UNIT – I
ELEMENTS OF LIGHT AND SOLID STATE PHYSICS

PART – A (2 MARKS)

1.What is meant by wave function? {DEC-13]

Wave function is the probability amplitude of finding the electron in an energy state of the solid. It is a complex displacement of matter wave (electron wave) and we can`t measure it.

2.Define depletion layer.

Deflection layer is the region in the p-n junction &it contains no free charge carriers it is existing on the both sides of a p-n junction& contains immobile ions it is called space charge layer.

3.What is density of states? MAY-11

Density of states is defined as the number of energy states per unit volume in an energy interval. It is calculate the number of charge carriers per unit volume of the solid.

4.What is meant by contact potential at the p-n junction?

Contact potential barrier arising due to the maintaining of constant Fermi level throughout the p-n junction.

5.What is the source of bioelectric signals?

The living tissues used as a power station generating multiple electrical signals with 2 internal sources namely muscles and nerves.

6. What are the types of electrodes?

- Microelectrodes
- Depth and needle electrodes
- Surface electrodes.

7.what is QCSE?

Quantum confined stark effect refers to the bending of potential well dueto transverse applied electric field and shifting of the absorptuion edge of exciton to lower energy side and resulting absorption of photons

8.What are the needs of the electrodes? JUNE-12

• Electrodes makes a transfer from the ionic conduction in the tissue to the electronic conduction which is necessary for making measurement.

• Electrodes plays an important part in the satisfactory recording of bioelectric signals and their choice requires careful consideration.

9.Mention the important semiconductors used in laser and LED's?NOV/DEC-13

InGaAsP-to produce wavelength from 1.3μm to 1.7μm GaAlAs-to produce wavelength from 0.8μmto 0.9μm

10.What is the effect of high rise time of drive current in LEDs?

If the rise time increases, carrier life time is increased and hence radiative reambination rate is decreased . these lead to decrease of bandwidth and output power of LED.

11.Define optoelectronics.

Optoelectronics is the branch of technology concerned with combined use of electronics and light. It can be defined as the study and application of electronic devices that source, detect, and control light. Optoelectronics can be considered as the subfield of photonics. Photonics includes the generation, emission, transmission, modulation, signal processing, amplification, detection, and sensing of light.

12.What is called as auger recombination

The Auger effect is a physical phenomenon in which the filling of an inner- shell vacancy of an atom is accompanied by the emission of an electron from the same atom. When a core electron is removed, leaving a vacancy, an electron from a higher energy level may fall into the vacancy, resulting in a release of energy. Although most often this energy is released in the form of

an emitted photon, the energy can also be transferred to another electron, which is ejected from the atom; this second ejected electron is called an Auger electron or auger recombination

13.What is meant by Polarization and what are the two methods of polarization

If the electric field vector of an EM wave propagation in free space vibrates in a specified plane, the wave is said to be plane polarized. Any real beam of light comprises many individual waves and in general the plane vibration of their electric fields will be randomly oriented. Such beam of light is un polarized and the resultant electric field vector changes orientation randomly in time. The light beams characterized by highly oriented electric fields and such light is referred as being polarized.

Polarization Methods:

1.Reflection 2.Absorption

14.What do you meant by interference? [NOV/DEC 2016]

It can be defined as the superimposition or mixing up of 2 or more waves which results in forming another new wave. Interference is denoted as I.

15.State Malus Law

Malus stated that the intensity of polarized light transmitted through the analyser varies as the square of cosine of the angle between the plane of transmission of the analyser and the plane of polarizer $I_1 = I_0 \cos^2\theta$

16.Define radiative recombination and non-radiative recombination process.

When temperature rises up, if a photon is released then that type of process is known as radiative recombination. If no emission of photon occurs, then that type of process is known as non-radiative process.

17.Distinguish fresnel and fraunhofer diffractions

S.No	Fresnel Diffractions	Fraunhofer Diffractions
1	Either point source or an illuminated narrow slit is used	Extended source at infinite distance is use
2	Wavefront undergoing diffractions is either spherical cylindrical	Wavefront undergoing diffractions is a wavefront
3	Source and the screen are at finite dist from the obstacle producing diffracti	Source and the screen are at infinite dist from the obstacle producing diffraction
4	No lens is used to focus the rays	Converging lens is used to focus the p rays

18.Differentiate diffraction and scattering

- Diffraction is a phenomenon observed only in waves, but scattering is phenomenon observed in both waves and particles
- Diffraction is a property of propagation of waves ,where as scattering is a property of wave interactions
- Diffraction can be taken as evidence for the wave nature of light. Some forms of scattering (Compton scattering) can be taken as evidence for the particle nature of light.

19.Differentiate between coherent and incoherent light

Coherent light is light in which the photons are all in 'step' – other words the change of phase within the beam occurs for all the photons at the same time. There are no abrupt phase changes within the beam. Light produced by lasers is both coherent and monochromatic (of one 'colour'). Incoherent sources emit light with frequent and random changes of phase between the photons. (Tungsten filament lamps and 'ordinary' fluorescent tubes emit incoherent light).

20.What is meant by Primitive cell?

A primitive cell is a unit cell constructed so that it contains only one lattice point (each vertex of the cell sits on a lattice point which is shared with the surrounding cells, each lattice point is said to contribute 1/n to the total number of lattice points in the cell where n is the number of cells sharing the lattice point). A primitive cell is built on the primitive basis of the direct lattice, namely a crystallographic basis of the vector lattice L such that every lattice vector t of L may be obtained as an integral linear combination of the basis vectors, a, b, c.

21. Define optoelectronics.

Optoelectronics is the branch of technology concerned with combined use of electronics and light. It can be defined as the study and application of electronic devices that source, detect, and control light. Optoelectronics can be considered as the subfield of photonics. Photonics includes the generation, emission, transmission, modulation, signal processing, amplification, detection, and sensing of light.

22. Define optoelectronic devices.

Optoelectronic devices can be defined as electrical to optical or optical to electrical transducers. This means that these devices are capable of converting light into electrical form as well as electricity into light form.

23. What do you meant by corpuscular theory?

Corpuscular theory states that light is made up of small particles called corpuscles, which travel in straight line with finite velocity and also possesses sufficient kinetic energy.

24. Give the expression for wave nature of light.

Wave nature of light explains light as the combination of both time varying electric field and magnetic field. The equation of wave nature of light can be written as,

25. Define Snell's law.

Snell's law can be defined as, the refractive indices between two media will be equal i.e.,

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

26. What do you meant by the term interference?

Interference can be defined as the superimposition or mixing up of two or more waves, which results in forming another new wave. Interference is denoted as 'I'.

27. What is meant by diffraction?

Diffraction refers to change in wave parameters when it encounters an obstacle. It can be defined as the apparent bending of wave around small obstacles or spreading out of wave when it passes through some openings.

28. What do you meant by the term wavefront?

Wavefront is the locus i.e., line or a wave propagating in three dimension or a surface of points having same phase.

