FIBER OPTIC SOURCE

CHARACTRISTIC	LED	LASER
Coherence	Non-Coherent	Coherent
Chromaticity	Many wavelengths	Highly Monochromatic
Spectral Width	36 to 40nm	2nm
Divergence	Cosine power distribution	Narrow pencil beam
Output Power	Low (pW)	High
Modes	Feeds MM Fiber Only	Can feed MM and SM
Bit Rate	< 100-200Mbps	> 2Gbps
Cost	Less expensive	More expensive
Construction	Simple- pn junction	Complex–Laser cavity
Emission	Spontaneous	Stimulated

CHOICE OF SOURCE

- Parameters for choice – geometry of fiber, attenuation, group velocity, group delay distortion, modal characteristics.

- LED – Low power, Multimode, Less precision requirement.

- LASER – High power, Single/Multimode, High precision, Fiber with high attenuation, Longer distance application etc.

LED

- LED is a forward-biased p-n junction, emitting light through spontaneous emission, a phenomenon referred to as electroluminescence.
- The emitted light is incoherent with a relatively wide spectral width of 30-60 nm.

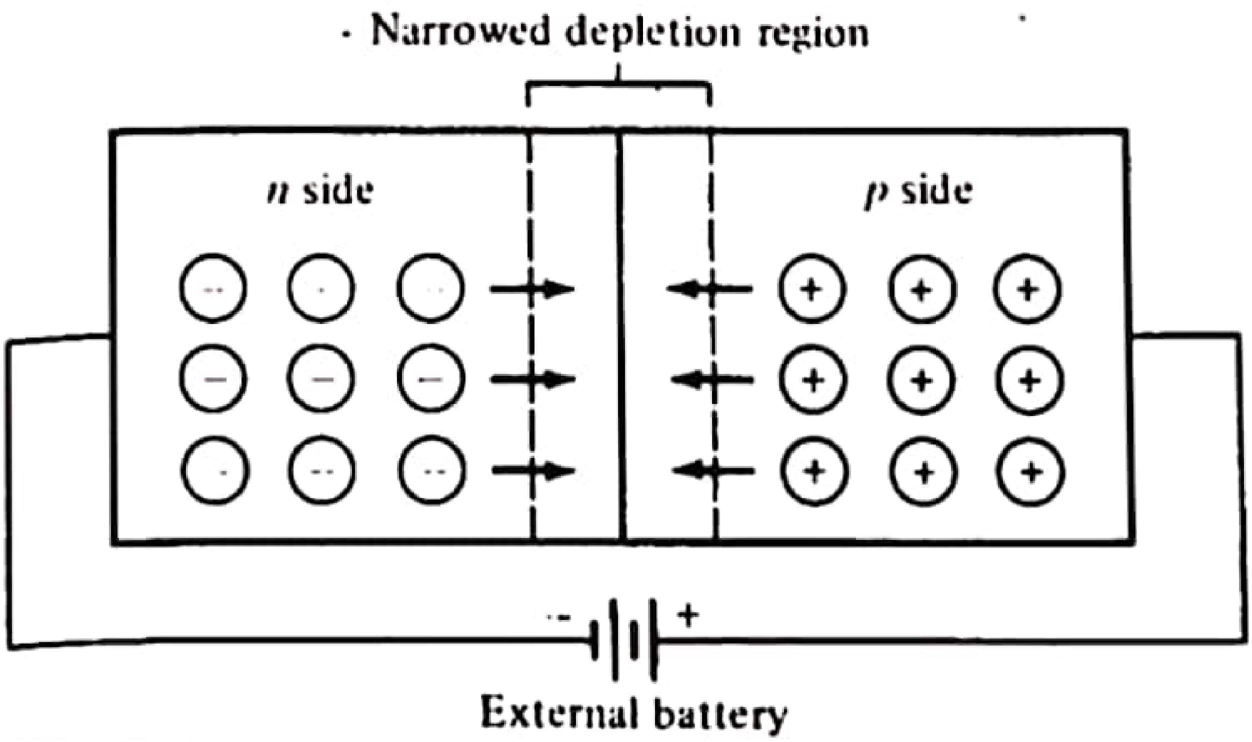
LED

- LED light transmission is also inefficient, with only about 1 % of input power, or about 100 microwatts, eventually converted into «launched power» which has been coupled into the optical fiber.
- However, due to their relatively simple design, LEDs are very useful for low-cost applications.

