DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB103J -SEMICONDUCTOR PHYSICS
Module-II
Lecture-VIII- SLO1,SLO2

Basic Structure of p-n Junction, Band Diagram of p-n Junction in Thermal Equilibrium

Basic Structure of p-n Junction, Band Diagram of p-n Junction in Thermal Equilibrium

- p-n junction is one of the basic building blocks of integrated circuits. Such a junction can be formed by selective diffusion or ion implantation of n-type or p-type dopant to the p-type or n-type semiconductor.

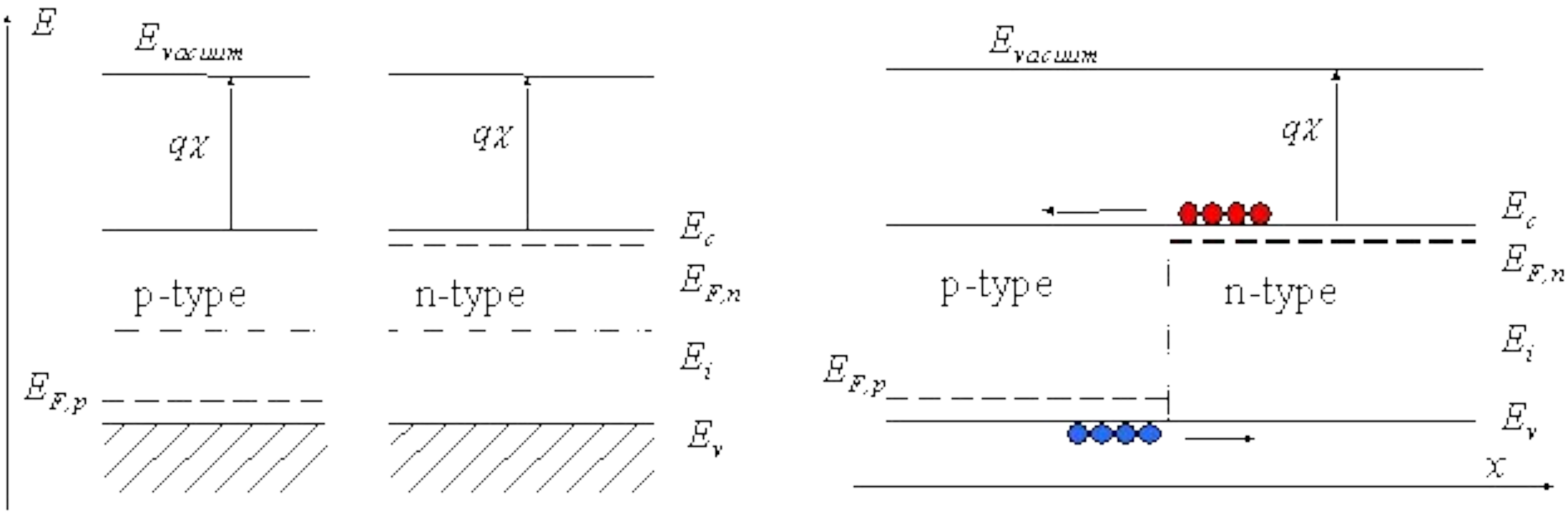
- When p-region and n-region are brought in close contact a p-n junction forms due to the diffusion of charge carriers. While, holes diffuse from p region to n region, electrons diffuse from n region to p region.

- Under thermal equilibrium a built in electric field directed from positive to negative charge which gives rise to drift current and no net transport of carriers due to diffusion is observed across the potential barrier(also called as depletion region).

- At thermal equilibrium, drift and diffusion component of current must cancel each other, J_n and J_p is zero. Hence the Fermi level must be constant throughout and the electron and hole concentrations on both sides remain same.

- While in thermal equilibrium no external voltage is applied between the *n*-type and *p*-type material, there is an internal potential, ϕ_i, which is caused by the work function difference between the *n*-type and *p*-type semiconductors. This potential equals the *built-in* potential.

