UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	ADVANCED SEMICONDUCTOR DEVICES
COURSE CODE	:	BEJ 43303 / BED 41003
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 (a) Consider a silicon *npn* BJT at $T = 300\ K$ with these parameters:

$$D_n = 25\ cm^2/s,\ A_{BE} = 4.5 \times 10^{-5}\ cm^2,\ n_{B0} = 10^{13}\ cm^{-3},\ x_B = 0.2\ \mu m,$$

Calculate the range of v_{BE} that produces current collector within $0.1 < i_C < 0.4\ mA$.
(7 marks)

(b) Analyse **ONE (1)** possible reason the concentration of excess minority carrier is very high at location near to BE junction.

(5 marks)

(c) Given a silicon JFET has the following parameters:

$$N_d = 10^{16}\ cm^{-3},\ V_D = 2.4\ V,\ V_G = 0\ V,\ T = 300\ K$$

Calculate the required concentration of acceptor (N_a) to produce space charge width $h = 0.6206\ \mu m$.

(7 marks)

(d) Given a silicon MESFET has a set of parameters as follows:

$$\phi_{Bn} = 0.65\ V,\ N_a = 2 \times 10^{14}\ cm^{-3},\ N_d = 10^{17}\ cm^{-3},\ a = 10^4\ \text{Å},\ V_D = 0.5\ V,$$
$$V_G = 0\ V,\ I_P = 4 \times 10^{-5}\ A,\ V_P = 1.2\ V,\ T = 300\ K$$

Calculate the drain current (I_D) of this transistor.

(6 marks)

Q2 (a) Given the condition of a silicon *n*-type DG MOSFET operating in saturation region at $T = 300\ K$ is as follows:

$$t_{Si} = 900\ \text{Å},\ t_{ox} = 100\ \text{Å},\ \varepsilon_{r(ox)} = 3.9,\ V_D = 0.75\ V,\ V_G = 0.25\ V,\ V_0 = 0.05\ V,$$
$$C_{ox} = 10\ nF,\ I_D = 15\ \mu A$$

Calculate the ratio of width to length $\left(\frac{W}{L}\right)$ of this transistor.

(7 marks)

(b) Analyse the significance of width quantization property in FinFET structure.
(5 marks)

(c) Consider a silicon BJT is operating in emitter bandgap narrowing condition has the following parameters:

$$V_{BE} = 0.65\ V,\ N_B = 5 \times 10^{14}\ cm^{-3},\ N_E = 2 \times 10^{16}\ cm^{-3},\ x_B = 1.5\ \mu m,$$
$$x_E = 4\ \mu m,\ L_B = 9\ \mu m,\ L_E = 17\ \mu m,\ D_E = 18\ cm^2/s,\ D_B = 12\ cm^2/s,$$
$$\Delta E_g = 10^{-20}\ J$$

Determine the emitter injection efficiency $(\gamma)$for this device.

(7 marks)

(d) Suppose a silicon JFET is operating in channel length modulation condition has parameters as follows:

$$V_D = 3.4\,V,\ V_{Dsat} = 1.8\,V,\ N_d = 5 \times 10^{14}\ cm^{-3},\ L = 1.5\ \mu m,\ W = 7.5\ \mu m,\ a = 10\ \mu m$$

Determine the pinch current (I_P') of this transistor.

(6 marks)

Q3 (a) Given a silicon varactor operates with linearly graded junction has the following parameters:

$$B = 2 \times 10^{15}, W_D = 12.5\ \mu m, V_R = 4\ V,$$
$$N_a = 4 \times 10^{14}\ cm^{-3}, N_d = 1.5 \times 10^{16}\ cm^{-3}$$

Determine the differential capacitance (C_D) and sensitivity (m) of this varactor.

(6 marks)

(b) Calculate the breakdown voltage (V_B) and depletion region width (W_D) of a gallium arsenide two-sided diode that has doping concentration of $N = 10^{17}\ cm^{-3}$. Use diagram in **Figure Q3(b)** to aid your calculation.

