UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EBB 525/3 – Electronic Materials & Optical Devices

Duration : 3 hours

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

This paper consists of THREE questions from PART A, THREE questions from PART B and ONE question from PART C.

Instruction: Answer **TWO** questions from PART A, **TWO** questions from PART B and **ONE** question from PART C. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.

The answers to all questions must start on a new page.

All questions must be answered in English.

PART A

1. [a] Sketch the general shape of the optical absorption coefficient in a semiconductor as a function of wavelength.

(20 marks)

[b] Explain briefly how to fabricate a transparent conductive oxide (TCO) based on tin oxide (SnO_2) thin films.

(30 marks)

[c] What semiconductor materials can be used to produce emission at 1.5 eV? Of these materials, are any compatible with readily available substrates (e.g. GaAs or InP)? Use Figure 1 as a reference.

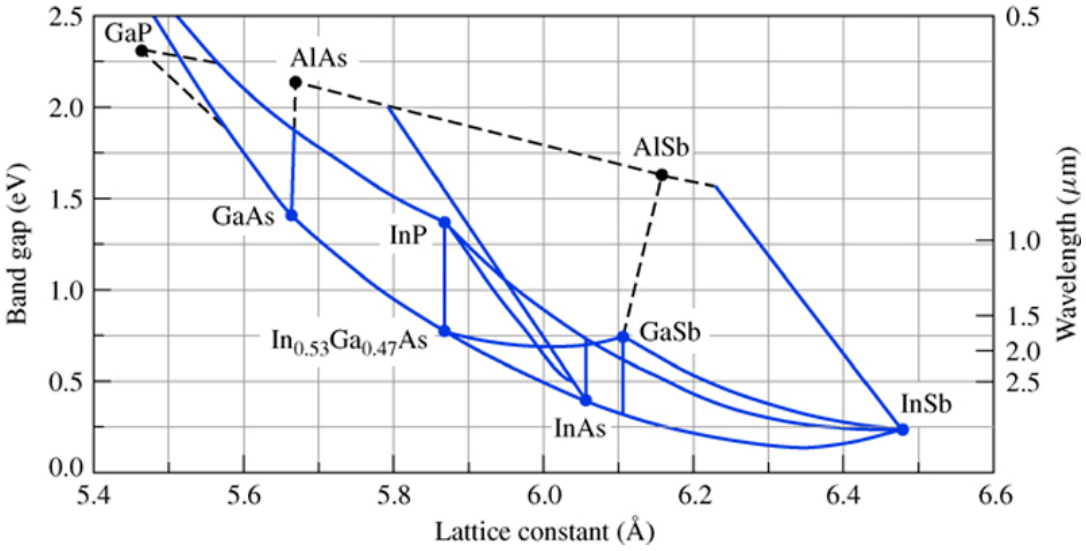

Figure 1.

(50 marks)

2. [a] Suppose you are 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 $h\nu = E_g$ and use the data given in Figure 2. (Please don't use band gap data from other references!).

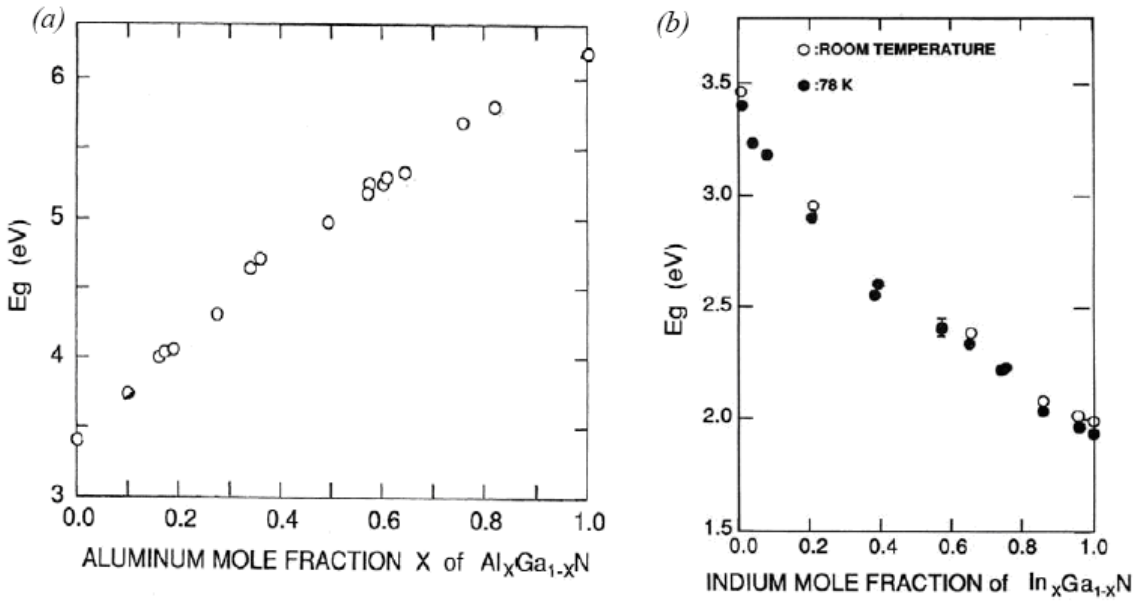

Figure 2.

