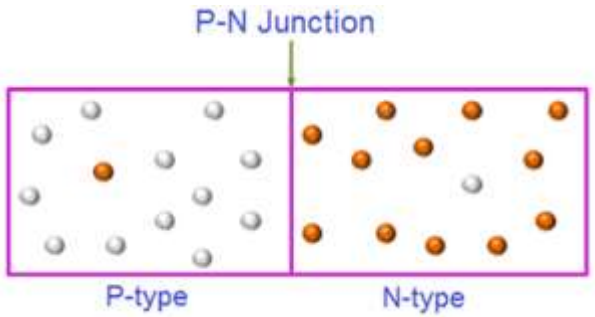
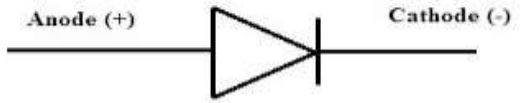
Electronic Devices

Lecture 4
P-N Junction

Dr. Roaa Mubarak

Diode symbol





- Diode current voltage Relation :

$$I_D = I_s \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

V_D : *Voltage across diode*
I_D : *Diode current*
I_s : *Reverse sturation current*
V_T: *Thermal voltage*
η: *Ideality Factor Constant (Si* $\eta=2$, *Ge* $\eta=1$)

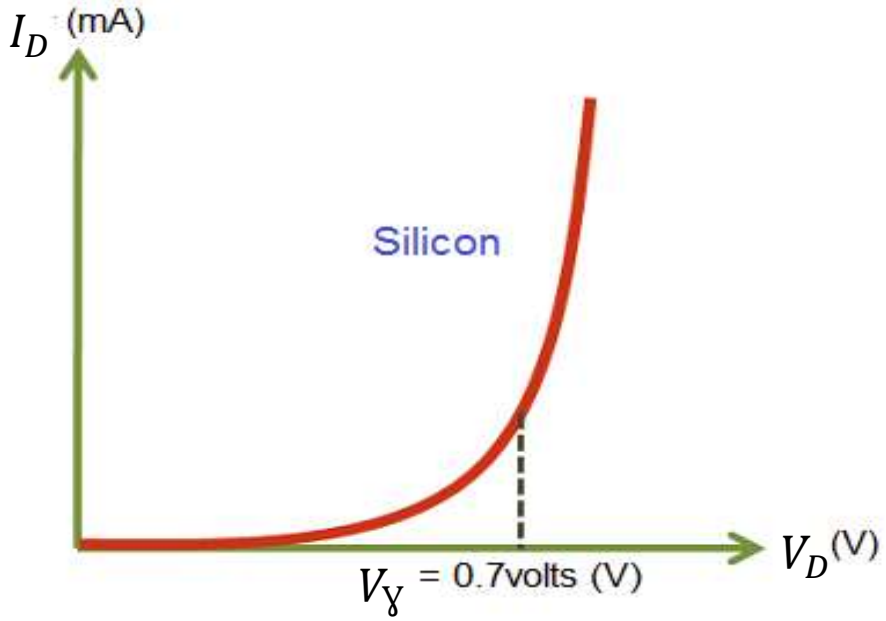
V-I Characteristics

$$I_D = I_s \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

Forward $e^{\frac{V_D}{\eta V_T}} >> 1$

VT<< VD,

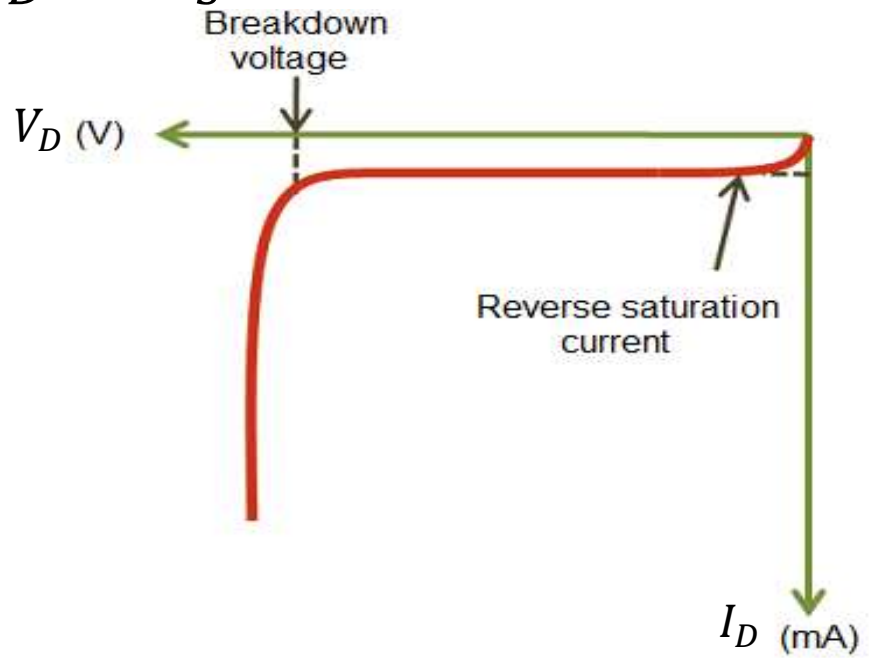
$$I_D = I_s \left(e^{\frac{V_D}{\eta V_T}} \right)$$



