QUESTION BANK

Name of the Department : Electronics and Communication Engineering. M.E VLSI Design

Subject Code & Name : VL4073 & MEMS AND NEMS

Year & Semester : II & III

UNIT – I

UNIT-I OVERVIEW

PART – A

1.Define MEMS.

Micro-electro-mechanical systems It involves a mechanical response to an applied electrical signal or an electrical response resulting from mechanical deformation

2.List the historical development of MEMS.

- Richard Feynman in 1959 - There is plenty at the bottom
- Westinghouse in 1969 - Resonant gate FET
- Pressure sensor in 1970's - back etched Si wafer
- Kurt Peterson in 1980's - micro-positioning disc drive heads
- Micromachining in late 1980's - electronic industry

3.State the advantages of MEMS.

- Miniaturization,
- multiplicity,
- ability to directly integrate the devices in to microelectronic

4.What are the applications of MEMS in consumer products?

- Bicycle computers
- Fitness gear using hydraulics
- Digital fire pressure gauges
- Smart toys

5.Give the examples to MEMS.

Accelerometer, actuators, computer micro fluidic ink jet printer, gears, propellers,turbines, pumps, mirrors, motors, radio-elements, radiation sensor, detectors

6.Why si preferred as substrate material in MEMS?

- It is mechanically stable ,it can be integrated into electronics on the same substrate such as p/n –type ,piezoresistor can be integrated with the si substrate
- It have a greater flexblity in design and manufacture with silicon than with substrate are well established and documented

$SiC+SiO_2$---→Si+CO+SiO

7.Define NEMS.

Nano-electro-mechanical systems involves a mechanical response to an applied electrical signal or an electrical response resulting from mechanical deformation and using still miniature circuit and nano-materials

8.State the properties of MEMS.

Minimize energy and material use, redundancy and arrays, integration withelectronics, reduction of power budget, faster devices, increased selectivity andsensitivity, improved reproducibility, improved accuracy and reliability.

9.What is micro-electronics?

The science of integrating many transistors on one chip, began. Early “integrated circuits” (ICs) contained only a handful of devices, but advances in the technology soon made it possible to dramatically increase the complexity of “microchips.What r the adv of using piezoresistor,capacitors as s/l transducers

10.State the steps in fabricating micro-system.

Starting material, clean, oxide, protect front, backside implant, strip,photolithography, implant, strip, clean, drive in, photolithograph, etch oxide, strip,clean, metal, photolithography, etch Al, strip, backside metal, sinter.

11.State the advantages of micro-system.

- Low cost,
- low power,

- miniaturization,
- high performance,
- integration

12. Write about the silicon compounds in MEMS and its features.

SiO_2

- Its an electric insulator
- Low electric resistivity
- Surface layer micromachining

Polymers

- Plastics
- Si-rubber

Polymer molecules

13.State the important micro-fabrication methods.

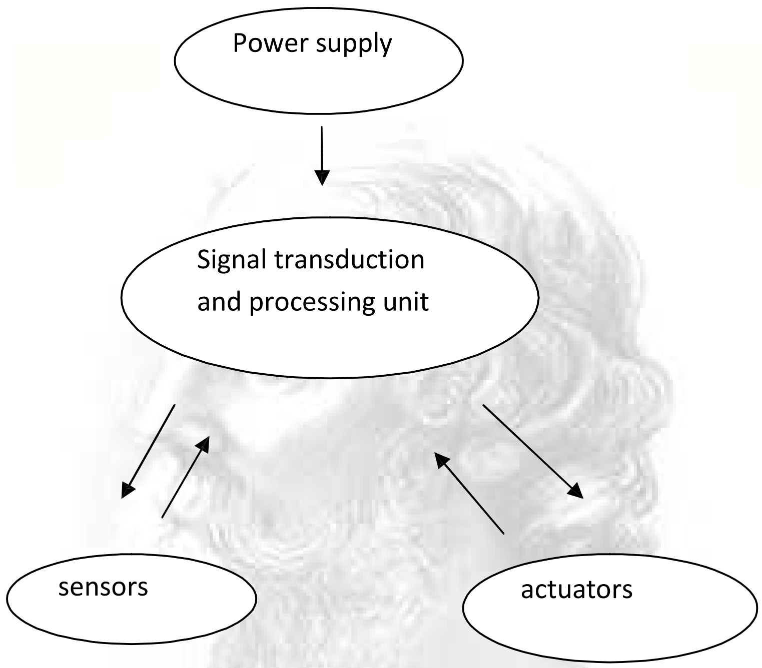
- Bulk micromachining
- surface micromachining
- LIGA
- micro-system packaging

14.List the typical characteristics of micro electronics and Microsystems.

