University of Anbar
College of Engineering
Dept. of Electrical Engineering

Fundumantal of Electronic I

Second Class

Chapter01: Semiconductor Diodes

Lec01_p3

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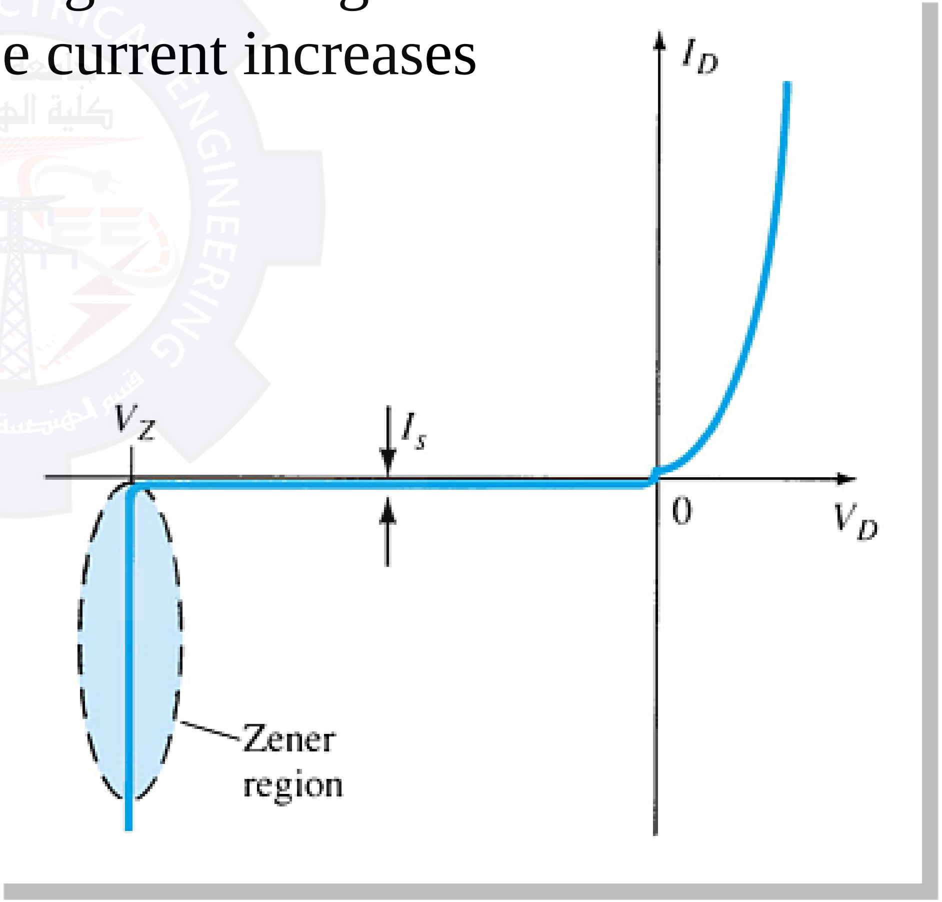
Zener Region

The Zener region is in the diode's reverse-bias region.

At some point the reverse bias voltage is so large the diode breaks down and the reverse current increases dramatically.

- The maximum reverse voltage that won't take a diode into the zener region is called the peak inverse voltage (PIV) or peak reverse voltage (PRV).
- The voltage that causes a diode to enter the zener region of operation is called the zener voltage (V_Z).



