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فيزياء
استاتيكا
دوائر كهربية
الكترونيات
ميكانيكا الانشائات
هيدروليكا
مدرس خصوصي
اونلاين
حضوري
يحصل الطالب علي
. مقاطع فيديوهات لشرح المقرر بشكل وافي
. ملخص للمادة Pdf للمذكرة والمراجعة
. محاضرات مباشرة علي برنامج زووم
لمناقشة الأجزاء الغير مفهومة
. تواصل مستمر مع معلم المادة
للتواصل
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CHAPTER 1

Semiconductor Diodes

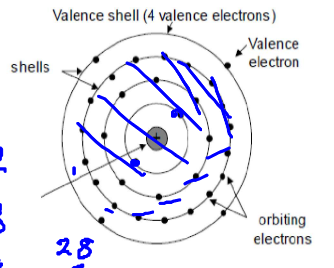
Semiconductor Materials: Ge, Si, and GaAs

Semiconductors are a special class of elements having a conductivity between that of a good conductor and that of an insulator.

- They fall into two classes : single crystal and compound
- Single crystal : Germanium (Ge) and silicon (Si).
- Compound : gallium arsenide (GaAs),
  cadmium sulfide (CdS),
  gallium nitride (GaN),
  gallium arsenide phosphide (GaAsP)

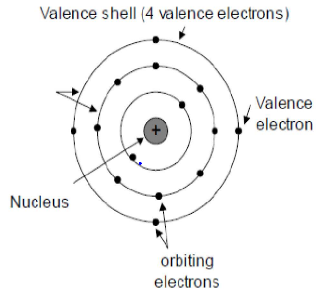
The three semiconductors used most frequently in the construction of electronic devices are **Ge**, **Si**, and **GaAs**.

Atomic Structure



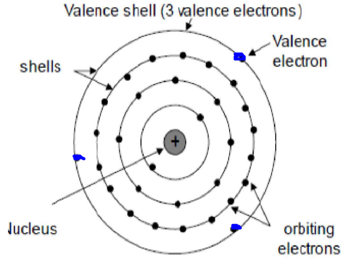
Germanium

32 orbiting electrons (tetravalent)



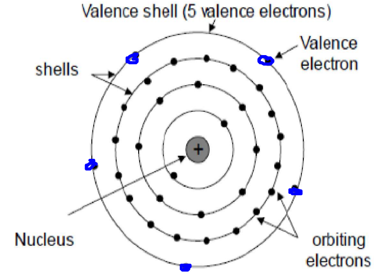
Silicon

14 orbiting electrons (Tetravalent)



Gallium

31 orbiting electrons (trivalent)



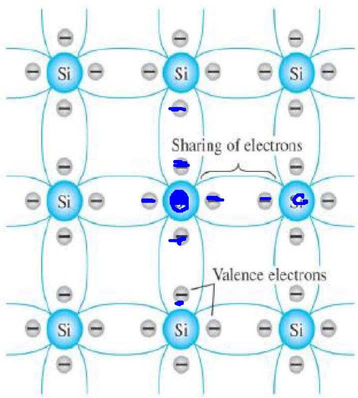
Arsenic

33 orbiting electrons (pentavalent)

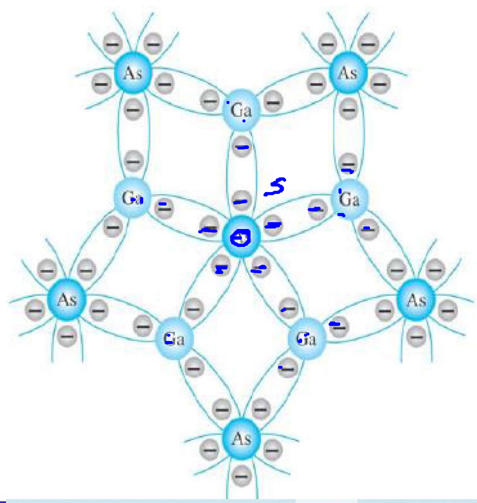
- Valence electrons: electrons in the outermost shell.
- Atoms with four valence electrons are called tetravalent.
- Atoms with three valence electrons are called trivalent, and those with five are called pentavalent.

