UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

EBB 525/3 - Electronics Materials & Optical Devices

Duration : 3 hours

Please ensure that this examination paper contains FIVE printed pages before you begin the examination.

This paper contains SEVEN questions.

Instructions: Answer **FIVE** questions. If a candidate answers more than five questions only the first five questions in the answer sheet will be graded.

Answer to any question must start on a new page.

All questions must be answered in English.

1. [a] Briefly explain the following terms:

    (i) electronic materials

    (ii) Moore's law

(40 marks)

[b] SiO_2-based gate oxide is replacing by alternative materials. What are the requirements of these materials to be considered as an alternative gate oxide?

(60 marks)

2. [a] Explain the different between a direct tunneling process and Fowler-Nordheim tunneling process through a dielectric.

(30 marks)

[b] Explain the main characteristics required for a low dielectric constant (k) material to be employed in a deep-submicron CMOS structure.

(30 marks)

[c] Explain some of the important issues in high dielectric-constant (k) gate stack materials in deep-submicron CMOS structure.

(40 marks)

3. [a] Briefly explain four (4) types of charge conduction mechanisms through a dielectric.

(40 marks)

[b] Discuss in detail why low dielectric constant (k) material is used as Inter-level Dielectric (ILD) in a deep-submicron CMOS structure.

(60 marks)

4. [a] Explain the challenges of using high dielectric constant material as an alternative gate oxide in a deep-submicron CMOS structure.

(50 marks)

[b] How does a dielectric mirror differ from a regular mirror? Why regular mirror is not suitable for semiconductor lasers development.

(25 marks)

[c] How exactly do semiconductor lasers operate differently from light-emitting diodes (LEDs)?

(25 marks)

5. As we know, there are many promising achievement on the research and applications of III-V compound semiconductor. For example, LED traffic light uses InGaN/AlGaN, AlInGaP and AlGaAs compounds to generated blue-green, yellow and red lights, respectively.

(a) Explain the reason why energy gaps of $Al_xGa_{1-x}N$ and $In_xGa_{1-x}N$ alloys are dependent on their compositions.

(30 marks)

(b) Explain why direct bandgap semiconductors are preferred instead of indirect bandgap semiconductors for LED applications.

(20 marks)

(c) Explain light emission mechanism of a GaN p-n junction LED, as shown in Figure 1. (A sketch might help)

(50 marks)

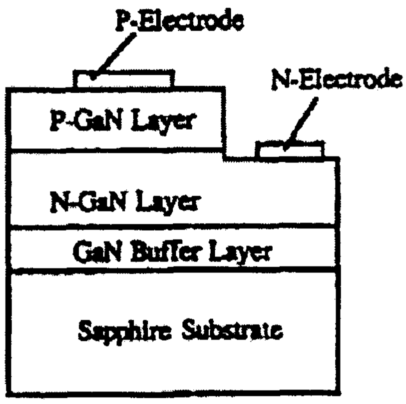

Figure 1 - The structure of the GaN pn junction LEDs.

6. [a] Suppose you are an engineer and assigned to build (i) blue and (ii) green LEDs, using $Al_xGa_{1-x}N$ or $In_xGa_{1-x}N$ alloys. Calculate possible compositions for each material. Assume that $h_v = E_g$ and use the data given in Figures 2. (Please don't use band gap data from other references!).

(60 marks)

[b] Why does a double heterostructure LED (DH-LED) device perform more efficient if compared to a conventional p-n junction LED?

(40 marks)