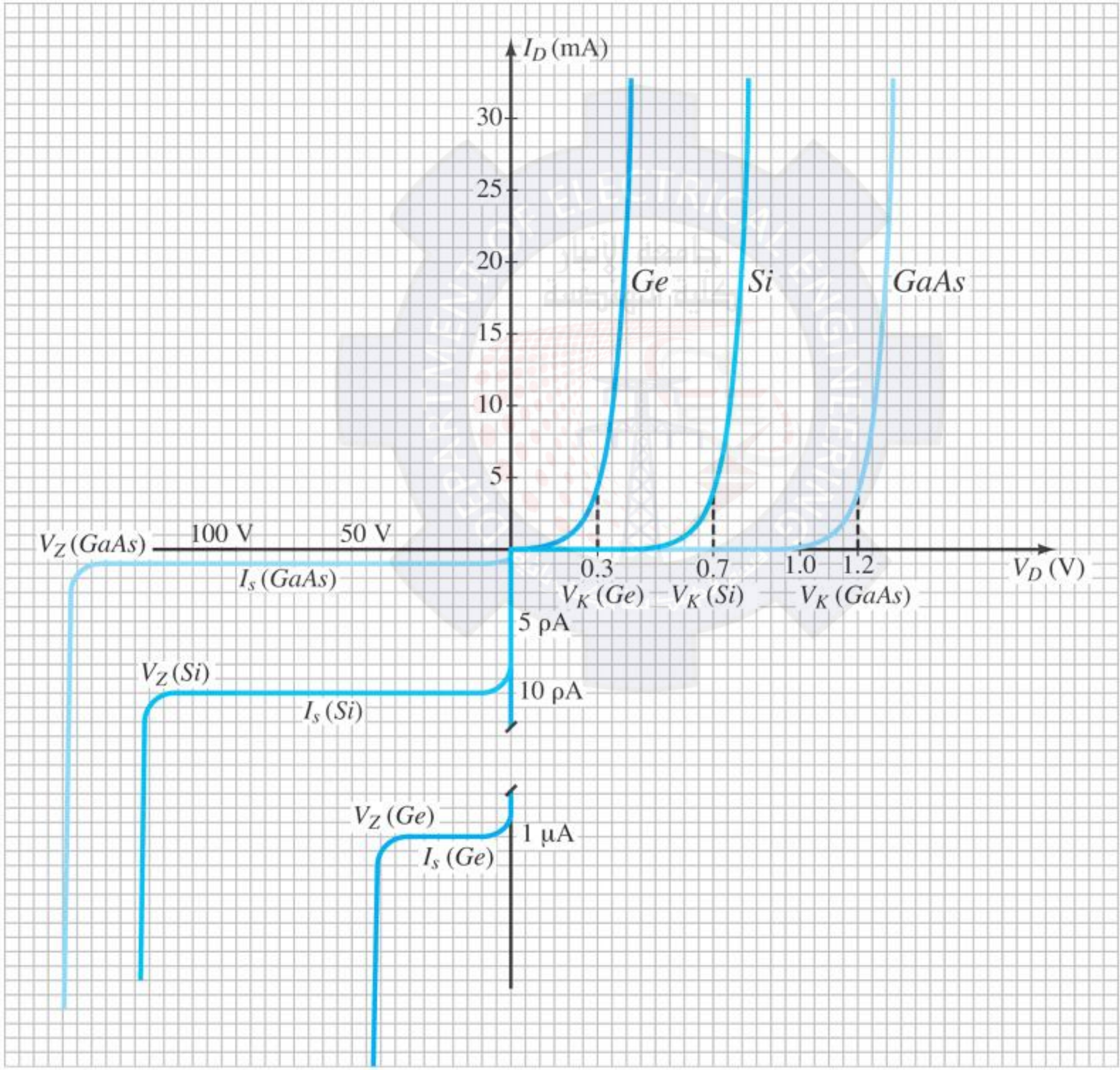
Forward Bias Voltage

The point at which the diode changes from no-bias condition to forward-bias condition occurs when the electrons and holes are given sufficient energy to cross the *p-n* junction. This energy comes from the external voltage applied across the diode.

