OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Micro-Electromechanical Systems (Mems)

R. U. Sonje[1], S. V. Borde[2]
[1, 2]Mechanical Department, Govt. Polytechnic, Nashik, Nashik, Maharashtra (India)

Abstract: *Micro-electro-mechanical systems (MEMS) have been identified as one of the most promising technologies and will continue to revolutionize the industry as well as the industrial and consumer products by combining silicon-based microelectronics with micro-machining technology. All the spheres of industrial application including robots conception and development will be impacted by this new technology. If semiconductor microfabrication was contemplated to be the first micro-manufacturing revolution, MEMS is the second revolution. The paper reflects the results of a study about the state of the art of this technology and its future influence in the development of the construction industry. The interdisciplinary nature of MEMS utilizes design, engineering and manufacturing expertise from a wide and diverse range of technical areas including integrated circuit fabrication technology, mechanical engineering, materials science, electrical engineering, chemistry and chemical engineering, as well as fluid engineering, optics, instrumentation and packaging.*
Keywords: *MEMS, Electronics, Construction, Sensors, Automation*

I. Introduction

MEMS is a process technology used to create tiny integrated devices or systems that combine mechanical and electonic components. They are fabricated using integrated circuit (IC) batch processing techniques and can range in size from a few micrometers to millimetres. These devices (or systems) have the ability to sense, control and actuate on the micro scale, and generate effects on the macro scale. MEMS can be found in systems ranging across automotive, medical, electronic, communication and defence applications. Current MEMS devices include accelerometers for airbag sensors, inkjet printer heads, computer disk drive read/write heads, projection display chips, blood pressure sensors, optical switches, microvalves, biosensors and many other products that are all manufactured and shipped in high commercial volumes.

II. What Is Mems?

Micro electromechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate through micro fabrication technology (Semiconductor chip)**.**These devices (or systems) have the ability to sense, control and actuate on the micro scale, and generate effects on the macro scale.

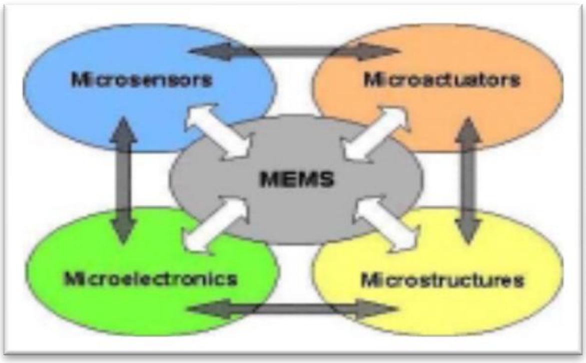


Fig.(1):Components of MEMS

III. Components In Mems

3.1Transducer

A transducer is a device that transforms one form of signal or energy into another form. The term transducer can therefore be used to include both sensors and actuators and is the most generic and widely used term in MEMS.

3.2 Sensor

A sensor is a device that measures information from a surrounding environment and provides an electrical output signal in response to the parameter it measured. These energy domains include:

- Mechanical - force, pressure, velocity, acceleration, position.
- Thermal - temperature, entropy, heat, heat flow.
- Chemical - concentration, composition, reaction rate.
- Radiant - electromagnetic wave intensity, phase, wavelength, polarization reflectance.
- Magnetic - field intensity, flux density, magnetic moment, permeability.
- Electrical - voltage, current, charge, resistance, capacitance, polarization.

3.3Actuator

An actuator is a device that converts an electrical signal into an action. It can create a force to manipulate itself, other mechanical devices, or the surrounding environment to perform some useful function.

IV. Classification Of MEMS

4.1 Bio MEMS

An area of particular interest in home-based medical applications where patients can use devices to monitor their own conditions, such as blood and urine analysis.