Criterion	Micro electronics	Microsystem
Components	Standardised	hetrogeneous
Production numbers	10^5-10^8	10^2-10^6
Applications	Electronical	Mechanical,electronical,optical
Structural dimension	2D	3D
Design	Automated	Hetrogeneus with limited

		support

15. Draw the components of microsystem.



PART – B

1. Tabulate the historical development of MEMS.
2. Explain various properties of MEMS in detail.
3. Explain all about Microsystems briefly.
4. Explain briefly about microelectronic devices.
5. Write short notes on applications of MEMS and NEMS.
6. Discuss on materials for MEMS.

UNIT –II

MEMS FABRICATION TECHNOLOGIES

PART – A

1.Which polymers are suitable for mems?

- Polycarbonate,
- PMMA,
- Epoxy,
- Acrylic

2.What is meant by sputtering?

It is achieved by bombarding a target with energetic ion, typically Ar+ ion. Atom at the surface of target are knocked loose and transferred to the substrate, wheredeposition occurs.

3.What is photolithography?

Masks contain the pattern of windows which are transferred to the surface of the silicon wafers using a process called photolithography. The patterns are first transferred from the mask to a light sensitive material called photo-resist. Chemical or plasma etching is then used to transfer the pattern from the photo-resist to the barrier material on the surface of the wafer.

4.What is meant by ion implantation?

In this process, an ion implanter is used. An ion implanter is a high voltage particle accelerator producing a high velocity beam of impurity ion which can penetrate the surface of the silicon target wafer.

5.Define diffusion.

At high temperature, impurity atom hops from one crystal lattice site to another. The impurity atoms thereby substitute for a silicon atom in the lattice. At hightemperature, vacancies may also be created by displacing silicon atoms from theirnormal lattice position into the vacant interstitial space between lattice sites.

6.State the laws of diffusion.

Fick's I law J = - D dN(x,t)/dx

Fick's II law dN/dt = D d2N/dx2

Where D=D0 e-Q/RT

7.Define epi-taxy.

CVD can be used to deposit Si onto surface of a Si wafer. Under appropriate condition, the Si wafer acts as a seed crystal and a single crystal Si layer is grownon the surface of the wafer.

8.What are bulk surface machining and surface machining?

Surface machining – etching on the surface of wafer poly Si.Bulk surface machining – removes bulk substrate (large pits, holes to the back sideof a wafer, sawing, etc.)

9.What is the need for MEMS modeling and simulation?

There are many reasons why we need modeling and simulation for MEMS, among which are:

(i) Due to small dimensions of MEMS, direct experimentation for determination of some physical properties of MEMS is difficult, and measurement errors occur when dealing with these micro-level systems.

(ii) Time reduction: Designers need simulation tools that allow them try "what If "experiments in hours instead of days and weeks, thus reducing time to market

10.List out some additive materials

The materials deposited on the substrates include all those associated with integrated circuit processing. These are either epitaxial, polycrystalline, or amorphous silicon, silicon nitride, silicon dioxide, silicon oxynitride, or a variety of metals and metallic compounds, such as Cu, W, Al, Ti, and TiN, deposited by chemical (CVD) or physical vapor deposition (PVD) processes.

11.Give the example of conducting polymers.

Polyacetylene

polyaniline (PAn), polypyrroles (PPy), polythiophenes (PT) and polyphenylene vinylenes (PPV)

12.What are the types of MEMS packages?

Once the IC has been produced, it requires a housing that will protect it from damage. This damage could result from moisture, dirt, heat, radiation, or other sources. The housing protects the device and aids in its handling and connection into the system in which the IC is used. The three most common types of packages are the modified transistor-outline (TO) package, the flat pack, and the dual inline package (DIP).

13.Define Dual Inline Package.

The dual inline package (DIP) was designed primarily to overcome the difficulties associated with handling and inserting packages into mounting boards. DIPs are easily inserted by hand or machine and require no spreaders, spacers, insulators, or lead-forming tools. Standard hand tools and soldering irons can be used to field-service the devices. Plastic DIPs are finding wide use in commercial applications, and a number of military systems are incorporating ceramic DIPS.

