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MEMS and Study of various Actuators

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Abstract - *Recently the MEMS (micro electro mechanical structure) technology have become very popular. MEMS devices are being deployed in airbag, automotive industry, nation defense, telecommunication, healthcare, smart phones, our computers, cars, dishwasher etc. MEMS had a great impact on our lives. MEMS is kind of machine that contain both electrical and mechanical components on silicon substrate. It consists of moving parts smaller than human hair. It is also known as microstructure technology. They have several advantages like smaller size, better performance and low power consumption. Thus the MEMS technology is an important concern for all the times. MEMS have potential to compete with IC technology. Its applications are able to help us, take care of us control things for us and much more.*

In this paper, we survey the different type of actuators in MEMS, about mems its history, components, current and future of MEMS applications.

Further it discuss different mechanism of actuation and working of one of type of actuator. It also includes literature review about MEMS technology followed by conclusion and references.

Key Words: ***MEMS, miniaturization, actuators, microstructure, electrostatic and actuation etc***

1. INTRODUCTION

MEMS (micro electro mechanical structure) are unification of mechanical, electronic elements, senor, actuators on a common silicon substrate through microfabrication technology. MEMS is an unconventional technology .They are attractive for many applications because of their small size and weight which allows system to be miniaturized and used to interact with in local environment .These smaller devices can think, act, sense and communicate are replacing their bulk counterpart[7]. MEMS make devices ranging in size from 1-100um.

For e.g. MEMS enabled electrically driven motor smaller than diameter of human hair.

This shows on what level mems devices works and manufactured. MEMS not about single devices or application nor defined by single fabrication process or limited to few materials but mems is a fabrication approach that conveys advantage of miniaturization of multiple components. MEMS technology creates entirely new product [4][5].

1.1 History of MEMS

- MEMS came in to existence since Richard Feynman gave presentation "there is plenty of room at bottom "variety of micromachined sensor, actuator emerged.

- First product was developed in 1960s when accurate hydraulic pressure sensor was needed for aircraft.
- Such devices were further refined in 1980's were implanted in fuel injected car engines to monitor intake- manifold pressure.
- In late 1980's MEMS accelerometer for car airbags were developed as a less expensive.
- Taking spotlight today is optical MEMS, primary micro mirror which are used as digital light processor.[8]

1.2 Components of MEMS

MEMS components are categorized in to 6 parts:

1) Sensors- class of MEMS designed to sense changes and interacts with their environment.

2) Actuators- are devices designed to provide power to other component as MEMS devices.
RF mems- used to switch or transmit high frequency ,RF signals.[10]
3) Optical MEMS- used to direct, reflect, filter and amplify light like switches, reflectors.
4) Bio mems- devices designed to interact with protein, biological cells.

1.3 Applications of MEMS

- TELECOMMUNICATIONS- has a broad way of applications from micro relays in line card to complex multi tunable system for wireless communication.
- AUTOMOTIVE INDUSTRY- has used MEMS to control and sense car's relationship with environment and act as per that.
- HEALTHCARE- in this micro fabricated silicon micro pressure sensors used for blood pressure monitoring, respiration, kidney dialysis or any organ transplant etc.
- GENERAL APPLICATIONS-are generally used in pressure, chemical, vibration and temperature sensor and various light reflector switches accelerometer(for airbags, pacemakers) .Micro actuators used for data storage and read/write heads are general applications of .
- COMMUNICATION SATELLITES -MEMS ***offer*** significant benefits for future satellite systems since they can realize various electrical and mechanical functions in a fraction of the size, weight, **and** power consumption of corresponding traditional "macro" systems.

1.4 Working Principle

It involves a very simple concept actuator that is component of MEMS takes an input that may be of any type like mechanical, thermal, pressure convert it in to electrical which is taken as input by sensor part and then sensor act as per input it receive. Sensors are class of MEMS designed to sense, change and interact with the environment as mentioned in figure 1.

