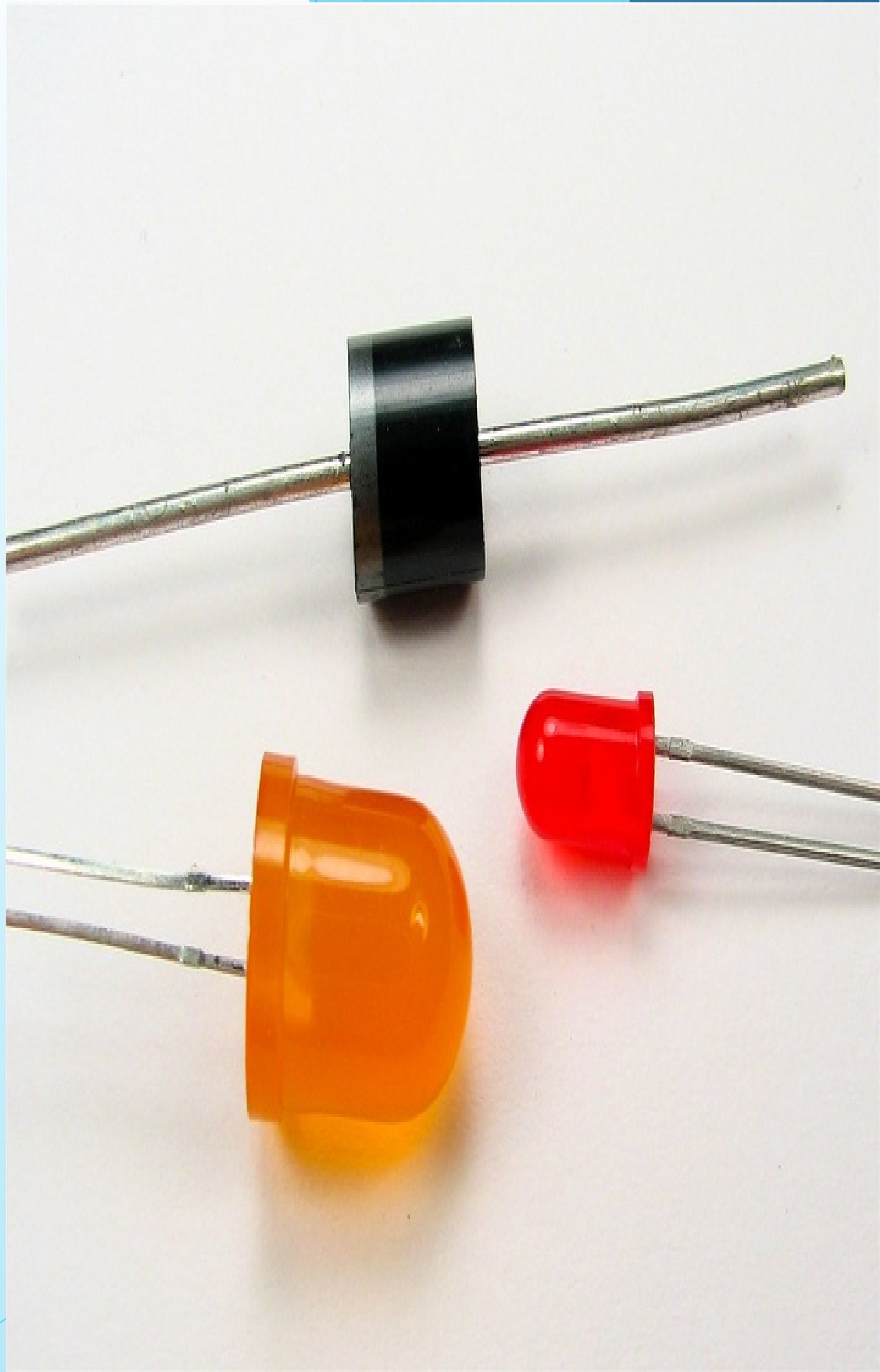
