**BE (2015)Pattern**

**404190 Broadband Communication Systems**

**UNIT II Light wave Systems**

**5. Questions & Answers on Optical Sources : The Laser and Light – Emitting Diode**

The section contains questions on optical sources basics, semiconductor injection laser, injection laser structures and characteristics, non semiconductor lasers, tunable and infrared lasers, led power, led structures and characteristics.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Optical Sources : Laser Basics”.

1. A device which converts electrical energy in the form of a current into optical energy is called as \_\_\_\_\_\_\_\_\_\_\_ a) Optical source b) Optical coupler c) Optical isolator d) Circulator View Answer

Answer: a Explanation: An Optical source is an active component in an optical fiber communication system. It converts electrical energy into optical energy and allows the light output to be efficiently coupled into the Optical fiber.

2. How many types of sources of optical light are available? a) One b) Two c) Three d) Four View Answer

Answer: c Explanation: Three main types of optical light sources are available. These are wideband sources, monochromatic incoherent sources. Ideally the optical source should be linear.

3. The frequency of the absorbed or emitted radiation is related to difference in energy E between the higher energy state E2 and the lower energy state E1. State what h stands for in the given equation?

E = E2 - E1 = hf

a) Gravitation constant b) Planck’s constant c) Permittivity d) Attenuation constant View Answer

Answer: b Explanation: In the given equation, difference in the energy E is directly proportional to the absorbed frequency (f) where h is used as a constant and is called as Planck’s constant. The value of h is measured in Joules/sec & is given by- h = 6.626×10-34Js.

4. The radiation emission process (emission of a proton at frequency) can occur in \_\_\_\_\_\_\_\_\_\_ ways. a) Two b) Three c) Four d) One View Answer

Answer: a Explanation: The emission process can occur in two ways. First is by spontaneous emission in which the atom returns to the lower energy state in a random manner. Second is by stimulated emission where the energy of a photon is equal to the energy difference and it interacts with the atom in the upper state causing it to return to the lower state along with the creation of a new photon.

5. Which process gives the laser its special properties as an optical source? a) Dispersion b) Stimulated absorption c) Spontaneous emission d) Stimulated emission View Answer

Answer: d Explanation: In Stimulated emission, the photon produced is of the same energy to the one which cause it. Hence, the light associated with stimulated photon is in phase and has same polarization. Therefore, in contrast to spontaneous emission, coherent radiation is obtained. The coherent radiation phenomenon in laser provides amplification thereby making laser a better optical source than LED.

6. An incandescent lamp is operating at a temperature of 1000K at an operating frequency of 5.2×1014 Hz. Calculate the ratio of stimulated emission rate to spontaneous emission rate. a) 3×10-13 b) 1.47×10-11 c) 2×10-12 d) 1.5×10-13 View Answer

Answer: b Explanation: The ratio of the stimulated emission rate to the spontaneous emission rate is given

by- Stimulated emission rate/ Spontaneous emission rate = 1/exp (hf/KT)-1.

7. The lower energy level contains more atoms than upper level under the conditions of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Isothermal packaging b) Population inversion c) Thermal equilibrium d) Pumping View Answer

Answer: c Explanation: Under the conditions of thermal equilibrium, the lower energy level contains more atoms than the upper level. To achieve optical amplification, it is required to create a non-equilibrium distribution such that the population of upper energy level is more than the lower energy level. This process of excitation of atoms into the upper level is achieved by using an external energy source and is called as pumping.

8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in the laser occurs when photon colliding with an excited atom causes the stimulated emission of a second photon. a) Light amplification b) Attenuation c) Dispersion d) Population inversion View Answer

Answer: a Explanation: Laser emits coherent radiation of one or more discrete wavelength. Lasers produce coherent light through a process called stimulated emission. Light amplification is obtained through stimulated emission. Continuation of this process creates avalanche multiplication.

9. A ruby laser has a crystal of length 3 cm with a refractive index of 1.60, wavelength 0.43 μm. Determine the number of longitudinal modes. a) 1×102 b) 3×106 c) 2.9×105 d) 2.2×105 View Answer

Answer: d Explanation: The number of longitudinal modes is given by- q = 2nL/λ Where q = Number of longitudinal modes n = Refractive index

L = Length of the crystal λ = Peak emission wavelength.

10. A semiconductor laser crystal of length 5 cm, refractive index 1.8 is used as an optical source. Determine the frequency separation of the modes. a) 2.8 GHz b) 1.2 GHz c) 1.6 GHz d) 2 GHz View Answer

Answer: c Explanation: The modes of laser are separated by a frequency internal δf and this separation is given by- δf = c/2nL Where c = velocity of light n = Refractive index L = Length of the crystal.

11. Doppler broadening is a homogeneous broadening mechanism. a) True b) False View Answer

Answer: b Explanation: Doppler broadening is a inhomogeneous broadening mechanism. In this broadening, the individual groups of atoms have different apparent resonance frequencies. Atomic collisions usually provide homogeneous broadening as each atom in collection has same resonant frequency and spectral spread.

12. An injection laser has active cavity losses of 25 cm-1 and the reflectivity of each laser facet is 30%. Determine the laser gain coefficient for the cavity it has a length of 500μm. a) 46 cm-1 b) 51 cm-1 c) 50 cm-1 d) 49.07 cm-1 View Answer

Answer: d Explanation: The laser gain coefficient is equivalent to the threshold gain per unit length and is given by – gth = α + 1/L ln (1/r) Where α = active cavity loss

L = Length of the cavity r = reflectivity.

13. Longitudinal modes contribute only a single spot of light to the laser output. a) True b) False View Answer

Answer: a Explanation: Laser emission includes the longitudinal modes and transverse modes. Transverse modes give rise to a pattern of spots at the output. Longitudinal modes give only a spot of light to the output.

14. Considering the values given below, calculate the mode separation in terms of free space wavelength for a laser. (Frequency separation = 2GHz, Wavelength = 0.5 μm) a) 1.4×10-11 b) 1.6×10-12 c) 1×10-12 d) 6×10-11 View Answer

Answer: b Explanation: The mode separation in terms of free space wavelength is given by- δλ = λ2/c δf Where δf = frequency separation λ = wavelength c = velocity of light

This set of Optical Communications test focuses on “Optical Emission From Semiconductors”.

1. A perfect semiconductor crystal containing no impurities or lattice defects is called as \_\_\_\_\_\_\_\_\_\_ a) Intrinsic semiconductor b) Extrinsic semiconductor c) Excitation d) Valence electron View Answer

Answer: a Explanation: An intrinsic semiconductor is usually un-doped. It is a pure semiconductor. The number of charge carriers is determined by the semiconductor material properties and not by the impurities.

2. The energy-level occupation for a semiconductor in thermal equilibrium is described by the \_\_\_\_\_\_\_\_\_\_

a) Boltzmann distribution function b) Probability distribution function c) Fermi-Dirac distribution function d) Cumulative distribution function View Answer

Answer: c Explanation: For a semiconductor in thermal equilibrium, the probability P(E) that an electron gains sufficient thermal energy at an absolute temperature so as to occupy a particular energy level E, is given by the Fermi-Dirac distribution. It is given by- P(E) = 1/(1+exp(E-EF/KT)) Where K = Boltzmann constant, T = absolute temperature, EF = Fermi energy level.

3. What is done to create an extrinsic semiconductor? a) Refractive index is decreased b) Doping the material with impurities c) Increase the band-gap of the material d) Stimulated emission View Answer

Answer: b Explanation: An intrinsic semiconductor is a pure semiconductor. An extrinsic semiconductor is obtained by doping the material with impurity atoms. These impurity atoms create either free electrons or holes. Thus, extrinsic semiconductor is a doped semiconductor.

4. The majority of the carriers in a p-type semiconductor are \_\_\_\_\_\_\_\_\_\_ a) Holes b) Electrons c) Photons d) Neutrons View Answer

Answer: a Explanation: The impurities can be either donor impurities or acceptor impurities. When acceptor impurities are added, the excited electrons are raised from the valence band to the acceptor impurity levels leaving positive charge carriers in the valence band. Thus, p-type semiconductor is formed in which majority of the carriers are positive i.e. holes.

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is used when the optical emission results from the application of electric field. a) Radiation b) Efficiency c) Electro-luminescence d) Magnetron oscillator View Answer

Answer: c Explanation: Electro-luminescence is encouraged by selecting an appropriate semiconductor material. Direct band-gap semiconductors are used for this purpose. In band-to-band recombination, the energy is released with the creation of photon. This emission of light is known as electroluminescence.

6. In the given equation, what does p stands for?

p = 2πhk

a) Permittivity b) Probability c) Holes d) Crystal momentum View Answer

Answer: d Explanation: The given equation is a relation of crystal momentum and wave vector. In the given equation, h is the Planck’s constant, k is the wave vector and p is the crystal momentum.

7. The recombination in indirect band-gap semiconductors is slow. a) True b) False View Answer

Answer: a Explanation: In an indirect band-gap semiconductor, the maximum and minimum energies occur at different values of crystal momentum. However, three-particle recombination process is far less probable than the two-particle process exhibited by direct band-gap semiconductors. Hence, the recombination in an indirect band-gap semiconductor is relatively slow.

8. Calculate the radioactive minority carrier lifetime in gallium arsenide when the minority carriers are electrons injected into a p-type semiconductor region which has a hole concentration of 1018cm-3. The recombination coefficient for gallium arsenide is 7.21\*10-10cm3s-1. a) 2ns b) 1.39ns c) 1.56ns d) 2.12ms View Answer

Answer: b Explanation: The radioactive minority carrier lifetime ςrconsidering the p-type region is given by- ςr = [BrN]-1 where Br = Recombination coefficient in cm3s-1 and N = carrier concentration in n-region.

9. Which impurity is added to gallium phosphide to make it an efficient light emitter? a) Silicon b) Hydrogen c) Nitrogen d) Phosphorus View Answer

Answer: c Explanation: An indirect band-gap semiconductor may be made into an electro-luminescent material by the addition of impurity centers which will convert it into a direct band-gap material. The introduction of nitrogen as an impurity into gallium phosphide makes it an effective emitter of light. Such conversion is only achieved in materials where the direct and indirect band-gaps have a small energy difference.

10. Population inversion is obtained at a p-n junction by \_\_\_\_\_\_\_\_\_\_ a) Heavy doping of p-type material b) Heavy doping of n-type material c) Light doping of p-type material d) Heavy doping of both p-type and n-type material View Answer

Answer: d Explanation: Population inversion at p-n junction is obtained by heavy doping of both p-type and n-type material. Heavy p-type doping with acceptor impurities causes a lowering of the Fermi-level between the filled and empty states into the valence band. Similarly n-type doping causes Fermi-level to enter the conduction band of the material.

11. A GaAs injection laser has a threshold current density of 2.5\*103Acm-2 and length and width of the cavity is 240μm and 110μm respectively. Find the threshold current for the device. a) 663 mA b) 660 mA c) 664 mA d) 712 mA View Answer

Answer: b Explanation: The threshold current is denoted by Ith. It is given by- Ith = Jth \* area of the optical cavity Where Jth = threshold current density Area of the cavity = length and width.

12. A GaAs injection laser with an optical cavity has refractive index of 3.6. Calculate the reflectivity for normal incidence of the plane wave on the GaAs-air interface. a) 0.61 b) 0.12 c) 0.32

d) 0.48 View Answer

Answer: c Explanation: The reflectivity for normal incidence of the plane wave on the GaAs-air interface is given by- r = ((n-1)/(n+1))2 where r=reflectivity and n=refractive index.

13. A homo-junction is an interface between two adjoining single-crystal semiconductors with different band-gap energies. a) True b) False View Answer

Answer: b Explanation: The photo-emissive properties of a single p-n junction fabricated from a single-crystal semiconductor material are called as homo-junction. A hetero-junction is an interface between two single-crystal semiconductors with different band-gap energies. The devices which are fabricated with hetero-junctions are said to have hetero-structure.

14. How many types of hetero-junctions are available? a) Two b) One c) Three d) Four View Answer

Answer: a Explanation: Hetero-junctions are classified into an isotype and an-isotype. The isotype hetero-junctions are also called as n-n or p-p junction. The an-isotype hetero-junctions are called as p-n junction with large band-gap energies.

15. The \_\_\_\_\_\_\_\_\_\_\_\_\_\_ system is best developed and is used for fabricating both lasers and LEDs for the shorter wavelength region. a) InP b) GaSb c) GaAs/GaSb d) GaAs/Alga AS DH View Answer

Answer: d Explanation: For DH device fabrication, materials such as GaAs, Alga AS are used. The band-gap in this material may be tailored to span the entire wavelength band by changing the AlGa composition. Thus, GaAs/ Alga As DH system is used for fabrication of lasers and LEDs for shorter wavelength region (0.8μm-0.9μm).

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “The Semiconductor Injection Laser”.

1. Stimulated emission by recombination of injected carriers is encouraged in \_\_\_\_\_\_\_\_\_\_ a) Semiconductor injection laser b) Gas laser c) Chemist laser d) Dye laser View Answer

Answer: a Explanation: Stimulated emission by use of optical cavity in crystal structure is used in semiconductor injection diodes. This provides the feedback of protons which gives injection laser many important advantages over other sources like LED’s.

2. In semiconductor injection laser, narrow line bandwidth is of the order? a) 1 nm or less b) 4 nm c) 5 nm d) 3 nm View Answer

Answer: a Explanation: A narrow line bandwidth of order 1 nm or less is used. This narrow bandwidth is useful in minimizing the effects of material dispersion.

3. Injection laser have a high threshold current density of \_\_\_\_\_\_\_\_\_\_ a) 104Acm-2 and more b) 102Acm-2 c) 10-2Acm-2 d) 10-3Acm-2 View Answer

Answer: a Explanation: Injection laser have a high threshold current density of 104Acm-2due to lack of matter and in-efficient light sources. These high current densities are largely utilized in pulse mode in order to minimize junction and thus avert damage.

4. ηT is known as slope quantum efficiency. a) True b) False View Answer

Answer: b Explanation: ηD is known as slope quantum efficiency. It gives a measure rate of optical output

power change with current and thus it determines slope of output characteristics in the region. So, ηT is referred to as slope quantum efficiency.

5. The total efficiency of an injection laser with GaAs active region is 12%. The applied voltage is 3.6 V and band gap energy for GaAs is 2.34 eV. Determine external power efficiency. a) 7.8 % b) 10 % c) 12 % d) 6 % View Answer

Answer: a Explanation: The total external power efficiency is defined as η = ηT(Eq/V)\*100 = 0.12 (2.34/3.6) \*100 = 7.8 %.

6. In a DH laser, the sides of cavity are formed by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Cutting the edges of device b) Roughening the edges of device c) Softening the edges of device d) Covering the sides with ceramics View Answer

Answer: b Explanation: In a DH laser, the sides of cavity are formed by the roughening edges of the device. This is done so as to reduce the unwanted emission in these directions and limit the number of horizontal transversal modes.

7. A particular laser structure is designed so that the active region extends the edges of devices. a) True b) False View Answer

Answer: a Explanation: Laser structures are particularly designed so that the active region does not extend beyond the edges. This is done to reduce problems like difficult heat sinking, lasing from multiple filament in wide active areas, unsuitable light output geometry for efficient coupling and also to reduce required threshold current.

8. Gain guided laser structure are \_\_\_\_\_\_\_\_\_\_ a) Chemical laser b) Gas laser c) DH injection laser d) Quantum well laser View Answer

Answer: c Explanation: DH injection lasers are known as gain guided laser structure. This is because the optical mode distribution along the junction plane is decided by optical gain.

9. Laser modes are generally separated by few \_\_\_\_\_\_\_\_\_\_ a) Tenths of micrometer b) Tenths of nanometer c) Tenths of Pico-meter d) Tenths of millimeter View Answer

Answer: b Explanation: The spacing in between modes is about a few tenths of nanometer. The spacing of the modes depends on optical cavity length where each one corresponds to an integral number of lengths.

10. The spectral width of emission from the single mode device is \_\_\_\_\_\_\_\_\_\_ a) Smaller than broadened transition line-width b) Larger than broadened transition line-width c) Equal the broadened transition line-width d) Cannot be determined View Answer

Answer: a Explanation: Single mode device has a smaller spectral width as compared to that of broadening transition line-width. This is because for a single-mode operation, the laser optical output must have only a single longitudinal and single transverse mode.

11. Single longitudinal mode operation is obtained by \_\_\_\_\_\_\_\_\_\_ a) Eliminating all transverse mode b) Eliminating all longitudinal modes c) Increasing the length of cavity d) Reducing the length of cavity View Answer

Answer: d Explanation: Single longitudinal mode operation is obtained by reducing the length L of cavity. Length must be reduced until the frequency separation of adjacent modes is given in the equation δf = c/2nL is larger than gain curve. Then only single mode falling in transition line width will oscillate in laser cavity.

12. A correct DH structure will restrict the vertical width of waveguide region is? a) 0.5μm. b) 0.69 μm c) 0.65 μm

d) Less than 0.4 μm View Answer

Answer: d Explanation: The vertical width DH structure should be less than 0.4μm. This allows only fundamental transverse mode and removes any interference of higher order transverse modes on emitted longitudinal waves.

13. The external power efficiency of an injection laser with a GaAs is 13% having band gap energy of 1.64 eV. Determine external power efficiency. a) 0.198 b) 0.283 c) 0.366 d) 0.467 View Answer

Answer: a Explanation: The external power efficiency of an injection laser is given by ηep = ηT (Eq/V)\*100 ηT = ηep/100 (v/Eg) = 13/100 (2.5/1.64) = 0.198

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Some Injection Laser Structures”.

1. In multimode injection lasers, the construction of current flow to the strip is obtained in structure by \_\_\_\_\_\_\_\_\_\_ a) Covering the strip with ceramic b) Intrinsic doping c) Implantation outside strip region with protons d)Implantation outside strip region with electrons View Answer

Answer: c Explanation: The current flow is realized by implanting the region outside strip with protons. This implantation makes the laser highly resistive and gives superior thermal properties due to absence of silicon dioxide layer.

2. What is the strip width of injection laser? a) 12 μm b) 11.5 μm c) Less than 10 μm d) 15 μm View Answer

Answer: c Explanation: A strip width less than or equal to 10 μm is usually preferred in injection lasers. This width range provides the lasers highly efficient coupling into multimode fibers as comapred to single mode fibers.

3. Some refractive index variation is introduced into lateral structure of laser. a) True b) False View Answer

Answer: a Explanation: Gain guided lasers possess several undesirable characteristics, nonlinearities in light output versus current characteristics, high threshold current, low differential quantum efficiency, movement of optical a;ong junction plane. This problems can be reduced by introducing refractive index variations into lateral structure of lasers so that optical mode is determined along the junction plane.

