SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR

SESI II : 2024/2025

DEO50033 : OPTOSEMICONDUCTOR

TARIKH : 14 MEI 2025
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **ENAM (6)** halaman bercetak.
Bahagian A: Struktur (3 soalan)
Bahagian B: Esei (2 soalan)
Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SECTION A: 60 MARKS

BAHAGIAN A: 60 MARKAH

INSTRUCTION:

This section consists of **THREE (3)** subjective questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **TIGA (3)** soalan subjektif. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1 (a) Describe **TWO (2)** types of LED.

*Terangkan **DUA (2)** jenis LED.*

[5 marks]

[5 *markah*]

CLO1 (b) Discuss types and recombination process in designing light emitting diode (LED).

Bincangkan tentang jenis dan proses penggabungan semula dalam mereka bentuk diod pemancar cahaya (LED).

[5 marks]

[5 *markah*]

CLO1 (c) GaN is doped with Indium and Arsenic at concentrations of 10^{18} cm^{-3} and 10^{15} cm^{-3} respectively. Calculate the carrier lifetime for minority carrier lifetime in all the doping concentrations. Given that the bimolecular recombination coefficient, β of GaN is 10^{-10} cm^3/s.

GaN didopkan dengan Indium dan Arsenik pada kepekatan 10^{18} cm^{-3} dan 10^{15} cm^{-3}. Kira hayat pembawa untuk hayat pembawa minoriti dalam semua peringkat doping. Diberi bahawa pekali penggabungan semula dwimolekul, β GaN ialah 10^{-10} cm^3/s.

[10 marks]

[10 *markah*]

QUESTION 2

SOALAN 2

CLO1 (a) Describe carrier distribution in p-n homojunctions.
Jelaskan taburan pembawa dalam pincang homo p-n.

[5 marks]
[*5 markah*]

CLO1 *(b)* Discuss the concept of the light escape cone.
Bincangkan tentang kon konsep pelepasan cahaya.

[5marks]
[*5 markah*]

CLO1 (c) A GaAs light emitting diode (LED) produces 10^{17} photons per second at active region with a wavelength of 650 nm when 10^{18} electrons per second are injected. The device has extraction efficiency of 75% and is biased with 5 V. Calculate number of photons emitted to free space, injection current, input electrical power, output optical power and power converted to heat in this device.

Suatu diod pemancar cahaya (LED) GaAs menghasilkan 10^{17} foton sesaat di kawasan aktif dengan panjang gelombang 650 nm apabila 10^{18} elektron sesaat disuntik. Peranti ini mempunyai kecekapan pengekstrakan sebanyak 75% dan dibiaskan dengan 5 V. Kira bilangan foton yang dipancarkan ke ruang bebas, arus suntikan, kuasa elektrik input, kuasa optik output dan kuasa yang ditukar kepada haba dalam peranti ini.

[10 marks]
[*10 markah*]

QUESTION 3

SOALAN 3

CLO1 (a) Identify the source of the heat generated in the junction.

Kenal pasti punca kepada haba yang terjana dalam simpang.

[5 marks]

[*5 markah*]

CLO1 (b) Explain the significance of junction temperature.

Terangkan kepentingan suhu simpang..

[5 marks]

[*5 markah*]

CLO1 (c) GaAs with $N_A = 4 \times 10^{18}\,cm^{-3}$, $N_D = 2 \times 10^{18}\,cm^{-3}$ emits photons of 10^{16} per second at active region when 10^{17} electrons are injected. Given bias voltage = 5.0V, $\frac{kT}{q} = 25mV, \eta_i = 1.79 \times 10^6\ cm^{-3}$. Calculate threshold voltage, V_{th} , *injection current*, I_{inj} and *injected power*, P_{inj}.

GaAs dengan $N_A = 4 \times 10^{18}\,cm^{-3}$, $N_D = 2 \times 10^{18}\,cm^{-3}$ *memancarkan foton* 10^{16} *sesaat di kawasan aktif apabila* 10^{17} *elektron disuntik. Diberi voltan pincang = 5.0V,* $kT/q = 25mV$, , $\eta_i = 1.79 \times 10^6\,cm^{-3}$. *Kira* V_{th} ,I_{inj} *dan* P_{inj}.

[10 marks]

[*10 markah*]

SECTION B: 40 MARKS

BAHAGIAN B: 40 MARKAH

INSTRUCTION:

This section consists of **TWO (2)** essay questions. Answer **ALL** the questions.

