Sub:- ICT

Q1) What is hybrid IC. Explain different feature of IC.

Ans: Hybrid IC :-

A film IC is supplemented and connected to film circuit elements, such a composite film discrete ckt is called Hybrid IC. HIC is a microcircuit, which represent a combination of film passive element and discrete active element, such a ~~composite~~ disposed on a common insulating substrate.

Hybrid ICs are divided into thick film and thin film IC's

Thick film HIC's :-

The Fabrication of thick film HIC is simple. Different layer of various links are deposited on an insulating substrate of size of few centimeters.

Features :-

1. In a Thick film IC, the deposition process is done Mechanically, which does not permit fabrication of films less than 10 to 20 μm in thickness.
2. Thick film technology is simple, so the thick film HIC's are easily available and are cheaper
3. The Mechanical method of deposition can not ensure sufficient capacitors i.e. can not produce precision elements.

Thin film HIC :-

① Thin film HIC's require more complex technology as than thick film HIC's. the deposition process requires specific tooling and equipment which are costly.

Feature :-

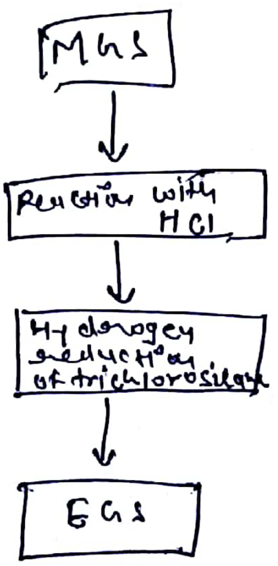
① The deposition rate of thin film is very less, the deposition of film over 1 or 2 μm thick can easily peeled off.

② Film thickness can be controlled easily due to low rate of film growth. This ensure close tolerances on the value of resistors an capacitors.

Q. 2 Explain Electronic grade silicon. What is the Float zone growth.

2 An :- Electronic Grade Silicon :-

Electronic grade silicon is a polycrystalline material of high purity. it is the raw material for the prepration of single crystal sillicon. EGS is one of the purest material and has very small impurity level measured in parts per million to parts per millions.



$Si + 3HCl \rightarrow SiHCl_3 + H_2$

$2SiHCl_3 + 2H_2 \rightarrow 2Si + 6HCl$

① Metallurgical Grade (MGS) is produced by in a Submerged electrode arc. The furnace is charged with quartize, a relatively pure form of sand and carbon in the form of coal, coak & wood.

$$SiC\ (solid) + SiO_2\ (S) \longrightarrow Si\ (l) + SiO\ (g) + CO\ (g)$$

② After obtaining MGS, The next process step is to pulverize the silicon mechanically and to react it with anhydrous hydrogen cloride to form $SiHCl_3$

$$Si\ (s) + 3HCl\ (g) \longrightarrow SiHCl_3\ (g) + H_2\ (g) + Heat$$

③ EGS is prepared from the purified $SiHCl_3$ by using Chemical vapour deposition (CVD) & hydrogen reduction of trichlorosilane.

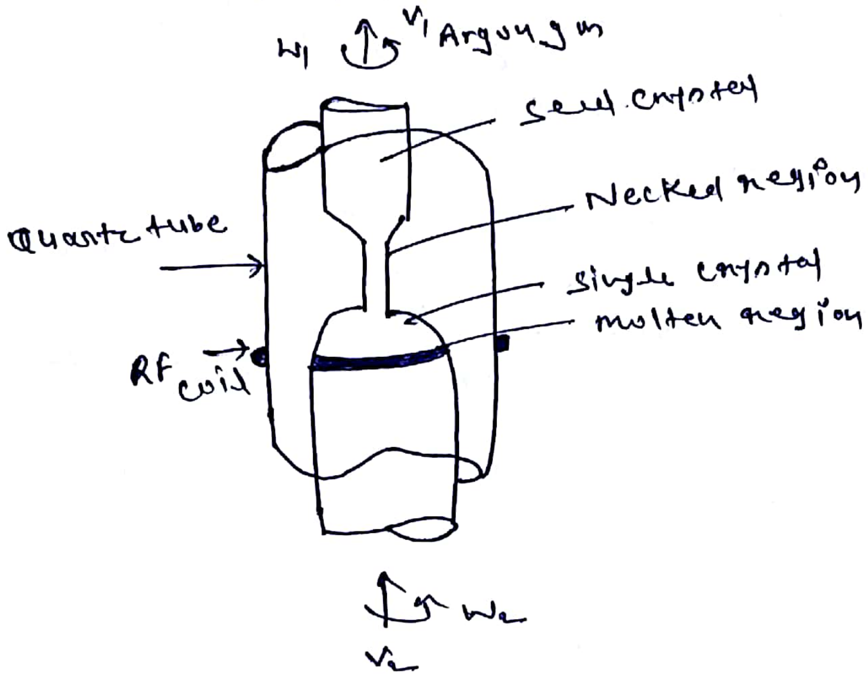
$$2SiHCl_3(g) + 2H_2\ (g) \longrightarrow 2Si\ (s) + 6HCl\ (g)$$

ii) Ans :-

Float zone Growth :

Float zone refining growth techniques preffered when extremly high purity silicon is required. This technique is not Generally used for GaAs. Float zone method is able to provide lower ~~Combination~~ Contamination with carrier concentration as low as $10^{11}\ cm^{-3}$

The basic feature this growth technique is that the molten part of the sample is supported entirely by the solid part.



A rod of highly pure polycrystalline material is held in chuck. A metal coil driven by a high power radio radio frequency (RF) signal is slowly passed along the length of rod. The field set up by RF power includes eddy current in rod that causes heat. The power ~~off~~ of coil is set such that only the part of rod closest to the coil get melted. Alternatively focused electron beams can be used to locally melt the rod.

Advantages:

① charge is purified by repeated passage of zone.
② Steady state growth possible
③ Radial temp. gradient are high.

Q.3 What is Flick law? Give solution of the Flick law.

3 Ans:- **Fick Law** :- The basic Theory of diffusion of Fick is based on the analogy b/w material Transfer in a solution and heat transfer by conduction.

① Flick first law :-

According to Fick's law particle diffuse from higher concentration to a lower concentration and the flux density is proportional to the concentration gradient.

$$J = -D \frac{\partial C(x,t)}{\partial x} \quad -①$$

J = rate of transfer of solute / unit area

D = Diffusivity

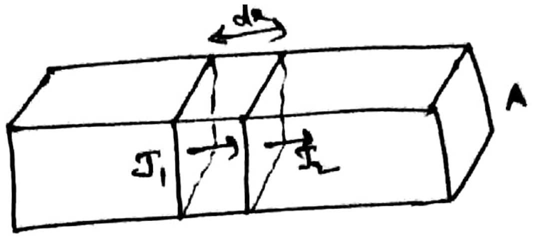
C = Concentration of solute

x = Coordinate axis in direction of solute flow

t = diffusion time.

