**Carrier Statistics – Worked out problems 2**

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

Saumitra R Mehrotra, Dragica Vasileska and Gerhard Klimeck

Q1) Test the accuracy of use Maxwell-Boltzmann (MB) statistics compared to Fermi-Dirac (FD) statistics?

A1) Let us set-up an experiment to test the deviation in hole carrier concentration (P) in Si at T-300K as we move our Fermi level (Ef) close to Si valence band edge (Ev). We will use MB and FD statistics.

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| --- | --- | --- | --- |
| Ef -Ev | P (/cm3) with MB | P (/cm3) with FD | % difference |
| 6\*kT | 5.471x1016 | 5.465x1016 | 0.109 |
| 5\*kT | 1.439x1017 | 1.435x1017 | 0.278 |
| 4\*kT | 3.785x1017 | 3.757x1017 | 0.754 |
| 3\*kT | 9.955x1017 | 9.768x1017 | 1.91 |
| 2\*kT | 2.618x1018 | 2.494x1018 | 4.97 |
| 1\*kT | 6.887x1018 | 6.116x1018 | 12.6 |
| 0 | 1.811x1019 | 1.386x1019 | 30.66 |



Q2 ) Find the temperature range for which Ge, n-type doped at 1015/cm3 can operate in extrinsic regime (i.e. n=ND+).

A2) Select *Ge* as the material and choose *Fermi-Dirac Statistics*. Set donor doping level at 1015/cm3. Run the temperature sweep.

 Select *3D electron/hole density with temperature* output plot. It can be deduced from the plot that Ge, n-type doped at 1015/cm3 remains extrinsic for the range of **180K<T<330K.**