LED

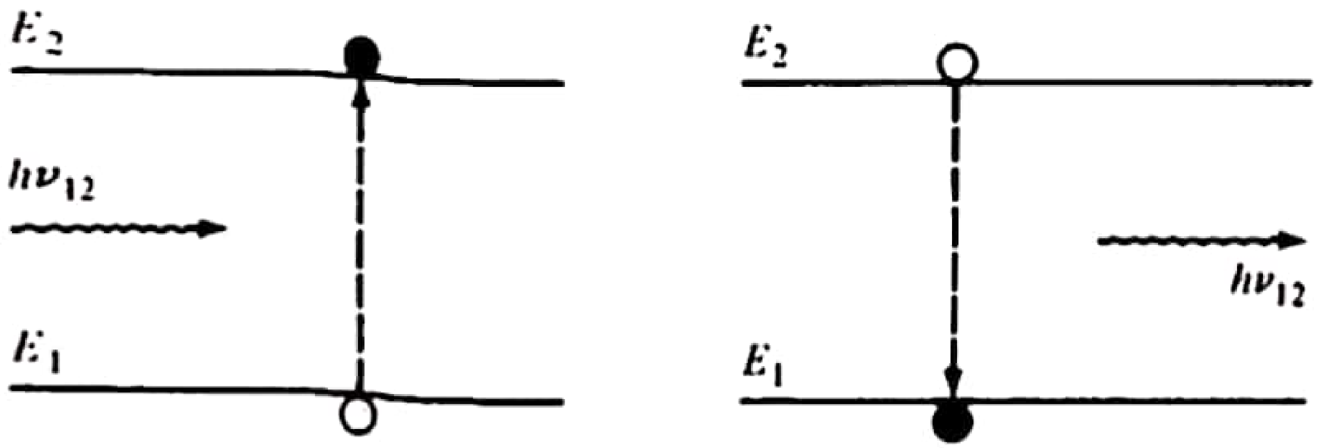
- Communications LEDs are most commonly made from gallium arsenide phosphide (GaAsP) or gallium arsenide (GaAs)
- Because GaAsP LEDs operate at a longer wavelength than GaAs LEDs (1.3 micrometers vs. 0.81-0.87 micrometers), their output spectrum is wider by a factor of about 1.7.

P-N JUNCTION



- If proper material chosen, recombination energy release is light.
- p-side lightly doped and n-side highly doped.
- Major recombination in p-side.

