UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2003/2004

September/October 2003

EBB 525/3 - Electronic Materials & Optical Devices

Time : 3 hours

Please ensure that this paper consists of FIVE printed pages before you proceed with the examination.

This paper contains SEVEN questions.

Answer any FIVE questions. If a candidate answer more than five questions, only the first five answered will be examined and awarded marks.

Answer to any question must start on a new page.

All questions must be answered in English.

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1. [a] What is Fermi level?

(10 marks)

[b] Derive the Fermi-Dirac distribution function at $E=E_F$ (i.e. at Fermi energy). Discuss the behavior of the function at 0K for $E>E_F$ and $E<E_F$. Provide neat sketches of the functions for each case.

(20 marks)

[c] Derive the expression for the equilibrium concentration of electrons in the conduction band and holes in the valence band.

(60 marks)

[d] Show that $n_o p_o = n_i^2$ where n_o = equilibrium electron concentration, p_o = equilibrium hole concentration and n_i = intrinsic carrier concentration.

(10 marks)

2. [a] What is the need for biasing a BJT?

(10 marks)

[b] What is the mechanism used to control the base current?

(10 marks)

[c] With the help of a neat sketch discuss the output characteristics of a BJT biased in the linear mode of operation.

(30 marks)

[d] Analyze the single battery biasing circuit for a common-emitter npn BJT in linear mode of operation. Provide the circuit diagrams and discuss the input and output loop.

(50 marks)

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3. [a] Draw the circuit and small signal model of a common-emitter npn BJT circuit with the following parameters:

V_{CC} = 24 V (supply voltage)

R_B = 600 kΩ (base resistor)

R_L = 5 kΩ (load resistor)

β = 50 (common-emitter current gain)

g_m = 2/30 mho (transconductance)

Input signal E_i and coupling capacitor C_c.

(30 marks)

[b] Derive the expression for the standard form of voltage gain and evaluate r_π, R_{in} and A_v for the above circuit.

(30 marks)

[c] Show the graphical analysis of the signal current and voltages for a common-emitter circuit with the following parameters:

Base signal current I_{bp} = 10 μA,

DC collector current I_C = 1.5 mA

DC base current I_B = 30 μA

I_C = 1.0 mA and 0.5 mA for I_B = 20 μA and 10 μA respectively.

The DC load line intersects the I_C axis at 2 mA and V_{CE} axis at 20 V.

(40 marks)

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4. [a] Draw the current voltage characteristic curves for a JFET and define the ON resistance, saturation region and pinch-off voltage.

(30 marks)

[b] How does gate biasing affect the output characteristics of the JFET?

(20 marks)

[c] Describe with the help of neat sketches the function of a MOS (Metal oxide semiconductor) capacitor with a p-type semiconductor substrate under both positive and negative biasing conditions. Draw the corresponding energy band diagrams.

(50 marks)

5. [a] Describe the principle of operation and applications of a light emitting diode. Provide neat sketches.

(40 marks)

[b] What are the properties that make light attractive for information processing?

(60 marks)

6. [a] What is meant by high field transport in electronic devices? Describe it for Si and GaAs.

(50 marks)

[b] Describe what happens in the presence of extremely high electric field.

(50 marks)

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7. [a] Describe the principle of operation of a P-I-N photodetector.

(50 marks)

[b] Discuss the choice of material and frequency response of a photodetector.

(50 marks)

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