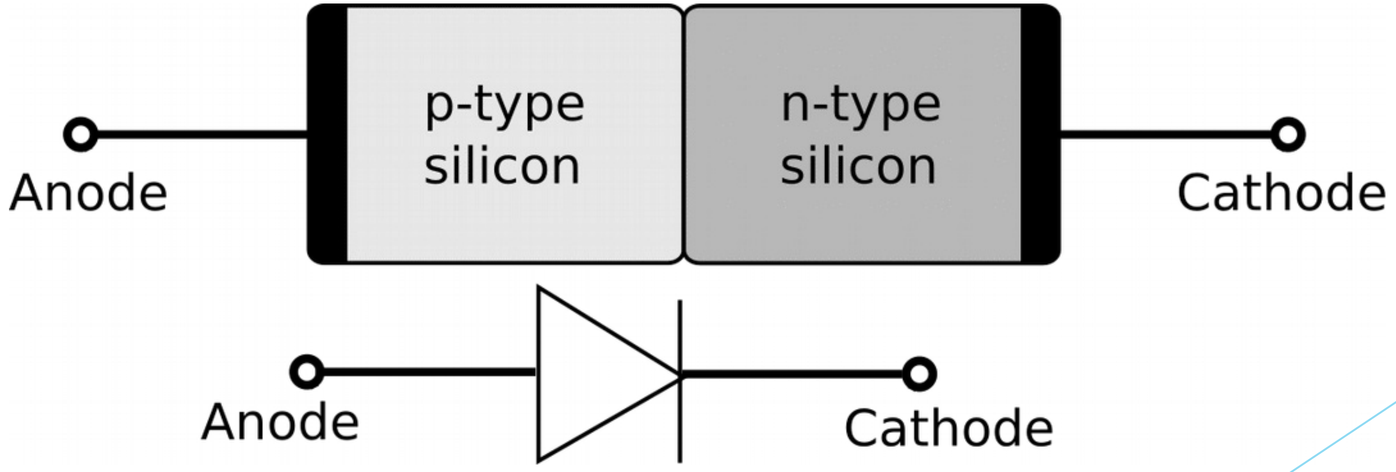
P-N Junction Diode
&
Diode Equation



