxide and PMMA. Nano sized $BaTiO_3$, TiO_2 and PMMA has been well mixed in the beaker [20]. Various rotation and temperature are optimized at varying percentage. We have used 10, 30, 50, 70, 90 wt% and pure PMMA and pure TiO_2. Fig.4 is the overall flow diagram of methodology been selected for the work.

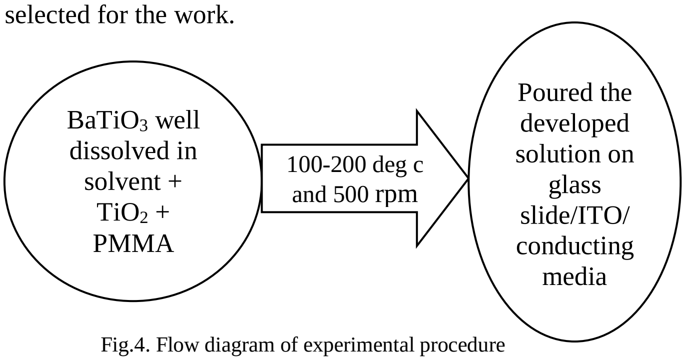

Fig.4. Flow diagram of experimental procedure

b) Thin films

Due to the nano dimensions of materials chosen and well optimized environmental conditions, the thin films have been deposited on glass/ITO and conducting substrate.
The films collected which have very less i.e. few microns in size treated as thin films.

c) Scherer Equation

It relates the size of sub micron meter particles to the broadening of a peak in XRD pattern. It is named after Paul Scherrer. It is used in the determination of size of particles of crystals in the form of powder.
The Scherrer equation can be written as:

$$\tau = K \lambda / \beta \cos \theta \text{ micron}$$

Where τ = mean size of ordered domains (micron), K = dimensionless shape factor, λ = X-ray wavelength (micron), β = line broadening at half the maximum intensity and θ = Bragg angle (degree).

Under the domain of nano and micro level, there is a direct relationship between the size and wt%.

d) Microfluidics Technology

The technology consists of micron size production, control and applications of the fluids, is termed as Microfluidics technology. PDMS and SU8 have been well suited for all types of Microfluidics design. Lithographic process is the main reason, how we can be able to manufactured micron level design.

II. EXPERIMENTAL PROCEDURE

Chemical bath deposition and Microfluidics technology has been sandwiched to design a sensor which may find it application as EN (electronic nose or e nose). Fig 5 shows the electrical setup for micro fabrication in lab.

Fig. 5 Experimental design

III. RESULTS AND DISCUSSION

Physical characterization : Fig.6 shows XRD pattern of synthesized desig. In XRD (Crystalogrpahic Ray diffraction), the peaks are coming at certain frequencies (2Theta=24.0 degree) which may confirm the presence of TiO_2 + PMMA bonding.

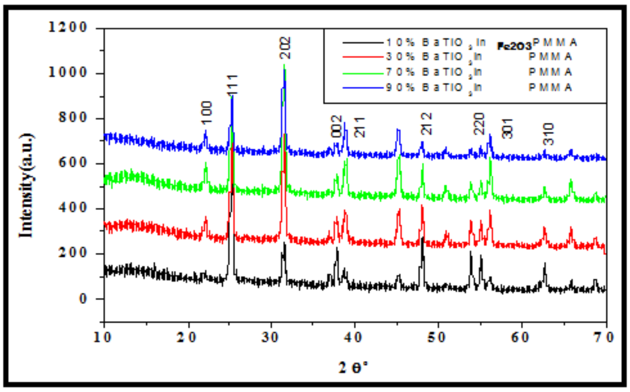

Fig. 6 XRD pattern

Morphological results: Fig7 shows the outcome of research.In this figure, using confocal microscopy, we got the exact sizeof channel fabricated(several microns in width). Through these fabricated channel, sample was made to pass.

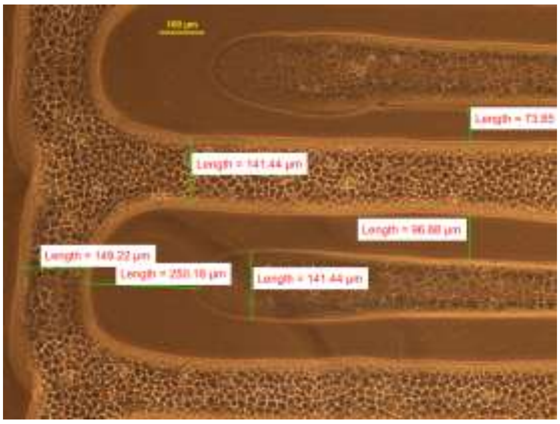

Fig.7. Morphology of channel design

Electrical results : Fig.8 below shows the electrical channel. By using spin coated and making electrical conductance patch at both end of the PDMS channel, we may able to divert condcutive particles (Gold and Silver Nano Particles) , flowing through the micron channel.

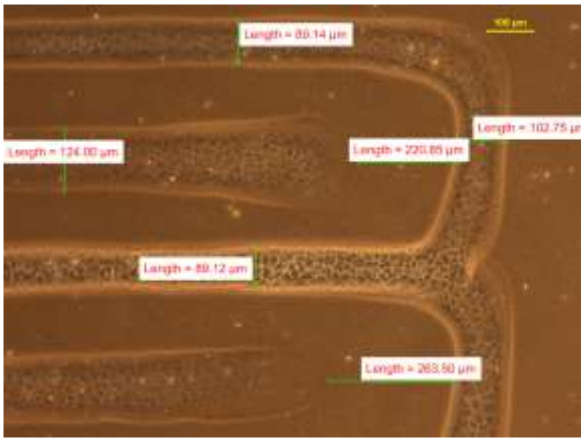

Fig. 8 Morphogical channel design.

Sensor related results: Fig.9 shows pdms channel fabricated. On glass substrate, spin coated gold of several microns are deposited. Then firmly and finaly creation of the micron level channel are done using Teflon tape. That channel was made for flowing samples through it.

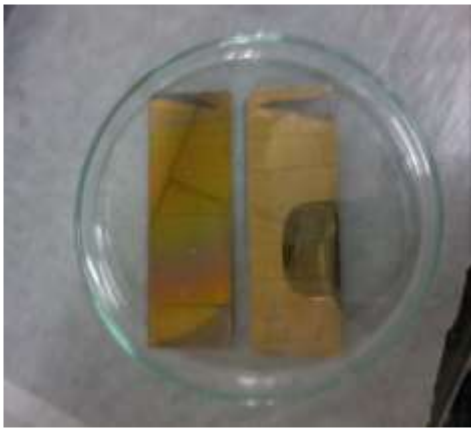

Fig. 9 PDMS channel

IV. CONCLUSION

The nano sized $BaTiO_3$ and TiO_2 with PMMA are best for such kind of sensor design. Microfluidics technology combined with chemical method are best suited for air pollution detection system.

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