

A

Seminar report

On

**(MEMS)**

Submitted in partial fulfillment of the requirement for the award of degree  
Of Mechanical

**SUBMITTED TO:**

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## **Preface**

I have made this report file on the topic **MICROELECTROMECHANICAL SYSTEMS (MEMS)**, I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to .....who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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## Introduction

Micro electromechanical systems (MEMS) are micrometer-scale devices that integrate electrical and mechanical elements.

They have been used in diverse applications, from display technologies to sensor systems to optical networks. MEMS are attractive for many applications because of their small size and weight, which allow systems to be miniaturized.

To further explore the challenges and opportunities of MEMS, this article describes some fundamental technologies associated with MEMS design and operation. First, the advantages and challenges of MEMS are discussed.

Then manufacturing processes are presented, followed by the methods used to generate micro-scale forces and motions. Finally, several example MEMS applications are highlighted.

## **What are MEMS?**

(Micro-electromechanical Systems)

- Fabricated using micromachining technology
- Used for sensing, actuation or are passive micro-structures
- Usually integrated with electronic circuitry for control and/or information processing

## APPLICATION OF MEMS

- Inertial navigation units on a chip for munitions guidance and personal navigation.
- Electromechanical signal processing for ultra-small and ultra low-power wireless communications.
- Distributed unattended sensors for asset tracking, environmental monitoring, and security surveillance.
- Integrated fluidic systems for miniature analytical instruments, propellant, and combustion control.
- Weapons safing, arming, and fuzing.
- Embedded sensors and actuators for condition-based maintenance.
- Mass data storage devices for high density and low power.
- Integrated micro-optomechanical components for identify-friend-or-foe systems, displays, and fiber-optic switches.

## **Components**

- MicroElectronics
- MicroSensors
- MicroActuators
- MicroStructures

### **MicroElectronics**

The microelectronics of a MEMS are very similar to chips as we think of them today.

The microelectronics act as the "brain" of the system.

It receives data, processes it, and makes decisions. The data received comes from the microsensors in the MEMS.

### **MicroSensors**

The microsensors act as the arms, eyes, nose, etc. They constantly gather data from the surrounding environment and pass this information on to the microelectronics for processing.

These sensors can monitor mechanical, thermal, biological, chemical, optical and magnetic readings from the surrounding environment.

### **MicroActuators**

A microactuator acts as a switch or a trigger to activate an external device. As the microelectronics is processing the data received from the microsensors, it is making decisions on what to do based on this data. Sometimes the decision will involve activating an external device. If this decision is reached, the microelectronics will tell the microactuator to activate this device.

### **MicroStructures**

Due to the increase in technology for micromachining, extremely small structures can be built onto the surface of a chip. These tiny structures are called micro structures and are actually built right into the silicon of the MEMS.

Among other things, these microstructures can be used as valves to control the flow of a substance or as very small filters. Below is a picture of a microfluidic device containing fuel filters and an exit port.

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## **MANUFACTURING PROCESS OF MEMS**

Today, we have the capability to produce almost any type of MEMS devices. To fully understand what MEMS are, we must first understand the basic of the MEMS manufacturing process, fabrication process, and their material compositions.

### **MATERIALS**

MEMS are generally made from a material called polycrystalline silicon which is a common material also used to make integrated circuits. Frequently, polycrystalline silicon is doped with other materials like germanium or phosphate to enhance the materials properties. Sometimes, copper or aluminium is plated onto the polycrystalline silicon to allow electrical conduction between different parts of the MEMS devices. Now, that we understand the material composition of MEMS devices.

### **PHOTOLITHOGRAPHY**

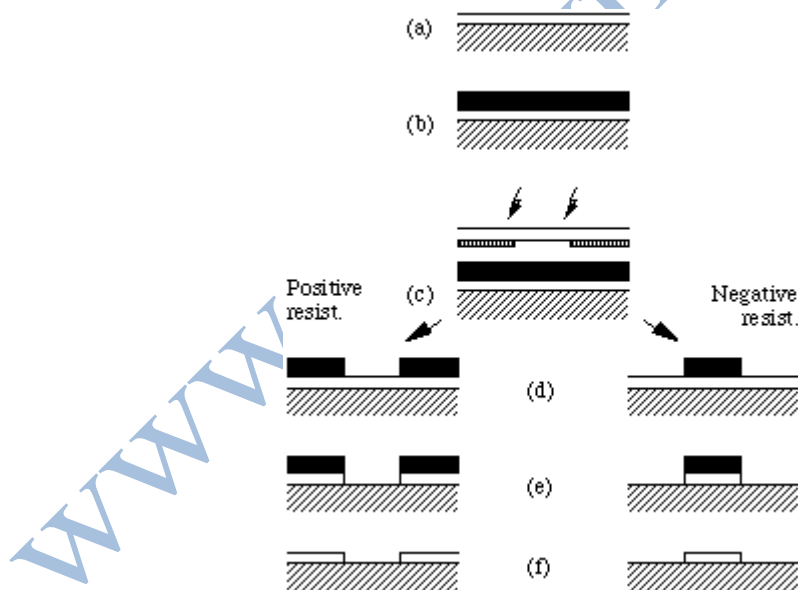
Photolithography is the basic technique used to define the shape of micro machine structures in the three techniques outlined below. The technique is essentially the same as that used in the microelectronics industry, which will be described here. The differences in the photolithographic techniques for Excimer laser micromachining and LIGA will be outlined in the relevant sections.