29. What are light sources and name the different types of light sources?

Light sources are also known as thermal sources or classical sources. All light sources are related to light. These sources are named like this because they radiate electromagnetic energy in direct relation to their temperature.

Light sources are divided into two namely, blackbody sources and line sources.

30.**What are blackbody sources?**

Blackbody sources are opaque bodies or hot dense glasses which radiate energy in all wavelength. These sources absorb all components and allow only black components. These sources emit energy proportional to 4^{th} power of absolute temperature i.e.,

$W = \sigma T^4$

31.What are line sources?

Line sources radiate at discrete wavelength. This is because it has only less interaction between particles or atoms of wave.

32.What do you understand by the quantum mechanical concepts of light?

Quantum mechanical concepts of light suggest three concepts. The first one is light possesses dual nature i.e., it has both particle and wave nature. The second concept is the amplitude of wave is

related to the probability of locating the particle in a given region of space. The third concept is the wave function has to be find out. Wave function can be defined as probability of finding particle in the region of space between x and x+dx, y and y+dy, and z+dz. Wave function 'Ψ' is given as Ψ* Ψdxdydz.

33.What do you meant by semiconductors and name the different types of semiconductors?

Semiconductors are materials which has a medium conductivity. That means its conductivity is below conductors and higher than insulators. There are two types of semiconductors namely intrinsic semiconductors and extrinsic semiconductors.

34.What are intrinsic semiconductors?

Intrinsic semiconductors are semiconductor crystals which contain no impurities or lattice defects. In this material there are no charge carriers. As temperature rises, electron-hole pairs are generated. The value of n material varies exponentially with temperature and this acts as the charge carriers in intrinsic semiconductor.

35.What are extrinsic semiconductors?

Extrinsic semiconductors are semiconductors formed by the process called doping. Doping increases the number of charge carriers. Doping refers to adding appropriate amount of impurities to increase conductivity of material. By doping, we can either make n-type material or a p-type material. In n-type material the majority carriers are electrons and in p-type material the majority carriers are holes.

36.List out the major differences between intrinsic and extrinsic semiconductors.

The major differences between intrinsic and extrinsic semiconductors are listed below,

Intrinsic Semiconductor	Extrinsic Semiconductor
Contains no impurities Contains no defect structure No charge carriers Electron-hole pairs are generated due to ri temperature.	Made by adding impurities. May occur defect in structure when impu are added. Contains both majority and minority cl carriers Electron-hole pairs are generated due to ac of impurities.

37.Define radiative recombination and non-radiative recombination process.

When temperature rises up, if a photon is released then that type of process is known as radiative recombination.

If no emission of photon occurs, then that type of process is known as non-radiative process.

38.Name the two ways in which recombination can occur? The two ways of recombination are,

- Band-to-band or direct recombination process
- Defect center or indirect recombination process

39.**Explain about band-to-band recombination and defect center recombination.**

In direct recombination, an electron in conduction band makes a transaction directly to valence band to recombine with hole, thereby makes a radiative recombination process by releasing a photon.

In indirect recombination process, recombination takes place via recombination traps or centers. These traps and centers occurs when impurities are added. Here, these traps will capture carrier of one type and centers will capture carrier opposite type, which inturn leads to electron hole recombination.

40. **What are Miller indices of crystal?**

Ordinarily, Miller indices are always integers by definition, and this constraint is physically significant. To understand this, suppose that we allow a plane (abc) where the Miller "indices" a, b and c (defined as above) are not necessarily integers.

If a, b and c have rational ratios, then the same family of planes can be written in terms of integer indices (hkℓ) by scaling a, b and c appropriately: divide by the largest of the three

numbers, and then multiply by the least common denominator. Thus, integer Miller indices implicitly include indices with all rational ratios.

PART – B (16 MARKS)

1. From the Schrodinger equation, explain the formation of energy bands in solids. [May/June-2013] [NOV/DEC-2016] .

- Derivation
- Schematic diagram
- Graph
- Energy band diagram

2.Derive the expression for concentration of electrons and holes in an intrinsic semiconductor, with relevant diagrams. [May/June-2013] [APR/MAY 2017]

- Equation
- Energy band diagram
- Illustration of band-band recombination

3. Explain

i).Wave nature of light and the principle of superposition [Nov/Dec-2013] [Nov/Dec 2016]

ii).With a neat diagram explain the interference effects in a thin film of refractive index "n"

- Derivation
- Principle
- Diagram
- Refractive index
- Interference

4.Explain in detail about the excess carriers in semiconductors and hence derive an expression for the variation of excess carriers concentration with distance and time.

- The density of states
- The fermi-Dirac distribution
- Carrier densities for an n-type semiconductor.
- Equation
- Graphical representation

5. Discuss about drift and diffusion of carriers with relevant mathematical expressions.

- Minority carrier injection and diffusion
- Derivation
- Diagram

6. Discuss about the Schematic laout and geometric for a Youngs double slit interference experiment

- Schematic layout
- Interference Principle
- Equation

UNIT II

DISPLAY DEVICES AND LASERS

PART-A

1.What do you meant by display devices?

Display device is an output device for presenting information in visual form. When the input information is supplied with an electrical signal, then that display device is called an electronic display device. There

are two categories of display device. Display device that emit their own radiation or active devices and display device that modulate the incident radiation to provide display information.

2.What are the different luminescent processes?

The different luminescent processes are

i. Electroluminescent processes
ii. Cathodoluminescent processes
iii. Photoluminescent processes
iv. Injection luminescent processes

3.Define the different types of luminescent processes.

- Electroluminescent processes are luminescent process in which excitation results from the application of electric field.
- In cathodoluminescent process, excitation occurs due to the bombardment with beam of electrons.
- In photoluminescent processes, excitation occurs from the absorption of photons.
- In injection luminescent processes, excitation occurs by electron-hole recombination by crossing the pn junction diode.

4. Name the different types of display devices. Different types of display devices are

- Plasma devices
- Numeric display devices
- LED
- LCD
- Lasers

5.What are plasma devices?

Plasma devices are display devices in which, emission of light takes place when an electric current is passed through a gas. Free electrons are present in the gas. When an electric current is passed these free electrons acquire high kinetic energy and collide with the atoms in gas. This lead to energy level greater than the ground level. After that, it will again loose energy and reaches in the ground state by emitting light.

6.Discuss briefly about LCD.

This is one of the most common passive display device. LCD consumes least power compared to all other display devices. There are two types of LCDs namely, reflective LCD and transmissive LCD. Reflective LCD requires front end illumination and transmissive LCD requires rear end illumination.

7. What are the two types of LCD and compare both?

The two types of LCDs are reflective LCD and transmissive LCD. Comparisons between the two are,

lective LCD	nsmissive LCD
It requires front end illumination	It requires rear end illumination

8.What do you meant by nematic ordering and cholesteric ordering?