Basic Structure of p-n Junction, Band Diagram of p-n Junction in Thermal Equilibrium



(a) (b)

Flatband diagram

Energy band diagram of a p-n junction (a) before and (b) after merging the n-type and p-type regions

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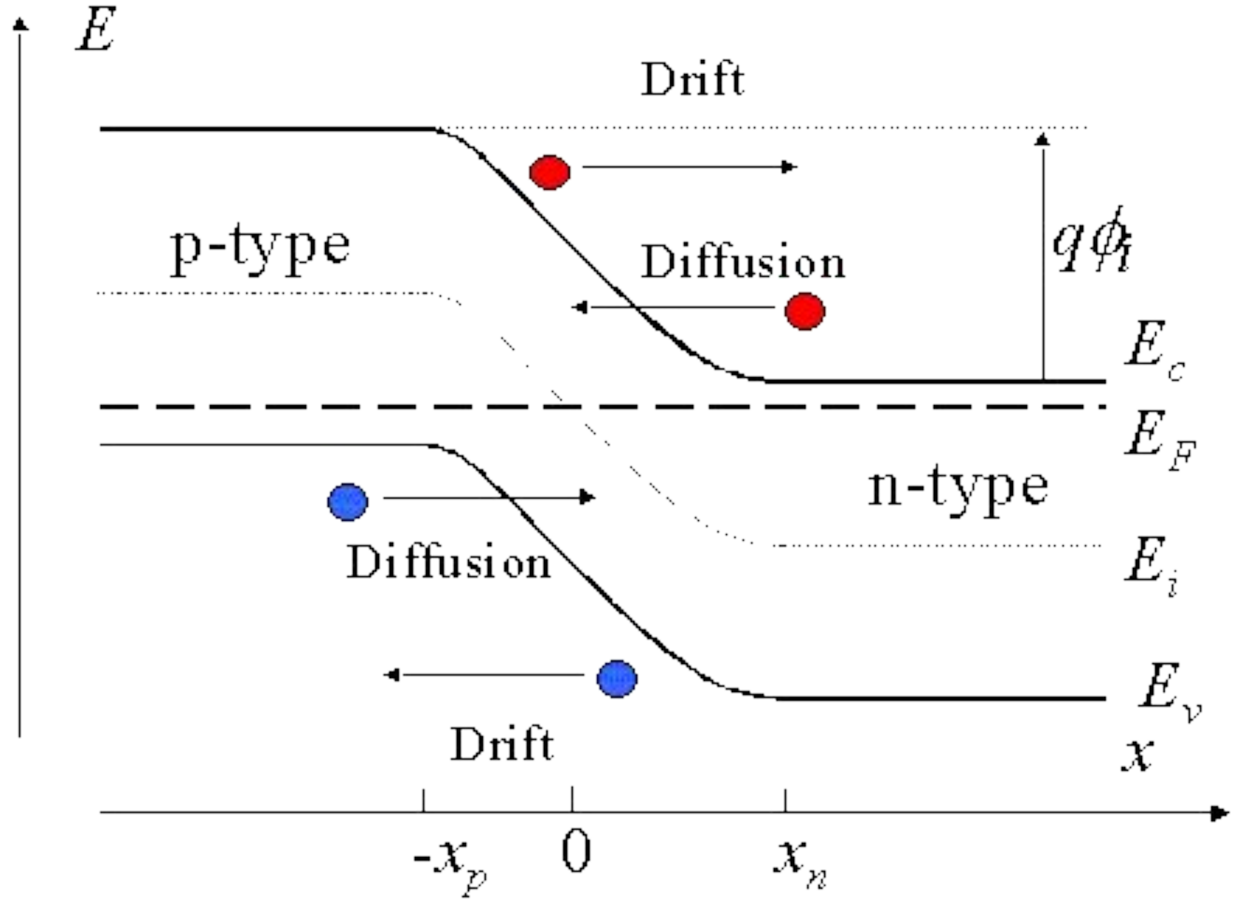

Energy band diagram of a p-n junction in thermal equilibrium

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- Fermi level on p-region and n-region is given by

$E_F = E_{ip} - kT\ln(N_a/n_i)$ for p-region

$E_F = E_{in} - kT\ln(N_d/n_i)$ for n-region

E_F(p-region) = E_F(n-region)

$E_{ip} - E_{in} = kT\ln(N_a N_d/n_i^2)$

If $E_{ip} - E_{in} = V_{bi}$, Built in Potential, then $V_{bi} = kT\ln(N_a N_d/n_i^2)$