The forward bias voltage required for a:

- **gallium arsenide diode ≅ 1.2 V**
- **silicon diode ≅ 0.7 V**
- **germanium diode ≅ 0.3 V**

Comparison Ge, Si, GaAs



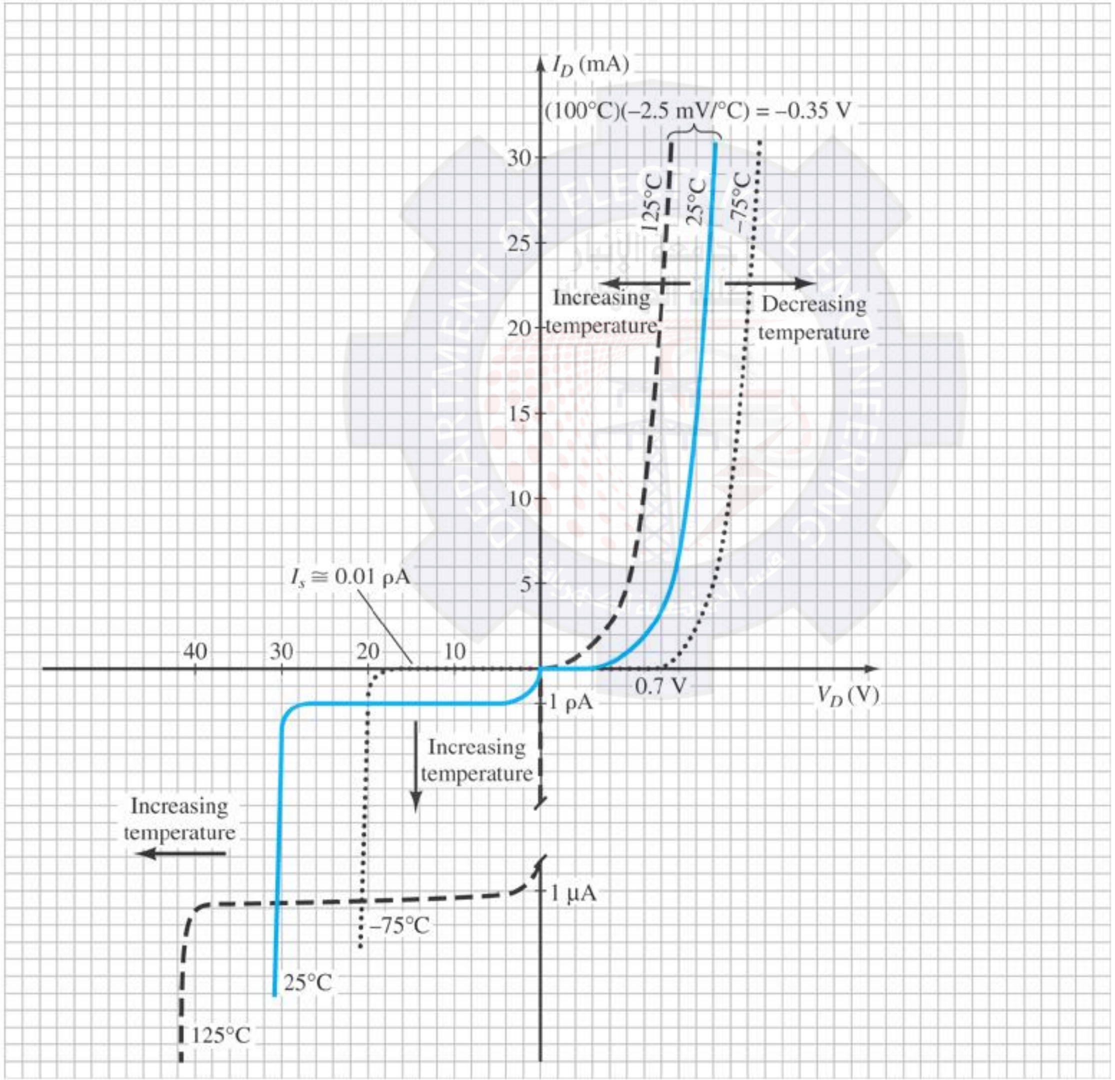
Temperature Effects

As temperature increases it adds energy to the diode.