② Second law :- Consider a long bar having uniform sectional area A. Now let consider small volume of length dx then

$$\frac{J_2 - J_1}{\Delta x} = \frac{\partial J}{\partial x} \quad -②$$



where J_2 is the flux leaving the volume and J_1 is the flux entering the volume

The continuity eqn

$$A\,dx\,\frac{\partial c}{\partial t} = -A\,(J_2 - J_1) = -A\,dx\,\frac{\partial J}{\partial x}$$

$$\frac{\partial C(x,t)}{\partial t} = -\frac{\partial J}{\partial x} \qquad — (3)$$

from first law

$$\frac{\partial C(x,t)}{\partial t} = -\frac{\partial}{\partial x}\left(-D\frac{\partial c}{\partial x}\right) \qquad — (4)$$

when the concentration of the solute is low the diffusivity at a given temp. may be treated as a constant

$$\frac{\partial c}{\partial t} = D\,\frac{\partial^2 c(x,t)}{\partial x^2} \qquad — (5)$$

second law finally expressed

$$\boxed{\frac{\partial c}{\partial t} = D\nabla^2 C}$$

Q.4 what is annealing ? Give solution of the Fick law

4 Ans :

Annealing :- Ion implantation damages the Target and displaces many atom from their lattice site for each implanted ion. Annealing is therefore required to repair lattice damage and put dopant atom on substitutional site where they will be electrically active. The success of annealing is measured in terms of the fraction of dopant that is electrically active. This is found using Hall Technique. A part from repairing of damage, dopant annealing is also required do minimize diffusion so that shallow implants remain shallow

Methods of Annealing :-

(a) Furnace Annealing

In furnace annealing, Annealing characteristics depends on the dopant type and dose involved for amorphous silicon regrowth is by solid phase epitaxy (SPE). The amorphous / crystalline. interface moves toward the surface at fixed velocity that depend on temp., doping and crystal orientation. The activation energy for SPE is 2.3 ev which indicate that the process involves bond breaking at the interface.

Rapid Thermal Annealing :-

The perpose of Annealing is to repair ~~latt~~ lattice damage while minimize ~~are~~ activation diffusion. The process of repair require energy of about 5ev whereas the same required for the process of diffusion is around 3 or 4ev.

Rapid Thermal annealing is divided in to three categories :-

1. Adiabatic Annealing
2. Thermal flux Annealing
3. isothermal Annealing

5 Q. Write short notes on (a) oxidation techniques (b) oxide properties
5 Ans :-

(a) Oxidation Techniques :-

The oxide layer growth must ~~exhbit~~ exhibits good electrical characteristics and provide long term reliability. The thin oxide growth must be reproducible and uniform to obtain these characteristics. The growth of oxide should be slow enough. There are different techniques of oxide growth.

1. Dry / HCl Dry ~~oxi~~ oxidation
2. wet oxidation
3. High pressure oxidation
4. plasma oxidation.

(b) Oxide properties :-

For thin oxide the role of interface ($Si - SiO_2$) is very important in determining the oxide properties. The properties of thin oxides are determined by the processing conditions and these are

1. At reduced temp.
2. Refractive index of dry oxides decreases with increase temp.

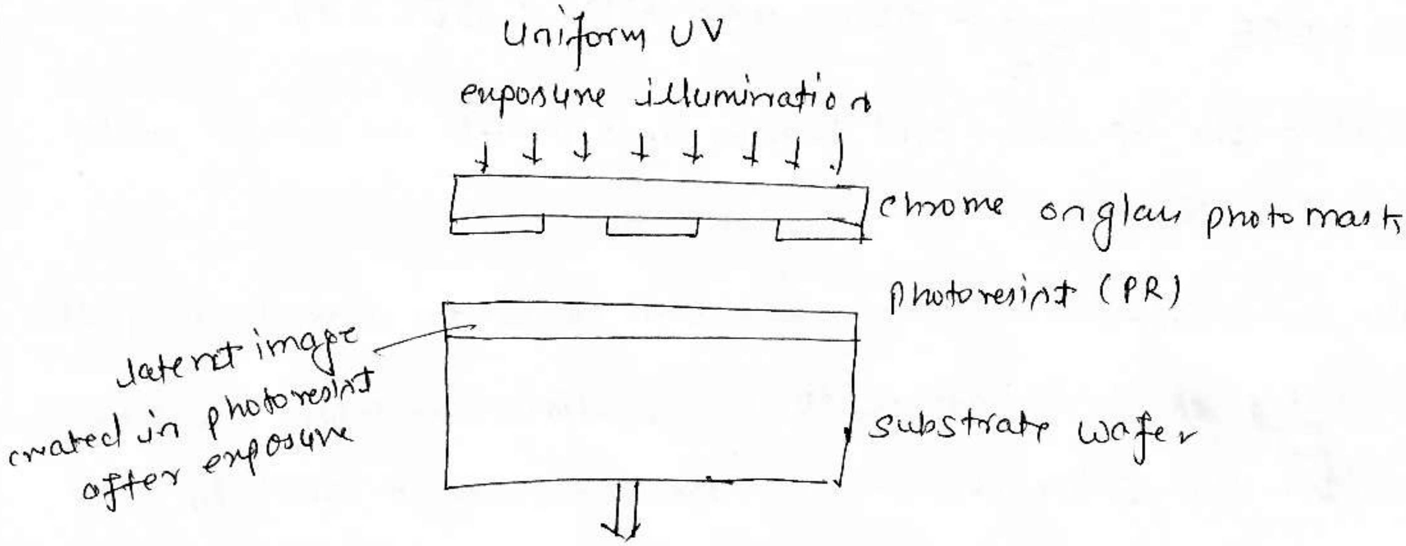
(3) Density of oxide grown at lower temp. is more than that of grown at higher temp.

(4) Etch rate of thermal oxides varies with oxide density and with oxidation temp.

Q.1 Explain the Top down and bottom up Approach in detail with suitable diagram

Ans The microelectronics industry was born out of the invention of the transistor ~~of the~~ in 1947 to 1948 by William Shockley, Walter Brattain and John Bardeen of Bell Laboratories and by the invention of the integrated circuit (IC) in 1958 by Jack Kilby of Texas Instruments and Robert Noyce of Fairchild Semiconductor corporation. In 1965, Gordon Moore observed that the number of transistor per square inch on an IC chip roughly double every 12 months. This general rule of thumb is now called Moore's Law, and has approximately held through the present time, although now the number ~~of~~ is taken double every 18-24 months.
Because of the diminishing feature size of transistors and other components, one could say that electronics industry is already 'doing' nanotechnology. Another very important practical aspect of reducing feature size is that manufacturing processes must also be changed, at great expense.

Lithography :- the problem of shrinking the size of devices fabricated through optical lithography can be readily understood. Lithography can be defined as the process of using electromagnetic energy to transfer a pattern from a mask to a resist layer deposit on the surface of the substrate, which is also called as wafer, in order to



wet chemical development

Negative Photoresist — Positive Photoresist

photopolymerized where exposed and rendered insoluble to the developer

Exposure decomposes a development inhibitor and developer solution only dissolves photoresist in the exposed areas.

⇒ photoresist is applied to the Si wafer.

⇒ Optical energy is directed at a photomask containing opaque and transparent regions.

⇒ Selection of photoresist that are exposed to the light coming through the mask undergo chemical reactions

- ↦ for a negative photoresist
- ↳ In a positive photoresist

⇒ Different steps may be transfer to perform the pattern from the resist to the wafer

- ↦ Etching may be used to remove substrate material.
- ↳ material

↦ Doping can occur, a beam of dopant ions can be accelerated towards the wafer.

Bottom-up Approach:- The birth of nano technology was occurs when the very famous physicist Richard Feynman gives a quote in his speech titled "There's plenty of Room at the Bottom". In contrast to the top-down approach, this nanoscale building is called the bottom-up approach and represents a much more radical technology shift, which is currently being explored in research laboratories. Moving individual atoms one by one is time-consuming process and researchers are looking at more efficient methods of building nanoscopic structures.

