EE566 Solid State Devices

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Assignment 3
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Due: 02/14/2005

Reading
Chapter 3 & 4 of Muller/Kamins/Chan **(MKC)**

Data: GaN Material constants of interest (300K):
$\varepsilon_s=9.0\varepsilon_0$ | $\varepsilon_0=8.85\text{x}10^{-14}$F/cm | $F_{BR}=5\text{x}10^{6}$V/cm | $q=1.6\text{x}10^{-19}$ C
For other material constants & parameters go to - http://www.ioffe.rssi.ru/SVA/NSM/.

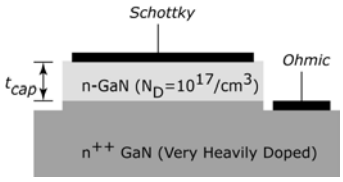
Problem 1[1]

MKC Problem 3.7.

Problem 2

MKC Problem 3.17.

Problem 3



The GaN structure shown was grown epitaxially, but due to the carelessness of the grower, the thickness of the cap layer t_{cap} was not recorded. After growth, a Schottky-diode was formed by etching and metal evaporation steps, by depositing Nickel ($q\Phi_B$=1eV) on the cap layer, and an ohmic contact on the heavily doped layer under it. From your knowledge of device physics, you will find the thickness of the cap layer, t_{cap}. You have to figure out where to draw charge-field-band diagrams in the way.

a) What is the depletion thickness x_{depl} with *no applied bias* for a Nickel- (very long n-GaN) Schottky diode with doping $N_D=10^{17}/cm^3$? What is the electric field at the surface of the semiconductor of the long Schottky diode? Is it larger or smaller than the breakdown field for GaN F_{BR}?

b) The careless grower had performed a capacitance-voltage measurement on the structure shown above. He tells you that the capacitance *did not change appreciably* as he increased the reverse bias on the Schottky diode. However, he forgot to note down the *value* of the (constant) capacitance! Using his information, what can be inferred about t_{cap} in relation to x_{depl} calculated in part (a)? If he had recorded the capacitance, could you have found t_{cap}?

c) You take matters into your own hands, and measure the current-voltage characteristic of the Schottky diode. You observe that the diode has a sharp and well-defined breakdown at a reverse bias of $|V_R|$=38.4 Volts. Find t_{cap}.

Problem 4

I need a Schottky diode such that
a) It "turns-on" (see Section 3.6 in MKC) at 2 Volts, and
b) The current-voltage characteristics are not affected by visible wavelengths of light.
Design such a diode. Choose your metal, semiconductor, doping, and justify each step. Find the electrical breakdown voltage of the diode you have designed. Also, calculate and plot the current density vs applied voltage (*J-V*) you expect for your design.

[1] Remember to use proper units and label every figure/plot. Turn in your answers worked out neatly. Please attach this question sheet to your solution when you turn it in.