In nematic ordering, the molecules are aligned parallel to each other. The molecules are free to move each other with the properties of liquid. It consists of two benzene rings linked with a central group. Eg: 4-methoxybenzylidine-4-butylanaline.

In cholesteric ordering, materials are made up of large number of planes having nematic structure. In this type, the ordering changes from one below the other. Distance between planes of same orientation is referred to as pitch.

9. Mention some important LED materials.

- Gallium Arsenide(GaAs)
- Gallium Phosphide(GaP)
- Gallium Arsenide Phosphide($GaAs_{1-x}P_x$)
- Gallium Aluminum Arsenide($Ga_xAl_{1-x}As$)

10.What are the two common electroluminescent devices?

- A.c. powder display
- D.c power display

11.What are numeric display devices?

This is also a type of optical display device. Numerical displays are used for conveying more information compared to other display devices. It is a simplest display format used to form the numbers from 0 to 9. It consists of seven bar segments. Each bar consists of several discrete display elements depending on size. More complex characters can be obtained using 7 x 5 matrix. This type consists of 7 rows and 5 columns. In LED, if we are using numerical display of this type, these 35 elements will be grown to a single substrate. Here each bars consists of 35 discrete elements. All the characters are less than 5mm.

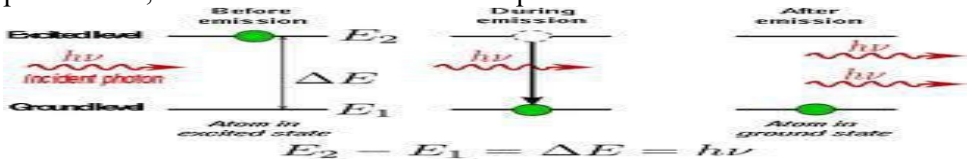
12. What do you meant by laser?

A laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on the stimulated emission of photons. The term "laser" originated as an acronym for Light Amplification by Stimulated Emission of Radiation. The emitted laser light is notable for its high degree of spatial and temporal coherence, unattainable using other technologies.

13.What do you meant by spontaneous emission and stimulated emission?

In spontaneous emission process, electron drops to the lower level in an entirely random way and stimulated emission process in which electron is triggered to undergo the transition in presence of photons of energy E_2-E_1. Under normal conditions we will see only spontaneous emission.

Stimulated emission is the process by which an atomic electron (or an excited molecular state) interacting with an electromagnetic wave of a certain frequency may drop to a lower energy level, transferring its energy to that field. A photon created in this manner has the same phase, frequency, polarization, and direction of travel as the photons of the incident wave.



14.What is meant by population inversion and how it is achieved in laser medium?

Population inversion occurs when a system such as a group of atoms or molecules exists in state with more members in an excited state than in lower energy states. The concept is of fundamental importance in laser science because the production of a population inversion is a necessary step in the workings of a standard laser.

15.What is meant by optical pumping in lasers?

Optical pumping is a process in which light is used to raise (or "pump") electrons from a lower energy level in an atom or molecule to a higher one. It is commonly used in laser construction, to pump the active laser medium so as to achieve population inversion.

16.Discuss about the threshold conditions in laser.

The major threshold conditions in laser are,

- A steady state level of oscillation should be reached when rate of amplification is balanced by rate of loss in continuous laser.
- Population inversion is a necessary condition in pulse laser.
- The gain coefficient must be large enough to overcome losses and oscillations.

17.What are major causes of losses in laser?

- Transmission at the mirrors
- Absorption and scattering at the mirrors
- Absorption in the laser medium

- Scattering at laser medium
- Diffraction losses at the mirrors

18.What do you meant by mode locking?

Mode locking is a technique for producing periodic, high power, short duration laser pulses. Normally laser cavity supports many modes simultaneously. In such lasers output depends on phases, frequencies, and amplitude of the nodes.

19.Mention the different classes of laser.

The different classes of laser are,

- Doped insulator laser
- Semiconductor lasers
- Gas lasers
- Dye lasers

20.State Heisenberg's uncertainty principle

In quantum mechanics, the Heisenberg uncertainty principle states a fundamental limit on the accuracy with which certain pairs of physical properties of a particle, such as position and momentum, can be simultaneously known. The uncertainty principle was a monumental discovery in the early development of quantum theory. It implies that it is impossible to simultaneously measure the present position while also determining the future motion of a particle or of any system small enough to require quantum mechanical treatment.

21.What is LED?

LED is the light emitting diode &consists of a forward biased p-n junction the recombination of electrons from conduction band with the hole in the valence band,produces emission of light .the energy difference b/w the conduction electron
&bound electron in the valence band is quantum as the energy of the light photon.

22.What is a cryotron? { MAY-13]

Cryotron is a switching element made from two different superconductors arranged in a manner that one superconductor in the form of a straight wire is enclosed by another superconducting coiland is based on the disappearance of superconducting state in a superconductor

23.What are liquid crystals?{ MAY-12]

Liquid crystals are the intermediate phases of the crystal they have both fluid
&crystalline properties. During the application of electricfield , there is a change in the orientation of liquid crystal molecules.

24.What are the advantages of liquid crystal display?[MAY-13}

- It is very cheap.
- It irequires very small power. For 1cm^2 display area if requires 1micro wave It is very thin
- It can be viewed under avide range of lighting conditions

25.What is meant by intrinsic absorption?

Intrinsic absorption means the IRabsorption and ultraviolet absorption by fiber material(SIO2). IR asorption is due to Si-O coupling .uv absorption is due to electronic absorption bands.

26.What is meant by electro-absorption?

Absorption of photons whose energy is less then the bandgap energy of a semiconductor by mens of applied electric field.

27.What are high TC superconducttors? { DEC-12]

High tc superconductors are the superconductors which have higher superconducting transituion temperature (>80k) their properties cannot be explained by BCS theory.

28.What are the laser light properties ?

1. higher monochromacity 2.high intensity ,3.high coherence,4.high directionality. The above properties are obtained by stimulated emission.

29.What is meant by laser action?

Laser action means the amplification of light by stimulated emission of radiation .to get laser action there should be population inversion and stimulated emission should take place.

30.What is meant by threshold condition for laser oscillation?

There should be a minimum amount of population inversion from which laser oscillation starts. This is called threshold condition for laser oscillations there to start the laser oscillation

31.What are the drawbecks of homojunction laser diodes?

Threshold current is very large.

The output beam has large

divergence Coherence and stability are poor Optical confinement is very poor

32.Define internal quantum efficiency of a laser or LED?

η= Radiative recombination rate per unit volume

sum of radiative recombination rate and non radiative recombination rate per unit volume

33.What are the factors that decrease the life time of laser diode?

2. increase of temperature,2.aging,3. High current density.

34.How does the LED Work?

Due to higher population of injected minority carrier there is enormous radiative recombination when there is forward bias across the active layer of LED.

