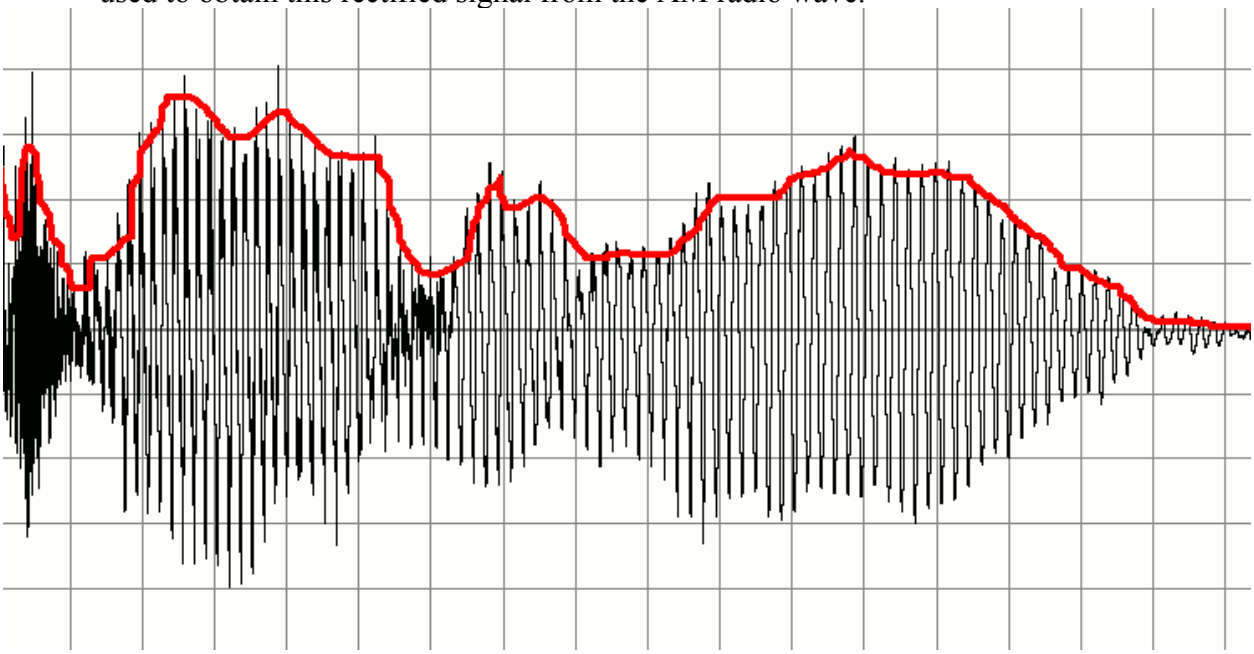
Quiz 9 Properties of Materials CME 300
December 2, 2011

1) An isolated atom displays energy levels defined by quantum mechanics. A crystalline solid displays energy bands with a density of states function describing the distribution of the population of electrons in a band and a band gap.
-What is the relationship between the separation between energy states for isolated atoms and the band gap in a semiconductor? (This can be answered with a graph)

2) The number of charge carriers in an intrinsic semiconductor, n, follows an Arrhenius function. The number of charge carriers, n, can also be measured using the Hall effect since $R_H = 1/(n|e|)$ and $V_H = R_H I B/d$.

-Explain how the Hall effect measurement is conducted to obtain n (sketch the device).
-Explain how you would obtain the band gap energy from n.
-Why might you want to know the band gap if you were designing a solar cell?

3) A diode is the simplest microelectronics device. Diodes are often produced from doped (extrinsic) semiconductors.
Sketch the layout for a diode.
Explain how a pn junction diode functions.
The following graph shows an AM (amplitude modulated) radio wave that has been rectified to produce a radio signal (top "envelope" curve). Explain how a diode could be used to obtain this rectified signal from the AM radio wave.



ANSWERS: Quiz 9 Properties of Materials CME 300
December 2, 2011

1) An isolated atom displays energy levels defined by quantum mechanics. A crystalline solid displays energy bands with a density of states function describing the distribution of the population of electrons in a band and a band gap.
-What is the relationship between the separation between energy states for isolated atoms and the band gap in a semiconductor? (This can be answered with a graph)

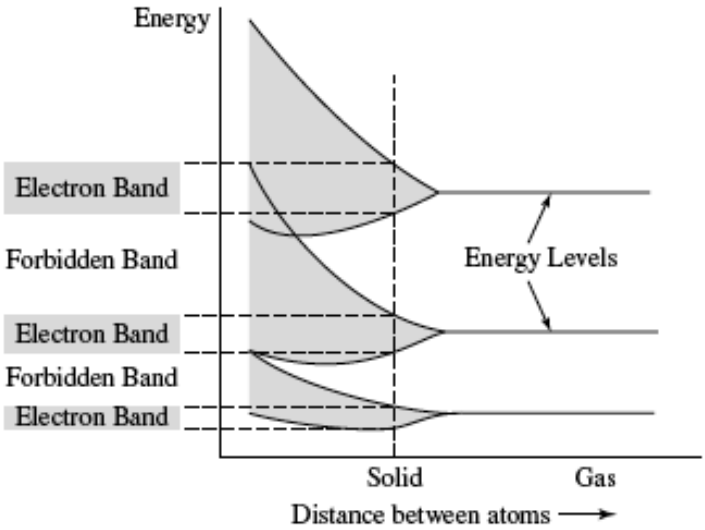


FIGURE 11.5. Schematic representation of energy levels (as for isolated atoms) and widening of these levels into energy bands with decreasing distance between atoms. Energy bands for a specific case are shown at the left of the diagram.

