SEMICONDUCTOR DIODE LASER

There are two types of semiconductor lasers. They are,

1. Homo-junction Semiconductor laser 2. Hetero-junction Semiconductor laser

Homo-junction Semiconductor laser

Definition:

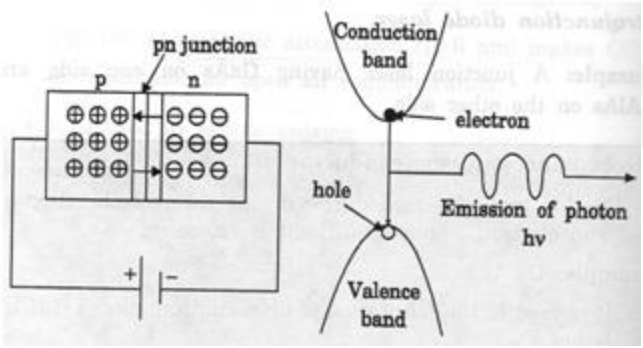
If the p-n junction is formed in a single crystalline material, then it is called as homo-junction laser.

Ex: Single crystal of Gallium Arsenide (GaAs).

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

Principle:

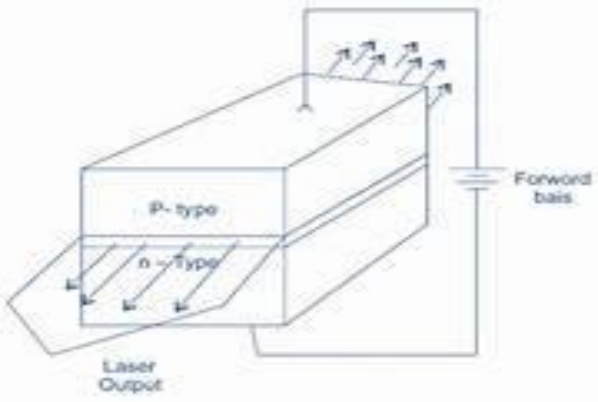
The electrons in the n-region recombine with the holes in the p-region when it is forward biased. During recombination they emit radiations in the form of light. This photon induces other charges, hence stimulated emission takes place which leads to laser light.



Construction:

Figure shows the basic construction of the semiconductor laser. The active medium is a single crystal of gallium arsenide. It is cut in the form of a platelet having a thickness of 0.5 mm.

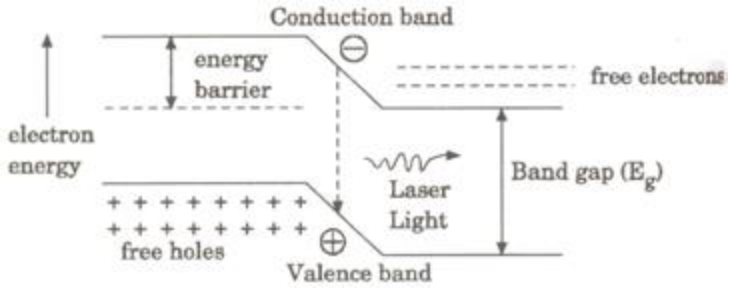
The platelet have two region p region and n region. The thickness of the p-n junction layer is very thin, so that the emitted radiations have less divergence. The end faces of the junction diode are polished well and kept parallel. They act as optical resonator through which the emitted light is coming out.



Working:

The p-n junction is forward biased. The electrons and holes are injected into the junction region.

The region around the junction contains large amount of electrons within the conduction band and large amount of holes in the valence band. If population inversion is achieved the electrons and the holes recombine each other and produces radiation in the form of light.



When the forward bias is increased, more and more photons are produced and it stimulates the recombination process in the release of photons in phase. The photons moving at the plane of the junction travels back and forth to grow its strength. After gaining enough strength, it gives out the laser beam of wavelength 8400 A^0.

The wavelength of laser light is given by

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

$$\boxed{\lambda = \frac{hc}{E_g}}$$

$$where, E_g \rightarrow band\ gap\ energy\ in\ joule$$

Advantages

1. This laser is very small in size and compact.
2. It has high efficiency.
3. The laser output can be easily increased by increasing the junction current.
4. It is operated with less power than ruby and CO_2 lasers.
5. It requires very little additional equipments.
6. It emits a continuous wave output or pulsed output.