ARAHAN:

*Bahagian ini mengandungi **DUA (2)** soalan esei. Jawab **SEMUA** soalan tersebut.*

QUESTION 1

SOALAN 1

CLO1

Given the parameters for GaAs are $\alpha = 5.41 \times 10^{-4} \frac{\text{eV}}{\text{K}}, \beta = 204\text{K}$, $\text{Nc} = 4.7 \times 10^{17}\ \text{cm}^{-3}, \text{Nv} = 7 \times 10^{18}\text{cm}^{-3}$. Calculate the linear temperature coefficient of forward voltage of a GaAs LED with $N_A = 10^{18}\ \text{cm}^{-3}$ and $N_D = 10^{17}\ \text{cm}^{-3}$ at room temperature and the decrement in forward voltage if the ambient temperature is increased from 15 °C to 30 °C by neglecting internal heating.

Diberi parameter untuk GaAs ialah $\alpha = 5.41 \times 10^{-4} \frac{eV}{K}, \beta = 204K, Nc = 4.7 \times 10^{17}\ cm^{-3}, Nv = 7 \times 10^{18} cm^{-3}$. *Kirakan pekali suhu linear bagi voltan hadapan LED GaAs dengan* $N_A = 10^{18}\ \text{cm}^{-3}$ *dan* $N_D = 10^{17}\ \text{cm}^{-3}$ *pada suhu bilik dan susut voltan hadapan jika suhu ambien dinaikkan dari 15 °C hingga 30 °C dengan mengabaikan pemanasan dalaman.*

[20 marks]

[*20 markah*]

QUESTION 2

SOALAN 2

CLO1

A photonic engineer is required to design a high efficiency LED that produces red light with ability to handle vertical current flow. Analyze the LED design considerations in terms of material, structure, current layer and package in order to meet the desired specifications.

Jurutera fotonik dikehendaki untuk merekabentuk LED kecekapan tinggi yang menghasilkan cahaya merah dengan keupayaan untuk mengendalikan aliran arus menegak. Analisiskan rekabentuk LED pertimbangkan dari segi bahan, struktur, lapisan arus dan pakej untuk memenuhi spesifikasi yang dikehendaki.

[20 marks]

[*20 markah*]

SOALAN TAMAT

LISTS OF FORMULA

SENARAI FORMULA

1. $R = \beta np$

2. $\tau_{n/p} = \frac{1}{\beta N_{A/D}}$

3. $\tau = \frac{1}{\beta(N_A + N_D)}$

4. $\eta_{int} = \frac{number\ of\ photons\ emmited\ from\ active\ region\ per\ second}{number\ of\ electrons\ injected\ into\ LED\ per\ second}$

5. $\eta_e = \frac{number\ of\ photons\ emmited\ into\ free\ space\ per\ second}{number\ of\ photons\ emmited\ from\ active\ region\ per\ second}$

6. $\eta_{ext} = \frac{number\ of\ photons\ emmited\ into\ free\ space\ per\ second}{number\ of\ electrons\ injected\ into\ LED\ per\ second}$

7. $\eta_{power} = \frac{P}{IV} = \frac{P_{out}}{P_{in}}$

8. $I_{inj} = number\ of\ electrons\ injected\ into\ LED\ per\ second\ \times q$

9. $P_{heat} = P_{in} - P_{out}$

10. $P_{in} = I_{inj} \times V_A$

11. $R_s = \frac{(V_F - V_{th})}{I_{inj}}$

12. $Fraction\ of\ light\ power\ can\ escape = 0.5\ (1 - \cos\theta_C)$

13. $L_{n/p} = \left(D_{n/p}\tau_{n/p}\right)^{\frac{1}{2}}$

14. $D_{n/p} = \frac{kT}{q}\mu_{n/p}$

15. $V_D = \frac{kT}{q}\ln\frac{N_A N_D}{{n_i}^2}$

16. $W_D = \sqrt{\frac{2\varepsilon}{e}(V_D - V)\frac{N_A + N_D}{N_A \times N_D}}$

17. $Tj = Rthjs \times (Vd \times Id) + Ta$

18. $Rthja = \frac{Tjmax - Tamax}{Vd \times Imax}$

19. $Rthsa = Rthja - Rthjs$

20. $\frac{dVf}{dT} = \frac{k}{e}\ln\frac{N_D N_A}{N_c N_v} - \frac{\alpha T(T+2\beta)}{e(T+\beta)^2} - \frac{3k}{e}$