SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

OPTICAL AND MICROWAVE ENGINEERING

III YEAR/ VI SEMESTER

UNIT 4-OPTICAL SOURCES-LED,ILD CHARACTERISTICS

LIGHT SOURCES

LED (Light emitting diode):

- Made from material such as AlGaAs and GaAsP
- Light is emitted when holes and electrons recombine

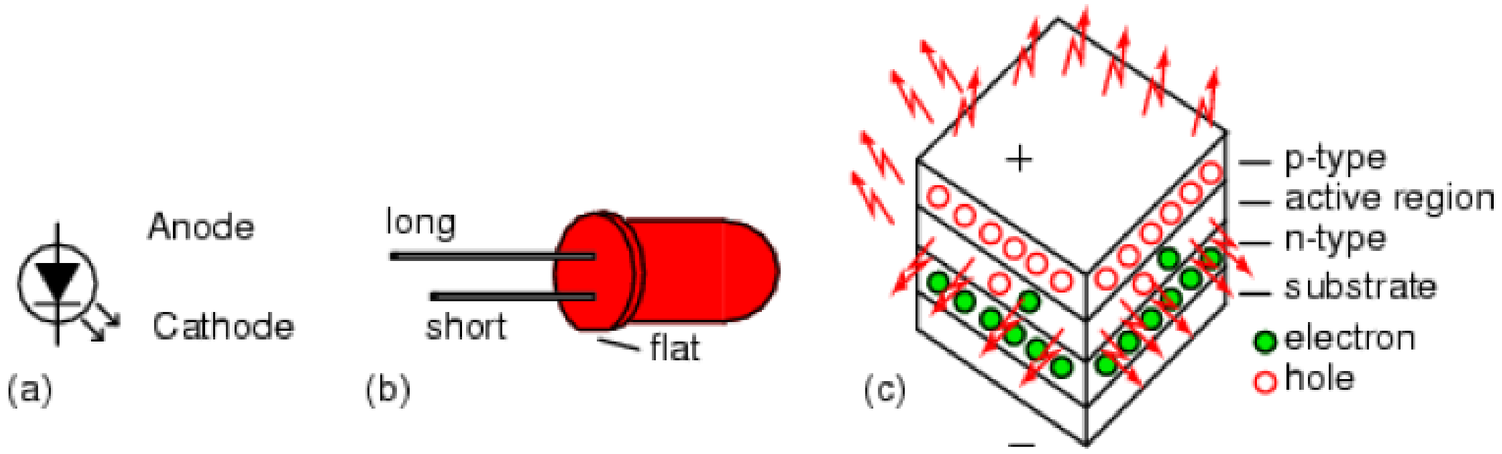
ILD (Injection Laser diode):

- Similar in construction as LED but ends are highly polished to reflect photons back and fourth

LIGHT EMITTING DIODE

Basic LED operation:

The normally empty conduction band of semiconductors populated by electron injected into it by the forward current through the junction, and the light is generated with electrons recombine with holes. This the mechanism by which light is emitted from LED.



LIGHT EMITTING DIODE

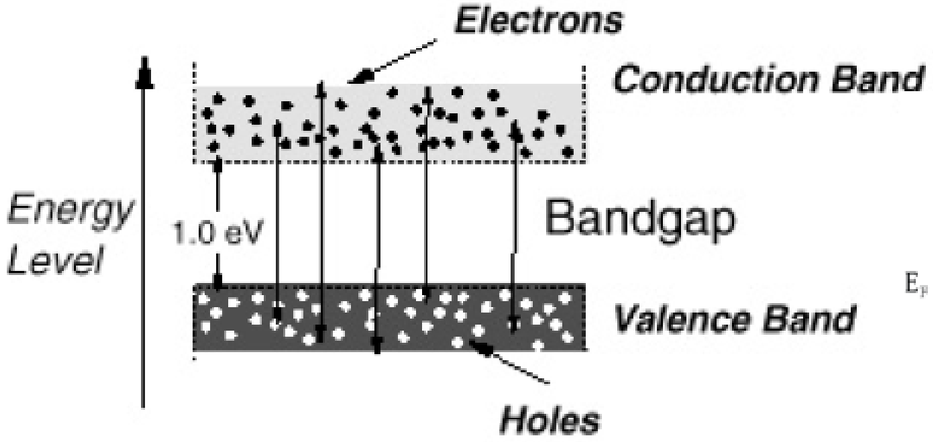
- For fiber-optics, the LED should have a high radiance (light intensity), fast response time and a high quantum efficiency.