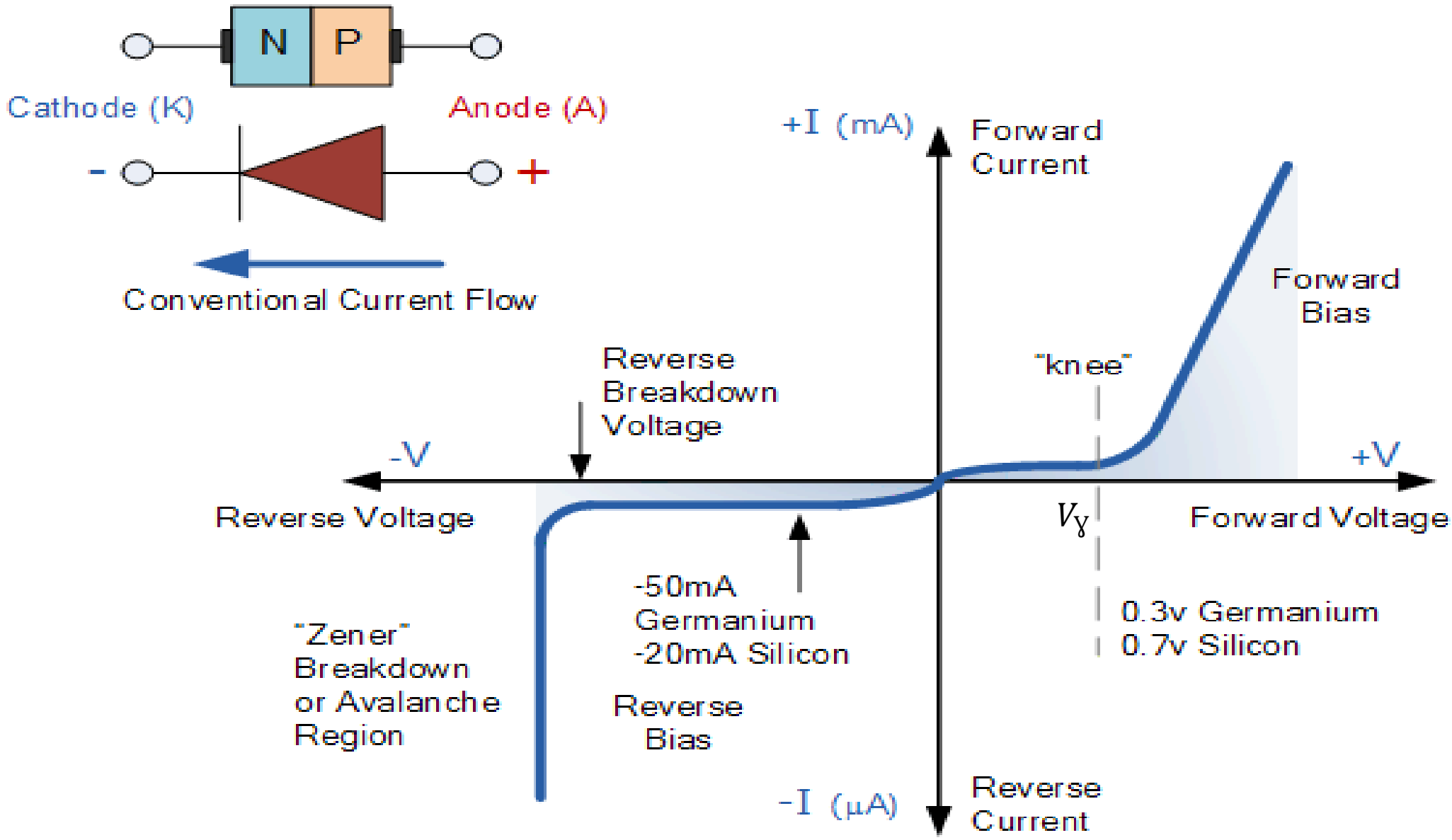
Reverse $e^{\frac{V_D}{\eta V_T}} \ll 1$