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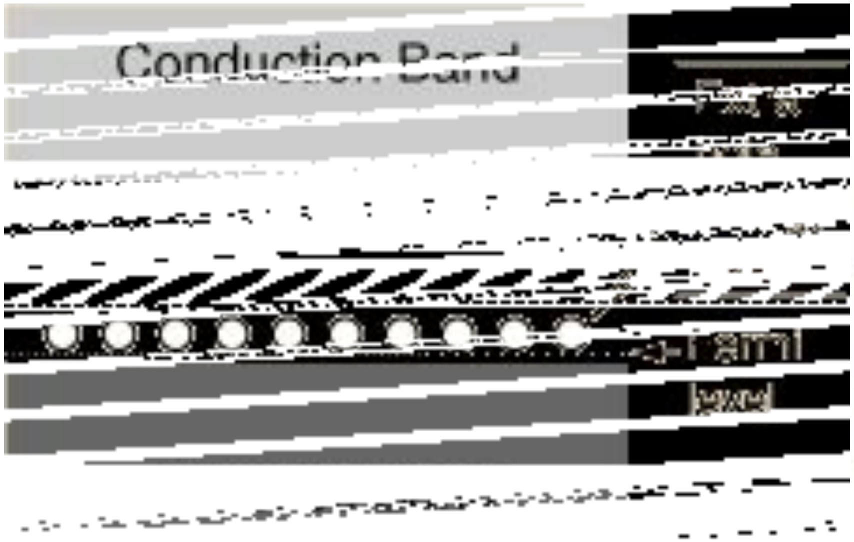

