Design and Fabrication of Smart Micro Reservoir for Biomedical Application

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Abstract-This paper describes the design and fabrication of smart reservoir integrated with MEMS cantilever for bio medical application. A reservoir is a kind of trap where fluid can be collected for biological sensing purposes. These smart reservoir is integrated with the cantilevers of desired shapes of well defined length, width, thickness and hence spring constant. These smart reservoirs are coated with unique chemical composition to attract particular foreign antigen present in the fluid and hence providing the platform for reaction to occur. The smart reservoir also provides sufficient time for reaction and can be further triggered to open the associated micro valve. The exact amount of fluid in reservoir is sensed by the MEMS cantilever in term of stress developed because of fluid trapped inside the reservoir which is the novelty of this system. The reservoir integrated with cantilever is fabricated using MEMS technology and thereby provides a cost effective fabrication process. The range of weight of liquid that can be collected is decided by the size of the reservoir during designing. The present paper describes design and fabrication for the smart micro reservoir integrated with MEMS cantilever for biomedical sensing purposes. The cantilever beams of V shaped and rectangular shaped with an integrated reservoir of 15 µm height were designed and fabricated for the spring constant values k=0.006 N/m and of k=0.01. The smart reservoir thus fabricated is made of a 1.0 µm thick of silicon dioxide and 0.3 µm of PECVD silicon nitride using TMAH as an etchant.

Keywords:smart micro reservoir,microfluidic,mico channel, MEMS technology,back to front alignment marks,micro valve

Introduction

Micro Electro Mechanical System(MEMS) Technology has played an important role in the field of sensors and nanotechnology. Different complicated structure has easily been fabricated using this technology. This technique allows the batch fabrication of complex structure and hence reduces the cost of fabrication which is the key feature of this technique. One of the important MEMS structure that led to the revolution in the field of nanotechnology was MEMS cantilever. These MEMS cantilever when used with atomic force microscopy(AFM) led us to visualize topographical image of the sample at atomic level. The topographical image of the sample is obtained by the means of a flexible cantilever having a sharp tip at the end, scanning(is also called raster scanning)over the sample. During the last two decades advances in the micro-electro-mechanical systems (MEMS) have facilitated development of sensor that involve transduction of mechanical energy and rely heavily on mechanical phenomena[1-3].development of micro fabricated cantilever for biological sensing signified an important milestone in establishing efficient technological approaches to MEMS sensor. Chemical reaction occurring on the surface of micro cantilever led to development of stress and change of resonance frequency in the cantilever. This paper describes the design and fabrication for smart micro reservoir for biomedical applications. Micro reservoir acts like a trap where sample can be collected for bio sensing application. These traps are integrated with MEMS cantilever commonly made of silicon dioxide or/and silicon nitride materials. The exact amount of sample under testing can be sensed by the development of stress or shift in the resonance frequency of a cantilever which is the novelty of the work presented in this paper. The stress developed on the edges can be easily converted in to electrical signal by means of polysilicon piezo-resistors arranged in Wheatstone bridge configuration.

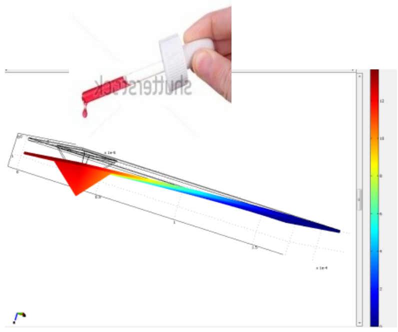

Fig1.1 showing the schematic working of smart reservoir as smart balance meter integrated with MEMS cantilever

The present paper describes the design as well as fabrication of smart reservoir by MEMS technology.COMSOL 3.3a Multiphysics is used as simulation platform taking blood as a sample.Since these reservoir are fabricated using MEMS technology hence they are cheap and reliable.The range of weight that can be best sensed by cantilever can be varied during designing.

Design and Simulation

The simulation result uses blood as a sample having taken density as 1060kg/m^3 .The size of trap taken as 21 µm and height as 15 µm. These traps are made of 1.0µm of silicon dioxide and 0.3 µm of silicon nitride

Design	Length (µm)	Width (µm)	Thickness (µm)	Spring Constant (k) (N/m)	Simulated Resonance Frequency with Tip (Khz)
1	214	40	1	0.006	25.10
2	214	40	1	0.01	30.26

Table 1: Design Parameters for Microcantilever for trap of size 21 µm and height of 15 µm

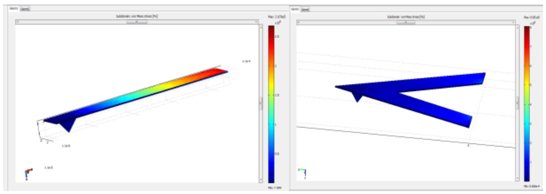

Fig.2.1 Simulated Result of rectangular & triangular cantilever integrated with smart reservoir having design parameter1&2.The maximum stress was found as **535**Pa **&1610Pa** respectively at the fixed edges

Fabrication

In the fabrication of reservoir integrated with micro-cantilever based on MEMS Technology, starting silicon wafer is a double sided polished (100) oriented with a size of 2 inch diameters in a batch of few tens in numbers in a commercial fabrication foundry. The silicon wafer went under different level of film deposition (silicon dioxide and silicon nitride) and lithography. The back to front alignment technique[4] was used which is novel etch stop technique to control the etching depth of smart reservoir with replacing Boron Etch Stop technique and Electro chemical Etch stop technique and serves as a basic step for the realizing of cavities/ diaphragms for different kind of MEMS application and thus the micro-beams structures.

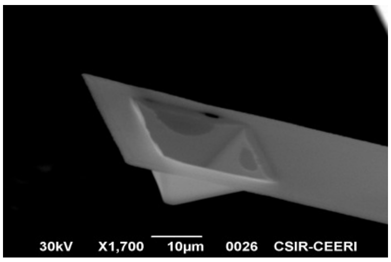

Fig 3.1 showing the SEM image of smart reservoir attached to rectangular cantilever

These traps can be made of any dimension with controlled height using back to front alignment technique. This technique provides the cheap and accurate method to decide the thickness of the diaphragm as well as thickness of many complex MEMS structure.

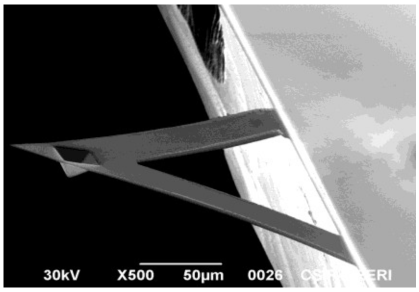

Fig 3.2 showing the SEM image of smart reservoir attached to triangular cantilever

Conclusion

Smart reservoir integrated with rectangular and V shaped MEMS cantilever were successfully designed and fabricated. The fabrication process uses back to front alignment mark and hence provide a cost effective technique for realizing MEMS structure. This smart reservoir acts as a trap where sample can be easily collected. These traps are coated with particular chemical attracting the composition present in the sample for reaction to occur. The effect of this reaction lead to formation of stress at the edges which can be directly converted in to electrical signal by polysilicon piezoresistor arranged in the Wheatstone bridge configuration and hence provide the promising tool for elemental analysis of the sample. The smart reservoir integrated with MEMS cantilever can monitor volume of the sample trapped with high accuracy by the development of stress on the edges or by change in the resonance frequency of the cantilever.

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