35.What is Photoluminescence [NOV/DEC 2016]

In Photoluminescence energy is transferred to the crystal by the absorption of a photon**.**

36.What are the different Luminescence Process

Luminescence is the general term used to describe the emission of radiation from a solidwhen it is supplied with some form of energy. We may distinguish between the various types of luminescence by the method of excitation. For example:

Photoluminescence: excitation arises from the absorption of photons

Cathode luminescence: excitation is by bombardment with a beam of electrons

*Electroluminescence:*excitation results from the application of an electric field (which may be either a.c. or d.c.)

37.Differentiate between characteristic and non characteristic energy level system in phosphors

Some of the more commonly used phosphors are zinc sulphide doped with silver: ZnS:Ag (blue); zinc cadmium sulphide doped with copper:$Zn_xCd_{1\_x}S$:Cu (green); and yttrium oxysulfide doped with europium and terbium:Y_2O_2S:Eu,Tb (red).The first two materials are non characteristics materials and latter is characteristic materials.

38.What is meant by Injection Luminescence

The basic structure giving rise to injection luminescence is that of a p-n junction diode operated under forward bias which. Under forward bias majority carriers from both sides of the junction cross the depletion layer and enter the material at the other side, where they are then the minority type of carrier and cause the local minority carrier population to be larger than normal. This situation is described as *minority carrier injection.* The excess minority carriers diffuse away from the junction recombining with majority carriers.

39.What is meant by stokes shift? [NOV/DEC2013]

- **Stokes shift** is the difference between positions of the band maxima of the absorption and emission spectra (fluorescence and Raman being two examples) of the same electronic transition. It is named after Irish physicist George G. Stokes.
- When a system (be it a molecule or atom) absorbs a photon, it gains energy and enters an excited state. One way for the system to relax is to emit a photon, thus losing its energy (another method would be the loss of energy as heat). When the emitted photon has less energy than the absorbed photon, this energy difference is the Stokes shift.
- The Stokes shift is the result of two actions: Vibrational relaxation or dissipation and solvent reorganisation. A fluorophore is a dipole, surrounded by water molecules. When a fluorophore enters an excited state, its dipole moment will change, but water molecules will not be able to adapt this quickly. Only after vibrational relaxation, there will be a realignment of their dipole moments.

40.What do you understand by threshold condition in laser

It was explained above that a steady state level of oscillation is reached when the rate of amplification is balanced by the rate of loss. This is the situation in continuous output (CW)lasers; it is a little

different in pulse lasers. Thus, while a population inversion is a necessary condition for laser action. it is not a sufficient one because the minimum (i.e. threshold value) of the gain coefficient must be large enough to overcome the losses and sustain oscillations. The threshold gain.

41.What is meant by threshold condition for laser oscillations?

There should be a minimum amount of population inversion from which laser oscillation starts. This is called threshold condition for laser oscillations. Therefore to start the laser oscillation the gain coefficient should exceed the threshold value.

42.What are the type of lasers

- Doped insulator lasers
- Semi conductor lasers
- Gas lasers
- Liquid dye lasers

PART-B

1. Explain the construction and operation of CRT screen. Also explain the principal of obtaining colour display in CRT with relevant diagram

- Schematic diagram
- Cross section of CRT Tube
- Explanation

2. Explain the mechanism of electro luminescence with neat diagram and also explain about operation of ac electroluminescence device. NOV/DEC 2013 NOV/DEC2016

- Construction of a a.c electro luminescence device
- Construction of a d.c electro luminescence device
- Equation
- Graph

3. Explain the operation of LED and also derive an expression for the frequency response and modulation bandwidth of an LED [APR/MAY 2017]

- LED construction
- Diagram
- Frequency Response of LED
- Modulation circuits
- Equation

4. Explain the construction and operation of LCD [MAY/JUNE 2013]

- LCD construction
- Diagram
- Behavior of molecules in a liquid
- Explanation

5. Discuss the theory of population inversion and threshold condition in two layer laser system and also explain the various transition involved in a four level system Population inversion [MAY/JUNE 2013] [NOV DEC 2016] [APR/MAY 2017]

- Attainment of a population inversion
- Four level system
- Diagram
- Layer explanation

6. Describe the concept of producing high power short duration pulses from laser.What are the various methods to accomplish this? Explain them [NOV/DEC 2013]

- Mode locking of laser
- Non mode locked laser
- Mode locked laser
- Active Mode Locking
- Derivation

UNIT – III

OPTICAL DETECTION DEVICES

PART A

1. What is a photodiode?

A photodiode is a reverse biased diode which absorbs light &converts it into charge carriers or electric current.

2. What are the properties of photodiodes? { MAY-12]

Every photodiode should have low dark current , wide wavelength response &high quantum efficiency .it should have low rise time &fast response.

3. What is meant by binary digital modulation?

The analog signal is sampled and binary coded in the form of "ones"and "zeros.

4. State franz –keldysh effect.

Franz –keldysh effect refers to the absorption of photons having energies less than the bandgap of the semiconductor by means of applying a strong electric field.

5. State stark effect.

Stark effect refers to the energy shift and corresponding electron tunneling by absorption of photons whose energy is less then the band gap of the semiconductor by means of applying a strong electric field.

6. What are the different factors that determine the response time of photodetector? { MAY-12]

(i)transit time of charge carriers
(ii)diffusion time of charge carriers
(iii) time constant RC of the photo detector circuit.

7. What are the condition for total internal reflection.

(i) Light should travel from denser medium to rarer medium.
(ii) the angle of incidence should be greater then the critical angle of the denser medium.

8. Define V-number of fiber.

V-number of fiber indicates the number of possible propagation modes in the core

$$V=2\pi/\lambda a(N.A)$$

Number of propagating modes through the step index fiber $N=V^2/2$

9.What are the different noises present in the avalanche photodiode? { MAY-12]

(i)quantum noise ,(ii)dark current noise (iii)thermal noise and (iv)avalanche multiplication.

10.What are the required properties of photo detector?

(i)high quantum efficiency.
(ii) low rise time or fast response
(iii)low dark current.

11. Explain thermal detectors.

Thermal detectors are devices that work by absorbing the incident photon. It consists of a sensing element and an heat sink connected to it. The sensing element will absorb the photon, which results in production of heat. This heat produced will increases the temperature of heat sink connected to it.

12. What is the internal quantum efficiency of photodetector?

efficiency is also known as responsivity. It is defined as the ratio of the number of photo generated carriers to incident photons and thus a unit less quantity.

η= Number of corresponding electrons in the external circuit/ Number of incident photons

13. Explain photoconductors.

It is the simplest optical detector. It exhibits an internal gain mechanism. It also clearly demonstrates the gain-bandwidth limitations. Its operation is based on the

increase in conductivity of specific region with photon excitation. The generated electrons and holes arecollected at opposite end and results in photocurrent.