4. Buried hetero-junction (BH) device is a type of \_\_\_\_\_\_\_\_\_\_\_\_\_ laser where the active volume is buried in a material of wider band-gap and lower refractive index. a) Gas lasers. b) Gain guided lasers. c) Weak index guiding lasers. d) Strong index guiding lasers. View Answer

Answer: d Explanation: In strong index guiding lasers, a uniformly thick, planar active waveguide is achieved by lateral variations in confinement layer thickness or refractive index. In Buried hetero-junction (BH) devices, strong index guiding along junction plane introduces transverse mode control in injection lasers.

5. In Buried hetero-junction (BH) lasers, the optical field is confined within \_\_\_\_\_\_\_\_\_\_ a) Transverse direction b) Lateral direction c) Outside the strip d) Both transverse and lateral direction View Answer

Answer: d Explanation: Optical field is strongly confined in both transverse and lateral direction. This provides strong index guiding of optical mode along with good carrier confinement.

6. A double-channel planar buried hetero-structure (DCP BH) has a planar active region, the confinement material is? a) Alga AS b) InGaAsP

c) GaAs d) SiO2 View Answer

Answer: b Explanation: The planar active region made up of InGaAsP can be seen in double-channel planar buried hetero-structure (DCP BH). This material confinement provides a very high power operation with CW output power up to 40 mW in longer wavelength region.

7. Problems resulting from parasitic capacitances can be overcome \_\_\_\_\_\_\_\_\_\_ a) Through regrowth of semi-insulating material b) By using oxide material c) By using a planar InGaAsP active region d) By using a AlGaAs active region View Answer

Answer: a Explanation: The use of reverse-biased current confinement layers introduces parasitic capacitances which reduces high speed modulation of BH lasers. This problem can be reduced by regrowth of semi-insulating material or deposition of dielectric material. This causes increase in modulation speeds of 20 GHz.

8. Quantum well lasers are also known as \_\_\_\_\_\_\_\_\_\_ a) BH lasers b) DH lasers c) Chemical lasers d) Gain-guided lasers View Answer

Answer: b Explanation: DH lasers are known as Quantum well lasers. The carrier motion normal to active layer is restricted in these devices. This results in quantization of kinetic energy into discrete energy levels for carriers moving in that direction. This phenomenon is similar to quantum mechanical problem of one dimensional potential well which is seen in DH lasers.

9. Quantum well lasers are providing high inherent advantage over \_\_\_\_\_\_\_\_\_\_ a) Chemical lasers b) Gas lasers c) Conventional DH devices d) BH device View Answer

Answer: c Explanation: Quantum well lasers exhibit high incoherent advantage over conventional DH lasers. In Quantum well laser structures, the thin active layer results in drastic changes in electronic and optical properties over conventional DH laser structures. This changes are due to

quantized nature of discrete energy levels with step-like density and also allow high gain and low carrier density.

10. Strip geometry of a device or laser is important. a) True b) False View Answer

Answer: a Explanation: Near fluid intensity distribution corresponding to single optical output power level in plane of junction can be seen in GaAs or AlGaAs lasers. This distribution is in lateral direction and is determined by the nature of lateral waveguide. The single intensity maximum shows the fundamental lateral mode is dominant.

11. Better confinement of optical mode is obtained in \_\_\_\_\_\_\_\_\_\_ a) Multi Quantum well lasers b) Single Quantum well lasers c) Gain guided lasers d) BH lasers View Answer

Answer: a Explanation: As compared to all lasers including single quantum well lasers, multi-Quantum well lasers are having better confinement of optical mode. This results in a lower threshold current density for these devices.

12. Multi-quantum devices have superior characteristics over \_\_\_\_\_\_\_\_\_\_ a) BH lasers b) DH lasers c) Gain guided lasers d) Single-quantum-well devices View Answer

Answer: b Explanation: Lower threshold currents, narrower bandwidths, high modulation speeds, lower frequency chirps and less temperature dependence are parameters determining characteristics of a particular laser. All the above parameters make multi-quantum devices superior over DH lasers.

13. Dot-in-well device is also known as \_\_\_\_\_\_\_\_\_\_ a) DH lasers b) BH lasers c) QD lasers d) Gain guided lasers View Answer

Answer: c Explanation: Quantum well lasers are devices in which device contains a single discrete atomic structure or Quantum-dot. These are elements that contain electron tiny droplets which forms a quantum well structure.

14. A BH can have anything from a single electron to several electrons. a) True b) False View Answer

Answer: b Explanation: Quantum-dot lasers are fabricated using semiconductor crystalline materials. They have a particular dimension ranging from nm to few microns. The size, shape of these structures and number of electrons they contain are precisely controlled.

15. QD lasers have a very low threshold current densities of range \_\_\_\_\_\_\_\_\_\_ a) 0.5 to 5 A cm-2 b) 2 to 10 A cm-2 c) 10 to 30 A cm-2 d) 6 to 20 A cm-2 View Answer

Answer: d Explanation: Low-threshold current density between 6 to 20 A cm-2 is obtained with InAs/InGaAs QD lasers which emit at a wavelength of 1.3 μm and 1.5 μm Such low values of threshold current densities make these lasers possible to create stacked or cascaded QD structures. These structures provide high optical gain for short-cavity transmitters and vertical cavity surface-emitting lasers.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on ” Single Frequency Injection Lasers”.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ may be improved through the use of frequency-selective feedback so that the cavity loss is different for various longitudinal modes. a) Frequency selectivity b) Longitudinal mode selectivity c) Electrical feedback d) Dissipated power View Answer

Answer: b Explanation: Improved longitudinal mode selectivity can be achieved using structures which gives loss discrimination between the desired and all the unwanted modes. Thus, mode discrimination can be seen. To allow for stable mode operation, the use of frequency-selective feedback approach is undertaken.

2. Device which apply the frequency-selective feedback technique to provide single longitudinal operation are referred to as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) DSM lasers b) Nd: YAG lasers c) Glass fiber lasers d) QD lasers View Answer

Answer: a Explanation: DSM lasers are also known as single frequency lasers. Such devices provide single longitudinal mode operation hence called as dynamic single mode lasers. These lasers reduce fiber intra-modal dispersion within high speed systems.

3. Which of the following does not provide single frequency operation? a) Short cavity resonator b) DSM lasers c) Coupled cavity resonator d) Fabry-Perot resonator View Answer

Answer: d Explanation: DSM lasers, short cavity resonators, coupled cavity resonators employ frequency selective feedback approach and provide single mode operation. However, the Fabry-Perot resonator allows several longitudinal modes to exist within the gain spectrum of the device.

4. A method for increasing the longitudinal mode discrimination of an injection laser which is commonly used? a) Decreasing refractive index b) Increasing the refractive index c) Increasing cavity length d) Shortening of cavity length View Answer

Answer: d Explanation: The longitudinal mode discrimination of an injection laser is indirectly proportional to the cavity length. Thus, as the cavity length is shortened, the mode discrimination will get increase. If the cavity length is reduced from 250 to 25 units, the mode spacing is increased from 1 to 10 nm.

5. Conventional cleaved mirror structures are difficult to fabricate with the cavity lengths below \_\_\_\_\_\_\_\_\_\_ a) 200 μm and greater than 150 μm b) 100 μm and greater than 50 μm c) 50 μm d) 150 μm View Answer

Answer: c Explanation: cleaved laser mirrors are used in Fabry-Perot resonator which does not give result for shorter cavity lengths. These lengths may vary from 20 μm to 50μm. Hence micro-cleaved or etched resonator is used for shorter cavity lens.

6. In the given equation, corrugation period is given by lλb/2Ne. If λb is the Bragg wavelength, then what does ‘l’ stand for? a) Length of cavity b) Limitation index c) Integer order of grating d) Refractive index View Answer

7. The first order grating (l=1) provide the strongest coupling within the device. a) True b) False View Answer

Answer: a Explanation: The period of corrugation is given by lλb/2Ne includes order of grating. The second grating provide larger spatial period and thus helps in fabrication. If the order of grating is 1, then the device is coupled at high level.

8. The semiconductor lasers employing the distributed feedback mechanism are classified in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ categories. a) One b) Two c) Three d) Four View Answer

Answer: b Explanation: Considering the device operation, semiconductor lasers are classified into two broad categories referred to as distributed feedback laser and distributed Bragg reflector laser. In the DFB laser, optical grating is applied over the entire active region, whereas in DBR lasers, the grating is etched only near the cavity ends.

9. DBF-BH lasers exhibit low threshold currents in the range of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 40 to 50 mA b) 21 to 30 mA c) 2 to 5 mA d) 10 to 20 mA View Answer

Answer: d Explanation: DFB lasers are used to provide single frequency semiconductor optical sources.

DFB-BH lasers, developed in laboratories exhibit high modulation speeds, output power but low threshold currents in the range of 10 to 20 mA.

10. Fabry-Perot devices with BH geometries high modulation speeds than DFB-BH lasers. a) True b) False View Answer

Answer: b Explanation: DFB-BH lasers exhibit low threshold currents but high output power and modulation speeds. DFB-BH laser is fabricated by etching or grating. Fabry-perot devices provide modulation speeds of M-bits per seconds whereas, DFB-BH lasers provides modulation speeds of G-bits/sec.

11. The InGaAsP/InP double channel planar DFB-BH laser with a quarter wavelength shifted first order grating provides a single frequency operation and incorporates a phase shift of \_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) π/2 Radians b) 2π Radians c) π Radians d) 3π/2 radians View Answer

Answer: a Explanation: The performance of DFB laser is improved by modifying a grating, which in turn introduces an optical phase shift. The phase shift depends on the wavelength used. A quarter wavelength shifted first order grating incorporates the phase shift of π/2 in the corrugation at the center of laser cavity.

12. The narrow line-width obtained under the CW operation for quarter wavelength shifted DFB laser is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 2 MHz b) 10 MHz c) 3 MHz d) 1 MHz View Answer

Answer: c Explanation: A quarter wavelength shifted DFB laser provides a large gain difference between the central mode and side modes. It provides improved dynamic single mode stability. Narrow line-width of around 3 MHz can be obtained under CW operation.

13. Line-width narrowing is achieved in DFB lasers by a strategy referred as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Noise partition b) Grating c) Tuning

d) Bragg wavelength detuning View Answer

Answer: d Explanation: Line-width narrowing is achieved in DFB lasers by detuning the lasing wavelength towards the shorter wavelength side of gain peak. It increases the differential gain between the central mode and nearest side mode. This strategy is called as Bragg wavelength detuning.

14. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a technique used to render the non-conducting material around the active cavity by producing permanent defects in the implanted area. a) Dispersion b) Ion de-plantation c) Ion implantation d) Attenuation View Answer

Answer: c Explanation: Ion implantation approach concentrates the injection current in active region. Current confinement is realized by ion implantation. Ions are implanted into a selective area of a semiconducting material to make it non-conducting.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Injection Laser Characteristics”.

1. The threshold temperature coefficient for InGaAsP devices is in the range of \_\_\_\_\_\_\_\_\_\_ a) 10-40 K b) 40-75 K c) 120-190 K d) 150-190 K View Answer

Answer: b Explanation: The threshold temperature coefficient for InGaAsP devices is in between 40 and 75 K. This range shows higher temperature sensitivity due to intrinsic physical properties of InGaAsP material system, Auger recombination, inter-valence band absorption, carrier leakage effects over hetero-junctions.

2. The process where the energy released during the recombination of an electron-hole event getting transferred to another carrier is known as \_\_\_\_\_\_\_\_\_\_ a) Inter-valence bond absorption b) Auger recombination c) Carrier leakage effects d) Exothermic actions View Answer

Answer: b Explanation: Auger recombination is a process where energy is released. This energy is released during the recombination of electron-hole and this released energy is transferred to another electron-hole event. During this process, when a carrier is excited to a higher energy level, it loses its excessive amount of energy by emitting a phonon in order to maintain thermal equilibrium. It consists of number of different processes each process involving three particles (2 electrons and 1 or 2 holes and 1 electron).

3. Auger recombination can be reduced by using \_\_\_\_\_\_\_\_\_\_ a) Strained MQW structure b) Strained SQW structure c) Gain-guided strained structure d) Strained Quantum dots lasers View Answer

Answer: a Explanation: Auger recombination is a process where energy is released during recombination of electron-hole event is transferred to another event. This loss mechanism can be reduced by using strained by using MCQ laser structure. Strain can be either compressive or tensile, modifying the valence band energy levels of material and therefore can be used to increase energy.

4. High strain in strained MCQ structure should be incorporated. a) True b) False View Answer

Answer: b Explanation: Strain is introduced in thin layers of quantum wells by making small differences in lattice constants. High strain should be avoided because it causes damage in these thin-quantum layers. Also carrier leakage adds at high temperatures since it represents processes that prevent carrier from recombination thus reducing device efficiency.

5. The parameter that prevents carrier from recombination is \_\_\_\_\_\_\_\_\_\_ a) Auger recombination b) Inter-valence band absorption c) Carrier leakage d) Low temperature sensitivity View Answer

Answer: c Explanation: Carrier leakage is the parameter that prevents carriers (electrons, holes) from recombination. At high temperatures, carrier leakage represents all those processes preventing carriers from recombination. It therefore increases the lasing threshold and thus reduces device efficiency.

6. Determine the threshold current density for an AlGaAs injection laser with T0=180k at 30°C. a) 6.24 b) 9.06 c) 3.08 d) 5.09 View Answer

Answer: d Explanation: The threshold current density for a laser is given by- Ith = exp(T/T0) For AlGaAs device, Ith(30)=exp(T/T0) = exp(293/180) = 5.09.

7. The phenomenon occurring when the electron and photon population within the structure comes into equilibrium is known as \_\_\_\_\_\_\_\_\_\_ a) Auger recombination b) Inter-valence band absorption c) Carrier leakage d) Relaxation oscillations View Answer

Answer: d Explanation: Phenomenon occurring when the electron and photon population within the structure comes into equilibrium is known as Relaxation oscillations. The application of a current state to device resulting in a switch delay which is followed by high frequency damped oscillations.

8. When a current pulse reaches a laser having parasitic capacitance after the initial delay time, that pulse will \_\_\_\_\_\_\_\_\_\_ a) Have no effect b) Will get vanished c) Becomes narrower d) Gets broader View Answer

Answer: d Explanation: The pulse will be broadened when it will reach a laser with parasitic capacitance after initial time delay. This is because when a current pulse reaches the laser, the parasitic capacitance of laser provides a source of current over the period when there is high photon density. As electron density is repetitively built up and reduced quickly, there will be several pulses at laser output as photon density will be high resulting in relaxation oscillations.

9. Reducing delay time and \_\_\_\_\_\_\_\_\_\_\_\_ are of high importance for lasers. a) Auger recombination b) Inter-valence band absorption c) Carrier leakage effects

d) Relaxation oscillations View Answer

Answer: d Explanation: For lasers generally a switch-on delay time may last for 0.5ns and relaxation oscillations behind twice that period. This behavior can produce serious deterioration in shape of laser pulse at a data rate of 100Mbits. So time delay and Relaxation oscillations are highly desirable for lasers.

10. Dynamic line-width broadening under the direct modulation of injection current is known as \_\_\_\_\_\_\_\_\_\_ a) Auger recombination b) Inter-valence band absorption c) Carrier leakage effects d) Frequency Chirping View Answer

Answer: d Explanation: Frequency Chirping is a phenomenon which is due to Dynamic line-width broadening under direct modulation of a single longitudinal mode. Semiconductor laser cause a dynamic shifting of peak wavelength emitted from device. Strong coupling between the free carrier density and refractive index of device present in semiconductor structure results in gain-induced variations which also causes Frequency Chirping.

11. A particular characteristic or parameter that occurs during analog transmission of injection lasers is? a) Noise b) Mode hopping c) Carrier leakage effects d) Frequency Chirping View Answer

Answer: a Explanation: During analog transmission, noise behavior of device is main thing that affects the operation of injection laser. This noise may be due to instabilities in kinks in light output versus current characteristics, reflection of light back to device and mode partition noise.

12. Intensity of output from semiconductor injection lasers leading to optical intensity noise is due to \_\_\_\_\_\_\_\_\_\_ a) Fluctuations in amplitude b) Mode hopping c) Carrier leakage effects d) Frequency Chirping View Answer

Answer: a Explanation: Fluctuations in the laser output or intensity of laser output leads to optical intensity noise. These fluctuations are generally caused by temperature variations and spontaneous emission in the laser output. This randomness in fluctuations creates a noise source known as relative intensity noise (RIN).

13. In multimode lasers the optical feedback from unnecessary external reflections affecting stability of frequency and intensity is? a) Remains unaffected b) Increased gradually c) Reduced d) Gets totally vanished View Answer

Answer: c Explanation: The effect due to unwanted external reflections in multimode laser is reduced. This is because the reflections are spread along any fiber modes so they are weakly coupled back into laser mode.

14. Reduction in the number of modes in multimode fiber increases the mode partition noise. a) False b) True View Answer

Answer: a Explanation: Mode partition noise is a result of laser spectral fluctuations and so a reduce in number of modes results in low pulse-width spreading thus providing low values of intermodal dispersion in the fiber. And so, the mode partition noise is decreased in multimode fiber due to reducing the number of modes.

15. The behavior of laser occurring when current is increased above threshold particularly is? a) Mode hopping b) Auger recombination c) Frequency chirping d) Noise View Answer

Answer: a Explanation: Mode hopping results in the hopping of modes to a higher wavelength. This mode hopping occurs in all injection lasers and is due to increase in temperature. Mode hopping is not a continuous function of drive current but occurs above 1 to 2 mA. Mode hopping alters characteristics of laser and results in kinks in characteristics of single mode device

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Non – Semiconductor Lasers”.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ lasers are presently the major laser source for optical fiber communications. a) Semiconductor b) Non-Semiconductor c) Injection d) Solid-state View Answer

Answer: c Explanation: Injection laser coupling using discrete lasers have proved to fruitful. Such lenses provide for relaxation for an alignment tolerances normally required for fiber coupling. Certain non-semiconductor sources are making its lace in the optical fiber communication. At slowly present, injection lasers are mostly used as laser sources.

2. In Nd: YAG lasers, the maximum doping levels of neodymium is \_\_\_\_\_\_\_\_\_\_\_\_ a) 0.5 % b) 1.5 % c) 1.8 % d) 2 % View Answer

Answer: b Explanation: The Nd: YAG laser structure is formed by doping of yttrium- aluminum -garnet (YAG) with neodymium. The energy levels for lasing transition and pumping are provided by neodymium ions. The maximum doping level of neodymium in YAG is around 1.5 %.

3. Which of the following is not a property of Nd: YAG laser that enables its use as an optical fiber communication source? a) Single mode operation b) Narrow line-width c) Long lifetime d) Semiconductors and integrated circuits View Answer

Answer: d Explanation: Nd: YAG laser is a non-semiconductor laser. It does not include the use of semiconductors and thus cannot take advantage of well-developed technology associated with integrated circuits. Single mode operation, narrow line-width, lifetime are the properties that are useful for optical communication.

