Student ID :

Islamic University of Technology (IUT)

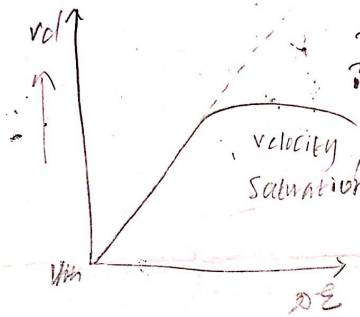
Organization of Islamic Cooperation (OIC)

Department of Electrical and Electronic Engineering

Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 2A Date : 07-08-2019 Time : 25 Minutes Marks : 15

1. Explain with diagram how electron drift velocity is affected by high electric field in semiconductors. 4



this limit occurs near the mean thermal velocity ($\simeq 10^7$ cm/s) and represent the point which added energy imparted by the field is transferred to the lattice rather than increasing the carrier velocity.

2. Without using equations, mention the applications of Hall effect. 4

- The Hall effect can be used to give quite accurate values for carrier concentration.
- Hall effect allow us to find out whether the charge carriers in a conductor are positive or negative charge.
- Drift speed

3. A Si sample is doped with 10^{16} boron atoms/cm^3. What is the resistivity of the sample at 300 K? Mobilities of electron and holes in Si are 1350 cm^2/V-s and 480 cm^2/V-s, respectively. 3

$\sigma = q(1350+480)n$

$= 1.6\times10^{-19}(1830)10^{16}$

$= 2.928\ \Omega^{-1}\text{-cm}^{-1}$

4. Derive the equation of time dependent excess electron concentration generated by a short optical pulse without considering diffusion. Make necessary assumptions during derivation. 4

$g(T) = \alpha_r n_i^2 = \alpha_r n_0 p_0$

$g(T) + g_{op} = \alpha_r np = \alpha_r (n_0+\delta n)(p_0+\delta p)$

$g(T)_0 + g_{op} = \alpha_r n_0 p_0 \propto [(n_0+p_0)\delta n + \delta n^2]$

$g_{op} = \alpha_r (n_0+p_0)\delta n = \frac{\delta n}{\tau_n}$

$\delta n = \delta p = g_{op}\tau_n$

Student ID : 2cthms

Islamic University of Technology (IUT)

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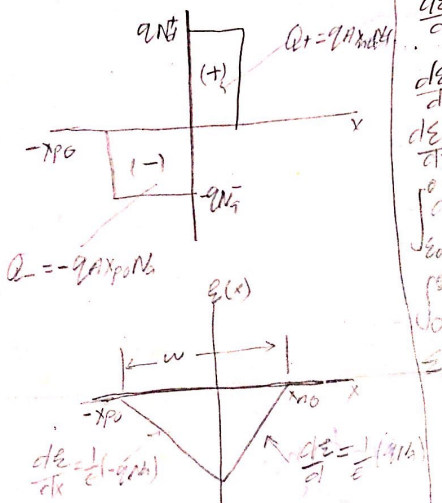
Department of Electrical and Electronic Engineering

Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 3C Date : 01-10-2019 Time : 25 Minutes Marks : 15

1. Draw the charge density versus distance and electric field versus distance diagrams of a p-n junction in equilibrium and derive the equation of maximum electric field using Poisson's equation. 2+2



$$\frac{d\mathcal{E}(x)}{dx} = \frac{q}{\varepsilon}(p - n + N_D - N_A)$$

$$\frac{d\mathcal{E}(x)}{dx} = \frac{q}{\varepsilon} N_D \qquad 0 < x < x_{no}$$

$$\frac{d\mathcal{E}(x)}{dx} = \frac{q}{\varepsilon} N_A \qquad -x_{po} < x < 0$$

$$\int_{\mathcal{E}_0}^{0} d\mathcal{E} = \frac{q}{\varepsilon} N_D \int_0^{x_{no}} dx \qquad 0 < x < x_{no}$$

$$\int_{\mathcal{E}_0}^{0} d\mathcal{E} = \frac{q}{\varepsilon} N_A \int_{-x_{po}}^{0} dx \qquad -x_{po} < x < 0$$

$$-\mathcal{E}_0 = -\frac{q}{\varepsilon} N_D x_{no} = -\frac{q}{\varepsilon} N_A x_{po}$$

2. Draw the total minority carrier concentration versus distance diagrams for a p-n junction under forward bias and under reverse bias. 4

3. An abrupt Si p^+-n junction has $N_d = 10^{15}$ cm^{-3}, $\tau_p = 10$ μs, $\mu_n = 1300$ cm^2/V-s and $\mu_p = 450$ cm^2/V-s on n-side and $N_a = 5\times10^{18}$ cm^{-3} on p-side. Cross sectional area of the junction is 10^{-4} cm^2 and temperature is 300 K. Find out the diode current under 0.4 V forward bias. 4

$I_0 = \frac{D_p}{L_p} p_n + \frac{D_n}{L_n} n_p$ — ignoring.