VD<< VT,

$$I_D = -I_s$$



V-I Characteristics



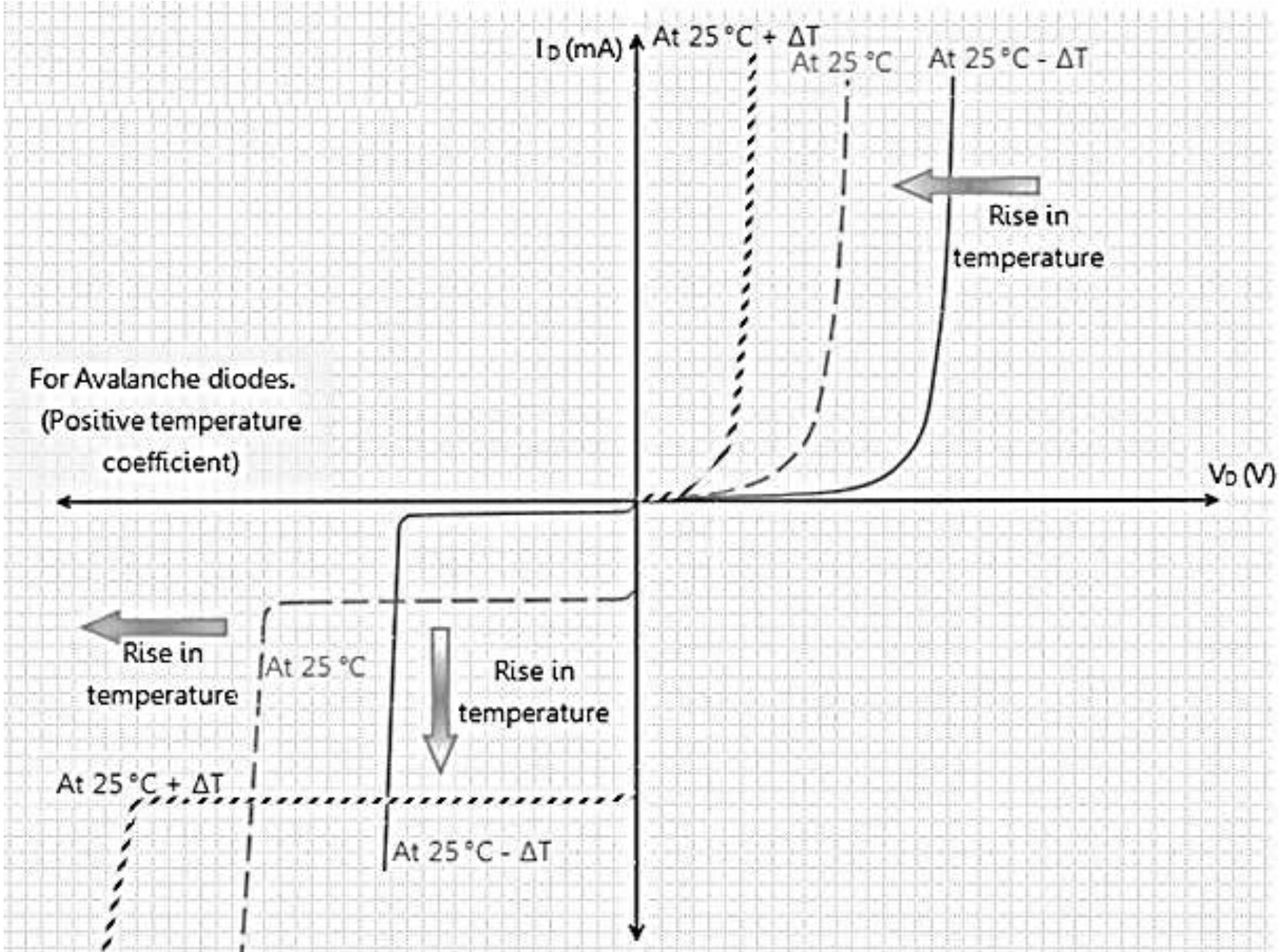
Temperature Effects

- Since I_s, V_T are function of temperature, So diode Char. Also vary with temperature.
- For silicon the charge is approximately 2mv/˚C
- The change in I_s is 7 percent /˚C
- The value of I_s is doubled every 10˚C rise in temperature.