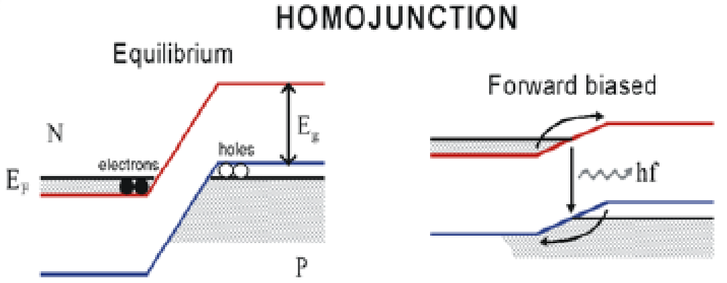
LED Structures:

- Planar LED
- Dome LED
- Surface emitter LED
- Edge emitter LED

Basic LED operation

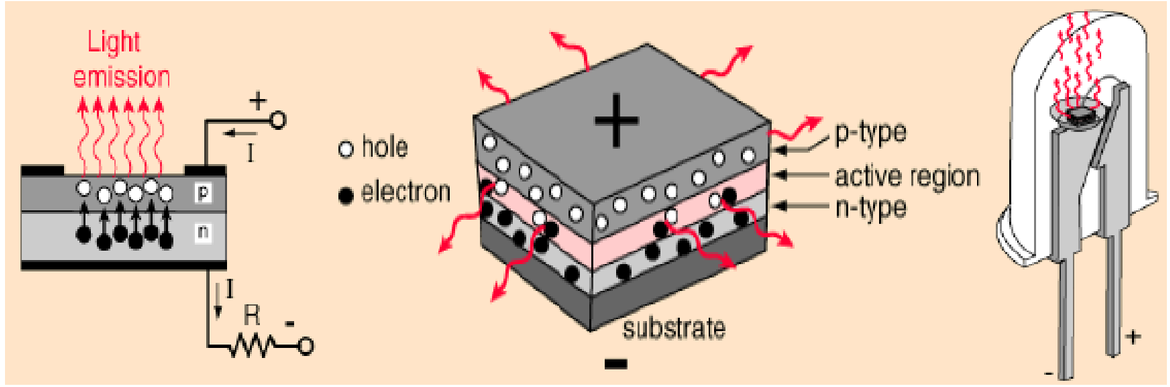
- A PN junction acts as the active or recombination region.
- When the PN junction is forward biased, electrons and holes recombine either radiatively (emitting photons) or non-radiatively (emitting heat). This is simple LED operation.

