LIGHT EMITTING DIODE (LED)

Principle

- It is a *'p-n'* junction diode made from directbandgap semiconductor in which electron hole pair recombination results in the emission of photon of wavelenth $\lambda = \frac{hc}{E_g}$.
- ***Injection luminescence*** is the principle used.

Construction

1. A *'n'* type layer is grown on a substrate and a *'p'* type layer is deposited on it by diffusion.
2. Since carrier recombination takes place in the *'p'* layer, it is deposited upper most.
3. For maximum light emission, a metal film anode is deposited at the outer edges of the *'p'* layer.
4. The bottom of the substrate is coated with a metal (gold) film.
5. It reflects most of the light to the surface of the device and also provides cathode connection.
6. Figure 4.17 shows the circuit and symbol of LED.

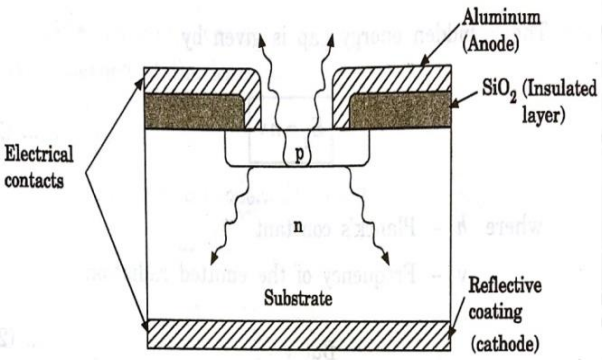

Fig: 4.16. Cross sectional view of LED

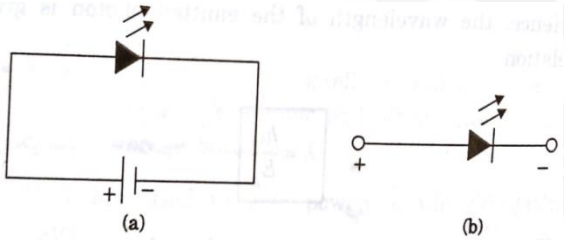

Fig. 4.17 Circuit and symbol of LED

Working

1. *'p-n'* junction diode is forward biased.
2. Now, electrons from *'n'* region and holes from *'p'* region are move towards the junction.
3. So the depletion region (junction) is reduced.
4. When we increase the forward bias, electrons and holes will cross the junction and recombine with each other.

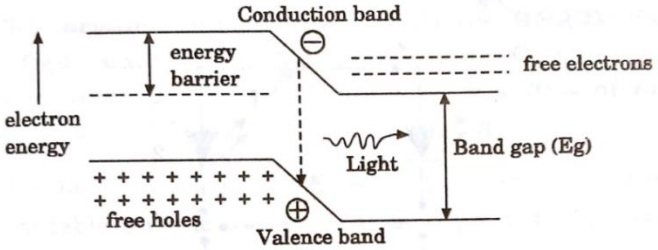

Fig: 4.18 Energy band for LED

5. If one electron meets a hole, recombination takes place and one photon is emitted.
6. Emitted photon will strike another electron or hole to recombine.
7. It is a chain reaction, likewise large number of recombinations takes place and large number of photons are emitted.
8. All these photons are reflected from reflective coating grow in strength.
9. After enough strength high intensity light is coming out.

Advantages

1. It is very small in size. 2. Different colours of display. 3. Its cost is low.
4. It works under a wide range of temperature. 5. It is a very wide range of operation.
6. It has long life time. 7. It can be operated even at very low voltage.
8. Its intensity can be controlled easily. 9. Dome shaped LED has less scattering losses.

Disadvantages

1. Power output is low. 2. Intensity is less than laser. 3. The light will not have directionality.
4. The light cannot travel through longer distances.

Applications

1. These are used in numeric and alphanumeric display devices. 2. They are used as pilot light.
3. They are used as indicator lamps. 4. Infrared LEDs are used in burglar alarms.
5. They are used in wireless communication.

ORGANIC LED (OLED)

- Organic Light Emitting Diode, shortly called OLED is new type of electronic device which emits light, consuming very less energy.
- It overcomes the drawback of LCD, in which we suffer from poor viewing angle.

Principle

- An organic light emitting diode (OLED) is light emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current.

Construction

1. The 2 - layer OLED consists of a cathode and an anode, in between which we have two organic layers. 1. Emissive layer
   2. Conductive layer, made up of different conductivities.
2. All the layers are grown over a transparent substrate, through which the light has to be emitted.
3. Necessary biasing is given for the OLED, in which such a way that the anode is given positive and the cathode is given negative as shown in above figure.

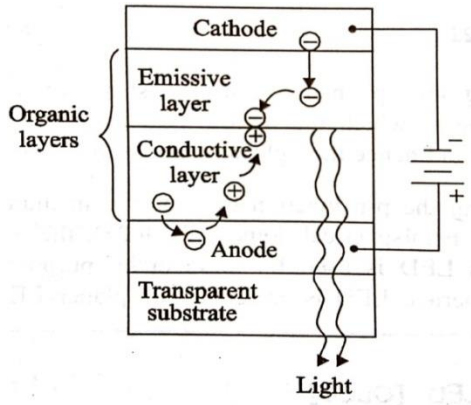

Fig. 4.24

Working

1. Voltage is applied across the OLED.
2. Due to the applied voltage, the cathode gives electrons to the emissive layer.
3. The anode attracts an electron from the conductive layer and creates a hole in the conductive layer as in fig.
4. Thus, anode gives an electron and a hole.
5. After sometimes, the emissive layer is having large number of electrons and the conductive layer having large number of holes.
6. Due to electrostatic forces between these electrons and holes, they come closer and recombine with each other.
7. The recombination occurs closer to the emissive layer because electrons are less mobile than the holes.
8. This process producing light in emissive region after there has been a drop in energy levels of the electrons.
9. This light is emitted through the transparent substrate as shown in figure.