4. The Nd: YAG laser has a narrow line-width which is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) < 0.01 nm b) > 0.01 nm c) > 1 mm d) > 1.6 mm View Answer

Answer: a Explanation: The Nd: YAG laser has several properties which make it an active optical source. One of such properties is its narrow line-width. It is less than 0.01 nm which is useful for reducing dispersion of optical links.

5. The strongest pumping bands is a four level system of Nd: YAG laser at wavelength of range\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 0.25 and 0.56 nm b) 0.75 and 0.81 nm c) 0.12 and 0.23 nm d) 1 and 2 nm View Answer

Answer: b Explanation: The Nd: YAG laser is a four level system. It consists of number of pumping bands and fluorescent transitions. The strongest pumping bands are the wavelengths of 0.75μm and 0.81μm. and gives lasing transition at 1.064μm and 1.32μm. Single mode emission is usually obtained at these wavelengths.

6. The Nd: YAG laser is costlier than earth-doped glass fiber laser. a) True b) False View Answer

Answer: a Explanation: The most important requirement of the Nd: YAG laser is pumping and modulation. These two requirements tend to give a cost disadvantage in comparison with earth-doped glass fiber laser. Also it is easier and less expensive to fabricate glass fiber in earth-doped laser.

7. It is a resonant cavity formed by two parallel reflecting mirrors separated by a mirror separated by a medium such as air or gas is? a) Optical cavity b) Wheatstone’s bridge c) Oscillator d) Fabry-perot resonator View Answer

Answer: d Explanation: Resonant cavity is formed between two mirrors where fiber core doped with earth ions is placed. This cavity is 250-500 μm long and 5 to 15 μm wide. A Fabry-perot resonator oscillates at resonant frequency for which there is high gain.

8. In a three level system, the threshold power decreases inversely with the length of the fiber gain medium. a) True

b) False View Answer

Answer: b Explanation: If the imperfection losses are low then in a four level system the threshold power decreases inversely with the length of the fiber gain medium. A three level consists of an optimum length. This optimum length gives the minimum threshold power which is independent of the value of imperfection losses.

9. Which of the following co-dopant is not employed by neodymium and erbium doped silica fiber lasers? a) Phosphorus pent oxide b) Germania c) Nitrogen d) Alumina View Answer

Answer: c Explanation: Silica based glass fibers are proved to be the best host material till date. These silica fibers are doped with neodymium and erbium. These dopants include co-dopants such as phosphorus pent-oxide, germanium and alumina.

10. Dopants levels in glass fiber lasers are generally \_\_\_\_\_\_\_\_\_\_\_ a) Low b) High c) Same as that of GRIN rod lens laser d) Same as that of semiconductor laser View Answer

Answer: a Explanation: Dopant levels are low in glass fibers (nearly 400 parts per million). This is because of increasing in concentration quenching which increases with the doping level. It may cause the reduction in the population of the upper lasing level as well as crystallization within the glass matrix.

11. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ fibers include addition of lead fluoride to the core glass in order to raise the relative refractive index. a) Solid-state b) GaAs c) Semiconductor d) ZBLANP View Answer

Answer: d Explanation: Up-conversion pumping of laser material is used to convert an infrared laser output to a visible laser output. ZBLANP is host material on which laser action at all wavelengths can

be obtained by pumping. The relative refractive index is increased by addition of lead fluoride which makes it a very interesting host material.

12. The lasing output of the basic Fabry-perot cavity fiber is restricted to between \_\_\_\_\_\_\_\_\_\_\_\_ a) 1 and 2 nm b) 5 and 10 nm c) 3 and 6 nm d) 15 and 30 nm View Answer

Answer: b Explanation: the gain spectrum of rare earth ions may be seen over a wavelength range of 50 nm. The lasing output will thus be narrow unless the dielectric on the mirror is arranged. Such a narrow line-width is not used for a broadband optical source.

13. In Fabry-perot laser, the lower threshold is obtained by \_\_\_\_\_\_\_\_\_\_\_ a) Increasing the refractive index b) Decreasing the refractive index c) Reducing the slope efficiency d) Increasing the slope efficiency View Answer

Answer: c Explanation: The finesse of Fabry-perot cavity provides a measure of its filtering properties. When the finesse is high the splitting ratio is low thus lowering the laser threshold in an optical cavity without mirror. In Fabry-perot laser, mirrors are present and thus lower threshold is obtained by reducing the slope efficiency.

14. When did the non-semiconductor laser developed? a) 1892 b) 1946 c) 1985 d) 1993 View Answer

Answer: c Explanation: Non-semiconductor sources are crystalline and glass wave-guiding structures. They are doped with rare earth ions and are good optical sources. The development of these sources started in the year 1985. Example: Nd: YAG laser.

15. Y3Al5 O12 is a molecular formula for \_\_\_\_\_\_\_\_\_\_\_\_\_ a) Ytterbium aluminate b) Yttrium oxide c) Ytterbium oxy-aluminate d) Yttrium-aluminum garnet View Answer

Answer: d Explanation: The atomic number of Yttrium is 39. It is the base element of Yttrium-aluminum garnet. Y3Al5 O12, doped with rare earth ion neodymium to form Nd: YAG laser structure

This set of Optical Communications Quiz focuses on “Narrow – Linewidth and Wavelength – Tunable Lasers”.

1. Which of these factors are critical in affecting the system performance in the case of coherent optical fiber transmission? a) Laser line-width and stability b) Refractive index and index difference c) Core cladding diameter d) Frequency View Answer

Answer: a Explanation: The system employing intensity modulation does not consider line-width and stability as the factors of utmost importance. In coherent optical source transmission, laser line-width and stability are critical factors. These factors affect the system performance and are in the range of 0.5-1 Megahertz.

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ occurs as a result of the change in lasing frequency with gain. a) Frequency multiplication b) Dispersion c) Attenuation d) Line-width broadening View Answer

Answer: d Explanation: Line-width broadening is a fundamental consequence of spontaneous emission process. It is related to the fluctuations in the phase of the optical fields. These phase fluctuations are due to the phase noises associated with the spontaneous emission process.

3. Laser cavity length can be extended by \_\_\_\_\_\_\_\_\_\_\_ a) Increasing the refractive index b) Reducing frequency c) Introduction of external feedback d) Using GRIN-rod lenses View Answer

Answer: c Explanation: the lasers having long external cavity are referred to as LEC lasers. The extension of the laser cavity length by introduction of external feedback can be achieved by using an external cavity with a wavelength dispersive element.

4. What is the purpose of wavelength dispersive element is LEC lasers? a) Wavelength selectivity b) Reduction of line-width c) Frequency multiplication d) Avalanche multiplication View Answer

Answer: a Explanation: A wavelength dispersive element is a part of the laser cavity. It is required because the long resonator structure has very closely spaced longitudinal modes which necessitates additional wavelength selectivity.

5. An effective method to reduce the line-width is to make the cavity longer. a) True b) False View Answer

Answer: a Explanation: As the laser power increases, the device line-width decreases. The output power f laser cannot be mode arbitrarily large. Thus, the line-width is reduced by making the cavity longer. Longer cavity also enables increased wavelength selectivity.

6. Which devices are used to modulate the external cavity in order to achieve the higher switching speeds? a) Electromagnetic b) Acousto-optic c) Dispersive d) Lead View Answer

Answer: b Explanation: The devices are tuned mechanically to extend the cavity of laser. The disadvantage of using mechanically tuned devices is low. Thus, electro-optic devices are used to modulate the external cavity in order to achieve higher switching speeds.

7. How many techniques are used to tune monolithic integrated devices (lasers)? a) Five b) One c) Two d) Three View Answer

Answer: c Explanation: There are two techniques which can be employed to tune monolithic integrated devices. In the first method, the mode selectivity of a coupled cavity structure is used. Other

method is used to a refractive index change in the device cavity provided by application of an electric field.

8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ laser can be produced when a coupler section is introduced between the amplifier and phase sections of a structure. a) SG-DBR b) GCSR c) Y 4-shifted d) DSM View Answer

Answer: b Explanation: DBR lasers are capable of wavelength tuning. Grating assisted co-directional coupler with sampled reflector (GCSR). Laser is capable of a tuning range greater than 40 nm. It consists of a co-directional coupler between the amplifier and the phase section.

9. The rare-earth-doped fiber lasers have spectral line-width in the range of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 0.1 to 1 nm b) 1.2 to 1.5 nm c) 6 to 10 nm d) 2 to 2.3 nm View Answer

Answer: a Explanation: The rare-earth-doped fiber lasers have spectral line-width in the range of 0.1 to 1 nm. These line-widths are too long for high speed transmission is possible in this range.

10. The lasing line-width of Fox-smith resonator is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Less than 1 MHz b) 1 MHz c) 2 MHz d) Greater than 3 MHz View Answer

Answer: a Explanation: Fox-smith resonator employs a fused coupled fabricated from erbium-doped fiber. Narrower spectral line-width can be obtained using a resonator. It provides favorable line-widths than semiconductor laser.

11. What is the widest tuning range obtained in optical fiber laser structure? a) 60 nm b) 80 nm c) More than 100 nm d) 100 nm View Answer

Answer: c Explanation: A tuning range greater than 100 nm by using an erbium-doped photonic crystal fiber. A wider tuning range greater than 100 nm is obtained at wavelength 1.55 nm.

12. How many techniques can be used to increase the injection cavity length? a) One b) Two c) Three d) Four View Answer

Answer: b Explanation: Two techniques can be used to increase the injection laser cavity length. These are using laser chips and by extending a cavity with a passive medium such as air, glass etc.

13. The mechanism which results from a refractive index change in the passive waveguide layer is called as \_\_\_\_\_\_\_\_\_\_\_ a) Absorption b) Spontaneous emission c) Monolithic inversion d) Bragg wavelength control View Answer

Answer: d Explanation: A wider wavelength tuning length is obtained by separating the Bragg region in the passive waveguide and by introducing a phase region within a waveguide control mechanism provides phase control. It takes place by some changes in a passive waveguide layer.

14. How many sections are included in a sampling grating distributed Bragg-reflector laser (SG-DBR)? a) Four b) Five c) Three d) Two View Answer

Answer: b Explanation: In SG-DBR laser, five sections are longitudinally integrated together on a semiconductor substrate. These five sections include two diffraction Bragg grating sections, a gain, a phase and an amplifier section.

15. Fiber based lasers provide diffraction-limited power at higher levels than solid-state laser. a) True b) False View Answer

Answer: a Explanation: In fiber lasers, the active gain medium is doped with rare earth elements. These lasers have active regions several kilometers long and thus provide high optical gain. Solid-state lasers, on the other hand, provide diffraction limited power at lower levels

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Mid Infrared and Far Infrared Lasers”.

1. The parameters having a major role in determining threshold current of efficiency of injection laser are \_\_\_\_\_\_\_\_\_\_\_ a) Angle recombination and optical losses b) Frequency chirping c) Relaxation oscillation d) Mode hopping View Answer

Answer: a Explanation: Optical losses due to free carrier absorption are more because of their dependence on square of the wavelength. Also irradiative recombination through Auger recombination contributes to it. Both these effects cause more problems in md-infrared wavelengths and so are of much importance art high temperature due to high concentration of free carriers. They also limit maximum operating temperatures.

2. Auger current is mostly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for material with band gap providing longer wavelength emission. a) Unaffected b) Lesser c) Larger d) Vanishes View Answer

Answer: c Explanation: The total current required for injection laser threshold is more than that provided to radioactive recombination as Auger current is added. This current depends on electronic band structure of material and often consists of different Auger transitions. So it is larger for materials with band gaps providing longer wavelength emission.

3. Injection lasers operating in smaller wavelengths are subjected to increased carrier losses. a) True b) False View Answer

Answer: b Explanation: Injection lasers operating in longer wavelengths (mid and far infrared) are subjected to increased carrier losses as compared to devices operating up to 1.6μm. This is from nonradiative recombination through Auger interaction. This recombination energy is dissipated

as thermal energy to other free carriers. If band gap of semiconductor is increased, occurrence of these events gets increased.

4. Devices based on quaternary PbSnSeTe and their ternary compounds, emit at wavelength? a) Between 3-4 μm b) Longer than 4 μm c) Between 3.5 to 4.2 μm d) Between 2 to 3 μm View Answer

Answer: b Explanation: Quaternary devices emit at wavelength longer than 4μm. Auger effects are less in these alloys which provide lower current thresholds and higher maximum operating temperature.

5. Replacing Sn with Eu, Cd or Ge in some \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the band gap. a) Remove the band gap b) Does not affect c) Decreases d) Increases View Answer

Answer: d Explanation: When in a particular alloy laser for example PbSnSeTe, if Sn is replaced with Eu, Cd or Ge, there is an increase in band gap. This increase in band gap provides the laser to operate in shorter wavelength.

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6. Lasing obtained in \_\_\_\_\_\_\_\_\_\_ when 191 mW of pump light at a wavelength of 0.477 μm is launched into laser. a) Ternary PbSnSeTe alloy laser b) Quaternary PbSnSeTe alloy laser c) Doped Fluoro-zirconate fiber d) Ternary PbEuTe alloy laser View Answer

Answer: c Explanation: When Fluoro-zirconate fiber lasers are doped with Erbium helium or thulium, there are emission at 2-3 μm wavelength range. But lasing was obtained in this doped Fluorozirconate fiber at a wavelength of 0.477μm.

7. The thulium doped fiber laser when pumped with alexandrite laser output at 0.786 μm, the laser emits at \_\_\_\_\_\_\_\_\_\_\_ a) 0.6 μm b) 0.8 μm c) 2.3 μm

d) 1.2μm View Answer

Answer: c Explanation: The thulium system emits at 2.3 μmwhen subjected to alexandrite laser at 0.786 μm. this system is four levels in which the pump band is upper lasing level at 2.3μm.

8. The diode-cladding-pumped Erbium praseodymium-doped fluoride device operates at wavelength. a) Around 3 μm b) 4 μm c) 2.6 μm d) 1.04 μm View Answer

Answer: a Explanation: The diode-cladding-pumped Erbium praseodymium-doped fluoride device operates at a wavelength of 3 μm. This laser is capable of producing a very high output power of about 1W or more. It consists of double clad fluoride fiber.

9. A technique based on inter-sub band transition is known as \_\_\_\_\_\_\_\_\_\_\_ a) Auger recombination b) Frequency chirping c) Inter-valence band absorption d) Quantum cascading View Answer

Answer: d Explanation: The quantum cascaded laser is a layered semiconductor device having a series of coupled quantum wells grown on GaAs or Imp substrate. This principle of QC lasers provides emission of an optical signal around full wavelength range. Quantum mechanical band structure determines the emitted wavelength.

10. In a QC laser, a same electron can emit number of photons. a) True b) False View Answer

Answer: a Explanation: The QC laser operates by pumping a energy level and then using the energy in a controlled manner. This gives some energy each time over several steps. And since a QC laser structure includes a series of energy levels the same electron emits a number of photons while cascading down through each energy level.

11. The phenomenon resulting in the electrons to jump from one state to another each time emitting of photon is known as \_\_\_\_\_\_\_\_\_\_\_

a) Inter-valence band absorption b) Mode hopping c) Quantum cascading d) Quantum confinement View Answer

Answer: d Explanation: In Quantum confinement, charge carriers are trapped in a small area and this occurs in quantum wells at nanometer scale. When the quantum layer size raises to a size comparable to emission wavelength, the electron motion becomes perpendicular to plane of layer. Due to this, the electrons jump from one state to another each time from one state to another.

12. A QC laser is sometimes referred as \_\_\_\_\_\_\_\_\_\_\_ a) Unipolar laser b) Bipolar laser c) Gain guided laser d) Non semiconductor laser View Answer

Answer: a Explanation: A QC laser utilizes only n-type of charge carriers. Their operation is entirely based on electrons and holes play no part in this, so they are known as unipolar lasers.

13. In QC lasers, it is possible to obtain different output signal wavelengths. This can be achieved by \_\_\_\_\_\_\_\_\_\_\_ a) Inter-valence band absorption b) Mode hopping c) Quantum cascading d) Selecting layers of different thickness View Answer

Answer: d Explanation: In QC laser, electrons emit energy. This energy emitted at this stage determines wavelength of radiation and it depends only on thickness of the layer. Thus output signal wavelength is dependent on thickness of lasers.

14. QC lasers \_\_\_\_\_\_\_\_\_\_\_\_\_\_ the performance characteristics. a) Have negligible effects b) Does not affects c) Improves d) Degrades View Answer

Answer: c Explanation: QC lasers are based on inter sub band transition techniques. They have ability of carrying large amount of currents. A single electron is enough to generate number of photons.

Thus, provides an increase in output signal power which is greater than thousands at same wavelength due to large number of cascaded stages.

15. An MQW cascaded laser is more advantageous because of \_\_\_\_\_\_\_\_\_\_\_ a) Mode hopping b) Auger recombination c) Control over layers of material d) Properties of material View Answer

Answer: c Explanation: In MQW cascaded layers, cascading creates number of injector/collector and active region in single stage. Each region contains a single quantum wells. Such structures permit maximum injection/collection of current and thereby produce a large number of photons. This formation of any injector/collector and active regions is achieved through precise control of several hundreds of layers of the material, where each layer should only be few nanometers thick

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “LED Power and Efficiency”.

1. The absence of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in LEDs limits the internal quantum efficiency. a) Proper semiconductor b) Adequate power supply c) Optical amplification through stimulated emission d) Optical amplification through spontaneous emission View Answer

Answer: c Explanation: The ratio of generated electrons to the electrons injected is quantum efficiency. It is greatly affected if there is no optical amplification through stimulated emission. Spontaneous emission allows ron-radiative recombination in the structure due to crystalline imperfections and impurities.

2. The excess density of electrons Δnand holes Δpin an LED is \_\_\_\_\_\_\_\_\_\_\_\_ a) Equal b) Δpmore than Δn c) Δn more than Δp d) Does not affects the LED View Answer

Answer: a Explanation: The excess density of electrons ΔnandΔp (holes) is equal. The charge neutrality is maintained within the structure due to injected carriers that are created and recombined in pairs. The power generated internally by an LED is determined by taking into considering the excess electrons and holes in p- and n-type material respectively.

3. The hole concentration in extrinsic materials is \_\_\_\_\_\_\_\_\_ electron concentration. a) much greater than b) lesser than c) equal to d) negligible difference with View Answer

Answer: a Explanation: In extrinsic materials, one carrier type will be highly concentrated than the other type. Hence in p-type region, hole concentration is greater than electron concentration in context of extrinsic material. This excess minority carrier density decays with time.