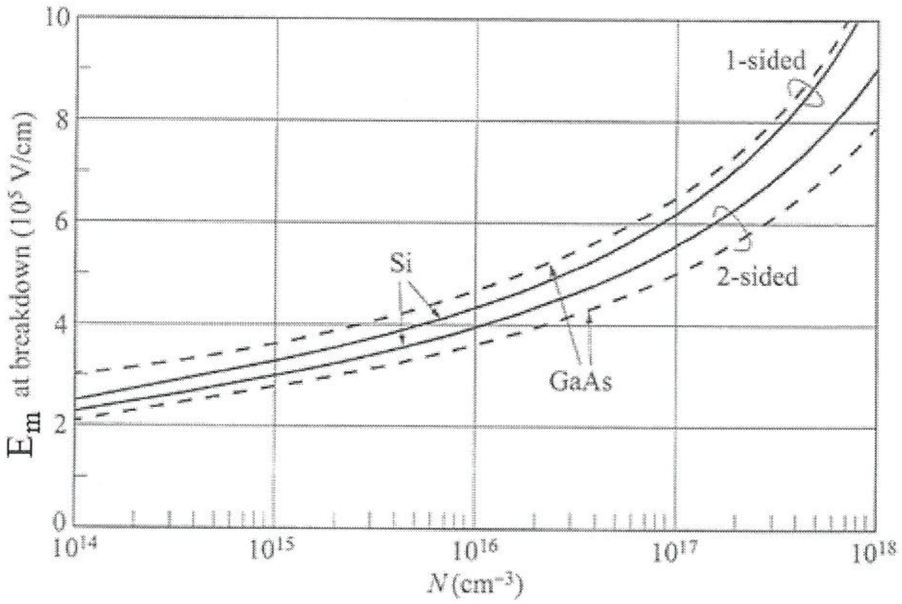

Figure Q3(b)

(7 marks)

(c) Based on your answer in part **Q3(b)**, determine the power density limit (P_m) of this diode, given saturation velocity $v_s = 10^4\ cms^{-1}$.

(7 marks)

(d) Analyse the significance of high doping concentration in avalanche region in IMPATT diodes.

(5 marks)

Q4 (a) Given a silicon power MOSFET at $T = 300\ K$ has the following parameters:

$$W_{poly} = 1.6\ \mu m,\ W_G = 2.1\ \mu m,\ N_a = 10^{14}\ cm^{-3},\ N_d = 8 \times 10^{15}\ cm^{-3},$$
$$t_{ox} = 120\ \text{Å},\ t_{Eox} = 100\ \text{Å},\ t = 5\ \mu m,\ x_{PL} = 80\ \text{Å}$$

Find the breakdown voltage (V_B) and input capacitance (C_{IN}) of this device.

(6 marks)

(b) Given a silicon power MOSFET at $T = 300\ K$ has the following parameters:

$$C_{ox} = 12 \times 10^{-8}\ F/cm,\ V_G = 0.25\ V,\ V_D = 9\ V,\ V_{Th} = 0.08\ V,\ L = 1.8\ \mu m,$$
$$Z = 11\ \mu m,\ W_{cell} = 3.8\ \mu m,\ N_a = 3 \times 10^{14}\ cm^{-3},\ N_d = 7 \times 10^{16}\ cm^{-3},$$
$$K_0 = 0.0322$$

Find the saturation drain current (I_{Dsat}) and transconductance (g_m) of this device.

(7 marks)

(c) Consider a silicon thyristor experiences breakdown in reverse blocking mode operation with depletion region covers 60% of n_1 region. It also has the following parameters:

$$W_{n1} = 25\ \mu m,\ L_{n1} = 6\ \mu m,\ V_B = 2 \times 10^3\ V,\ V_{AK} = 4.5\ V,\ n = 6$$

Calculate the actual breakdown voltage (V_{BR}) and puncthrough voltage (V_{PT}) of this thyristor.

(7 marks)

(d) Analyse possible reason that causes punchthrough breakdown mechanism mostly occurs in low doping concentration for any given width of n_1 region.

(5 marks)

- END OF QUESTIONS -