Higher Technological Institute

المعهد التكنولوجي العالي

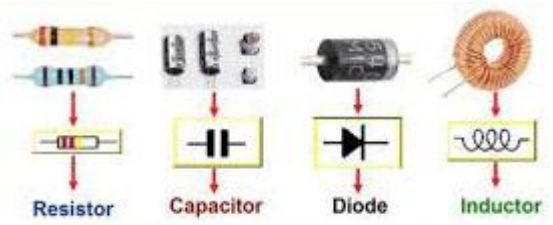
العاشر من رمضان

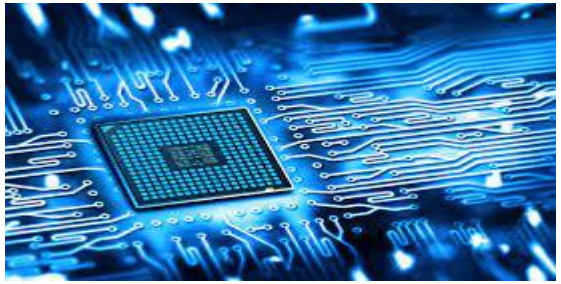
Electronics 1

BSC 113

Summer 2021-2022

Lecture 12





Introduction to Semiconductors

INSTRUCTOR

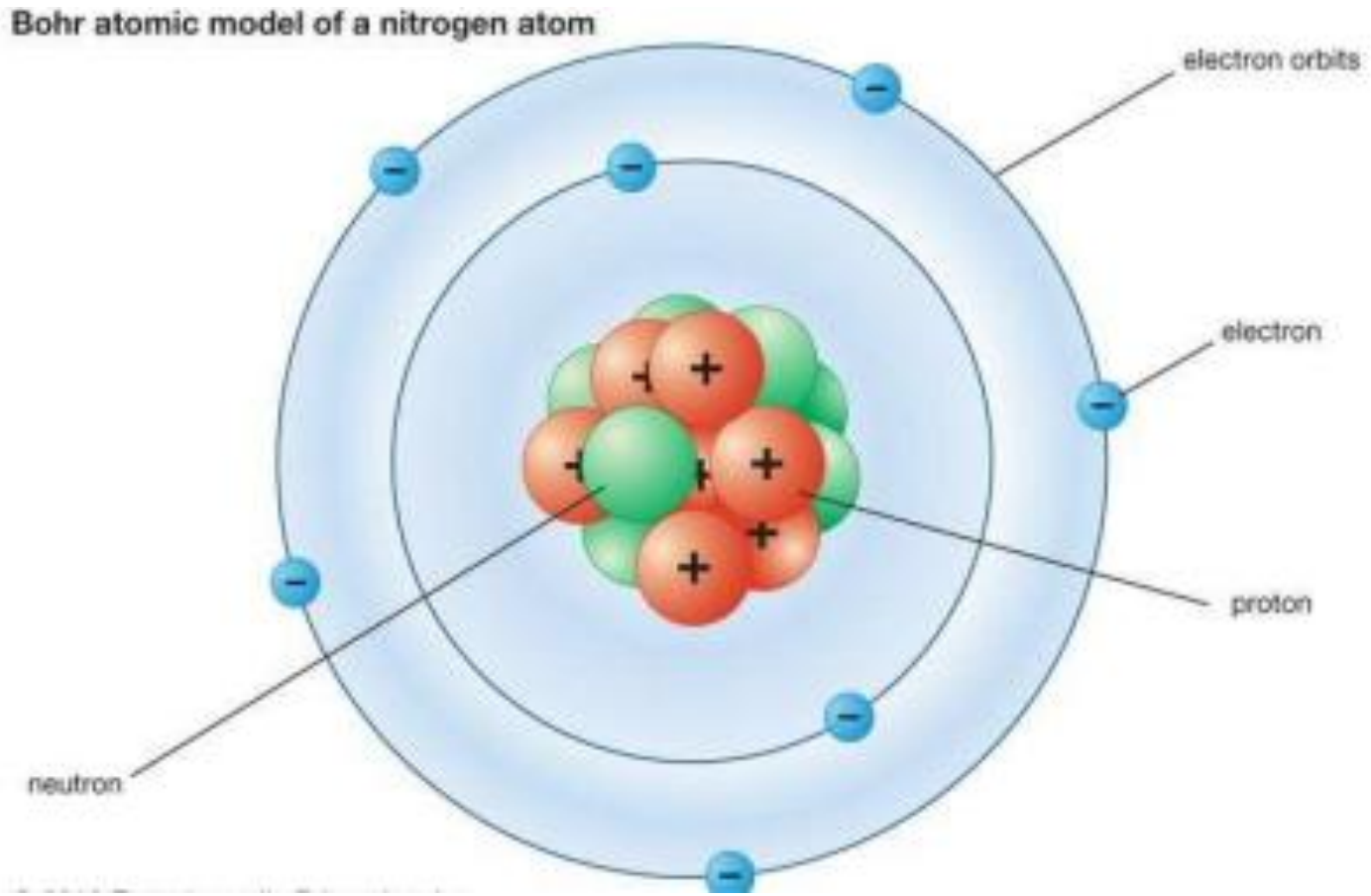
DR / AYMAN SOLIMAN

➢ Contents

1) Definitions of atom
2) Basic of materials
3) Semiconductor concepts
4) doping process
5) N-type material
6) P-type material
7) Introduction to diode
8) models of diode