Disadvantages

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

Applications:

- It is used in fiber optic communication.
- It is used to produce coherent laser diodes.
- It is used to heal the wounds of IR radiation
- It can be used as a pain killer.
- It is used in printers for computer printouts.

Hetro junction semiconductor laser:

Definition:

If the p-n junction is made up of the different material with two regions, n-type and p-type is called as hetero-junction laser. Ex: hetero-junction laser can be formed between **GaAs** and **GaAlAs**.

Principle:

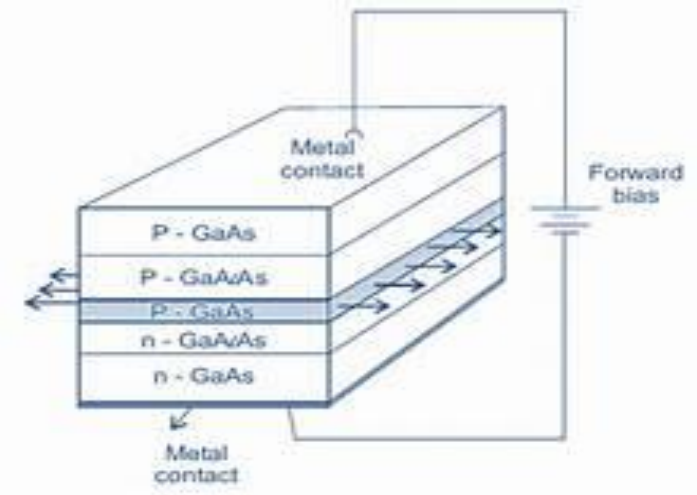
The electron in conduction band combines with a hole in the valence band and hence the recombination of electron and hole produces energy in the form of light. This photon on turn may produce another electron in the conduction band to valence band and thereby stimulate the emission of another photon.

Construction:

It consists of five layers. A layer of Ga-As .P-type (3^{rd} layer) will act as the active region. This layer is sandwiched between the two layer having wider band gap.

GaAlAs-p-type (2^{nd} layer) and GaAlAs n-type (4^{th} layer).Electric current applied to the crystal through the electrode which is fixed on the top and bottom

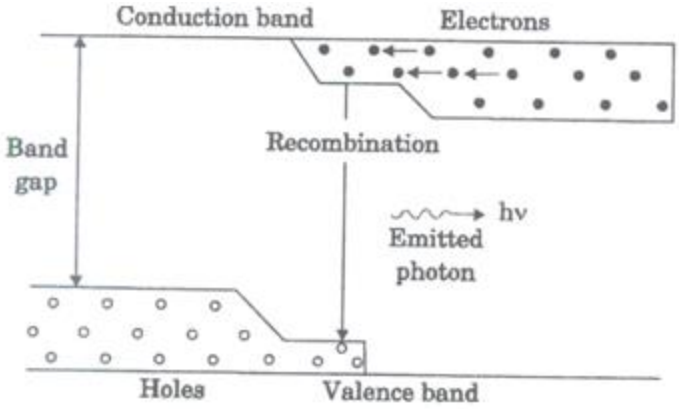
layer. The end faces of the junctions of 3rd and 4thlayer are well polished and parallel to each other. They act as the optical resonator.



Working:

When the p-n junction is forward biased to the charge carriers are produced in the wide band gap layers (2nd and 4th layer). These charge carriers are injected the active region (3rd layer).The charge carriers are continuously injected from 2nd and 4 th layer to 3ed layer until the population inversion is achieved.

At this state, some of the injected charge carriers recombine and produces spontaneously emitted photons. They stimulate the injected charge carriers to emit photon. As a result more number of stimulated emissions arises and this large number of photons is produced. These photons are reflected back and forth at the junction and hence an intense, coherent beam of laser emerges out from the p-n junctions of active region ie, between 3rd and 4th layer. The wavelength of the emitted radiation is nearly $8000A^0$.



Advantages:

- It produces continuous wave output.
- Power output is very high.

Disadvantages:

- It is very difficult to from different layers of p-n junction.
- Cost is very high.

Applications:

- It is used in optical communications.
- It is used in computers, especially on CD-ROMS.