14.What are the usage of multilayer boards?

- reduce weight
- conserve space in interconnecting circuit modules
- eliminate costly and complicated wiring harnesses
- provide shielding for a large number of conductors
- provide uniformity in conductor impedance for high-speed switching systems
- allow greater wiring density on boards

15.Define and explain DRIE.

Deep reactive-ion etching (**DRIE**) is a highly anisotropic etch process used to create deep penetration, steep-sided holes and trenches in wafers/substrates, typically with high aspect ratios

16.Give the MEMS simulation software tools.

- System level tools
- Field solvers

- Finite Elements based tools
- Conventor Ware
- Comsol Multiphysiscs

17.Give the types of lithographic process.

Lithography is a general name given to processesusedto transfer patterns on to a substrate to define structures that make up devices

(i) Optical lithography: Uses light

(ii) Electron Beam lithography: Uses electrons

(iii) Ion beam lithography: Uses energetic ions to bombard and pattern surfaces

(iv) X-ray lithography: uses x-rays to bombard

(v) Soft lithography: Uses mechanical contact indentation to transfer patterns

18.Define LIGA.

Another popular high aspect ratio micromachining technology is called LIGA, which is a German acronym for "LIthographie Galvanoformung Adformung". This is primarily a non-silicon based technology and requires the use of synchrotron generated x-ray radiation.

19.List the functions of MEMS package.

Mechanical support, protection from the environment, and electrical connection to other system components.

PART – B

1.Explain the fabrication of MEMS by dry etching and wet etching.

2.(i) Explain the process of sputtering.

(ii) What are the applications of this process in nanotechnology?

3. Explain the process of photolithography.

4. Write an essay about photo-resist and its types.

5. Discuss about the processes

(i) ion implantation,

(ii) diffusion and

(iii) exudation

6. Explain the steps involved in LIGA process.

UNIT –III MICRO SENSORS

PART – A

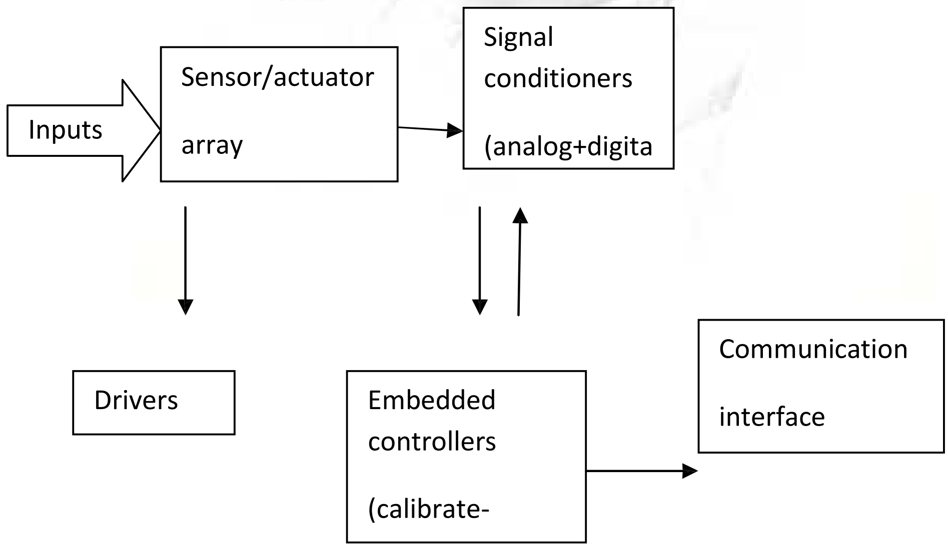
1.Classify the MEM displacement sensors.

Capacitive	AFM	Optical	Electron
Parallel plate Fringe	Piezoresistive Fringe Piezoelectric	On chip	Tunnel

2.Which is called as smart material? List few smart materials.

A system or material which has built in intrinsic sensors, actuators and control mechanisms whereby it is capable of sensing, responding to it in a predetermined manner and extent, in short / appropriate time, and reverting to its original state as soon as the stimulus is removed.

3.Draw the architecture of microsensor.



4. Define damping mechanism sources.

The damping mechanisms arise from three sources:

1. The energy lost to a surrounding fluid (1/Qa);
2. The energy coupled through the resonator's supports to a surrounding solid(1/Qs)v
3. The energy dissipated internally within the resonator's material (1/Qi).