14. What do you mean by Kerr effect?

Magneto-optic Kerr effect (MOKE) is one of the magneto-optic effects. It describes the changes of light reflected from magnetized media. The light that is reflected from a magnetized surface can change in both polarization and reflected intensity. The effect is identical to the Faraday effect except that the magneto-optical Kerr effect is a measurement of the reflected light, while the Faraday effect is a measurement of the transmitted light.

15. What are the different types of photodetectors?

The different types of photodetectors are,

- ✓ Photoconductors
- ✓ Pin diodes
- ✓ Avalanche photodiode
- ✓ Intrinsic photodetectors
- ✓ Extrinsic photodetectors

16. What are the factors that limit the response time of photodiodes? NOV/DEC2016

The factors that limit the response time of photodiodes are,

- Diffusion time of carriers to the depletion region
- Drift time of carriers to the depletion region
- Junction capacitance effects

17. Define noise equivalent power.

It is defined as the power of sinusoidally modulated chromatic radiation, which would result in the same root mean square output signal in an ideal noise free detector as the noise signal encountered in the real detector. If we assume that noise power generated in a detector is proportional to its sensitive area A, then the noise current will vary as A1/2. Here we define a new unit NEP* and it can be written as

$$NEP^* = NEP/(A\Delta f)^{1/2}$$

The reciprocal of this is known as specific detectivity D* and it is written as

$$D^* = (A\Delta f)^{1/2}/NEP$$

18. Discuss briefly about pin photodiode.

A PIN diode is a diode with a wide, lightly doped 'near' intrinsic semiconuctor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.

19. Define Pockels effect.

The Pockels effect or Pockels electro-optic effect, produces birefringence in an optical medium induced by a constant or varying electric field. It is distinguished from the Kerr effect by the fact that the birefringence is proportional to the electric field, whereas in the Kerr effect it is quadratic in the field. The Pockels effect occurs only in crystals that lack inversion symmetry, such as lithium or gallium arsenide and in other concentrate symmetric media such as electric-field poled polymers or glasses.

20. What is the working principle of thermal detectors?

Thermal detectors are devices that work by absorbing the incident photon. It consists of a sensing element and an heat sink connected to it. The sensing element will absorb the photon, which results in production of heat. This heat produced will increases the temperature of heat sink connected to it.

21.Explain thermal detectors.

Thermal detectors are devices that work by absorbing the incident photon. It consists of a

sensing element and an heat sink connected to it. The sensing element will absorb the photon, which results in production of heat. This heat produced will increases the temperature of heat sink connected to it.

22.What is the internal quantum efficiency of photodetector?

Quantum efficiency is also known as responsivity. It is defined as the ratio of the number of photo generated carriers to incident photons and thus a unit less quantity.

η=Number of corresponding electrons in the external circuit Number of incident photons

23.Explain photoconductors.

It is the simplest optical detector. It exhibits an internal gain mechanism. It also clearly demonstrates the gain-bandwidth limitations. Its operation is based on the increase in conductivity of specific region with photon excitation. The generated electrons and holes are collected at opposite end and results in photocurrent.

24.What do you mean by Kerr effect?

Magneto-optic Kerr effect (MOKE) is one of the magneto-optic effects. It describes the changes of light reflected from magnetized media. The light that is reflected from a magnetized surface can change in both polarization and reflected intensity. The effect is identical to the Faraday effect except that the magneto-optical Kerr effect is a measurement of the reflected light, while the Faraday effect is a measurement of the transmitted light.

25.Name the different types of thermal detectors? The different types of thermal detectors are,

- Thermoelectric detectors
- Bolometer
- Pneumatic detectors
- Pyroelectric detectors

26.Define photodetectors.

Photodetector is an optoelectronic device that absorbs optical energy and converts it into electrical energy that produces photocurrent. Photodetectors are used to detect optical signal ranging over a very wide range of optical spectrum.

27.What are the different types of photodetectors?

The different types of photodetectors are,

- Photoconductors
- Pin diodes
- Avalanche photodiode
- Intrinsic photodetectors
- Extrinsic photodetectors

28.What are the two types of photoconductors?

The two types of photoconductors are a.c. photoconductors and d.c. photoconductors.

29.What are the factors that limit the response time of photodiodes?

The factors that limit the response time of photodiodes are,

- Diffusion time of carriers to the depletion region
- Drift time of carriers to the depletion region
- Junction capacitance effects

30.Define responsivity.

Responsivity is also known as Quantum efficiency. Responsivity is defined as the ratio of the number of photo generated carriers to incident photons and thus a unit less quantity.

Responsivity =Number of corresponding electrons in the external circuit

Number of incident photons

31.Define noise equivalent power.

It is defined as the power of sinusoidally modulated chromatic radiation, which would result in the same root mean square output signal in an ideal noise free detector as the noise signal encountered in the real detector. If we assume that noise power generated in a detector is proportional to its sensitive area A, then the noise current will vary as $A^{1/2}$. Here we define a new unit NEP* and it can be written as

$$NEP^* = NEP/(A\Delta f)^{1/2}$$

The reciprocal of this is known as specific detectivity D* and it is written as

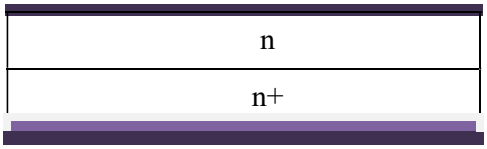
$$D^* = (A\Delta f)^{1/2}/NEP$$

32.Discuss briefly about pin photodiode.

A PIN diode is a diode with a wide, lightly doped 'near' intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.

33.How Schottky photodiodes are made?

In Schottky photodiode, a thin metal coating is applied to an n-type silicon substrate. When an electron-hole pair is generated within the depletion region, the electron and hole will be separated by the action of internal field.



34.Define Pockels effect.

The Pockels effect or Pockels electro-optic effect, produces birefringence in an optical medium induced by a constant or varying electric field. It is distinguished from the Kerr effect by the fact that the birefringence is proportional to the electric field, whereas in the Kerr effect it is quadratic in the field. The Pockels effect occurs only in crystals that lack inversion symmetry, such as lithium niobate or gallium arsenide and in other noncentro- symmetric media such as electric-field poled polymers or glasses.

35.What is a bolometer?

Bolometer is a thermal detector. The structure of bolometer is similar to wheatstone bridge. In this, a sensing element is placed instead of one of the resistor. This sensing element will absorb the incident radiation.

36.**What is the working principle of thermal detectors?**

Thermal detectors are devices that work by absorbing the incident photon. It consists of a sensing element and an heat sink connected to it. The sensing element will absorb the photon, which results in production of heat. This heat produced will increases the temperature of heat sink connected to it.

37.**What do you meant by a photodiode?**

A photodiode is a type of photodetector capable of converting light into either current or voltage, depending upon the mode of operation. The common, traditional solar cell used to generate electric solar power is a large area photodiode. Photodiodes are similar to regular semiconductor diodes except that they may be either exposed or packaged with a window or optical fiber connection to allow light to reach the sensitive part of the device.