الرابطة التساهمية

Covalent Bonding



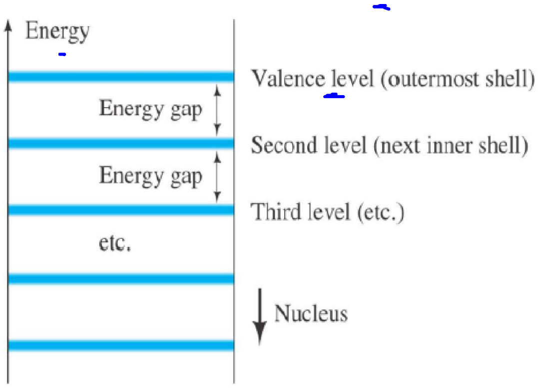
Covalent bonding of Si crystal



There is sharing of electrons, five electrons provided by As atom and three by the Ga atom.

This bonding of atoms, strengthened by the sharing of electrons, is called **covalent bonding**

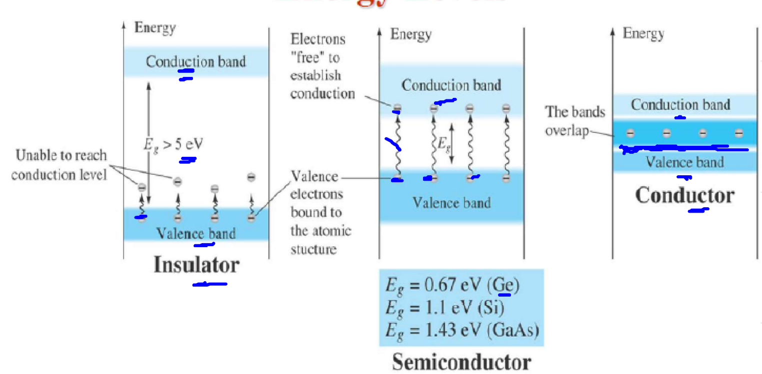
Energy Levels



(a)

The farther an electron is from the nucleus, the higher is the energy state.

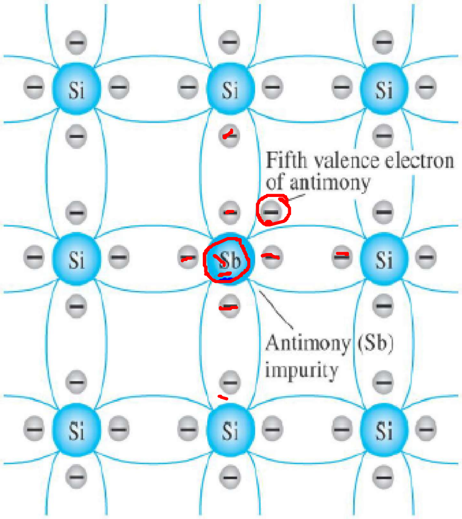
Energy Levels



An electron in the valence band of silicon must absorb more energy than one in the valence band of germanium to become a free carrier. [free carriers are free electrons due only to external causes such as applied electric fields established by voltage sources or potential difference.

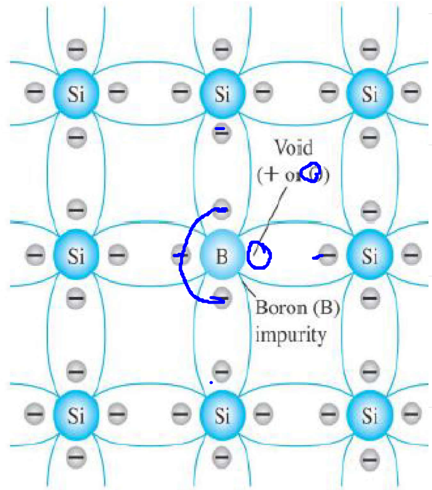
n-Type and p-Type materials

n-Type Material



Doping with Sb, (antimony)

p-Type Material



Boron (B)