4. The carrier recombination lifetime becomes majority or injected carrier lifetime. a) True b) False View Answer

Answer: b Explanation: The initial injected excess electron density and τrepresents the total carrier recombination time. In most cases, Δnis a small fraction of majority carriers and contains all minority carriers. So in these cases, carrier recombination lifetime becomes minority injected carrier lifetime τi.

5. In a junction diode, an equilibrium condition occurs when \_\_\_\_\_\_\_\_\_\_\_\_ a) Δngreater than Δp b) Δnsmaller than Δp c) Constant current flow d) Optical amplification through stimulated emission View Answer

Answer: c Explanation: The total rate at which carriers are generated in sum of externally supplied and thermal generation rates. When there is a constant current flow in this case, an equilibrium occurs in junction diode.

6. Determine the total carrier recombination lifetime of a double heterojunction LED where the radioactive and nonradioactive recombination lifetime of minority carriers in active region are 70 ns and 100 ns respectively. a) 41.17 ns b) 35 ns c) 40 ns d) 37.5 ns View Answer

Answer: a Explanation: The total carrier recombination lifetime is given by

τ = τrτnr/τr+τnr = 70× 100/70 + 100 ns = 41.17 ns Where τr = radiative recombination lifetime of minority carriers τnr = nonradioactive recombination lifetime of minority carriers.

7. Determine the internal quantum efficiency generated within a device when it has a radiative recombination lifetime of 80 ns and total carrier recombination lifetime of 40 ns. a) 20 % b) 80 % c) 30 % d) 40 % View Answer

Answer: b Explanation: The internal quantum efficiency of device is given by ηint = τ/τr = 40/80 ×100 = 80% Where τ = total carrier recombination lifetime τr = radiative recombination lifetime.

8. Compute power internally generated within a double-heterojunction LED if it has internal quantum efficiency of 64.5 % and drive current of 40 mA with a peak emission wavelength of 0.82 μm. a) 0.09 b) 0.039 c) 0.04 d) 0.06 View Answer

Answer: b Explanation: The power internally generated within device i.e. double-heterojunction LED can be computed by Pint = ηint hci/eλ = 0.645×6.626×10-34×3×108×40×10-3/ 1.602×10-19 × 0.82 × 10-6 = 0.039 W Where ηint = internal quantum efficiency h = Planck’s constant c = velocity of light i = drive current e = electron charge λ = wavelength.

9. The Lambertian intensity distribution \_\_\_\_\_\_\_\_\_\_ the external power efficiency by some percent. a) Reduces b) Does not affects

c) Increases d) Have a negligible effect View Answer

Answer: a Explanation: In Lambertian intensity distribution, the maximum intensity I0is perpendicular to the planar surface but is reduced on the sides in proportion to the cosine of θ i.e. viewing angle as apparent area varies with this angle. This reduces the external power efficiency. This is because most of the light is tapped by total internal refraction when radiated at greater than the critical angle for crystal air interface.

10. A planar LED fabricated from GaAs has a refractive index of 2.5. Compute the optical power emitted when transmission factor is 0.68. a) 3.4 % b) 1.23 % c) 2.72 % d) 3.62 % View Answer

Answer: c Explanation: The optical power emitted is given by Pe = PintFn2/4nx2 = Pint (0.680×1/4×(2.5)2) = 0.0272 Pint. Hence power emitted is only 2.72 % of optional power emitted internally. Where, Fn2 = transmission factor nx = refractive index.

11. A planar LED is fabricated from GaAs is having a optical power emitted is 0.018% of optical power generated internally which is 0.018% of optical power generated internally which is 0.6 P. Determine external power efficiency. a) 0.18% b) 0.32% c) 0.65% d) 0.9% View Answer

Answer: d Explanation: Optical power generated externally is given by ηcp = (0.018Pint/2Pint)\*100 Where, Pint = power emitted ηcp = external power efficiency.

12. For a GaAs LED, the coupling efficiency is 0.05. Compute the optical loss in decibels. a) 12.3 dB b) 14 dB

c) 13.01 dB d) 14.6 dB View Answer

Answer: c Explanation: The optical loss in decibels is given by- Loss = -10log10 ηc Where, ηc = coupling efficiency.

13. In a GaAs LED, compute the loss relative to internally generated optical power in the fiber when there is small air gap between LED and fiber core. (Fiber coupled = 5.5 \* 10-4Pint) a) 34 dB b) 32.59 dB c) 42 dB d) 33.1 dB View Answer

Answer: b Explanation: The loss in decibels relative to Pint is given by- Loss = -10log10Pc/Pint Where, Pc = 5.5 \* 10-4Pint.

14. Determine coupling efficiency into the fiber when GaAs LED is in close proximity to fiber core having numerical aperture of 0.3. a) 0.9 b) 0.3 c) 0.6 d) 0.12 View Answer

Answer: a Explanation: The coupling efficiency is given by ηc = (NA)2 = (0.3)2 = 0.9.

15. If a particular optical power is coupled from an incoherent LED into a low-NA fiber, the device must exhibit very high radiance. a) True b) False View Answer

Answer: a Explanation: Device must have very high radiance specially in graded index fiber where Lambertian coupling efficiency with same NA is about half that of step-index fibers. This high

radiance is obtained when direct bandgap semiconductors are fabricated with DH structure driven at high current densities.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “LED Structures”.

1. The amount of radiance in planer type of LED structures is \_\_\_\_\_\_\_\_\_\_\_\_ a) Low b) High c) Zero d) Negligible View Answer

Answer: a Explanation: Planer LEDs are fabricated using liquid or vapor phase epitaxial processes. Here p-type is diffused into n-type substrate which creates junction. Forward current flow through junction provides Lambertian spontaneous emission. Thus, device emits light from all surfaces. However a limited amount of light escapes the structure due to total internal reflection thus providing low radiance.

2. In optical fiber communication \_\_\_\_\_\_\_\_\_\_\_\_\_ major types of LED structures are used. a) 2 b) 4 c) 6 d) 3 View Answer

Answer: c Explanation: Optical fiber communication involves the use of 6 different major LED structure. These are the surface emitter, edge emitter, the super luminescent, the resonant cavity LED, planar LEDs and Dome LEDs.

3. As compared to planar LED structure, Dome LEDs have \_\_\_\_\_\_\_\_\_\_\_\_\_\_ External power efficiency \_\_\_\_\_\_\_\_\_\_\_ effective emission area and \_\_\_\_\_\_\_\_\_\_\_\_\_ radiance. a) Greater, lesser, reduced b) Higher, greater, reduced c) Higher, lesser, increased d) Greater, greater, increased View Answer

Answer: b Explanation: In Dome LEDs, the diameter of dome is selected so as to maximum the internal emission reaching surface within critical angle of GaAs. Thus, dome LEDs have high external power efficiency. The geometry of Dome LEDs is such that dome is much larger than active recombination area, so it has greater emission era and reduced of radiance.

4. The techniques by Burros and Dawson in reference to homo structure device is to use an etched well in GaAs structure. a) True b) False View Answer

Answer: a Explanation: Burros and Dawson provided a technique to restrict emission to small active region within device thus providing high radiance. Etched well in a GaAs substrate is used to prevent heavy absorption of emitted region and physically accommodating the fiber. These structures provide low thermal impedance allowing high current densities of high radiance.

5. In surface emitter LEDs, more advantage can be obtained by using \_\_\_\_\_\_\_\_\_\_\_\_ a) BH structures b) QC structures c) DH structures d) Gain-guided structure View Answer

Answer: c Explanation: DH structures provide high efficiency from electrical and optical confinement. Along with efficiency, they provide less absorption of emitted radiation.

6. Internal absorption in DH surface emitter Burros type LEDs is \_\_\_\_\_\_\_\_\_\_\_\_ a) Cannot be determined b) Negligible c) High d) Very low View Answer

Answer: d Explanation: The larger band gap confining layers and the reflection coefficient at the back crystal space is high in DH surface emitter Burros type LEDs. This provides good forward radiance. Thus these structure LEDs have very less internal absorption.

7. DH surface emitter generally give \_\_\_\_\_\_\_\_\_\_\_\_ a) More coupled optical power b) Less coupled optical power c) Low current densities d) Low radiance emission into-fiber View Answer

Answer: a Explanation: The optical power coupled into a fiber depends on distance, alignment between emission area and fiber, SLED emission pattern and medium between emitting area and fiber.

All these parameters if considered, reduces refractive index mismatch and increases external power efficiency thus providing more coupled optical power.

8. A DH surface emitter LED has an emission area diameter of 60μm. Determine emission area of source. a) 1.534\*10-6 b) 5.423\*10-3 c) 3.564\*10-2 d) 2.826\*10-9 View Answer

Answer: d Explanation: The emission area A of source is given by A = π(30\*10-6) 2= 2.826\*10-9cm2.

9. Estimate optical power coupled into fiber of DH SLED having emission area of 1.96\*10-5, radiance of 40 W/rcm2, numerical aperture of 0.2 and Fresnel reflection coefficient of 0.03 at index matched fiber surface. a) 5.459\*10-5 b) 1.784\*10-3 c) 3.478\*102 d) 9.551\*10-5 View Answer

Answer: d Explanation: The optical power coupler in the step index fiber of SLED is given by Pc = π(1-r) A RD(NA) 2 = 3.14 (1-0.03)\*1.96\*10-5\*40\*(0.2) 2 = 9.551\*10-5W.

10. In a multimode fiber, much of light coupled in the fiber from an LED is \_\_\_\_\_\_\_\_\_\_\_\_ a) Increased b) Reduced c) Lost d) Unaffected View Answer

Answer: c Explanation: Optical power from an incoherent source is initially coupled into large angle rays falling within acceptance angle of fiber but have more energy than Meridional rays. Energy from these rays goes into the cladding and thus may be lost.

11. Determine the overall power conversion efficiency of lens coupled SLED having forward current of 20 mA and forward voltage of 2 V with 170 μWof optical power launched into multimode step index fiber. a) 1.256\*10-5

b) 4.417\*102 c) 4.25\*10-3 d) 2.14\*10-3 View Answer

Answer: c Explanation: The overall power conversion efficiency is determined by η pc = Pc/P = 170\*10-6/20\*10-3\*2 = 4.25\*10-3.

12. The overall power conversion efficiency of electrical lens coupled LED is 0.8% and power applied 0.0375 V. Determine optical power launched into fiber. a) 0.03 b) 0.05 c) 0.3 d) 0.01 View Answer

Answer: a Explanation: Optical power launched can be computed by η pc = Pc/P Pc = η pc\* P = 0.8 \* 0.0375 = 0.03.

13. Mesa structured SLEDs are used \_\_\_\_\_\_\_\_\_\_\_\_ a) To reduce radiance b) To increase radiance c) To reduce current spreading d) To increase current spreading View Answer

Answer: c Explanation: The planar structures of Burros-type LED allow lateral current spreading specially for contact diameters less than 25 μm.This results in reduced current density and effective emission area greater than contact area. This technique to reduce current spreading in very small devices is Mesa structured SLEDs.

14. The InGaAsP is emitting LEDs are realized in terms of restricted are \_\_\_\_\_\_\_\_\_\_\_\_ a) Length strip geometry b) Radiance c) Current spreading d) Coupled optical power View Answer

Answer: a Explanation: The short striped structure of these LEDs around 100 μmimproves the external efficiency of LEDs by reducing internal absorption of carriers. These are also called truncated strip E-LEDs.

15. The active layer of E-LED is heavily doped with \_\_\_\_\_\_\_\_\_\_\_\_ a) Zn b) Eu c) Cu d) Sn View Answer

Answer: a Explanation: Zn doping reduces the minority carrier lifetime. Thus this improves the device modulation bandwidth hence active layer is doped in Zn in E-LEDs.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “LED Characteristics”.

1. Intrinsically \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are a very linear device. a) Injection lasers b) DH lasers c) Gain-guided d) LEDs View Answer

Answer: d Explanation: The ideal light output power against current characteristics for an LED linear. This tends to be more suitable for analog transmission where several constraints are put in linearity of optical source.

2. Linearizing circuit techniques are used for LEDs. a) True b) False View Answer

Answer: a Explanation: In practice, LEDs exhibit nonlinearities depending on configuration used. Thus, to allow its used in high quality analog transmission system and to ensure linear performance of device, linearizing circuit techniques is used.

3. The internal quantum efficiency of LEDs decreasing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ temperature. a) Exponentially, decreasing b) Exponentially, increasing c) Linearly, increasing

d) Linearly, decreasing View Answer

Answer: b Explanation: The light emitted from LEDs decreases. This is due to increase in p-n junction temperature. Thus, this results in exponentially decreasing internal quantum efficiency with temperature increment.

4. To utilize \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of SLDs at elevated temperatures, the use of thermoelectric coolers is important. a) Low-internal efficiency b) High-internal efficiency c) High-power potential d) Low-power potential View Answer

Answer: c Explanation: The output characteristics of SLDs are typically of nonlinear in nature. This is observed with a knee becoming apparent at an operating temperature around 20 degree c. Thus, to utilize high-power potential of these devices at elevated temperature, thermoelectric coolers are necessarily used.

5. For particular materials with smaller bandgap energies operating in \_\_\_\_\_\_\_\_\_\_\_\_\_ wavelength, the linewidth tends to \_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 2.1 to 2.75 μm, increase b) 1.1 to 1.7 μm, increase c) 2.1 to 3.6 μm, decrease d) 3.5 to 6 μm, decrease View Answer

Answer: b Explanation: For materials with smaller bandgap, linewidth increases to 50 to 160 nm. This increases in band gap is due to increased doping levels and formation of bandtail states.

6. The active layer composition must be adjusted if a particular center wavelength is desired. a) True b) False View Answer

Answer: a Explanation:There is a difference in output spectra between surface and edge emitting LEDs when devices have generally heavily doped and lightly doped active layers by reduction in doping.

7. In optical fiber communication, the electrical signal dropping to half its constant value due to modulated portion of optical signal corresponds to \_\_\_\_\_\_\_

a) 6 dB b) 3 dB c) 4 dB d) 5 dB View Answer

Answer: b Explanation: Modulation bandwidth in optical communication is often defined in electrical/optical terms. So when considering electrical circuitry in optical fiber system, electrical 3 dB point or frequency at which output electrical power is reduced by 3 dB bandwidth with respect to input electrical power.

8. The optical 3 dB point occurs when currents ratio is equal to \_\_\_\_\_\_\_\_\_\_\_\_\_ a) 83 b) 22 c) 12 d) 34 View Answer

Answer: c Explanation: In optical regime, the bandwidth is defined by frequency at which output current has dropped to ½ output input current system.

9. The optical bandwidth is \_\_\_\_\_\_\_\_\_\_\_\_\_ the electrical bandwidth. a) Smaller b) Greater c) Same as d) Zero with respect to View Answer

Answer: b Explanation: The difference between optical and electrical bandwidth In terms of frequency depends on the shape of the frequency response of the system. If the system response is assumed to be Gaussian, then optical bandwidth is a factor of √2 greater than electrical bandwidth.

10. When a constant d.c. drive current is applied to device, the optical o/p power is 320 μm. Determine optical o/p power when device is modulated at frequency 30 MHz with minority carrier recombination lifetime of LED i.e. 5ns. a) 4.49\*10-12 b) 6.84\*10-9 c) 1.29\*10-6 d) 2.29\*10-4 View Answer

Answer: d Explanation: The output o/p at 30 MHz is

Pc(30 MHz) = Pdc/(1+(wΓi)2)1/2 = 320\*10-6/(1+(2π\*30\*10-6\*5\*10-9)2)1/2 = 2.29\*10-4W.

11. The optical power at 20 MHz is 246.2 μW. Determine dc drive current applied to device with carrier recombination lifetime for LED of 6ns. a) 3.48\*10-4 b) 6.42\*10-9 c) 1.48\*10-3 d) 9.48\*10-12 View Answer

Answer: a Explanation: The optical output power at 20 MHz is Pe(20 MHz) = Pdc/(1+(WTi)2)1/2 246.2\*10-6 = Pdc/(1+(2π\*20\*10-6\*5\*10-9)2)1/2 Pdc = 3.48\*10-4.

12. Determine the 3 dB electrical bandwidth at 3 dB optical bandwidth Bopt of 56.2 MHz. a) 50.14 b) 28.1 c) 47.6 d) 61.96 View Answer

Answer: b Explanation: The 3dB electrical bandwidth is given by B = Bopt/ √2 = 56.2/2 = 28.1 MHz.

13. The 3 dB electrical bandwidth B is 42 MHz. Determine 3dB optical bandwidth Bopt. a) 45.18 b) 59.39 c) 78.17 d) 94.14 View Answer

Answer: b Explanation: The 3dB electrical bandwidth is B = Bopt/√2 Bopt = B\*√2 = 42\*√2 = 59.39 MHz.

14. Determine degradation rate βrif constant junction temperature is 17 degree celsius. a) 7.79\*10-11 b) 7.91\*10-11

c) 6.86\*10-11 d) 5.86\*10-11 View Answer

Answer: a Explanation: The degradation rate βris determined by βr = β0exp (-Ea/KT) = 1.89\*107exp (-1\*1.602\*10-19/1.38\*10-23\*290) = 7.79\*10-11 h-1.

15. Determine CW operating lifetime for LED with βrt = -0.58 and degradation rate βr = 7.86\*10-11 h-1. a) 32.12

b) 42 c) 22.72 d) 23.223 View Answer

Answer: c Explanation: The CW operating lifetime is given by t = Ln 0.58/7.86\*10-11 = 22.72h-1

**6. Questions on Optical Detectors**

The section contains questions on device types, absorption, optical detection principles, quantum efficiency, semiconductor photodiodes, infrared photodiodes and metal semiconductors

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Device Types”.

1. \_\_\_\_\_\_\_\_\_\_\_\_ converts the received optical signal into an electrical signal. a) Detector b) Attenuator c) Laser d) LED View Answer

Answer: a Explanation: A detector is an essential component of an optical fiber communication system. It dictates the overall system performance. Its function is to convert optical signal into an electrical signal. This electrical signal is then amplified before further processing.

2. The first generation systems of optical fiber communication have wavelengths between \_\_\_\_\_\_\_\_\_\_\_ a) 0.2 and 0.3 μm b) 0.4 and 0.6 μm c) 0.8 and 0.9 μm d) 0.1 and 0.2 μm View Answer

Answer: c Explanation: The first generation systems operated at a bit-rate of 45 Mbps with repeater spacing of 10 km. It operates at wavelengths between 0.8 and 0.9μm. These wavelengths are compatible with AlGaAs laser and LEDs.

3. The quantum efficiency of an optical detector should be high. a) True b) False View Answer

Answer: a Explanation: The detector must satisfy stringent requirements for performance and compatibility. The photo detector thus produces a maximum electrical signal for a given amount of optical power; i.e. the quantum efficiency should be high.

4. Which of the following does not explain the requirements of an optical detector? a) High quantum efficiency b) Low bias voltages c) Small size d) Low fidelity View Answer

Answer: d Explanation: The size of the detector must be small for efficient coupling to the fiber. Also, ideally, the detector should not require excessive bias voltages and currents. The fidelity and quantum efficiency should be high.

