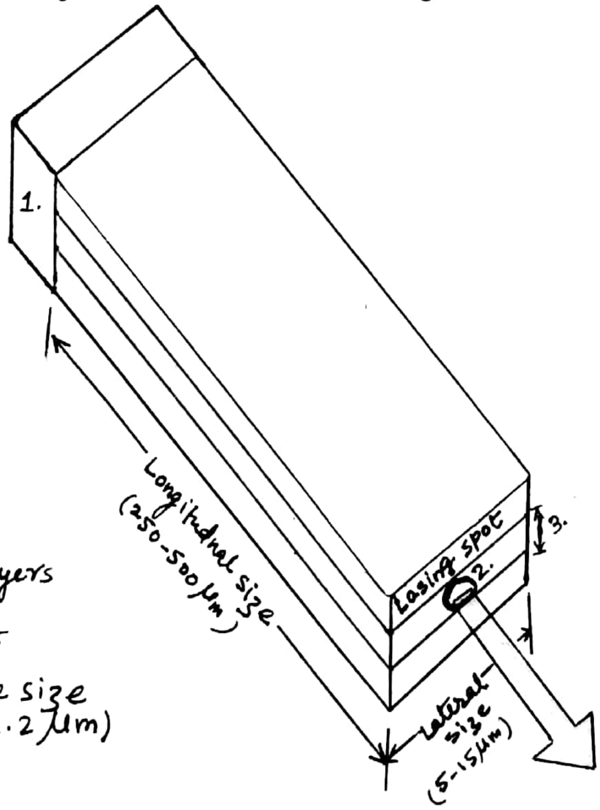
LASER DIODE

(light amplification by stimulated emission of radiation)

Laser diode (semiconductor laser) produces highly monochromatic and highly directional beam of light. However the Laser diode differs from other lasers in that it is small (order of 0.1mm) and is easily modulated at high frequencies simply by modulating the biasing current. Because of these unique properties, the Semiconductor laser is one of the most important light sources for optical-fiber communication. Gallium-Arsenide was the first material to emit laser radiation.

The most commonly used type of Laser diode is "Fabry-Perot resonator cavity". It works on the principle of "Simulated emission".

Fabry Perot cavity Resonator: The constructional details and the various dimensions are shown in figure 1. The formation of Fabry Perot cavity is shown in figure 2.



1. Dielectric Reflecting layers
2. Lasing spot
3. Transverse size (0.1 to 1.2 μm)

Optical o/p to be coupled into the fiber.

Fig 1: Construction

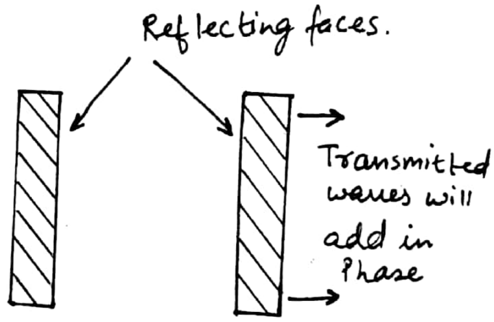


Fig 2: Fabry Perot Resonator cavity

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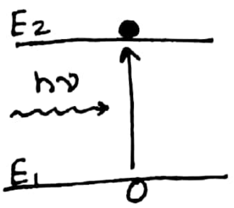
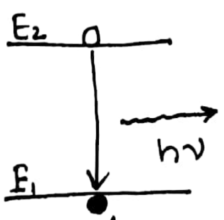
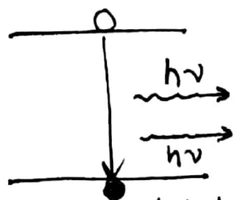
WORKING: Laser action is the result of three main process
a) Absorption b) spontaneous emission c) stimulated emission



a) Absorption



b) spontaneous emission



c) stimulated emission

Lasers works on the principle of stimulated emission of photons. It involves three major steps.

Step 1: Absorption - When a photon having energy $h\nu$ strikes on the device, then an electron in Ground state E_1 absorb the energy and jumps to excited state E_2. This step is called Photon absorption as shown in figure a.

Step 2: spontaneous emission: When electron returns to the ground state from its any unstable excited state E_2, it emits a photon of energy $h\nu$ as shown in figure b. This is called spontaneous emission. In this process there is no external stimulation. These emission are isotropic and random in phase, this type of emission is used in LED's.

Step 3 stimulated emission: when electron is present in its excited state, if a photon of energy $h\nu$ strike on the device when the electron is in still in its excited states, the electron is immediately stimulated to drop to the ground state and give off a photon of energy $h\nu$. This emitted photon is in phase with the incident photon, and the resultant emission is known as stimulated emission as shown in figure c. stimulated emission will exceed absorption only if the population of the excited state is greater than that of the ground state. This condition is known as population inversion.

Simplest example of this type of emission can be understood by considering Fabry-perot resonating cavity. Fabry perot resonat cavity structure is shown in figure 2. It has two partially reflecting mirror surfaces facing each other. This forms the basis of fabry perot cavity. Light get trapped in the cavity and reflects back and forth. The back and forth reflection of Light within the cavity causes the electric field of the Light to interface on Successive round trips.

The wavelength that are at resonant frequencies interface constructively and their amplitude add when they exit the device as shown in figure 2. The resonating wavelength are called "longitudinal modes" of cavity. Since they resonate along the length of the cavity.

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figure 3. shows the behaviour of the resonatat wavelength for three values of mirror respectively.

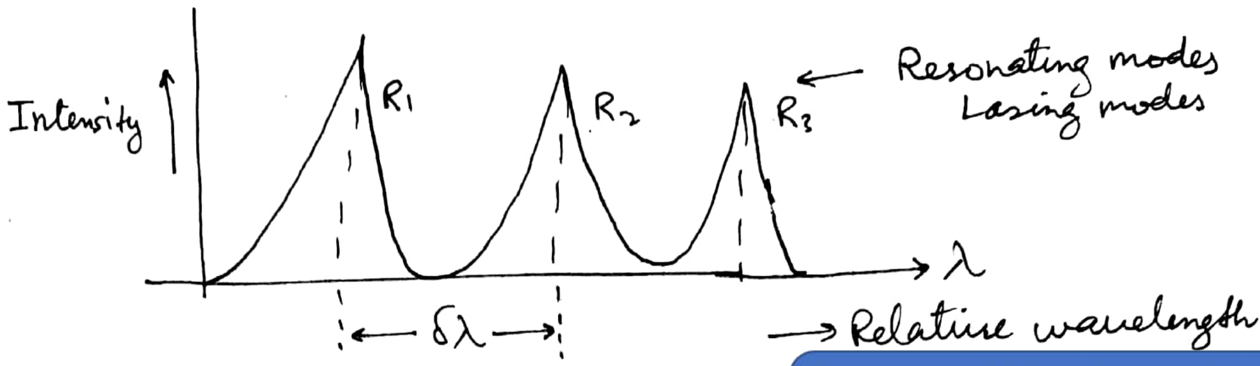

Fig 3: Resonating modes

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The Number of Longitudinal modes is given by,

$$m = \frac{2Ln}{\lambda}$$

where, L = length of laser
n = Refractive Index
λ = wavelength.

frequency of separation between Lasing mode is given by

$$\delta f_m = \frac{c}{2Ln}$$

where δf_m = frequency spacing ; $c = 3 \times 10^8 ms^{-1}$
L = length of laser.

The spacing between the Lasing modes is given by

$$\delta\lambda = \frac{\lambda^2}{2Ln}$$

where,

λ = Emissive wavelength at peak Value
L = Length of Laser
n = Refractive Index