Figure shows a thin film of some material (eg. silicon dioxide) on a substrate of some other material (eg. silicon wafer). It is desired that some of the silicon dioxide (oxide) is selectively removed so that it only remains in particular areas on the silicon wafer. Firstly, a mask is produced. This will typically be a chromium pattern on a glass plate. The wafer is then coated with a polymer which is sensitive to ultraviolet light called a photo resist. Ultraviolet light is then shone through the mask onto the photo

resist. The photo resist is then developed which transfers the pattern on the mask to the photo resist layer.

There are two types of photo resist, termed positive and negative photo resist. Where the ultraviolet light strikes the positive resist it weakens the polymer, so that when the image is developed the resist is washed away where the light struck it – transferring a positive image of the mask to the resist layer. The opposite occurs with the negative resist. Where the ultraviolet light strikes negative resist it strengthens the polymer, so when developed the resist that was not exposed to ultraviolet light is washed away – a negative image of the mask is transferred to the resist.

A chemical (or some other method) is used to remove the oxide where it is exposed through the openings in the resist. Finally, the resist is removed leaving the patterned oxide.



## **SILICON MICROMACHINING**

There are number of basic techniques that can be used to pattern thin films that have been deposited on a silicon wafer, and to shape the wafer itself, to form a set of basic microstructures (bulk micromachining).

The techniques for depositing and patterning thin films can be used to produce quite complex microstructures on the surface of silicon wafer (surface silicon micromachining).

Electrochemical etching techniques are being investigated to extend the set of basic silicon micromachining techniques. Silicon bonding techniques can also be utilized to extend the structures produced by silicon micromachining techniques into multilayer structures.

## BASIC TECHNIQUES

There are 3 basic techniques associated with silicon micromachining. They are:

1. Deposition of thin films of materials.
2. Removal of material by wet chemical etching.
3. Removal of material by dry chemical etching.

## THIN FILMS

There are number of different techniques that facilitate the deposition or formation of very thin films of different materials on a silicon wafer. These films can then be patterned using photolithographic techniques and suitable etching techniques. Common materials include silicon dioxide (oxide), silicon nitride (nitride), polycrystalline silicon, and aluminium.

The number of other materials can be deposited as thin films, including noble metals such as gold. Noble metals will contaminate microelectronic circuitry causing it to fail, so any silicon wafers with noble metals on them have to be processed using equipments specially set aside for the purpose.

Noble metal films are often patterned by a method known as “lift off,” rather than wet or dry etching.

## WET ETCHING

Wet etching is a blanket name that covers the removal of material by immersing the wafer in a liquid bath of the chemical etch ant. Wet etch ants fall into two broad categories; isotropic etch ants and anisotropic etch ants.

Isotropic etch ants attack the material being etched at the same rate in all directions. Anisotropic etch ants attack the silicon wafer at different rates in different

directions, and so there is more control of shapes produced. Some etchants attack silicon at different rates depending on the concentration of impurities in the silicon.

## **DRY ETCHING**

The most common form of dry etching for micromachining applications is reactive ion etching. Ions are accelerated towards the material to be etched, and the etching reaction is enhanced in the direction of travel of ion. Reactive ion etching is an anisotropic etching technique. Deep trenches and pits of arbitrary shape and with vertical walls can be etched in a variety of materials including silicon, oxide, and nitride. Unlike anisotropic wet etching, RIE is not limited by the crystal planes in the silicon.

## **LIFT OFF**

Lift off is a stenciling technique often used to pattern noble metal films. There are a number of different techniques; the one outlined here is an assisted lift off method. A thin film of assisting material (eg. oxide) is deposited. A layer of resist is put over this and patterned as for photolithography, to expose the oxide in the pattern desired for the metal.

