Kaferelsheikh University
Department of Electrical Engineering
Subject: Electronic Devices
Academic Number: ECE3107
Full Mark: 100 degree

Faculty of Engineering
Year: 3rd Electronics and Electrical Communications
Final Exam: 2 pages
Time allowed: 3 h

Date: 30 /12/2018

This exam measures ILOs no: a5, a13,b5,a8 ,b6, b8,c5, d1,d7

Question #1: (20 Mark)

1- Simple large Signal MOSFET model has basic regions of operation. Explain them?

2- Explain the carrier's concentration at extremely high temperature and low temperature? Determine applications depend in that behavior?

3- An N-type silicon sample has a uniform density $N_d = 10^{17}\text{cm}^{-3}$ of arsenic, and a P-type sample has $N_a = 10^{15}\text{cm}^{-3}$. A third sample has both impurities present at the same time.

a- Find the equilibrium minority carrier concentrations at 300 K in each sample.

b- Find the conductivity of each sample at 300 K.

c- Find the Fermi level in each material at 300 K with respect to either the conduction band edge (E_c) or the valence band edge (E_v).

Question #2: (20 Mark)

1- Enhancement NMOS transistor, as the value of v_{ds} increase it causes the effective L (channel length) to decrease which causes the current to increase. Drive an expression for channel modulation effect.

2- Explain the ohmic contact and drive an expression for the specified contact resistance Rc.

3- Suppose you have samples of Si, Ge, and Ge, and GaAs at T = 300 K, all with the same doping level of $Nd^+ - Na^- = 3 \times 10^{15}$ /cm^3. Assuming all dopants are ionized, for which material is p most sensitive to temperature (the sensitivity of p is defining by $\delta p/\delta T$)? What is your conclusion regarding the relation between Eg and temperature sensitivity of minority carrier concentration?

Question#3: (20 Mark)

1. Which are the most important breakdown mechanisms in a reverse-biased p-n junction? Describe succinctly (no more than one paragraph for each process) how they work and how they trigger the breakdown process.

2. A Si p-n junction has dopant concentrations $N_D = 2 * 10^{15}$ cm^{-3} and $N_A = 2 * 10^{16}$ cm^{-3}. A p-n junction is reverse-biased with $V_a = -10V$. Determine the percent change in

junction (depletion) capacitance and built-in potential if the doping in the p region is increased by a factor of 2.

3. Derive the following expression:

$$p = \frac{1}{4}\left(\frac{2\, m_h\, KT}{\pi\, h^2}\right)^{3/2} e^{(E_v - E_F)/KT} = N_v\, e^{(E_v - E_{cF})/KT}$$

Question #4: (20 Mark)

1- Compare between the following:
- Minority carrier injection
- Minority carrier extraction

2- Sketch the band diagram of MOS capacitor. show the effect of applied voltage "flat band voltage"

3- Determine the metal-semiconductor work function difference ΦMS (in eV) in an MOS structure with p-type Si for the case where the gate is Al ($qxM = 3{,}2$ eV), n$^+$ poly silicon (poly crystalline Si, assume it is identical to normal Si), and p$^+$ poly silicon. Assume $NA = 6 * 10^{15}$ cm^{-3} and $T = 300$ K.

Question #5: (20 Mark)

1- Power diode device can be used in high frequency or no, why? If no, illustrate that device. Then sketch Reverse –recovery characteristics for power diode then define softness factor.

2- Sketch the band diagram of schottky contact. Clear an expression of the total current in it "With comments".

3- Calculate the maximum width of the depletion layer w_{max} (at the onset of inversion) and the maximum depletion charge $|Qd,\ max\ |$ in p-type Si, GaAs, and Ge semiconductors of an MOS structure with $NA = 10^{16}$ cm^{-3} and at $T = 300$ K, for si, $n_i = 1.5 * 10^{-10} cm^{-3}$, $\varepsilon_r = 11.7$. For Ge, $n_i = 2.5 * 10^{-12} cm^{-3}$, $\varepsilon_r = 16$ and for GaAs $n_i = 2.5 * 10^{-12} cm^{-3}$, $\varepsilon_r = 13.2$.

Best Wishes الاسئلة فى صفحتين Dr. noha abd al salam, Committee of Correctors and Testers