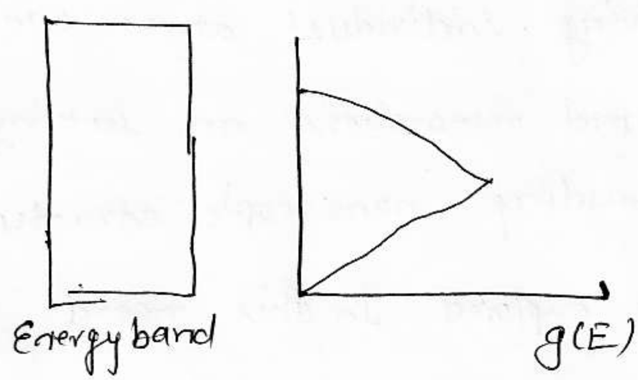
Many avenues are being explored in this regard, including chemical or biological self assembly of devices, ~~or~~ or mechanical assembly of device by other small devices (called assemblers)

Since the objects are tiny, often electrophoretic forces, dielectrophoretic forces and capillary forces can be profitably used.

Thus in the future of nanotechnology, the bottom up approach has received a lot of attention.

Q.2 Explain the effect of crystal size on density of states and Band gap.

Ans fermi-dirac statistics, fermi-Energy:- In a crystalline solid, the energy and volume density states change across the energy band. Generally, the no. of energy levels which correspond to the electronics wave functions in the crystal, in the central region of the band are expected to be very large



Density of states across an energy band

Therefore the number of electron energy states per unit volume over the energy interval E ~ E+dE, are called the density of states (DOS) and defined as $\rho(E)\,dE$, when $\rho(E)$ is the DOS.

Thus the number of states per unit volume up to some energy E will be

$$N_V(E) = \int_0^E \rho(E)\,dE$$

The expression for the density of states for a 3D crystal is

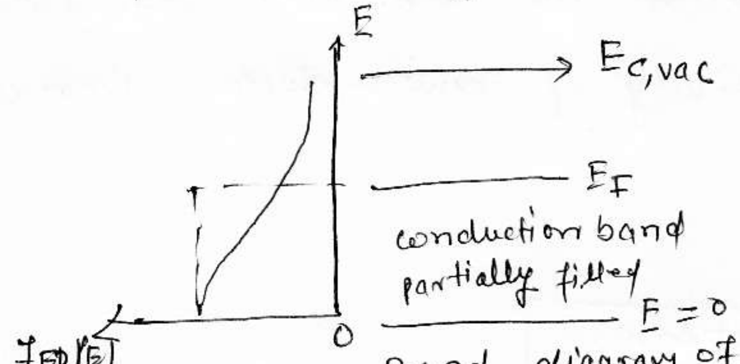
Epot ⇒ is a potential energy, which may be the conduction band edge or valence band edge. E_c or E_V respectively.

For 2D structure, such as quantum well, the confinement of carriers in one spatial direction results in the formation of quantum states for motion in this direction.

$$\rho(E)_{2D} = \frac{m^*}{\pi h^2} \sum_i H(E-E_i)$$

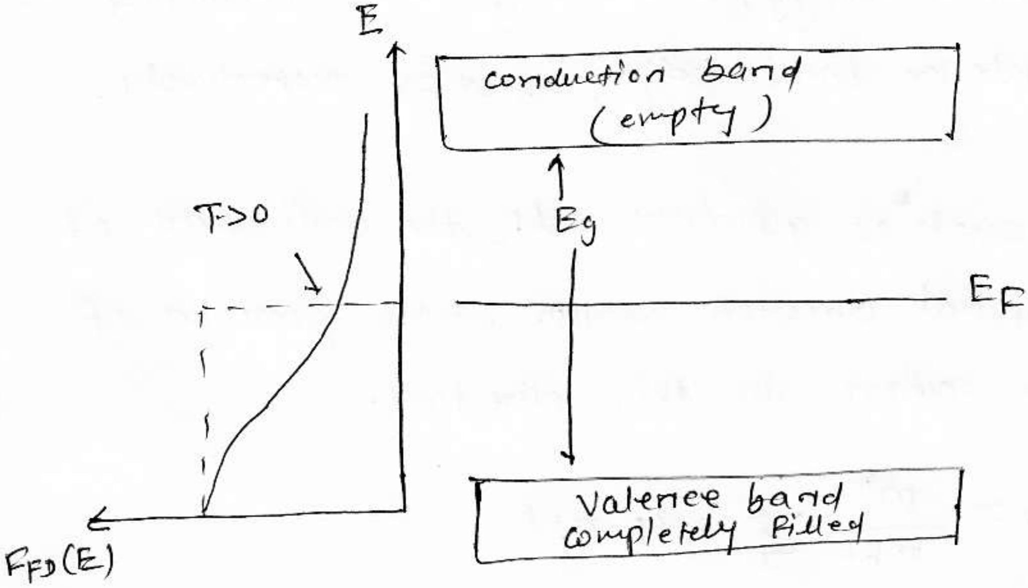
when $H(E-E_i)$ - is the Heaviside function

For metals, the Fermi energy is defined as that energy for which at T=0 all levels in conduction band below it are filled with electrons, while all levels above it are empty. Electron are free to move into empty states of conduction band with only a small electric field E, leading to high electrical conductivity.



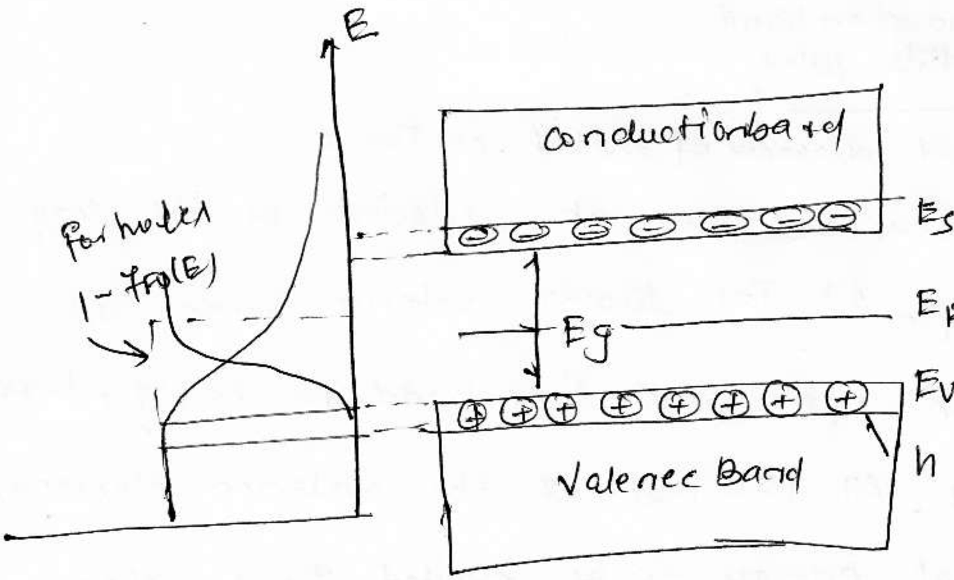
Band diagram of metal at T=0 K

For insulators, the Fermi level lies at midpoint of the large (6-10eV) forbidden gap. At T=0 lower valence band is filled with electron and upper conduction band is empty, leading to zero conductivity. AT T>0 most of the valence electrons



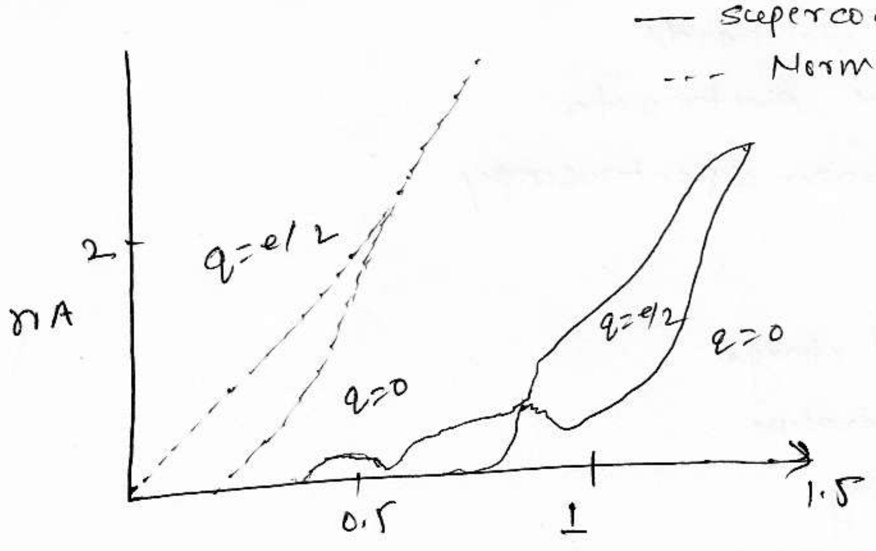
Band diagram of insulator.