38.Define signal to noise ratio in photoconductors.

It is defined as the ration of conductivity of thermal noise to conductivity of dark current.

SNR = $(\text{conductivity})_{light}/(\text{conductivity})_{dark}$

39.How is a photodiode designed and why it is designed so?

A photodiode is designed to operate in reverse bias condition. If an electron-hole pair is generated by photon absorption in this junction, the internal field will cause electron and hole to seprate.

40.What are the various processing steps taking place inside a photodetector? There are three steps involved in photodetector process and they are,

- Absorption of optical energy and generation of carriers
- Transportation of photo generated carrier with or without gain

Carrier collection and generation of photocurrent that flows through external circuit

PART - B

1. **Explain in detail the principle, construction, working and of a thermal detector and a photo conductive detector. [May/June-2013] NOV/DEC 2016**
   - Principle,
   - Construction,
   - Working
   - Diagram
   - Equation

2. Explain the principle, construction and working of pyro-electric detector. NOV/DEC2016
   - Principle,
   - Construction,
   - Working
   - Diagram
   - Equivalent circuit

3. Explain the principle and operation of photo transistors
   - Principle,
   - Construction,
   - Working
   - Diagram
   - Equation
   - Structure of Photo transistor

4. with an equivalent circuit, explain the factors affecting the bandwidth of a PIN photodiode. [May/June-2013] APR/MAY 2017
   - Principle
   - Equivalent circuit
   - Structure
   - Equation
   - Graph

5. Brief about the various noise sources in a photo multiplier tube.[May/June- 2013]
   - Definition
   - Construction
   - Structures of four common types of photomultiplier
   - Equation
   - Dynode biasing circuit

6. Explain in Silicon Photo diode and its Characteristics.
   - Definition

- Construction
- Diagram
- Characteristics

UNIT – IV
OPTOELECTRONIC MODULATOR
Part-A

1. Compare Analog Modulation Digital Modulation NOV/DEC 2016

S.No	Analog Modulation	Digital Modulation
1	Both message and carrier waves are continuous.	Message signal will be in continuous form and carrier will be digital
2	Requires higher SNR	Requires low SNR
3	Good for only low frequency and low bandwidth signals.	Good for high frequency and high bandwidth signals
4	High current levels are needed for modulating higher bandwidth signals	Lower current levels is needed for modulating higher bandwidth signals

2. Define electro-optic modulators and electro-optic effect.

Electro-optic modulators is an optical device in which a signal controlling element displays electro-optic effect to modulate a beam of light. The modulation can be done by changing phase, frequency, amplitude, or polarization of the modulated beam. Electro-optic effect refers to change in refractive index of the material resulting from application of a d.c. or low frequency electric field.

3. Define the term birefringence.

Birefringence refers, for a linearly polarized wave that is propagating in z-direction, itspolarization vector will depend on the direction of electric field. Due to this effect, the amplification of electric field in one direction will not be same in opposite direction.

4. What are magneto-optic devices? APR/MAY 2017

These are devices which work under magneto-optic effect. A magneto-optic effect is aphenomena in which an electromagnetic wave propagates through a medium that has been altered by the presence of a quasistatic magnetic field. In such a material, which is also called gyrotropic or gyromagnetic, left- and right-rotating elliptical polarizations can propagate at different speeds, leading to a number of important phenomena

5 . What are acoustoptic devices?

Acoustoptic devices are devices which work under acoustoptic effect. Acoustoptic effect refers to there will be a change in material permittivity ‘e’ due to mechanical strain ‘a’.

6. What do you mean by SEED?

This is a device exhibiting nonlinear absorption or reflection of an optical signal, photonic switching, bistability, and optically induced oscillations. It is a combination of a detector self biasing a n electro-absorption modulator. The working is based upon multiple quantum well (MQW)-III V technology.

7. What are acoustoptic modulators?

These devices will vary the acoustic wave properties such as amplitude, phase, frequency, or polarization to modulate acoustic wave. These properties can be varied by making the optical wave travelled through acoustic field.

8. What are the limitations of acoustoptic modulators?

The limitations of acoustoptic modulators are,

- The design is complex and should be carefully designed
- Switching speed is limited
- Light cannot be fully switched ON and OFF

9. Define acoustoptic filter.

The principle of operation of acoustoptic filter is based upon the wavelength of diffracted light. Wavelength depends on frequency. By tuning the frequency of acoustic wave, desired wavelength of optical wave can be diffracted.

10. Give the merits of PCM?

The non –linearities of the light source do not affect the quality of the transmitted signal.

Even though the transmitted signals are highly degraded or attenuated, the original analog signals may be obtained without any error. this is free from noise and temperature effects.

11. What are the types of microelectrodes?

- Metallic microelectrode
- Nonmetallic or micropipet.

12. What is the necessity of cladding for an optical fiber?

- ✓ To provide proper light guidance inside the core To avoid leakage of light from the fiber
- ✓ To give mechanical strength for the fiber.

13. Define relative refractive index difference .

$$\Delta = n1^2 - n2^2/2n1^2 = n1 - n2/n1$$

Thus the relative refractive index difference is the ratio between the refractive index difference.

14.What are skew rays? { MAY-13]

Skew rays are the rays following the helical path around the fiber axis when they travel through the fiber and they would not cross the fiber axis at any time.

15.What are meridional rays? { DEC-12]

Meridional rays are the rays following ZIG-Zag path when they travel through fiber and for every reflection it will cross the fiber axis.

16.What are microbending losses?

These occur due to bends in the fiber axis these microbending losses occur during cabling and stresses acting on the fiber.these produce mode coupling losses also.

17.Define cutoff wavelength of the fiber.

The cut off wavelength is defined as the minimum value of wavelength that can be transmitted through the fiber .the wavelengths greater than the cutoff wavelength can be transmitted.

$$\Lambda cutoff = 2\pi a(N.A)/V$$

18.What is material dispersion?

Material dispersion arises due to variation of refractive index of core with respect to wavelength of light this occur when $d^2 n1/d\lambda^2 \neq 0$

19.What is wave guide dispersion? { MAY-13]

Wave guide dispersion is due to finite frequency bandwidth and the dependence of mode group velocity on the frequency of light.

20. Why do we have smaller dispersion in graded index fibers?

Due to shaping the refractive index profile in the parabolic manner and by self focusing effect, the dispersion is small.

21.What is dark current noise? { NOV/DEC-13]

Dark current noise is due to the flow of current through the bias circuit even though there is no incident light.

22.Mention the advantages of high bandwidth.

The main advantages of using high bandwidth is we can able to modulate higher frequency signals with low SNR. Also, current needed is very low.

23.Name the different types of electro-optic modulators.

The different types of modulators are,

- Electro-optic amplitude modulation
- Quantum well modulators
- BRAQWET modulators

24.What are the drawbacks of analog modulation?

- requires high SNR
- for large bandwidth, higher amount of current is needed
- suitable only for low frequency signal modulation

25.Define electro-optic modulators.

