R 1
ece6453
HR2

ECE 6453 Solution key for
HOUR EXAM # 2

1. (a) The lateral electric field is independent of the vertical electricfield within the gate region

(b)

	Homo PN junction	p^+–N hetero-junction	M-S junction
Types of carrier for forward bias	e's & h's	e's (very few h's)	majority carriers (electrons, mostly)
Carrier transport mechanism	diffusion	Thermionic emission & diffusion	Thermionic emission
Nonideality in rev. bias	1. Generation in D.R. 2. Breakdown	1. Generation in D.R. 2. Breakdown	1. Generation in D.R. 2. field-assisted tunneling

(c) The barrier height is independent of the work fxn difference between the M-S junction.

(d) The majority current will flow through the substrate.
① Device cannot pinch-off
② g_m very low
Remedy: replace n-GaAs substrate w/ Semi-insulating GaAs substrate.

2. (a) Note that, if you use the equation sheet given in the test, you will get the answers as follows.

$$\Delta E_C = 0.55\,x = 0.25 \Rightarrow \underline{x = 0.45}$$

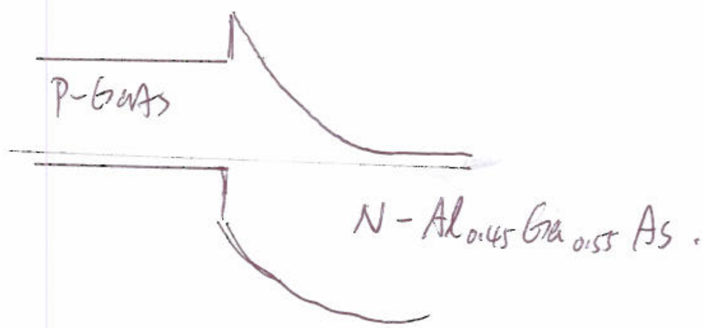
(b) electron thermionic dominant structure: $\underline{p^+ - N}$

Choose: p^+ = GaAs & N = AlGaAs.

(c) charge neutrality gives $x_{po} N_A = x_{no} N_D$

$$x_{po} \ll x_{No} \Rightarrow \boxed{\frac{N_A}{N_D} = 1000} \Rightarrow k = \frac{\epsilon_N N_d}{\epsilon_p N_a} = 0.001$$

(d)



(e) $$J_D \cong A^* T^2 \exp\left(-\frac{1}{kT}\,\frac{E_{gp} + \Delta E_C + k\Phi_n - \Phi_p}{1+k}\right)\left[\exp\left(\frac{q}{kT}\frac{V_a}{1+k}\right) - 1\right]$$

$$A^* = 120 \cdot \left(\frac{m_e^*}{m_0}\right)\ A/cm^2\text{-}K^2$$

$$\frac{m_e^*}{m_0} = 0.067 + 0.083 * 0.45 = 0.143$$

$$\Rightarrow \quad E_{gp} + \Delta E_C + k\Phi_n - \Phi_p - V_a = -(1+k)\ln\left(J_D / A^* T^2\right)$$

$$k = 0.001 \Rightarrow k\Phi_n \ll \Phi_p$$

$$\Rightarrow \quad \Phi_p = 0.103\ (V) \quad \eta' = -\Phi_p/kT = -3.96 \quad \boxed{N_D = 1.5\times10^{14}\,cm^{-3}}$$

$$N_A = N_V F_{1/2}(-3.96) = 2.51\times10^{+19} \times (0.48)^{3/2} \times 0.018 = \boxed{1.5\times10^{17}\,cm^{-3}}$$

3. (a) $V_T = \phi_B + \frac{E_{F0}}{q} - \phi_{00}' - \frac{\Delta E_C}{q}$

$\Delta E_C = 0.55 \times 0.4 = 0.22\,(eV)$ ← If you use data sheet provided in the test

$\epsilon_S = \epsilon_0(13.18 - 3.12 \times 0.4) = 11.932\,\epsilon_0$

$\phi_{00}' = \frac{q N_{D1}}{2\epsilon_S}(x_b - \delta)^2 = \frac{1.6 \times 10^{-19} \times 10^{18}}{2 \times 11.932 \times 8.85 \times 10^{-14}}(28 \times 10^{-7})^2 = 0.5939\,(V)$

$\phi_B = 1\,V$

$\Rightarrow$ $\boxed{V_T = 1.0 + 0.0518 - 0.5939 - 0.22 = 0.2379\,(V)}$

Note: If you follow the ΔE_C in the text book, it will give you $\boxed{V_T = 0.1791\,(V)}$

(b) $C_{ox}' = \frac{\epsilon_S}{x_b + \delta_b} = 0.279 \times 10^{-6}\ F/cm^2$

$V_{D,sat} = V_{GS} - V_T = 0.26\,(V)$ — if you use the sheet provided

$(= 0.32\,(V))$ — if you use text book equation

$I_D = \frac{W C_{ox}' \mu_n}{2L}(V_{GS} - V_T)^2$

$= \frac{800}{0.5} \times 0.279 \times 10^{-6} \times 6.5 \times 10^3 \times (V_{GS} - V_T)^2$

$\boxed{I_D = 187\,(mA)}$ — if you use the equation on the data sheet

$(\text{or} = 124\,(mA))$

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