Microfluidic Channel Farbication using Poly-Si as a Sacrificial Layer

Ranjan Kumar Maurya[1,2]
[1]CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI)
Pilani-333031, Rajasthan, India
[2]Academy of Scientific & Innovative Research (AcSIR),
New Delhi, India
Email: ranjan.ceeri88@gmail.com

Rahul Prajesh[1,2]
[1]CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI)
Pilani-333031, Rajasthan, India
[2]Academy of Scientific & Innovative Research (AcSIR),
New Delhi, India
Email: rahulprajesh@gmail.com

M.A. Alam[1]
[1]CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI)
Pilani-333031, Rajasthan, India
Email: mohdaftab93@gmail.com

Ajay Agarwal[1,2]
[1]CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI)
Pilani-333031, Rajasthan, India
[2]Academy of Scientific & Innovative Research (AcSIR),
New Delhi, India
Email: dr.ajay123@gmail.com

Abstract: ***In this work, process development for the realization of Microchannels is carried out using standard micro fabrication techniques with polysilicon as sacrificial material. Polysilicon (PolySi) material is deposited using LPCVD process. Thermal silicon oxide layer work as a capping layer after the polysilicon layer is released using wet chemical etching using Tetra Methyl Ammonium Hydroxide (TMAH). Fabricated microchannels are characterized using 3D optical imaging and scanning electron microscopy. Fabrication of the Microchannel with an open cross-section of 4 μm X 0.85 μm and 50 μm length is demonstrated.***

Keywords— Micro/nanofluidics, microchannel, ionic switch, FET

I. Introduction

Microfluidics has become a very attractive field for scientific community due to its capability to manipulate liquid at micro scale. Microfluidics has enormous applications in many biological tests, screening devices, biomarker detection for different diseases, micro-viscometer, ionic switch *etc.* [1-5]. The properties of the material of microfluidic channel plays an important role in the operation of microfluidic based devices. Different kind of fabrication techniques have been explored for microfluidic devices [6 -8]. The advancement in micro fabrication technologies have attracted many biologists for the development of miniaturized sensing platform for detection of different diseases due to their capability of low sample requirement of body fluids, better response time *etc.* Microfluidic devices also enable to integrate various processes like mixing, extraction, chemical treatment *etc.* on a single chip.

This paper reports a process development for fabrication of hydrophilic micro/nanofluidic channel for different applications such as biomarker detection for different diseases, micro-viscometer, ionic switch *etc.* This paper reports PolySi as a sacrificial layer for fabrication of micro/nano-fluidic channels and thermally grown silicon oxide layer works as a capping layer after removal of PolySi using wet chemical etching using Tetra Methyl Ammonium Hydroxide (TMAH). In many applications, the high quality of thermal SiO_2 is very essential such as FET based devices [9-11] to avoid gate leakage current and also for those devices which requires passive pumping.

II. Fabrication Details

The properties of the material for fluidic channels plays very important role in micro/ nano-fluidics. The material of microfluidic channel is decided based on their application. In most of the application, hydrophilic based microfluidic channel is preferred due to its ability to drive liquid without any external force. Here, SiO_2 is used to make microfluidic channel because of its hydrophilicity (contact angle < 90^o). In this work, a process is developed for realization of microfluidic channel using PolySi as the sacrificial layer Fig.1 represents the detailed process flow of micro channel fabrication. Fabrication is started with first lithography for patterning fluidic channel, post this 0.85 μm silicon is etched by Reactive ion etching (RIE) using SF_6 at power 200 watts. After RIE process, wafer was put in acetone for 20 minutes for photoresist removal. Fig. 2 represents 3-D optical image of RIE etched structure.

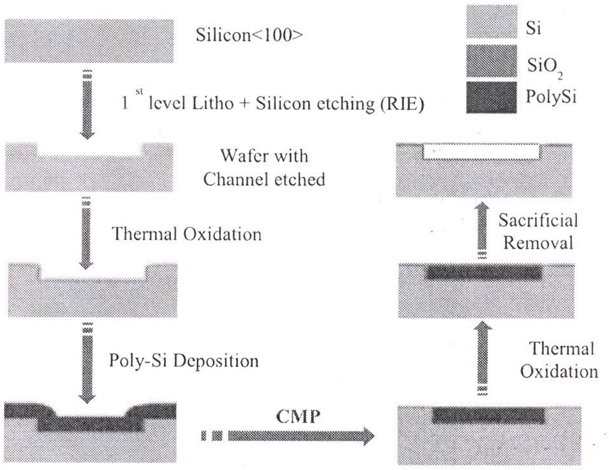

Fig.1: Detailed process flow for realization of micro/nanochannels

Then thermal oxidation is done to make channel hydrophilic for 90 minutes at 1100^0C to achieve 200 nm SiO_2. Post this, 1 μm PolySi is filled in the channel trenches and both the reservoirs using Low Pressure Chemical Vapor

Deposition (LPCVD) and the unwanted PolySi is removed using chemical mechanical polishing (CMP) for 20 minutes with rotation speed 30 RPM, slurry rate 110 ml/minute, back pressure 3 bar, front pressure 2 bar.

After CMP, thermal oxidation is performed to obtain 0.2 µm of SiO_2 and PolySi is removed using TMAH solution at 70^0C for 6.5 hrs. followed by 2^{nd} level lithography to open the window for reservoir to etch SiO_2 using RIE. Fig. 3 shows the microscopic images of microfluidic channel at different times during removal of sacrificial layer using TMAH at 70^o C without using CMP.