SPONTANEOUS EMISSION



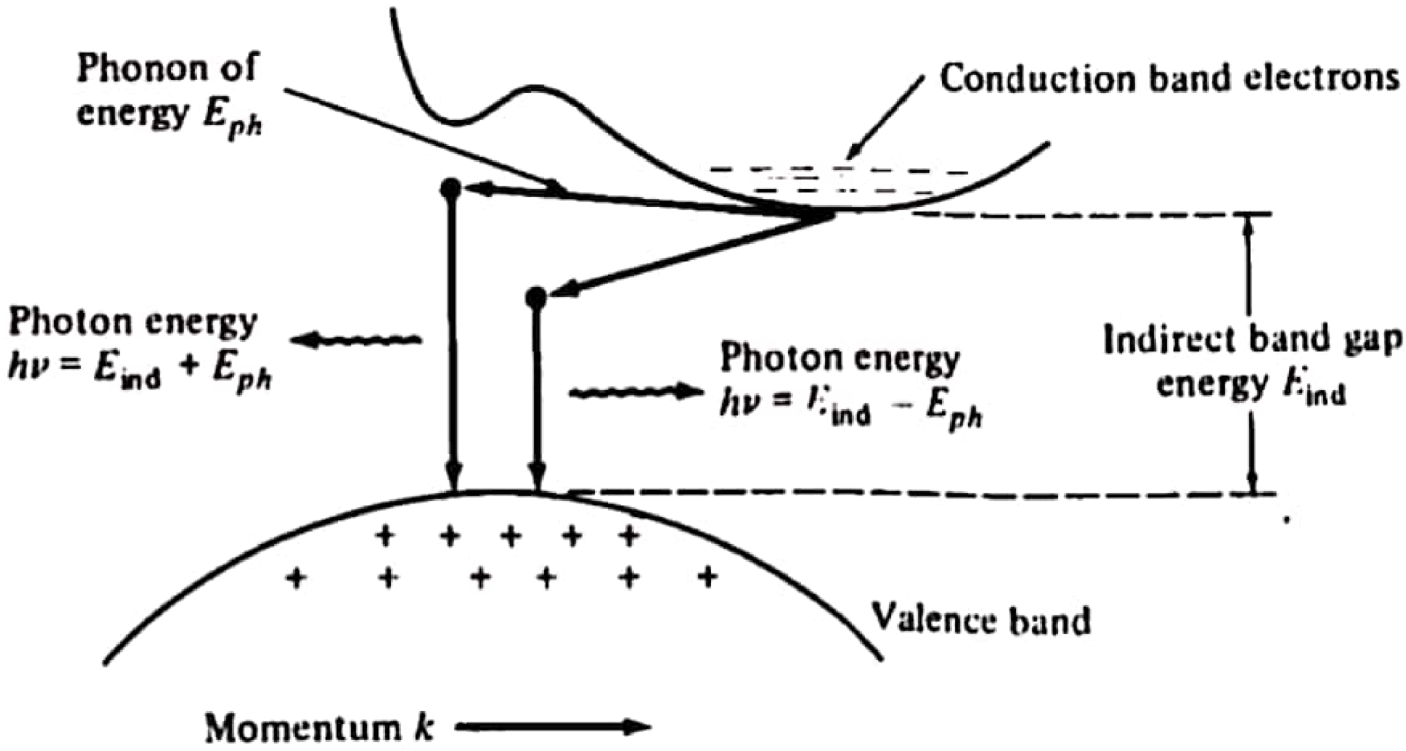
(a) Absorption (b) Spontaneous emission

$$h\nu_{12} = E_2 - E_1$$

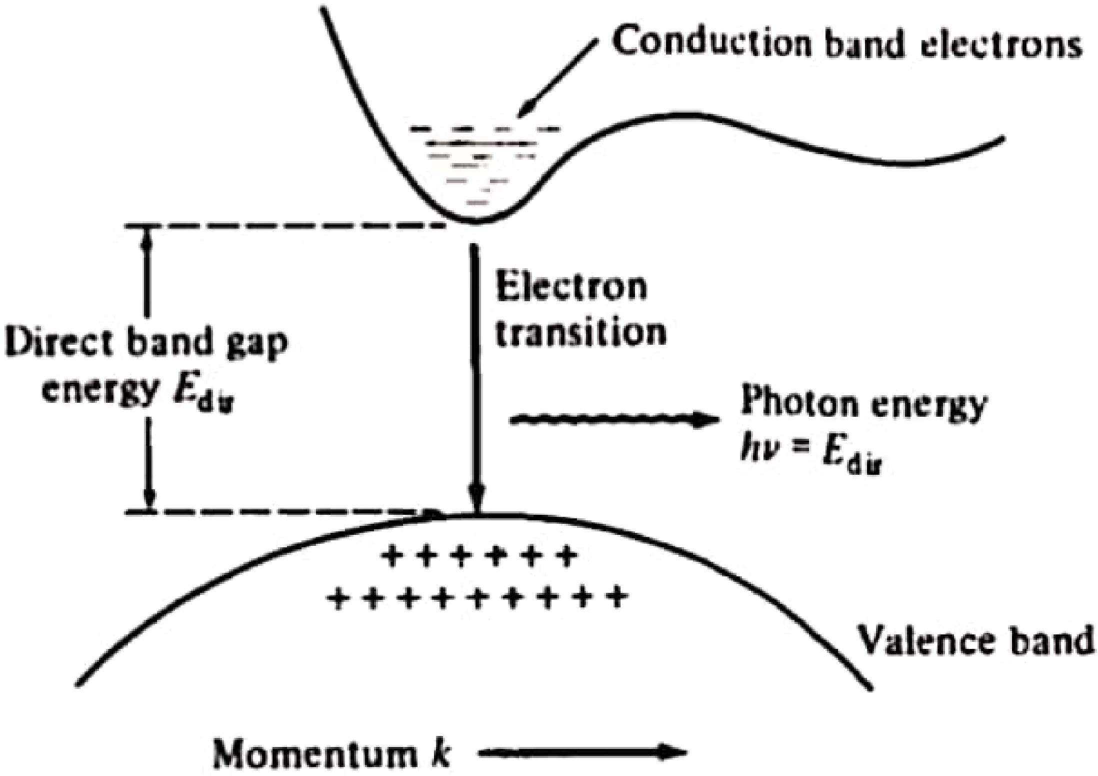
- h- Plank's constant = 6.625 x 10^{-34} Js

