NAME:______________________________ **PUID: :**______________________________

ECE 305 Exam 4: Spring 2015
March 27, 2015

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This is a closed book exam. You may use a calculator and the formula sheet at the end of this exam. Following the ECE policy, the calculator **must** be a Texas Instruments TI-30X IIS scientific calculator.

There are three equally weighted questions. To receive full credit, you must **show your work**.

The exam is designed to be taken in 50 minutes.

Be sure to fill in your name and Purdue student ID at the top of the page.

DO NOT open the exam until told to do so, and stop working immediately when time is called.

The last page is an equation sheet, which you may remove, if you want.

75 points possible, 10 per question

1) 25 points (5 point per part)

2) 25 points (5 points per part)

3) 25 points (5 points per part)

------------------------ Course policy ------------------------

I understand that if I am caught cheating in this course, I will earn an F for the course and be reported to the Dean of Students.

Read and understood: ______________________________________
signature

Answer the **five multiple choice questions** below by **drawing a circle** around the **one, best answer**.

1a) To make an ohmic contact to an p-type semiconductor, one could:

a) Select a metal with a workfunction smaller than that of the semiconductor.
b) Select a metal with a workfunction larger that that of the semiconductor.
c) Use a lightly doped semiconductor.
d) Insert a thin insulating layer under the metal.
e) Reduce the minority carrier lifetime in the semiconductor.

1b) For an ideal <u>metal-N-type</u> GaAs diode, which type of carrier transport dominates under <u>reverse bias</u>?

a) Electron injection from the metal to semiconductor.
b) Electron injection from the semiconductor to metal.
c) Hole injection from the metal to semiconductor.
d) Hole injection from the semiconductor to metal.
e) Electron-hole recombination in the semiconductor.

1c) The electrostatics of an ideal <u>metal-P-type</u> GaAs diode are similar to which of the following?

a) A p+/n junction.
b) A p/n junction.
c) An n+/p junction.
d) An n/p junction
e) None of the above.

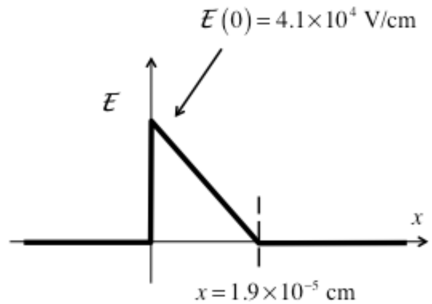
1d) The bandbending in the semiconductor is proportional to what?

a) The Schottky barrier height .
b) The semiconductor electron affinity.
c) The semiconductor workfunction.
d) The metal workfunction.
e) The built-in potential of the MS diode.

1e) What is the consequence of the fact that MS diodes are majority carrier devices, not minority carrier devices like NP diodes?

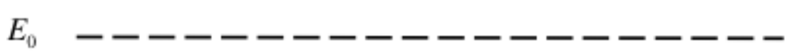
a) The barrier height is smaller than the bandgap.
b) The small signal model does not have a diffusion capacitance.
c) The small signal model does not have a junction capacitance.
d) The diode turn on voltage is smaller.
e) The series resistance is smaller.

2) The electric field vs. position for an MS junction in equilibrium is sketched below. (The depletion approximation is assumed, and you may assume that $K_S = 12$). Given the information provided, answer the following questions.



2a) Is the semiconductor N-type or P-type? Explain how you know.

2b) Draw and label the energy band diagram for the metal and semiconductor before they are joined together.

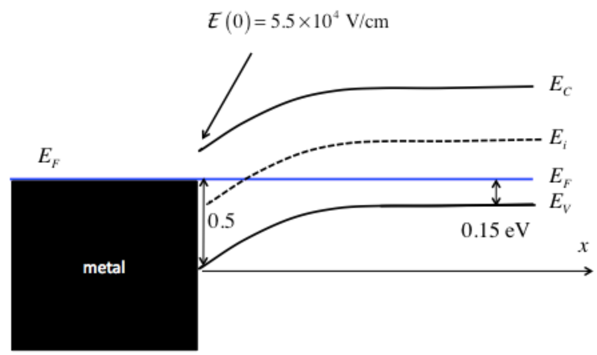


2c) What is the built-in voltage for this junction?

2d) Determine the numerical value of the doping density.

2e) If the voltage on the metal is $V = 0$, then is the voltage on the semiconductor positive or negative? You <u>must explain</u> your answer to receive credit.

3) Consider an ideal metal-semiconductor junction with the band diagram shown below. The semiconductor has a relative dielectric constant of 12 and an electron affinity of 4.0 eV. Answer the following questions.



3a) What is the built-in potential of this junction?

3b) What is the numerical value of the depletion layer width, W?

3c) What is the doping density of the semiconductor?

3d) What is the numerical value of the small signal capacitance measured under zero d.c. bias? You may assume that the area of the diode is $200\ \mu\text{m} \times 200\ \mu\text{m}$.

3e) The metal is grounded ($V = 0$), and a voltage of $V = -0.35$ is applied to the right side of the P-type semiconductor. Draw the energy band diagram and label the important quantities such as Fermi levels, bandbending, etc.