

Homework 1  
ENEE 694  
Fall, 2000  
Due Tues. Sept. 26

1) Use the depletion approximation to analytically solve the Poisson equation in 1-D for a  $2.0\mu\text{m}$  PN junction in equilibrium. Assume a uniform doping profile with  $N_D = 5.0 \times 10^{16}/\text{cm}^3$ ,  $N_A = 1.0 \times 10^{16}/\text{cm}^3$ . Plot the potential and the field versus position. Also calculate and graph the electron and hole concentrations throughout the device. Assume the junction is in the middle.

2) Use Newton's method to solve the Poisson equation in equilibrium for the same diode as described above. Calculate and plot the potential, electron and hole concentrations throughout the device. Graph the results on the same axes as the results from the depletion approximation. Also, plot the difference between the the results from numbers (1) and (2).

3) Use your simulator to calculate and graph the potential, field and carrier concentrations for the more realistic Gaussian-type dopant distribution. Assume that a PN junction is formed by diffusing an n-type dopant (phosphorus) into a uniformly doped p-type substrate. Assume that the diffusion leads to a dopant concentration with the following distribution:

$$N_D - N_A = 1.0 \times 10^{18} \exp - \left( \frac{x^2}{1.0 \times 10^{-5}} \right) - 1.0 \times 10^{16} \quad (1)$$

Linear units are centimeters.

4) Calculate and graph the potential and carrier concentrations for a MOS capacitor. Assume the oxide thickness is  $50\text{\AA}$ , and the substrate is uniformly doped,  $2\mu\text{m}$  deep, p-well with  $N_A = 1.0 \times 10^{17}$ . Assume the gate is made of degenerately doped n-type poly. Apply three different biases  $V_G = 0, 1, 2V$ .