2) The number of charge carriers in an intrinsic semiconductor, n, follows an Arrhenius function. The number of charge carriers, n, can also be measured using the Hall effect since $R_H = 1/(n|e|)$ and $V_H = R_H I B/d$.
-Explain how the Hall effect measurement is conducted to obtain n (sketch the device).
-Explain how you would obtain the band gap energy from n.
-Why might you want to know the band gap if you were designing a solar cell?

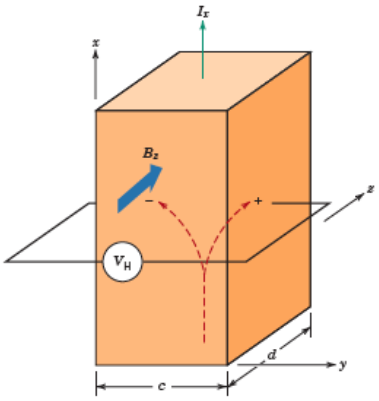


Figure 18.20 Schematic demonstration of the Hall effect. Positive and/or negative charge carriers that are part of the I_x current are deflected by the magnetic field B_z and give rise to the Hall voltage, V_H.

A current I is passed through the semiconductor and a magnetic field B is applied normal to the current. The voltage buildup normal to the current and magnetic field is measured. The polarity of the voltage gives the charge of the charge carrier and the magnitude of the

voltage is proportional to the number of charge carriers following the voltage equation, $V_H = IB / (dn|e|)$

A plot of ln(n) versus 1/T would give a line of slope $-E_g/2k$, where k is the Boltzman constant.

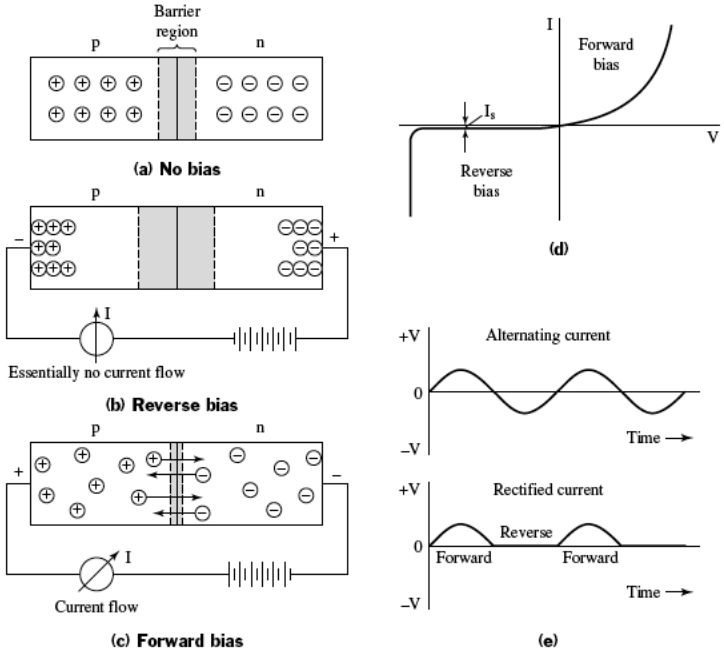
The band gap energy is used to calculate the wavelength of light that can be absorbed by the diode in a photo voltaic device, $E_g = h\nu = hc/\lambda$.

3) A diode is the simplest microelectronics device. Diodes are often produced from doped (extrinsic) semiconductors.

Sketch the layout for a diode.

Explain how a pn junction diode functions.

The following graph shows an AM (amplitude modulated) radio wave that has been rectified to produce a radio signal (top envelope curve). Explain how a diode could be used to obtain this signal from the AM radio wave shown.



At the junction between a p and n semiconductor a charge depletion layer is setup. In the p layer a negative charge is assimilated and in the n layer a positive charge is assimilated. Electrons can easily flow from p to n since the n layer is positively charged but inorder to flow in the reverse bias direction from n to p the electrons must overcome the negative charge at the p barrier region. This leads to the IV curve shown in the top right.

The diode can serve at a rectifier so it allows only the positive voltage from the AM signal to pass. This allows one to separate the signal from the carrier wave. The circuit would generally also need a capaciter and a resistance element to work as shown.