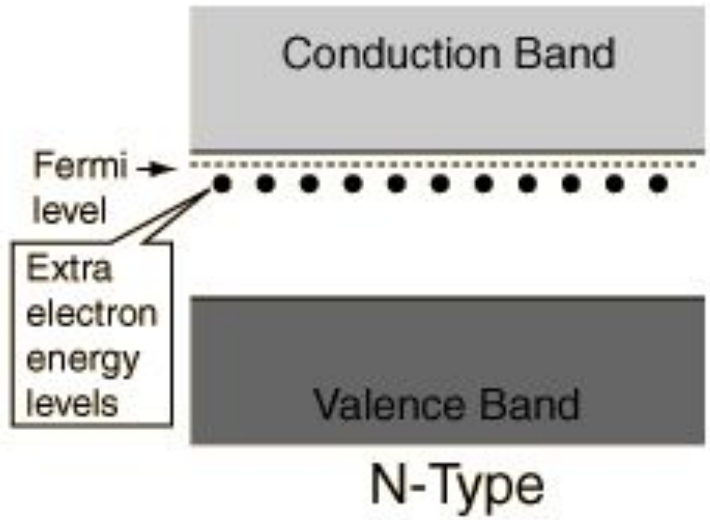

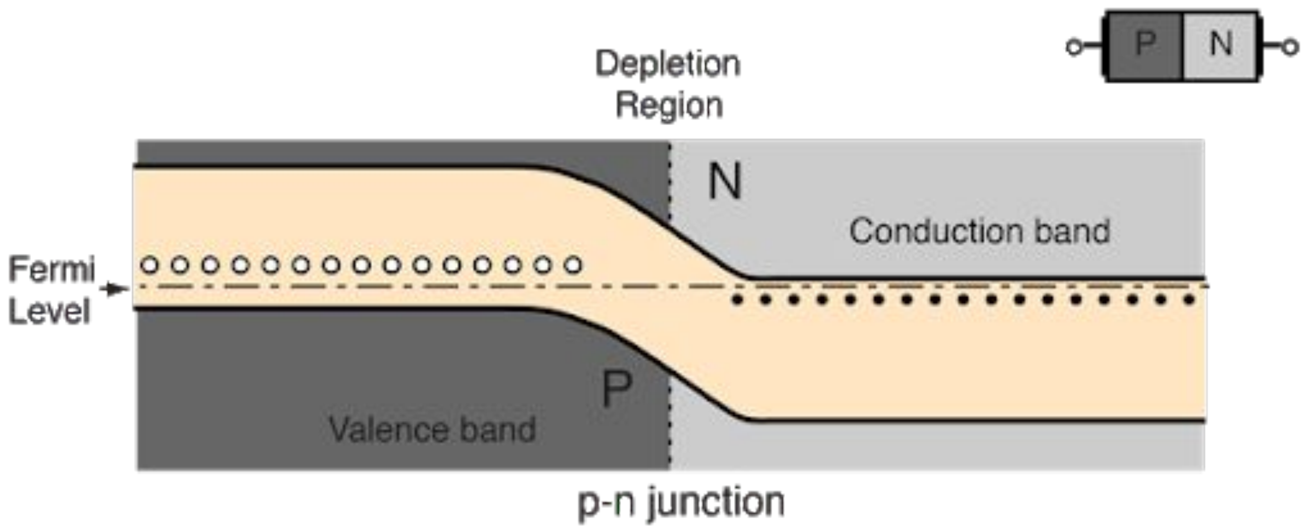

p-n junction under forward biasing

When the p-n junction is applied with external voltage both electrons and hole concentrations deviates from their equilibrium values. Also potential difference across depletion region deviates from its equilibrium value V_{bi} by an amount of applied bias.

When the p-n junction is forward biased by V_f ,ie., positive terminal of the battery is connected to the p-region and the negative terminal of the battery is connected to the n-region, the potential difference across the depletion region decreases by $V_{bi} - V_f$ .The width of depletion region decreases. Thus more electrons move from n region to p region and increase the diffusion current.

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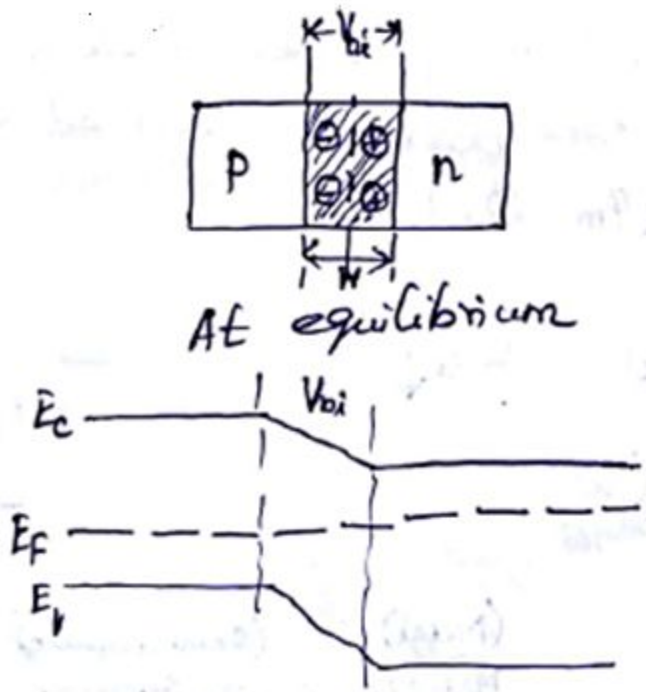

