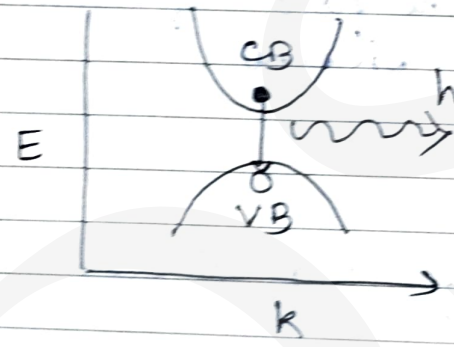
Semiconductor diode Laser (Homojunction)

A specifically fabricated Pn junction diode using direct band material, to emit laser light when forward biased is known as a diode laser or semiconductor injection laser.

PRINCIPLE

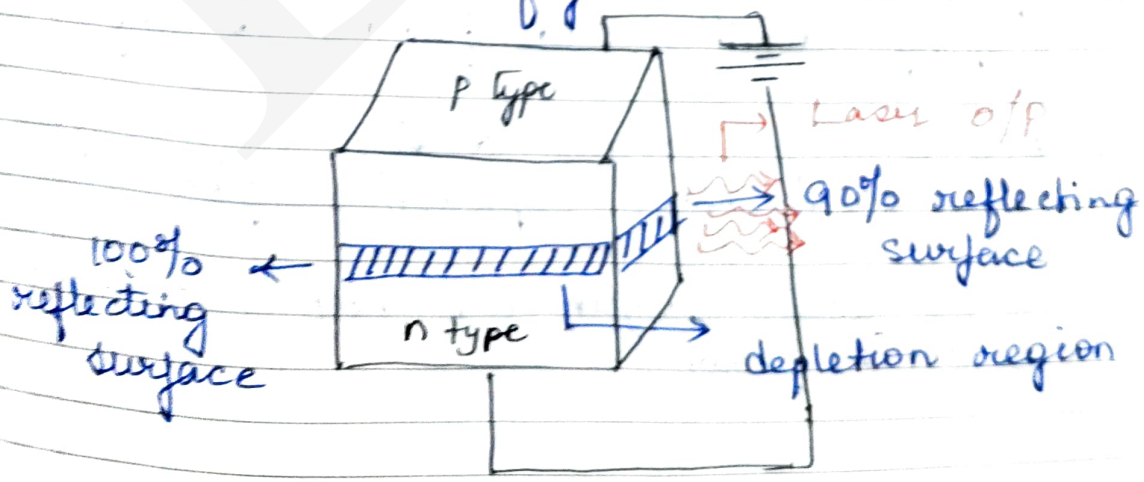
Radiative recombination triggered stimulated emission.

When a pn junction diode made up of direct bandgap material is forward biased, e^- & hole recombine to emit a photon. This photon triggers stimulated emission.



CONSTRUCTION

The basic structure of a Gallium Arsenide (GaAs) pn junction, used as injection laser is shown in figure



1. It consists of heavily doped junction diode in a form of thin rectangular wafer (1 mm x 1 mm x 200 μm)

2. The pair of parallel planes perpendicular to the plane of the junction is polished, while the two remaining sides of the diode are roughened.

3. Since, the refractive index of GaAs is high, it acts as optical resonator so that the external mirrors are not needed.

4. The upper and lower electrodes fixed in the p & n region helps in the flow of current to the diode while biasing.

Working

1. Junction diode is forward biased.
2. Population inversion is achieved
2. Electrons are injected into n region and holes are injected in p region.
3. Population inversion is achieved due to high doping densities and forward biasing.
4. Due to high current density, active region is created near depletion region.
5. In the active region e & hole recombine to emit a photon.

6. Emitted photons stimulate the emission of more photons.

7. These photons are internally reflected several times at the polished walls & once they gain sufficient intensity, they emerge out as LASER light.

8. The wavelength of emitted radiation depends upon —

(i) Band gap of semiconductor

(ii) Concentration of donor & acceptor atoms in GaAs

Eg of GaAs = 1.44 eV

$$\Rightarrow E_g = h\nu = h\frac{c}{\lambda}$$

$$\therefore \lambda = \frac{hc}{E_g} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{1.44 \times 1.6 \times 10^{-19}}$$

$$\lambda = 8626 \text{ Å} \quad (\text{IR region})$$

Characteristics

Type	Homojunction semi conductor laser
Active medium	PN junction diode.
Active centre	recombination / active region
Pumping	Direct pumping [biasing]
optical resonator	Junction of the diode
Power o/p	1 mW
Nature	Pulsed / continuous
λ	8400 – 8600 Å

Advantages

→ Easy to manufacture
→ compact in size (< 1mm)
→ Low cost

Disadvantages

→ Low power o/p
→ Beam has large divergence
→ Mostly pulsed & will be continuous only for sometime.
→ High threshold current density.

Energy level diagram