ν_{12} = Frequency of radiation

IN- DIRECT BAND GAP MATERIALS



Direct Band gap Materials



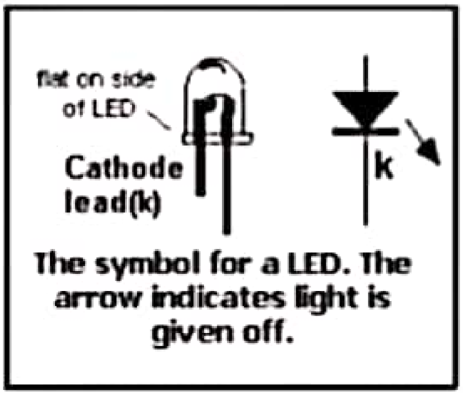
MATERIAL FOR LED

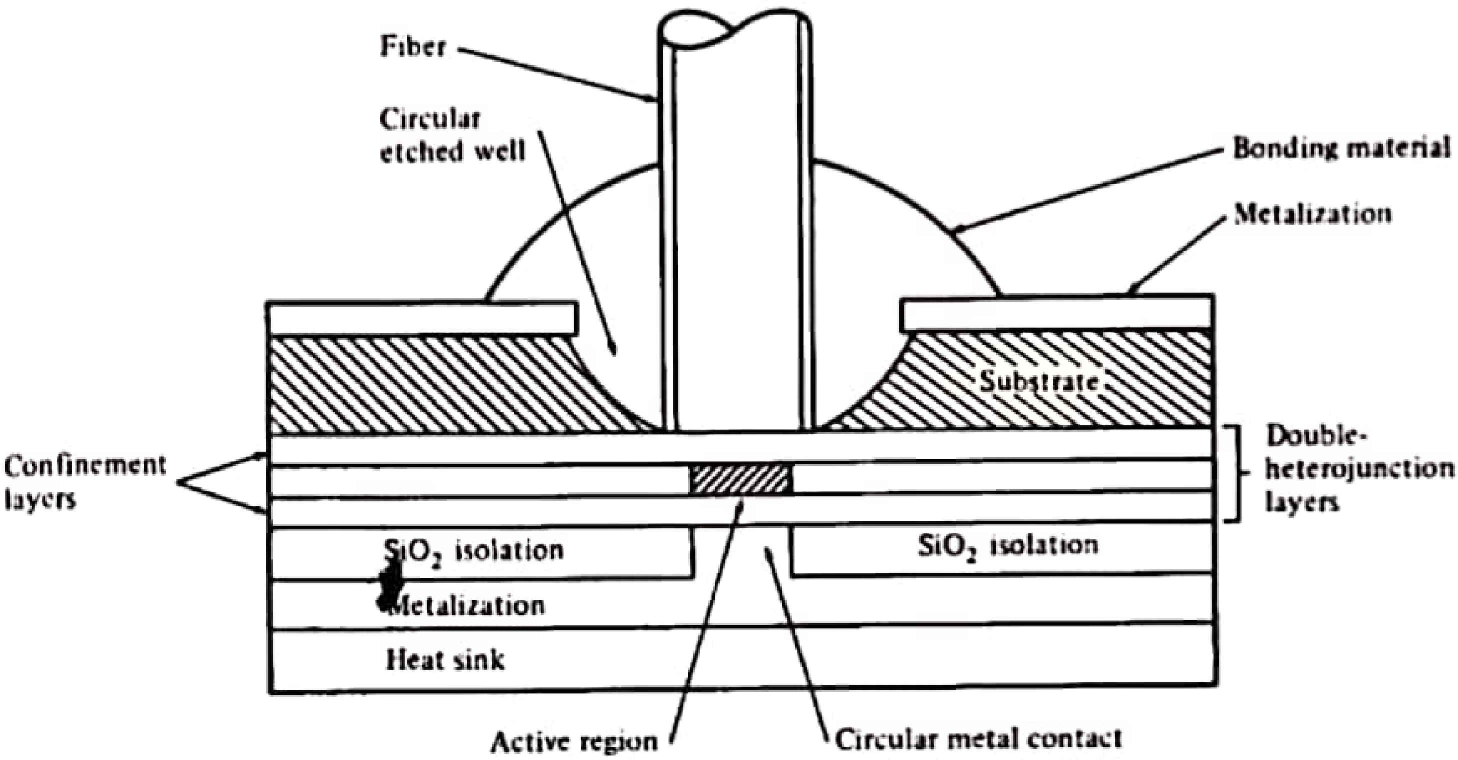
- **In-Direct band-gap materials**: Momentum of electrons in valance band and conduction band are not same. (Higher/lower)
- Electrons in conduction band have to search for Phonon(high energy lattice vibration) to balance momentum to convert to photon.
- This requires generation of phonon and photon simultaneously for every recombination.(Highly unlikely)
- This results in non-radiative recombination. Si, Ge
- **Direct band-gap materials**: Momentum of electrons in valance band and conduction band are same.
- This does not require generation of phonon and photon simultaneously for every recombination.
- This results in most recombinations radiative.

