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MICRO-ELECTROMECHANICAL SYSTEMS TECHNOLOGY TO IMPROVE THE PERFORMANCE OF VARIOUS INDUSTRIES: A STUDY

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Abstract: - Continuing advancement in Microelectromechanical Systems (MEMS) provides mankind with the ability never before conceivable to fly to dimensional spaces. New manufacturing techniques, new materials, machining equipment, new manufacturing devices, integration method and more detailed studies of micro-scale physics and surface chemistry. MEMS technology penetrates the automobile, medical, biotechnological, sports/entertainment, calculating, data storage, photonics/optics, computing, aerospace, precision tools/robotics and environmental monitoring industries within 10 years of its inaugurations. MEMS technology aims to improve the performance and time of development of potential components of the spacecraft. Micro-cilia actuator models provide a lightweight alternative to traditional miniature satellite docking systems. The system uses surface tiled with MEMS actuators rather than mechanical driven structures to direct the satellite to its site of docking.

Keywords—*Microelectromechanical Systems(MEMS), fabrication, Applications of MEMS, MEMS technology, MEMS Sensors.*

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I INTRODUCTION

In the last two decades, Microelectromechanical Systems (MEMS) ripened over various scientific journals. The interdisciplinary complexity of research required by the field can be described through these papers. Some papers were initially processed centrallyand were developed by means of traditional CMOS processes or variants of a MEMS system or structure was the core of excitement. Slowly, this excitement gave way to new fabrics, new processes, finer structures, and new devices. Once manufacturing processes or trade foundries for MEMS have been developed, MEMS design or system design changed emphasis. Emphasis. The research focus will shift to exploring a broad spectrum of applications during the introduction of a few commercially successful MEMS apps. The regions of application have begun to develop their own MEMS work but international conferences have become common today, dedicated to Bio-MEMS, Optical MEMS, Inertial MEMS, RF Sessions. There has been increased research speed, and complex testing and development facilities have mushroomed, and there has increased the desire to produce countless MEMS sensors and actuators. Nonetheless, we see lots of room at the bottom, even at the current rate of development. MEMS work in India has paralleled developments elsewhere in the last 2 decades, which were marginally lagging behind due to infrastructure restrictions. The documents were reexamined subsequently and the writers were asked to respond to reviewers ' critics. This rather slow process is a product of the papers presented in this special issue. We aim to bring you a cross-section of MEMS work covering new MEMS products, process technology, tools, applications, design and simulation, manufacturing and testing and system integration. [1].

MEMS is one of the most innovative 21st Century innovations and can revolutionize industrial and consumer goods by integrating silicone-based micro-electronics with micro-processing technology. We will affect our lives and also how we function amatively through microsystems and techniques. MEMS is the second revolution if the semi-conductive micro-products revolution was seen as the first. As manufacturing, MEMS has several distinct advantages. The interdisciplinary complexity or versatility of MEMS technology has resulted primarily in an unparalleled range of devices or cooperation between previous fields of technology (e.g. biology or microelectronics). Secondly, MEMS allows more successful components or instruments to be produced in conjunction with its method of batch manufacturing, all obvious benefits of smaller physical sizes, length, weight or cost. Third. Second. Second, MEMS offers the production basis for goods that can not be produced using other techniques. It makes MEMS a much more prevalent technology than built-in circuit microchips. Nevertheless, various technological or miniature problems need to be addressed or resolved before MEMS is able to realize its enormous potential. A variety of MEMS cilia systems were developed with the common purpose of moving small objects or positioning them underneath the force of gravity. Just like wild cilia, All these systems rely on a large number of actuators working together to achieve the common objective of moving a larger object than every individual cilium. Recent techniques range from air jets to piezoelectric actuators to electrothermy (multi-material) actuators with a single crystal silicon electrostatic actuator 8,9 biomorphic (biomaterial) actors. Paralyzed [2].