Majority and Minority carriers

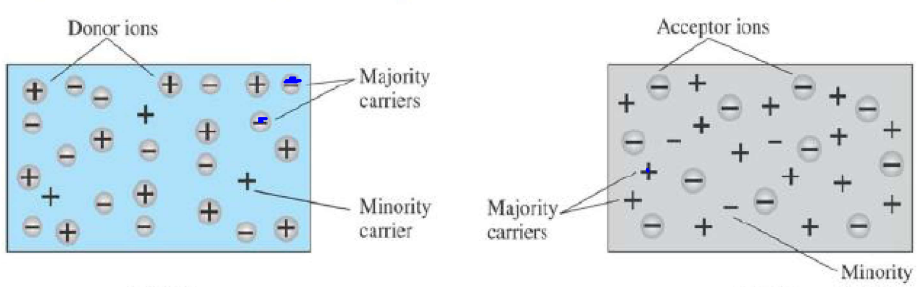
Two currents through a diode:

Majority Carriers

- The majority carriers in n-type materials are electrons.
- The majority carriers in p-type materials are holes.

Minority Carriers

- The minority carriers in n-type materials are holes.
- The minority carriers in p-type materials are electrons.

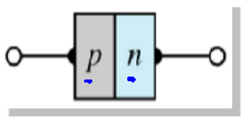


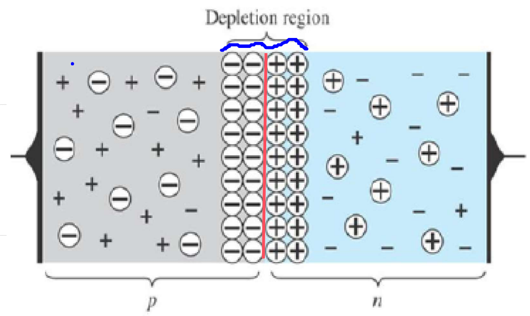
n-type *p*-type

p-n Junctions

One end of a silicon or germanium crystal can be doped as a *p*-type material and the other end as an *n*-type material.

The result is a *p-n* junction.



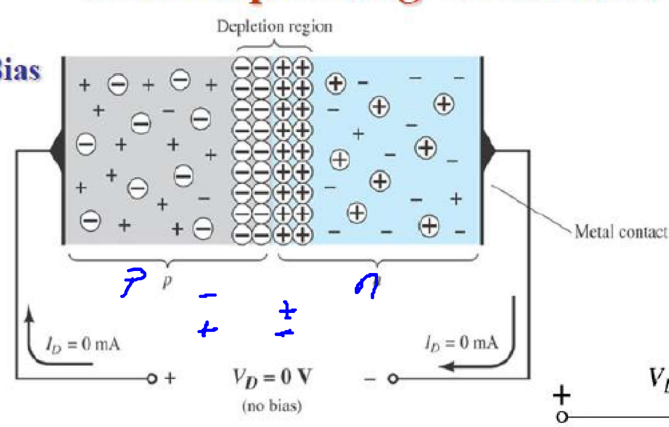


The result is the formation of a depletion region around the junction.

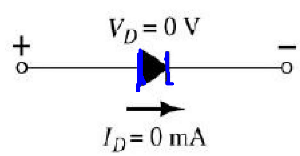
Diodes

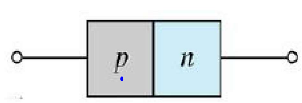
Diode Operating Conditions

No Bias



- No external voltage is applied: $V_D = 0$ V
- No current is flowing: $I_D = 0$ A
- Only a modest depletion region exists