CHOICE OF MATERIAL

- No pure semiconductor is direct band gap material.
- Binary, Ternary and quaternary combination of band III and band V materials can give direct band gap material.
- Can give almost all recombination radiative.
- Band III – Al, Ga, In
- Band V – P, As, Sb
- GaAs, GaAlAs, InGaAsP

SURFACE EMITTING LED
BURRUS/FRONT EMITTER LED

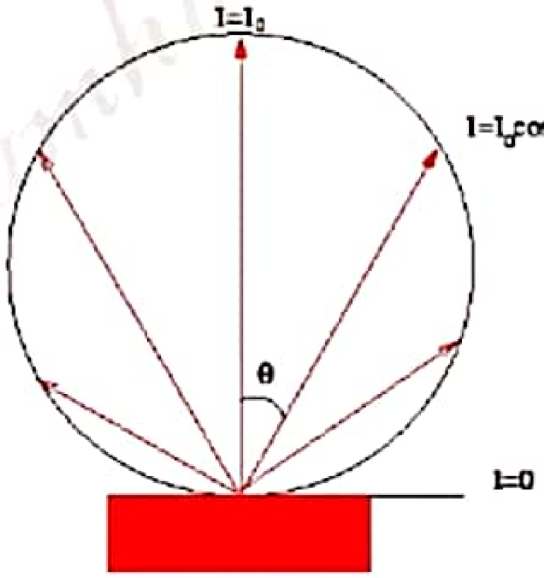




Scanned by CamScanner

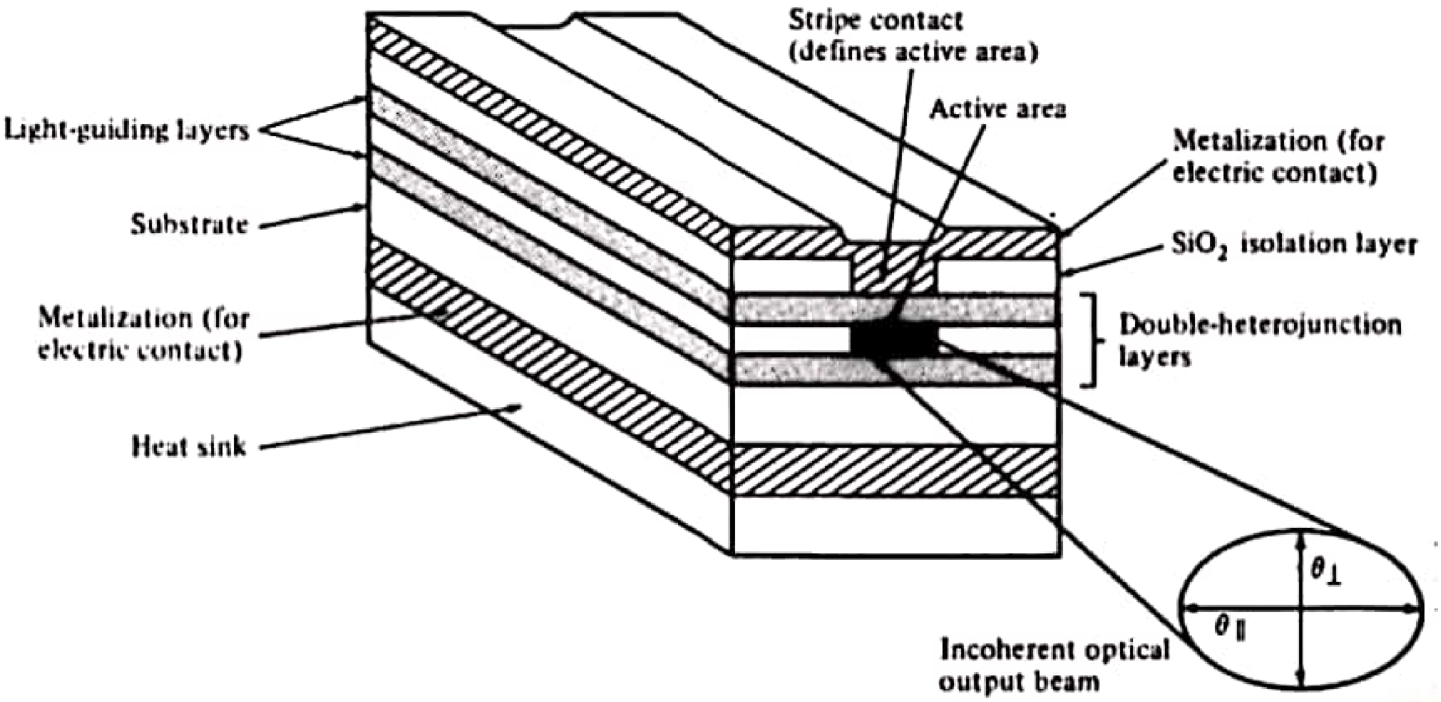
Surface Emitting LED

- Plane of active light emitting region perpendicular to axis of fiber.
- Fiber cemented into well.
- Active region approximately 50µm dia and 2.5 µ.m thick.
- Emission pattern isotropic with 120^0 half power beam width.