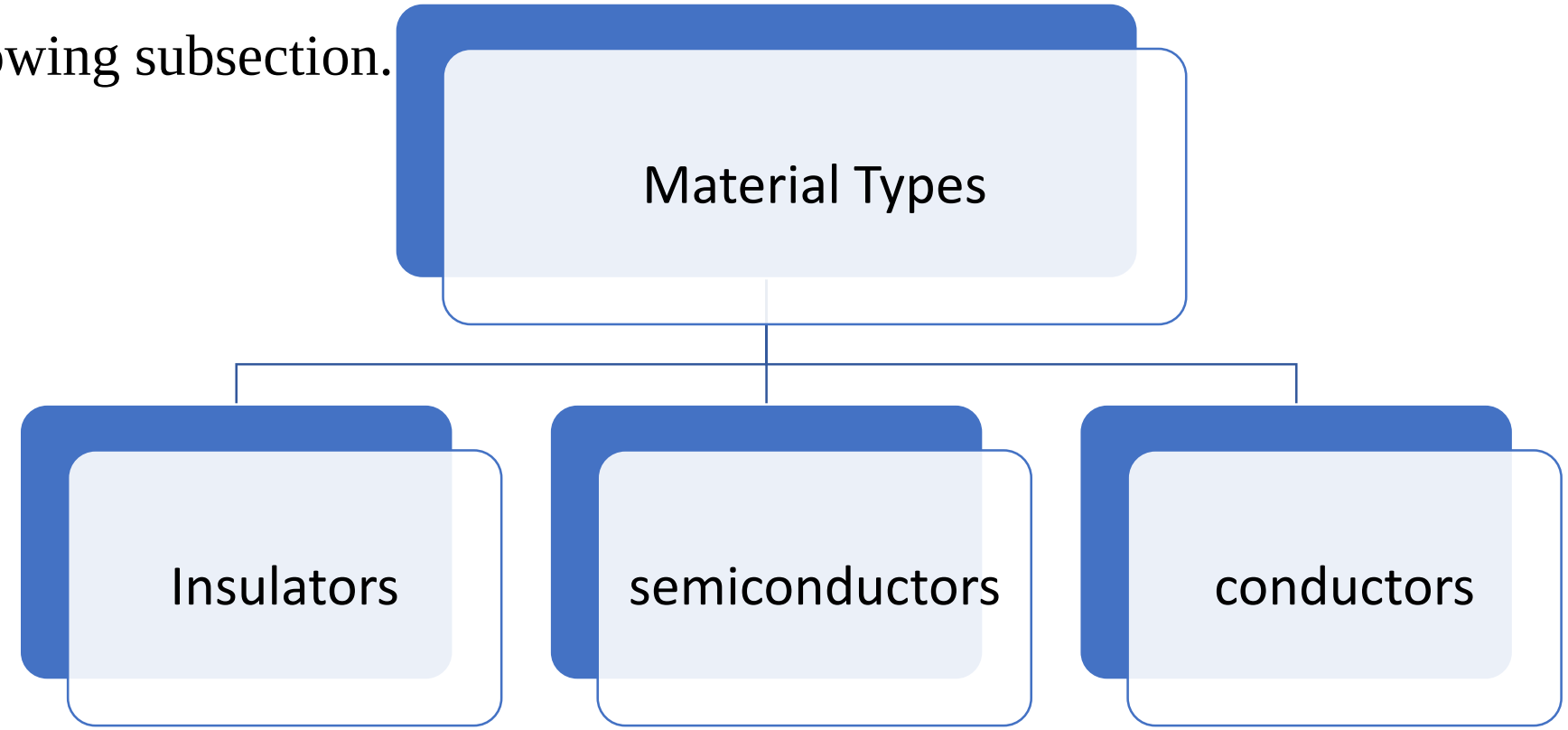
❑ 1. Definitions of atom

- The atom is considered the smallest particle of the element.

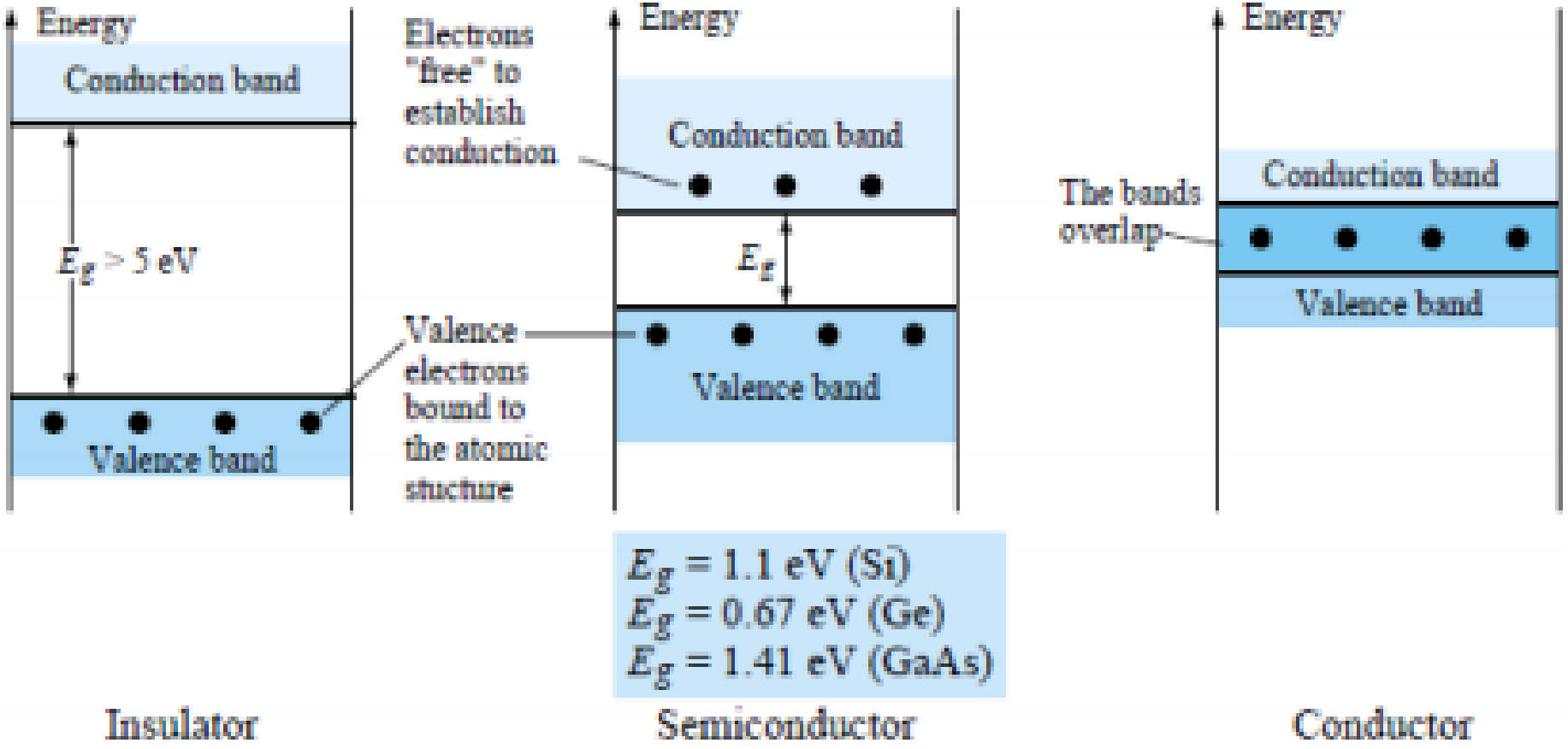


❑ 2. Basic of materials

➢ 2.1 Resistivity: We can define the resistivity as resistance of matter against flow the electrical current. Now the differences between materials will be stated in the following subsection.

