Non-Linear Devices

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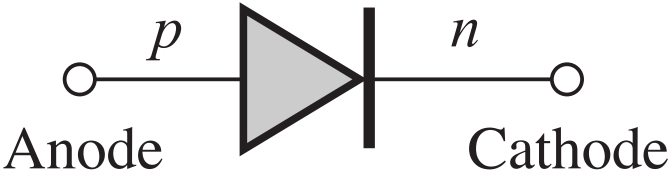
May 21, 2017

What a non-linear device does or it is suppose to do?



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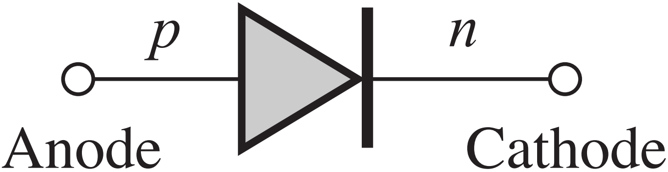
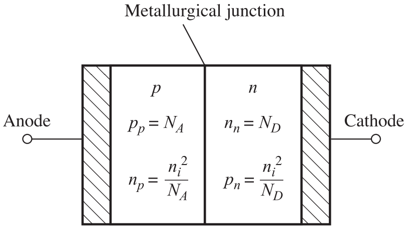
- 

- 

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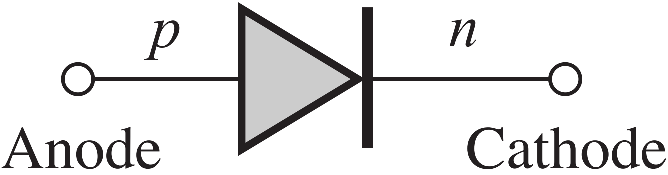
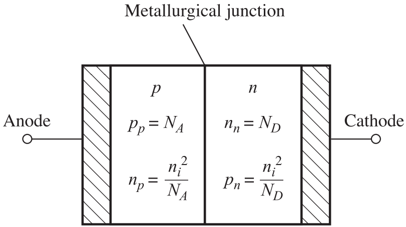
- 

  - 

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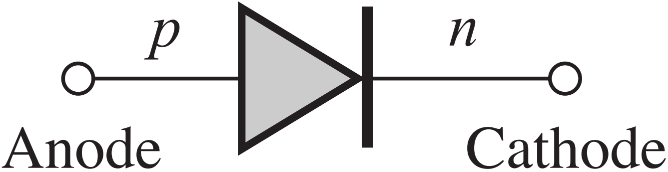
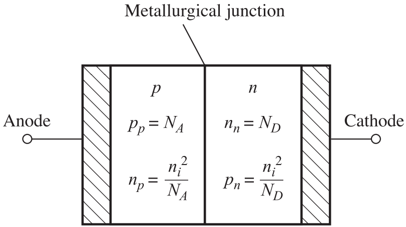
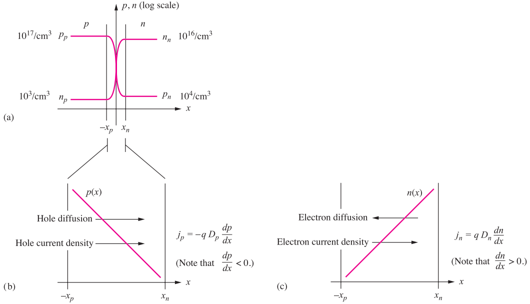


- 

- p-type side: p_p=10^{17} holes/cm^3 n_p=10^3 electrons/cm^3
- n-type side: p_n=10^4 holes/cm^3 n_n=10^{16} electrons/cm^3

Fabrication of Simple Structures

- 

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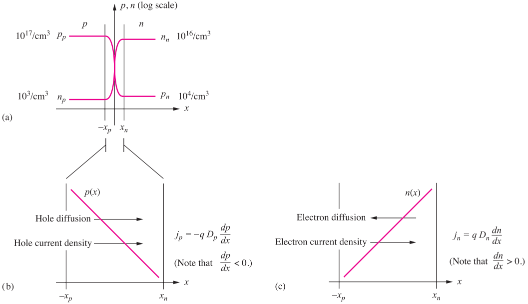
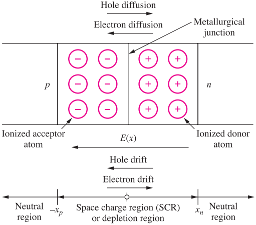
- 

