Recent Application and Future Development Scope in MEMS

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Abstract - *This paper deals with recent developments and future of micro-electromechanical systems, or MEMS. Micro-Electro-Mechanical Systems (MEMS) are extensively used in the field of scientific and engineering. MEMS encompass the process-based technologies used to fabricate tiny integrated devices and/or systems that integrate functionalities from different physical domains into one device Micro-Electro-Mechanical Systems. Such devices are fabricated using a wide range of technologies, having in common the ability to create structures with micro- and even nanometer accuracies. Micro-electromechanical systems (MEMS) are a process technology used to create tiny integrated devices or systems that combine mechanical and electrical components. They are fabricated using integrated circuit (IC) batch processing techniques and can range in size from a few micrometers to millimeters.*

Key Words: **MEMS, MST, GPS,MOEMS, PDMS etc.**

1. INTRODUCTION

This document is template. We ask that authors follow some MEMS, an acronym that originated in the United States, are also referred to as Micro System Technology (MST) in Europe and Micromachining in Japan. Regardless of terminology, the uniting factor of a MEMS device is in the way it is made. While the device electronics are fabricated using `computer chip' IC technology, the micromechanical components are fabricated by sophisticated manipulations of silicon and other substrates using micromachining processes.

MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move. The term used to define MEMS varies in different parts of the world. In the United States they are predominantly called MEMS, while in some other parts of the world they are called “Microsystems Technology” or “micro machined devices”. These devices (or systems) have the ability to sense, control and actuate on the micro scale, and generate effects on the macro scale.

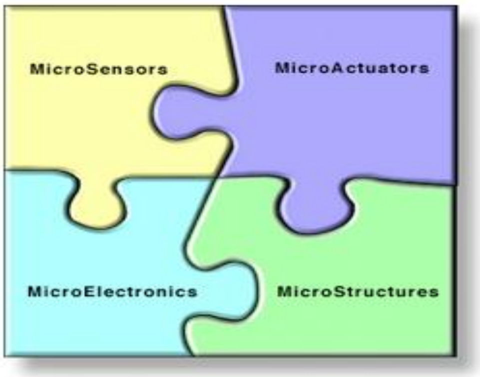

Fig.1: Components of MEMS

1.1 Recent development:

The experience gained from these early MEMS applications has resulted in an enabling technology for new biomedical applications (e.g. Lab on Chip) and optical or wireless communications, also referred to as respectively Micro Opto Electro Mechanical Systems (MOEMS), and Radio Frequency MEMS (RF MEMS).

1.2 Lab-On-Chip

Biochips are biological microchips that host reactions between DNA, proteins, chemical and biological reagents on glass, silicon or plastic plates in order to extract information.

The main advantages of Lab on Chip components include ease-of-use, speed of analysis, low sample and reagent consumption and high reproducibility due to standardization and automation. As is clear from the term Lab on Chip, the goal is to place the entire process of a laboratory onto a single chip. Micro fluidic systems therefore typically contain silicon micro machined pumps, flow sensors, micro channels, micro reactors and chemical sensors. They enable fast and easy manipulation and analysis of small volumes of liquids. The ability to receive test results in a few hours or even minutes, rather than a week or so, will make a vast difference in diagnosis and treatment, but also in the patient's well being. There are three main application areas for Lab on Chip: medical diagnostics, clinical diagnostics and life science research.

Lab on chip concepts have been developed and are being developed for many applications such as SARS, leukemia, breast cancer, dipolar disorder and a several infectious diseases.

From a unit shipment standpoint, Point of Care diagnostics is the largest (potential) segment, although in terms of turnover, the segment of life science research is larger, thanks to higher chip prices. Price of components here can run into several hundreds of dollars, while for POC diagnostics a few dollars or less is acceptable at most. Chips for specialized clinical diagnostics tests operate somewhere in the middle.

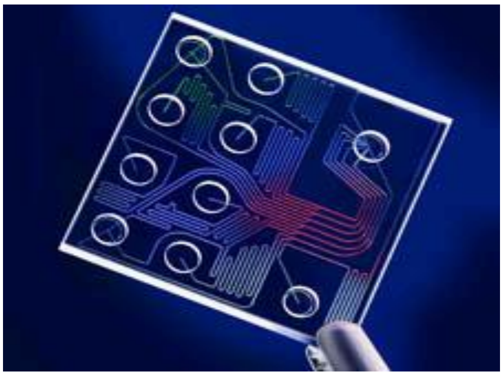

Fig.2 Lab on Chip

1.3 MOEMS

Optical communications has emerged as a practical means to address the network scaling issues created by the tremendous growth in data traffic caused, in part, due to the rapid rise of the use of internet. The most significant MOEMS based products include, variable optical attenuators, optical switching units and tunable filters. Their small size, low cost, low power consumption, mechanical durability, high accuracy, high switching density as well as the low cost batch processing of these MEMS-based devices make them a perfect solution to the problems of the control and switching of optical signals in telephone networks.

