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# EE566 Solid State Devices

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Dept of Electrical Engineering

University of Notre Dame

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## Assignment 3

Posted: 02/04/2007 (Sunday)

Due: 02/12/2007 (Monday)

### Reading

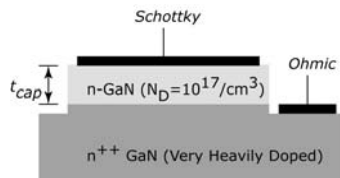
Chapters 3 & 4 of Muller/Kamins/Chan (MKC)

**Data:** GaN Material constants of interest (300K):

$\epsilon_s = 9.0\epsilon_0$  |  $\epsilon_0 = 8.85 \times 10^{-14} \text{F/cm}$  |  $F_{BR} = 5 \times 10^6 \text{V/cm}$  |  $q = 1.6 \times 10^{-19} \text{C}$

For other material constants & parameters go to - <http://www.ioffe.rssi.ru/SVA/NSM/>.

### Problem 1



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 ( $q\Phi_B = 1\text{eV}$ ) 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.

- What is the depletion thickness  $x_{depl}$  with *no applied bias* for a Nickel- (very long n-GaN) Schottky diode with doping  $N_D = 10^{17}/\text{cm}^3$ ? 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  $F_{BR}$ ?
- 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  $t_{cap}$ ?
- 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 2

I need a Schottky diode such that

- It "turns-on" (see Section 3.6 in MKC) at 2 Volts, and
- 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.

### Problem 3

Problem 3.12, MKC.

### Problem 4 (Practice problem for p-n junctions)

Problem 4.5, MKC.