5.What are called sensors?

Sensor is used for an element which produces a signal relating to the quantity being measured. I.e., an electrical resistance temperature element, the quantity being measured is temperature and the sensor transforms an input of temperature into a change.

6.What is meant by accuracy?

Closeness between measured value and actual value is called accuracy.

7.What is a displacement sensor?

Displacement sensors are concerned with the measurement of the amount by which some object has been moved.

8.What is a position sensor?

Position sensors are concerned with the determination of the position of some object with reference to some reference point.

9.Write about the contact sensors.

In contact sensors the measured object comes into mechanical contact with the sensor. For those linear displacement methods involving contact, there is usually a sensing shaft, which is in direct contact with the object being monitored by a sensor.

10.What is the use of the contact sensors?

The movement of the shaft may be used to cause changes in electrical voltage,resistance, capacitance, or mutual inductance. For angular displacement methods involving mechanical connection, the rotation of a shaft might directly drive,through gears, the rotation of the transducer element.

11.Write about the gauge factors for different types of strain gauges?

The gauge factor of metal wire or foil strain gauges with the metals generally used is about 2.0. Silicon p – and n – type semiconductor strain gauges have gauge factors of about + 100 or more for p- type silicon and – 100 or more for n – type silicon.

12.Define Young's Modulus.

A measure of the stiffness of a material in the elastic range. It is determined from the slope of a stress-strain curve obtained during tensile tests on a sample of the material. Young's modulus is also known as Modulus of Elasticity.

13.State the properties of piezoelectric material.

Material	Form	D_{33} (Pc/N)	Relative permitivity
Quartz	Single crystal	2	4
PVDF	Polymer	20	12
Barium titanate	Ceramic	190	2000

14.Give the types of pressure sensors.

Types of pressure sensors:

•An absolute pressure sensor that is referenced to a vacuum (P0 =0)

•A gauge-type pressure sensor that is referenced to atmospheric pressure(P0=1atm)

•A differential or relative type (P0 is constant

15.What is ultrasonic wae displacement sensor?

Send a wave Receive a wave Commonly piezo-ceramics (Lead titanate or lead zirconate) are used to generate and capture the wave. Applications: measure proximity, distance, level of liquids etc.

Advantages:

♦ can be used on conducting as well as non-conducting materials.

♦ Ultrasound is high frequency 50KHz, so low interference and less susceptible todirty environments.

♦ Can be used up to 5m.

PART – B

1.Explain mechanical sensors.

2.Explain working principle of Photo-resistive Pressure Sensor.

3.What are the types of thermal flow sensor? Explain any two of them with neat sketch.

4.Describe various pressure sensors and flow sensors.

5.Give the design and technical advances of microsensors.

6.Give a elaborate description on working principle and instrumentation of displacement, pressure and flow sensors.

UNIT –IV

MICRO ACTUATORS

PART – A

1.What is micro-motor?

6mm Series Coreless DC Micro-motor with application areas for medical, optical equipment, inspection systems and micro-positioning systems.

2.Give the examples typical uses of micro-actuators.

Micro-robotic systems, automatic focusing of a diaphragm mirror, computer, automotive electronics, aerospace control, other mechatronic products

3.What are micro-pumps?

In an electrostatic micro-pump, a fluid is moved in a capillary tube due to the force acting on ionic species in an electric field. The electric field is obtained through the supply of a high DC voltage across the capillary.

4.Define micro actuation.

It defines an actuator as a mechanical device for movig or controlling something.The actuator is a very important part of a microsystem that involves motion

The types are

- Thermal forces
- Shape memory alloys
- Piezoelectric crystals

5. Define Gauge factor.

A typical metal foil strain gauge is depicted in the sensitivity of a strain gauge is generally termed the gauge factor. This is a dimensionless quantity and is given by

GF= relative change in resistance/applied strain

6.Define electrostatic actuation.

Electrostatic actuation relies on the attractive force between two conductive plates or elements carrying opposite charges. A moment of thought quickly reveals that the charges on two objects with an externally applied potential between them can only be of opposite polarities.

7.What is Piezoelectric Actuation?

Piezoelectric actuation can provide significantly large forces, especially if thick piezoelectric films are used. Commercially available piezoceramic cylinders can provide up to a few newtons of force with applied potentials on the order of a few hundred volts. However, thin-film (<5μm) piezoelectric actuators can only provide a few millinewtons. Both piezoelectric and electrostatic methods offer the advantage of low power consumption as the electric current is very small.

