6 Non-Ideal Diode & Test Review Name:____________________________

Note – today you only have one in-class problem, that you do NOT need to turn in as homework. After you finish this problem, you may spend the rest of class asking me review questions for the test.

In-Class Problems

(1) A Si p+n diode is reverse based up to the point of electrical breakdown. The n-type doping is $N_D = 10^{15}$/cc.

(a) using the figure below, determine the breakdown voltage

(b) at the point of breakdown, what is the depletion region width?

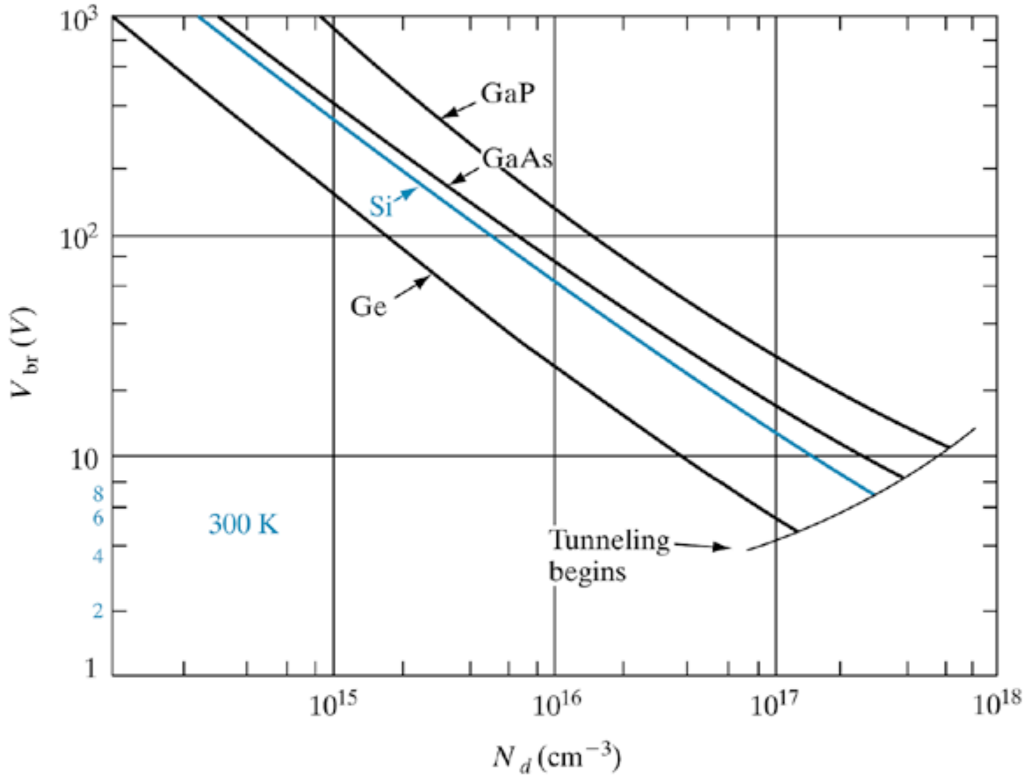
$$W = \sqrt{\frac{2\varepsilon kT}{q^2}\left(\ln\frac{N_A N_D}{n_i^2}\right)\left(\frac{1}{N_A}+\frac{1}{N_D}\right)} \qquad V_0 = \frac{kT}{q}\ln\frac{N_a N_d}{n_i^2}$$

Hint – you could use the above equations from Lecture 3, and notice that contact potential is already inside the equation for W. If you were to do so, and account for reverse bias voltage too, you would get the followign which is from Lecture 5. Remember, Vapp is negative!

$$W = \left[\frac{2\varepsilon\left(V_0 - V_{app}\right)}{q}\left(\frac{N_a + N_d}{N_a N_d}\right)\right]^{1/2}$$

(c) at the point of breakdown, using a simple (rough calculation), how much E-field is across the depletion region? ***Remember, in reality the E-field peaks at the physical PN junction, but for this calculation assume it is constant.***

(d) if we were to design the diode such that breakdown was always Zener breakdown, what would the new N_D value be?



(a)

400 V (1st tick is 200, second one 400, and so on…)

(b) Note, we don't need the part of the equation that is contact potential, we can just sub in the reverse bias voltage for that part since Vr >> Vo.

One can use Eq. 5-23b or Eq. 5-57. Also, x_n dominates W since $x_p \ll x_n$.

$$x_{n_o} \simeq W = \left[\frac{2\cdot\epsilon\cdot V_r}{q\cdot N_d}\right]^{\frac{1}{2}} = \left[\frac{2\cdot 11.8\cdot 8.85\cdot 10^{-14}\cdot 300\text{V}}{1.6\cdot 10^{-19}\text{C}\cdot 10^{15}\frac{1}{\text{cm}^3}}\right]^{\frac{1}{2}} = 2\cdot 10^{-3}\text{cm} = 20\mu\text{m}$$

The calculation above was for 300V, the answer for 400 V is the correct one and is: 22.9 μm.

(c) 400 V / 22.9 μm = 17 V / μm or 0.17 MV / cm

(d)

From Fig. 5-22 on page 201, increase N_D to >2 x 10^{17} /cc. This narrows W and therefore decreases the tunneling barrier formed by the separation of E_C and E_V inside the depletion region.

If get picky reading the log plot, looks like is about >3x10^{17}/cc.

(2) More diode current practice… Everyone should do well on the test on this, make sure you are solid on it, you know one of these WILL show up in one form or another!

An ideal Si p+n junction at 300K has the following parameters (you might not need them all).

p-side:	n-side:	General parameters
Na=10^{17}/cm^3	Nd=10^{15}/cm^3	ε_{Si}=11.8
Dn=18 cm^2/sec	Dp=25 cm^2/sec	
Ln=10^{-3} cm	Lp=10^{-2} cm	

a) What are the DRIFT and DIFFUSION current densities (A/cm^2) across the junction at an applied reverse bias of -2V?

b) What are the DRIFT AND DIFFUSION current density (A/cm^2) across the junction at a forward bias of 0.5? V?

a) [10 pts] What is the DRIFT and DIFFUSION current densities (A/cm^2) across the junction at an applied reverse bias of -2V?

Calculations:

$$J_o \simeq q\left(\frac{D_p}{L_p} p_n\right) = 1.6\times10^{-19} \cdot \frac{25}{10^{-2}} = 9\times10^{-11}\ A/cm^2$$
$$= 90\ pA/cm^2$$

Answer for DRIFT: 90 pA/cm^2

Answer for DIFFUSION: 0

b) [10 pts] What is the DRIFT AND DIFFUSION current density (A/cm^2) across the junction at a forward bias of 0.5? V?

Calculations:

$$J = J_o e^{qV/kT} = 9\times10^{-11} \cdot e^{0.5/0.0259} = 0.0218\ A/cm^2$$
$$= 22\ mA/cm^2$$

Answer for DRIFT: 90 pA/cm^2

Answer for DIFFUSION: 22 mA/cm^2

Review Session

I'll answer any question until the end of class! Use this time wisely and come prepared with questions you want to ask!