5. How many device types are available for optical detection and radiation? a) One b) Two c) Three d) Four View Answer

Answer: b Explanation: Two types of devices are used for optical detection and radiation. These are external photoemission and internal photoemission devices. External photoemission devices are too bulky and require high voltages for operation. Internal devices provide good performance and compatibility.

6. The \_\_\_\_\_\_\_\_\_\_\_ process takes place in both extrinsic and intrinsic semiconductors. a) Avalanche multiplication b) External photoemission c) Internal photoemission d) Dispersion View Answer

Answer: c Explanation: During intrinsic absorption, the received photons excite electrons from the valence band and towards the conduction band in the semiconductor. Extrinsic absorption involves impurity centers created with the material. Generally, intrinsic absorption is preferred for internal photoemission.

7. \_\_\_\_\_\_\_\_\_\_\_\_ are widely used in first generation systems of optical fiber communication. a) p-n diodes b) 4-alloys c) 3-alloys d) Silicon photodiodes View Answer

Answer: d Explanation: The first generation systems operates at wavelengths 0.8 and 0.9 μm. Silicon photodiodes have high sensitivity over the 0.8-0.9 μm wavelength band with adequate speed, long term stability. Hence, silicon photodiodes are widely used in first generation systems.

8. Silicon has indirect band gap energy of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) 1.2 eV b) 2 eV c) 1.14 eV d) 1.9 eV View Answer

Answer: c Explanation: Silicon’s indirect band gap energy of 1.14 eV gives a loss in response above 1.09μm. To avoid this, narrower bandgap materials are used. Hence, silicon’s usefulness is limited to first generation systems and not for second and third generation systems.

9. Which of the following detector is fabricated from semiconductor alloys? a) Photoconductive detector b) p-i-n detector

c) Photodiodes d) Photoemission detectors View Answer

Answer: a Explanation: The detectors fabricated from semiconductor alloys can be used for longer wavelengths. Photoconductive detector and hetero-junction transistor have found favor as a potential detector over a wavelength range of 1.1 to 1.6μm.

10. Silicon photodiodes provide high shunt conductance. a) True b) False View Answer

Answer: b Explanation: Semiconductor photodiodes provide best solution for detection in optical fiber communications. Silicon photodiodes have high sensitivity, negligible shunt conductance and low dark current

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Optical Detection Principles”.

1. P-n photodiode is forward biased. a) True b) False View Answer

Answer: b Explanation: p-n photodiode includes p and n regions. The electric field developed across the p-n junction sweeps holes and electrons to p and n regions respectively. P-n photodiode is thus reverse biased due to reverse leakage current.

2. The depletion region must be \_\_\_\_\_\_\_\_\_\_\_\_ to allow a large fraction of the incident light to be absorbed in the device(photodiode). a) Thick b) Thin c) Long d) Inactive View Answer

Answer: a Explanation: In p-n photodiode, intrinsic conditions are created in the depletion region. The depletion region must be thick in order to achieve maximum carrier pair generation. Also, its width must be limited to enhance the speed of operation of the p-n photodiode.

3. The process of excitation of an electron from valence band to conduction band leaves an empty hole in the valence band and is called as \_\_\_\_\_\_\_\_\_\_\_\_ a) Detection b) Absorption c) Degeneration of an electron-hole pair d) Regeneration of an electron-hole pair View Answer

Answer: d Explanation: A photon is incident in the depletion region of a device has an energy greater than or equal to the band gap energy of the fabricating material. This will cause excitation of an electron from valence to the conduction band. This creates an empty hole in valence band which is referred to as photo-generation of an electron-hole pair.

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ always leads to the generation of a hole and an electron. a) Repulsion b) Dispersion c) Absorption d) Attenuation View Answer

Answer: c Explanation: Absorption affects the electron and excites it to some other level say conduction band. This is called as photo-generation as absorption always leads to the generation of hole and electron. This does not mean that both contribute to the electronic transport.

5. The electron hole pairs generated in a photodiode are separated by the \_\_\_\_\_\_\_\_\_\_\_\_ a) Magnetic field b) Electric field c) Static field d) Depletion region View Answer

Answer: b Explanation: Electric field separates the electron-hole pairs in a photodiode. The electric field distribution is determined by an internal and an external field component. A reverse bias voltage is usually applied to the p-n photodiode.

6. Electric field in the depletion region should be high. a) True b) False View Answer

Answer: a Explanation: The electric field in the depletion region is always kept high in order to extract all

photogenerated carriers. Only the extracted electron hole pairs contribute to the overall photocurrent.

7. The photocurrent of an optical detector should be \_\_\_\_\_\_\_\_\_\_ a) Less b) More c) Linear d) Non-linear View Answer

Answer: c Explanation: A linear relationship must exist between the intensity of the incident light and the photocurrent. This makes the photodiode free of noise. It increases system performance.

8. How many types of optical detectors are available? a) One b) Four c) Two d) Three View Answer

Answer: d Explanation: Three types of optical detectors are available. These are diodes, photoconductors and photo-transistors. Diodes include p-n photodiodes, p-i-n diodes, avalanche photodiodes and schottky diodes.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Absorption”.

1. The absorption of photons in a photodiode is dependent on \_\_\_\_\_\_\_\_\_\_ a) Absorption Coefficient α0 b) Properties of material c) Charge carrier at junction d) Amount of light View Answer

Answer: a Explanation: Absorption in a photodiode is for producing carrier pans. Thus, photocurrent is dependent on absorption coefficient α 0of the light in semiconductor used to fabricate device.

2. The photocurrent in a photodiode is directly proportional to absorption coefficient. a) True b) False View Answer

Answer: a Explanation: The absorption of photons produces carrier pairs. Thus, photocurrent is dependent on absorption coefficient and is given by I = Po e(1-h)/hf(1-exp (-α rd)) Where r = Fresnel coefficient D = width of absorption region.

3. The absorption coefficient of semiconductor materials is strongly dependent on \_\_\_\_\_\_\_\_\_\_ a) Properties of material b) Wavelength c) Amount of light d) Amplitude View Answer

Answer: b Explanation: In some common semiconductors, there is a variation in absorption curves for materials. It is found that they are each suitable for different wavelength and related applications. This is due to difference in band gap energies. Thus absorption coefficient depends on wavelength.

4. Direct absorption requires assistance of photon. a) True b) False View Answer

Answer: b Explanation: Indirect absorption requires photon assistance resulting in conversation of energy and momentum. This makes transition probability less likely for indirect absorption than direct absorption where no photon is included.

5. In optical fiber communication, the only weakly absorbing material over wavelength band required is? a) GaAs b) Silicon c) GaSb d) Germanium View Answer

Answer: c Explanation: The transition over wavelength band in silicon is due to indirect absorption mechanism. This makes silicon weakly absorbent over particular wavelength band.

6. The threshold for indirect absorption occurs at wavelength \_\_\_\_\_\_\_\_\_\_ a) 3.01 μm b) 2.09 μm c) 0.92 μm

d) 1.09 μm View Answer

Answer: d Explanation: The band gap for silicon is 4.10 eV corresponding to threshold of 0.30 μm in ultraviolet. Thus it’s outside wavelength range is the one which is required.

7. The semiconductor material for which the lowest energy absorption takes place is? a) GaAs b) Silicon c) GaSb d) Germanium View Answer

Answer: d Explanation: Germanium absorption is by indirect optical transition. The threshold for direct absorption is at 1.53μm. Below this, germanium becomes strongly absorbing to corresponding link.

8. The wavelength range of interest for Germanium is \_\_\_\_\_\_\_\_\_\_ a) 0.8 to 1.6 μm b) 0.3 to 0.9 μm c) 0.4 to 0.8 μm d) 0.9 to 1.8 μm View Answer

Answer: a Explanation: Germanium is used in fabrication of detectors over the whole wavelength range i.e. first and second generation 0.8 to 1.6 μm while specially taking into consideration that indirect absorption will occur up to a threshold of 1.85 μm.

9. A photodiode should be chosen with a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ less than photon energy. a) Direct absorption b) Band gap energy c) Wavelength range d) Absorption coefficient View Answer

Answer: d Explanation: A photodiode selection must be made by choosing that diode having band gap energy less than photon energy corresponding to longest operating wavelength. This provides high absorption coefficient which ensures a good response and limits the thermally generated carriers to obtain low dark current with no incident light.

10. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ photodiodes have large dark currents. a) GaAs

b) Silicon c) GaSb d) Germanium View Answer

Answer: c Explanation: Germanium photodiodes provide narrow band gaps as compared to other semiconductor materials. This is main disadvantage with use of germanium photodiodes at shorter wavelength and thus they have large dark current.

11. For fabrication of semiconductor photodiodes, there is a drawback while considering \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) GaAs b) Silicon c) GaSb d) Germanium View Answer

Answer: d Explanation: Due to drawback with germanium to be used as fabricating material, there is an increased investigation of direct band gap III and V alloys for longer wavelength region.

12. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ materials are potentially superior to germanium. a) GaAs b) Silicon c) GaSb d) III – V alloys View Answer

Answer: d Explanation: The band gap energies for III – V alloys materials can be tailored to required wavelength. This can be achieved by changing relative concentration of their constituents which results in low dark currents. Thus, III – V alloys are superior potentially to germanium.

13. \_\_\_\_\_\_\_\_\_\_\_\_ alloys such as InGaAsP and GaAsSb deposited on InP and GaSb substrate. a) Ternary b) Quaternary c) Gain-guided d) III – V alloys View Answer

Answer: a Explanation: Ternary alloys are used to fabricate photodiodes for longer wavelength band. Thus, these alloys such as InGaAsP and GaAsSb are deposited on InP and GaSb substrates.

14. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ alloys can be fabricated in hetero-junction structures. a) InGaSb b) III – V alloys c) InGaAsP d) GaAsSb View Answer

Answer: b Explanation: III – V alloys enhances the high speed operations of hetero-junction structures. Thus these structures can be fabricated with III-V alloys.

15. The alloys lattice matched to InP responds to wavelengths up to 1.7μm is? a) InAsSb b) III – V alloys c) InGaSb d) InGaAs View Answer

Answer: d Explanation: Although there were difficulties in growth of IOnGaAs alloys, the problems are now reduced. These alloys lattice matched to InP responding to wavelength around 1.7 μmare widely utilized for fabrication of photodiodes operating around 1.7μm.

This set of Optical Communications Mcqs focuses on “Quantum Efficiency , Responsivity and Long – Wavelength Cut-Off”.

1. The fraction of incident photons generated by photodiode of electrons generated collected at detector is known as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Quantum efficiency b) Absorption coefficient c) Responsivity d) Anger recombination View Answer

Answer: a Explanation: Efficiency of a particular device is obtained by ratio of input given to that of output obtained. Thus, similarly, in photodiode, input i.e. incident photon and output generated electrons and their ratio is quantum efficiency.

2. In photo detectors, energy of incident photons must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ band gap energy. a) Lesser than b) Greater than c) Same as d) Negligible View Answer

Answer: b Explanation: While considering intrinsic absorption process, the energy of incident photon must be greater than band gap energy of material fabricating photo detector.

3. GaAs has band gap energy of 1.93 eV at 300 K. Determine wavelength above which material will cease to operate. a) 2.431\*10-5 b) 6.424\*10-7 c) 6.023\*103 d) 7.234\*10-7 View Answer

Answer: b Explanation: The long wavelength cutoff is given by λc = hc/Eg = 6.6268\*10-34\*2.998\*108/1.93\*1.602\*10-19 = 6.424\*10-7μm.

4. The long cutoff wavelength of GaAs is 0.923 μm. Determine bandgap energy. a) 1.478\*10-7 b) 4.265\*10-14 c) 2.784\*10-9 d) 2.152\*10-19 View Answer

Answer: d Explanation: Long wavelength cutoff of photo detector is given by λc = hc/Eg Eg = hc/λc = 6.6268\*10-34\*2.998\*108/0.923\*10-6 = 2.152\*10-19eV.

5. Quantum efficiency is a function of photon wavelength. a) True b) False View Answer

Answer: a Explanation: Quantum efficiency is less than unity as all of incident photons are not absorbed to create electrons holes pairs. For example quantum efficiency of 60% is equivalent to 60% of electrons collected per 100 photons. Thus efficiency is a function of photon wavelength and must be determined at a particular wavelength.

6. Determine quantum efficiency if incident photons on photodiodes is 4\*1011 and electrons collected at terminals is 1.5\*1011? a) 50% b) 37.5% c) 25%

d) 30% View Answer

Answer: b Explanation: Quantum efficiency is given by Quantum Efficiency = No. of electrons collected/No. of incident photons = 1.5\*1011/4\*1011 = 0.375 \* 100 = 37.5%.

7. A photodiode has quantum efficiency of 45% and incident photons are 3\*1011. Determine electrons collected at terminals of device. a) 2.456\*109 b) 1.35\*1011 c) 5.245\*10-7 d) 4.21\*10-3 View Answer

Answer: b Explanation: Quantum efficiency is given by Quantum efficiency = No. of electrons collected/No. of incident photons Electrons collected = Quantum efficiency \* number of incident photons = 45/100 \* 3\*1011 = 1.35\*1011.

8. The quantum efficiency of photodiode is 40% with wavelength of 0.90\*10-6. Determine the responsivity of photodiodes. a) 0.20 b) 0.52 c) 0.29 d) 0.55 View Answer

Answer: c Explanation: Responsivity of photodiodes is given by R = ηe λ/hc = 0.4\*1.602\*10-19 \* 0.90\*10-6/6.626\*10-34 \* 3\*108 = 0.29 AW-1.

9. The Responsivity of photodiode is 0.294 AW-1at wavelength of 0.90 μm. Determine quantum efficiency. a) 0.405 b) 0.914 c) 0.654 d) 0.249 View Answer

Answer: a Explanation: Responsivity of photodiode is R = ηe λ/hc η = RXhc/eλ = 0.294\*6.626\*10-34\*3\*108/ 1.602\*10-19\*0.90\*108 = 0.405 AW-1.

10. Determine wavelength of photodiode having quantum efficiency of 40% and Responsivity of 0.304 AW-1. a) 0.87 μm b) 0.91 μm c) 0.88 μm d) 0.94 μm View Answer

Answer: d Explanation: The Responsivity of photodiode is R = ηe λ/hc λ = Rhc/ηe = 0.304\*6.626\*10-34\*3\*108/0.4\*1.602\*10-19 = 0.94 μm.

11. Determine wavelength at which photodiode is operating if energy of photons is 1.9\*10-19J? a) 2.33 b) 1.48 c) 1.04 d) 3.91 View Answer

Answer: c Explanation: To determine wavelength, λ = hc/t = 6.626\*10-34\*3\*108/1.9\*10-19 = 1.04 μm.

12. Determine the energy of photons incident on a photodiode if it operates at a wavelength of 1.36 μm. a) 1.22\*10-34J b) 1.46\*10-19J c) 6.45\*10-34J d) 3.12\*109J View Answer

Answer: b Explanation: The wavelength of photodiode is given by λ = hc/t

E = hc/λ

= 6.626\*10-34\*3\*108/1.36\*10-6

= 1.46\*10-19J.

13. Determine Responsivity of photodiode having o/p power of 3.55 μm and photo current of 2.9

μm.

a) 0.451

b) 0.367

c) 0.982

d) 0.816

View Answer

Answer: d

Explanation: The Responsivity of photodiode is

R = Ip/Po

= 2.9\*10-6/3.55\*10-6

= 0.816 A/W.

14. Determine incident optical power on a photodiode if it has photocurrent of 2.1 μA and

responsivity of 0.55 A/W.

a) 4.15

b) 1.75

c) 3.81

d) 8.47

View Answer

Answer: c

Explanation: The Responsivity of photodiode is

R = Ip/Po

Po = Ip/R

= 2.1\*10-6/0.55

= 3.81 μm.

15. If a photodiode requires incident optical power of 0.70 A/W. Determine photocurrent.

a) 1.482

b) 2.457

c) 4.124

d) 3.199

View Answer

Answer: b

Explanation: The Responsivity of photodiode is given by

R = Ip/Po

Ip = R\*Po

= 0.70\*3.51\*10-6

= 2.457μm

This set of Optical Communications Multiple Choice Questions & Answers focuses on

“Semiconductor Photodiodes Without Internal Gain”.

1. The width of depletion region is dependent on \_\_\_\_\_\_\_\_\_\_\_ of semiconductor.

a) Doping concentrations for applied reverse bias

b) Doping concentrations for applied forward bias

c) Properties of material

d) Amount of current provided

View Answer

Answer: a

Explanation: The depletion region is formed by immobile positively and immobile negatively

charged donor and acceptor atoms in n- and p-type respectively. When carriers are swept

towards majority side under electric field, lower the doping, wider the depletion region.

2. Electron-hole pairs are generated in \_\_\_\_\_\_\_\_\_\_\_

a) Depletion region

b) Diffusion region

c) Depletion region

d) P-type region

View Answer

Answer: c

Explanation: Photons are absorbed in both depletion and diffusion regions. The position and

width of absorption region depends on incident photons energy. The absorption region may

extend throughout device in weakly absorption of photons. Thus carriers are generated in both

regions.

3. The diffusion process is \_\_\_\_\_\_\_\_\_\_\_\_\_ as compared with drift.

a) Very fast

b) Very slow

c) Negligible

d) Better

View Answer

Answer: b

Explanation: None.

4. Determine drift time for carrier across depletion region for photodiode having intrinsic region

width of 30μm and electron drift velocity of 105 ms-1.

a) 1×10-10 Seconds

b) 2×10-10 Seconds

c) 3×10-10 Seconds

d) 4×10-10 Seconds

View Answer

Answer: c

Explanation: The drift time is given by

tdrift = w/vd = 30×10-6/1×10-10 = 3×10-10 seconds.

5. Determine intrinsic region width for a photodiode having drift time of 4×10-10 s and electron

velocity of 2×10-10ms-1.

a) 3×10-5M

b) 8×10-5M

c) 5×10-5M

d) 7×10-5M

View Answer

Answer: b

Explanation: The drift time is given by

tdrift = w/vd

4×10-10 = w/2×105

= 4×10-10×2×105

= 8×10-5m.

6. Determine velocity of electron if drift time is 2×10-10s and intrinsic region width of 25×10-

6μm.

a) 12.5×104

b) 11.5×104

c) 14.5×104

d) 13.5×104

View Answer

Answer: a

Explanation: The drift time is given by

tdrift = w/vd

vd = 25×10-6/2×10-10 = 12.5×104ms-1.