Advantages

1. It has more advantages than CRT, LCD and LEDs. 2. They are light in weight.
3. Light emission is brighter than normal LED's. 4. OLED's do not require backlighting like LCD's
5. They have large field of view (about 170^0) 6. It consumes very less power.
7. It gives high resolution. 8. Up to 20% to 50% Cheaper than LCD Processes.
9. It is very thin and more flexible.

Disadvantages

1. OLED's can be easily damaged when water falls on it.
2. Blue OLED have less life time when compared to Red OLED.
3. Maintenance cost is high. 4. Manufacturing Cost is high.

Applications

- OLED's are used in

1. Mobile phone screens 2. Used in digital cameras. 3. Used in MP3 Players.
4. Used in Car radios 5. TV screens and computer monitors.
6. Automotive dash boards and backlight in cars. 7. Flexible display boards for displaying videos.

8. In future, news papers also may have OLED displays to refresh us with the latest or breaking news.

LASER DIODES

Principle:

- It is a specially fabricated p-n diode. It emits laser light when it is forward biased.

Construction:

1. Figure shows the basic construction of the homo-junction semiconductor laser.
2. The active medium is a p-n junction diode made from a single crystal of gallium arsenide (GaAs).
3. This crystal is cut in the form of a platelet having thickness of 0.5 mm.
4. The platelet consists of two regions N - region and P - region.
5. The metal electrodes are connected to both upper (n – region) and lower (p – region) surfaces of the semiconductor diode.
6. The forward bias voltage is applied through metal electrodes.
7. The photon emission is stimulated in a very thin layer of p-n junction (in the order of few microns).
8. The end faces of the pn junction diode are well polished and parallel to each other. They act as an optical resonator through which the emitted light is coming out.

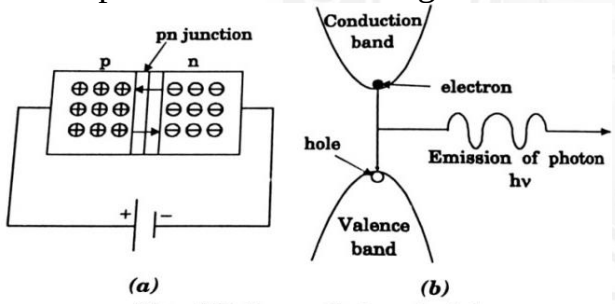

Fig. 4.21 Laser diode principle

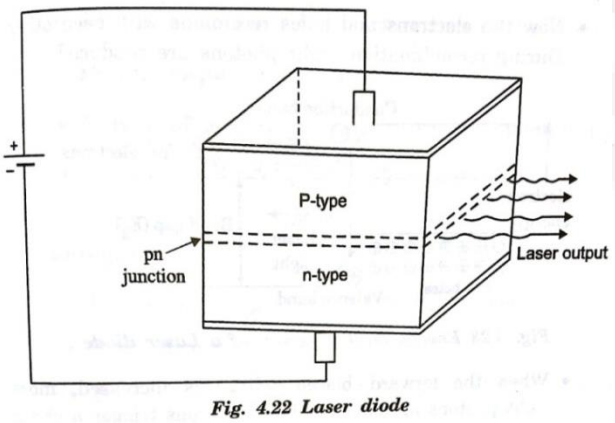

Fig. 4.22 Laser diode

Working:

1. Figure shows the energy level diagram of homo-junction semiconductor laser.
2. When the p-n junction is forward biased the electrons and holes are injected towards junction.
3. The region around junction contains large number of electrons in n-region (conduction band) and large amount of holes in the p-region (valance band).

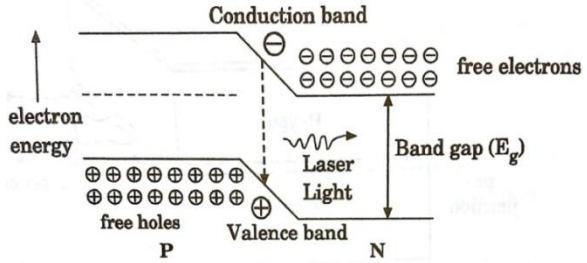

Fig. 4.23 Energy level diagram of a Laser diode

4. Now the electrons and holes recombine with each other.
5. During recombination, light photons are produced.
6. When the forward bias voltage is increased, more light photons are emitted.
7. These photons trigger a chain of stimulated recombinations resulting in the emission of more light photons in phase.
1. These photons travel back and forth between two polished surfaces of the junction. Thus the light photons grow in strength.
2. After gaining enough strength, laser beam of wavelength 8400 A^0 is emitted from the junction.

➢ The wavelength of laser light is given by,

$$E_g = h\vartheta = \frac{hc}{\lambda}\left(\because \vartheta = \frac{c}{\lambda}\right)$$

$$\therefore \lambda = \frac{hc}{E_g} where, E_g \rightarrow bandgapenergyinjoule$$

Advantages

1. This laser is very small in size and compact.
2. It has high efficiency.
3. It has longer life time.
4. Emitted laser light has high directionality.
5. Power output is very high.
6. It emits a continuous wave output
7. It requires very little additional equipments.
8. The laser output can be easily increased by increasing the junction current.

Disadvantages

1. Laser output beam has large divergence.
2. The purity and monochromacity are poor.
3. It has poor coherence and stability.

Applications:

1. This laser is widely used in fiber optic communication.
2. It is used in laser printers and CD plyers.
3. It is used to heal the wounds by infrared radiation.
4. It is also used as a pain killer.
5. Used in laser medicine especially dentistry.

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