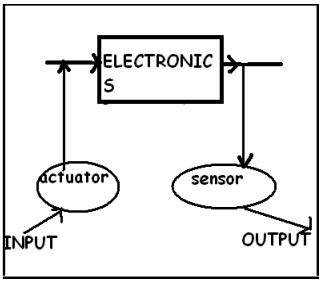

Fig1: working principle of MEMS technology [5]

2. Method of Actuation

- Electrostatic actuation
- Electromagnetic
- Piezoelectric
- Thermal actuation

Note: Actuation method is carried by actuators which are responsible for moving or controlling system operated by source of energy like electric current, pressure and convert that energy in to motion. Various actuation mechanisms present today can be classified as direct and indirect actuation methods. There is kind of indirect method which make uses of acoustic vibrations in order to shake a micro sensor similarly like a piece of paper that vibrates in front of a speaker from the compression waves in the air. Variant indirect method consists of a magnetic coat credited on a micro sensor such as a cantilever and an inductance coil below it to originate magnetic fields that attract and repel the cantilever into vibration. [14]

Electrostatic actuation: is a very promising approach. It is used to actuate silicon micromachined mirror plate electrostatically. It consist of two spring and two driving electrodes. Electrodes are connected electronically. [16]

Electrical isolation allows two electrodes to communicate with potential different that of a mirror plate .The voltage between electrodes and mirror generates an electrostatic force but it does

not start actuation process because of symmetry of field.

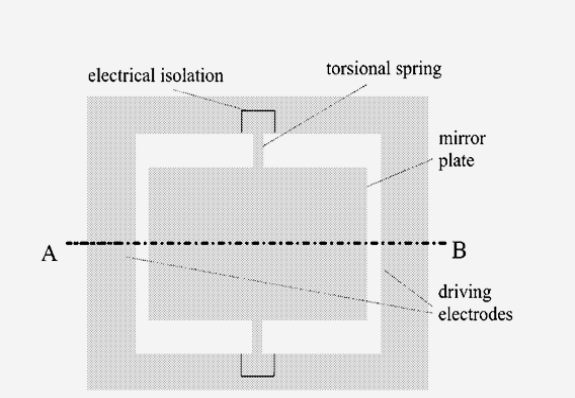

Fig 2: Illustration of electrostatic method of actuation of 1D Scanner [16]

Magnetic: In this case we cover mirror with coil, followed by putting it an field of permanent magnet or of an electromagnet. Depending on direction of current through coil, plate is deflected to left or right. There are two types of methods to actuate the micro mirror using magnetic actuation. One method is using Lorentz force to move a patterned coil by pulling external magnetic field. Second is by repulsive/attractive forces to attract and repel the magnetic material connected to the mirror from/to the actuator.

Thermal actuation: It takes advantage of thermal coefficients of two or more layer. In this the bimorph is heated by current resulting in a bending.

So, mirror plate attached to bimorph will be defected.

It involves very simple method of fabrication. But one of disadvantage is that it includes high power consumption and very slow response time.

Table -1: Summary of various actuation methods [15]

Actuation mechanism	Advantages	Disadvantages
Electromagnetic	Low actuation voltage comparatively large displacement	Challenge in minimizing
Piezoelectric	Higher switching speed	Quiet displacement range
Electro thermal	Low actuation voltage, easy fabrication	Slow response time
Electrostatic	Low power consumption and fast response	High actuation voltage

Piezoelectric actuation: it is one of another method of actuation which depends on electricity resulting from pressure. The bending of bimorph plate is induced by electric field.

It has low operation voltage with low power consumption

3. CONCLUSIONS

MEMS have already taken root impact in today's world. It will have dramatic impact on everything from aerospace to biotechnology. Reduction in cost and increase in performance of micro sensor, microactuators and Microsystems will enable an increase in use of these devices. A proportion between traditional micro actuation mechanisms has been shown.

Basis on comparison /proportion shown above in tabular form concludes that electrostatic actuation has more number of advantages which overcharge its disadvantages or we may say shortcomings comparative to other actuation mechanism.

Designing of various MEMS model are in progress through various software.

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