$$I_{s2} = I_{s1}\, x\, 2^{\left(\frac{T_2 - T_1}{10}\right)}$$

Example: I_{s1}= 1μA ------ then I_{s2}= $(1.07)^{10}$ ≈2 μA

Temperature Effects



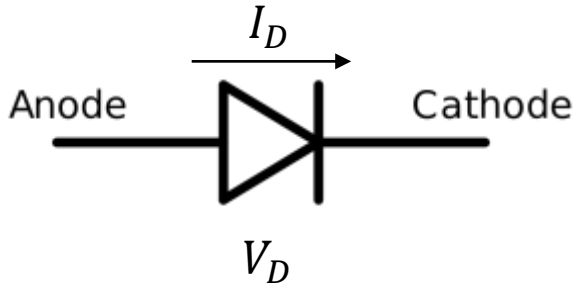
Diode Models

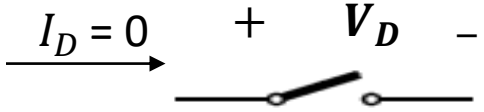
The diode as a circuit elements:

- Ideal Diode Model
- Large Signal model
- Small Signal model

The Ideal Diode Model

- The diode is designed to allow current to flow in only one direction.
- The perfect diode would be a perfect conductor in one direction (Forward bias) and a perfect insulator in the other direction (reverse bias).



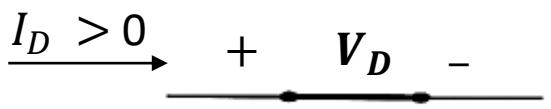


Reverse biased

$V_D < 0$, $I_D = 0$

Open Circuit

OFF



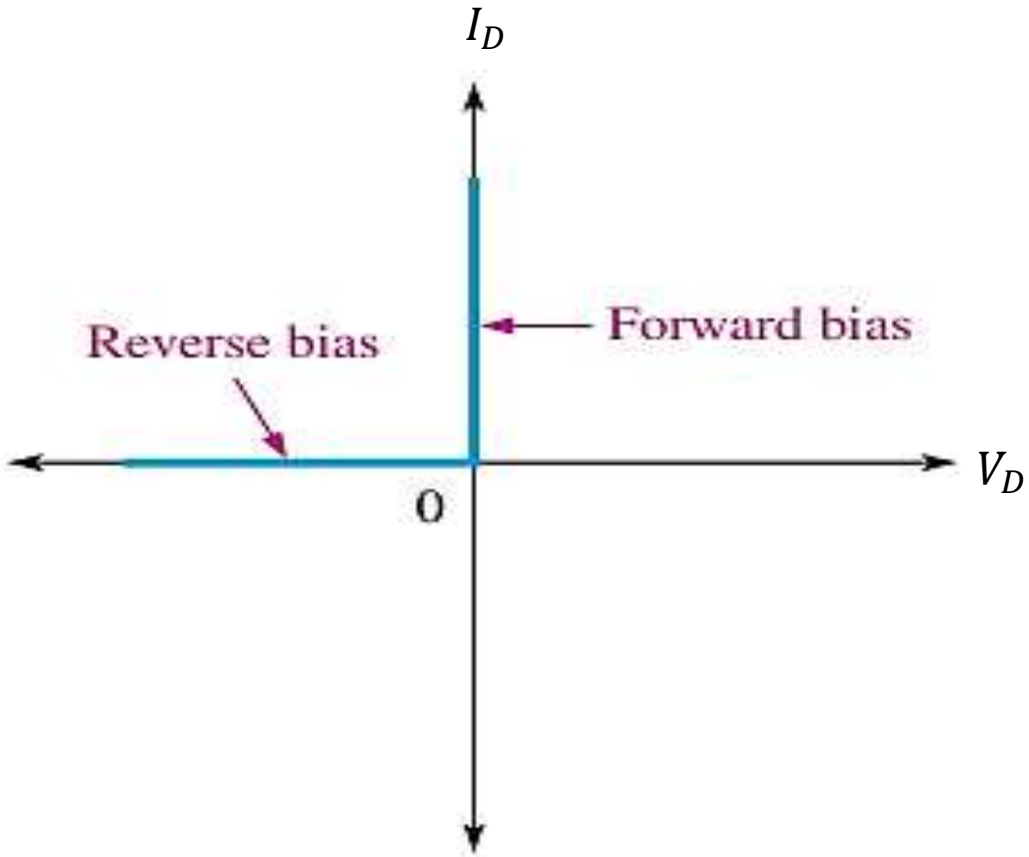
Forward biased

$V_D = 0$, $I_D > 0$

Short Circuit

ON

The Ideal Diode Model



Ideal V-I Characteristic Curve (blue)

The Ideal Diode Model

- **Example:**

Assume the diode in circuit below is ideal.

Determine the value I_D if:

a) Vs = 5 V b) Vs = -5V

Sol:

a) With Vs =5V, Diode is forward, for Ideal Model it replaced by short circuit.

$$I_D = \frac{Vs}{R} = \frac{5}{50} = 100mA$$

---

b) With Vs =-5V, Diode is Reverse, for Ideal Model it replaced by open circuit.

$I_D = 0$