- It reduces the required forward bias voltage for forward-bias conduction.
- It increases the amount of reverse current in the reverse-bias condition.

Germanium diodes are more sensitive to temperature variations than silicon or gallium arsenide diodes.

Temperature Effects



Resistance Levels

Semiconductors react differently to DC and AC currents.

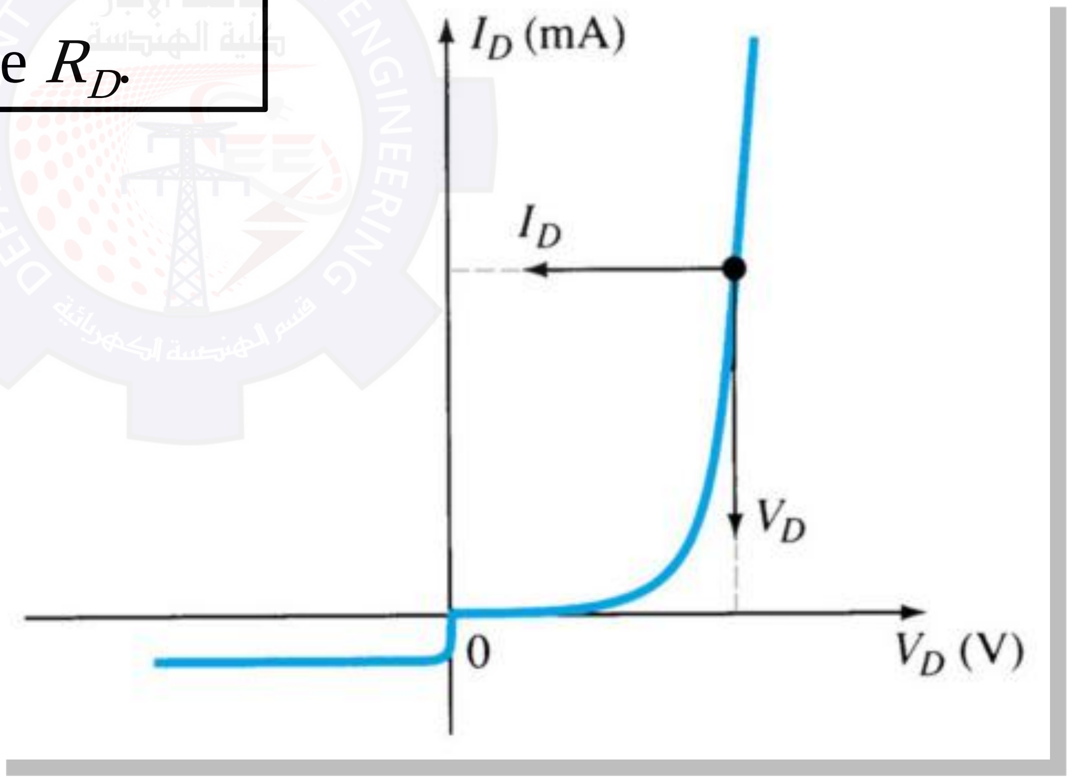
There are three types of resistance:

- **DC (static) resistance**
- **AC (dynamic) resistance**
- **Average AC resistance**

DC (Static) Resistance

For a specific applied DC voltage V_D, the diode has a specific current I_D, and a specific resistance R_D.

