I. PROBLEM SESSION 12

A. Problem 12.1

Space charge distribution in $p-n$ junctions: Consider a silicon-based junction as shown schematically in a fig.1 below.

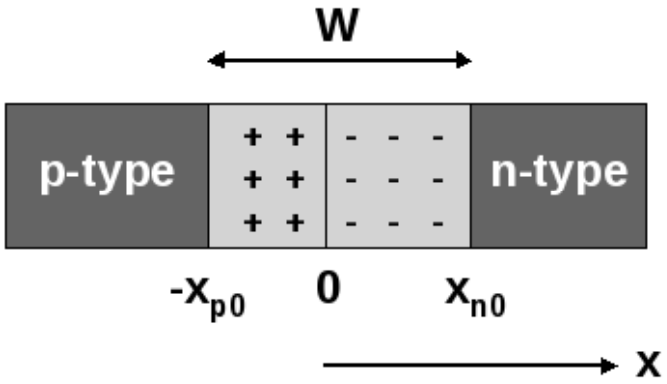

Figure 1: A p-n junction

Derive and sketch charge density, electric field, and potential within the space charge region W of the junction. Assume donor and acceptor concentrations of e^{16} and $4e^{17}cm^{-3}$ in the n- and p-type sides of the junction. Assume the contact area A of $2e^{-3}cm^{-2}$ and room temperature operation (i.e the intrinsic carrier concentration is $e^{10}cm^{-3}$). Calculate: a) The in-build potential b) The depth of the space charge region as well as x_{p0} and x_{n0} c) The charge associated with x_{p0} and x_{n0} d) The maximum amount (in terms of its absolute value) of the field

B. Problem 12.2

Forward and reverse bias: Sketch the changes happening in a p-n junction when forward or reverse bias is applied. Derive, sketch, and analyse the junction equation. Explain the junction equation in terms of carrier injection and diffusion.

C. Problem 12.3

Current and voltage in illuminated junctions. Assume the junction in Fig.1 is uniformly illuminated with solar photons so that an optical carrier generation rate (g_{op}) contributes to the generation current. Laterally, holes (electrons) generated within volumes of AL_p (AL_n) where L_p (L_n) are diffusion length for holes (electrons) contribute to the current. In addition, carriers generated within AW do not need to diffuse but are just swept by the electric field contributing to the current. How is the junction equation is modified by the illumination? Analyze the equation when the device is short and open circuited. What are meanings of short circuit current (J_{sc}) and open circuit voltage (V_{oc})?

The efficiency of a solar cell made of p-n junctions shown schematically in Fig.1 is proportional to the product of $J_{sc}V_{oc}$. Suggest possible scenarios for increasing the solar cell efficiency by modification of semiconductor material/junction properties.