- Lambertian pattern.
- Power decreases as cosine of θ.
- Source is equally bright when viewed from any direction.
- As projected area decreases as cosθ.
- Coupling not good.
- Highly divergent.



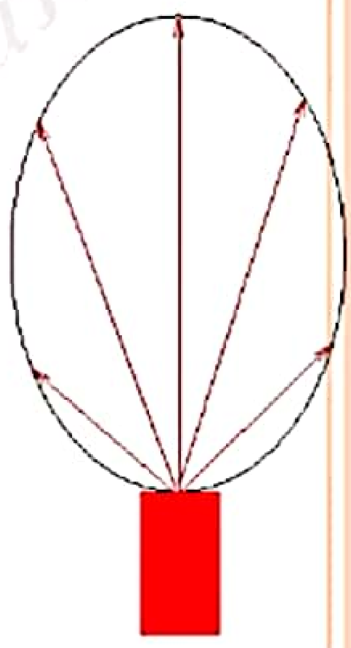
Surface Emitting LED

EDGE EMITTING LED



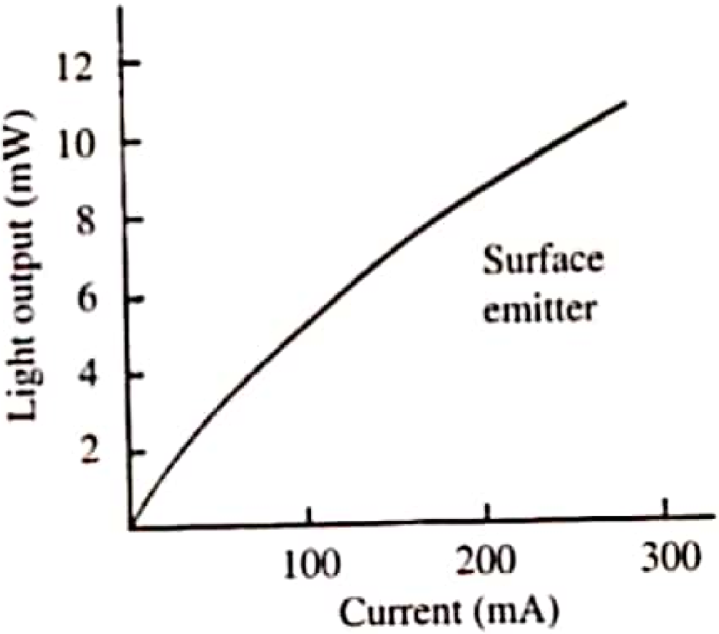
Edge Emitting LED

- Active region RI greater than side layers.
- Forms waveguide channel that directs optical radiation towards side into fiber.
- Active region 50-70μm wide, 100-150μm long.
- Emission pattern-
  - Lambertian 120^0 horizontally.
  - With proper choice of waveguide thickness, it can be 25^0 to 35^0 vertically.
- Better than Surface Emitter.

