RAMA UNIVERSITY

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FACULTY OF ENGINEERING AND TECHNOLOGY

MEMS-035

Lecture -01

MICRO-ELECTRO-MECHANICAL SYSTEMS

❖Abbreviation of “Micro Electro Mechanical System”.

❖ Microelectro-mechanical Systems are very small devices or groups of devices that can integrate both mechanical and electrical components.

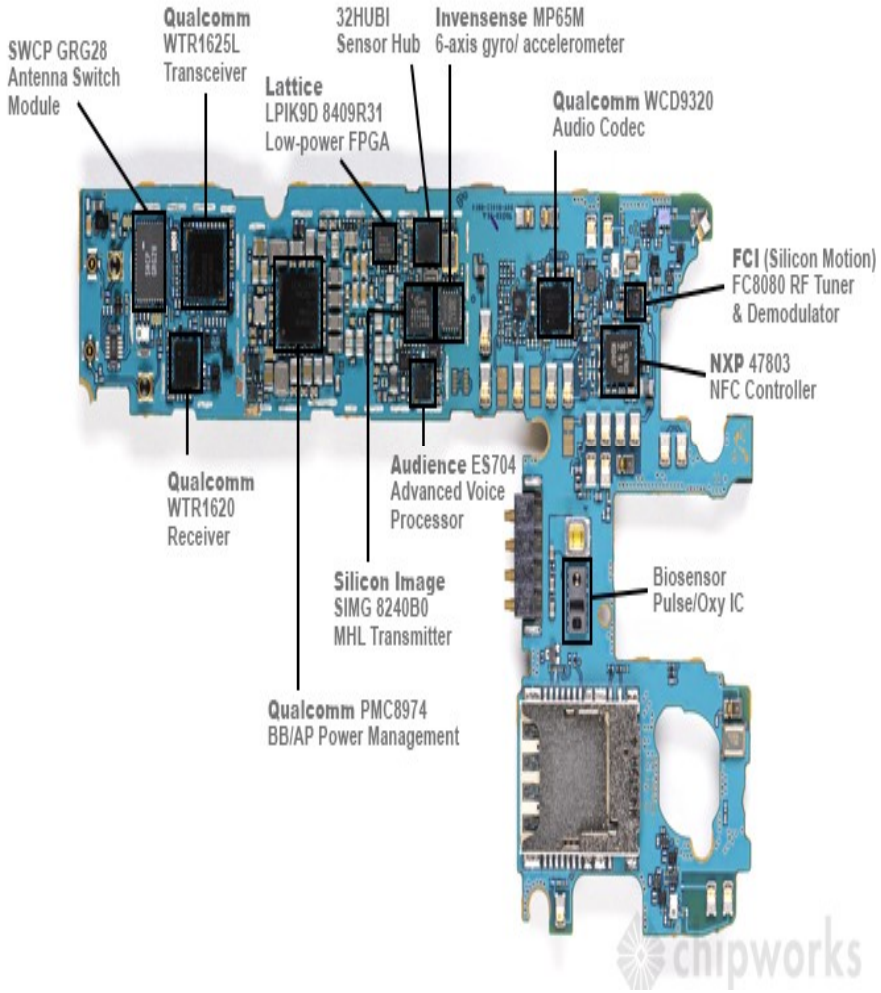
❖ MEMs are constructed on one chip with electrical circuitry for inputs and outputs of the electromechanical components.

❖ MEMs can consist of a combination of components in various scales: nano, micro, and milli.

❖ MEMs contain components of sizes in 1 micrometer to 1 millimeter.

❖ MEMs devices can sense, think, act and communicate.

❖ They redirect light, pump and mix fluids and detect molecules, heat, pressure or motion.



