3.1 Light Emitting Diode (LED)

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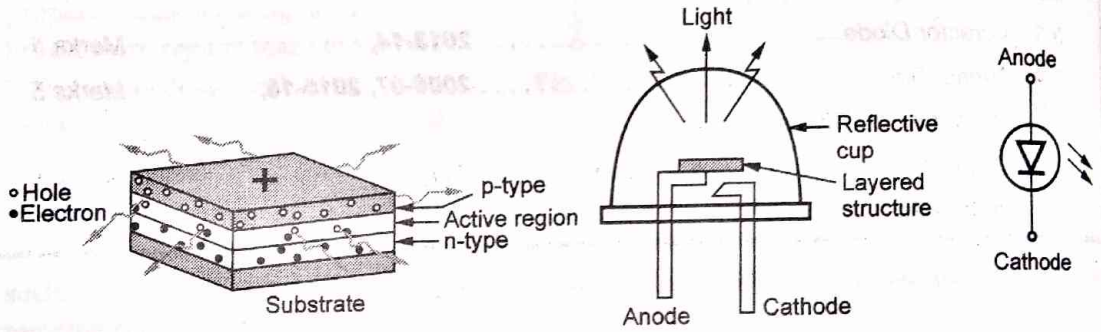
- A diode which emits light when forward biased is called a Light Emitting Diode (LED).

3.1.1 Construction of LED

- In LED three semiconductor layers on the substrate are used as shown in the Fig. 3.1.1 (a). In between p type and n type region, there exists a region called active region. This region is responsible for the emission of the light.
- The LED emits light all the way around the layered structure. This layered structure is placed in a tiny reflective cup so that the light gets reflected towards the desired exit direction. This cup type structure is shown in the Fig. 3.1.1 (b) while the symbol of the LED is shown in the Fig. 3.1.1 (c).



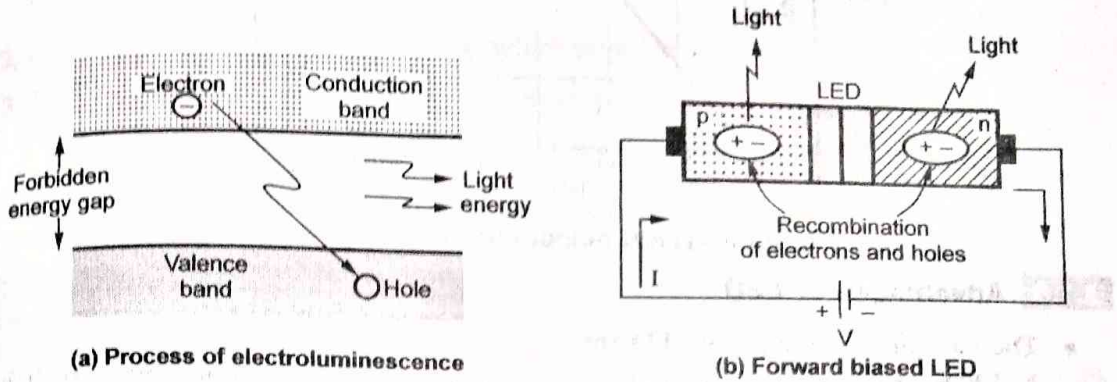
(a) Construction (b) Cup type structure (c) Symbol

Fig. 3.1.1 LED

3.1.2 Working Principle of LED

- The LED works on the principle of **electroluminescence**.
- When a p-n junction is forward biased, the electrons in n region cross the junction and recombine with holes in p region.
- The free electrons exist in the conduction band while the holes exist in the valence band.
- The energy level of free electrons is higher than the energy level of the holes.
- When electrons recombine with the holes, they move from conduction band to valence band which is at lower energy level.
- While moving, the additional energy is released by the free electrons which appears in the form of light due to the special material used in the LED.

