

UNIT IV

Optical properties of Materials

4.6 LASER Diodes(GaAs)

Characteristics

Active medium	- P-N junction diode
Active centre	- Recombination of electrons and holes
Pumping method	- Direct pumping
Optical Resonator	- Junction of diodes - polished
Power output	- 1 mW
Nature of output waveform	- Pulsed or Continuous
Wavelength	- $8400\text{\AA} - 8600\text{\AA}$
Band gap	- 1.44 eV

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

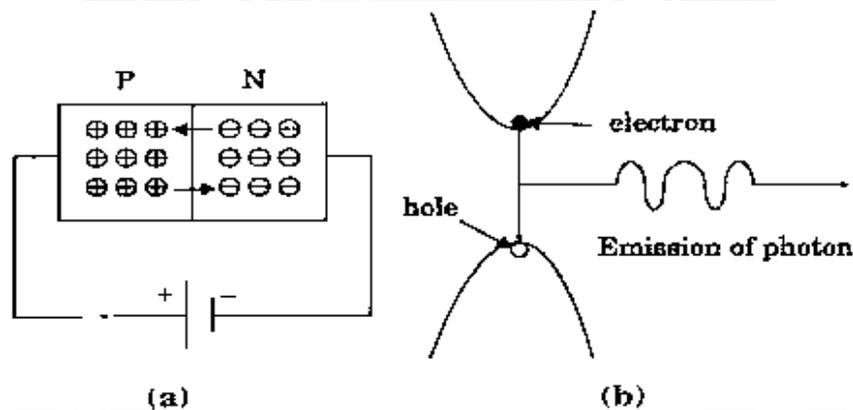
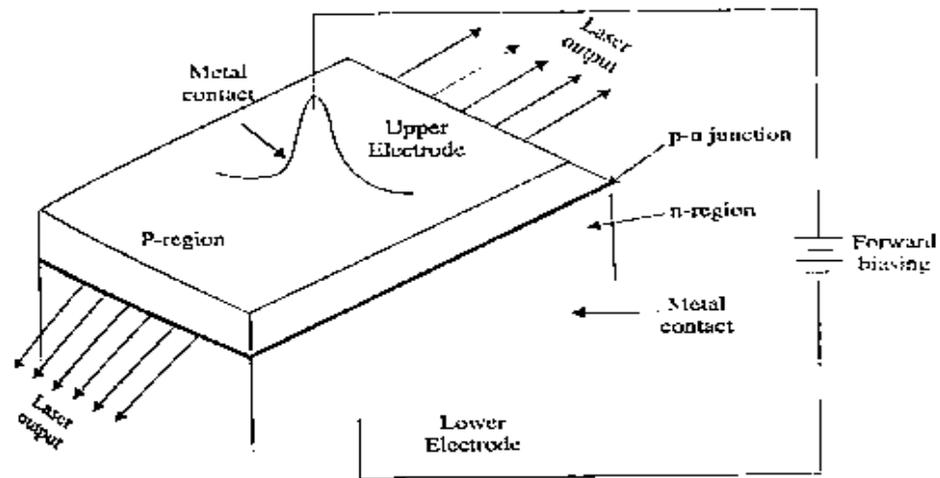
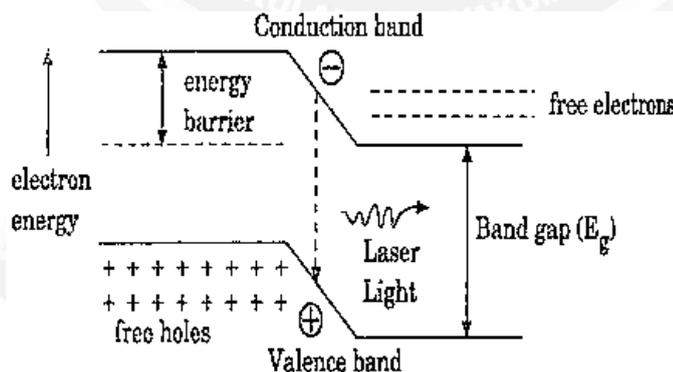


Fig:4.6.1 (a)semiconductor laser principle,(b)Emission of photon

photon, in turn may induce another electron in the conduction band (CB) to valence band(VB) and thereby stimulate the emission of another photon.

Construction:**Fig 4.6.2. Laser Diode**

The active medium is a p-n junction diode made from a single crystalline material i.e. Gallium Arsenide in which p-region is doped with germanium and n-region with Tellurium. The thickness of the p-n junction layer is very narrow so that the emitted laser radiation has large divergence. The junctions of the 'p' and 'n' are well polished and are parallel to each other as shown in figure. Since the refractive index of GaAs is high, it acts as optical resonator so that the external mirrors are not needed. The upper and lower electrodes fixed in the 'p' and 'n' region helps for the flow of current to the diode while biasing.

Working**Fig 4.6.3. Energy band diagram**

1. The population inversion in a p-n junction is achieved by heavily doping 'p' and 'n' materials, so that the Fermi level lies within the conduction band of n type and within the valence band of 'p' type as shown in figure.
2. If, the junction is forward biased with an applied voltage nearly equal to the band gap

voltage, direct conduction takes place. Due to high current density, active region is generated near the depletion region.

3. At this junction, if a radiation having frequency (ν) is made to incident on the p-n junction then the photon emission is produced as shown in figure.
4. Thus the frequency of the incident radiation should be in the range
5. Further, the emitted photons increase the rate of recombination of injection electrons from the n region and holes in p region by inducing more recombination.
6. Hence the emitted photons have the same phase and frequency as that of original inducing photons and will be amplified to get intense beam of LASER.
7. The wavelength of emitted radiation depends on i) the band gap and ii) the concentration of donor and acceptor atoms in GaAs.

Advantages

- i) It is easy to manufacture the diode.
- ii) The cost is low.

Disadvantages

- i) It produces low power output.
- ii) The output wave is pulsed and will be continuous only for some time.
- iii) The beam has large divergence.
- iv) They have high threshold current density.

Applications

1. It is widely used in fibre optic communications
2. It is used to heal the wounds by IR radiation.
3. It is also used as a pain killer.
4. It is used in printers, CD writing and reading.