For intrinsic semiconductor, Fermi level lies at the middle of the energy gap Eg. At T=0, valence band is completely filled and conduction band is empty, leading to zero conductivity. At T>0 electrons thermally excited from valence to the conduction band, leaving an empty state in the valence band, which is called the hole. Thus with increase in temperature, the conductivity of semiconductor increase.



Q.3 Explain the superconductivity with the help of suitable diagram.

Ans ⇒ The single electron tunneling transistor or simply single electron transistor (SET) is made of an island connected through two tunneling junctions to a drain and a source and through a capacitor to a gate electrode. The SET was fabricated in a Au / SiO / Al three layer process. Since, Al is superconductor, this device can be operated either in the superconductivity state or in the normal state when the superconductivity is suppressed by applying a magnetic field. The electrical characteristics of the capacitively coupled SET transistors are shown below. The current that flows through the two tunnel Junctions can be modulated by changing the charge on the gate.



Two current voltage curves are shown for this device can be in th normal device state and two curves in the superconductivity state. In the normal state, on the curve labeled $q=0$, no current flows until there is a finite voltage across the two junction. This is known as the coulomb blockade. The origin of the blockade has to due with energy that is necessary to add an extra electron to the island. The ~~com~~ coulomb blockade is maximized any time the charge on the gate is an integer multiple of the charge of an electron e^-. The coulomb blockade can be suppressed by adjusting gate charge to $(n+1/2)e$, where n is an integer. In this condition curve $e/2$ is observed.

other applications
- charge sensor
- Detection of infrared Radiation
- ultrasensitive microwave Transistor
- Temperature standards
- supersensitive electrometer
- single electron spectroscopy

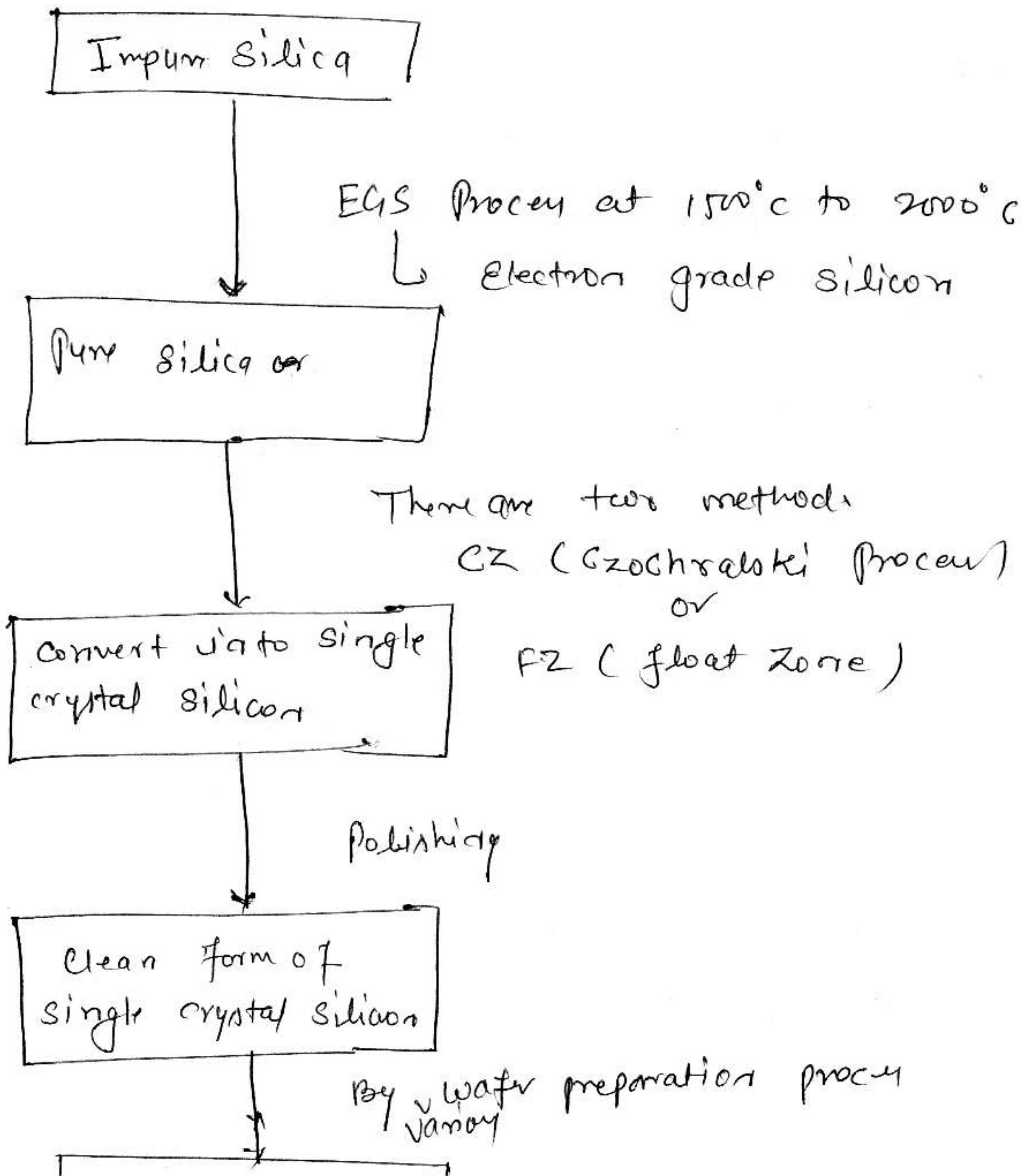
limitions
- Back ground charge
- Room temperature
- Co-tunneling
- Lithography technique

Q.4 Explain the various process involve for si processing method.

Ans more than 90%. of the earth's crust is composed of Silica (SiO_2) or silicate, making silicon the second most abundant element on earth. At present silicon is the most important semiconductor for the electronics industry and thus silicon-based devices constitute over 95%, of all semiconductor devices sold worldwide.

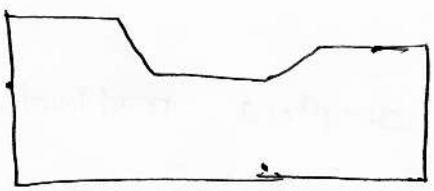
The most advanced semiconductor technologies for today and tomorrow require monocrystalline silicon with precise uniform chemical characteristics for instance controlled dopant and oxygen content. The process to transform raw silicon into a useable single-crystal substrate for modern semiconductor processes begins by mining for relatively pure silicon dioxide. Most si is now made by reduction of SiO_2 with carbon in an electronic furnace from 1500°C to 2000°C. With carefully selected pure sand, the result is commercial brown metallurgical Grade silicon (MGS) of 97%. purity or better. This silicon must be purified to bring impurities below the parts per billion level which can be used as semiconductors and have a high level of purity by 99.999.