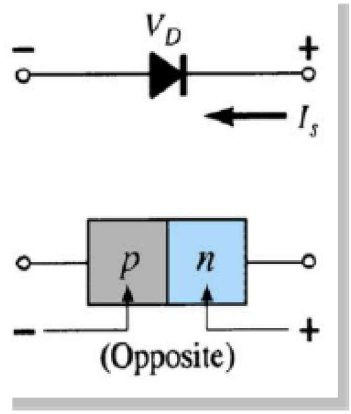


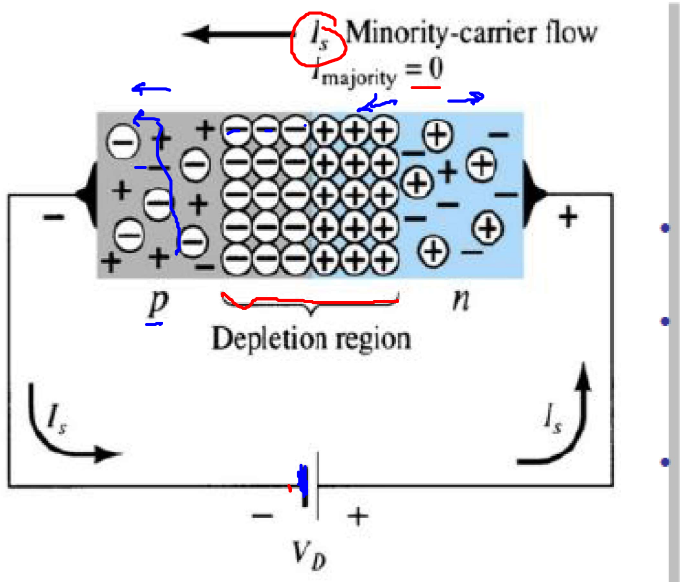


توصيل عاكس

Reverse Bias

External voltage is applied across the *p-n* junction in the opposite polarity of the *p-* and *n*-type materials.

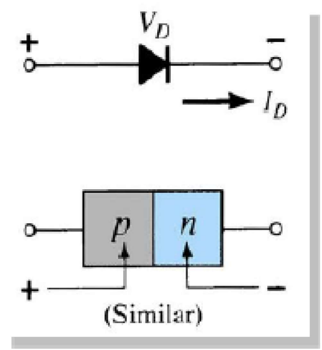


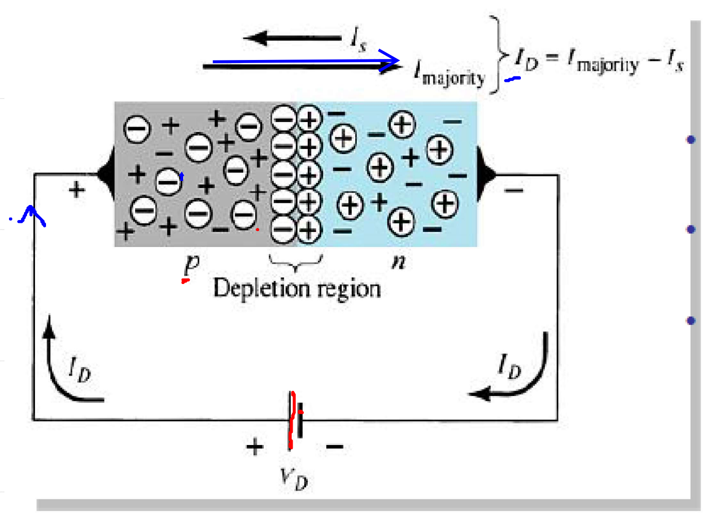


- The reverse voltage causes the depletion region to widen.
- The electrons in the *n*-type material are attracted toward the positive terminal of the voltage source.
- The holes in the *p*-type material are attracted toward the negative terminal of the voltage source.

Forward Bias

External voltage is applied across the *p-n* junction in the same polarity as the *p-* and *n*-type materials.