Microelectromechanical systems (MEMS), also written as micro-electro-mechanical systems (or microelectronic and microelectromechanical systems) and the related micromechatronics and microsystems constitute the technology of microscopic devices, particularly those with moving parts. They merge at the nanoscale into nanoelectromechanical systems (NEMS) and nanotechnology. MEMS are also referred to as micromachines in Japan and microsystem technology (MST) in Europe.

MEMS are made up of components between 1 and 100 micrometers in size (i.e., 0.001 to 0.1 mm), and MEMS devices generally range in size from 20 micrometres to a millimetre (i.e., 0.02 to 1.0 mm), although components arranged in arrays (e.g., digital micromirror devices) can be more than 1000 mm^2.[1] They usually consist of a central unit that processes data (an integrated circuit chip such as microprocessor) and several components that interact with the surroundings (such as microsensors).[2] Because of the large surface area to volume ratio of MEMS, forces produced by ambient electromagnetism (e.g., electrostatic charges and magnetic moments), and fluid dynamics (e.g., surface tension and viscosity) are more important design considerations than with larger scale mechanical devices. MEMS technology is distinguished from molecular nanotechnology or molecular electronics in that the latter must also consider surface chemistry.

II MICROELECTROMECHANICAL SYSTEMS

MEMS are small integrated electrical component systems or devices. Which vary between sub-micrometer level (or sub-micron) and the millimeter level, & in a given system a number of several million to millions may be usable. MEMS incorporates production techniques designed to include mechanical components such as columns, gear, diaphragms and springs in products in the integrated circuit industry The mechanical procedures on the micro-scale can be sensed, operated and triggered by these devices and can work individually or on tablets to trigger macro-scale effects. The micro-manufacturing technology allows the development of a wide range of devices that perform simple tasks individually but in combination perform complex functionalities.

MEMS is a system that can be described as miniaturized mechanical elements or electro-micro elements (e.g. devices or structures) at its most general form. Vitals of MEMS varies from well under micron at the bottom to few millimeters. MEMS device categories that vary between relatively straightforward structures lacking moving elements, and also very complex electromechanical systems including multiple moving elements, controlled by integrated microelectronics. MEMS's first major test is that there are several at least some mechanical parts, no matter whether these elements can shift or not. In various parts of the world, the definition used to describe MEMS varies. These are called MEMS mostly in the United States, while "microsystem technology" or "micro-machined machines" are named in some parts of the world".

A. MEMS MANUFACTURING TECHNOLOGIES

a) Bulk micromachining

oldest silicon-based MEMS paradigm is bulk micromachining. For the design of the micro-mechanical structures, the entire thickness of a wafer is used. Silicon is manufactured by different processes of etching. Anodic bonds of glass plates or extra silicon wafers are used for the integration of devices in the third dimension but for hermetic encapsulation. Bulk micromachining was crucial to allow high-performance pressure and accelerometers who changed the sensor industry shape in the 1980s.

b) Surface micromachining

Unlike the above-mentioned bulk micromachining, where tri-dimensional structures are graved into the substratum wafer, the surface micromachining consists of laying them on the substrate surface with thin films of new material. Sacrificial layers are usually always had to create free-standing structures like air-bridges; the material for the final structure shall be deposited after depositing such a sacrificial layer and designed using the above-mentioned micro-lithographical steps. Then an appropriate etching tool removes the spacer layer to free the desired structure.

c) High aspect ratio (HAR) silicon micromachining

The industries make sensors, jet-fed tin jets or other devices in either bulk or surface-silicone machinery. difference between the two has however in certain cases decreased. New printing methodology, deep reactive gravure, has allowed a good performance to be combined that's typical of bulk microworks. Structures and typical in-plan micromachining operations. Although structural layer thicknesses of 2 µm are typical in surface micromachining, HAR silicone micromachining can be 10-100 µm thick. [3].