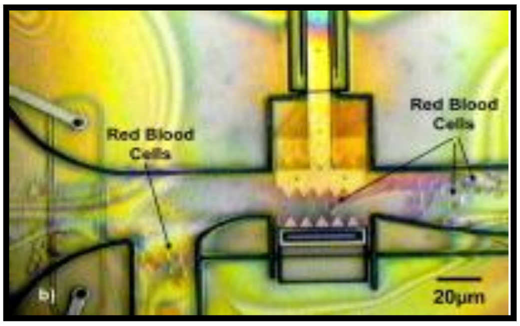


Fig.(2) A Bio MEMS device

A Bio MEMS device is actuated with 'micro teeth' to trap, hold and release single red blood cells (unharmed). The little balls in the channels are red blood cells.

4.2 MOEMS

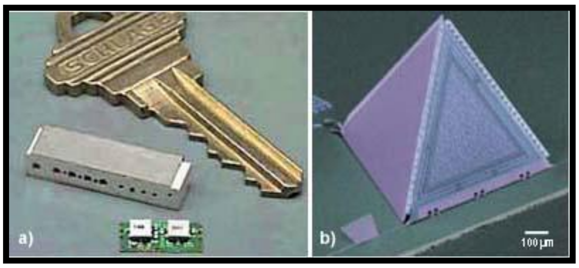
MEMS-based devices make them a perfect solution to the problems of the control and switching of optical signals in telephone networks.

Fig(3) A. MEMS optical cross connect

A MEMS optical cross connect consists of an array of microscopic mirrors, each the size of a pin head and able to tilt in various directions to steer.

4.3 RF MEMS

RF MEMS is one of the fastest growing areas in commercial MEMS technology. RF MEMS are designed specifically for electronics in mobile phones and other wireless communication applications such as radar, global positioning satellite systems (GPS) and steerable antennae. MEMS has enabled the performance, reliability and function of these devices to be increased while driving down their size and cost at the same time.



Fig(4) A

A miniature acoustic resonator, shown in the foreground, is one-fifth the size of a traditional component used in mobile phones and other wireless communications devices, and (b) on-chip micro-microphones may make it possible to build radios on a chip.The technology includes circuit tuning elements (capacitors/inductors, resonators, filters, microphones and switches). These low-loss ultra-miniature and highly integrative RF functions can and will eventually replace classical RF elements and enable a new generation of RF devices. As it can be seen today, if RF MEMS components continue to replace traditional components in today's mobile phones, then phones could become extremely small (the size of wristwatch is not too far away), require little battery power and may even be cheaper.

V. Materials Used To Fabricate MEMS

Silicon substrate (single crystal or polycrystalline)is preferable because; Homogeneous structure gives desirable electrical & mechanical properties. silicon's ability to be deposited in thin films is very suitable to MEMS. Provides high definition and reproduction of device shapes using photolithography. silicon microelectronics circuits are batch fabricated (a silicon wafer contains hundreds of identical chips not just one).

VI. Manufacturing Processes Of MEMS

The technique used for manufacturing MEMS and Microsystems components is called as Micromachining.
There are four methods of Micromachining.

1. Bulk Micromachining
2. Surface Micromachining
3. LIGA Process
4. Laser micromachining

6.1 Bulk Micromachining

Bulk micromachining involves the removal of part of the bulk substrate. It is a subtractive process that uses wet anisotropic etching or a dry etching method such as reactive ion etching (RIE), to create large pits, grooves and channels. Materials typically used for wet etching include silicon and quartz, while dry etching is typically used with silicon, metals, plastic and ceramics.

6.2 Surface Manufacturing

This method is used for production of microactuators.(Substrate: Silicon, Silicon Carbide).The material is deposited i.e. layer by layer (1 to 100µm thick) on top of substrate Phosposilicate Glass (PSG) sacrificial layer is deposited.Wet etching is used to remove sacrificial layer(HF or HCl is used as etchants)Structural layer of Polysilicon is deposited.

6.3 LIGA(Lithography, Galvanoformung, Abformung)

LIGA is an important tooling and replication method for high-aspect-ratio microstructures. The technique employs X-ray synchrotron radiation to expose thick acrylic resist of PMMA under a lithographic mask (see Figure 24 below).