COMPONENTS

Microelectronics:

- "brain" that receives, processes, and makes decisions
- data comes from microsensors

Microsensors:

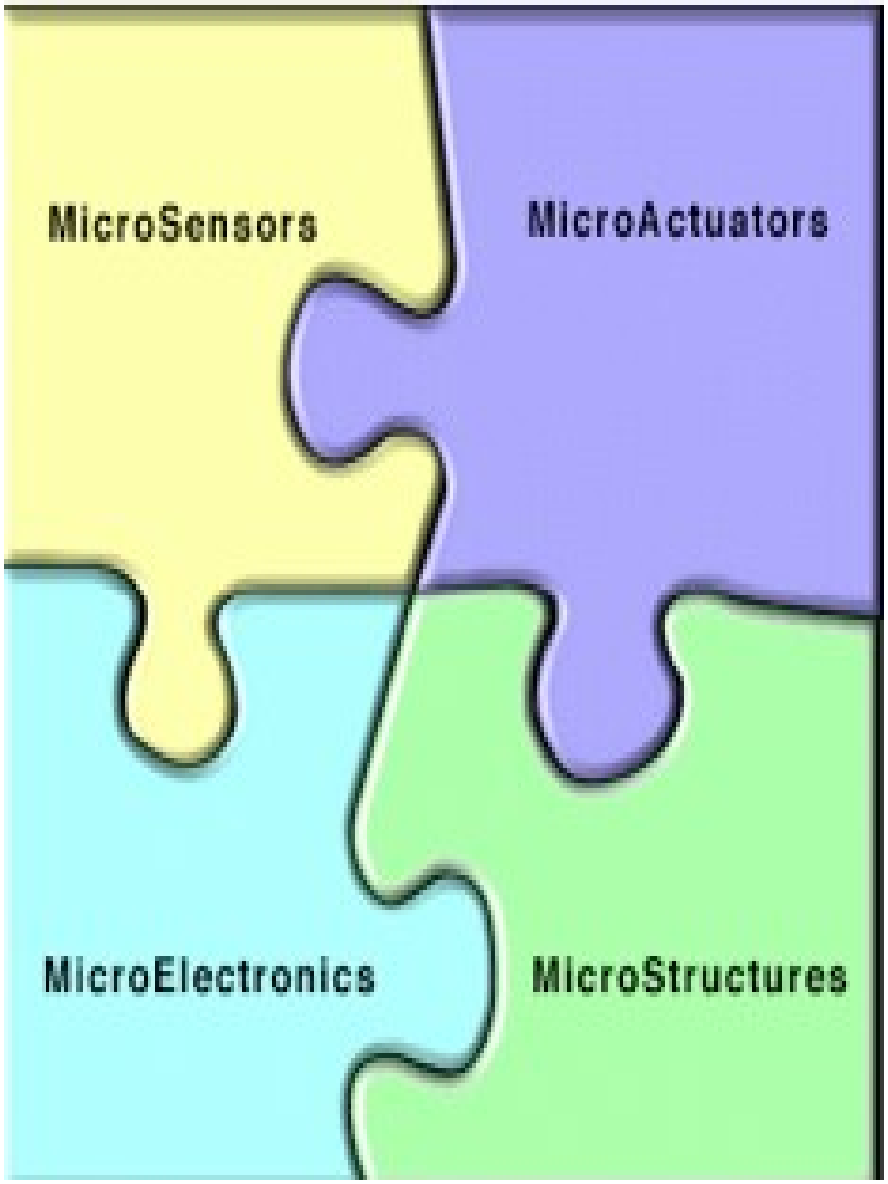
- constantly gather data from environment
- pass data to microelectronics for processing
- can monitor mechanical, thermal, biological, chemical optical, and magnetic readings

Microactuator:

- acts as trigger to activate external device
- microelectronics will tell microactuator to activate device

Microstructures:

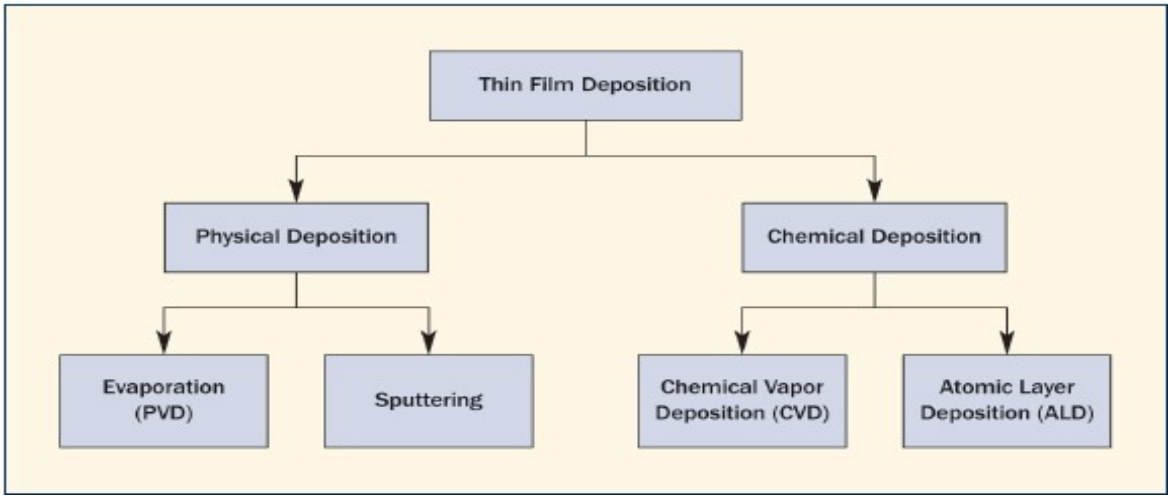
- extremely small structures built onto surface of chip
- built right into silicon of MEMS



Fabrication Processes

DEPOSITION

- deposit thin film of material (mask) anywhere between a few nm to 100 micrometers onto substrate
- **PHYSICAL:** material placed onto substrate, techniques include sputtering and evaporation
- **CHEMICAL:** stream of source gas reacts on substrate to grow product, techniques include chemical vapor deposition and atomic layer deposition
- **SUBSTRATES:** silicon, glass, quartz
- **THIN FILMS:** polysilicon, silicon Dioxide, silicon nitride, metals, Polymers



PATTERNING

- transfer of a pattern into a material after deposition in order to prepare for etching
- techniques include some type of lithography, photolithography is common

ETCHING

WET ETCHING: dipping substrate into chemical solution that selectively removes material

- process provides good selectivity, etching rate of target material higher that mask material

DRY ETCHING: material sputtered or dissolved from substrate with plasma or gas variations

- choosing a method: desired shapes, etch depth and uniformity, surface roughness, process compatibility, safety, cost, availability, environmental impact

FABRICATION METHODS

BULK MICROMACHINING:

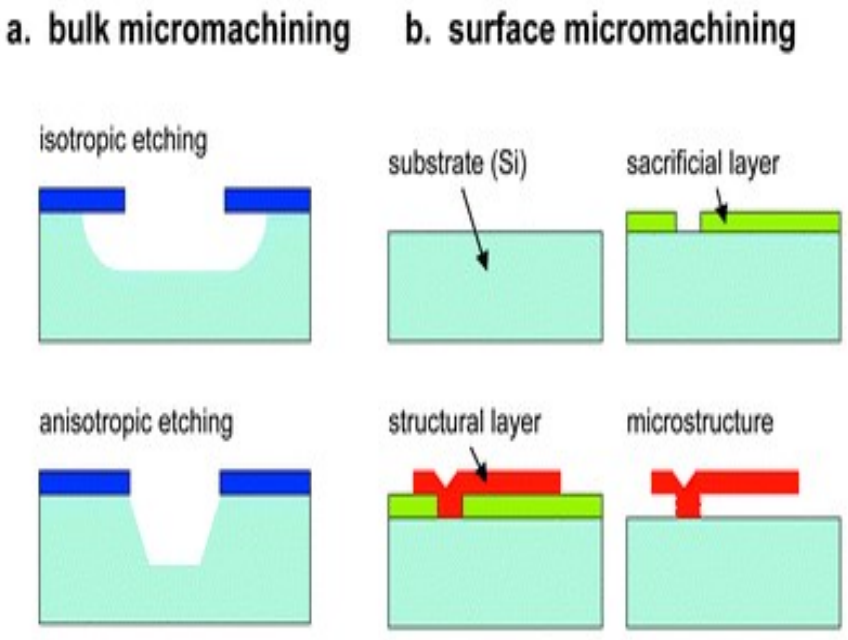
- oldest micromachining technology
- technique involves selective removal of substrate to produce mechanical components
- accomplished by physical or chemical process with chemical being used more for MEMS production
- chemical wet etching is popular because of high etch rate and selectivity
- isotropic wet etching: etch rate not dependent on crystallographic orientation of substrate and etching moves at equal rates in all directions
- anisotropic wet etching: etch rate is dependent on crystallographic orientation of substrate