Table 1. Applications of MEMS

Automotive	**Electronics**	**Medical**	**Communications**	**Defense**
Internal navigation sensors	Disk drive heads	Blood pressure sensor	Fiber-optic network components	Munitions guidance
Air conditioning compressor sensor	Inkjet printer heads	Muscle stimulators & drug delivery systems	RF Relays, switches and filters	Surveillance
Brake force sensors & suspension control accelerometers	Projection screen televisions	Implanted pressure sensors	Projection displays in portable communications devices and instrumentation	Arming systems
Fuel level and vapor pressure sensors	Earthquake sensors	Prosthetics	Voltage-controlled oscillators (VCOs)	Embedded sensors
Airbag sensors	Avionics pressure sensors	Miniature analytical instruments	Splitters and couplers	Data storage
"Intelligent" tires	Mass data storage systems	Pacemakers	Tuneable lasers	Aircraft control

The MEMS software, as a new technology, focuses instead on paradigms relating to technology products rather than goods. There are therefore a number of applications for a MEMS computer throughout a variety of industries. For example, in a cloud of dust that was used for nuclear separation originally, the MEMS head nozzle for inkjet printer has now been developed. [4].

MEMS has several distinct advantages as a manufacturing technology. In the first place, the interdisciplinary nature of MEMS technology and its micromachining techniques, as well as its diversity of applications has resulted in an unprecedented range of devices and synergies across previously unrelated fields (for example biology and microelectronics). Secondly, MEMS with its batch fabrication techniques enables components and devices to be manufactured with increased performance and reliability, combined with the obvious advantages of reduced physical size, volume, weight and cost. Thirdly, MEMS provides the basis for the manufacture of products that cannot be made by other methods. These factors make MEMS potentially a far more pervasive technology than integrated circuit microchips. However, there are many challenges and technological obstacles associated with miniaturization that need to be addressed and overcome before MEMS can realize its overwhelming potential.

A. TRANSDUCER

A transducer is a device that converts a signal or energy source into a different form. It means both sensors and actuators can be included in the word transducer and is the common and most used concept in MEMS.

B. SENSOR

A sensor is a device that senses environmental information which generates an electric output signal that meets the parameter determined. these data (or phenomena) have been classified according to energy domains sort, but in general MEMS devices overlap multiple domains or even do not fall into one category. Such areas of energy include:

a) **Mechanical** - Force, energy, pace, acceleration, location
b) **Thermal** - Air, heat flow, temperature, entropy
c) **Chemical** - Process, structure, rate of reaction
d) **Radiant** - Intensity of electromotive force, phase, wavelength, reflection polarization, refractive index, transmission
e) **Magnetic** - Intensity of the field, flow rate, magnetic moment, permitting
f) **Electrical** - Tension, current, load, resistance, power, polarization.

Actuator An actuator is an electrical signal turning mechanism into operation. To achieve an effective function you should generate a force to control yourself, other mechanical devices or the environment.[5,6,7,9].

III MEMS SENSORS

A well-known history of Si pressure sensors is the development of the micro-sensors. A microsensor is a sensor with at least one sub-millimeter physical dimension and can now be used for measurement or definition of an atmosphere or physical condition, including acceleration, altitude, force, pressure and/or temperature. Micro-machining techniques also have allowed the production of micro-activators, devices that accept a data signal as an input to operate on this signal as an output. For instance, microvalves for gas or fluid flow control, optical switches and mirrors for the reorientation or modulation of beams, or micro-pumps for positive fluid pressure growth. Sensors that are made better than their ordinary MEMS counterparts:

- Smaller in size
- Have lower power consumption
- More sensitive to input variations
- Cheaper due to mass production
- Less invasive than larger devices.

