Fermi Energy Calculation

Illustration

- Lets quickly recount the essentials:
  - The concentrations of electrons or holes in the conduction or valence bands are

$$n_e^- = N_{eff} \cdot f(E_C,E_F,T)$$

$$n_h^+ = N_{eff} \cdot [1 - f(E_V,E_F,T)]$$

  - The density of states for the donors and acceptors is simply their concentration N_D and N_A, we thus have :
- Concentration of non-ionized (neutral) donors N_D^o (i.e. the electron is still sitting on the donor level)

$$N_D^o = N_D \cdot f(E_D,E_F,T)$$

  - Concentration of ionized donors N_D^+ (i.e. the electron is in the conduction band).

$$N_D^+ = N_D \cdot [1 - f(E,E_F,T)]$$

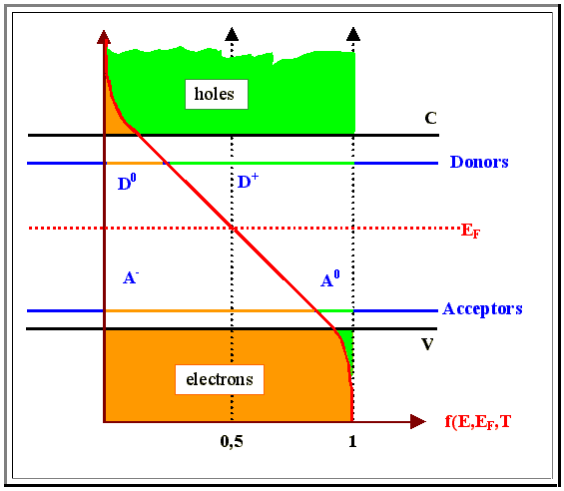
  - Concentration of ionized acceptors N_A^- (i.e. an electron from the valence band is sitting on the acceptor level):.

$$N_A^- = N_A \cdot f(E_A,E_F,T)$$

  - Finally, the concentration of neutral acceptors N_A^0; it is

$$N_A^o = N_A \cdot [1 - f(E_A,E_F,T)]$$

- This can be easily envisioned in a simple drawing



- The Fermi energy results from equating the sum of all negative charges with the sum of all positive charges.
  - The resulting equation is easily written down, but cannot be solved analytically.
  - That is why we do it numerically.
- In the following **JAVA** module, you can enter any (sensible) concentrations for donors and acceptors including their level in the bandgap and the temperature. The results can be displayed with adjustable axis (e.g. as Arrhenius plot with **lg y** over **1/*x*** or linearly; ***y*** over ***x***, or even as **sin *x*** over **cos *y*** if you fancy that) as a function of temperature. They include:
  - The position of the Fermi energy in the band gap (only half of the gap is shown)
  - The density of holes in the valence band
  - The density of electrons in the conduction band.

- This calls for a little work: **Note: You can enlarge any portion of a curve by simply pulling out a rectangle with the part of the curve you want enlarged in it.**
  - First look at intrinsic Silicon. Enter "=" for the concentration values of