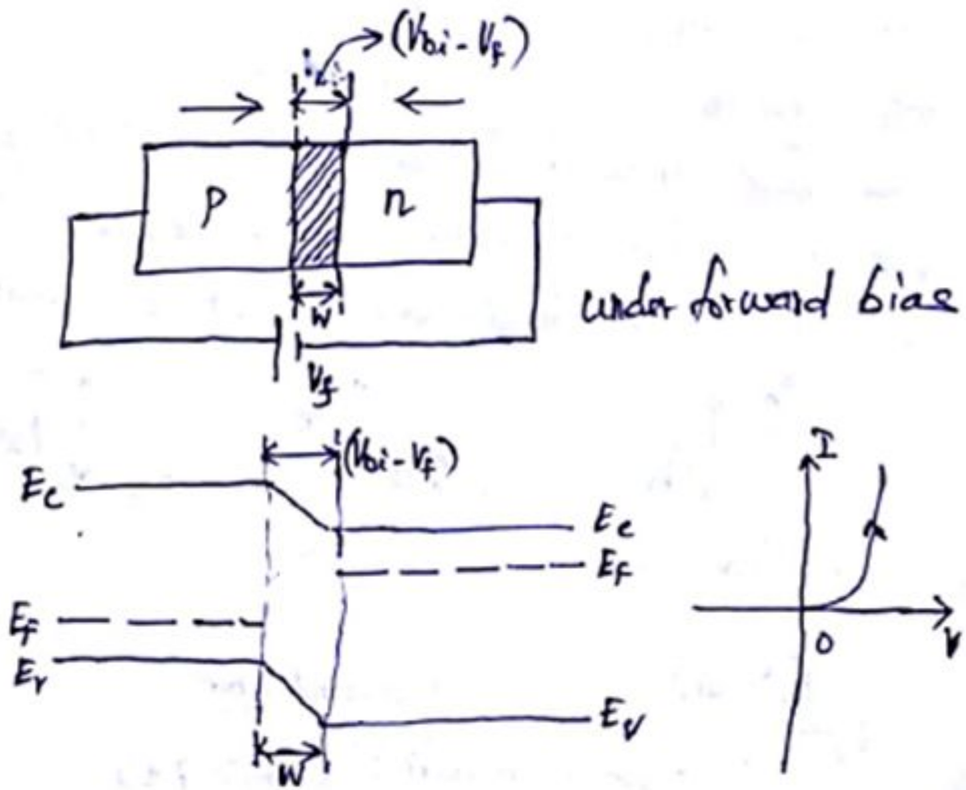

p-n junction under reverse biasing

When the p-n junction is reverse biased by V_r ,ie., positive terminal of the battery is connected to the n-region and the negative terminal of the battery is connected to the p-region, the potential difference across the depletion region increases by $V_{bi} + V_r$. The width of depletion region increases. Thus no electrons from n region and no holes from p region diffuse across the junction. Now the current is due to the diffusion of minority charge carriers in the p and n region which is extremely small.

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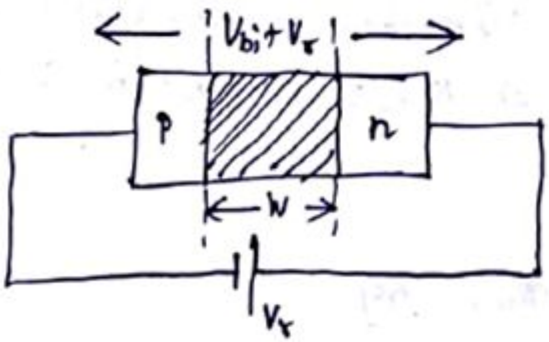