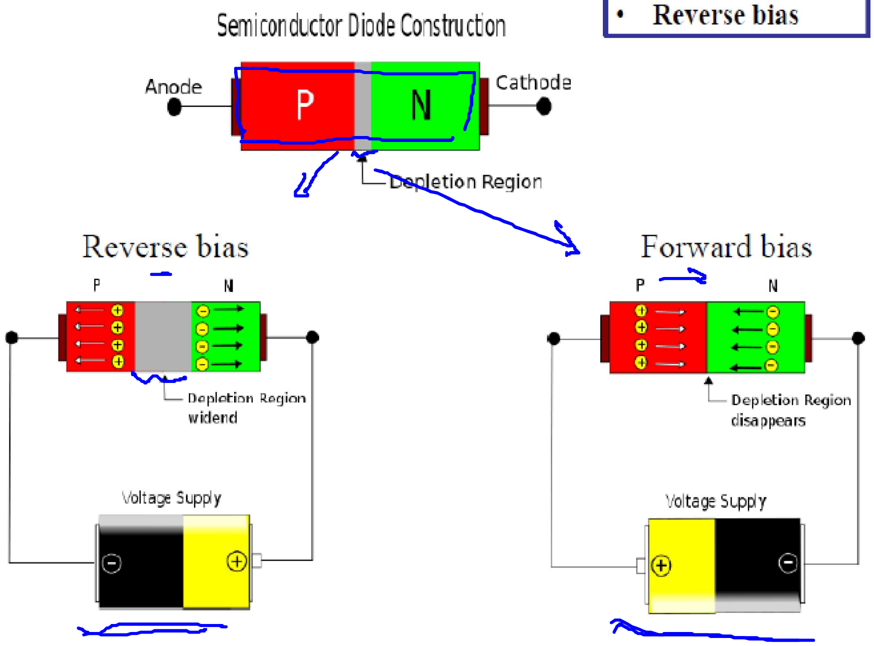




- The forward voltage causes the depletion region to narrow.
- The electrons and holes are pushed toward the *p-n* junction.
- The electrons and holes have sufficient energy to cross the *p-n* junction.

Diode Operating Conditions

- No bias
- Forward bias
- Reverse bias



Actual Diode Characteristics

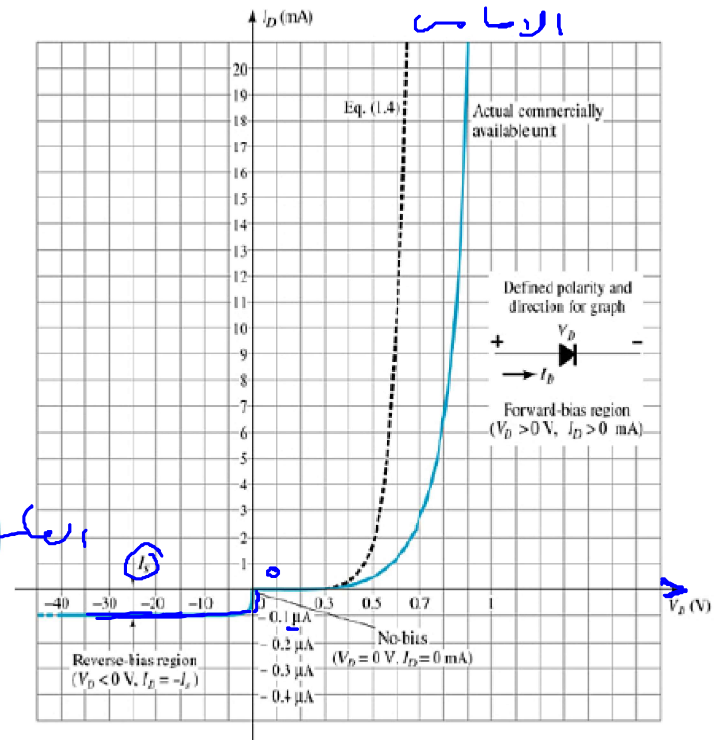
Note the regions for no bias, reverse bias, and forward bias conditions.

Carefully note the scale for each of these conditions.

The reverse saturation current is seldom more than a few microamperes.

$$I_D = I_S\left(e^{V_D/nV_T} - 1\right)$$

$$V_T = \frac{kT}{q}$$



Diode equation

$$I_D = I_S\left(e^{V_D/nV_T} - 1\right)$$

$$V_T = \frac{kT}{q}$$

where

V_T: is called the thermal voltage.

I_s: is the reverse saturation current.

V_D: is the applied forward-bias voltage across the diode.

n: is a factor function of operation conditions and physical construction. It has range between 1 and 2. assume n=1 unless otherwise noted.

K: is Boltzman's constant =1.38 x 10^{-23}

T: is temperature in kelvins = 273+temperature in C.

q: is the magnitude of electron charge = 1.6 x 10^{-19} C.