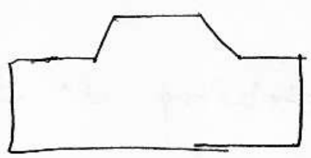
into samples with a singular crystal orientation, known as ingots using a Czochralski growth (CZ) process in a CZ furnace. After this the polishing of the single crystal silicon wafer is done and after a final clean, wafer are ready to use. There are many techniques which involved during the fabrication of semiconductor based devices

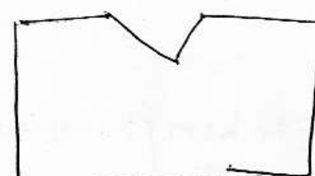


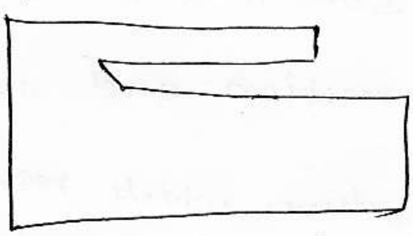
Q.5 Explain the type of etching. Also explain one in detail.

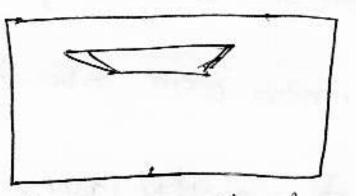
Ans – Etching is the process which makes it possible to selectively remove the deposite films or parts of the substrate in order to prepare a desired patterns, shaps, features or structures. It is necessary to etch the thin film on a substrate or the substrate itself, in order to form a functional MEMS structure. As opposed to chemical vapor deposition, etching removes material from the deposited layer. The portion of SiO_2 layer and subsequently the portion of photoresist layer require etching in order to obtain the structure.

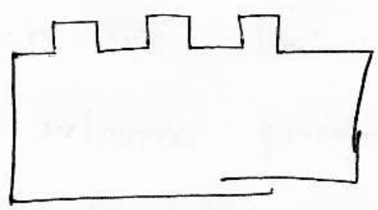

Pit / Plate


Step


Hole / groou

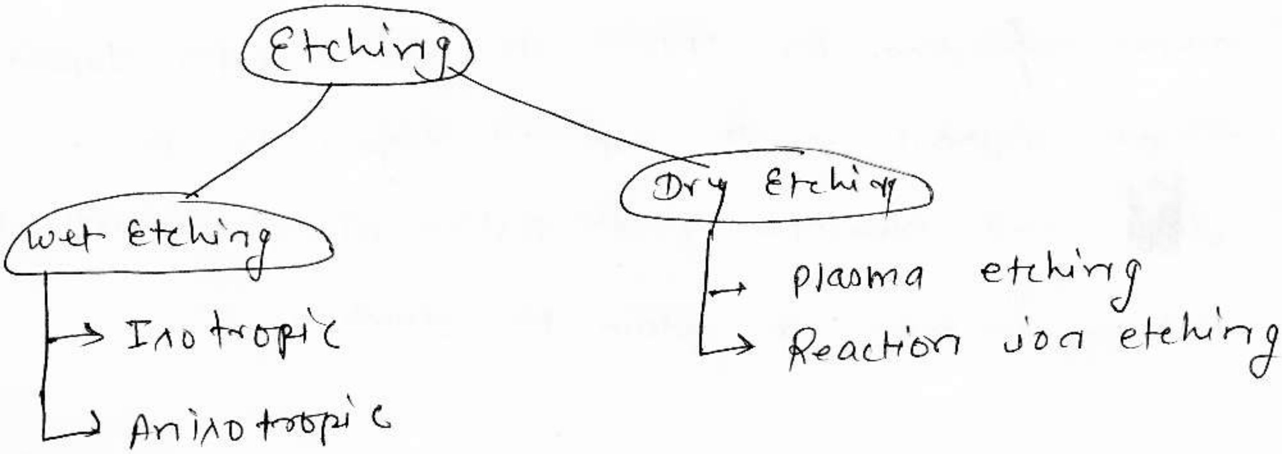

Tougne / cantilever


Bridge / diaphragm


Post / pos

Typical basic MEMS structures can be created by etching the substrate.

Two classes of etching process are common. they are wet and dry etching. wet etching removes the material selectively through chemical reaction. the material is immersed in a chemical solution, which reacts and subsequently dissolves the portion of the material which is in contact with the solution



Wet Etching: wet etching is the simplest method. It is important to note that the liquid solvent should not change the chemical properties of the dissolved material such as photoresist, SiO_2 etc. sometimes the wet etching involve more than one chemical reaction and is in fact applicable only to multi layer structures which require sequential etching.

The etchant is usually a mixture of acidic solution. The selectivity of the etchant plays a major role in wet etching.

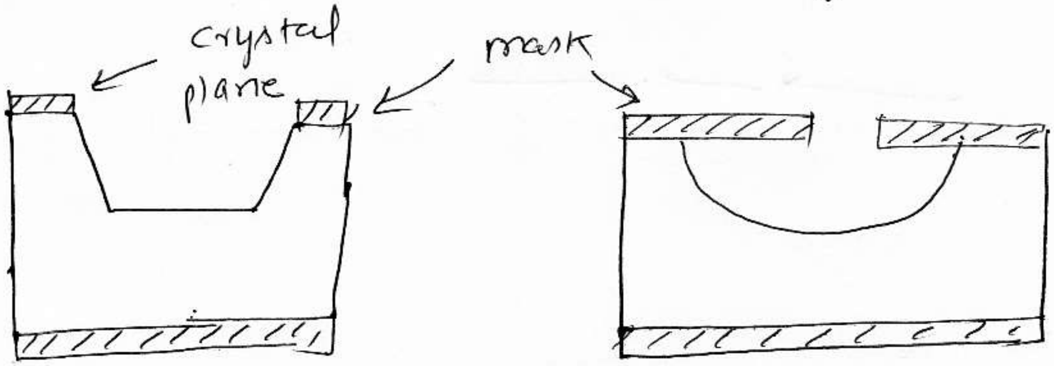
The sequence of operations within the wet etching process fall under three sub-activities

⇒ Diffusion of the etchant to the surface for removal. The operation is carried out at room temperature or slightly above, but preferably below 50°C.

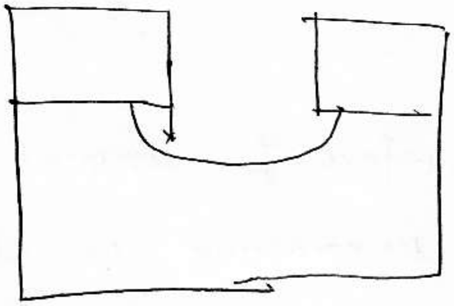
⇒ Establishment of reaction between the etchant and the material being removed.

⇒ Diffusion of the reaction by products form the reacted surface. this activity can also be called clearing.

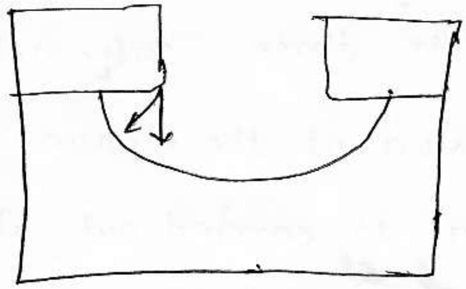
The dissolution of material due to chemical reaction may not be uniform in all directions. This characteristics of etching is called directionality. The wet etching rate is crystallographic plane orientation dependent. Accordingly the wet etching can be classified as whether the process etches the material anisotrophically or isotropically.