Electro-optic modulators is an optical device in which a signal controlling element displays electro-optic effect to modulate a beam of light. The modulation can be done by changing phase, frequency, amplitude, or polarization of the modulated beam.

26.Define the term electro-optic effect.

Electro-optic effect refers to change in refractive index of the material resulting from application of a d.c. or low frequency electric field.

27.Define the term birefringence.

Birefringence refers, for a linearly polarized wave that is propagating in z-direction, its polarization vector will depend on the direction of electric field. Due to this effect, the amplification of electric field in one direction will not be same in opposite direction.

28.What are mageneto-optic devices?

These are devices which work under magneto-optic effect. A magneto-optic effect is a phenomena in which an electromagnetic wave propagates through a medium that has been altered by the presence of a quasistatic magnetic field. In such a material, which is also called gyrotropic or gyromagnetic, left- and right-rotating elliptical polarizations can propagate at different speeds, leading to a number of important phenomena

29.What are acoustoptic devices?

Acoustoptic devices are devices which work under acoustoptic effect. Acoustoptic effect refers to there will be a change in material permittivity ‘ε’ due to mechanical strain ‘α’.

30.What do you mean by SEED?

This is a device exhibiting nonlinear absorption or reflection of an optical signal, photonic switching, bistability, and optically induced oscillations. It is a combination of a detector self biasing a n electro-absorption modulator. The working is based upon multiple quantum well (MQW)-III V technology.

31.What are the different types of SEED?

The different types of SEED are,

- R-SEED or Resistor Loaded SEED Function

- D- SEED
- S- SEED
- L-SEED

32.Why we go for bipolar controller modulator?

In SEED, the path and effects of the signal and control beam are same. So, it is difficult to distinguish between the two. Also it does not have any gain. To achieve larger tolerance gain is very sufficient. So we go for bipolar controller modulator.

33.What are the advantages of bipolar controller modulator?

- High gain
- Large uniform electric field

34.Mention the categories of acoustoptic devices.

The categories of acoustoptic devices are

- Acoustoptic modulator
- Acoustoptic filter
- Acoustoptic defelctors

35.What are acoustoptic modulators?

These devices will vary the acoustic wave properties such as amplitude, phase, frequency, or polarization to modulate acoustic wave. These properties can be varied by making the optical wave travelled through acoustic field.

36.What are the limitations of acoustoptic modulators? The limitations of acoustoptic modulators are,

- The design is complex and should be carefully designed
- Switching speed is limited
- Light cannot be fully switched ON and OFF

37.Define acoustoptic filter.

The principle of operation of acoustoptic filter is based upon the wavelength of diffracted light. Wavelength depends on frequency. By tuning the frequency of acoustic wave, desired wavelength of optical wave can be diffracted.

38.Mention the types of acoustoptic filter.

The types of acoustoptic filter are,

- Collinear filters
- Noncollinear filters

39.Define collinear filter and non-collinear filter.

Collinear filters does not need to be polarized for modulating the optical wave. Non-collinear filters has to be polarized for modulating.

40.What are acoustoptic deflectors?

Acoustoptic deflectors spatially controls the optical beam. In the operation, power of the transducer is kept at a constant level, while the acoustic wave frequency is varied to deflect the optical beam in different angular positions.

PART –B

1. Explain the concept of external modulation and compare with direct modulation.

- Tabulation
- Explanation
- Diagram.

2. Briefly explain about the Analog and Digital Modulation.

- Explanation
- Diagram.
- Types

- Waveform

3.i) Explain the concept of birefringence in Uniaxial crystal with necessary diagrams. [May/June-2013]

- Diagram
- Construction
- Explanation

4.Explain with neat diagram, the construction of electro optic effect based External modulator. Also deduce the expression of modulated light.

[Nov/Dec - 2015]

- Diagram
- Construction
- Derivation

UNIT V

OPTOELECTRONIC INTEGRATED CIRCUITS

PART A

1. What are the other sources to produce dispersion?

The spectral spread of the light source and improper shaping of refractive index profile create dispersion in the fibers.

2. What is meant by Isolation? { MAY-13]

(i) Improper grounding of the system is one of the most common (ii) measurement problems and noise. Signal conditioners with (iii)prevent these problems. Such devices pass the signal from (iv)measurement device without a physical or galvanic connection (v)transformer,optical of capacitive coupling techniques.

3.What is meant by electrooptic effect? { DEC-13]

Electrooptic effect refers to the change of refractive index of the medium by the applied electric field and hence modulation of light is obtained.

4.What is pockels effect? { DEC/NOV-12]

The change in refractive index of the medium is directly proportional to the applied field strength.

5. What are the different component of an optical transmitter?

1.encoder or signal snaping circuit 2.modulator or driver circuit,3.optical source

6. What are the different component of an optical receiver?

1.optical detector 2.pre- amplifier,3.variable gain voltage amplifier4.fixed gain amplifier 5.decoder or demodulator.

7.Distinguish between analog storage and digital storage.

In analog storage the signal recorded is a representation of the original signal in digital storage ,the signal is sampled and each sample is converted into a number through A/Dconverter .these binary numbers are written or recorded.

8.Define optical switching.

Optical switching refers tonthe phenomenon in which transmission of an optical field through a device is switched among two or more possible states by optical means

9. What are optoelectronic integrated circuits?

Optoelectronic integrated circuits refers to the integration of electric and optical components and optical interconnection. Optoelectronic devices makes electrons and photons to perform single function. These devices are capable of converting optical to electric form and vice versa.

10. What are active guided wave devices and give examples?

Active guided wave devices refers to the active components present in the guided wave. These devices can be integrated with OEIC with active optoelectronic devices.

11. Mention the applications of optoelectronic integrated circuits

It is applicable in the field of telecommunication and radar applications.

12. List out the advantages of optoelectronic integrated circuits. NOV/DEC2016

- ✓ Low cost
- ✓ Large scale integration
- ✓ Photonic devices and circuits can serve unique functions
- ✓ New functional capabilities can be emerge by integrating electronic and photonic devices and circuit

13. What are the disadvantages of hybrid integration?

- ✓ Design is complex
- ✓ Damage in any of the device will affect the entire working.

14. Distinguish between hybrid and monolithic integration.

Hybrid Integration	**Monolithic Integration**
1. As the name suggests discrete devices c separate functional block or chips are connected using	1. In monolithic integration all active and passive components are
electronic or optical interconnections	fabricated on the same chip.
2. No planarity	2. Planarity is high
3. Complex design	3. Less complex

15. Define waveguide.

A waveguide is a dielectric region through which light is propagated. These regions were also surrounded by dielectric regions or air having smaller dielectric medium.

16. Mention the types of waveguides. The different types of waveguide are,

- ✓ Ridge waveguide
- ✓ Buried channel waveguide
- ✓ Strip-loaded waveguide

17. Explain briefly about directional coupler.

This is simplest coupler formed by the integration of optical circuit. This is useful in transferring energy from one waveguide to another. It consists of 2 parallel waveguides. Transfer of optical energy takes place between these 2 waveguides.