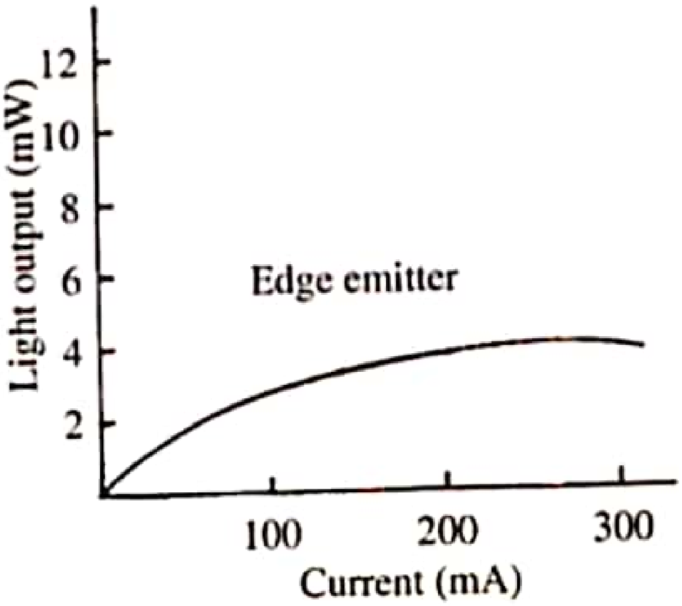


Edge Emitting LED

OPTICAL OUTPUT



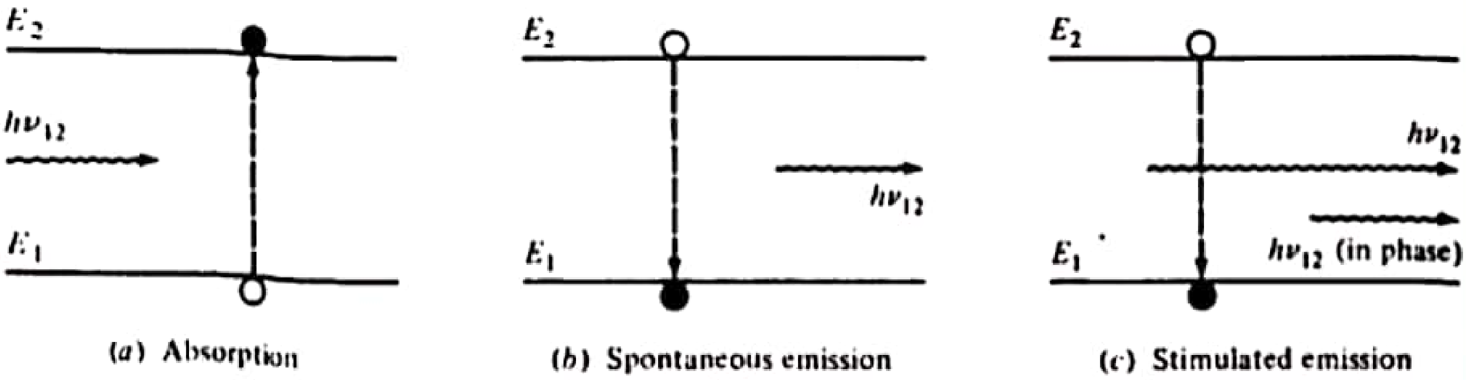
Highly divergent, high power



Less divergent, low power

LASER

Light Amplification by Stimulated Emission of Radiation



$$h\nu_{12} = E_2 - E_1$$

- *h*- Plank's constant = 6.625 x 10^{-34} Js

ν_{12} = Frequency of radiation

STIMULATED EMMISSION

- Electron at higher excited energy level E_2, is impinged with external stimulation = photon energy = hv_{12}
  - Electron is forced to come down to stable state E1, radiating energy hv_{12}
- Electron can be stimulated mush before its natural spontaneous transition time.
- Emitted photon by stimulation emission has same frequency, phase and polarization as the incident photon.

