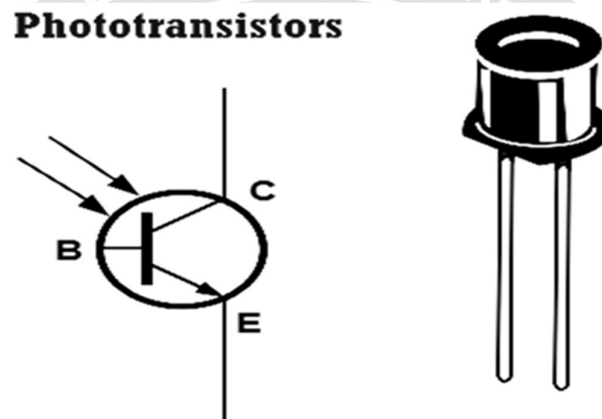


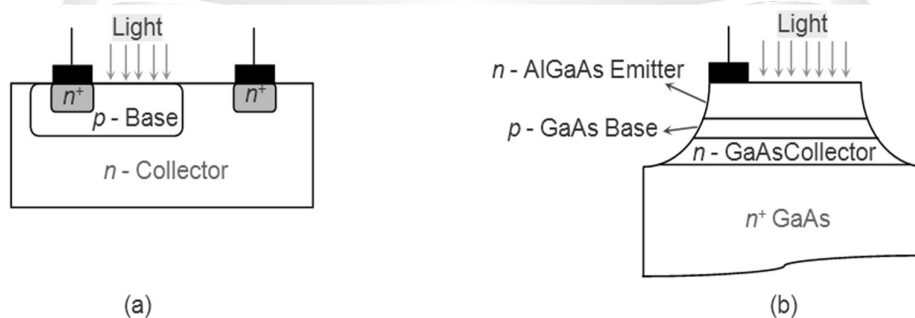
## 5.9 PHOTO TRANSISTOR

Phototransistors are either tri-terminal (emitter, base and collector) or bi-terminal (emitter and collector) semiconductor devices which have a light-sensitive base region. Although all transistors exhibit light-sensitive nature, these are specially designed and optimized for photo applications. These are made of diffusion or ion-implantation and have much larger collector and base regions in comparison with the ordinary transistors. These devices can be either homojunction structured or heterojunction structured, as shown by Figure respectively.



**Fig:5.9.1 Symbol of Photo Transistor**

In the case of homojunction phototransistors, the entire device will be made of a single material-type; either silicon or germanium. However to increase their efficiency, the phototransistors can be made of non-identical materials (Group III-V materials like GaAs) on either side of the pn junction leading to heterojunction devices. Nevertheless, homojunction devices are more often used in comparison with the hetero junction devices as they are economical.