7. Compute junction capacitance for a p-i-n photodiode if it has area of 0.69×10-6m2, permittivity

of 10.5×10-13Fcm-1 and width of 30μm.

a) 3.043×10-5

b) 2.415×10-7

c) 4.641×10-4

d) 3.708×10-5

View Answer

Answer: b

Explanation: The junction capacitance is given by,

Cj = εsA/w = 10.5×10-13×0.69×10-6/30×10-13

= 2.415×10-7F.

8. Determine the area where permittivity of material is 15.5×10-15Fcm-1 and width of 25×10-6 and

junction capacitance is 5pF.

a) 8.0645×10-5

b) 5.456×10-6

c) 3.0405×10-2

d) 8.0645×10-3

View Answer

Answer: d

Explanation: The junction capacitance is given by,

Cj = εsA/ w = 5×10-12×25×10-6/15.5×10-15

= 8.0645×10-3m2.

9. Compute intrinsic region width of p-i-n photodiode having junction capacitance of 4pF and

material permittivity of 16.5×10-13Fcm-1 and area of 0.55×10-6m2.

a) 7.45×10-6

b) 2.26×10-7

c) 4.64×10-7

d) 5.65×10-6

View Answer

Answer: b

Explanation: The junction capacitance is given by,

Cj = εsA/ W

w = εsA/Cj

= 16.5×10-13 × 0.55×10-6/4×10-12

= 2.26×10-7.

10. Determine permittivity of p-i-n photodiode with junction capacitance of 5pF, area of

0.62×10-6m2 and intrinsic region width of 28 μm.

a) 7.55×10-12

b) 2.25×10-10

c) 5×10-9

d) 8.5×10-12

View Answer

Answer: b

Explanation: The junction capacitance is given by,

Cj = εsA/ W

εs = Cj w/A = 5×10-12×28×10-6/0.62×10-6

= 2.25×10-10Fcm-1.

11. Determine response time of p-i-n photodiode if it has 3 dB bandwidth of 1.98×108Hz.

a) 5.05×10-6sec

b) 5.05×10-7Sec

c) 5.05×10-7sec

d) 5.05×10-8Sec

View Answer

Answer: c

Explanation: The maximum response time is

Maximum response time = 1/Bm = 1/1.98×108 = 5.05×10-9sec.

12. Compute maximum 3 dB bandwidth of p-i-n photodiode if it has a max response time of 5.8

ns.

a) 0.12 GHz

b) 0.14 GHz

c) 0.17 GHz

d) 0.13 GHz

View Answer

Answer: c

Explanation: The maximum response time is

Maximum response time = 1/Bm

= 1/5.8×10-9 = 0.17 GHz.

13. Determine maximum response time for a p-i-n photodiode having width of 28×10-6m and

carrier velocity of 4×104ms-1.

a) 105.67 MHz

b) 180.43 MHz

c) 227.47 MHz

d) 250.65 MHz

View Answer

Answer: c

Explanation: Maximum 3 dB bandwidth of photodiode is given by

Bm = Vd/2ΠW = 4×10-4/2×3.14×28×10-6 = 227.47 MHz.

14. Determine carrier velocity of a p-i-n photodiode where 3dB bandwidth is1.9×108Hz and

depletion region width of 24μm.

a) 93.43×10-5

b) 29.55×10-3

c) 41.56×10-3

d) 65.3×10-4

View Answer

Answer: b

Explanation: Maximum 3 dB bandwidth of photodiode is given by

Bm = Vd/2ΠW

Vd = Bm × 2Π × W

= 1.98×108×2Π×24×10-6

= 29.55×10-3.

15. Compute depletion region width of a p-i-n photodiode with 3dB bandwidth of 1.91×108and

carrier velocity of 2×104ms-s.

a) 1.66×10-5

b) 3.2×10-3

c) 2×10-5

d) 2.34×104

View Answer

Answer: a

Explanation: Maximum 3 dB bandwidth of photodiode is given by

Bm = Vd/2ΠW

W = Vd/Bm2Π

= 2×10-5/1.91×108×2Π

= 1.66×10-5m

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Semiconductor Photodiodes With Internal Gain”.

1. \_\_\_\_\_\_\_\_\_\_\_ has more sophisticated structure than p-i-n photodiode.

a) Avalanche photodiode

b) p-n junction diode

c) Zener diode

d) Varactor diode

View Answer

Answer: a

Explanation: Avalanche photodiode is second major type of detector in optical communications.

This diode is more sophisticated so as to create a much higher electric field region.

2. The phenomenon leading to avalanche breakdown in reverse-biased diodes is known as

\_\_\_\_\_\_\_

a) Auger recombination

b) Mode hopping

c) Impact ionization

d) Extract ionization

View Answer

Answer: c

Explanation: In depletion region, almost all photons are absorbed and carrier pairs are generated.

So there comes a high field region where carriers acquire energy to excite new carrier pairs. This

is impact ionization.

3. \_\_\_\_\_\_\_ is fully depleted by employing electric fields.

a) Avalanche photodiode

b) P-I-N diode

c) Varactor diode

d) P-n diode

View Answer

Answer: a

Explanation: APD is fully depleted by electric fields more than 104V/m. This causes all the

drifting of carriers at saturated limited velocities.

4. At low gain, the transit time and RC effects \_\_\_\_\_\_\_\_

a) Are negligible

b) Are very less

c) Dominate

d) Reduce gradually

View Answer

Answer: c

Explanation: Low gain causes the dominance of transit time and RC effects. This gives a

definitive response time and thus device obtains constant bandwidth.

5. At high gain, avalanche buildup time \_\_\_\_\_\_\_\_

a) Is negligible

b) Very less

c) Increases gradually

d) Dominates

View Answer

Answer: d

Explanation: High gain causes avalanche buildup time to dominate. Thus the bandwidth of

device decreases as increase in gain.

6. Often \_\_\_\_\_\_\_\_\_\_ pulse shape is obtained from APD.

a) Negligible

b) Distorted

c) Asymmetric

d) Symmetric

View Answer

Answer: c

Explanation: Asymmetric pulse shape is acquired from APD. This is due to relatively fast rise

time as electrons are collected and fall time dictated by transit time of holes.

7. Fall times of 1 ns or more are common.

a) False

b) True

View Answer

Answer: b

Explanation: The use of suitable materials and structures give rise times between 150 and 200 ps.

Thus fall times of 1 ns or more are common which in turn limits the overall response of device.

8. Determine Responsivity of a silicon RAPD with 80% efficiency, 0.7μm wavelength.

a) 0.459

b) 0.7

c) 0.312

d) 0.42

View Answer

Answer: a

Explanation: The Responsivity of a RAPD is given by-

R = ηeλ/hc A/w where, η=efficiency, λ = wavelength, h = Planck’s constant.

9. Compute wavelength of RAPD with 70% efficiency and Responsivity of 0.689 A/w.

a) 6μm

b) 7.21μm

c) 0.112μm

d) 3μm

View Answer

Answer: c

Explanation: The wavelength can be found from the Responsivity formula given by-

R = ηeλ/hc. The unit of wavelength isμm.

10. Compute photocurrent of RAPD having optical power of 0.7 μw and responsivity of 0.689

A/W.

a) 0.23 μA

b) 0.489 μA

c) 0.123 μA

d) 9 μA

View Answer

Answer: b

Explanation: The photocurrent is given byIP=P0R. Here IP = photocurrent, P0=Power, R =

responsivity.

11. Determine optical power of RAPD with photocurrent of 0.396 μAand responsivity of 0.49

A/w.

a) 0.91 μW

b) 0.32 μW

c) 0.312 μW

d) 0.80 μW

View Answer

Answer: d

Explanation: The photocurrent is given by IP = P0R. Here IP = photocurrent, P0 = Power, R =

responsivity.

P0 = IP/R gives the optical power.

12. Determine the Responsivity of optical power of 0.4μW and photocurrent of 0.294 μA.

a) 0.735

b) 0.54

c) 0.56

d) 0.21

View Answer

Answer: a

Explanation: The photocurrent is given by IP = P0R. Here IP = photocurrent, P0 = Power, R =

responsivity.

R = IP/P0 gives the responsivity.

13. Compute multiplication factor of RAPD with output current of 10 μAand photocurrent of

0.369μA.

a) 25.32

b) 27.100

c) 43

d) 22.2

View Answer

Answer: b

Explanation: The multiplication factor of photodiode is given by-

M = I/IP where I = output current, IP = photocurrent.

14. Determine the output current of RAPD having multiplication factor of 39 and photocurrent of

0.469μA.

a) 17.21

b) 10.32

c) 12.21

d) 18.29

View Answer

Answer: d

Explanation: The multiplication factor of photodiode is given by-

M = I/IP where I = output current, IP = photocurrent. I = M\*IP gives the output current inμA.

15. Compute the photocurrent of RAPD having multiplication factor of 36.7 and output current

of 7μA.

a) 0.01 μA

b) 0.07 μA

c) 0.54 μA

d) 0.9 μA

View Answer

Answer: a

Explanation: The multiplication factor of photodiode is given by-

M = I/IP where I = output current, IP = photocurrent. IP = I/M Gives the output current inμA.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Mid Infrared and Far Infrared Photodiodes”.

1. In the development of photodiodes for mid-infrared and far-infrared transmission systems,

lattice matching has been a problem when operating at wavelengths \_\_\_\_\_\_\_\_\_\_\_\_

a) 1 μm

b) Greater than 2 μm

c) 2 μm

d) 0.5 μm

View Answer

Answer: b

Explanation: Lattice matching for alloy materials is obtained at wavelengths above 2 μm. For

example, a lattice-matched alloy material system (GaSb) was utilized in a p-i-n photodiode for

high speed operation at wavelengths up to 2.3 μm.

2. What is generally used to accommodate a lattice mismatch?

a) Alloys

b) Attenuator

c) Graded buffer layer

d) APD array

View Answer

Answer: c

Explanation: The use of indium alloy cause inherent problems of dislocation-induced junction

leakage and low quantum efficiency. To avoid these problems, a compositionally graded buffer

layer is used to accommodate a lattice mismatch.

3. HgCdTe material system is utilized to fabricate long-wavelength photodiodes.

a) True

b) False

View Answer

Answer: a

Explanation: HgCdTe family alloys allow resonant characteristics via hole ionization. Its band

gap energy variation enables optical detection to far-infrared. Thus, this material can be used for

fabrication of long-wavelength photodiodes.

4. Avalanche photodiodes based on HgCdTe are used for \_\_\_\_\_\_\_\_\_\_\_\_\_\_ in both the near and

far infrared.

a) Dispersion

b) Dislocation

c) Ionization

d) Array applications

View Answer

Answer: d

Explanation: Avalanche photodiodes based on HgCdTe are used for array applications. The

materials of APDs based on HgCdTe possess uniform avalanche gain across an array. This

variation in gain is variation in gain is lower in HgCdTe as compared with silicon.

5. The detection mechanism in \_\_\_\_\_\_\_\_\_\_\_\_ relies on photo excitation of electrons from

confined states in conduction band quantum wells.

a) p-i-n detector

b) Quantum-dot photo detector

c) p-n photodiode

d) Avalanche photodiodes

View Answer

Answer: b

Explanation: Quantum-dot photo detector’s detection mechanism involves photo excitation of

electrons. This process of photo excitation in photo detectors is similar to that in the Quantumdot

semiconductor optical amplifier. The dots-in-well in Quantum-dot detector is called as

DWELL structure.

6. When determining performance of a photo detector \_\_\_\_\_\_\_\_\_\_\_ is often used.

a) No. of incident photon

b) No. of electrons collected

c) Responsivity

d) Absorption coefficient

View Answer

Answer: c

Explanation: The expression for quantum efficiency does not include photon energy. Thus for

characterizing performance of photo detector, Responsivity is used.

7. The important parameter for exciting an electron with energy required from valence band to

conduction band is?

a) Wavelength

b) Absorption coefficient

c) Responsivity

d) Band gap energy

View Answer

Answer: a

Explanation: As wavelength of incident photon becomes longer, the photon energy is less than

energy required to excite electron. Mostly parameters of photodiode are dependent on

wavelength.

8. \_\_\_\_\_\_\_\_\_\_ is less than or unity for photo detectors.

a) Absorption coefficient

b) Band gap energy

c) Responsivity

d) Quantum efficiency

View Answer

Answer: d

Explanation: Quantum efficiency determines the absorption coefficient of semiconductor

material of photo detector. It is not all incident photons are absorbed to create electron-hole

pairs. Thus quantum efficiency must be less than unity.

9. There must be improvement in \_\_\_\_\_\_\_\_\_\_ of an optical fiber communication system.

a) Detector

b) Responsivity

c) Absorption Coefficient

d) Band gap energy

View Answer

Answer: a

Explanation: If proper and improved and highly efficient detector is utilized, it will then reduce

the repeated stations. It will also lower down both capital investment and maintenance cost.

This set of Optical Communications online test focuses on “Phototransistors and Metal –

Semiconductor – Metal Photodetectors”.

1. The \_\_\_\_\_\_\_\_\_\_\_\_\_ is photosensitive to act as light gathering element.

a) Base-emitter junction

b) Base-collector junction

c) Collector-emitter junction

d) Base-collector junction and Base-emitter junction

View Answer

Answer: a

Explanation: Base-collector junction is photosensitive in n-p-n phototransistor and act as light

gathering element. This light absorbed affects the base current and gives multiplication of

primary photocurrent in device.

2. A large secondary current \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in n-p-n InGaAs phototransistor is achieved.

a) Between base and collector

b) Between emitter and collector

c) Between base and emitter

d) Plasma

View Answer

Answer: b

Explanation: The photo-generated holes are swept to the base. This increases the forward bias

device. This generates secondary current between emitter and collector.

3. \_\_\_\_\_\_\_ emitter-base and collector-base junction capacitances is achieved by use of heterostructure

along with \_\_\_\_\_\_\_\_\_ base resistance.

a) Low, high

b) High, low

c) Low, low

d) High, negligible

View Answer

Answer: c

Explanation: In hetero-structure, there is low doping level in emitter and collector which is

coupled with heavy doping base. This is due low emitter-base and collector-base junction

capacitance and low base resistance. This allows large current gain.

4. A \_\_\_\_\_\_\_\_ is created by hetero-junction at collector-base junction.

a) Potential barrier

b) Depletion region

c) Parasitic capacitance

d) Inductance

View Answer

Answer: a

Explanation: Potential barrier is created at emitter-base junction by hetero-junction. This

eliminates hole junction from base. This is achieved when junction is forward-biased and

provides good emitter-base efficiency.

5. Phototransistors based on hetero-junction using \_\_\_\_\_\_\_\_\_ material are known as waveguide

phototransistors.

a) InGaP

b) InGaAs

c) InGaAsP/ InAlAs

d) ErGaAs

View Answer

Answer: c

Explanation: Phototransistor using InGaAsP/ InAlAs are known as waveguide phototransistors.

They function as waveguide phototransistors. They function as high performance photo-detectors

at 1.3 micro-meter wavelength. They utilize a passive waveguide layer under active transistor

region.

6. A phototransistor has collector current of 18 mA, incident optical power of 128 μW with a

wavelength of 1.24 μm. Determine an optical gain.

a) 1.407 \*102

b) 19.407 \*102

c) 2.407 \*102

d) 3.407 \*102

View Answer

Answer: a

Explanation: The optical gain is given by-

G0=hcIc/λeP0, where h=Planck’s constant, Ic=collector current, λ=wavelength, P0=incident

optical power.

7. For a phototransistor having gain of 116.5, wavelength of 1.28 μm, optical power 123μW.

Determine collector current.

a) 0.123 mA

b) 0.0149 mA

c) 1.23 mA

d) 0.54 mA

View Answer

Answer: b

Explanation: The collector current is given by-

Ic= G0λeP0/ hc, where h=Planck’s constant, Ic=collector current, λ=wavelength, P0=incident

optical power.

8. The detection mechanism in the \_\_\_\_\_\_\_\_\_\_\_\_ photo-detector includes inter sub-band

transitions.

a) Dwell

b) Set

c) Avalanche

d) Futile

View Answer

Answer: a

Explanation: The inter sub-band transitions are also known as type-2 transitions. It comprises of

mini-bands within a single energy band, The detection mechanism in DWELL photo-detector

includes inter sub-band transitions.

9. Which of the following is the difference between the n-p-n and conventional bipolar

transistor?

a) Electric property

b) Magnetic property

c) Unconnected base

d) Emitter base efficiency

View Answer

Answer: c

Explanation: The n-p-n bipolar transistor differs in the following ways: base is unconnected,

base-collector junction is photosensitive as a light gathering element.

10. The n-p-n hetero-junction phototransistor is grown using \_\_\_\_\_\_\_\_\_\_\_\_\_\_

a) Liquid-phase tranquilizers

b) Liquid-phase epistaxis

c) Solid substrate

d) Hetero poleax

View Answer

Answer: b

Explanation: The technique LPE consists of a thin layer of n-type collector based on a p-type

base layer. Liquid phase epistaxis is used in hetero-junction technology.

11. The \_\_\_\_\_\_\_\_\_\_\_\_\_ at emitter-base junction gives good emitter base injection efficiency.

a) Homo-junction

b) Depletion layer

c) Holes

d) Hetero-junction

View Answer

Answer: d

Explanation: The hetero-junction at the emitter-base junction effectively eliminates hole

injection from the base when the junction is forward biased. This gives good emitter-base

injection efficiency.

12. Waveguide phototransistors utilize a \_\_\_\_\_\_\_\_\_\_\_ waveguide layer under the \_\_\_\_\_\_\_\_\_

transistor region.

a) Active, passive

b) Passive, active

c) Homo, hetero

d) Hetero, homo

View Answer

Answer: b

Explanation: Waveguide phototransistors are based on hetero-junction structure. They function

as high-performance photo-detectors and thus utilize a passive waveguide layer under the active

transistor region.

13. What is the main benefit of the waveguide structure over conventional hetero-junction

phototransistor?

a) High depletion region

b) Depletion width

c) Increased photocurrent, responsivity

d) Low gain

View Answer

Answer: c

Explanation: Waveguide structure offers increased photocurrent. Photocurrent is directly

proportional to the responsivity; thus in turn increases responsivity.

14. Waveguide structure provides high quantum efficiency.

a) True

b) False

View Answer

Answer: b

Explanation: Responsivity and quantum efficiency follow a different path. They are indirectly

proportional to each other. Thus, in waveguide structure, as the responsivity increases, quantum

efficiency remains low.

15. Metal-semiconductor-metal (MSM) photo-detectors are photoconductive detectors.

a) True

b) False

View Answer

Answer: a

Explanation: MSM photo-detectors are the simplest of photo-detectors. It provides the simplest

form of photo-detection within optical fiber communications and are photoconductive.

**7. Questions & Answers on Direct Detection Receiver Performance Considerations**

The section contains questions and answers on noise, receiver noise and structures, fet pre

amplifiers and high performance receivers.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Noise”.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_ refers to any spurious or undesired disturbances that mask the received signal

in a communication system.

a) Attenuation

b) Noise

c) Dispersion

d) Bandwidth

View Answer

Answer: b

Explanation: Noise is an unwanted and undesirable quantity. It affects the received signal in a

communication system. In optical fiber communication systems, noise is due to the spontaneous

fluctuations rather than erratic disturbances.

