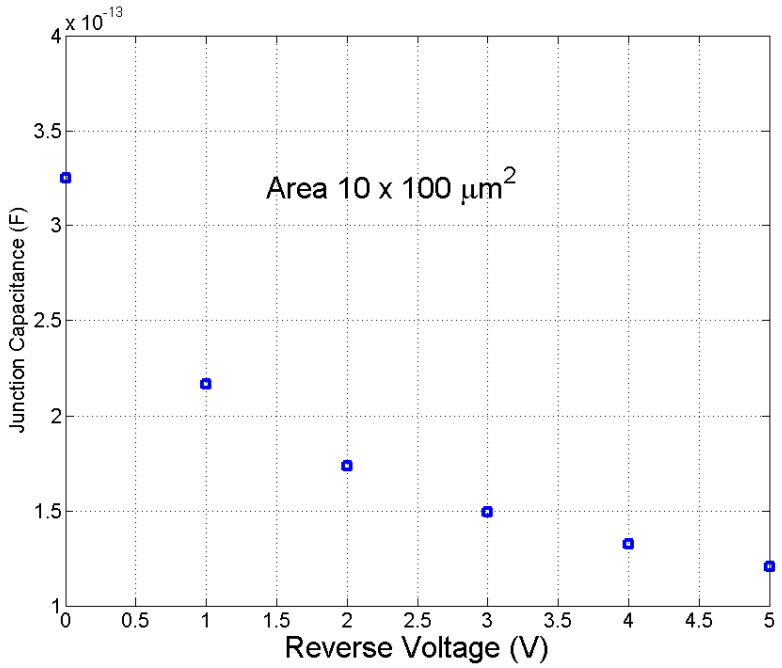
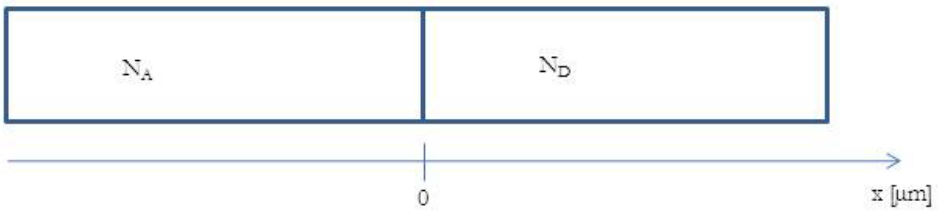
## Problems to student recitation 3

1. Draw figures that illustrate the concepts of quasi-Fermi levels and applied junction voltage for both forward and reverse applied voltage!
2. The small signal capacitance of a $p^+n$ junction ($N_A >> N_D$) is measured (using a CV meter) and the result is displayed in the figure below. Determine the donor concentration $N_D$ from the measurement data.

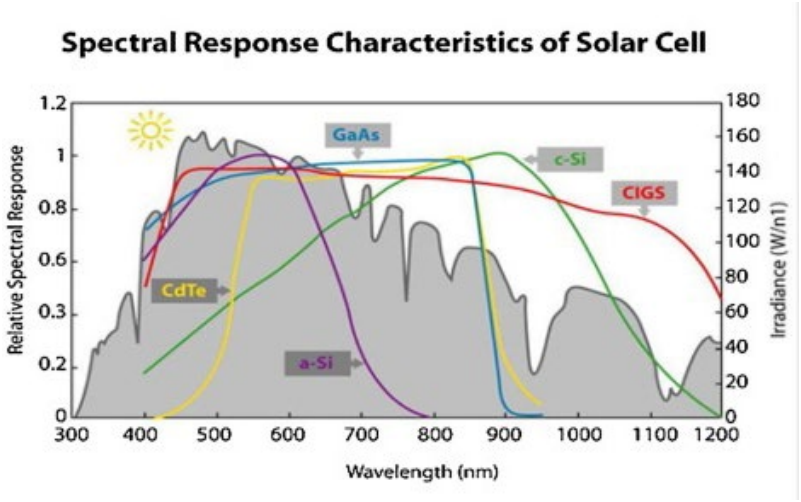



3. Calculate the electric field at the two positions $x$ = -0.1 and $x$ = 0.1 μm in the picture below. The semiconducting material is Si and the device is at thermal equilibrium.
   $N_A = 10^{19}$ cm$^{-3}$ and $N_D = 5 \cdot 10^{16}$ cm$^{-3}$.
   What does the result mean in simple word, recall the definition of neutral and depletion regions!



4. The efficiency of a solar cell depends on the bandgap of the semiconductor layer. In the figure below the spectral response of a few materials is indicated together with the solar spectrum.

Estimate the bandgaps of the shown materials and compare to theoretical values.

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5. Rewrite Eq. 4.9.5 to support the following statement.

"The minority carriers that are thermally generated within one diffusion length from the depletion region are collected by the junction and are responsible for the reverse saturation current."

Hint use the following relation:

$$L = \sqrt{D\tau}$$

6. Assume that you have a pn-junction where the n-side has a donor concentration of $1\times10^{16}$ cm$^{-3}$.

Calculate and draw a graph of the built-in potential for a range of acceptor doping concentrations that could be used in real diodes.