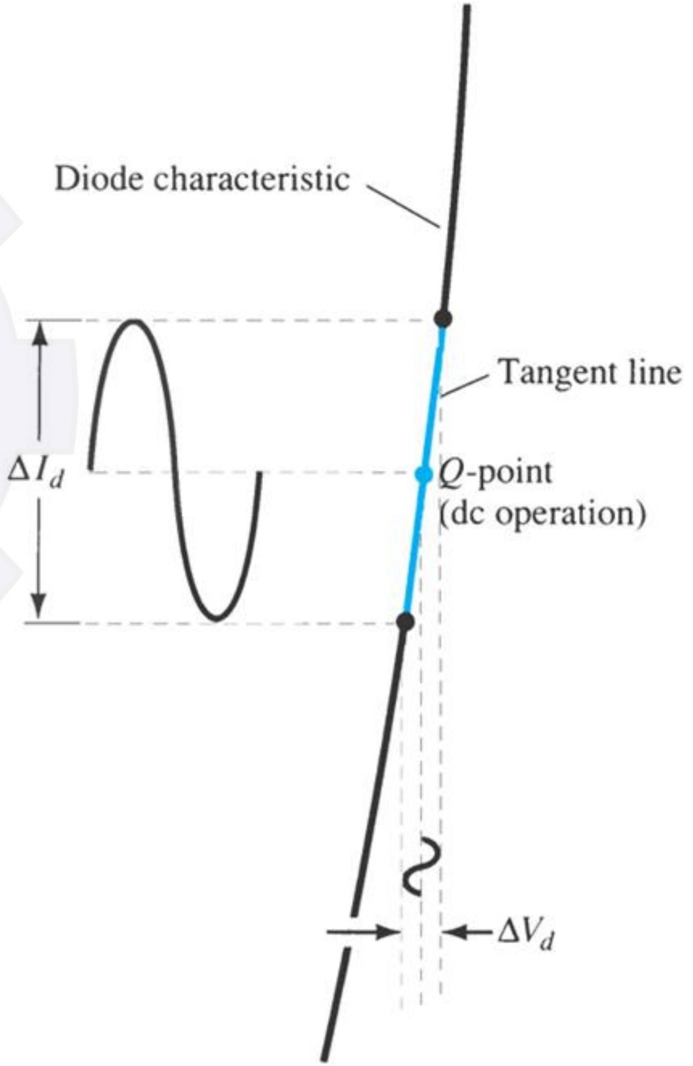
$$R_D = \frac{V_D}{I_D}$$



AC (Dynamic) Resistance

The dynamic resistance is the resistance offered by the diode to the AC signal. Is is equal to the slope of the *VI* characteristics (dV/dI or $\Delta V/\Delta I$) ,

$$r_D = \frac{\text{change in voltage}}{\text{resulting change in current}} = \frac{dV}{dI} = \frac{\Delta V}{\Delta I}$$



AC (Dynamic) Resistance

$$\text{since } I_D = I_s\left(e^{V_D/nV_T} - 1\right) \quad , \quad \frac{dI_D}{dV_D} = \frac{I_s}{nV_T} e^{V_D/nV_T}$$

$$\frac{dI_D}{dV_D} = \frac{1}{nV_T}\left(I_D + I_s\right) \quad , \quad \text{since } I_D >> I_s \ , \ \frac{dI_D}{dV_D} \cong \frac{I_D}{nV_T}$$

$$\frac{dV_D}{dI_D} = r_D = \frac{nV_T}{I_D}$$

for n=1, and at room temperature of 27°C, T=273+27=300K

$$V_T = \frac{KT}{q} = \frac{\left(1.38\times10^{-23}\right)}{1.6\times10^{-19}} \cong 26mV$$

$$\boxed{r_D = \frac{26mV}{I_D}}$$

AC (Dynamic) Resistance

In the forward bias region: $$r'_d = \frac{26\,\text{mV}}{I_D} + r_B$$

- The resistance depends on the amount of current (I_D) in the diode.
- r_D = 26 mV/I_D is the resistance of the p-n junction and does not include the resistance of the semiconductor material itself (the *body* resistance).
- r_B is added to account for body resistance and it ranges from a typical 0.1 Ω to 2 Ω.

In the reverse bias region:

$$\mathbf{r'_d} = \infty$$

The resistance is effectively infinite. The diode acts like an open.

Average AC Resistance

$$r_{av} = \frac{\Delta V_d}{\Delta I_d} \Big| \text{ pt. to pt.}$$

AC resistance can be calculated using the current and voltage values for two points on the diode characteristic curve.