The oxide is then wet etched so as to undercut the resist. The metal is then deposited on the wafer, typically by a process known as evaporation. The metal pattern is effectively stenciled through the gaps in the resist, which is then removed lifting off the unwanted metal with it. The assisting layer is then stripped off leaving the metal pattern alone.

## EXCIMER LASER MICROMACHINING

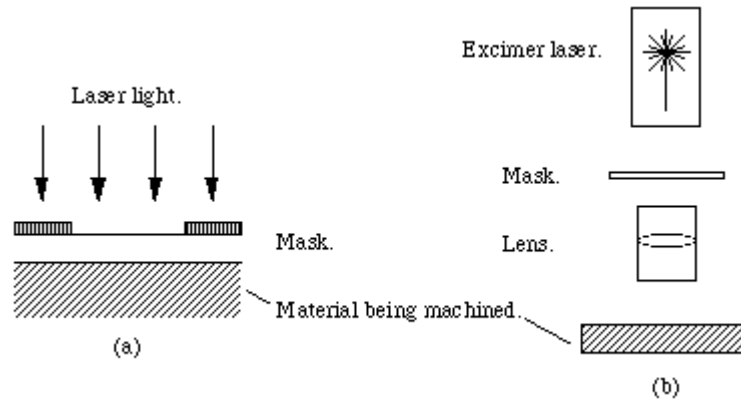
Excimer lasers produce relatively wide beams of ultraviolet laser light. One interesting application of these lasers is their use in micromachining organic materials (plastics, polymers, etc). This is because the excimer laser doesn't remove material by burning or vaporizing it, unlike other types of laser, so the material adjacent to the area machined is not melted or distorted by heating effects.

When machining organic materials the laser is pulsed on and off, removing material with each pulse. The amount of material removed is dependent on the material itself, the length of the pulse, and the intensity (fluency) of the laser light. Below certain threshold fluency, dependent on the material, the laser light has no effect.

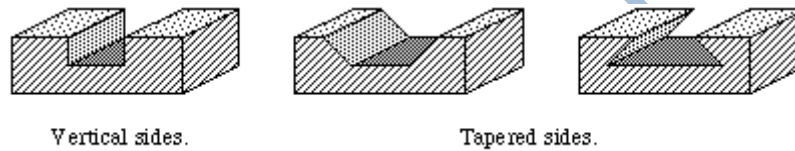
As the fluency is increased above the threshold, the depth of material removed per pulse is also increased. It is possible to accurately control the depth of the cut by counting the number of pulses. Quite deep cuts (hundreds of microns) can be made using the excimer laser.

The shape of the structures produced is controlled by using chrome on quartz mask, like the masks produced for photolithography. In the simplest system the mask is placed in contact with the material being machined, and the laser light is shone through it.

A more sophisticated and versatile method involves projecting the image of the mask onto the material. Material is selectively removed where the laser light strikes it.



Structures with vertical sides can be created. By adjusting the optics it is possible to produce structures with tapered sidewalls.



## **FABRICATION PROCESS IN MEMS**

### **Advanced Micro Systems Fabrication Technologies**

- Plastics Technologies
- Glass Technologies
- Silicon Technologies
- Metals Technologies

### **Precision Machining Technologies**

- Jet Deposition Technologies
- Laser Sintering Technologies
- Jet Molding Technologies
- Electrical Discharge Machining
- Micro milling / drilling
- 3-D Micro Fabrication Technologies

### **Emerging Silicon Micro Fabrication Technologies**

- Deep Reactive Ion Etching
- Electroplated Photo resist
- Integration of Piezoelectric Devices

## ADVANTAGES OF MEMS

There are four main advantages of using MEMS rather than ordinary large scale machinery.

- Ease of production.
- MEMS can be mass-produced and are inexpensive to make.
- Ease of parts alteration.
- Higher reliability than their macro scale counterparts.

## DISADVANTAGES OF MEMS

- Due to their size, it is physically impossible for MEMS to transfer any significant power.
- MEMS are made up of Poly-Si (a brittle material), so they cannot be loaded with large forces.

To overcome the disadvantages, many MEMS researchers are working hard to improve MEMS material strength and ability to transfer mechanical power.

Nevertheless, MEMS still have countless number of applications as stated below.

## CONCLUSION

Thus hereby we concluded our presentation in the topic of MEMS which is going to be the future of the modern technical field in the growth of micro sensor based applications such as automotive industries, wireless communication, security systems, bio medical instrumentation and in armed forces.

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## References

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