(a) Anisotropics (b) Anisotropics showing



(c) Isotropic



(d) Isotropic showing directionality

The isotropic material will dissolve uniformly in all directions. the isotropic etching materials are removed uniformly from all the direction. Anisotropic etching is useful in producing Vee groves, pyramids and channel into the surface of wafer. The commonly used anisotropic etchants are KOH (Potasium Hydroxide), NaOH, LiOH, CsOH, NH_4OH.

the most commonly used isotropic etchants for silicon are mixture of hydrofluoric acids (HF), HNO_3, CH_3COOH, HF : HNO_3 : CH_3COOH is called HNA. the ratio is 3:2:5 by volum.

JNIT JAGANNATH GUPTA INSTITUTE OF ENGINEERING & TECHNOLOGY JAIPUR

I-Mid Term Examination Session 2018

B.Tech 4th Year 8th Semester

Branch: EC **Subject: Operating system**

Time: **Subject Code:8EC4.2A**

Date: **Max. Marks: 20**

OUESTIONS WITH SOLUTION

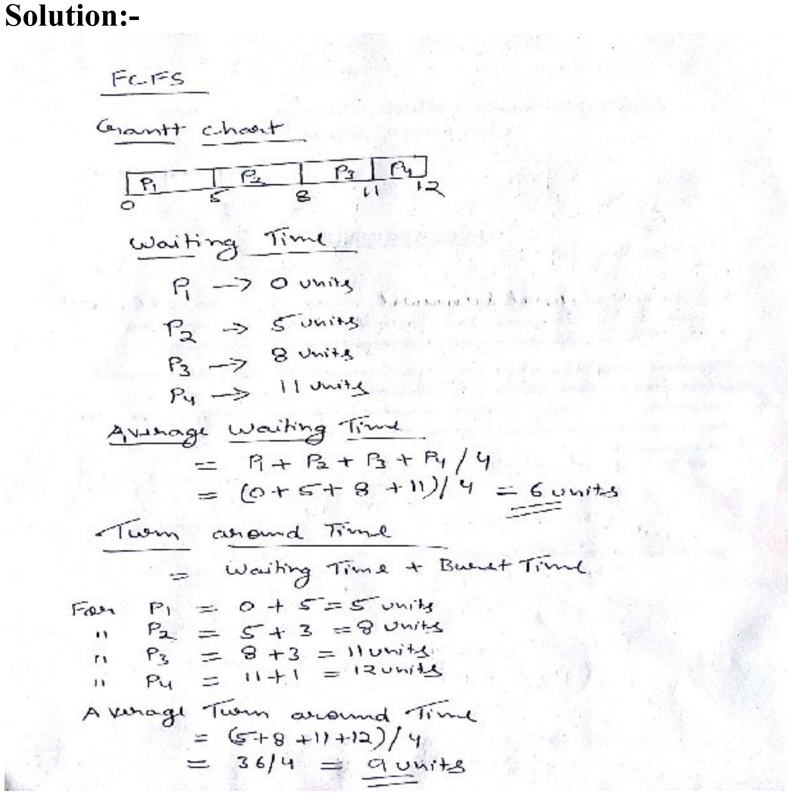
1. **Consider the following:**

PROCESS	BURST TIME	ARRIVAL-TIME	PRIORITY
P1	5	0	4
P2	3	1	7
P3	3	2	2
P4	1	3	6

Find the average waiting time and average turn-around time using Following scheduling algorithm:

(a) FCFS

Solution:-


FCFS

Gantt chart

| P1 | P2 | P3 | P4 |
0 5 8 11 12

Waiting Time

P1 → 0 units

P2 → 5 units

P3 → 8 units

P4 → 11 units

Average Waiting Time

= P1 + P2 + P3 + P4 / 4

= (0+5+8+11)/4 = 6 units

Turn around Time

= Waiting Time + Burst Time

For P1 = 0 + 5 = 5 units

" P2 = 5 + 3 = 8 units

" P3 = 8 + 3 = 11 units

" P4 = 11 + 1 = 12 units

Average Turn around Time

= (5+8+11+12)/4

= 36/4 = 9 units

(b) SJF(preemptive)
Solution:

SJF (preemptive)

Gantt chart

P1	P2	P4	P3	P1

0 1 2 3 4 5 8 12

P2 P3 P4

Waiting Time of P1 → 0 + (8 − 1) = 7 units
" P2 → 0 units
" P3 → 5 − 2 = 3 units
" P4 → 4 − 3 = 1 units

Average waiting Time = (7+0+3+1)/4 = 11/4 = 2.75 units

Turn Around Time = Waiting Time + Burst Time
Turn around of P1 → 7 + 5 = 12 units
P2 → 0 + 3 = 3 units
P3 → 3 + 3 = 6 units
P4 → 1 + 1 = 2 units

Average Turn around Time
= (12+3+6+2)/4
= 5.75 units

(c) Round-Robin(quantum=1 unit)
Solution:

Round-Robin when Time Quantum = 1 unit

Gantt chart

P1	P2	P3	P4	P1	P2	P3	P1	P2	P3	P1	P1

0 1 2 3 4 5 6 7 8 9 10 11 12

Waiting Time of P1 = 0 + (4−1) + (7−5) + (10 − 8)
= 0 + 3 + 2 + 2 = 7 units
" of P2 = 1 + (5−2) + (8−6) = 6 units
" of P3 = 2 + (6 − 3) + (9 − 7) = 7 units
" of P4 = 3 units

Average waiting Time = (7+6+7+3)/4 = 23/4 = 5.75

Turn Around Time = Burst Time + Waiting Time
Turn around Time of P1 = 7+5 = 12 units
" P2 = 6+3 = 9 units
" P3 = 7+3 = 10 units
" P4 = 3 + 1 = 4 units

Average Turn around Time
= (12+9+10+4)/4
= 35/4
= 8.75 units

2. **Explain Process and operation on process in Detail.**

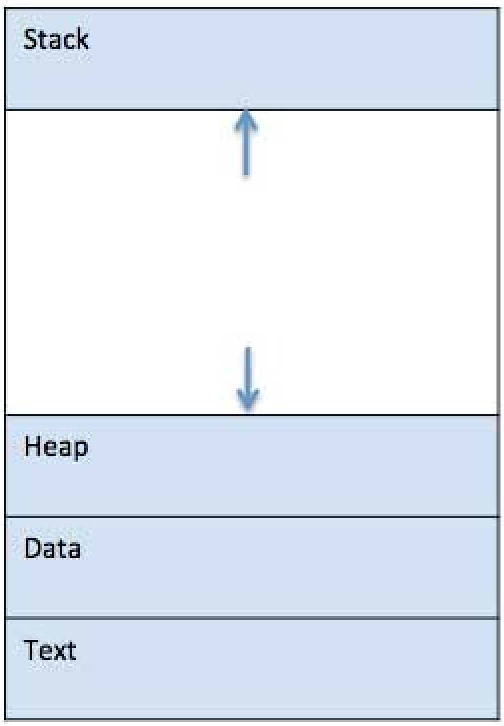
Solution:-

A process is basically a program in execution. The execution of a process must progress in a sequential fashion.

A process is defined as an entity which represents the basic unit of work to be implemented in the system.

To put it in simple terms, we write our computer programs in a text file and when we execute this program, it becomes a process which performs all the tasks mentioned in the program.