A. TYPES OF MEMS SENSORS

There are now the most different types of sensors on the market, like,

a) Mechanical Sensors

MEMS is the mechanical sensor style accelerometer. MEMS accelerometers also brought traditional crash airbag deployment devices to vehicles. In the past technology approach, many large accelerometers with discrete components with separate electronics in front of fuel bags were used and cost more than 50 $per unit. The vehicle is fitted with airbags, which ensures that an IC (integrated circuit) is small by a sensor "MEMS accelerometer." The sensor senses rapid decline (CMIIW slows down too quickly), which then tells the device to swing the airbag.

b) Optical Sensors

An interferometric fiber micro-electric system sensor with a high sensitivity premised on diaphragm has been developed and tested in the interior of high-voltage transformer for on-line acoustic wave detection by partial discharges (PD). The device is generally made according to interference with Fabric Perot, which is put as a pressure-sensitive element in the micro-machined rectangular silicone membrane.

c) Thermal Sensors

Thermal sensors detect and digitally convert the temperature. TMP006 is the newest class of ultra-small, low-power or low-cost passive in fraternity sensors designed using MEMS technology TI (Texas Instrument). It consumes 90 percent more energy and seems to be 95 percent smaller than existing solutions. In totally new markets or requests, contactless temperature measurement is possible.

d) Chemical & Biological Sensors

Piezoelectrical MEM resonant sensors recognized for their excellent mass resolution have been explored for several applications, such as DNA hybridization, protein-legend interactions, or immuno-sensor production. The work was also performed against toxins, organic chemicals or radioactive ions. The majority of MEMS resonant sensors for piezo-electric applications are acoustically sensors (with special layers of cover) for selective but label-free biological events in real-time. These label-free technologies were currently dedicated to reactive yet quantitative analysis of the biological system. [3].

Materials used in MEMS fabrication

A. SILICON

Silicon is a material used in modern consumer electronics to create the most integrated circuitry. It has various mechanical or chemical advantages: single crystal silicon is a very suitable material from Hookean and is a good material for the manufacture of MEMS. This means there is almost no hysteresis if silicon is curved but almost no loss of energy. This is a perfect material that needs a lot of small motions or high friability, as silicone is very tired, can be found in thousands to trillions of dollars (Petersen, K.E. 1982).

B. POLYMERS

Although the electronics industry provides the silicon industry with an economical degree of the scale, crystalline silicon remains a complex & relatively expensive commodity. On the other hand, polymers with large quantities with a wide range of material characteristics can be made. MEMS devices can be generated with polymers by injecting, pregnancy or stereo lithographing, but are perfectly right to microfluidic requestslike blood test cartridges that are disposable.

C. METALS

MEMS components can also be produced using metals. While silicone does not have any mechanical advantages for metals, metals can show very high levels of durability when used within its limitations. Metals may be plated, evaporated or sputtered by electroplating. Gold, nickel, iron, copper, bronze, titanium, tungsten, platinum or silver are the most common metals.

D. CERAMICS

Silicium, aluminum, titanium, or silicon carbide, as well as other ceramics nitrides, are commonly used in MEMS processing due to beneficial material properties combinations [10].

IV LITERATURE REVIEW

Singh et al. [2019]A MEMS thin Fe65Co35 magnetic actuator have been developed. The actuator of the magnet has been fitted with just a mechanical resonance frequency finite element method for 25 to kHz. The stack lifting layer comprises a-Si / SiO2/Fe65Co35 multilayer, that requires compression of SiO2 or Fe65Co35 compressive layers. The synthesis of two-layered film cancelations results in an undeformed micro actuator offset by stress. Luminaires are also mounted on a piezo disco as well as an experimental resonance frequency, which is approximately 25,275 kHz, with a Doppler laser vibrometer above the simulated resonance frequency. The vector of magnetostriction was calculated to be 135/ ppm using the cantilever deflection method. A variety of stress-compensated MEMS magnet devices could be generated by stress compensation throughout the bilayers [11].

Mehmood et al. [2018]This paper givesa systematic appraisal of critical analysis of the collection of MEMS materials by means of Ashby's literature method of the last two decades. The efficiency or material indexes have been summarized for various microsystems and MEMS tools. In addition, literature has collected all MEMS materials as the most suitable materials proposed for a range of MEMS systems & applications. A case study using microscale properties with 51 compatible MEMS materials was submitted in order to show that the use of different materials ' mass properties is not a choice for selecting MEMS materials. This paper will direct researchers and technical engineers in the design and manufacturing of various microsystems and MEMS sensors, electric motors or devices. [12].