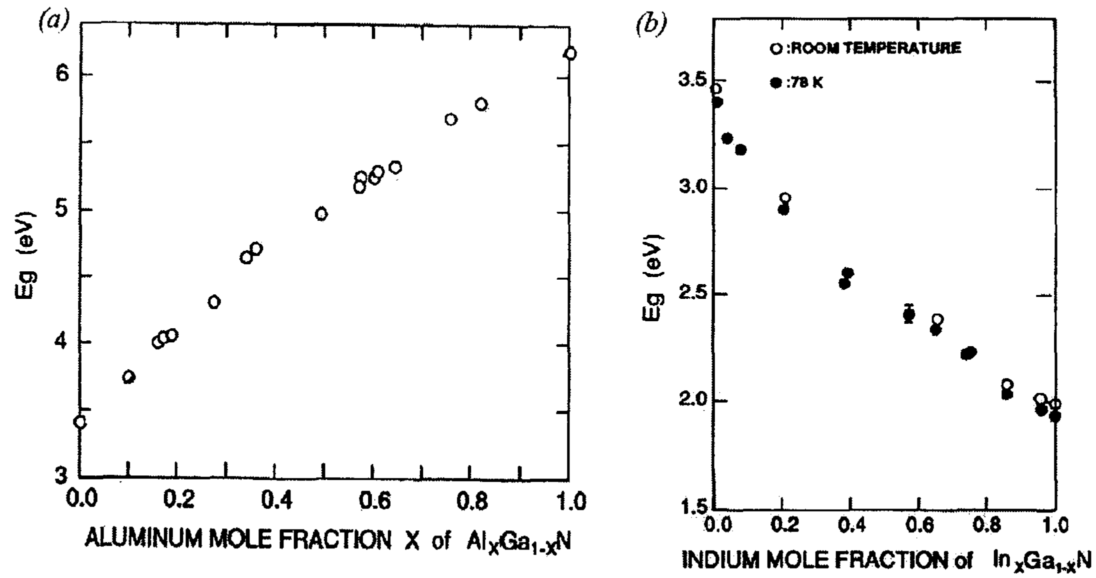

Figure 2 - Composition dependence of the direct energy gap E_g of (a) $Al_xGa_{1-x}N$ alloys, and (b) $In_xGa_{1-x}N$ alloys.

7. [a] There are three (3) types of solar cell materials (monocrystalline, polycrystalline and amorphous). Explain what are the advantages and weakness of these materials.

(30 marks)

[b] Solar spectrum irradiance at air mass 1 (AM1) is shown in Figure 3. Based on the band gap value of given materials, choose and explain a very promising material for solar energy conversion application: Ge = 0.78 eV, Si = 1.17 eV, InP = 1.35 eV, GaAs = 1.42 eV, GaP = 3.30 eV, ZnO = 3.40 eV, and ZnS = 3.6 eV.

(40 marks)

[c] How does a solar photovoltaic plant produce energy?

(30 marks)

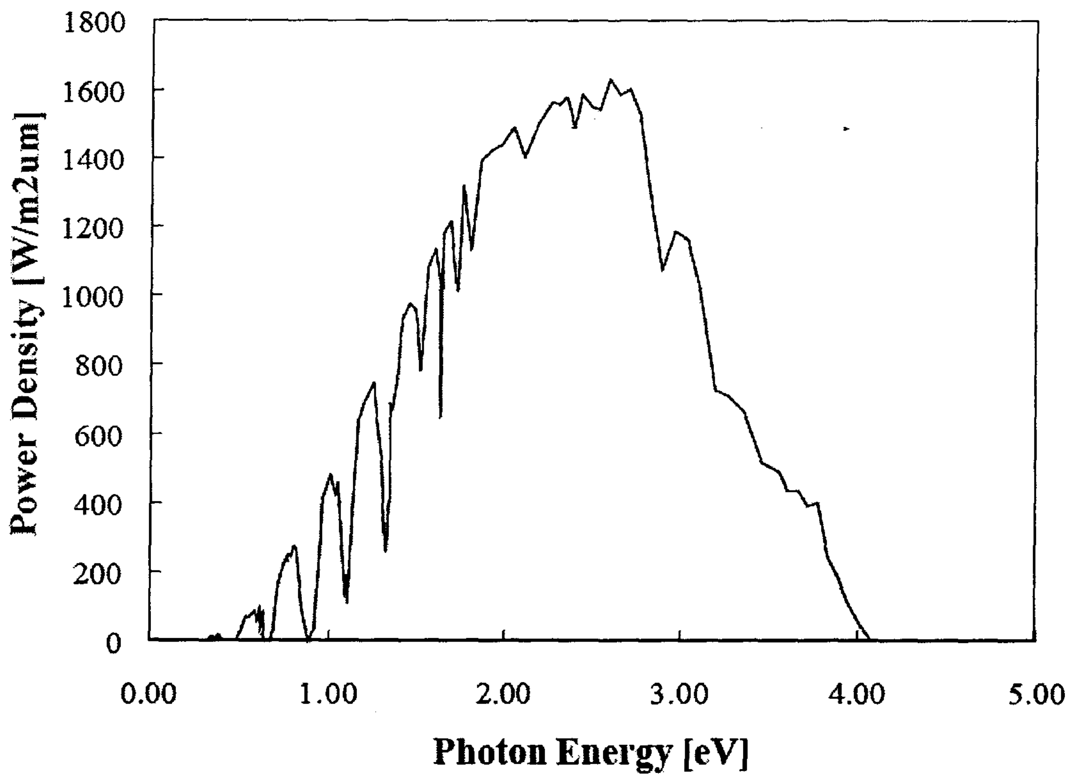

Figure 3 - Solar spectrum irradiance
(power per unit area and unit wavelength) at air mass 1 (AM1).

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