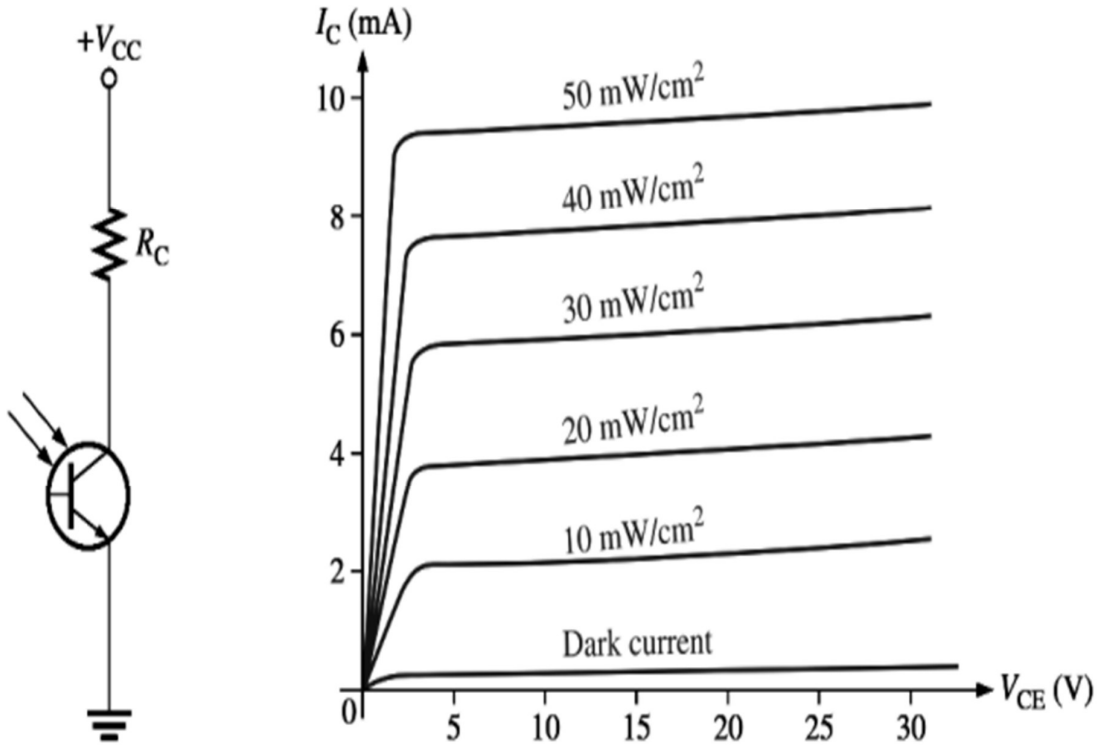


**Fig:5.9.2 Photo Transistor (a) Homo Junction (b) Hetero Junction**

The circuit symbol for npn phototransistors is shown by Figure 2 which is nothing but a transistor (with or without base lead) with two arrows pointing towards the base

indicating its sensitivity to light. Similar symbolic representation holds well even in the case of pnp phototransistors with the only change being the arrow at emitter pointing in, instead of out.

**Phototransistor circuit      Phototransistor collector characteristic curves**



**Fig:5.9.3 Characteristics of Photo Transistor**

The behavior of phototransistors is identical to that of normal transistors except the fact that here the effect brought-about by the base voltage will be experienced due to the incident light. This can be made clearer by analyzing the following points

1. The characteristics of phototransistors are similar to those of normal transistors except that they have base current replaced by light intensity. This means that even these devices have three operating regions viz., cut-off, active and saturation. This further implies that the phototransistors can be used for either switching (cut-off and saturation mode dependent) applications or for amplification (active mode operation), just like ordinary transistors.
2. The phototransistors can be configured in two different configurations viz., common collector and common emitter, depending on the terminal which is common between the input and output terminals, similar to normal transistors.

3. A small reverse saturation current, called dark current, flows through the phototransistor even in the absence of light whose value increases with an increase in the value of temperature, a property identical to that exhibited by the ordinary transistors.
4. Phototransistors are prone to permanent damage due to breakdown if the voltage applied across the collector-emitter junction increases beyond its breakdown voltage, just as in the case of normal transistors.

Generally, in the case of phototransistor circuits, the collector terminal will be connected to the supply voltage and the output is obtained at the emitter terminal while the base terminal, if present, will be left unconnected. Under this condition, if light is made to fall on the base region of the phototransistor, then it results in the generation of electron-hole pairs which give rise to base current, nothing but the photo-current, under the influence of applied electric field. This further results in the flow of emitter current through the device, resulting in the process of amplification. This is because, here, the magnitude of the photo-current developed will be proportional to the luminance and will be amplified by the gain of the transistor leading to a larger collector current. The output of the phototransistor depends on various factors like

- Wavelength of the incident light
- Area of the light-exposed collector-base junction
- DC current gain of the transistor.

Further, the characteristics of a particular phototransistor can be expressed in terms of its

- Luminous sensitivity defined as the ratio of photoelectric current to the incident luminous flux
- Spectral response which decides the longest wavelength which can be used as the sensitivity of the phototransistors is a function of wavelength
- Photoelectric gain which indicates its efficiency of converting light into an amplified electrical signal
- Time constant which influences its response time.

However, it is important to note that the speed of response and the phototransistor gain are inversely proportional to each other, meaning which one decreases if the other increases.

### Advantages of Phototransistor

1. Simple, compact and less expensive.
2. Higher current, higher gain and faster response times in comparison with photodiodes.
3. Results in output voltage unlike photo resistors.
4. Sensitive to a wide range of wavelengths ranging from ultraviolet (UV) to infrared (IR) through visible radiation.
5. Sensitive to large number of sources including incandescent bulbs, fluorescent bulbs, neon bulbs, lasers, flames and sunlight.
6. Highly reliable and temporally stable.
7. Less noisy when compared to avalanche photodiodes.
8. Available in wide variety of package types including epoxy-coated, transfer-molded and surface mounted.

### Disadvantages of Phototransistor

1. Cannot handle high voltages if made of silicon.
2. Prone to electric spikes and surges.
3. Affected by electromagnetic energy.
4. Do not permit the easy flow of electrons unlike electron tubes.
5. Poor high frequency response due to a large base-collector capacitance.
6. Cannot detect low levels of light better than photodiodes.

### Applications of Phototransistor

1. Object detection
2. Encoder sensing
3. Automatic electric control systems such as in light detectors
4. Security systems
5. Punch-card readers
6. Relays
7. Computer logic circuitry
8. Counting systems
9. Smoke detectors
10. Laser-ranging finding devices

11. Optical remote controls
12. CD players
13. Astronomy
14. Night vision systems
15. Infrared receivers
16. Printers and copiers
17. Cameras as shutter controllers
18. Level comparators