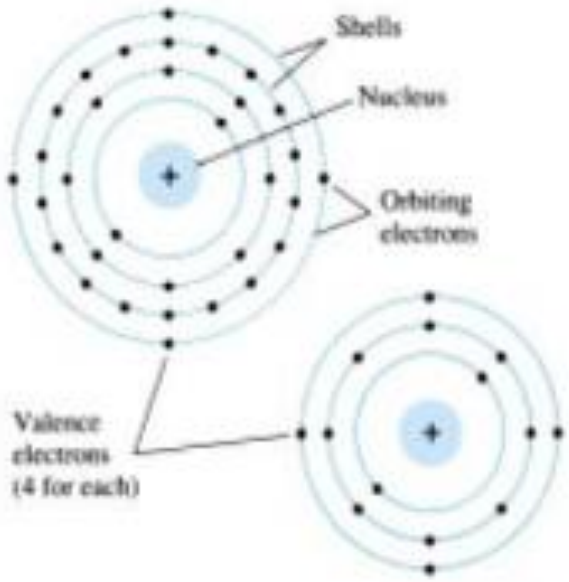


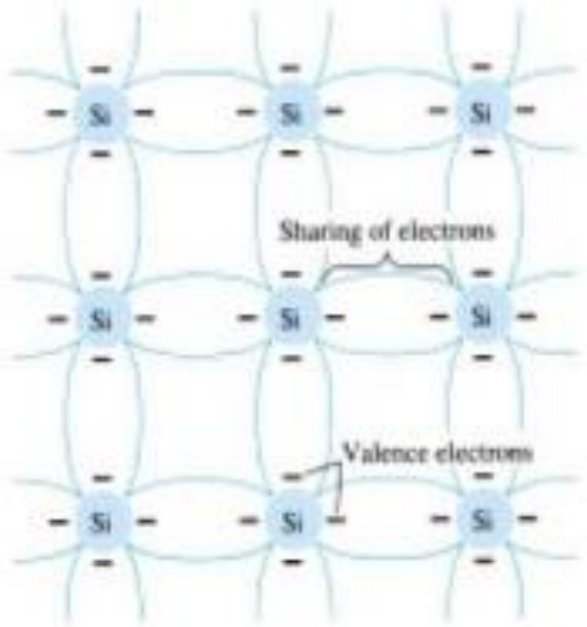
❑ Material Types



❑ Semiconductor concepts

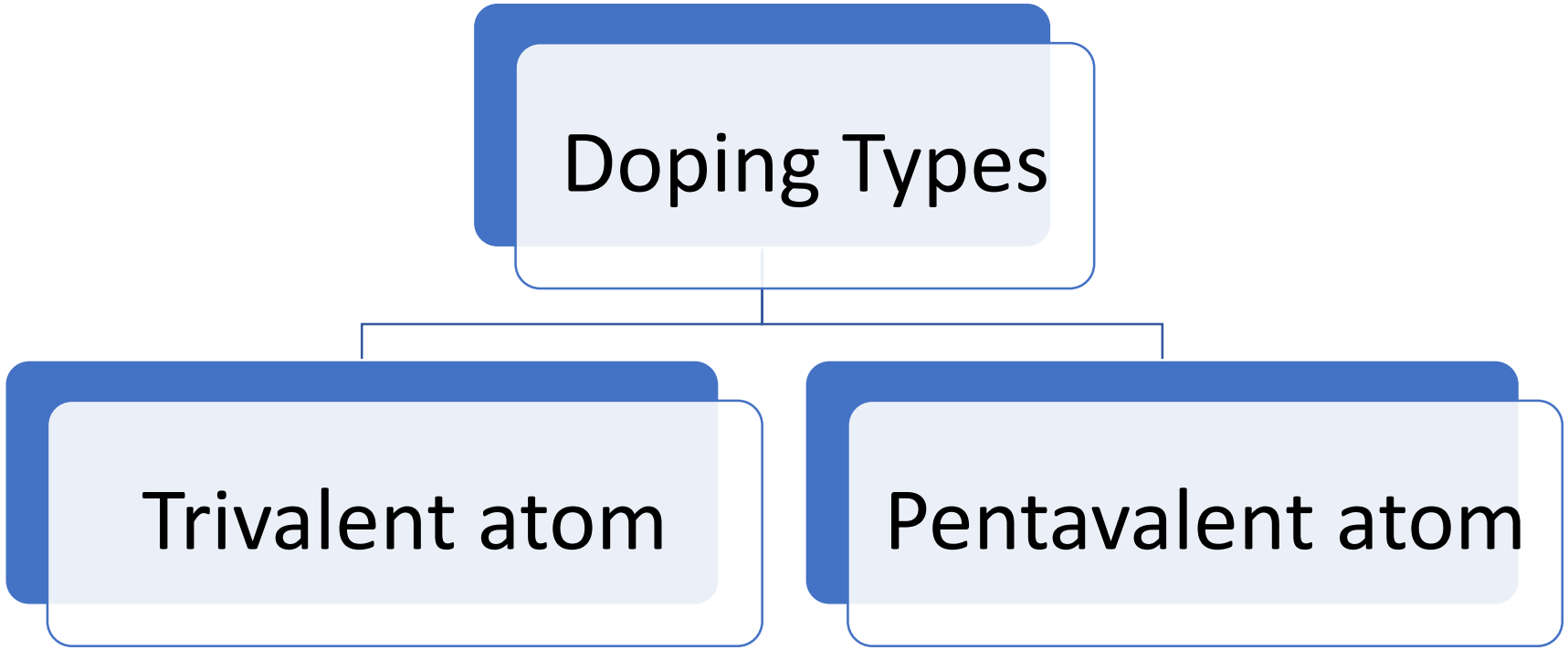
- The more popular semiconductor materials are Silicon (Si) which has 14 electrons and germanium (Ge) which has 32 electrons. All semiconductors have 4 electrons at the Fermi level.





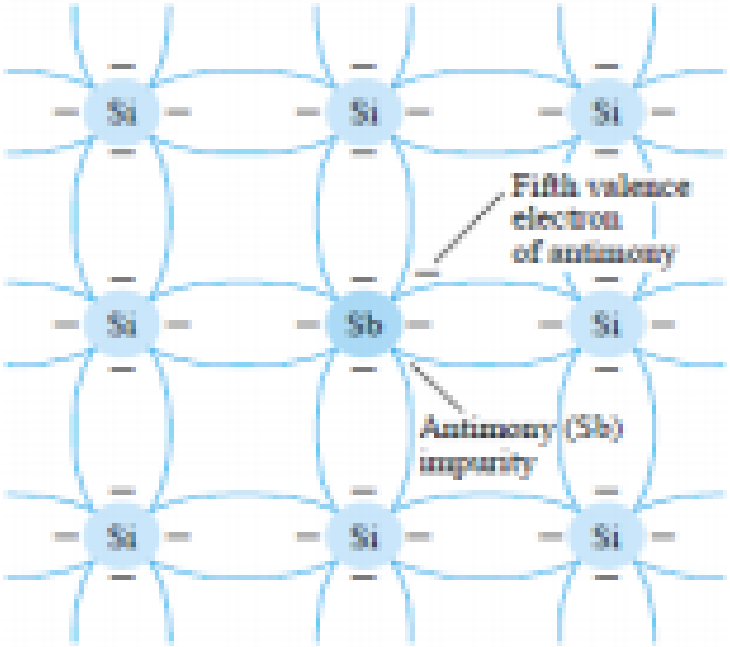
❑ doping process

- The doping is control process by adding impurities to pure semiconductors to enhance its conductivity to electrical current.