Amiri et al. [2018] This paper illustrate the problems of MEMS packaging technology. MEMS consists of a MEMS unit and an electronic signal conditioning system. MEMS is classified into a single point of view by sensor type, actuator or structure. MEMS technology in specific is used for automobile, electronic, research, biotechnology or business applications. Few approaches, like low energy ovens, vacuum or silicon glass, have been addressed. The paper discusses the primary process, like the wafer or wafer, including fine film packaging. [13].

Saadon et al. [2015]MEMS piezoelectric harvester is an important subject in different scientific papers. This harvester expands the application of wireless sensor networks and other technologies by providing renewable or potentially limitless alternative power supply for traditional energy sources. A way of capturing environmental vibrations around a computer has seen a dramatic increase in the use of piezoelectric materials For MEMS technologies that capture or transform ambient movements to electric energy, Piezoelectrical microgeneration is really attractive because of its simplicity. These microgenerators could be an alternative to battery approaches for future utilities, particularly remote systems. In this paper, we presented a model of MEMS power collector simulation with a Coventrate system to ambient vibration excitation. The MEMS power harvester, which operates in the ambient arousal of the 67 to 70 Hz regular band, generates a power output of 6.8 € TV, and 0.4 volts, at 20.1k-ohms of power, in the base acceleration of 0.2 to 1.3 g. [14].

Mamillaet al.[2014]This paper explores MEMS micro-manufacturing processes. Largely silicone micromachining was a major advance of MEMS. Silicon Micromachining means the creation of silicon or silicon substrate microscopic mechanical components. Silicon micro working is constructed of two technologies: bulk manufacturing in which structures on a silicon substrate or micro-working substrate are grafted, where layers of liquids on the surface create micro-mechanical layers. Substrate micromachining Two basic Silicon Micro-Machining Processes are high volume micromachining or surface machining, and silicone wafer linking is generally required for the production of silicone. [15].

Ozevinetal.[2014]This chapter will address new MEMS sensors that are specifically designed for monitoring of civil structures by structural health (SHM). Thanks to diverse production capabilities that enable the integration of multiple sensor elements on the same system as well as on-chip electronics, MEMS sensors have tremendous potential for advancing SHM methods. The sensor groups generally provided by micro-making methods include accelerometer, a sensor of acoustic emission, strain or sensor of corrosion. The chapter first reviews the sensor materials, micromachining methods, and sensor characteristics. The chapter then discusses typical MEMS sensor designs used for SHM, application examples, and future trends. Further reading and references are provided at the end of the chapter[16].

Nakashima-Paniaguaet al.[2014]In this paper, we present a method for evaluating alternatives for process steps in the development of micro-electro-mechanical systems (MEMS). A standardized process flow description for MEMS manufacturing is explained in detail. We also build an impeccable inference system thatpermits MEMS developers to capture user expectations to determine alternatives to complete process steps needed to construct a product. In the final part of this review, two case studies have been discussed: alternative evaluation for impurity or PZT. Of each situation, we have a clear preference for some alternatives using a set of data from user preference to test a set of criteria of potential alternative solutions, which show the effectiveness of the proposed system & how effective this system is in improving MEMS production processes [17].

Kim et al. [2011]The micro-gripper for micro-manipulation is an integral tool. For a robotic micro-manipulation device, a new microgravity manufacturing process is being built using MEMS technology. In the Pseudo-Rigid Body Model, a measurement is made of the mechanical rigidity of this influencer in order to measure the gripping power of these various scales and materials.Simulations and experiments may check the validity of the proposed model. This micro-grabber is an experimental robotic microsystem, a suitable handler, as well as a realistic grip test for the study of the robotic handling system [18].