8.Define magnetic actuation.

Lorentz forces form the dominant mechanism in magnetic actuation on a miniaturized scale. This is largely due to the difficulty in depositing permanently magnetized thin films. Electrical current in a conductive element that is located within a magnetic field gives rise to an electromagnetic force—the Lorentz force—in a direction perpendicular to the current and magnetic field. This force is proportional to the current, magnetic flux density, and length of the element.

9.What is Actuation Using Shape-Memory Alloys?

Finally, of all five schemes, shape-memory alloys undoubtedly offer the highest energy density available for actuation. The effect can provide very large forces when the temperature of the material rises above the critical temperature, typically around 100ºC. The challenge with shape-memory alloys lies in the difficulty of integrating their fabrication with conventional silicon manufacturing processes

10.How SME works?

NiTi alloys are generally more expensive and change from austenite to martensite upon cooling; Mf is the temperature at which the transition to martensite completes upon cooling. Accordingly, during heating As and Af are the temperatures at which the transformation from martensite to austenite starts and finishes. Repeated use of the shape-memory effect may lead to a shift of the characteristic transformation temperatures (this effect is known as functional fatigue, as it is closely related with a change of microstructural and functional properties of the material).

11.Applications of Shape Memory Alloys

- Aircraft
- Piping
- Automotive
- Telecommunication
- Robotics
- Medicine

12.Give the Types of SMA.

The two main types of shape-memory alloys are the copper-aluminium-nickel, and nickel-titanium and (NiTi) alloys but SMAs can also be created by alloying zinc, copper, gold and iron. The most common shape memory material is Nitinol. This particular alloy has very good electrical and mechanical properties, long fatigue life,and high corrosion resistance. As an actuator, it is capable of up to 5% strain recovery and 50,000 psi restoration stress with many cycles.

13.Give the types of micropumps.

- Piezopump
- Electro static pump
- Ball valve operated

14.List the types of micromotors.

linear motor and rotary motor

15.Give the working principle of microgripper.

The gripping action at the tip of the gripper is initiated by applying a voltage across theplates attached to the drive arms and the closure arm. The electrostatic force generatedby these pairs of misaligned plates tends to align them, causing the drive arms to bend,which in turn closes the extension arms for gripping. These microgrippers can be adapted to micromanipulators or robots in micromanufacturing processes or microsurgery.

16.Applications of actuators

Microswitches ,SMA are the materials that have a “memory” of their original geometry (shape) at atypically elevated temperature of production. These alloys are deformed into different geometry at typically room temperature. The deformed SMA structures will return to their original shapes when they are heated to the elevated temperature at their productions. Ti-Ni is a common SMA.

PART – B

1. Discuss about Actuation Using Thermal Forces.
2. Explain on Actuation Using Shape Memory Alloys.
3. Explain about Actuation Using Piezoelectric Crystals.
4. Briefly explain Actuation using Electrostatic Forces.
5. Briefly explain micromechanical motors and pumps.

UNIT-V

NANO SYSTEMS AND QUANTUM MECHANICS

PART – A

1.What is meant by atomic structures?

Structure of atom.

2.What is quantum mechanics?

Quantum mechanics is the field of physics that explains how extremely small objects simultaneously have the characteristics of both particles (tiny pieces of matter) and waves (a disturbance or variation that transfers energy).

3.What is meant by molecular dynamics?

Molecular dynamics (MD) is a computer simulation method that analyzes the movement of atoms and molecules over time.

4. Define molecular wires.

Molecular wires are molecular chains that conduct electricity and are used in molecular electronics.

5. Define molecular circuits.

It include the biological components and their interactions that comprise the workings of these signaling motifs.

6.What is EMF?

Electromotive force (EMF) is a measure of the energy that's transferred to an electric circuit per unit of electric charge. It's measured in volts, which is the same unit as potential difference.

PART – B

1.Explain in detail about the Atomic Structures and Quantum Mechanics.

2. Brief about Molecular and Nanostructure Dynamics.
3.Discuss on Density Functional Theory.
4. Write short notes on Nanostructures and Molecular Dynamics.
5. Explain on Electromagnetic Fields and their quantization,
6. Discuss about Molecular Wires and Molecular Circuits.