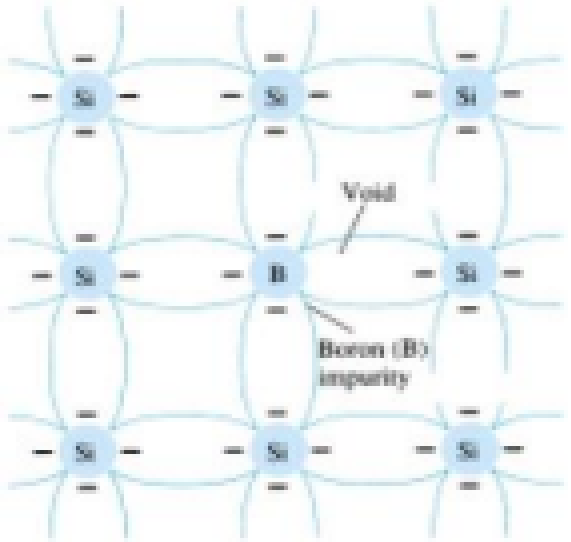
❑ N-type material

- This type is negative type with majority of electrons and minority of holes. The doping in this type is happened by pentavalent atom which has five electrons in the Fermi level. Four of them complete covalent bonds and still one free electron to conduct electrical current



❑ P-type material

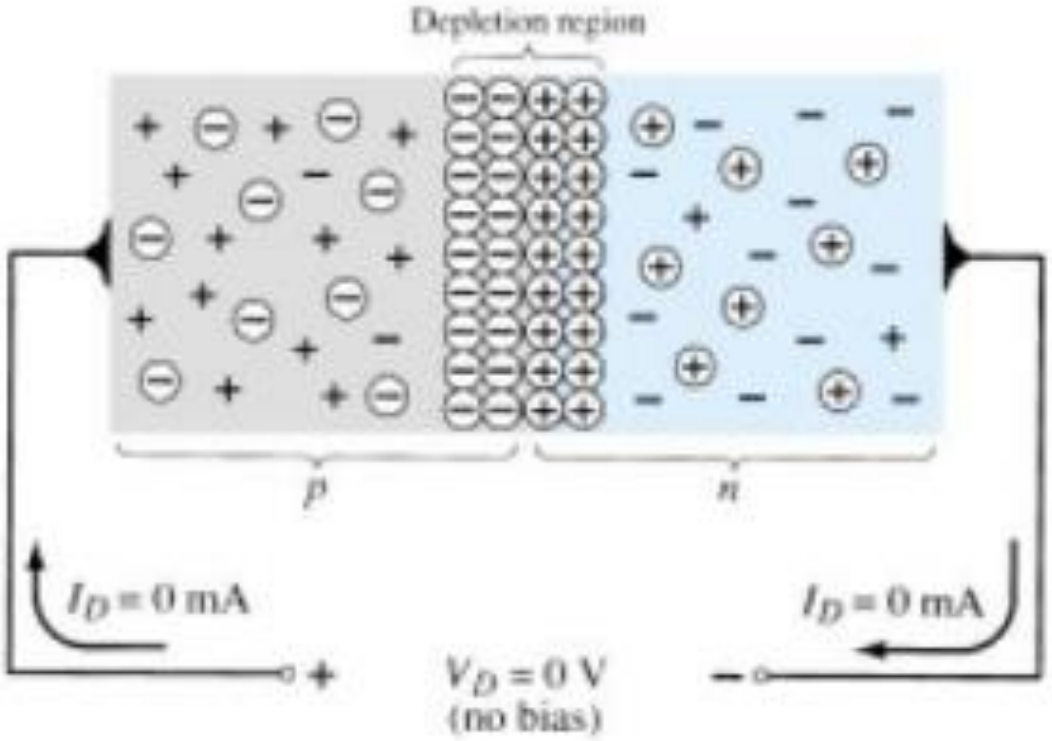
- This type is positive type with majority of holes and minority of electrons. The doping in this type is happened by trivalent atom which has three electrons in the Fermi level. all of them complete covalent bonds and still one hole needs one free electron to conduct electrical current



❑ Depletion layer

- First, we will put N-type material beside P-type material. The diffusion of electrons will be happened from N-type to P-type.
- The second step is the recombination between electrons and holes to complete electron and hole pairs.
- The third step is the ionization which makes the N-type change from neutral state to positive ions (Donor's atoms) and the P-type change from neutral state to negative ions (Acceptors atoms). At the equilibrium between the attraction force between positive ions and electrons and the repulsion force between negative ions and electrons complete the depletion layer

❑ Depletion layer



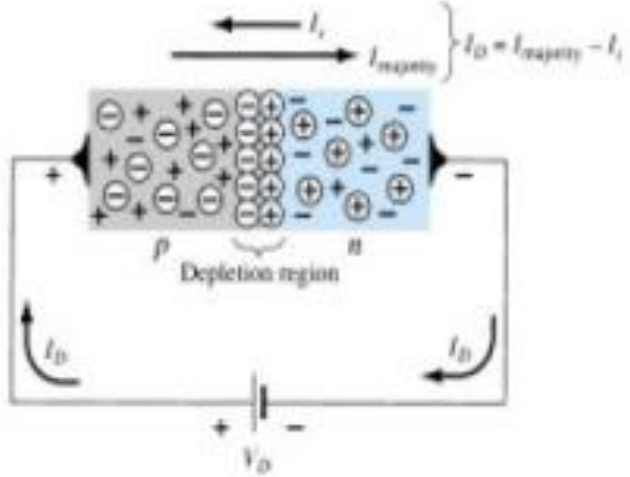
❑ Forward bias

- Forward bias (F.B): the connection is positive DC battery with P-type and negative DC battery with N-type generate two repulsion force between them then depletion region width is reduced then flow the electrical current I_D.

$$I_D = I_s\left(e^{\frac{kV_d}{T_k}} - 1\right) \qquad (5\text{-}1)$$

where:

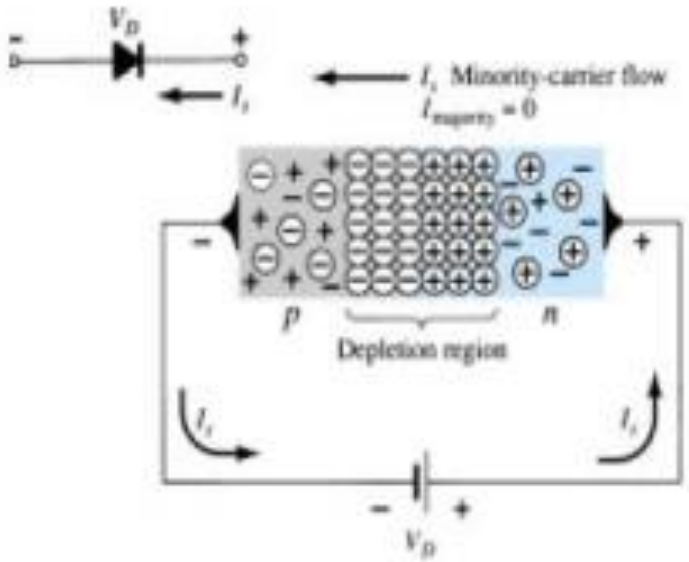
V_d: Voltage on diode.
k: 11,600/η with η ■ 1 for Ge and η ■ 2 for Si.
T_k: T_C + 273.



(b) F.B

❑ Reverse bias

- Reverse bias (R.B): the connection is positive DC battery with N-type and negative DC battery with P-type generate two attraction force between them then depletion region width is increased then no flow the electrical current or flow small reverse saturation current I_s.