V CONCLUSION

MEMS has been established by integrating silicone-based microelectronics in conjunction with micro-machining technology and it will continue to revolutionize the industry as well as industrial products and consumers. This modern technology would influence all fields of industrial application, including the design and development of the robot. If the first micro-production revolution was imagined, MEMS is the second revolution. As micro-manufacturing is envisaged. The paper represents the results of a study on the state of art and the potential impact of this technology on the construction industry's growth.

REFERENCES

1. https://www.ias.ac.in/article/fulltext/sadh/034/04/0529-0530
2. David M. Meller," A DOCKING SYSTEM FOR MICROSATELLITES BASED ON MEMS ACTUATOR ARRAYS", American Institute of Aeronautics and Astronautics
3. Azharuddin Allamin Shaikh," MICRO-ELECTROMECHANICAL SYSTEM (MEMS) SENSOR", International Journal of Scientific & Engineering Research, Volume 3, Issue 11, November-2012 1 ISSN 2229-5518
4. Memscap, http://www.memscap.com
5. Kovacs, G.T.A., Micromachined Transducers Sourcebook, McGraw-Hill, New York, NY, 1998.
6. Lion, K.S., Transducers: Problems and Prospects, IEEE Transactions on Industrial Electronics and Control Instrumentation, Vol. IECI-16, No.1, July 1969, pp. 2-5.
7. White, R.M., A Sensor Classification Scheme, IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, Vol UFFC-34, No.2, March 1987, pp. 124-126.
8. Ristic, Lj. [Ed.], Sensor Technology and Devices, Artech House, London, 1994.
9. University of Stanford, http://www.stanford.edu/group/SML/ee321/ho/MEMS-01-intro.pdf
10. Mamilla, V. R., & Chakradhar, K. S. (2014). Micro Machining for Micro Electro Mechanical Systems (MEMS). Procedia Materials Science, 6, 1170–1177. doi:10.1016/j.mspro.2014.07.190
11. Singh, J., Kumar, A., &AroutChelvane, J. (2019). Stress compensated MEMS magnetic actuator based on magnetostrictive Fe65Co35 thin films. Sensors and Actuators A: Physical, 294, 54–60. doi:10.1016/j.sna.2019.05.008
12. Mehmood, Z., Haneef, I., &Udrea, F. (2018). Material selection for Micro-Electro-Mechanical-Systems (MEMS) using Ashby's approach. Materials & Design, 157, 412–430. doi:10.1016/j.matdes.2018.07.058
13. Amiri, I. S., Ariannejad, M. M., Vigneswaran, D., Lim, C. S., &Yupapin, P. (2018). Performances and Procedures modules in Micro Electro Mechanical System Packaging Technologies. Results in Physics. doi:10.1016/j.rinp.2018.09.008
14. Saadon, S., &Sidek, O. (2015). Micro-Electro-Mechanical System (MEMS)-Based Piezoelectric Energy Harvester for Ambient Vibrations. Procedia - Social and Behavioral Sciences, 195, 2353–2362. doi:10.1016/j.sbspro.2015.06.198
15. Mamilla, V. R., & Chakradhar, K. S. (2014). Micro Machining for Micro Electro Mechanical Systems (MEMS). Procedia Materials Science, 6, 1170–1177. doi:10.1016/j.mspro.2014.07.190
16. Ozevin, D. (2014). Micro-electro-mechanical-systems (MEMS) for assessing and monitoring civil infrastructures. Sensor Technologies for Civil Infrastructures, 265–302e. doi:10.1533/9780857099136.265
17. Nakashima-Paniagua, T., Doucette, J., & Moussa, W. (2014). Fabrication process suitability ranking for micro-electro-mechanical systems using a fuzzy inference system. Expert Systems with Applications, 41(9), 4123–4138. doi:10.1016/j.eswa.2013.12.018
18. Kim, B.-S., Park, J.-S., Hun Kang, B., & Moon, C. (2012). Fabrication and property analysis of a MEMS micro-gripper for robotic micro-manipulation. Robotics and Computer-Integrated Manufacturing, 28(1), 50–56. doi:10.1016/j.rcim.2011.06.005