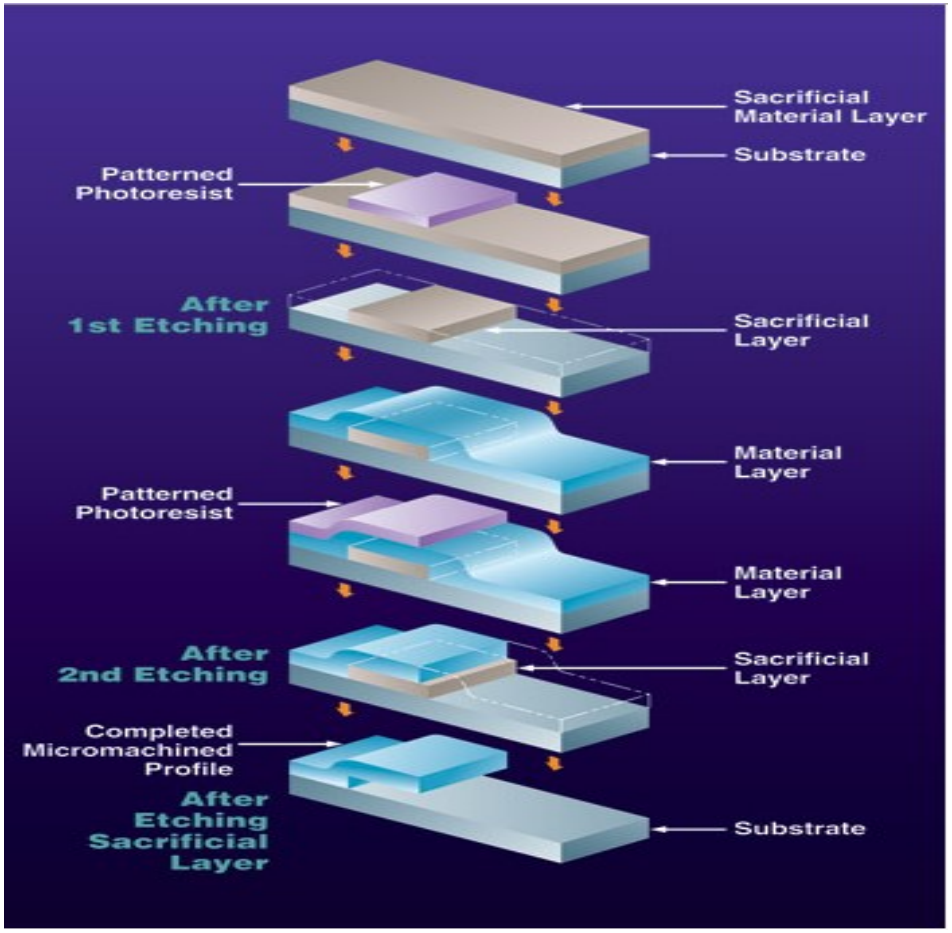
Surface Micromachining:

- Process starts with deposition of thin-film that acts as a temporary mechanical layer (sacrificial layer)
- Device layers are constructed on top
- Deposition and patterning of structural layer
- Removal of temporary layer to allow movement of structural layer

BENEFITS: variety of structure, sacrificial and etchant combinations, uses single-sided wafer processing allows higher integration density and lower resultant per die cost compared to bulk micromachining

