

A Review of MEM Sensors

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ABSTRACT

This paper presents What is MEM's technology ,which are different fabrication techniques of MEMS, MEMS technologies are the rising star in the sensors market. MEM sensors are smart sensors , application of MEMS Sensors in different areas , Future scope of MEM Sensors

Keywords: MEMS Technology , Fabrication Techniques, MEM Sensors , Smart Sensor

1. INTRODUCTION

What is MEMS?

Micro-Electro-Mechanical Systems, or 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 microfabrication. 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 "micromachined devices".

While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable (and perhaps most interesting) elements are the microsensors and microactuators. Microsensors and microactuators are appropriately categorized as "transducers", which are defined as devices that convert energy from one form to another. In the case of microsensors, the device typically converts a measured mechanical signal into an electrical signal.[1]

2. Different Fabrication Techniques of MEMS

- 1] **Bulk micromachining** - whereby the bulk of the Si substrate is etched away to leave behind the desired micromechanical elements
- 2] **Wafer bonding** - permits an Si substrate (aka 'wafer') to be attached to another substrate, typically Si or glass, to construct more complex 3D microstructures such as microvalves and micropumps
- 3] **Surface micromachining** - where the structures are built on top of the substrate and not inside of it, enabling fabrication of multi-component, integrated micromechanical structures not possible using bulk micromachining
- 4] **Micromolding** - a process using molds to define the deposition of the structural layer, and enabling the manufacture of high aspect ratio 3D microstructures in a variety of materials such as ceramics, glasses, metals, and polymers
- 5] **LIGA** - a micromolding process that combines extremely thick-film resists (>1 μm thick) and high-energy x-ray lithography, to enable the manufacture of high-aspect-ratio 3D microstructures in a wide variety of materials
- 6] **High aspect ratio micromachining (HAR)** - combines aspects of both surface and bulk micromachining to allow for silicon structures with extremely high aspect ratios through thick layers of silicon (hundreds of nanometers, up to hundreds of micrometers) [2]

3. MEM Sensors are smart sensors

According to 'Smart Sensors: An International Market Report' (BizAcumen, Inc.) sensor networks and smart sensors are being used widely in industries, including automotive, medical, industrial, entertainment, security, and defence due to increased usage of process controls and sensing elements in different sectors. Use of smart sensors in counter-terrorism applications including cargo tracking, biometrics among others is also increasing. Smart systems are being readily accepted by the auto industry as automakers explore ways to save lives, deflect safety concerns and prompt costly litigation. Smart systems can sense an impending crash, its nature, the presence of occupants, their position, and determine the type of airbags to be fired and the force and speed of their deployment. Motion-tracking sensors and inertial sensors based on micro-electromechanical system (MEMS) are widely being used in medical applications.

Implantable devices that are small in size and yet possess high reliability, and handheld devices for use in diagnostics and home monitoring mainly drive the demand for such sensors.

Strong growth expected for sensors based on MEMS-technologies, smart sensors, sensors with bus capabilities and embedded processing. Sensors based on MEMS and NEMS technologies and intelligent (smart) sensors are at the focus of the current sensor development. MEMS technologies allow to miniaturize sensors and, at the same time, to integrate their sensor elements with microelectronic functions in minimal space. MEMS technologies make it possible to mass-produce sensors more and more cost-effectively while improving their functionality and miniaturizing them. Thus, major sensor and electronics manufacturers expect that within a few years, there will be complete sensor integrated on one chip and having its own local intelligence for information processing.

But what does it mean a “smart sensor” ? In some languages “smart” and “intelligent” are translated from English by the same word that normally means “intelligent”. But in English there is a difference. It is a reason of existing of two widely used smart and intelligent sensor definitions. The first one is more related to technological or so-called “smart” aspects; the second one is more related to functional or so-called “intelligent” aspects. The first definition was formulated by the following way: smart sensor is a combination of a sensor, an analog interface circuit, an analog to digital converter (ADC) and a bus interface in one housing [3,4]. It was the first smart sensor definition and is used widely till now. A smart sensor can be made as integrated (if all elements of smart sensors are integrated into one chip) or hybrid sensor. The second definition was formulated by the following manner: intelligent sensor is the sensor that has one or several intelligent functions, and is used often in various references. There was also an attempt to merge both “technological” and “intelligent” aspects of smart sensors in a single definition [5]: smart sensor is one chip, without external components, including the sensing, interfacing, signal processing and intelligence (self-testing, self-identification or self-adaptation) functions. Some interesting smart and intelligent sensors definitions in its developments were described in [6].

What does it make a sensor to be “intelligent” ? Very often it means a presence of microcontroller or microprocessor. However, it is a necessary but not enough condition. Sometimes a microcontroller is used only for calculation according to predetermined equations. Speaking about intelligent sensors various intelligent functions mean a self-testing, self-validation, self-checking, self-diagnosis, self-adaptation, self-identification, self-calibration, self-compensation, self-etc ...

In common case, a smart sensor can not have any intelligent function, as well as an intelligent sensor can not be a smart. In other turn, *an intelligent sensor system* can be based on any sensors, not only on smart or intelligent.

Modern microelectronics and MEMS technologies and its rapid developments bring new possibilities for integration of all smart sensors elements, in other turn, novel methods of measurements and advanced algorithms introduce more intelligence into smart, intelligent sensors and systems. The aim of this editorial article is not to formulate a precision, modern definition of smart (intelligent) sensor (it is a call for standardization), but rather to distinguish further perspectives and modern trends in smart (intelligent) sensors development.