2. How many types of noise are observed because of the spontaneous fluctuations in optical fiber

communication systems?

a) One

b) Four

c) Two

d) Three

View Answer

Answer: d

Explanation: There are three types of noise because of the spontaneous fluctuations in optical

fiber communication systems. These are thermal noise, the dark current noise and quantum

noise. These noise types are not caused by the electronic interference.

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is caused due to thermal interaction between the free electrons and the

vibrating ions in the conduction medium.

a) Thermal noise

b) Dark noise

c) Quantum noise

d) Gaussian noise

View Answer

Answer: a

Explanation: Thermal noise is basically a spontaneous fluctuation caused due to thermal

interaction of electrons and ions. It is especially prevalent in resistors at room temperature.

Thermal noise is measured in the form of current and is called as thermal noise current.

4. A small leakage current still flows from the device terminals even if there is no optical power

incident on the photo detector.

a) True

b) False

View Answer

Answer: a

Explanation: A reverse leakage current that flows from the device terminals is called as dark

current. This dark current contributes to the total system noise. This gives random fluctuations

about the average particle flow of the photocurrent.

5. \_\_\_\_\_\_\_\_\_\_\_ distribution provides the description the random statistics of light emitted in

black body radiation.

a) Poisson

b) Cumulative

c) Probability

d) Bose-Einstein

View Answer

Answer: d

Explanation: Incoherent light is emitted by independent atoms and therefore there is no phase

relationship between the emitted photons. The property dictates an exponential intensity

distribution which is identical to Bose-Einstein distribution.

6. The probability of zero pairs being generated when a light pulse is present is given by which

of the following equation?

a) P(0/1) = exp(-Zm)

b) P(x) = exp (Zm)

c) P(y) = x (0) + x(1)

d) P(z) = P(-Zm)

View Answer

Answer: a

Explanation: The probability of zero pairs being generated when a light pulse is present is given

by equation –

P (0/1) = exp(-Zm)

Where, P (0/1) represents the system error probability p(e) and Zm is variance of the probability

distribution.

7. The minimum pulse energy needed to maintain a given bit-error-rate (BER) which any

practical receiver must satisfy is known as \_\_\_\_\_\_\_\_\_\_\_

a) Minimal energy

b) Quantum limit

c) Point of reversed

d) Binary signaling

View Answer

Answer: b

Explanation: A perfect photo detector emits no electron-hole pairs in the absence of illumination.

The error probability determines a standardized fundamental limit in digital optical

communications. This limit is termed as quantum limit.

8. A digital optical fiber communication system requires a maximum bit-error-rate of 10-9. Find

the average number of photons detected in a time period for a given BER.

a) 19.7

b) 21.2

c) 20.7

d) 26.2

View Answer

Answer: c

Explanation: The probability of error is given by-

P(e) = exp(-Zm)

Where, Zm = No. of photons

Here P(e) = 10-9, therefore Zm is calculated from above relation.

9. For a given optical fiber communication system, P(e) = 10-9, Zm = 20.7, f = 2.9×1014, η = 1.

Find the minimum pulse energy or quantum limit.

a) 3.9×10-18

b) 4.2×10-18

c) 6.2×10-14

d) 7.2×10-14

View Answer

Answer: a

Explanation: The minimum pulse energy or quantum limit is given by –

Emin = Zmhf/η

Where, Zm = Number of photons

h = Planck’s constant

f = frequency

η = Quantum efficiency.

10. An analog optical fiber system operating at wavelength 1μmhas a post-detection bandwidth

of 5MHz. Assuming an ideal detector and incident power of 198 nW, calculate the SNR (f =

2.99×1014Hz).

a) 46

b) 40

c) 50

d) 52

View Answer

Answer: c

Explanation: The SNR is given by –

S/N = ηP0/2hfB

Where, η = 1 (for ideal detector)

P0 = incident power

h = Planck’s constant

B = Bandwidth.

11. The incident optical power required to achieve a desirable SNR is 168.2nW. What is the

value of incident power in dBm?

a) -37.7 dBm

b) -37 dBm

c) – 34 dBm

d) -38.2 dBm

View Answer

Answer: a

Explanation: Incident power in denoted by P0. It is given by –

P0 = 10log10(P0(watts))

Where P0(watts) = incident power in Watts/milliWatt.

12. In the equation given below, what does τstands for?

Zm = ηP0τ/hf

a) Velocity

b) Time

c) Reflection

d) Refractive index

View Answer

Answer: b

Explanation: In the given equation, Zm is the variance of the probability distribution. The number

of electrons generated in time τis equal to the average of the number of photons detected over

this time period Zm. Hence, τ is the time and P0 is the incident power, ηis the quantum efficiency

and f is the frequency.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Receiver Noise”.

1. Which are the two main sources of noise in photodiodes without internal gain?

a) Gaussian noise and dark current noise

b) Internal noise and external noise

c) Dark current noise & Quantum noise

d) Gaussian noise and Quantum noise

View Answer

Answer: c

Explanation: The two main sources of noise in photodiodes without internal gain are dark current

noise and quantum noise. They are regarded as shot noise on the photocurrent. These noise are

together called as analog quantum noise.

2. The dominating effect of thermal noise over the shot noise in photodiodes without internal

gain can be observed in wideband systems operating in the range of \_\_\_\_\_\_\_\_

a) 0.4 to 0.5 μm

b) 0.8 to 0.9 μm

c) 0.3 to 0.4 μm

d) 0.7 to 0.79 μm

View Answer

Answer: b

Explanation: When the photodiode is without internal avalanche gain, the detector load resistor

and active elements’ thermal noise in the amplifier tends to dominate. It is seen in wideband

systems operating in the 0.8 to 0.9 μmwavelength band. This is because the dark currents in the

silicon diodes can be made very small.

3. A silicon p-i-n photodiode incorporated in an optical receiver has following parameters:

Quantum efficiency = 70%

Wavelength = 0.8 μm

Dark current = 3nA

Load resistance = 4 kΩ

Incident optical power = 150nW.

Bandwidth = 5 MHz

Compute the photocurrent in the device.

a) 67.7nA

b) 81.2nA

c) 68.35nA

d) 46.1nA

View Answer

Answer: a

Explanation: The photocurrent is given by

Ip = ηP0eλ/hc

Where η = Quantum efficiency

P0 = Incident optical power

e = electron charge

λ = Wavelength

h = Planck’s constant

c = Velocity of light.

4. In a silicon p-i-n photodiode, if load resistance is 4 kΩ, temperature is 293 K, bandwidth is

4MHz, find the thermal noise in the load resistor.

a) 1.8 × 10-16A2

b) 1.23 × 10-17A2

c) 1.65 × 10-16A2

d) 1.61 × 10-17A2

View Answer

Answer: d

Explanation: The thermal noise in the load resistor is given by –

it

2 = 4KTB/RL

Where T = Temperature

B = Bandwidth

RL = Load resistance.

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a combination of shunt capacitances and resistances.

a) Attenuation

b) Shunt impedance

c) Shunt admittance

d) Thermal capacitance

View Answer

Answer: c

Explanation: Admittance is a measure of how easily a circuit will allow a current to flow. It is

the inverse of impedance and is measured in Siemens. It is a combination of shunt capacitances

and resistances.

6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is used in the specification of optical detectors.

a) Noise equivalent power

b) Polarization

c) Sensitivity

d) Electron movement

View Answer

Answer: a

Explanation: Noise equivalent power is defined as the amount of incident optical power per unit

bandwidth required to produce an output power equal to detector output noise power.

Noise equivalent power is the value of incident power which gives an output SNR of unity.

7. A photodiode has a capacitance of 6 pF. Calculate the maximum load resistance which allows

an 8MHz post detection bandwidth.

a) 3.9 kΩ

b) 3.46 kΩ

c) 3.12 kΩ

d) 3.32 kΩ

View Answer

Answer: d

Explanation: The load resistance is given by-

RL = 1/2πCdB

Where

B = Post detection bandwidth

Cd = Input capacitance

RL = Load resistance.

8. The internal gain mechanism in an APD is directly related to SNR. State whether the given

statement is true or false.

a) True

b) False

View Answer

Answer: a

Explanation: The internal gain mechanism in an APD increases the signal current into the

amplifier. This improves the SNR because the load resistance and amplifier noise remains

unaffected.

9. \_\_\_\_\_\_\_\_\_\_\_\_ is dependent upon the detector material, the shape of the electric field profile

within the device.

a) SNR

b) Excess avalanche noise factor

c) Noise gradient

d) Noise power

View Answer

Answer: b

Explanation: Excess avalanche noise factor is represented as F (M). Its value depends upon the

detector material, shape of electric field profile and holes and electrons inclusion. It is a function

of multiplication factor.

10. For silicon APDs, the value of excess noise factor is between \_\_\_\_\_\_\_\_\_

a) 0.001 and 0.002

b) 0.5 and 0.7

c) 0.02 and 0.10

d) 1 and 2

View Answer

Answer: c

Explanation: The excess noise factor (K) is same as that of the multiplication factor. In case of

holes, the smaller values of K produce high performance and therefore the performance is

achieved when k is small. For silicon APDs, k = 0.02 to 0.10.

11. \_\_\_\_\_\_\_\_\_\_ determines a higher transmission rate related to the gain of the APD device.

a) Attenuation

b) Gain-bandwidth product

c) Dispersion mechanism

d) Ionization coefficient

View Answer

Answer: b

Explanation: Gain-bandwidth product is defined as Gain multiplied by the bandwidth. Gain is a

dimensionless quantity but the gain-bandwidth product is therefore measured in the units of

frequency.

12. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ APDs are recognized for their high gain-bandwidth products.

a) GaAs

b) Alloy-made

c) Germanium

d) Silicon

View Answer

Answer: d

Explanation: Silicon APDs possess a large asymmetry of electron and hole ionization coefficient.

Thus, they possess high gain-bandwidth products. These APDs do not operate at high

transmission rates.

13. APDs do not operate at signal wavelengths between 1.3 and 1.6μm.

a) True

b) False

View Answer

Answer: a

Explanation: APDs having high gain-bandwidth products do not operate at signal wavelengths

between 1.3 and 1.6 μm.Hence, these APDs are not prefered for use in receivers operating at

high transmission rates.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“FET Pre – Amplifiers”.

1. \_\_\_\_\_\_\_\_\_\_\_\_ is the lowest noise amplifier device.

a) Silicon FET

b) Amplifier-A

c) Attenuator

d) Resonator-B

View Answer

Answer: a

Explanation: FET operates by controlling the current flow with an electric field produced by an

applied voltage on the gate of the device. Silicon FET is fabricated for low noise devices. It is the

lowest noise amplifier device available.

2. FET device has extremely high input impedance greater than \_\_\_\_\_\_\_\_\_

a) 107 Ohms and less than 108

b) 106 Ohms and less than 107

c) 1014 Ohms

d) 1023 Ohms

View Answer

Answer: c

Explanation: FET operation involves the applied voltage on the gate of the device. The gate

draws virtually no current, except for leakage, giving the device extremely high input impedance.

3. The properties of a bipolar transistor are superior to the FET.

a) True

b) False

View Answer

Answer: b

Explanation: bipolar transistor operates by controlling the current flow with an electric field

produced with a base current. The properties of a bipolar transistor are limited by its high transconductance

than the FET.

4. Bipolar transistor is more useful amplifying device than FET at frequencies \_\_\_\_\_\_\_\_\_\_\_\_\_

a) Above 1000 MHz

b) Equal to 1 MHz

c) Below 25 MHz

d) Above 25 MHz

View Answer

Answer: d

Explanation: In FETs, the current gain drops to values near unity at frequencies above 25MHz.

The trans-conductance is fixed with decreasing input impedance. Therefore, bipolar transistor is

more useful amplifying device at frequencies above 25MHz.

5. High-performance microwave FETs are fabricated from \_\_\_\_\_\_\_\_\_\_\_

a) Silicon

b) Germanium

c) Gallium arsenide

d) Zinc

View Answer

Answer: c

Explanation: Since the mid- 1970s, the development of high-performance microwave FETs

found its way. These FETs are fabricated from gallium arsenide and are called as GaAs metal

Schottky field effect transistors (MESFETs).

6. Gallium arsenide MESFETs are advantageous than Silicon FETs.

a) True

b) False

View Answer

Answer: a

Explanation: Gallium arsenide MESFETs are Schottky barrier devices. They operate with both

low noise and high gain at microwave frequencies (GHz). Silicon FETs cannot operate with wide

bands.

7. The PIN-FET hybrid receivers are a combination of \_\_\_\_\_\_\_\_\_\_\_\_\_\_

a) Hybrid resistances and capacitances

b) Pin photodiode and low noise amplifier (GaAs MESFETs)

c) P-N photodiode and low noise amplifier (GaAs MESFETs)

d) Attenuator and low noise amplifier (GaAs MESFETs)

View Answer

Answer: b

Explanation: The PIN-FET or p-i-n/FET receiver utilizes a p-i-n photodiode along with a low

noise preamplifier (GaAs MESFETs). It is fabricated using thick-film integrated circuit

technology. This hybrid integration reduces the stray capacitance to negligible levels.

8. PIN-FET hybrid receiver is designed for use at a transmission rate of \_\_\_\_\_\_\_\_\_\_\_\_\_

a) 130 Mbits-1

b) 110 Mbits-1

c) 120 Mbits-1

d) 140 Mbits-1

View Answer

Answer: d

Explanation: At 140 Mbits-1, the performance of PIN-FET hybrid receiver is found to be

comparable to germanium and alloy APD receivers. A digital equalizer is necessary as the highimpedance

front end effectively integrates the signal at 140 Mbits-1.

9. It is difficult to achieve higher transmission rates using conventional \_\_\_\_\_\_\_\_\_\_

a) Voltage amplifier

b) Waveguide Structures

c) PIN-FET or APD receivers

d) MESFET

View Answer

Answer: c

Explanation: It is difficult to achieve higher transmission rates due to limitations in their gain

bandwidth products. Also, the trade-off between the multiplication factor requirement and the

bandwidth limits the performance of conventional receivers.

10. Which receiver can be fabricated using PIN-FET hybrid approach?

a) Trans-impedance front end receiver

b) Gallium arsenide receiver

c) High-impedance front-end

d) Low-impedance front-end

View Answer

Answer: a

Explanation: Trans-impedance front-end receivers are fabricated using the PIN-FET hybrid

approach. An example of such receivers consists of a GaAs MESFET and two complementary

bipolar microwave transistors.

11. A silicon p-i-n photodiode utilized with the amplifier and the receiver is designed to accept

data at a rate of \_\_\_\_\_\_\_\_\_\_\_

a) 276Mbits-1

b) 274 Mbits-1

c) 278Mbits-1

d) 302Mbits-1

View Answer

Answer: b

Explanation: A silicon p-i-n photodiode is used with the low-noise preamplifier. This

preamplifier is based on a GaAs MESFET. Thus, a receiver using p-i-n photodiode accepts a

data rate of 274 Mbits-1 giving a sensitivity around -35dBm.

12. What is usually required by FETs to optimize the figure of merit?

a) Attenuation of barrier

b) Matching with the depletion region

c) Dispersion of the gate region

d) Matching with the detector

View Answer

Answer: d

Explanation: Total capacitance is given by Ct = Cd + Ca. The figure of merit is optimized when

Cd=Ca. This requires FETs to be matched with the detectors. This requires FETs to be matched

with the detectors. This procedure is usually not welcomed by the device and is not permitted in

current optical receiver design

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“High Performance Receivers”.

1. How many design considerations are considered while determining the receiver performance?

a) Three

b) Two

c) One

d) Four

View Answer

Answer: a

Explanation: Three main considerations are utilized for determining the receiver performance.

Noise performance is a major design consideration providing a limitation to the sensitivity. Other

two considerations are bandwidth and dynamic range.

2. FET preamplifiers provide higher sensitivity than the Si-bipolar device.

a) True

b) False

View Answer

Answer: a

Explanation: At low speeds, the FET preamplifiers provide higher sensitivity than the Si-bipolar

device. It is apparent that below 10Mbits-1the Si MOSFET preamplifier provides a lower noise

performance than GaAs MESFET.

3. What is the abbreviation of HBT?

a) Homo-junction unipolar transistor

b) Homo-junction bipolar transistor

c) Hetero-junction bipolar transistor

d) Hetero-Bandwidth transcendence

View Answer

Answer: c

Explanation: HBT is abbreviated as Hetero-junction bipolar transistor. It comprises a selectively

doped hetero-junction FET. It is a high-speed, low-noise transistor device.

4. What type of receivers are used to provide wideband operation, low-noise operation?

a) APD optical receivers

b) Optoelectronic integrated circuits (OEICs)

c) MESFET receivers

d) Trans-impedance front-end receivers

View Answer

Answer: b

Explanation: A strategy for the provision of wideband, low-noise receivers involves the use of pi-

n photodiode detector along with the monolithic integration of the device with semiconductor

alloy FETs. It has an operating wavelength of 1.1 to 1.6 μmranges.

5. \_\_\_\_\_\_\_\_\_\_\_ circuits extends the dynamic range of the receiver.

a) Monolithic

b) Trans-impedance

c) Automatic Error Control (AEC)

d) Automatic Gain Control (AGC)

View Answer

Answer: d

Explanation: AGC circuit extends the dynamic range by diverting excess photocurrent away

from the input of the receiver. The receiver dynamic range is an important performance

parameter as it provides a measure of the difference between the sensitivity and its overload

level.

6. The sensitivity of the low-impedance configuration is \_\_\_\_\_\_\_\_\_\_\_\_

a) Good

b) Poor

c) Great

d) Same as that of high-impedance configuration

View Answer

Answer: b

Explanation: A receiver saturation level is determined by the value of the photodiode bias

resistor. The photodiode bias resistor valve is indirectly proportional to the sensitivity but is

directly proportional in low impedance configuration. The low resistor value provides less

sensitivity in the low-impedance configuration.

7. What is generally used to determine the receiver performance characteristics?

a) Noise

b) Resistor

c) Dynamic range & sensitivity characteristics

d) Impedance

View Answer

Answer: c

Explanation: Dynamic range and sensitivity characteristics involve a graph of received power

level and the value of feedback resistor. The high value of photodiode bias resistor in the high

impedance front end causes high sensitivity and a narrow dynamic range. These factors prove

useful for determining the performance characteristics of receiver.

8. The \_\_\_\_\_\_\_\_\_\_ technique eliminates the thermal noise associated with the feedback resistor

in the trans-impedance front end design.

a) Compensation

b) Resonating impedance

c) Electromagnetic

d) Optical feedback

View Answer

Answer: d

Explanation: The optical feedback strategy proves most useful at low transmission rate. The use

of optically coupled feedback has demonstrated dynamic ranges of around 40 dB for p-i-n

receivers operating at modest bit rates. It removes thermal noise associated with the feedback

resistor.