1.4 RF MEMS

RF MEMS constitute one of the fastest growing areas in commercial MEMS technology. RF MEMS are designed specifically for use within the electronics in mobile phones and other wireless communication applications such as radar, global Positioning satellite systems (GPS) and steerable antenna. The main advantages gained from such devices include higher isolation and therefore less power loss and an ability to be integrated with other electronics. MEMS have enabled the performance, reliability and function of these devices to be enhanced while driving downs their size and cost at the same time.

The technology includes passive devices such as capacitors/inductors, filters and resonators (see figure 3). But also active devices such as switches (see figure 4). These low-loss ultra-miniature and highly integrated RF functions can replace classical RF elements and enable a new generation of RF devices and systems. It must be stated that in spite of considerable effort from the industry over the last years, only a handful of companies have come close to commercialization.

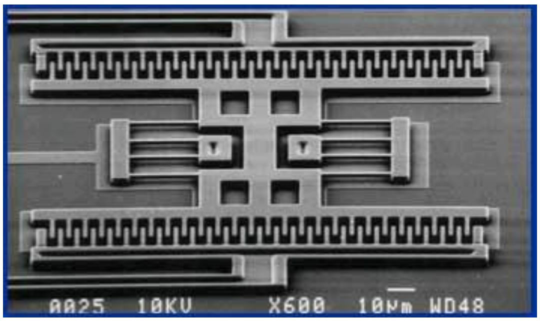

Fig. 3 Combdrive resonator

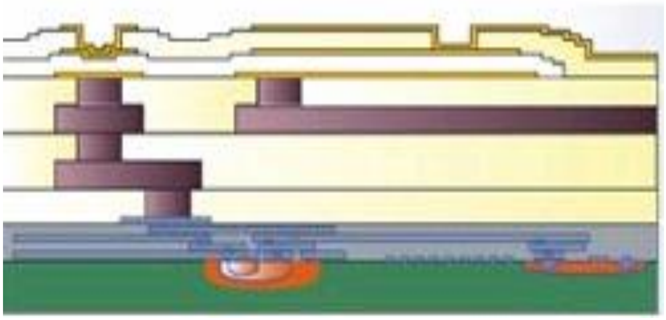

Fig.4 Schematic cross section RF MEMS switch

2. FABRICATION

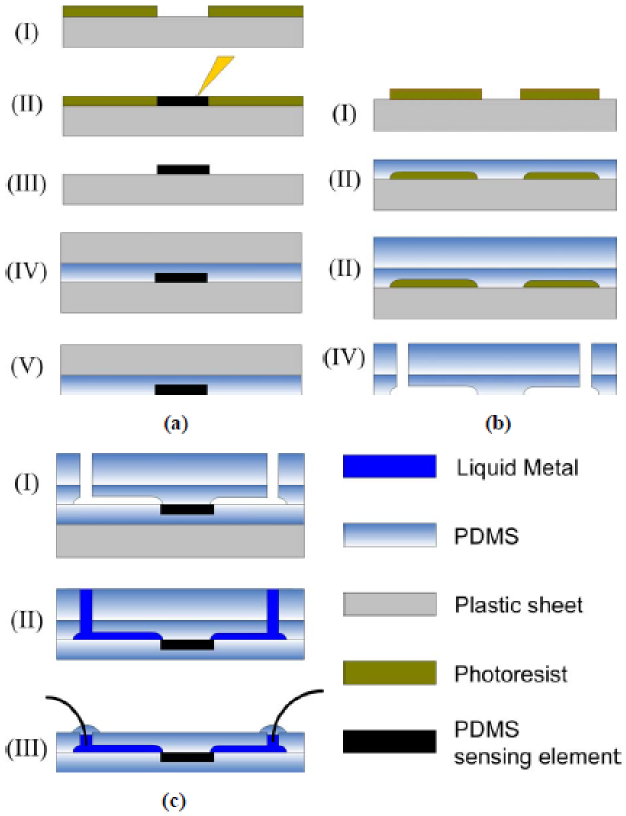

Fig.5 Fabrication process flow: (a) Sensing element layer fabrication process, (b) Interconnect layer, (c) bonding two layer and make electrical connection out.