$n_p \ll p_n$

$I = qA\left(\frac{D_p}{L_p} p_n + \frac{D_n}{L_n} n_p\right)\left(e^{qV/kT} - 1\right)$

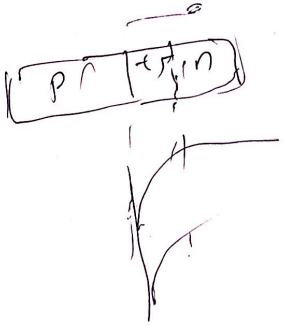
I_0

$L_p = \sqrt{D_p \tau_p}$

$D_p = \frac{kT}{q}\mu_p$

4. Using energy band diagram of only one scenario, discuss how a rectifying metal-semiconductor junction allows current flow in only one direction. 3

$\Phi_m > \Phi_s$ n-type



Student ID : 2dnas

Islamic University of Technology (IUT)

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Department of Electrical and Electronic Engineering

Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 4A Date : 16-10-2019 Time : 25 Minutes Marks : 15

1. For an ideal MOS structure in inversion (semiconductor is p-type), draw the energy band diagram versus distance (from Si-SiO_2 interface into Si), charge density versus distance, electric field versus distance and electrostatic potential versus distance diagrams. 8

2. Briefly describe the ways to control threshold voltage of MOSFET.

3. Give the definition of body effect. 1

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Islamic University of Technology (IUT)

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Department of Electrical and Electronic Engineering

Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 1C Date : 24-12-2021 Time : 20 Minutes Marks : 15

1. Define direct bandgap and indirect bandgap semiconductors with examples. Which kind of semiconductor is suitable for making LED? Why? 4+2

2. Without using equations, mention the applications of Hall effect. 3

3. A Ge sample is doped with 2×10^{17} phosphorous atoms/cm^3. Find equilibrium electron and hole concentrations at 300 K. Also locate the Fermi level, E_F in Ge bandgap from the valence band edge E_V. Ge bandgap $E_g = 0.67$ eV, Boltzmann constant $k = 8.62\times10^{-5}$ eV/K, intrinsic carrier concentration $n_i = 2.5\times10^{13}$ cm^{-3}. 3+3

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Department of Electrical and Electronic Engineering

Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 2B Date : 07-01-2022 Time : 20 Minutes Marks : 15

1. Starting from continuity equation for holes deduce the equation for steady-state excess hole concentration as a function of distance from the injection point for steady-state carrier injection in the semiconductor. 7

2. Draw the charge density versus distance and electric field versus distance diagrams of a p-n junction in equilibrium. 3

3. An abrupt Si p-n junction has $N_a = 10^{17}$ cm^{-3} on p-side and $N_d = 10^{18}$ cm^{-3} on n-side. The junction has circular cross-section of area 4×10^{-6} cm^2. Relative permittivity of Si is 11.8. Calculate: i) W and ii) $\mathscr{E}_0$ where symbols have their usual meanings. 5

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Course no. : Phy 4421 Course Title : Semiconductor Devices

Class Test : 3 Date : 15-03-2022 Time : 25 Minutes Marks : 15

1. Using energy band diagram, discuss how an ohmic metal-semiconductor junction allows current flow in both directions using p-type semiconductor. 3

2. An abrupt Si p-n junction has $N_d = 10^{16}$ cm^{-3}, $\tau_p = 10$ μs, $\mu_n = 1300$ cm^2/V-s and $\mu_p = 450$ cm^2/V-s on n-side and $N_a = 5\times10^{17}$ cm^{-3}, $\tau_n = 1$ μs, $\mu_n = 800$ cm^2/V-s and $\mu_p = 250$ cm^2/V-s on p-side. Cross sectional area of the junction is 10^{-3} cm^2 and temperature is 300 K. Find out the diode current under 0.3 V forward bias. 4

3. For an ideal MOS structure in inversion (semiconductor is p-type), draw the energy band diagram versus distance (from Si-SiO_2 interface into Si), charge density versus distance, electric field versus distance and electrostatic potential versus distance diagrams. 8