- Practically when LED is forward biased, the holes from p region and electrons from n region enter the active region between p and n regions. In the active region recombination of electrons and holes take place and the energy is released in the form of a light.
- The energy released depends on the forbidden gap energy which determines the wavelength and the colour of the emitted light.
- Fig. 3.1.2 shows the principle of working of LED.



(a) Process of electroluminescence (b) Forward biased LED

Fig. 3.1.2 Principle of operation of LED

3.1.3 Materials of LED

- The materials which are the mixtures of Gallium, Arsenic and Phosphorus, are used in LED to obtain different colour of light.
- The colour of light depends on wavelength which depends on the forbidden energy gap value.
- The various materials and colour obtained are given in the Table 3.1.1.

Sr. No.	Material	Symbol	Colour
1.	Gallium Arsenide	GaAs	Infrared (invisible)
2.	Gallium Phosphide	GaP	Red or Green
3.	Gallium Arsenide Phosphide	GaAsP	Red or Yellow

Table 3.1.1

3.1.4 Output Characteristics of LED

- The amount of power output translated into light is directly proportional to the forward current I_f. More the forward current I_f, the greater is the output light. The graph of forward current and output light in mW is shown in the Fig. 3.1.3. This is called **output characteristics** for LED.

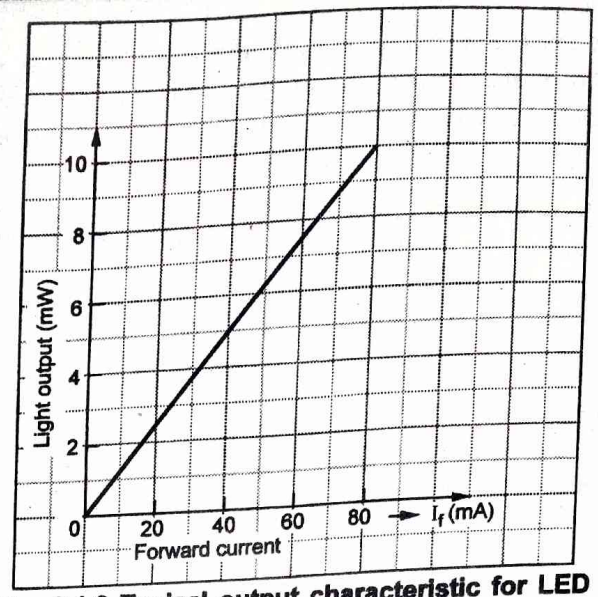


Fig. 3.1.3 Typical output characteristic for LED

3.1.5 Advantages of LED

- The various advantages of LED are,
  1. LEDs are small in size, and hence can be regarded as point source of light. Because of their small size, several thousand LEDs can be packed in one sq. metre area.
  2. The brightness of light emitted by LED depends on the current flowing through LED. Hence the brightness of light can be smoothly controlled by varying the current. This makes possible to operate LED displays under different ambient lighting conditions.
  3. LEDs are fast operating devices. They can be turned on and off in time less than 1 microsecond.
  4. The LEDs are light in weight.
  5. The LEDs are available in various colours.
  6. The LEDs have long life.
  7. The LEDs are cheap and readily available.
  8. The LEDs are easy to interface with various other electronic circuits.
  9. Some LEDs radiate infrared light which is invisible but still useful in some applications like burglar alarm systems.

3.1.6 Applications of LED

- The various applications of LED are,
  1. All kinds of visual displays i.e. seven segment displays and alpha numeric displays. Such displays are commonly used in the watches and calculators.

2. In the optical devices such as optocouplers.
3. As on-off indicator in various types of electronic circuits.
4. Some LEDs radiate infrared light which is invisible. But such LEDs are useful in remote controls and applications like burglar alarm.

3.1.7 Disadvantages of LED

The various disadvantages of LED are,

1. It draws considerable current requiring frequent replacement of battery in low power battery operated devices.
2. Luminous efficiency of LEDs is low which is about 1.5 lumen/watt.
3. The characteristics are affected by temperature.
4. Need large power for the operation compared to normal p-n junction diode.