When a program is loaded into the memory and it becomes a process, it can be divided into four sections ─ stack, heap, text and data. The following image shows a simplified layout of a process inside main memory −



S.N.	Component & Description
1	Stack The process Stack contains the temporary data such as method/function parameters, return address and local variables.
2	Heap This is dynamically allocated memory to a process during its run time.
3	Text

	This includes the current activity represented by the value of Program Counter and the contents of the processor's registers.
4	Data This section contains the global and static variables.

3. What is operating System? Explain any 5 types of OS.
   Solution:

Operating systems are there from the very first computer generation and they keep evolving with time. In this chapter, we will discuss some of the important types of operating systems which are most commonly used.

Batch operating system

The users of a batch operating system do not interact with the computer directly. Each user prepares his job on an off-line device like punch cards and submits it to the computer operator. To speed up processing, jobs with similar needs are batched together and run as a group. The programmers leave their programs with the operator and the operator then sorts the programs with similar requirements into batches.

The problems with Batch Systems are as follows −

- Lack of interaction between the user and the job.
- CPU is often idle, because the speed of the mechanical I/O devices is slower than the CPU.
- Difficult to provide the desired priority.

Time-sharing operating systems

Time-sharing is a technique which enables many people, located at various terminals, to use a particular computer system at the same time. Time-sharing or multitasking is a logical extension of multiprogramming. Processor's time which is shared among multiple users simultaneously is termed as time-sharing.

The main difference between Multiprogrammed Batch Systems and Time-Sharing Systems is that in case of Multiprogrammed batch systems, the objective is to maximize processor use, whereas in Time-Sharing Systems, the objective is to minimize response time.

Multiple jobs are executed by the CPU by switching between them, but the switches occur so frequently. Thus, the user can receive an immediate response. For example, in a transaction processing, the processor executes each user program in a short burst or quantum of computation. That is, if nusers are present, then each user can get a time quantum. When the user submits the command, the response time is in few seconds at most.

The operating system uses CPU scheduling and multiprogramming to provide each user with a small portion of a time. Computer systems that were designed primarily as batch systems have been modified to time-sharing systems.

Advantages of Timesharing operating systems are as follows −

- Provides the advantage of quick response.
- Avoids duplication of software.
- Reduces CPU idle time.

Disadvantages of Time-sharing operating systems are as follows −

- Problem of reliability.
- Question of security and integrity of user programs and data.
- Problem of data communication.

Distributed operating System

Distributed systems use multiple central processors to serve multiple real-time applications and multiple users. Data processing jobs are distributed among the processors accordingly.

The processors communicate with one another through various communication lines (such as high-speed buses or telephone lines). These are referred as loosely coupled systems or distributed systems. Processors in a distributed system may vary in size and function. These processors are referred as sites, nodes, computers, and so on.

The advantages of distributed systems are as follows −

- With resource sharing facility, a user at one site may be able to use the resources available at another.
- Speedup the exchange of data with one another via electronic mail.
- If one site fails in a distributed system, the remaining sites can potentially continue operating.
- Better service to the customers.
- Reduction of the load on the host computer.
- Reduction of delays in data processing.

Network operating System

A Network Operating System runs on a server and provides the server the capability to manage data, users, groups, security, applications, and other networking functions. The primary purpose of the network operating system is to allow shared file and printer access among multiple computers in a network, typically a local area network (LAN), a private network or to other networks.

Examples of network operating systems include Microsoft Windows Server 2003, Microsoft Windows Server 2008, UNIX, Linux, Mac OS X, Novell NetWare, and BSD.

The advantages of network operating systems are as follows −

- Centralized servers are highly stable.
- Security is server managed.
- Upgrades to new technologies and hardware can be easily integrated into the system.
- Remote access to servers is possible from different locations and types of systems.

The disadvantages of network operating systems are as follows −

- High cost of buying and running a server.
- Dependency on a central location for most operations.
- Regular maintenance and updates are required.

Real Time operating System

A real-time system is defined as a data processing system in which the time interval required to process and respond to inputs is so small that it controls the environment. The time taken by the system to respond to an input and display of required updated information is termed as the response time. So in this method, the response time is very less as compared to online processing.

Real-time systems are used when there are rigid time requirements on the operation of a processor or the flow of data and real-time systems can be used as a control device in a dedicated application. A real-time operating system must have well-defined, fixed time constraints, otherwise the system will fail. For example, Scientific experiments, medical imaging systems, industrial control systems, weapon systems, robots, air traffic control systems, etc.

There are two types of real-time operating systems.

Hard real-time systems

Hard real-time systems guarantee that critical tasks complete on time. In hard real-time systems, secondary storage is limited or missing and the data is stored in ROM. In these systems, virtual memory is almost never found.

Soft real-time systems

Soft real-time systems are less restrictive. A critical real-time task gets priority over other tasks and retains the priority until it completes. Soft real-time systems have limited utility than hard real-time systems. For example, multimedia, virtual reality, Advanced Scientific Projects like undersea exploration and planetary rovers, etc.

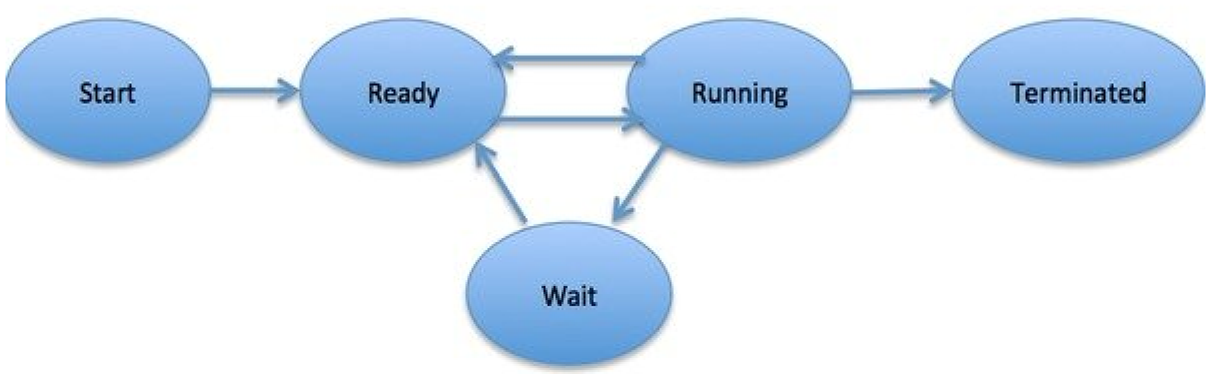
4. Write short note on:-
   (a) Process states and PCB
   Solution:

Process Life Cycle or states

When a process executes, it passes through different states. These stages may differ in different operating systems, and the names of these states are also not standardized.

In general, a process can have one of the following five states at a time.

S.N.	State & Description
1	Start This is the initial state when a process is first started/created.
2	Ready The process is waiting to be assigned to a processor. Ready processes are waiting to have the processor allocated to them by the operating system so that they can run. Process may come into this state after Start state or while running it by but interrupted by the scheduler to assign CPU to some other process.
3	Running Once the process has been assigned to a processor by the OS scheduler, the process state is set to running and the processor executes its instructions.
4	Waiting Process moves into the waiting state if it needs to wait for a resource, such as waiting for user input, or waiting for a file to become available.
5	Terminated or Exit Once the process finishes its execution, or it is terminated by the operating system, it is moved to the terminated state where it waits to be removed from main memory.



