National University of Sciences and Technology

EDC Assignment No. 1

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As intrinsic Silicon is doped with a pentavalent Phosphorus at room temperature (30°C), which is **n-type doping**. Hence the carrier concentration of silicon at room temperature is given as:

$$n_i = BT^{\frac{3}{2}} e^{-\frac{E_g}{kT}}$$

$$B = 7.3 \times 10^{15} cm^{-3} K^{-\frac{3}{2}}$$

$$k = 8.62 \times 10^{-5} \frac{eV}{K}$$

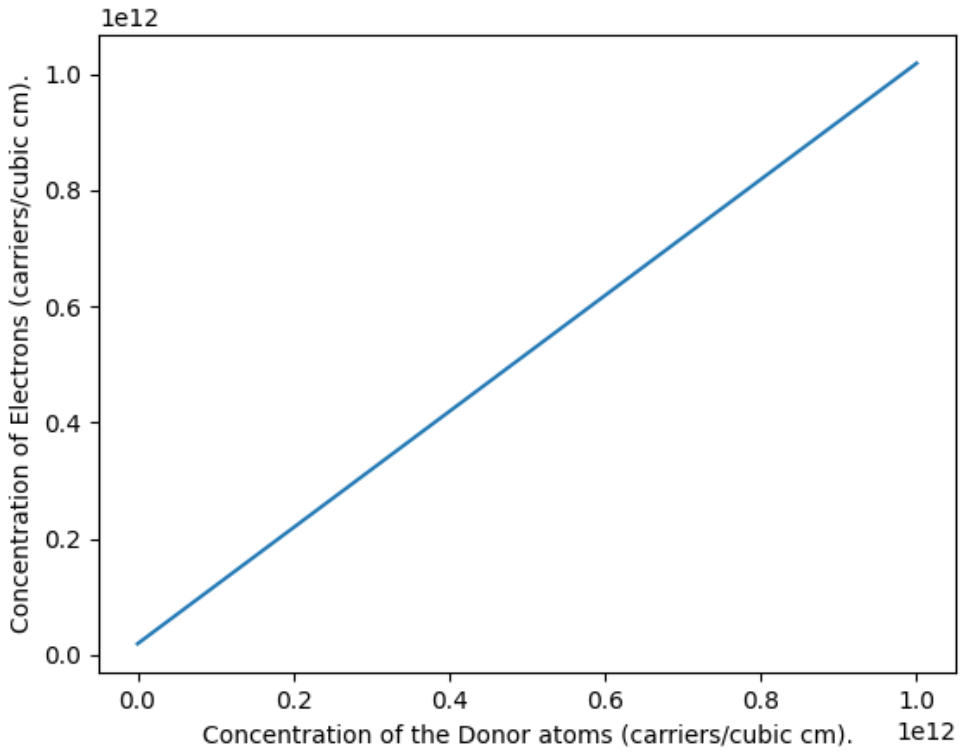
$$E_g = 1.12\ eV$$

At room temperature;

$$n_i = B = 1.90189 \times 10^{10}\ \frac{carrier}{cm^3}$$

Task a:

Concentration of electrons:

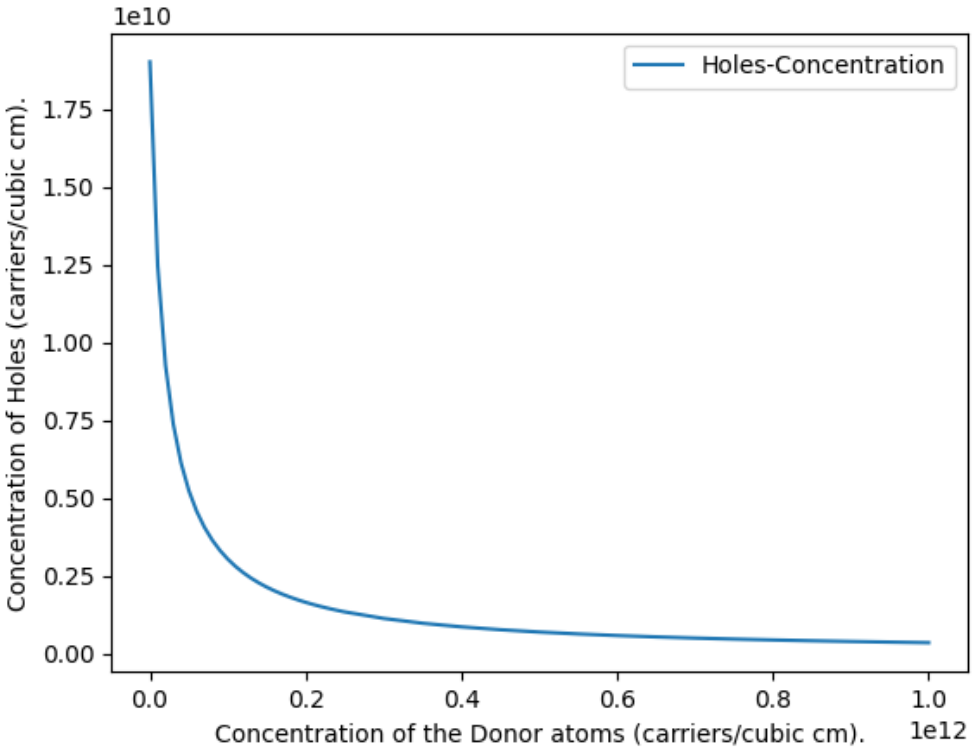


The number of electrons in n-type doping are given by the following relation;

$$n_n = n_i + N_D$$

Hence, the graph of the curve is a staright line with a shift of n_i.

Concentration of holes:



The number of holes in n-type doping are given by the following relation;

$$n_n p_n = n_i^2$$

$$n_n = n_i + N_D$$

$$p_n = \frac{n_i^2}{n_i + N_D}$$

Hence, the graph of the curve is a hyperbolic (exponentially decreasing) line with a shift of n_i.

Task b:

The resistivity of Silicon atom is given as;

$$\rho = \frac{1}{q(\mu_p p_n + \mu_n n_n)}$$

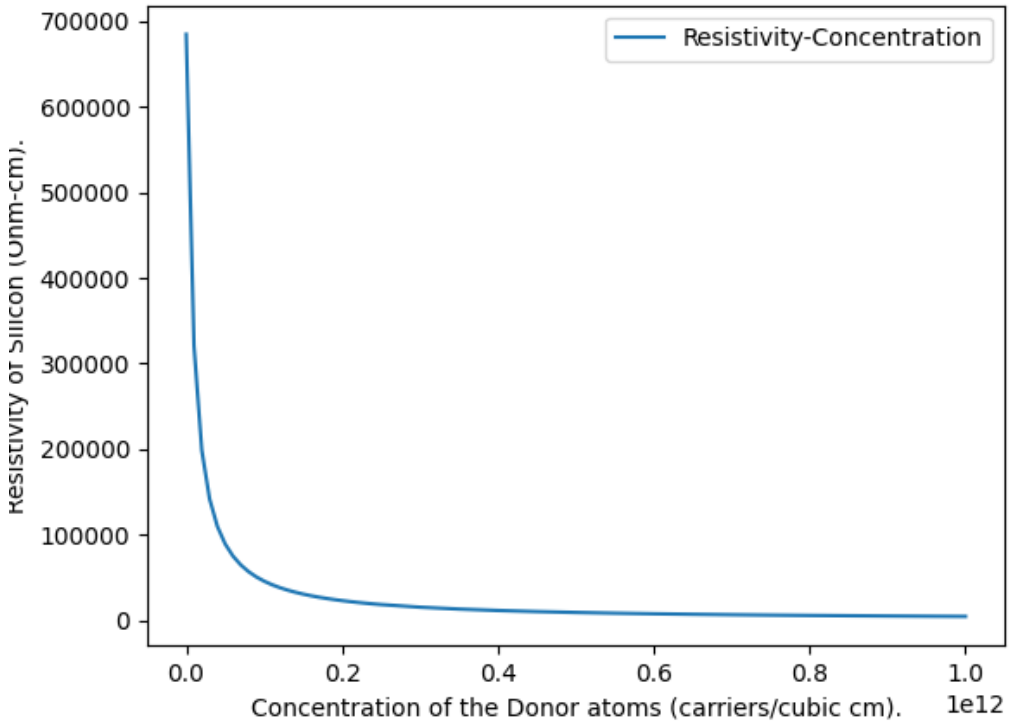
Where, "q" is the charge on a single carrier (electron). And μ_p and μ_n are the mobility of holes and electron in silicon.

$$\rho = \frac{1}{q(\frac{\mu_p\, n_i^2}{n_i\ +\ N_D} + \mu_n N_D)}$$

Further,

$$\rho = \frac{n_i\ +\ N_D}{q(\mu_n N_D^2 + \mu_n n_i N_D + \mu_p\, n_i^2)}$$

The above equation is plotted using matplotlib (python).



INDIVIDUAL PERFORMANCE:

Muhammad Saud Zahir:

Coding using Python, understanding the libraries (such as matplotlib, simpy and numpy) to plot the functions. Derivation of the resistivity equation as an explicit function depending on number of donor atoms.

Muhammad Ibrahim:

Verification of the code and equations. Manually checking of the graph and code verification.