From technological “smart” point of view an IC-compatible 3D micro-structuring technology is being developed [5]. An integrated smart sensor should contain all elements including wireless communication and power management. Without doubt, innovative technology concept such as smart systems integration will play a crucial role in this respect. Smart systems, defined as intelligent, often miniaturized, technical subsystem with their own and independent functionality evolving from microsystems technology. Smart systems are able to sense and diagnose complex situations. They are “predictive”, they have the capability to decide and help to decide as well as to interact with the environment [7].

4. Flexibility of MEMS

MEMS (microelectromechanical sensors including accelerometers, gyroscopes, digital compasses, inertial modules, pressure sensors, humidity sensors and microphones), **smart sensors** and **sensor hubs**, **UV index sensors**, **temperature sensors** and **touch sensors**.

Offers:

- 1) A unique sensor portfolio, from discrete to fully-integrated solutions, to fulfill every design need.
- 2) High-volume manufacturing capacity to provide cost-competitive solutions, fast time-to-market and security of supply.
- 3) High performance sensor fusion to improve the accuracy of multi-axis sensor systems in order to enable new emerging and highly-demanding applications, such as indoor navigation and location based services

- 4) High-level quality products, already tested in different application fields, including mobile, portable, gaming, consumer, automotive and health care
- 5) Multiple dedicated sites to MEMS foundry, assembly and testing lines, with in-house complete dual source[8]

5. Application of MEM sensors in different areas

- **MEMS pressure sensors** sense, monitor and transmit in **Automotive industry** for Tire pressure, Fuel pressure, Oil pressure, Air flow, Absolute air pressure within the intake manifold of the engine
- **Barometric PS** -used in wind tunnels and for weather monitoring applications.
- **Smart Roads** -millions of MEMS sensors are incorporated into roads to gather and transmit information about road conditions.[9]
- **Smart Dust** is a network of micro-sized wireless MEMS sensors that communicate with each other through tiny transmitters. Smart dust sensors (such as MEMS pressure sensors) could be scattered around a building, a piece of property, embedded in clothing, or in road beds.[10]
- **MEMS inertial sensors** are designed to sense a change in an object's inertia, and then convert, or transduce inertial force into a measurable signal. They measure changes in acceleration, vibration, orientation and inclination. This is done through the use of micro-sized devices called accelerometers and gyroscopes.
- In addition to sensors, MEMS consist of pumping devices, gear trains, moveable mirrors, miniature robots, tweezers, tools and lasers.
- These devices have found numerous applications with various fields such as biomedical, optical, wireless networks, aerospace, and consumer products.
- **MEMS in the Medical Field**
 - Precise dispensers for small amounts of liquids found in needleless injectors and drug delivery systems.
 - Sub-dermal glucose for monitoring monitor glucose levels and deliver of the insulin.
 - Medical diagnostics for blood analysis, cells counts and urinalysis.
 - Polymerase chain reaction (PCR) for DNA replication.
 - DNA microarrays for testing of genetic diseases and other biological markers
- **Optical Applications of MEMS**
 - The objective for optical MEMS is to integrate optical, mechanical and electronic functions into one device. Optical MEMS have already been quite successful in display technologies.
 - Two commercial devices –Digital Mirror Devices and Grating Light Valve -redirect light to create high definition imaging from digital signals. Both of these devices are used in video projection systems such as rear and front projection televisions.
 - Texas Instrument's Digital Mirror Devices (DMD) have been used for several years in a variety of projection systems including video projection and digital cinema. The technology is called digital light processing or DLPTM, a trademark owned by Texas Instruments
- **Other Applications of MEMS**
 - MEMS nozzles and pumps for inkjet printers
 - RF devices –Switches, phase shifter resonators, filters and variable antennas
 - Fuel delivery systems that can control propellant motion
 - Coating sensors that compensate for coating problems (adhesion, surface [11])

6. Future scope

The operating efficiency of combustion engines, energy conversion equipment, and many manufacturing processes will be improved by more capable MEMS systems. More advanced MEMS systems offer significant potential for technological advances in medical diagnostics, autonomous robotic systems, communications, and computer systems.

Three different, somewhat disparate topics were discussed to support this thesis. First, data from various market surveys and trade publications was presented to demonstrate that the sale of MEMS devices into commercial markets is significant and growing. Profits from the sale of these devices will provide the resources and incentive for continued technology development independent of government investment.

Second, a sampling of the many types of MEMS devices available was presented. This survey attempted to illustrate the broad range of applications as well as the diversity in materials and processes used to produce MEMS devices. It also illustrated how recent progress of integrating packaging into the fabrication process has yielded smaller devices that can be produced in state of the art CMOS fabs at very low cost.

Finally, a simple radio transceiver was used to illustrate the need to incorporate a plethora of small, discrete devices of diverse construction into a cost sensitive, consumer product. Experiments using a variety of selfassembly techniques have yielded encouraging results that suggest it will indeed be possible to assemble these miniature, complex systems at an affordable cost.[12]

7. Conclusion

Modern microelectronics and MEMS technologies and its rapid developments bring new possibilities for integration of all smart sensors elements, in other turn, novel methods of measurements and advanced algorithms introduce more intelligence into smart, intelligent sensors and systems. MEMS technologies are perceived as being all-encompassing solutions, when in actual fact, they remain a largely one product, one process business. Smart sensors will be smarter and intelligent sensors will have more artificial intelligence, and finally, we will get real smart, intelligent sensors using MEMS.

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