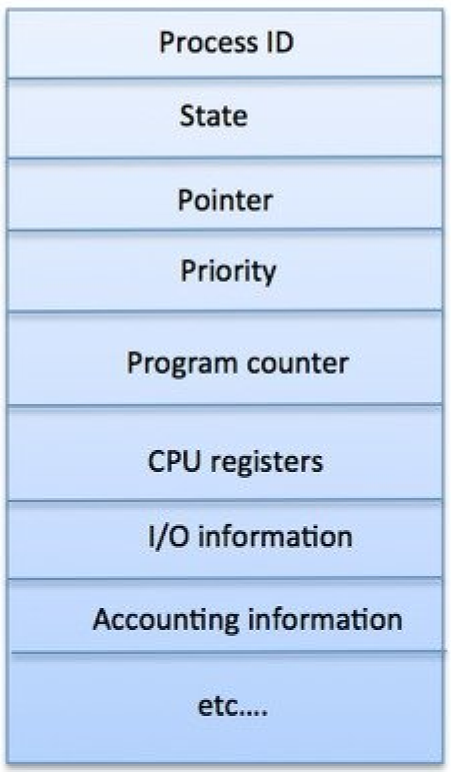
Process Control Block (PCB)

A Process Control Block is a data structure maintained by the Operating System for every process. The PCB is identified by an integer process ID (PID). A PCB keeps all the information needed to keep track of a process as listed below in the table −

S.N.	Information & Description
1	Process State The current state of the process i.e., whether it is ready, running, waiting, or whatever.
2	Process privileges This is required to allow/disallow access to system resources.
3	Process ID Unique identification for each of the process in the operating system.
4	Pointer A pointer to parent process.
5	Program Counter Program Counter is a pointer to the address of the next instruction to be executed for this process.
6	CPU registers Various CPU registers where process need to be stored for execution for running state.
7	CPU Scheduling Information Process priority and other scheduling information which is required to schedule the process.
8	Memory management information This includes the information of page table, memory limits, Segment table depending on memory used by the operating system.

9	Accounting information This includes the amount of CPU used for process execution, time limits, execution ID etc.
10	IO status information This includes a list of I/O devices allocated to the process.

The architecture of a PCB is completely dependent on Operating System and may contain different information in different operating systems. Here is a simplified diagram of a PCB −



The PCB is maintained for a process throughout its lifetime, and is deleted once the process terminates.

(b) Operating system services
Solution:

An Operating System provides services to both the users and to the programs.

- It provides programs an environment to execute.
- It provides users the services to execute the programs in a convenient manner.

Following are a few common services provided by an operating system −

- Program execution

- I/O operations
- File System manipulation
- Communication
- Error Detection
- Resource Allocation
- Protection

Program execution

Operating systems handle many kinds of activities from user programs to system programs like printer spooler, name servers, file server, etc. Each of these activities is encapsulated as a process.

A process includes the complete execution context (code to execute, data to manipulate, registers, OS resources in use). Following are the major activities of an operating system with respect to program management −

- Loads a program into memory.
- Executes the program.
- Handles program's execution.
- Provides a mechanism for process synchronization.
- Provides a mechanism for process communication.
- Provides a mechanism for deadlock handling.

I/O Operation

An I/O subsystem comprises of I/O devices and their corresponding driver software. Drivers hide the peculiarities of specific hardware devices from the users.

An Operating System manages the communication between user and device drivers.

- I/O operation means read or write operation with any file or any specific I/O device.
- Operating system provides the access to the required I/O device when required.

File system manipulation

A file represents a collection of related information. Computers can store files on the disk (secondary storage), for long-term storage purpose. Examples of storage media include magnetic tape, magnetic disk and optical disk drives like CD, DVD. Each of these media has its own properties like speed, capacity, data transfer rate and data access methods.

A file system is normally organized into directories for easy navigation and usage. These directories may contain files and other directions. Following are the major activities of an operating system with respect to file management −

- Program needs to read a file or write a file.
- The operating system gives the permission to the program for operation on file.

- Permission varies from read-only, read-write, denied and so on.
- Operating System provides an interface to the user to create/delete files.
- Operating System provides an interface to the user to create/delete directories.
- Operating System provides an interface to create the backup of file system.

Communication

In case of distributed systems which are a collection of processors that do not share memory, peripheral devices, or a clock, the operating system manages communications between all the processes. Multiple processes communicate with one another through communication lines in the network.

The OS handles routing and connection strategies, and the problems of contention and security. Following are the major activities of an operating system with respect to communication −

- Two processes often require data to be transferred between them
- Both the processes can be on one computer or on different computers, but are connected through a computer network.
- Communication may be implemented by two methods, either by Shared Memory or by Message Passing.

Error handling

Errors can occur anytime and anywhere. An error may occur in CPU, in I/O devices or in the memory hardware. Following are the major activities of an operating system with respect to error handling −

- The OS constantly checks for possible errors.
- The OS takes an appropriate action to ensure correct and consistent computing.

Resource Management

In case of multi-user or multi-tasking environment, resources such as main memory, CPU cycles and files storage are to be allocated to each user or job. Following are the major activities of an operating system with respect to resource management −

- The OS manages all kinds of resources using schedulers.
- CPU scheduling algorithms are used for better utilization of CPU.

Protection

Considering a computer system having multiple users and concurrent execution of multiple processes, the various processes must be protected from each other's activities.

Protection refers to a mechanism or a way to control the access of programs, processes, or users to the resources defined by a computer system. Following are the major activities of an operating system with respect to protection −

- The OS ensures that all access to system resources is controlled.

- The OS ensures that external I/O devices are protected from invalid access attempts.
- The OS provides authentication features for each user by means of passwords.

5. **What is monitor? How are semaphore used for critical section problem?**

Solution:-

In concurrent programming, a monitor is a synchronization construct that allows threads to have both mutual exclusion and the ability to wait (block) for a certain condition to become true. Monitors also have a mechanism for signaling other threads that their condition has been met. A monitor consists of a mutex (lock) object and condition variables. A condition variable is basically a container of threads that are waiting for a certain condition. Monitors provide a mechanism for threads to temporarily give up exclusive access in order to wait for some condition to be met, before regaining exclusive access and resuming their task.

Another definition of monitor is a thread-safe class, object, or module that uses wrapped mutual exclusion in order to safely allow access to a method or variable by more than one thread. The defining characteristic of a monitor is that its methods are executed with mutual exclusion: At each point in time, at most one thread may be executing any of its methods. By using one or more condition variables it can also provide the ability for threads to wait on a certain condition (thus using the above definition of a "monitor"). For the rest of this article, this sense of "monitor" will be referred to as a "thread-safe object/class/module".

Semaphores

- originally, semaphores were flags for signalling between ships
- a variable used for signalling between processes

- operations possible on a semaphore:
    - initialization
        - done before individual processes try to operate on the semaphore
    - two main operations:
        - wait (or acquire)
        - signal (or release)
    - the wait and signal operations are atomic operations (e.g., the test-and-set at the top of the loop of wait is done before losing the processor)
    - e.g., a resource such as a shared data structure is protected by a semaphore. You must acquire the semaphore before using the resource and release the semaphore when you are done with the shared resource.

wait(S):

while S $\leq$ 0 do

no-op;

S.value := S.value - 1;

signal(S):

S := S + 1;

In either case, the initial value for S:

1. equals 1 if only one process is allowed in the critical section (binary semaphore)
2. equals n if at most n processes are allowed in the critical section

Semaphore Solution to the Critical Selection Problem

repeat

wait(mutex);

critical section

signal(mutex);

remainder section

until false;

Process 1
empty = n S = 1 check S $\leq$ 0 • S = 1 so do not busy wait

Alternative Implementation of Wait and Signal

wait(S): this code is executed atomically

S.value := S.value - 1;
if S.value < 0
then begin

add this process to S.L;
suspend this process;

end;