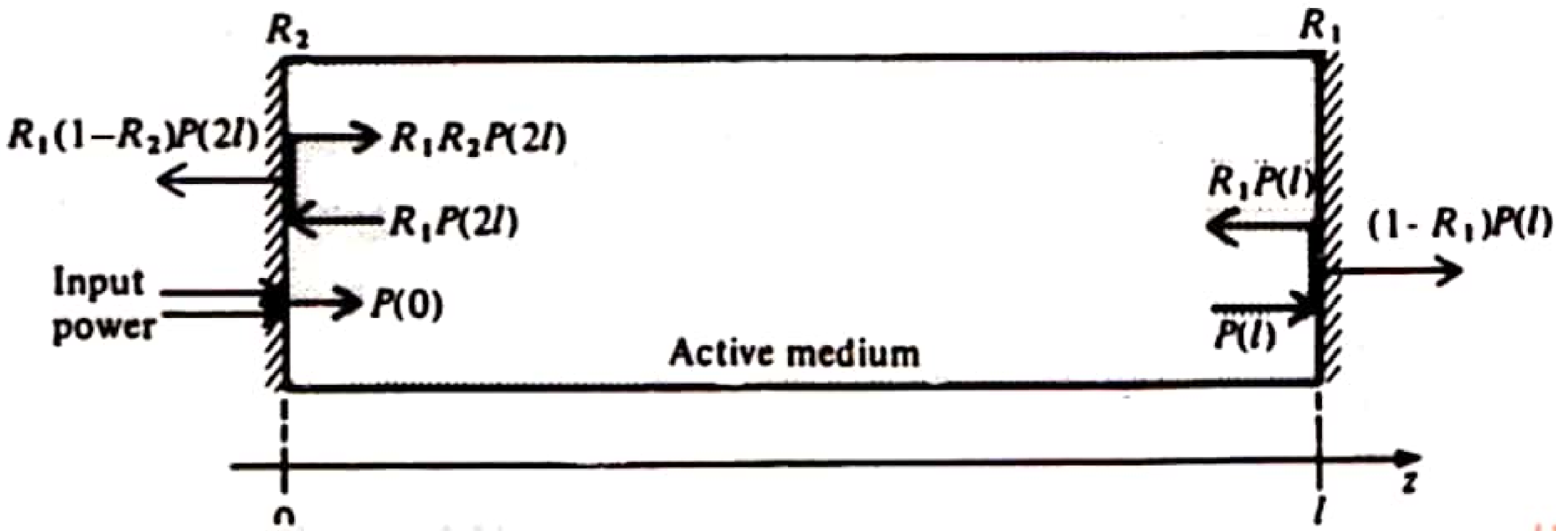
Population Inversion

- In thermal equilibrium, density of electrons in non-excited lower level E_1 is much more than excited level E_2.
- Most photons emitted will be absorbed. Stimulated emission negligible.
- Stimulated emission will exceed absorption only if population of excited stage is greater than that of ground state.
- Called Population Inversion.
- Inverted population is not an equilibrium condition.
- Hence requires pumping techniques.
- In semiconductor LASER, it is achieved by injecting electrons into material at device contact to fill lower energy state of conduction band.
- In pn junction diode, forward bias applied to inject e into conduction band of p-region or holed are injected into valance band of n-region.

Lasing Action

- Stage two:-
- Tries for sustaining the oscillations to act as source.
- Light generated remains guided in GaAs active layer of three layer hetero-structure acting as slab waveguide.
- Two sides of waveguide cleaved perpendicular to axis.
- Act as two parallel mirror facets.
- One side completely reflective and other partially transparent to emit light out.
- Part of light in direction of transparent facets will emit out.
- Light towards reflective facet will reflect back towards output suffering absorption all along.
- Only those wavelengths sustain for which round trip phase of reflected light is same as forward light.
- Rest will decay.

LASING ACTION



LASING ACTION

- Length of cavity l chosen to give 'gain' to chosen wavelength.
- All other wavelengths have 'loss'.
- Desired power suffers absorption and power loss as it travels.
- For overall gain, total gain > total loss.
- Constructive oscillations for desired wavelength.
- Light increases due to stimulated emission.
- Emitted photon in phase with incident photon stimulating the emission.