

What is MEMS?

- MEMS or Micro-Electro Mechanical System is a technique of combining Electrical and Mechanical components together on a chip, to produce a system of miniature dimensions.
- MEMS is the integration of a number of micro-components on a single chip which allows the microsystem to both sense and control the environment.
- The components are integrated on a single chip using micro fabrication technologies.



Mechanical



Electrical

What is a Sensor?

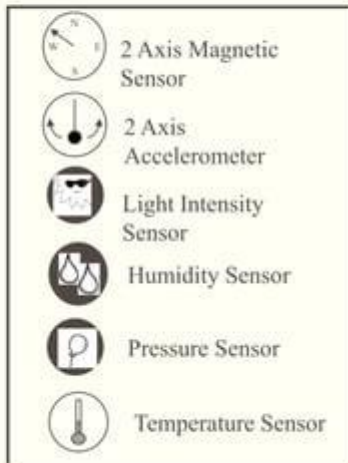
- A device used to measure a physical quantity (such as temperature) and convert it into an electronic signal of some kind (e.g. a voltage), without modifying the environment.

- **What can be sensed?**

Almost Everything!!!

Commonly sensed parameters are:

- Pressure
- Temperature
- Flow rate
- Radiation
- Chemicals
- Pathogens



But why MEMS for sensors?

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



Type of Sensors

Mechanical Sensors

- Strain Gauges
- Accelerometers
- Pressure Sensors
- Microphones
- Gyroscopes(Rotation Rate)

Optical Sensors

- Direct Sensors (Light → Electronic Signal)
- Indirect Sensors (Light → Intermediate Energy → Electronic Signal)
- Biological Light Sensors

Thermal Sensors

- Thermo mechanical (Dimension)
- Thermo Resistive (Resistance)
- Acoustic (Sound)
- Biological

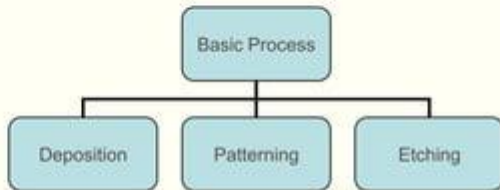
Chemical & Biological Sensors

- Electronic Nose
- Electronic Tongue

Fabrication

Materials used are:

- Silicon
- Polymers
- Metals
- Ceramics



Basic Process of Fabrication

- **Deposition**

- Deposition that happen because of a chemical reaction or physical reaction.

- **Patterning**

- The pattern is transfer to a photosensitive material by selective exposure to a radiation source such as light. If the resist is placed in a developer solution after selective exposure to a light source, it will etch away.

- **Etching**

- Etching is the process of using strong acid to cut into the unprotected parts of a metal surface to create a design in.
- There are two classes of etching processes:
 - Wet Etching
 - Dry Etching.

MEMS Manufacturing Technology

Bulk Micromachining

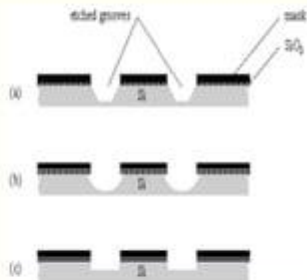
Surface Micromachining

High Aspect Ratio (HAR) Silicon Micromachining

MEMS Manufacturing Technology

Bulk Micromachining

- This technique involves the selective removal of the substrate material in order to realize miniaturized mechanical components.
- A widely used bulk micromachining technique in MEMS is chemical wet etching, which involves the immersion of a substrate into a solution of reactive chemical that will etch exposed regions of the substrate at very high rates.

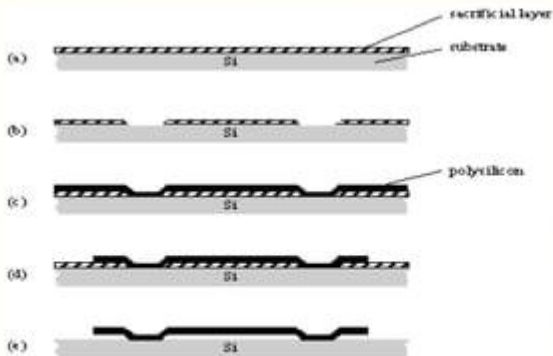


Etched grooves using
(a) Anisotropic etchants,
(b) Isotropic etchants,
(c) Reactive Ion Etching (RIE)

MEMS Manufacturing Technology

Surface Micromachining

- In surface micromachining, the MEMS sensors are formed on top of the wafer using deposited thin film materials.



- (a) Spacer layer deposition.
- (b) Patterning of the spacer layer.
- (c) Deposition of the microstructure layer.
- (d) Patterning of desired structure.
- (e) Stripping of the spacer layer resolves final structure.

MEMS Manufacturing Technology

High Aspect Ratio (HAR) Silicon 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).
- HAR MEMS technology enables a high degree of immunity to high-frequency, high-amplitude parasitic vibrations.

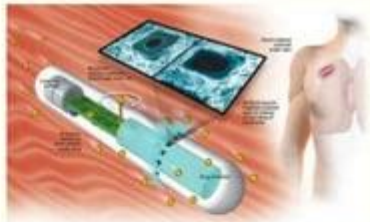


Applications in Medical Science

- **Biocavity Laser** : This device distinguishes cancerous from non cancerous cells thus aiding the surgeons in operations.



- **Smart Pill** :
 - Implanted in the body
 - Automatic drug delivery (on demand)



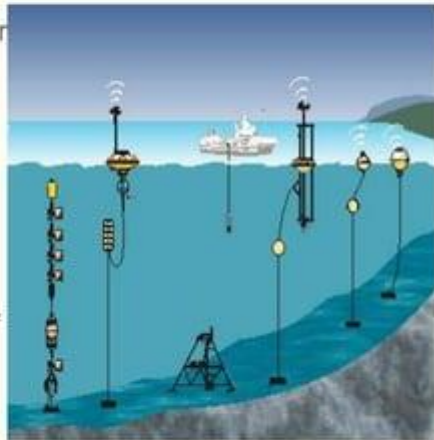
- **Sight for the blind** : MEMS based array that may be inserted in the retina of a blind person to provide partial sight



Applications in Marine Science

Sensing in marine environment maybe done for various reasons:

- Oil exploration and related applications
- Global weather predictions
- Monitor water quality for any contamination
- Measure parameters detrimental to the "health" of structures in the sea (like oil rigs and ships)
- Study of aquatic plants and animals
- In military operations



Applications in Marine Military Operations

- An array of MEMS sensors spread on the ocean floor could detect the presence of enemy submarines.
- MEMS sensors (pressure sensors, accelerometers etc.) are being used in anti-torpedo weapons on submarines and ships.
- MEMS sensors in torpedoes are responsible for
 - ✓ Detonating the torpedo at the right time
 - ✓ Hitting the target in a crowded environment
 - ✓ Prevent any premature explosion