- 

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- Space charge, from electromagnetics, is defined as ρ_c (C/cm^3), added by an electric field $\vec{E}$ (V/cm) through Gauss law

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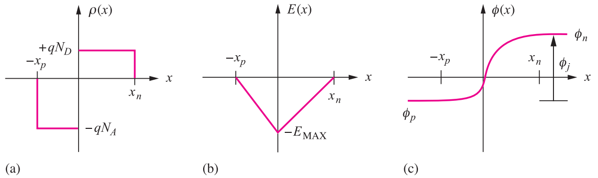

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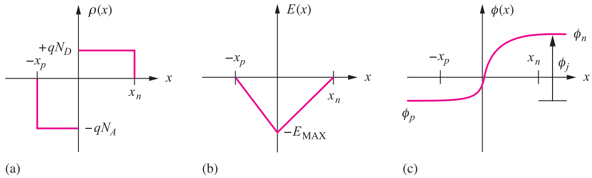

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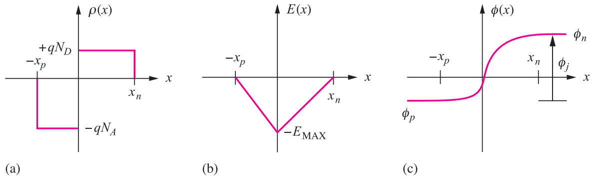

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- Space Charge Density for a p-type is -qN_A and it goes from the junction at x=0 to -x_p and for n-type is +qN_D
- As usual, the diode must be neutral, ergo

$$qN_A x_p = qN_D x_n$$

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- The total width of the depletion region w_{do}, is defined as:

$$w_{do} = (x_n + x_p) = \sqrt{\frac{2\epsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)\phi_j}$$

Whole you need to know about diodes

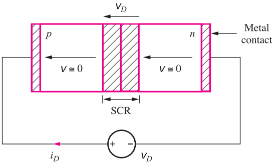

Figure 3.6 Diode with external applied voltage v_D.

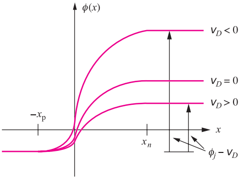

Figure 3.7 Electrostatic junction potential for different applied voltages.

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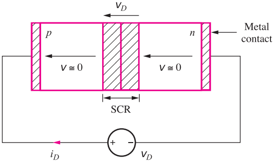
- 

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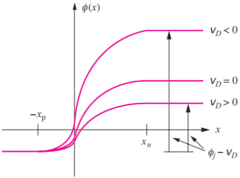

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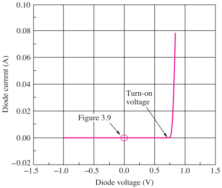
- 

Figure 3.8 Graph of the i-v characteristics of a pn junction diode.

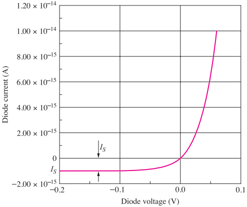


Figure 3.9 Diode behavior near the origin with $I_S = 10^{-15}$ A and $n = 1$.

Basic knowledge

As usual, everything has a model, even humans, of course for all the wrong things... As for the diode, we model it by using simple, well known and even sexy equations:

$$i_D = I_s \left[\exp\left(\frac{q v_D}{nkT} \right) - 1 \right] = I_s \left[\exp\left(\frac{v_D}{nV_T} \right) - 1 \right]$$

where: I_S = reverse saturation current of diode (A)
T = absolute temperature (K)
v_D = voltage applied to diode (V)
n = nonideality factor (dimensionless)
q = electronic charge (1.60×10^{-19} C)
V_T = k T /q = thermal voltage (V)
k = Boltzmann?s constant (1.38×10^{-23} J/K)

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- By considering n=1, the equation diode can be writen as:

$$i_D = I_S \left[\exp\left(\frac{v_D}{V_T} \right) \right]$$

Diode characteristics:Reverse bias

While bias in reverse bias, a few interesting characteristics occurs.
A very small reverse leakage current, approximately equal to I_S, flows through it
The current is quite small, we usually think of the diode as being in the nonconducting or off state when it is reverse-biased

Diode characteristics:Zero bias

It is important to remember that the i-v characteristic of the diode passes through the origin

For zero bias with $v_D = 0$, we find $i_D = 0$

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