Warm greetings:

Dear students

Welcome all. In this class we are going to discuss about

- Optoelectronic devices
  - LED
  - Photo diode
- Solar cell

Optoelectronic devices:

Optoelectronics deals with devices which convert electrical energy into light and light into electrical energy using semiconductors. Optoelectronic device is an electronic device which utilizes light for useful applications. We will discuss some important optoelectronic devices namely, light emitting diodes, photo diodes and solar cells.

i) Light Emitting Diode (LED)

- LED is a *p-n* junction diode which emits visible or invisible light when it is forward biased.
- Since electrical energy is converted into light energy, this process is also called electroluminescence.
- The circuit symbol of LED is shown in Figure 10.22(a). The direction of arrows indicates that light is emitted from the diode.

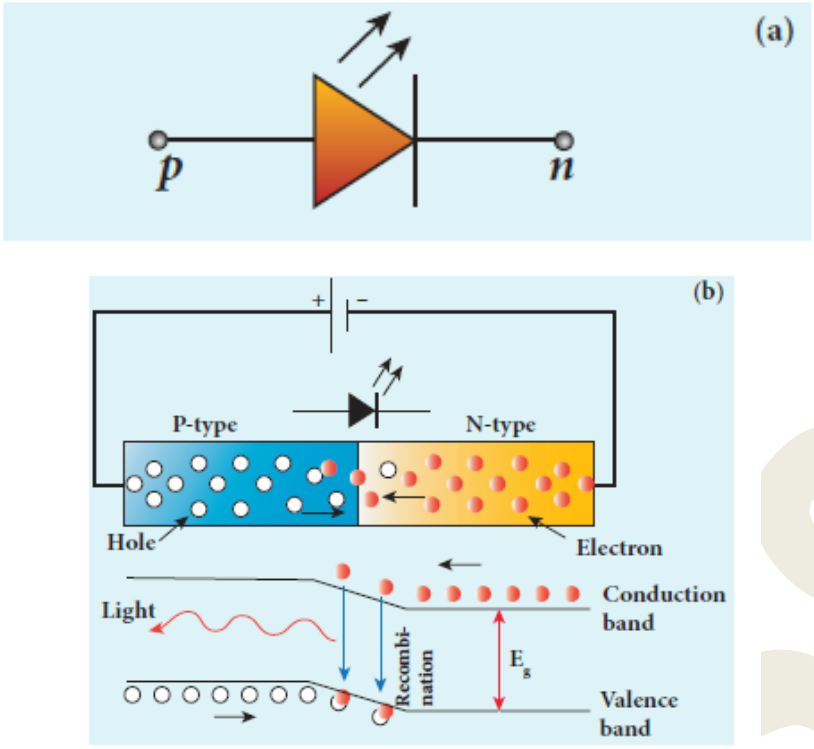

Figure 10.22 (a) Circuit symbol of LED (b) Schematic diagram to explain recombination process

- When the *p*-*n* junction is forward biased, the conduction band electrons on *n*-side and valence band holes on *p*-side diffuse across the junction.
- When they cross the junction, they become excess minority carriers (electrons in *p*-side and holes in *n*-side).
- These excess minority carriers recombine with oppositely charged majority carriers in the respective regions, i.e. **the electrons in the conduction band recombine with holes in the valence band** as shown in the Figure 10.22(b).
- During recombination process, energy is released in the form of light (radiative) or heat (non-radiative). For radiative recombination, a photon of energy *hv* is emitted.
- For non-radiative recombination, energy is liberated in the form of heat.
- The colour of the light is determined by the energy band gap of the material.
- Therefore, LEDs are available in a wide range of colours such as blue (SiC), green (AlGaP) and red (GaAsP). Now a days, LED which emits white light (GaInN) is also available.

Applications:

The light emitting diodes are used in

- indicator lamps on the front panel of the scientific and laboratory equipments.
- seven-segment displays.
- traffic signals, emergency vehicle lighting etc.
- remote control of television, airconditioner etc.

ii) Photodiodes:

A *p-n* junction diode which converts an optical signal into electric signal is known as photodiode. Thus, the operation of photodiode is exactly inverse to that of an LED. Photodiode works in reverse bias condition. Its circuit symbol is shown in Figure 10.23(a). The direction of arrows indicates that the light is incident on the photodiode.

The device consists of a *p-n* junction semiconductor made of photosensitive material kept safely inside a plastic case as shown in Figure 10.23(b). It has a small transparent window that allows light to be incident on the *p-n* junction. Photodiodes can generate current when the *p-n* junction is exposed to light and hence are called as light sensors.