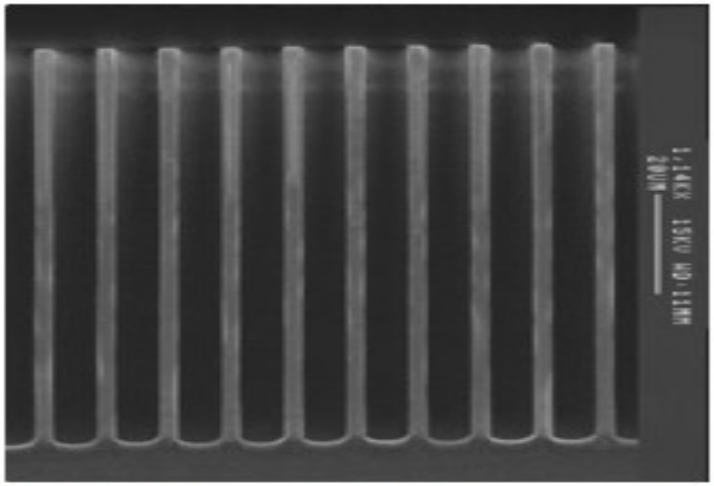
DISADVANTAGES: mechanical properties of most thin-films are usually unknown and reproducibility of their mechanical properties





WAFER BONDING

- Method that involves joining two or more wafers together to create a wafer stack
- Three types of wafer bonding: direct bonding, anodic bonding, and intermediate layer bonding
- All require substrates that are flat, smooth, and clean in order to be efficient and successful



cross section of a silicon wafer demonstrating trenches that can be fabricated using DRIE tech

HIGH ASPECT RATIO FABRICATION (SILICON)

- Deep reactive ion etching (DRIE)
- Enables very high aspect ratio etches to be performed into silicon substrates
- Sidewalls of the etched holes are nearly vertical
- Depth of the etch can be hundreds or even thousands of microns into the silicon substrate.

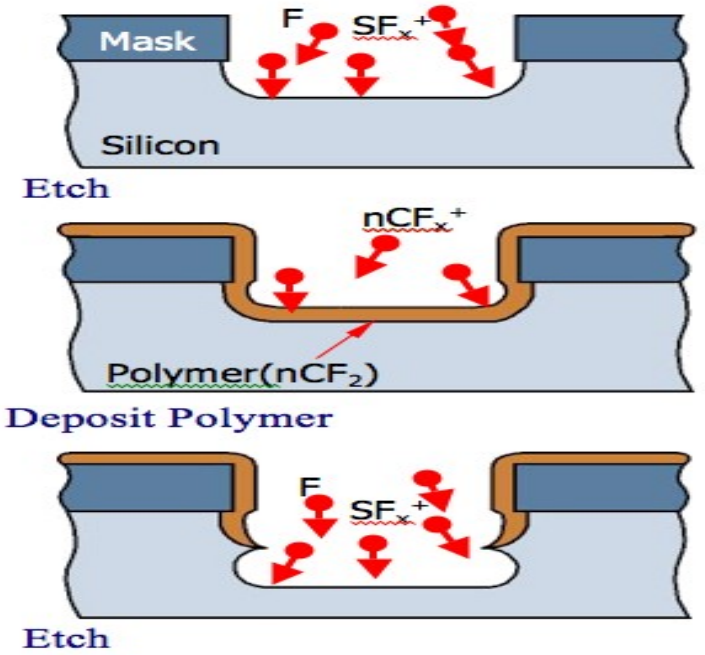


Figure 7: Illustration of how deep reactive ion etching works.

MEMS DEVICES USED IN SPACE EXPLORATION FIELD INCLUDE:

1.Accelerometers and gyroscopes for inertial navigation
2. Pressure sensors
3. RF switches and tunable filters for communication
4. Tunable mirror arrays for adaptive optics
5. Micro-power sources and turbines
6. Propulsion and attitude control
7. Bio-reactors and Bio-sensors, Micro-fluidics
8. Thermal control
9. Atomic clocks

Thank You