The exposed areas are chemically dissolved and, in areas where the material is removed, metal is electroformed, thereby defining the tool insert for the succeeding moulding step. LIGA is capable of creating very finely defined microstructures up to 1000 μm high. LIGA is limited by the need to have access to an X-ray synchrotron facility.

6.4 Laser Micromachining

Most laser micromachining processes are not parallel and hence not fast enough for effective MEMS fabrication. Nonetheless, they have utility in specialty micromachining or making moulds. Excimer laser micromachining is used particularly for the micromachining of organic materials (plastics, polymers etc.) as material is not removed by burning or vaporization. Hence, material adjacent to the machined area is not melted or distorted by heating effects. Lasers have found other applications in MEMS but only in a limited capacity; laser drilling, laser annealing and etching are the most common forms.

VII. Conclusions

The development of MEMS is demanding higher levels of electrical-mechanical interaction, as well as a higher level of knowledge of the physical world. Their use increases the systems' properties like reliability and level of integration. The development of microdevices in which are embedded the electronic circuits, sensors, actuators and engines, open new ways of solving industrial problems at lower cost and increased quality. MEMS sensors utilization permit to avoid the necessity of point-to-point wiring, realizing a digital output format, and obtaining greater precision. Embedded sensors in different type of structures permits the creation of what is called "smart structures", which can be used in civil and mechanical engineering projects.

VIII. The Future Of Mems

A. Industry Challenges

Some of the major challenges facing the MEMS industry include:

i) Access to Foundries:

MEMS companies today have very limited access to MEMS fabrication facilities, or foundries, for prototype and device manufacture. In addition, the majority of the organizations expected to benefit from this technology currently do not have the required capabilities and competencies to support MEMS fabrication. For example, telecommunication companies do not currently maintain micromachining facilities for the fabrication of optical switches. Affordable and receptive access to MEMS fabrication facilities is crucial for the commercialization of MEMS.

ii) Design, Simulation and Modeling:

Due to the highly integrated and interdisciplinary nature of MEMS, it is difficult to separate device design from the complexities of fabrication. Consequently, a high level of manufacturing and fabrication knowledge is necessary to design a MEMS device. Furthermore, considerable time and expense is spent during this development and subsequent prototype stage. In order to increase innovation and creativity, and reduce unnecessary 'time-to-market' costs, an interface should be created to separate design and fabrication. As successful device development also necessitates modeling and simulation, it is important that MEMS designers have access to adequate analytical tools. Currently, MEMS devices use older design tools and are fabricated on a 'trial and error' basis. Therefore, more powerful and advanced simulation and modeling tools are necessary for accurate prediction of MEMS device behavior.

iii) Packaging and Testing:

The packaging and testing of devices is probably the greatest challenge facing the MEMS industry. As previously described, MEMS packaging presents unique problems compared to traditional IC packaging in that a MEMS package typically must provide protection from an operating environment as well as enable access to it. Currently, there is no generic MEMS packaging solution, with each device requiring a specialized format. Consequently, packaging is the most expensive fabrication step and often makes up 90% (or more) of the final cost of a MEMS device.

REFERENCES

[1.] [Vittorio 2001]. Vittorio, Salvatore A.. Micro-Electromechanical Systems (MEMS), Cambridge scientific abstracts. October 2001.www.csa.com/hottopics/mems/oview.html

[2.] [Singer 2002]. Singer, Peter. MEMS Diversity and Advance Semiconductor International. October 1st, 2002.

[3.] [Silicon Microstructures, Inc]. Silicon Microstructures, Inc. Simplified Description in the Process to Fabricate Piezoresistive Pressure Sensors.www.simicro.com/pdffiles/PressureFab.pdf.

[4.] [Carrillo]. Carrillo, Daniela. MEMS Sensor Technology: Present and Future.Frost.com. www.frost.com/prod/news.nsf/0/2C5351EB5F6D414A86256CBE005C5ED4

[5.] [Atto-Okine 2002], Attoh-Okine Nii O. MEMS Application in Pavement Condition Monitoring-Challenges. Proceedings of the 19th International Symposium on Automation and Robotics in Construction (ISARC) 2002, pp. 387-392. Gaithersburg, USA.