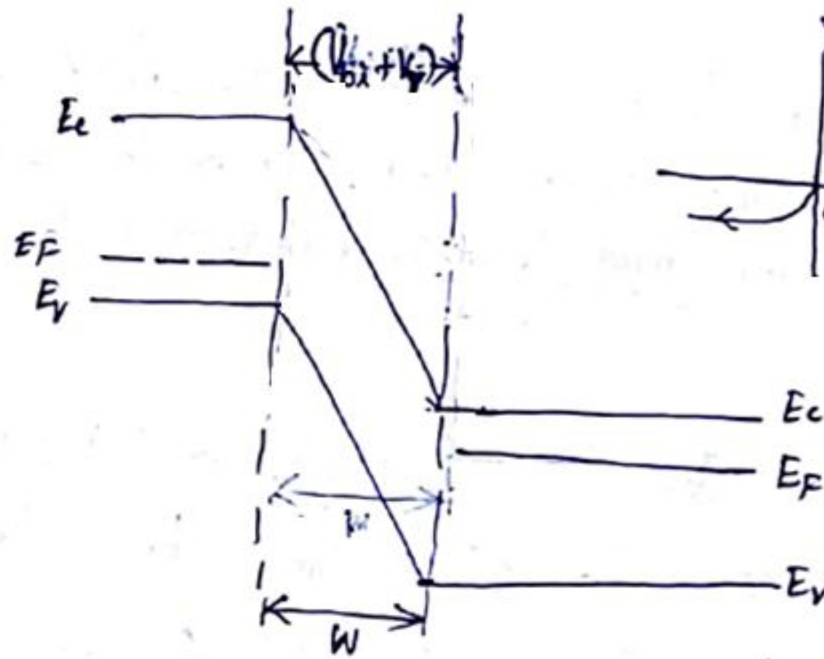

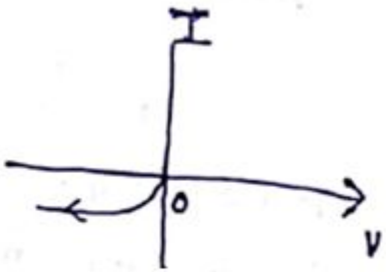

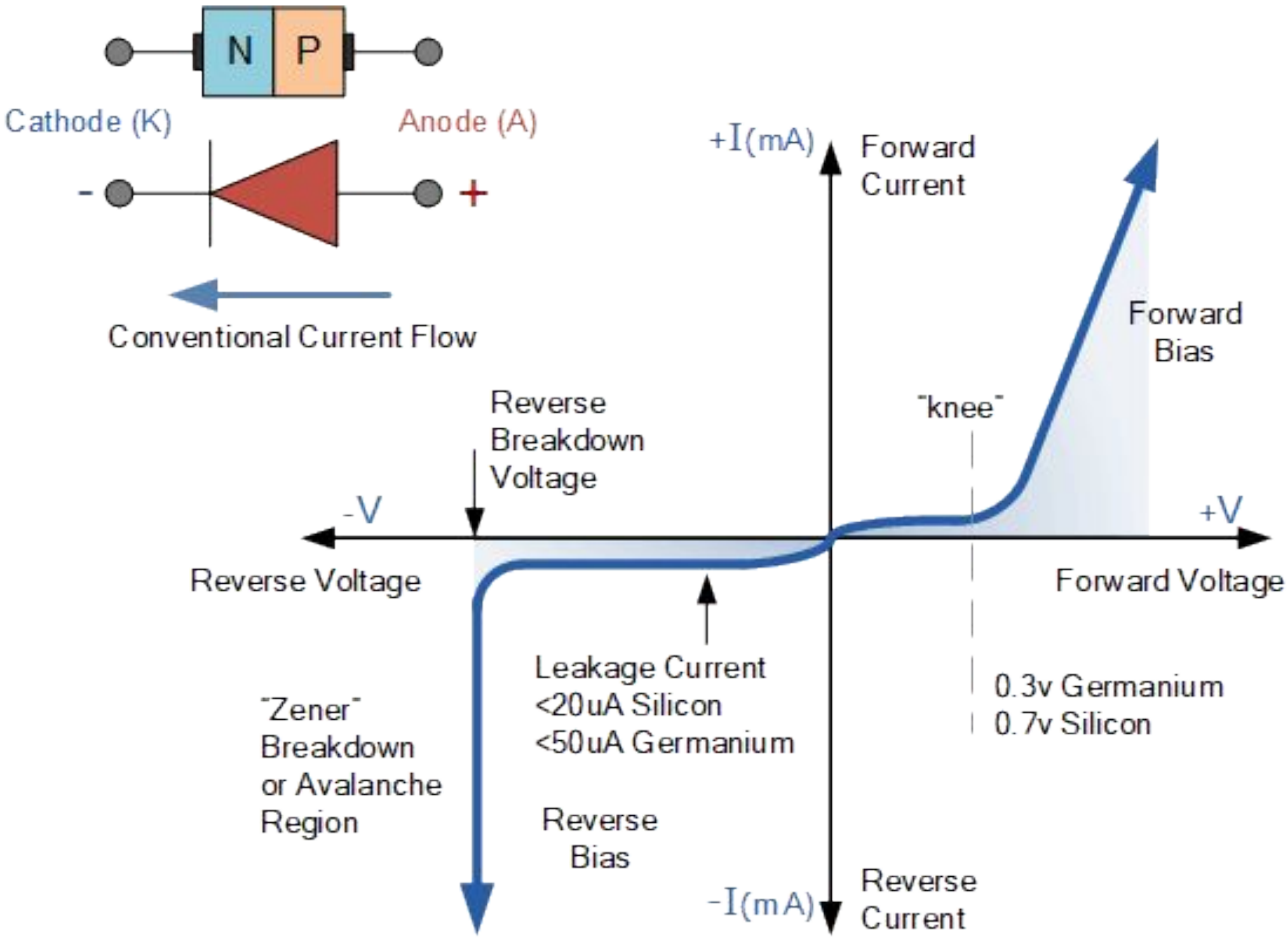

Junction Diode Symbol and Static I-V Characteristics

THANK YOU FOR LISTENING