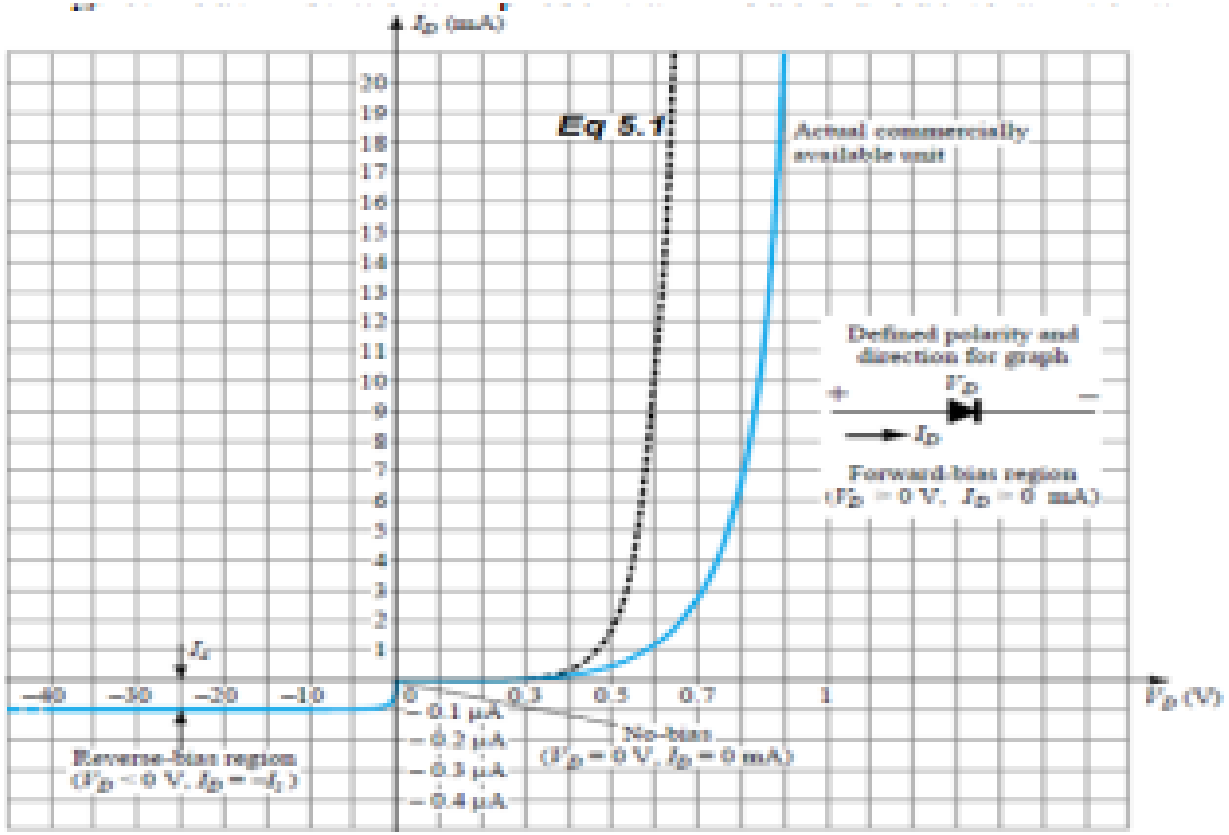


(a) R.B

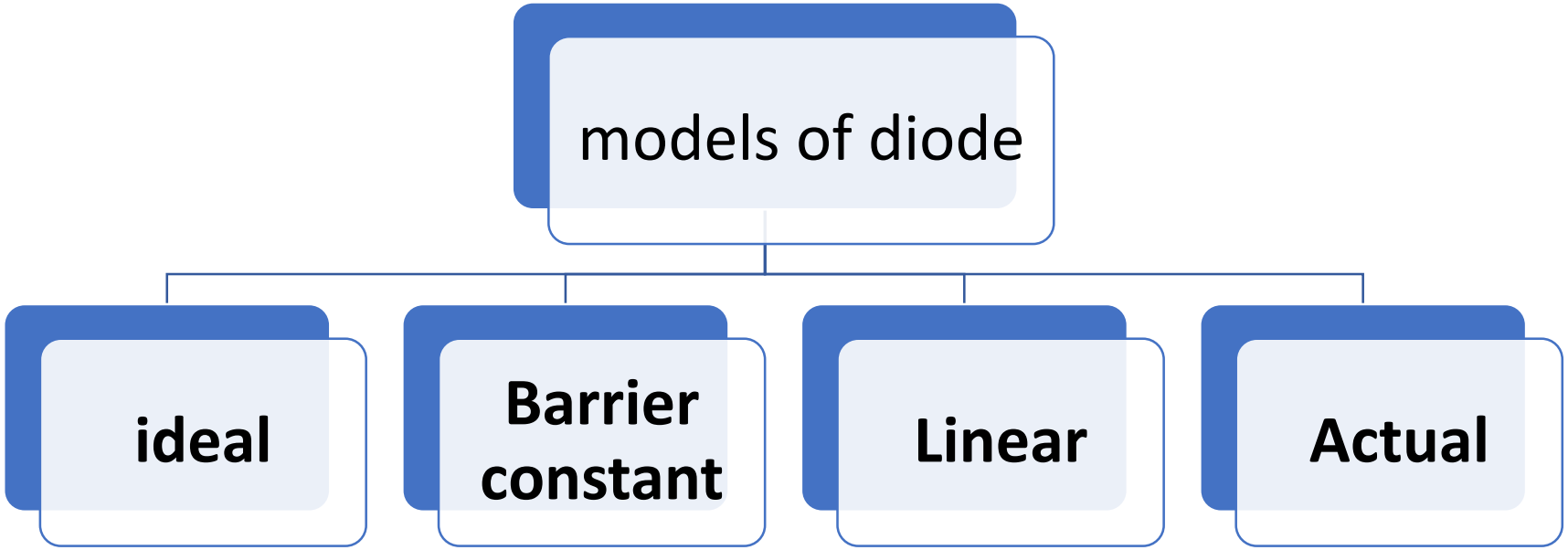
DIODE AND ITS APPLICATIONS

❑ Introduction to diode

- We can show the characteristics curve for diode can be presented as shown in Fig. but first we will present all models diode to arrive it.