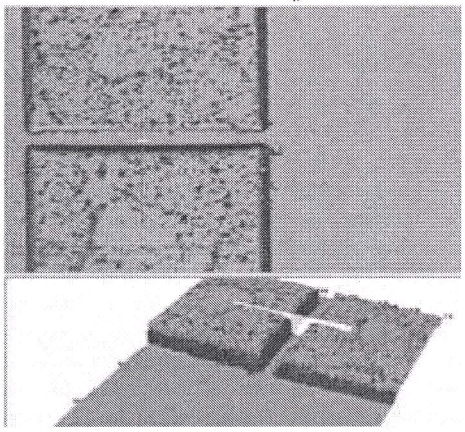

Fig. 2: 3-D Optical image of open microfluidic channel after RIE

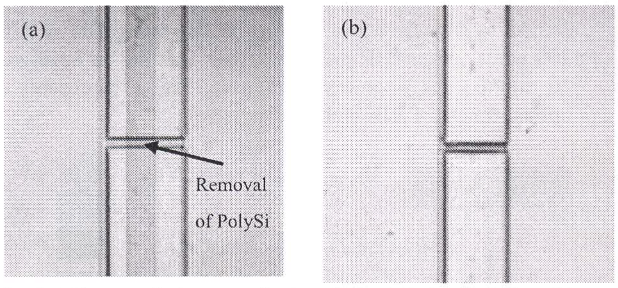

Fig. 3: Microscopic images of microchannel during PolySi etching in TMAH solution without using CMP (a) Partially removal of PolySi (b) complete removal of PolySi

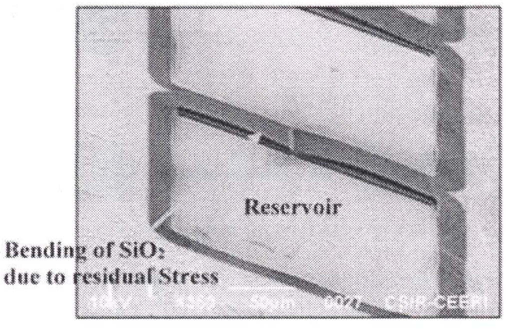

Fig.4: SEM image of complete device without CMP with channel length of 50µm and dimension of reservoir is 200µm×200µm

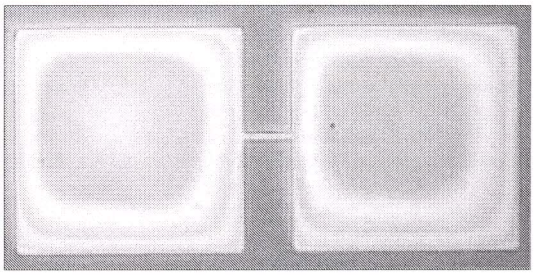

Fig. 5: Microscopic image of fabricated structure after thermal oxidation followed by CMP process

III. CHARACTERIZATION

Fabricated structures are characterized using 3-D optical profiler and Scanning Electron Microscopy (SEM). Both the released structures i.e. with and without CMP are characterized and analyzed using SEM and optical 3D profiler. Fig. 4 represents the SEM image of released structure without CMP which shows the bending of SiO_2 layer due to residual stress which is not required for a microfluidic channel. This problem is removed using CMP. Fig.5 represents the optical image of fabricated structure after thermal oxidation followed by CMP and stress free structures are observed. Fig. 6 represents the optical image of released structure along with SEM image of opening of microfluidic channel. Fig. 7 represents the SEM image of complete released structure.

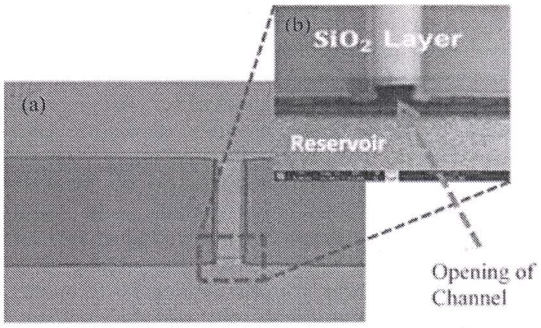

Fig. 6: (a) Optical image of released microfluidic channel (b) SEM image of microfluidic channel

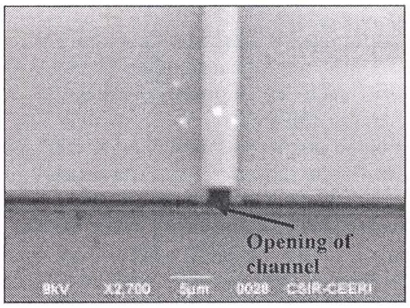

Fig. 7: SEM image of microfluidic channel with CMP process

Opening of released microfluidic channel is confirmed by a drop of DI water. It is observed under optical microscope that after some time the water reaches to the other reservoir of the released structure, which confirms the through and through opening of the channel. These fabricated hydrophilic microfluidic channels are the major component of a microfluidic device where a passive pumping of liquid is required. With the surface modification of inner wall of the fabricated microfluidic channel, device may be used for different biological sensing and also for controlling the movement of ions inside the channel.

IV. Conclusion

A process flow is developed to realize micro/nanofluidic channels with Poly-Si as a sacrificial layer using standard silicon process technique which allows us to cap the micro/nanochannels with high quality thermal SiO_2 which is very essential for many applications such as ionic switch, biosensing *etc.* Developed process may be used to fabricate different kind of microfluidic devices such as ionic switch, ionic controller devices, micro-viscometer, micro-mixers, lab-on-a-chip devices etc. for different applications and also various other applications such as cantilevers, hanging structures *etc.* where suspended structures are used.

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