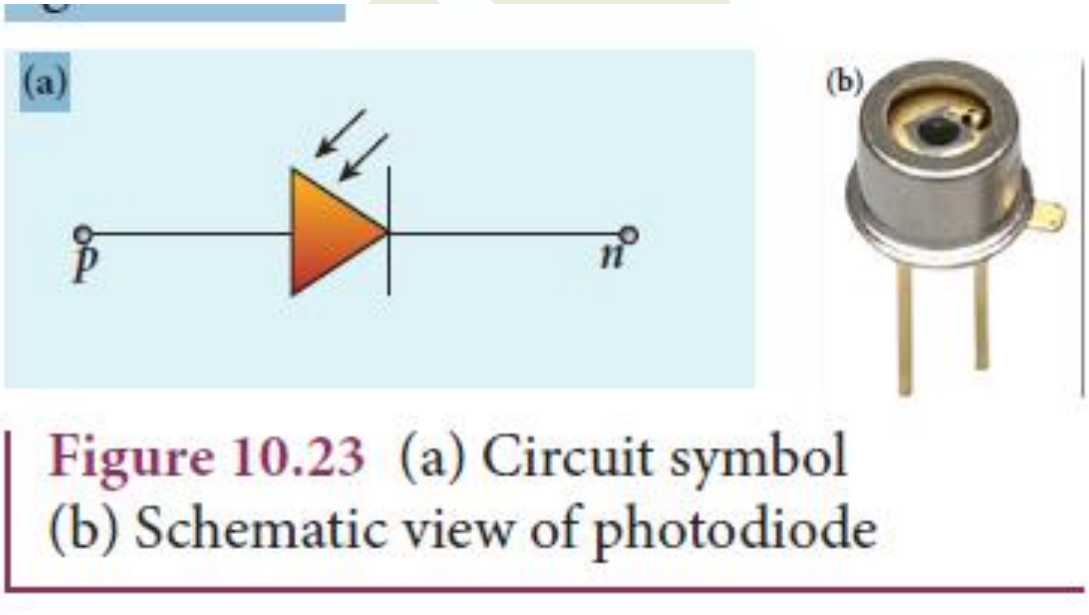

Figure 10.23 (a) Circuit symbol (b) Schematic view of photodiode

When a photon of sufficient energy (hv) strikes the depletion region of the diode, some of the valence band electrons are elevated into conduction band, in turn holes are developed in the valence band. This creates electron-hole pairs. The amount of electron-hole pairs generated depends on the intensity of light incident on the *p-n* junction.

These electrons and holes are swept across the *p-n* junction by the electric field created by reverse voltage before recombination takes place. Thus, holes move towards the *n*-side and

electrons towards the *p*-side. When the external circuit is made, the electrons flow through the external circuit and constitute the photocurrent.

When there is no incident light, there exists a reverse current which is negligible. This reverse current in the absence of any incident light is called dark current and is due to the thermally generated minority carriers.

Applications:

The photodiodes are used in

- alarm system
- count items on a conveyor belt
- photoconductors
- compact disc players, smoke detectors
- medical applications such as detectors for computed tomography etc.

iii) Solar cell:

- A solar cell, also known as photovoltaic cell, works on the principle of **photovoltaic effect**. Accordingly, the *p*-*n* junction of the solar cell generates emf when solar radiation falls on it. The construction details and cross-sectional view are shown in Figure 10.24.
- In a solar cell, electron–hole pairs are generated due to the absorption of light photons near the junction. Then the charge carriers are separated due to the electric field of the depletion region.
- Electrons move towards *n*–type silicon layer and holes move towards *p*-type silicon layer. The electrons reaching the *n*-side are collected by the front contact (metal finger contact) and holes reaching *p*-side are collected by the back is developed across solar cell**.**
- When an external load is connected to the solar cell, photocurrent flows through the load.
- Many solar cells are connected together either in series or in parallel combination to form a solar panel.
- Many solar panels are connected with each other to form solar arrays. For high power applications, solar panels and solar arrays are used.

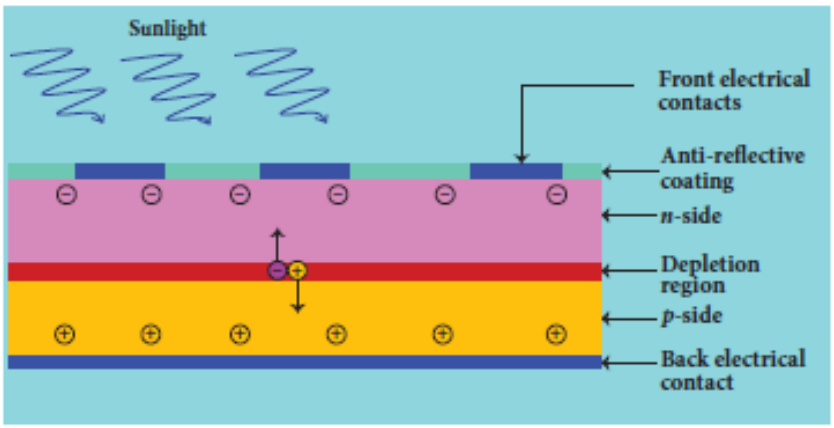

Figure 10.24 Cross-sectional view of a solar cell

Applications:

i) Solar cells are widely used in calculators, watches, toys, portable power supplies, etc.

ii) Solar cells are used in satellites and space applications.

iii) Solar panels are used for commercial production of electricity.

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