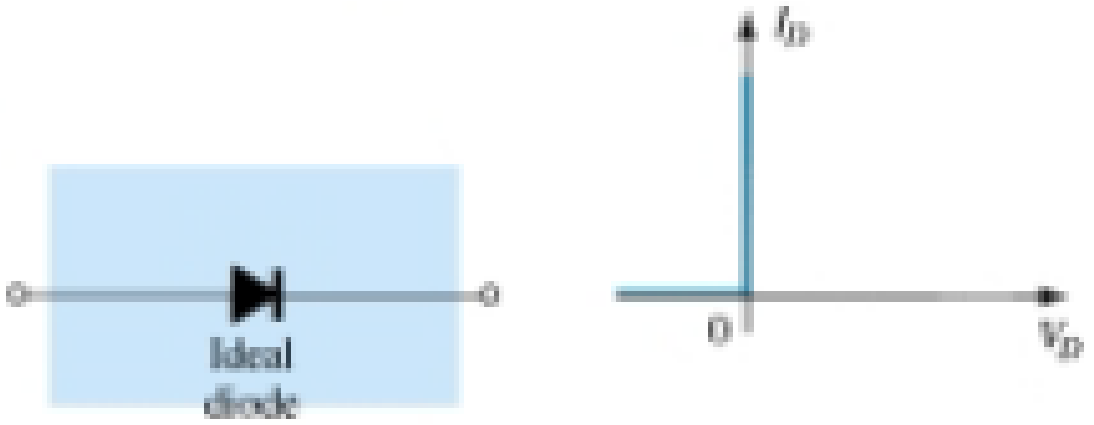


❑ models of diode



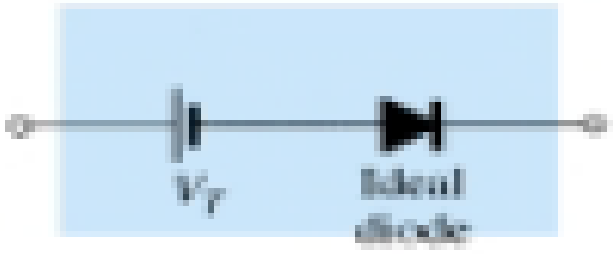
❑ 1. ideal model

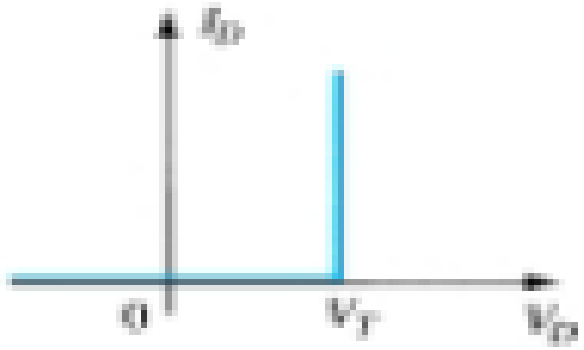
- As shown in Fig., this model makes diode as short circuit when is connected as F.B and open circuit when connected at R.B.



❑ 2. Barrier constant model

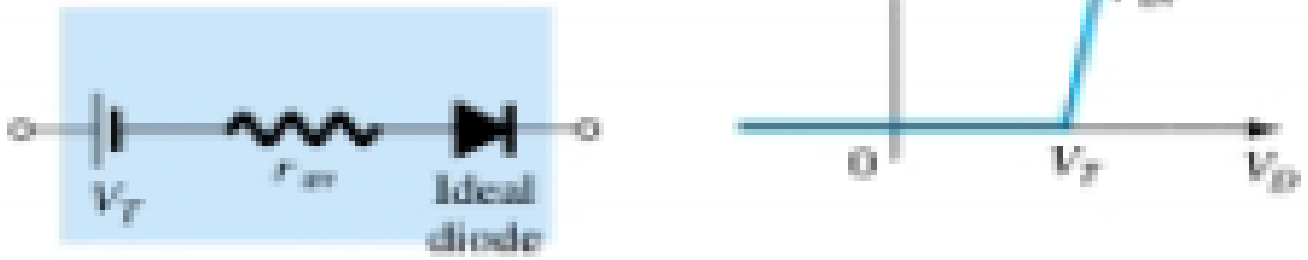
- As shown in Fig., this model make diode as Battery when is connected as F.B and open circuit when connected at R.B.





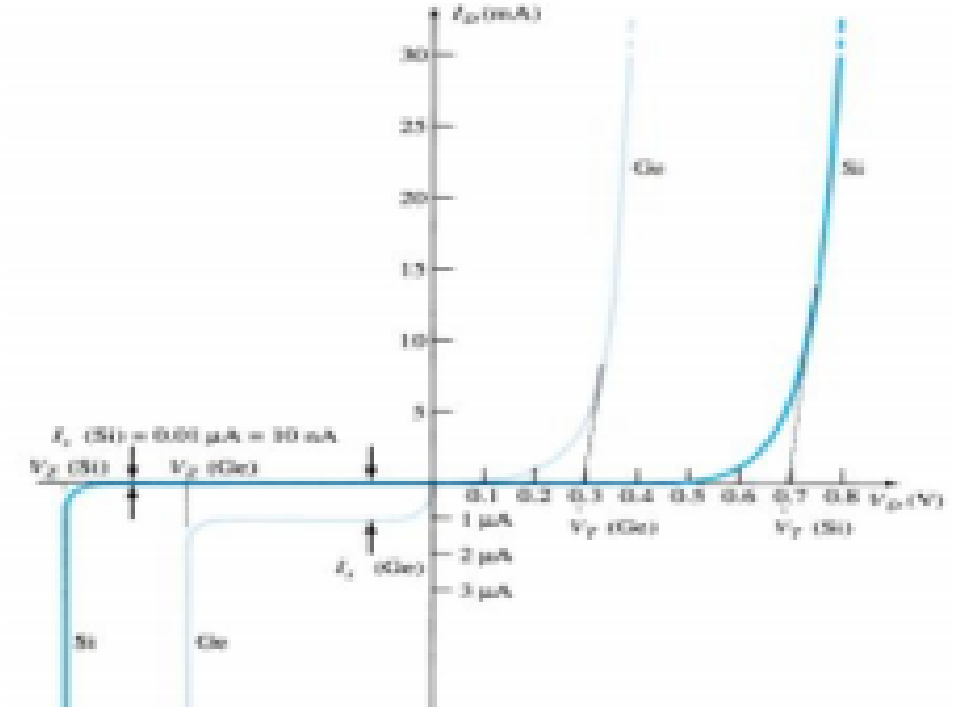
❑ 3. Linear model

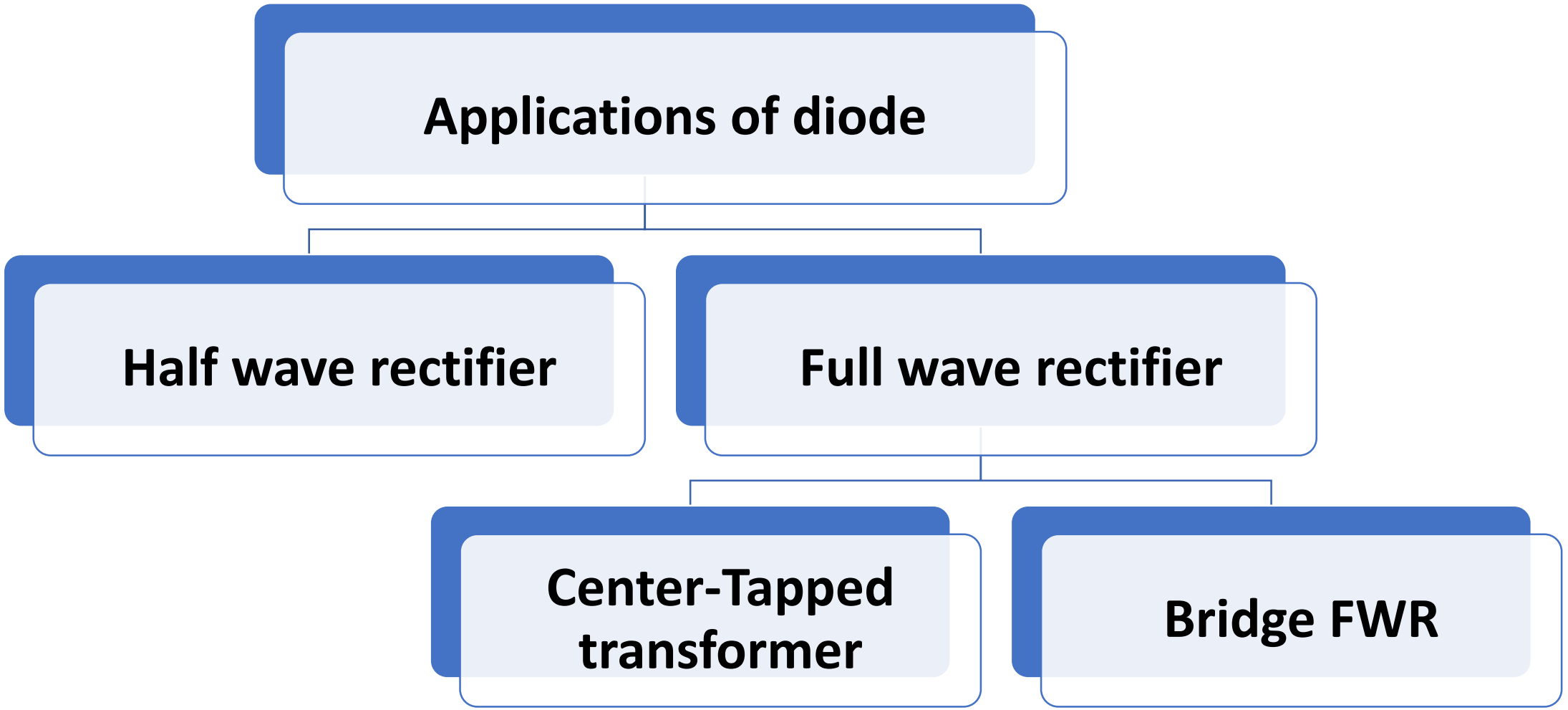
- As shown in Fig., this model make diode as battery with resistor when is connected as F.B and open circuit when connected at R.B.