18. What is the objective of OEIC?

The objective of OEICs is to bring fiber systems to home and individual subscribers in the form of telephone links and broadcast cable TV. In order to extend optoelectronic technologies to subscriber, the systems need the development of lasers with precise frequency control and tenability and wavelength-selective detectors and receivers. Data transmission rates of several tens of gigabits/sec will be attained by these circuits and systems.

19. List out Application of Electronic Integrated Circuits.

- ➢ Telecommunication
- ➢ Local Area network
- ➢ Radar

20. Mention the types of integrated receivers

- Front- end photo receivers
- MODFET

21. What are the disadvantages of hybrid integration?

- Design is complex
- Damage in any of the device will affect the entire working

22.How guided waves can be formed?

Guided wave devices are used for routing optical signal on a chip and also for make it perform the functions of directional coupling, filtering, and modulation. Simplest method for forming guided waves is by introducing free carriers in the semiconductor material. This will reduce the refractive index of the material.

23.What are optoelectronic integrated circuits?

Optoelectronic integrated circuits refers to the integration of electric and optical components and optical interconnection. Optoelectronic devices makes electrons and photons to perform single function. These devices are capable of converting optical to electric form and vice versa.

24.What are active guided wave devices and give examples?

Active guided wave devices refers to the active components present in the guided wave. These devices can be integrated with OEIC with active optoelectronic devices.

25.**Mention the applications of optoelectronic integrated circuits**

It is applicable in the field of telecommunication and radar applications.

26.**Mention the types of integrated transmitters.**Optoelectronic integrated transmitters can use either laser or LED as transmitting devices.

27.Mention the types of integrated receivers.

- Front-end photoreceivers
- MODFET

28.**Distinguish between hybrid and monolithic integration.**

Hybrid Integration	Monolithic Integration
As the name suggests discrete devices separate functional block or chips are connected electronic or optical interconnections No planarity Complex design	In monolithic integration all active and components are fabricated on the same chip. Planarity is high Less complex

29.**List out the advantages of optoelectronic integrated circuits.**

- Low cost
- Large scale integration
- Photonic devices and circuits can serve unique functions
- New functional capabilities can be emerge by integrating electronic and photonic devices and circuits

30.Define waveguide.

A waveguide is a dielectric region through which light is propagated. These regions were also surrounded by dielectric regions or air having smaller dielectric medium.

31.Mention the types of waveguides.

The different types of waveguide are,

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- ✓ Buried channel waveguide
- ✓ Strip-loaded waveguide

32.Explain briefly about directional coupler.

This is simplest coupler formed by the integration of optical circuit. This is useful in transferring energy from one waveguide to another. It consists of 2 parallel waveguides. Transfer of optical energy takes place between these 2 waveguides.

33.**What do you meant by front-end photoreceivers?**

The basic purpose of detector is to detect the incident light and convert it into an electrical signal containing the information on the light at transmitting end. The important performance characteristics of photoreceiver are operating bandwidth and sensitivity. Sensitivity plays a vital role in deciding the number of repeaters needed in a long haul communication system. The receiver sensitivity is defined as the minimum amount of optical power level needed at the receiver input so that the signal-to-noise ratio is greater than a given value.

34.What do you meant by MODFET?

MODFET refers to modulation doped field effect transistor. MODFET can be regrown with help of monolithic integration of $In_{0.53}Ga_{0.47}As$ photodiode with $In_{0.53}Ga_{0.47}As/In_{0.52}Al_{0.48}As$ modulation doped FET by regrowth on InP. The MODFET consists of a layer of undoped low-bandgap material forming a heterojunction with a highly doped high-bandgap material. Due to the electron affinities of the two layers, electrons are transferred from the high-bandgap material to low-bandgap material to form a two dimensional electron gas.

35.Write briefly about hybrid integration.

In this type of integration, as the name suggests discrete devices on separate functional block or chips are connected using electronic or optical interconnections. An example for this type of integration is junction laser with its driver circuit consisting of bipolar transistor to form a transmitter. Advantage of this type hybrid integration is the possibility of using high performance discrete devices as components. The disadvantages are lack of compactness and enhanced parasitic effects in terms of interconnects bonding and lead wires.

36.**Write briefly about monolithic integration.**

In monolithic integration all active and passive components are fabricated on the same chip. Unlike silicon ICs almost all parts are made with the same material and same processing steps. Monolithic integration can be achieved in either vertical or horizontal configuration. In the vertical scheme, electronic and optical structures are epitaxially grown sequentially with an isolation layer in between.

37.**What are the disadvantages of hybrid integration?**

- Design is complex
- Damage in any of the device will affect the entire working

38.**How can we achieve monolithic integration?**

Monolithic integration can be achieved using two schemes namely vertical scheme and horizontal scheme.

39.**What is the disadvantage of vertical monolithic integration?**

The disadvantage of vertical monolithic integration scheme is it lacks planarity.

40.**What is the objective of OEIC?**

The objective of OEICs is to bring fiber systems to home and individual subscribers in the form of telephone links and broadcast cable TV. In order to extend optoelectronic technologies to subscriber, the systems need the development of lasers with precise frequency control and tenability and wavelength-selective detectors and receivers. Data transmission rates of several tens of gigabits/sec will be attained by these circuits and systems.

41.**What is the advantages and disadvantages of horizontal scheme?**

Advantages	Disadvantages
It achieves planarity We can regrow the selective area	1. During the regrowing process, that place can have lar of traps and other electrically active defects that can performance of regrown area.

PART-B

1. i) Explain any two applications of OEIC in detail.
[May/June-2013] [NOV/DEC 2016]

- Definition
- Application
- Schematic block diagram of an optoelectronic phased array antenna system
- Theory

ii) Write a note on Monolithic and hybrid integration OEIC fabrication.
[May/June-2013]

- Definition
- Theory
- Schematic of Monolithic Integration
- Diagram- Fabrication

2. Draw the diagram of a PIN diode and HBT integrated front end photo receiver and explain its operation. [May/June-2013]

- Block diagram
- Equivalent circuit
- Equation
- Epitaxial hetero structure
- Eye diagram

3. Discuss the noise performance in integrated photo receivers. [May/June-2013]

- Definition
- Diagram
- Equivalent circuit
- Equation
- Frequency response

4. Describe the fabrication process of an opto electronic integrated transmitter circuit by molecular beam epitaxy regrowth. [May/June 2012]

- Circuit diagram
- Equation
- Equivalent circuit
- Waveform
- Equation

5. Explain the principles and operation of [Nov/Dec-2013] [NOV/DEC 2016]

i) Waveguide Coupler

ii) **Waveguide interferometer**

iii) Active directional coupler switch

- Definition
- Diagram
- Equation
- Operation