Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	SEMICONDUCTOR PHYSICS
COURSE CODE	:	BWC30203
PROGRAMME	:	3BWC
EXAMINATION DATE	:	DECEMBER 2015/JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

CONFIDENTIAL

ANSWER FIVE (5) QUESTIONS ONLY

Q1 (a) What is boule? Give two (2) examples of elemental semiconductor materials that is grown by Czochralski method?

(4 marks)

(b) Zone refining, a precursor of floating zone technique, was first developed by W. G. Pfann in 1951 at Bell Laboratories. This technique is used to grow single crystal of semiconductor materials. By sketching a simple diagram, point out the growth process by using floating zone technique.

(10 marks)

(c) Molecular beam epitaxy (MBE) is one of several epitaxial methods of depositing single crystals of semiconductor? Explain briefly the growth process by using this method.

(6 marks)

Q2 (a) (i) Explain the concept of donor and acceptor of impurity atoms.

(4 marks)

(ii) How do these donor and acceptor of impurity atoms interacts with intrinsic semiconductor to forming n-type and p-type semiconductor?

(6 marks)

(b) Explain briefly the

(i) carrier generation,

(2 marks)

(ii) carrier recombination.

(2 marks)

(c) How does the excess carrier (electrons and holes) is generated? Explain.

(6 marks)

Q3 (a) How does a p-n junction of a semiconductor is created?

(2 marks)

(b) Point out the formation of a depletion region in a semiconductor.

(8 marks)

(c) How does zener breakdown occur in a reverse biased p-n junction of a semiconductor?

(5 marks)

(d) Calculate the space charge width in a p-n junction for zero bias. Consider a Si p-n junction at $T = 300$ K with doping concentration of $N_a = 10^{16}$ cm^{-3} and $N_d = 10^{15}$ cm^{-3}. The built-in potential barrier, $V_{bi} = 0.635$ V.

(5 marks)

Q4 (a) Sketch and label the energy band diagram of a metal-n-type semiconductor before contact. From the sketched energy band diagram, point out the

(4 marks)

(i) metal work funtion, ϕ_m,

(4 marks)

(ii) electron affinity, χ,

(4 marks)

(iii) vacuum level.

(2 marks)

(b) An n-type Si semiconductor is made in contact with a tungsten metal. The Si was doped with $N_d = 10^{16}$ cm^{-3} at $T = 300$ K. The work function of the tungsten, $\phi_m = 4.55$ V, electron affinity of the Si, $\chi = 4.01$ V and potential in the n-type Si, $\phi_n = 0.206$ V. Calculate the

(i) barrier height, ϕ_{B0},

(3 marks)

(ii) built-in potential barrier, V_{bi}.

(3 marks)

Q5 (a) Consider a p-n junction diode under forward bias.

(i) Sketch a p-n junction diode diagram.

(2 marks)

(ii) Sketch a simple band diagram of p-n junction.

(4 marks)

(iii) Discuss the mechanism of current conduction in a p-n junction diode.

(7 marks)

(b) (i) Sketch and label a simple diagram of heterojunction gallium nitride (GaN) light emitting diode (LED) structure epitaxially grown on Si substrate. The diagram should be included the transparent conducting oxide (TCO) and metal contacts on both p-GaN and n-GaN layer.

(4 marks)

(ii) What is the function of using the TCO in the LED structure?

(3 marks)

Q6 (a) The metal-oxide-semiconductor field-effect-transistor (MOSFET) is used extensively in digital circuit applications.

(i) Propose a simple structure of an n-channel enhancement MOSFET.

(4 marks)

(ii) Explain the operational principle of the MOSFET based on the sketched structure.

(6 marks)

(b) By sketching a p-channel enhancement MOSFET and p-channel depletion MOSFET, explain the differentiation between them.

(10 marks)

- END OF QUESTION -

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LIST OF FORMULA

$J = qNv_d$	$E = \frac{p^2}{2m} =$	$p = \hbar k$
$F = ma^* = eE$	$W = \left\{ \frac{2\varepsilon_s V_{bi}}{e} \left[\frac{N_a + N_d}{N_a N_d} \right] \right\}^{1/2}$	$\phi_{B0} = \phi_m - \chi$
$V_{bi} = \phi_{B0} - \phi_n$	$\chi = E_{vac} - E_c$	

LIST OF CONSTANT

1.	Permittivity of free space	8.8541×10^{-12} m^{-3} kg^{-1} s^4 A^2
2.	Relative permittivity of Si	11.7
3.	Electron charge	1.602×10^{-19} C