What is a P-N Junction Diode?

- A P-N Junction Diode is one of the simplest semiconductor devices around, and which has the electrical characteristic of passing current through itself in one direction only.

- However, unlike a resistor, a diode does not behave linearly with respect to the applied voltage.



Equilibrium Currents across the P-N Junction:

- When the p-n junction is formed, a P.E barrier $|e|V_e$ is formed.

- Electrons and holes continuously flow across the junction; The net flow is zero as equal amounts flow in opposite directions.

- The number of electrons N_e in the conduction band is given as:

$$N_e = N_c \exp\left(-\frac{E_g - E_F}{k_B T}\right)$$

- Since E_g – E_f is much greater for the p-type than for the n-type, the numerical value of N_e at ambient temperatures is several orders of magnitude smaller for the p-type than the n-type.

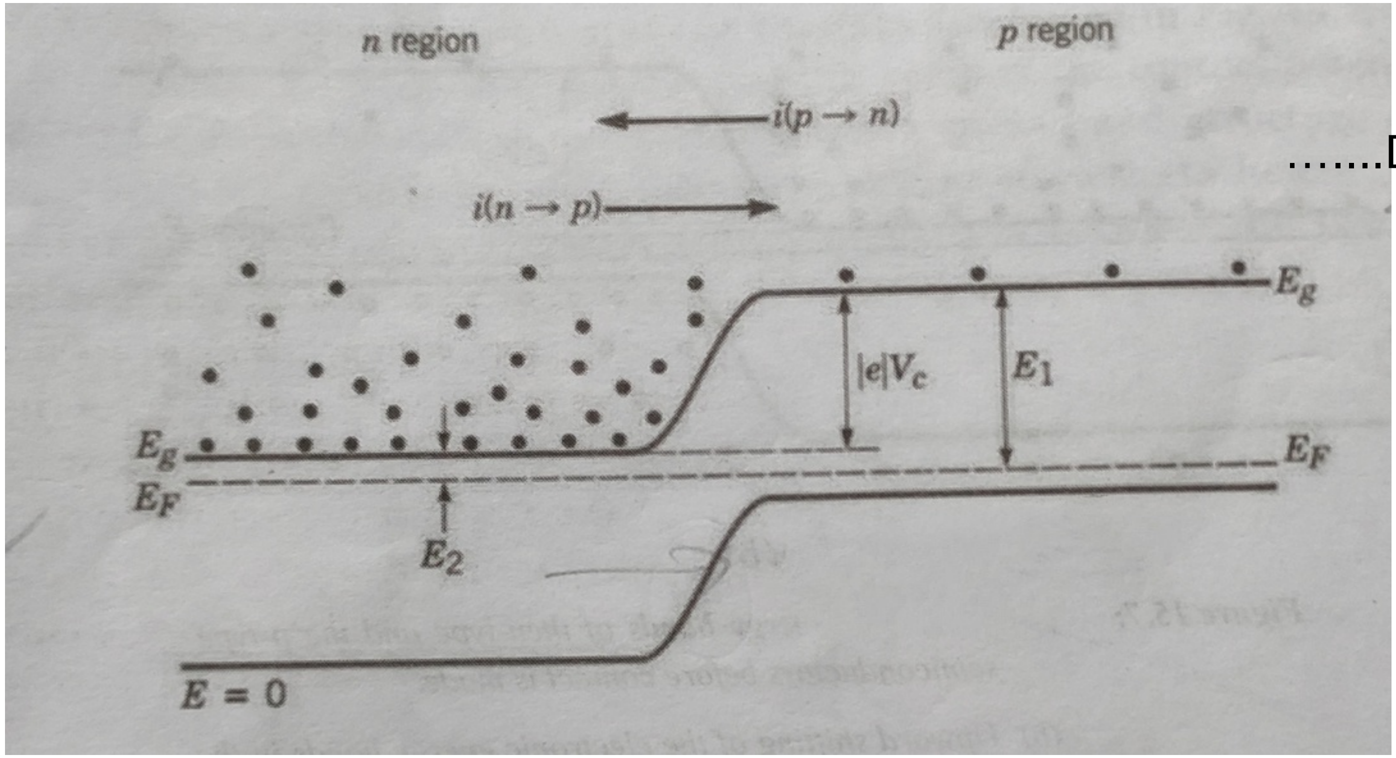
- The electrons (minority carriers) in the conduction band of the p region are not implemented by the P.E barrier from crossing the junction.

- The electron current from p to n, *i(p* ✉ *n)* will be proportional to the total number of electrons in the p region.

$$i(p \rightarrow n) = A \exp\left(-\frac{E_1}{k_B T}\right)$$

- After the function is formed, an equilibrium is established where there is no net flow of electrons (or holes) across the junction.

- The minority carriers electrons in the p side are not impeded by the energy barrier from crossing the function. This flow is compensated by the flow in opposite direction of those electrons in the n side with energies $E > |e|V_e$



…….Derive diode equation[10]

- In the n side there are a large number of electrons (majority carriers) in the conduction band.

- However, only those having energy equal to or greater than the barrier energy $|e|V_e$ will be able to cross the junction from the n side to p side.

- i(p ✉ n) will be proportional to the number of electron In the n region with energies greater than or equal to $|e|V_e$;

$$i(n \rightarrow p) = AN_e f\,(E \geq |e|\,V_c)$$

- Ne is the total number of electrons in the conduction band of the n side and
  $f(E >= |e|V_e)$ is the fraction of these electrons.

- The fraction of electrons having energies greater than the barrier |e|

$$f(E \geq |e|V_c) = \exp\left(-\frac{|e|V_c}{k_B T}\right).$$

$$i(n \rightarrow p) = A\exp\left(-\frac{E_2 + |e|V_c}{k_B T}\right)$$