**Carrier Statistics – Worked out problems**

**(** <http://nanohub.org/tools/fermi> )

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Q1) What is the intrinsic carrier concentration (Ni) for Si. Ge and GaAs?

A1) Set Ef=Ei (mid-gap) in *Carrier Statistics Lab* and compute carrier distribution at T=300K using Fermi-Dirac statistics. Checking for Ni in *Final Log* we find that,

 **Ni = 1x1010 /cm3 in Si**

 **Ni = 2.07x1013 /cm3 in Ge**

 **Ni = 2.25x106 /cm3 in GaAs**

Q2) A Si sample is doped with 1x1014 boron atoms/cm3. What is electron and hole density at 470K?

A2) Select Si material in *Carrier Statistics Lab* and select *Semiconductor Doping* option.

 Set *Acceptor Concentration* = 1x1014 /cm3

 And *Temperature = 470K*

 On running the simulation and checking the *Final Log* we find that,

 **n(/cm3) = 1.3400e+14**

 **p(/cm3) = 2.3399e+14**

 **ni(/cm3) = 1.7707e+14**

Q3) At what energy does the *n(E)* and *p(E)* have their maxima at 300K with respect to Ec and Ev in terms of kT?

A3) Let us select Si with Fermi level at mid-gap position (this is arbitrary, one can select a different Ef also). Select *Fermi-Dirac statistics* and *T=300K*.

 On computing with *Carrier Statistics Lab* we find that,

 Ec=1.12452 eV, Ev=0 eV

 Energy level at which n(E) is maximum=1.13718 eV

 Energy level at which p(E) is maximum= -0.0126609 eV

 **In terms of kT,**

**n(E) maxima lies at ~ 0.5\*kT+Ec and,**

**p(E) maxima lies at about ~ Ev-0.5\*kT.**

Q4) The Fermi level in a Si sample is located Ec-Eg/4 at T=300K. Compute and plot electron and hole distribution (numbers/cm3-eV) as a function of energy in conduction and valence bands. (●2.9 Robert F. Pierret, Semiconductor Device Fundamentals)

A4) In *Carrier Statistics lab* select Si material and *Fermi-Dirac Statistics* option.

 Set *Fermi level* at 0.84339 eV. Compute the carrier concentration now.



Figure 1 Hole Concentration

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 Figure 2 Electron Concentration