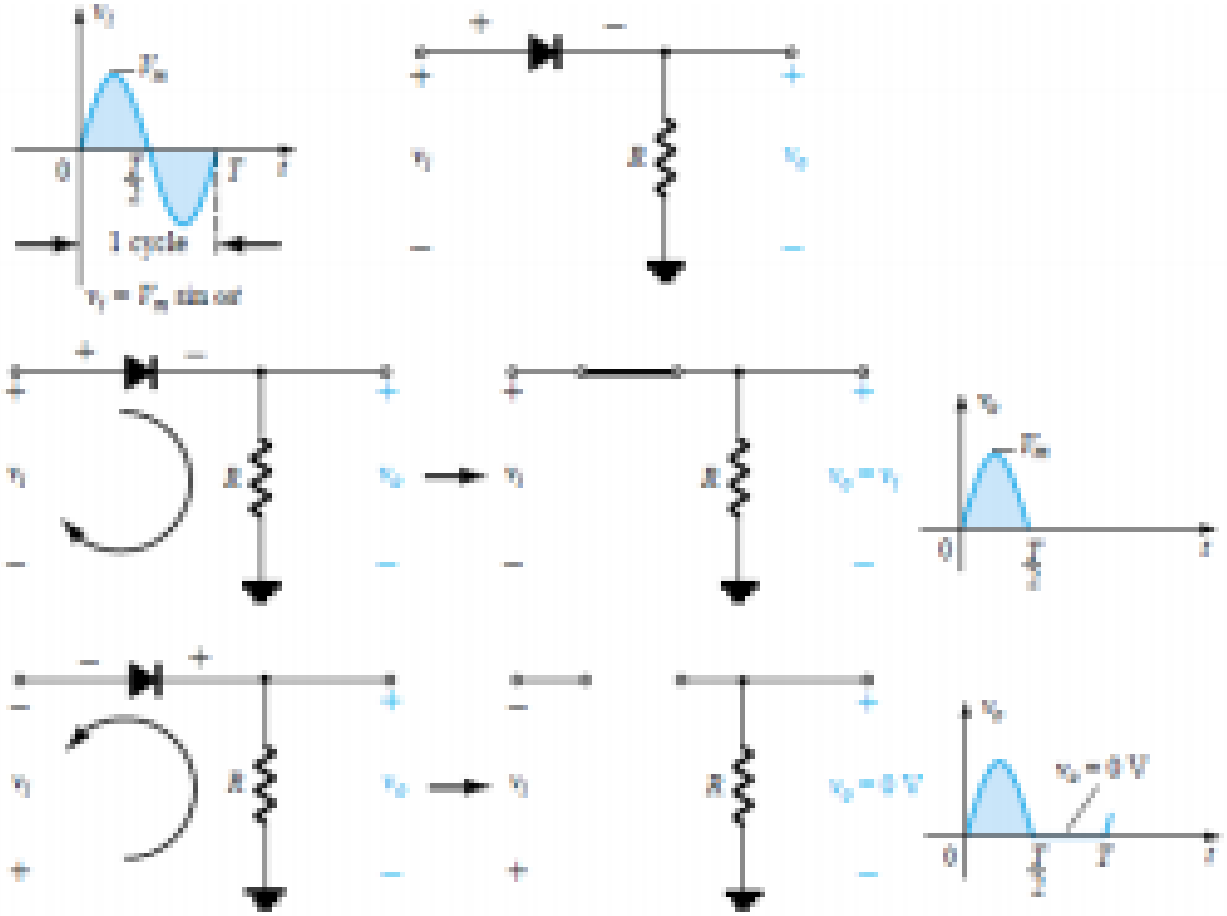
❑ 4. Actual model

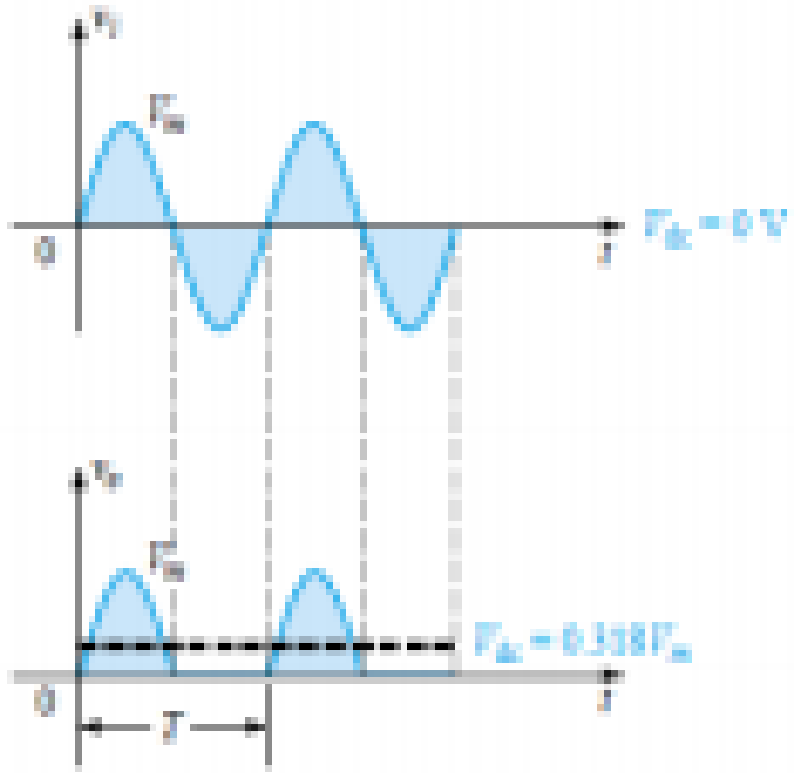
- As shown in Fig., this model make diode as battery with resistor when is connected as F.B and high resistor when connected at R.B.