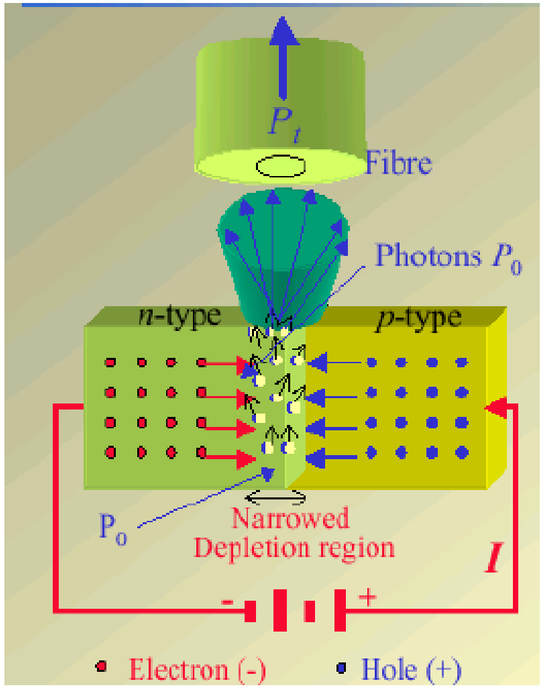




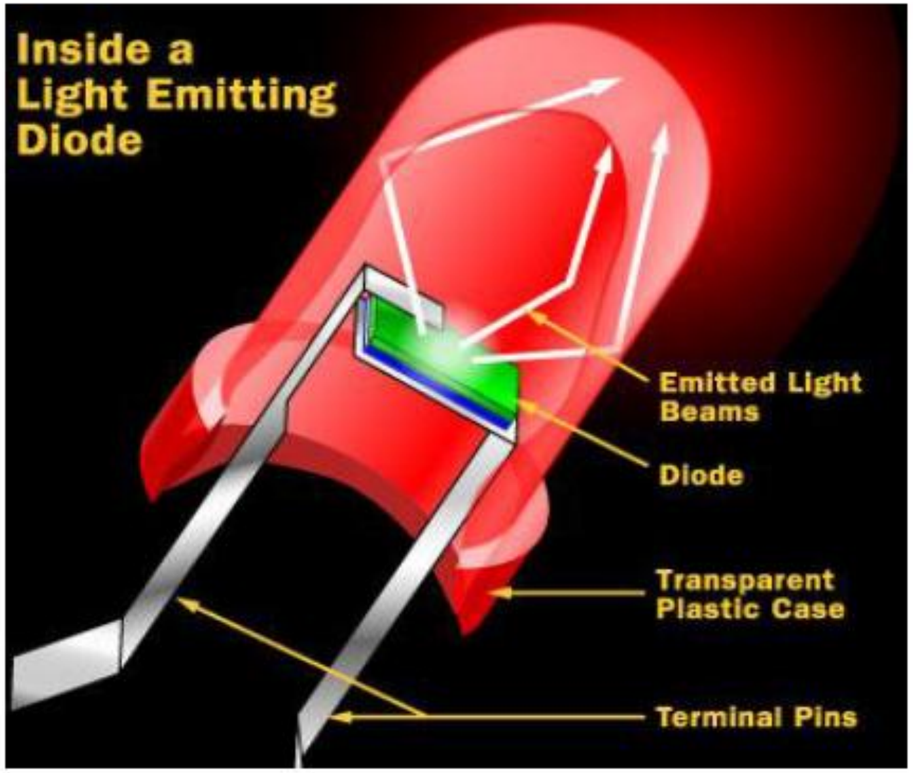
- Emitted wavelength depends on bandgap energy
- Transitions can take place from any energy state in either band to any state in the other band. This results in a range of different wavelengths produced in this spontaneous emission. This accounts for the fact that LEDs produce a range of wavelengths. Typically the range is about 80 nm or so.

Working of LED





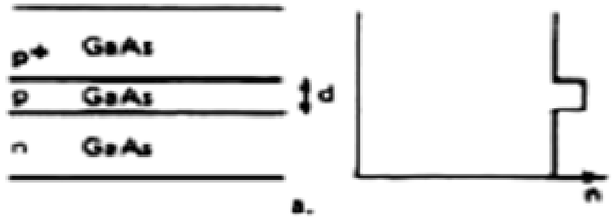
- Light is emitted at site of carrier recombination which is primarily close to the junction.
- However, the amount of radiative recombination and the emission area within the structure is dependent upon the semiconductor materials used and the fabrication of the device.



- Emits incoherent light through spontaneous emission.
- Used for Multimode systems with 100-200 Mb/s rates.
- Broad spectral width and wide output pattern.
- 850nm region: GaAs and AlGaAs
- 1300–1550nm region: InGaAsP and InP

- **Homojunctions**: P- type and N-type from same material

GaAs P	GaAs N



- Carriers are not confined
- Light is not confined

Structure and index of refraction n in gallium arsenide with a junction width d

- LED should have a high radiance (light intensity), fast response time and a high quantum efficiency for FO system

Heterojunction

- Heterojunction is the advanced junction design to reduce diffraction loss in the optical cavity.
- This is accomplished by modification in the material to control the index of refraction of the cavity and the width of the junction.
- The index of refraction of the material depends upon the impurity used and the doping level.
- The Heterojunction region is actually lightly doped with p-type material and has the highest index of refraction.
- The n-type material and the more heavily doped p-type material both have lower indices of refraction.
- This produces a light pipe effect that helps to confine the light to the active junction region. In the homojunction, however, this index difference is low and much light is lost.
- Double or single hetero-structure junction with better light output

ILD Characteristics

- Threshold current Vs Temperature
  - Threshold current in general tends to increase with temperature
- Dynamic response
  - Switch-on delay followed by damped oscillations known as relaxation oscillations
  - Serious deterioration at data rates above 100 Mbps if t_d is 0.5 ns and RO of twice this
  - t_d may be reduced by biasing the laser near threshold current
  - ROs damping is less straight forward

Injection Laser Diode (ILD)

- Distributed feedback lasers
  - Elegant approach to achieve single frequency operation
  - Use of distributed resonators which utilizes distributed Bragg diffraction grating
    - Provides periodic variation in refractive index
    - Only modes near Bragg wavelength is reflected constructively
  - Broadly classified as
    - DFB
    - DBR (Less well developed)

THANK YOU