9. The removal of the feedback resistor in the optical feedback technique allows reciever

sensitivity of the order of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

a) -54 dBm at 2Mbit/sec

b) -12 dBm at 2Mbit/sec

c) -64 dBm at 2Mbit/sec

d) -72 dBm at 2Mbit/sec

View Answer

Answer: c

Explanation: The removal of feedback resistor in the optical feedback technique allows low

noise performance. Low noise performance, in turn, affects sensitivity. The receiver sensitivity

gets high of the order of -64 dBm at 2Mbit/sec transmission rates.

10. The optical feedback technique is useful at low transmission rates.

a) True

b) False

View Answer

Answer: a

Explanation: The optical feedback technique is useful at low transmission rates because in this

case the feedback resistors employed are smaller than the optimum value for low-noise

performance. This is done to maintain the resistor at a practical size of 1MΩ. Large values of

feedback resistor limits the dynamic range.

11. How many types of optical amplifier technologies are available.

a) One

b) Three

c) Four

d) Two

View Answer

Answer: d

Explanation: There are two basic optical amplifier technologies available. They are

semiconductor optical amplifiers and fiber amplifiers. Both these devices are utilized in the preamplification

role.

12. The optimum filter bandwidth is typically in the range \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

a) 0.1 to 0.3 nm

b) 0.5 to 3 nm

c) 0.1 to 0.3 μm

d) 0.5 to 3 μm

View Answer

Answer: b

Explanation: The optimum fiber bandwidth is determined by detector noise, transmission rate

and the transmitter chirp characteristics. It is typically in the range of 0.5 to 3 nmas it depends

upon the filter insertion loss.

**8. Questions on Optical Amplification , Wavelength Conversion and Regeneration**

The section contains questions and answers on semiconductor optical amplifiers, fiber and

waveguide amplifiers and conversion.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Optical Amplifiers – Semiconductor Optical Amplifiers”.

1. For linear as well as in nonlinear mode \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are most important network

elements.

a) Optical amplifier

b) Optical detector

c) A/D converter

d) D/A converters

View Answer

Answer: a

Explanation: In single-mode fiber system, signal dispersion is very small, hence there is

attenuation. These systems don’t require signal regeneration as optical amplification is sufficient

so optical amplifier are most important.

2. The more advantages optical amplifier is \_\_\_\_\_\_\_\_\_\_\_\_

a) Fiber amplifier

b) Semiconductor amplifier

c) Repeaters

d) Mode hooping amplifier

View Answer

Answer: b

Explanation: Semiconductor optical amplifiers are having smaller size. They can be integrated to

produce subsystems. Thus are more profitable than other optical amplifier.

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cannot be used for wideband amplification.

a) Semiconductor optical amplifier

b) Erbium-doped fiber amplifier

c) Raman fiber amplifier

d) Brillouin fiber amplifier

View Answer

Answer: d

Explanation: Brillouin fiber amplifiers provide a very narrow spectral bandwidth. These

bandwidth can be around 50 MHz, hence cannot be employed for wideband amplification.

4. \_\_\_\_\_\_\_\_\_\_\_\_ is used preferably for channel selection in a WDM system.

a) Semiconductor optical amplifier

b) Erbium-doped fiber amplifier

c) Raman fiber amplifier

d) Brillouin fiber amplifier

View Answer

Answer: d

Explanation: Brillouin fiber provides amplification of a particular channel. This amplification

can be done without boosting other channels besides that particular channel.

5. For used in single-mode fiber \_\_\_\_\_\_\_\_\_\_ are used preferably.

a) Semiconductor optical amplifier

b) Erbium-doped fiber amplifier

c) Raman fiber amplifier

d) Brillouin fiber amplifier

View Answer

Answer: a

Explanation: Semiconductor optical amplifiers have low power consumption. There single mode

structure makes them appropriate and suitable for used in single mode fiber.

6. Mostly \_\_\_\_\_\_\_\_\_\_\_\_ are used in nonlinear applications.

a) Semiconductor optical amplifier

b) Erbium-doped fiber amplifier

c) Raman fiber amplifier

d) FPAs

View Answer

Answer: d

Explanation: FPAs have a resonant nature. This can be combined with their high internal fields.

They provide pulse shaping and bi-stable elements. Thus, are used widely in nonlinear

application.

7. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is superior as compared to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

a) TWA, FPA

b) FPA, TWA

c) EDFA, FPA

d) FPA, EDFA

View Answer

Answer: a

Explanation: In TWA operating in single-pass amplification mode, the Fabry-Perot resonance is

suppressed by facet reflectivity reduction. This affects in increasing of amplifier spectral

bandwidth. This makes them less dependence of transmission characteristics on fluctuations in

biased current, input signal polarization. Thus FPA are superior to TWA.

8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ are operated at current beyond normal lasing threshold current, practically.

a) Semiconductor optical amplifier

b) Erbium-doped fiber amplifier

c) Raman fiber amplifier

d) Brillouin fiber amplifier

View Answer

Answer: a

Explanation: The anti-reflection facet coatings affects in the form of increasing lasing current

threshold. This causes SOAs to be operated at current beyond normal lasing threshold current.

9. An uncoated FPA has peak gain wavelength 1.8μm, mode spacing of 0.8nm, and long active

region of 300 v. Determine RI of active medium.

a) 4.25×106

b) 3.75×107

c) 3.95×107

d) 4.25×109

View Answer

Answer: b

Explanation: n=λ2/2δλL=1.8×10-6/2×0.8×10-9×300×10-6=3.75×107.

10. Determine the peak gain wavelength of uncoated FPA having mode spacing of 2nm,and

250μmlong active region and R.I of 3.78.

a)2.25×10-4

b)4.53×10-8

c)1.94×10-6

d)4.25×109

View Answer

Answer: c

Explanation: The peak gain wavelength is given by

λ2=n2δλL=3.78×2×2×10-9×250×10-6=1.94×10-6m.

11. An SOA has net gain coefficient of 300, at a gain of 30dB. Determine length of SOA.

a) 0.32 m

b) 0.023 m

c) 0.245 m

d) 0.563 m

View Answer

Answer: b

Explanation: The length of SOA is determined by

L = Gs(dB)/10×g×loge = 30/10×300×0.434`= 0.023 m.

12. An SOA has length of 35.43×10-3m, at 30 dB gain. Determine net gain coefficient.

a) 5.124×10-3

b) 1.12×10-4

c) 5.125×10-3

d) 2.15×10-5

View Answer

Answer: c

Explanation: The net gain coefficient of SOA is given by

g = L×10×loge/Gs(dB) = 35.43×10-3×10×0.434/30

=5.125×10-3.

13. An SOA has mode number of 2.6, spontaneous emission factor of 4, optical bandwidth of 1

THz. Determine noise power spectral density.

a) 1.33×10-3

b) 5.13×1012

c) 3.29×10-6

d) 0.33×10-9

View Answer

Answer: a

Explanation: The noise power spectral density Past is

Past = mnsp(Gs-1) hfb

= 2.6×4(1000-1)×6.63×10-34×1.94×1014×1×1012

= 1.33×10-3W.

14. An SOA has noise power spectral density of 1.18mW, spontaneous emission factor of 4,

optical bandwidth of 1.5 THz. Determine mode number.

a) 1.53 × 1028

b) 6.14 × 1012

c) 1.78 × 1016

d) 4.12 × 10-3

View Answer

Answer: a

Explanation: The mode number is determined by

m = Past/nsp(Gs-1) hfB

= 1.18×10-3/4(1000-1)×6.63×10-34×1.94×1014×1.3×1012

= 1.53 × 10-34.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on

“Fiber and Waveguide Amplifiers”.

1. The spectral dependence on gain is always constant.

a) True

b) False

View Answer

Answer: b

Explanation: The spectral dependence on gain is mostly not constant. Thus the spectral

bandwidth for erbium-doped silica fibers is restricted to around 300 GHz.

2. ESA \_\_\_\_\_\_\_\_ the pumping efficiency of device.

a) Increases

b) Does not affects

c) Reduces

d) Has negligible effect on

View Answer

Answer: c

Explanation: In erbium fiber amplifier photons at pump wavelength promotes the electrons in

upper lasing level into a high state of excitation. These electrons decay non-radiate to

intermediate levels and then back to upper lasing level thereby reducing pumping efficiency.

3. Signal amplification is obtained in \_\_\_\_\_\_\_\_\_\_\_\_

a) Erbium-doped fluoro-zir-carbonate fiber multimode

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Brillouin fiber amplifier

View Answer

Answer: a

Explanation: To avoid excited state absorption (ESA). We should use different glass technology

in place by using a 488 nmpump wavelength; erbium-doped multimode fluoro zir carbonate fiber

provides gain at 1.525 μmwavelengths.

4. It is possible to construct a single rare-earth-doped fiber amplifier which provides

amplification for all-bands.

a) True

b) False

View Answer

Answer: b

Explanation: Each material has different absorption emission properties to absorb energy either

in single or multi steps. Also it possesses property to emit light in one or more narrow spectral

ranges. Thus we cannot construct a single earth-doped fiber for all bands.

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is constructed using erbium-doped glass.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Brillouin fiber amplifier

View Answer

Answer: a

Explanation: As compared to other glass, erbium-based micro fiber amplifier is more

advantageous. This amplifier provides high optical gain over just a few centimeters of fiber over

many meters.

6. \_\_\_\_\_\_\_\_\_\_\_\_ uses Er3+-doped erbium glass.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Brillouin fiber amplifier

View Answer

Answer: a

Explanation: The erbium-based micro fiber amplifier uses Er3+-doped erbium glass. It supports

the doping constructions of erbium ions at high levels as compared to conventional glasses.

7. The most advantageous amplification is \_\_\_\_\_\_\_\_\_\_\_\_

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Brillouin fiber amplifier

View Answer

Answer: c

Explanation: As compared to all the amplifications, Raman amplification is more advantageous.

It has self-phase matching between pump of signal together with broad gain bandwidth as

compared to other nonlinear processes.

8. \_\_\_\_\_\_\_\_\_ is also known as lump Raman amplifiers.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Discrete Raman amplifiers

View Answer

Answer: d

Explanation: Discrete Raman Amplifiers are lumped elements. This lumped element is to be

inserted in transmission line to provide gain.

9. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ extends the pump power into transmission line fiber.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Distributed Raman amplification

View Answer

Answer: d

Explanation: In Distributed Raman amplification, all pump power is confined to lumped element.

And it is distributed when the amplification takes place among several kilometers.

10. \_\_\_\_\_\_\_\_\_\_\_\_\_ are called hybrid Raman amplifier.

a) Lumped and distributed Raman Amplifiers

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Distributed Raman amplification

View Answer

Answer: a

Explanation: Lumped and distributed Raman Amplifiers can be combined together to be used in

wideband application. This combination increases overall amplified spectral bandwidth.

11. In \_\_\_\_\_\_\_\_\_\_\_ the ASE contributes most of noise.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Distributed Raman amplification

View Answer

Answer: d

Explanation: ASE contributes most of noise in Raman Amplification. The common sources of

noise include beating of signal with ASE, mixing, self-phase modulation and cross-plane

modulation.

12. In \_\_\_\_\_\_\_\_\_\_\_\_\_ Rayleigh scattering can be reduced.

a) An erbium-based micro fiber amplifier

b) Rare-earth-doped fiber amplifiers

c) Raman fiber systems

d) Distributed Raman amplification

View Answer

Answer: d

Explanation: Rayleigh scattering adverse effects can be reduced in Raman Amplification. This

can be done by employing two or more stages of amplification over single stage amplification

over fiber.

13. Compute the fiber nonlinear coefficient of a parametric optical amplifier having parametric

peak gain of 63.6 dB, signal power of 1.6W, length 520.

a) 2.78×10-2 W-1km-1

b) 9.61×10-3 W-1km-1

c) 3.25×10-3 W-1km-1

d) 5.61×10-4 W-1km-1

View Answer

Answer: b

Explanation: The fiber nonlinear coefficient can be found by

γ = Gp(dB)-log10(0.25)/Ppl×L × 1/10log10(2.718)2

= 63.6+6/1.6×1.6×520×1/8.7 = 9.61×10-3 W-1km-1.

14. Compute signal power for parametric amplifier having length of 500, nonlinear gain

coefficient 12.6×10-3 W-1km-1 and parametric peak gain of 63.9 dB.

a) 0.245 W

b) 0.012 W

c) 0.19 W

d) 0.342 W

View Answer

Answer: b

Explanation: Signal power is given by

Pp=Gp(dB)-log10(0.25)/γL× 1/10log10(2.718)2= 63.9+6/12.6×10-3×1/ 8.7

= 0.012 W.

15. Compute the gain of parametric amplifier having signal power of 1.6W, length of 500, nonlinear

coefficient of 10.19 \* 10-3W-1km-1.

a) 34.890

b) 19.15

c) 18.22

d) 16.11

View Answer

Answer: c

Explanation: Quadratic gain is given by-

Gp(dB)=10log10(γPplL)2

Where L=length of amplifier

Ppl=signal power

γ=nonlinear coefficient.

This set of Optical Communications online quiz focuses on “Wavelength Conversion and Optical

Regeneration”.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is defined as a process by which the wavelength of the transmitted

signal is changed without altering the data carried by the signal.

a) Wavelength conversion

b) Attenuation

c) Sigma management

d) Wavelength dispersion

View Answer

Answer: a

Explanation: Wavelength conversion observes the changes in the length of the wave. It does not

proportionate with the data carried by the signal or wave.

2. The device which is used to perform wavelength conversion is called as \_\_\_\_\_\_\_\_\_\_\_

a) Attenuator

b) Wavelength Gyrator

c) Wavelength Circulator

d) Wavelength translator

View Answer

Answer: d

Explanation: Wavelength translator changes the frequency of the wave and hence it is also called

as frequency changer. It does not affect the data carried by the wave.

3. A wavelength converter is termed as \_\_\_\_\_\_\_ if the converted wavelength is longer than the

original signal wavelength.

a) Down converter

b) Up converter

c) Attenuator

d) Shifter

View Answer

Answer: b

Explanation: A wavelength converter is capable of receiving an incoming signal at any

wavelength at the input port and produces output at the output port. A converter is termed as up

converter when the output signal wavelength is longer than the original signal wavelength.

4. The \_\_\_\_\_\_\_\_\_\_\_ converters cannot process different modulation formats.

a) Shifting

b) Optoelectronic wavelength

c) Opt-circular

d) Magnetic simulating

View Answer

Answer: b

Explanation: In optoelectronic wavelength converters, the information contained in the intensity,

frequency, phase of the signal is required to be reprocessed for the purpose of wavelength

conversion. It does not process all the modulation formats.

5. The optical medium, in case of optical wavelength conversion is \_\_\_\_\_\_\_\_\_\_\_

a) Depleted

b) Linear

c) Non-linear

d) Dispersive

View Answer

Answer: c

Explanation: The implementation of optical wavelength conversion involves non-linearity of the

optical medium. It can be either active or passive, each providing different nonlinear effects.

6. The process of imposing the nonlinear response of the medium onto the control signal is

known as \_\_\_\_\_\_\_\_\_\_\_\_\_\_ scheme.

a) Demodulation

b) Absorption

c) Cross-modulation

d) Repeater mixing

View Answer

Answer: c

Explanation: The cross-modulation scheme involves changes produced due to the intensity

variation of the intensity-modulated input signal. It takes place in the active cavity.

7. How many approaches are adopted by the cross-modulation scheme?

a) Four

b) Three

c) Two

d) Five

View Answer

Answer: a

Explanation: Based on the properties of the nonlinear medium, the cross-modulation scheme can

be divided into four main approaches. These are cross-gain modulation, cross-phase modulation,

cross-absorption modulation, differential polarization modulation.

8. \_\_\_\_\_\_\_\_\_\_ wavelength converters make use of a passive optical medium to exploit nonlinear

effects.

a) Bipolar

b) Optoelectronic

c) Magnetic

d) Coherent

View Answer

Answer: d

Explanation: The nonlinear effects include four-wave mixing and difference frequency

generation. Coherent wavelength converters use a passive medium to extend the changes of

nonlinear effects.

9. A \_\_\_\_\_\_\_\_\_\_\_\_\_ wavelength converter utilizes the nonlinear properties of a semiconductor

optical amplifier to perform the conversion process.

a) Cross-gain modulation

b) Cross-phase modulation

c) Cross-absorption modulation

d) Differential polarization modulation

View Answer

Answer: a

Explanation: Cross-gain modulation wavelength converter is also called as XGM wavelength

converter. It uses semiconductor optical amplifier(SOA) along with its nonlinear properties for

the conversion process.

10. The intensity modulated data on one signal wavelength is called as \_\_\_\_\_\_\_

a) Dispersed data

b) Pump signal

c) Probe signal

d) Frequency signal

View Answer

Answer: b

Explanation: Pump signal is intensity modulated data. It produces variations in the carrier density

within the SOA which provides inverted gain modulation in the SOA medium.

11. The probe signal is inverse to that of the pump signal.

a) True

b) False

View Answer

Answer: a

Explanation: The gain modulations of the pump signal are imprinted onto the probe signal. Thus,

the probe signal acquires the inverse copy of the pump signal, thereby contributing to the

wavelength conversion with the pump signal.

12. In the XGM converter, the transfer function maintains the rectangular shape.

a) True

b) False

View Answer

Answer: b

Explanation: By default, the ideal transfer function should be rectangular in shape. But it does

not apply the same for XGM converter as the amplitude gradually decreases.

13. The speed of operation of XGM wavelength conversion is determined by the

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the SOA.

a) Depletion level

b) Hole concentration

c) Carrier dynamics

d) Electron concentration

View Answer

Answer: c

Explanation: The carrier dynamics deals with the interaction time between the input and the

probe signal. On increasing the interaction time, the speed of operation of XGM wavelength

conversion is increased.

14. \_\_\_\_\_\_\_\_\_\_\_\_ is defined as the deviation in the emission frequency with respect to time

when a laser is driven by a time-varying current source.

a) Intensity probe

b) Dispersion

c) Attenuation

d) Frequency chirp

View Answer

Answer: d

Explanation: Frequency chirp occurs during the process of XGM and XPM. It is often termed as

instantaneous frequency variation.

15. When frequency chirp shifts the optical frequency towards the shorter wavelength, it is

known as \_\_\_\_\_\_\_\_

a) Red shift

b) Green shift

c) Yellow shift

d) Blue shift

View Answer

Answer: d

Explanation: When frequency chirp shifts the optical frequency towards the shorter wavelength,

it is known as blue shift. Similarly, when frequency chirp shifts the optical frequency towards the

longer wavelength, it is known as red shift.