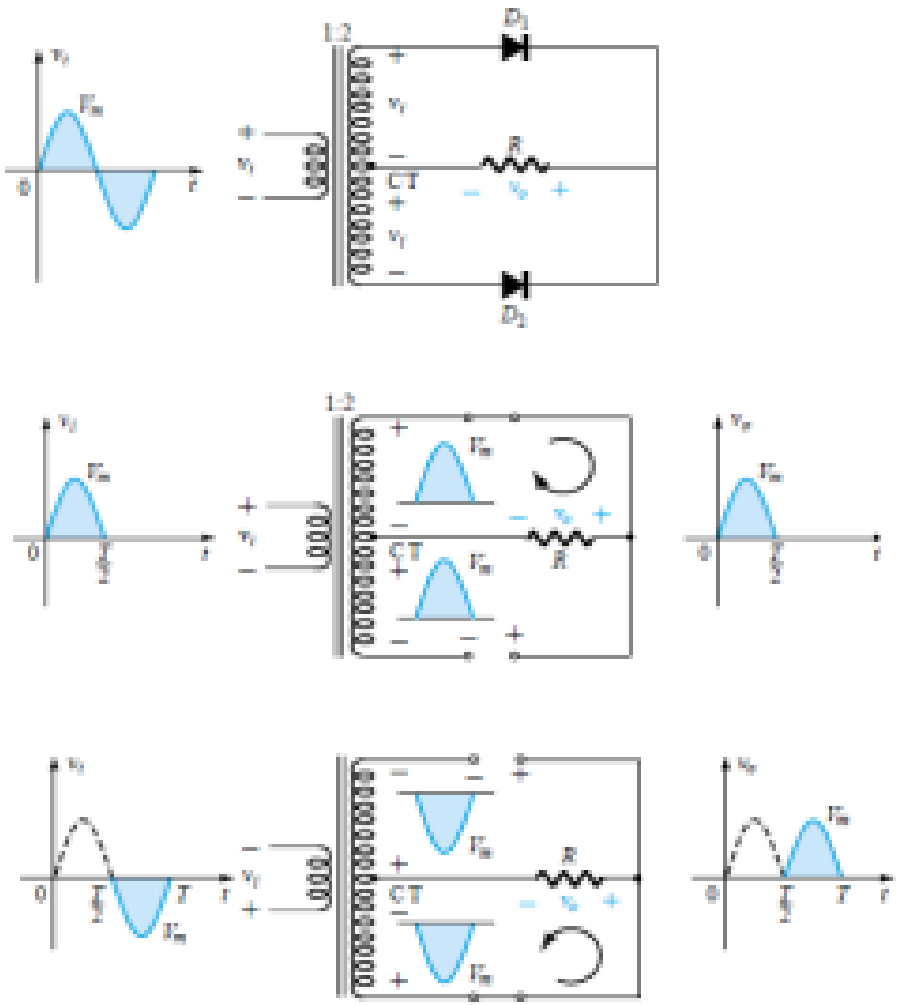

Applications of diode
Half wave rectifier
Full wave rectifier
Center-Tapped transformer
Bridge FWR

❑ Half wave rectifier (HWR)

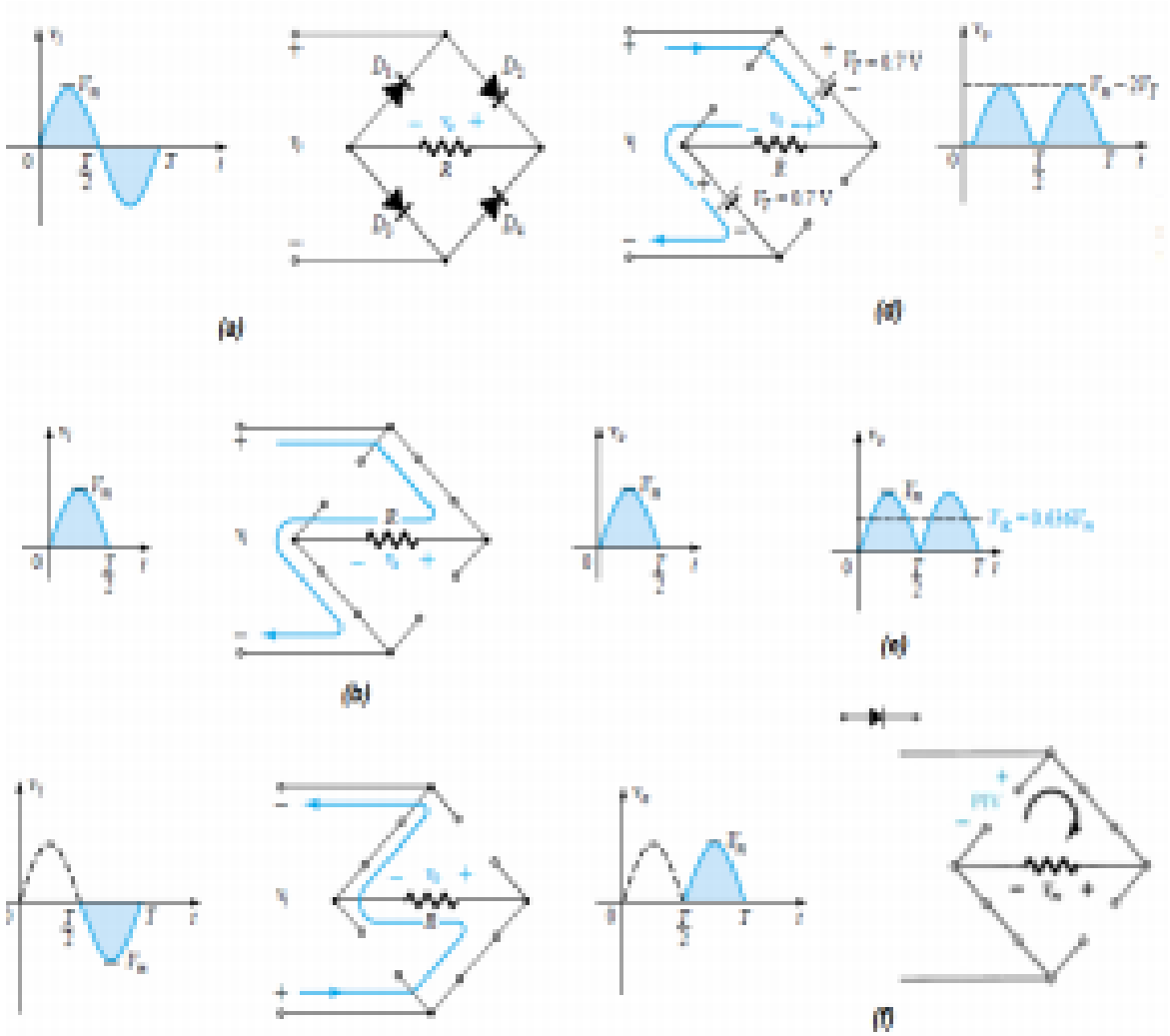




❑ Center-Tapped transformer FWR



❑ Bridge FWR



Thank you