As shown in Fig. 5, the fabrication of the sensor skin can be divided into 3 parts for clearly explanations. The first part is fabricating the sensing element layer shown in Fig. 5(a): First, two layers of photo resist AZ-4620 is patterned on a plastic sheet and a squeegee process is used to pattern the PDMS sensing material [3], which is PDMS elastomer mixed with 10% weight ratio MWNT. A further 90°C baking in oven is used to solidify the patterned PDMS sensing material, and then liquid PDMS is poured on the sensing element with another plastic sheet on top for easy transferring. After the liquid PDMS is cured in 90°C oven for 10 minutes, the bottom plastic sheet is peeled off. The second part is to make the electrical interconnect layer shown in Fig. 5(b): the first step is to pattern one layer of photo resist AZ-4620. Then the patterned photo resist is baked on 200°C hotplate for 20 minutes for reflow in order to reduce flow resistance of micro fluidic channel. Following that, liquid PDMS elastomer is spincoated at 1000/min and cured on the photo resist mould. For easy transfer, a thick PDMS layer is reversibly bonded on top of the micro fluidic channel layer. Finally, the bottom plastic sheet is peeled off from micro fluidic layer, and two through holes (500 μm in diameter) are manually drilled as inlet and outlet. The third part is to permanently bond the aforementioned two layers together to form the sensor skin shown as Fig. 5(c).

After processed in ICP Oxygen plasma for 15 seconds, they are bonded together by an apparatus that can adjust within 20μm error, further followed by baking for 10 minutes in 90°C oven. Then the bottom plastic is carefully peeled off. Then liquid metal is pumped by syringe through the inlet drilled into the micro fluidic channel and make overlap on the PDMS sensing element. After filling liquid metal into the micro fluidic channel, thick PDMs bulk is removed and a thin sensor skin is finally finished. In order to make electrical connection out, a metal wire is inserted into the holes to make contact with liquid metal, and then liquid PDMS is dipped on and later cured to hold the metal line.

3. RECENT APPLICATIONS

3.1 A directional microphone for hearing aids inspired by ears of the fly Ormia ochracea.

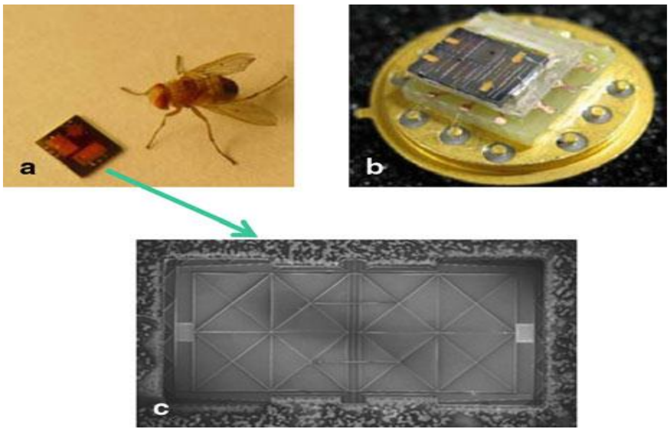

Fig.6 A directional microphone for hearing aids inspired by ears of the fly Ormia ochracea. **(a)** A picture for the chip containing polysilicon diaphragms next to the fly Ormia ochracea, **(b)** is a packaged microphone, and **(c)** is a SEM picture of the torsional polysilicon diaphragm, which is the backbone of the directional microphone.

3.2 Differential pressure sensors used in cars and trucks diesel engines emissions systems

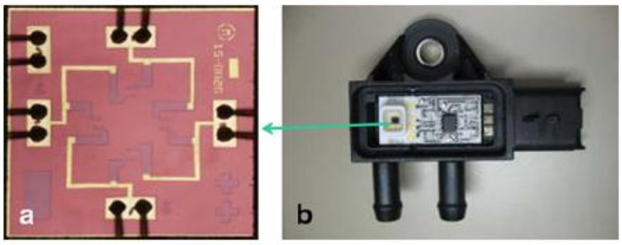

Fig. 7 Differential pressure sensors used in cars and trucks diesel engines emissions systems. **(a)** A micro-diaphragm with a piezoresistive 4-gauge bridge, **(b)** the packaged device.

4. CONCLUSION:

The fascination in the MEMS technology comes from their distinguished characteristics. MEMS are characterized by low cost, which is a direct consequence of the batch fabrication. They have lightweight and small size, which is desirable for compactness and convenience reasons. In addition, this has opened the gates for new possibilities of implementing MEMS in many places where large devices do not fit, such as engine of cars and inside the human body. Moreover, they consume very low power, which not only does reduce the operational cost but also enables the development of long-life and self-powered devices that can harvest the small amount of energy they need from the environment during their operation.

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