(50 marks)

[b] Figure 3 shows a typical *I*-*V* characteristic of a solar cell. Determine I_{sc}, V_{oc}, and η. The incident power is 15 mW.

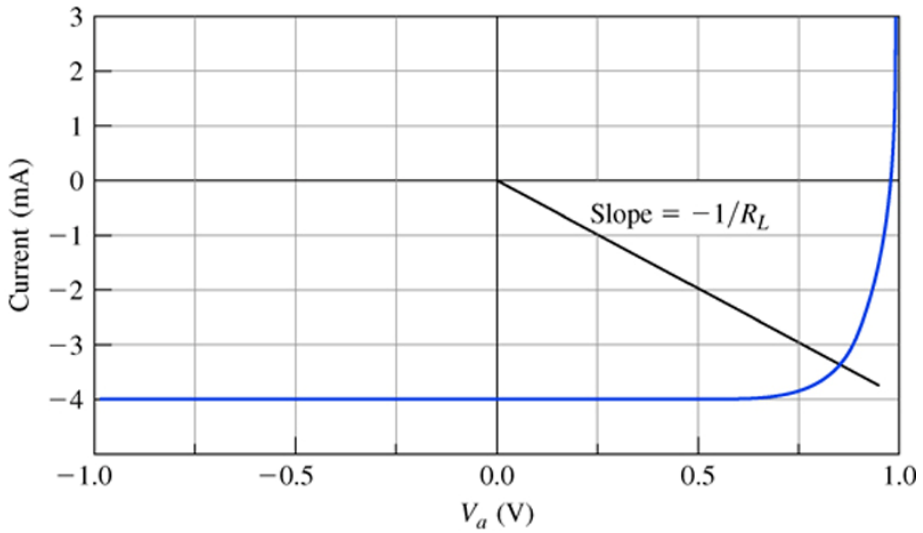

Figure 3.

(50 marks)

3. [a] Sketch a typical optical storage device structures and explain briefly the function of each layer.

(30 marks)

[b] Figure 4 shows a solar spectrum irradiance at air mass 0 and 1 (AM0 and AM1). 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] Which material in 4[b] will absorbs more of the total solar spectrum? Explain why.

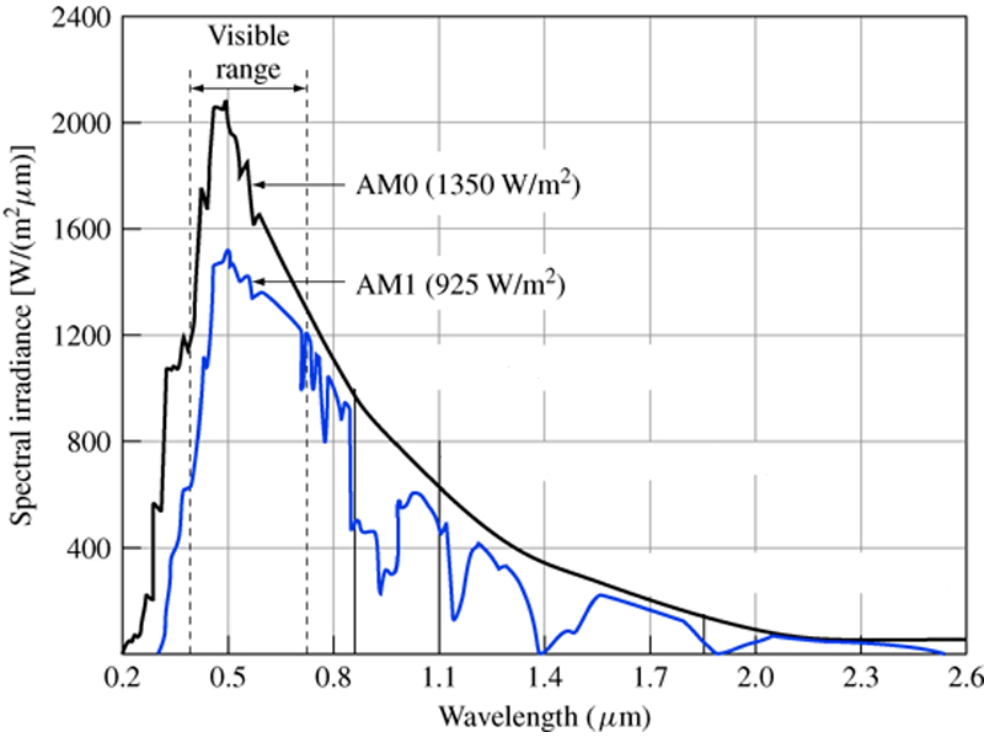

Figure 4.

(30 marks)

PART B

4. Providing enough safe drinking water has been a challenge in space exploration. In long-duration missions, there is a necessity to recycle water in order to assure conditions of self-sufficiency and sustainability. The inability of conventional treatment processes to decompose organic chemicals and inactivate pathogenic microorganisms in water resources has propelled the development of the use of advanced oxidation process utilizing a photocatalyst to clean recycle water. You are to design an APO photocatalysts reactor to be used in space shuttle for a long duration mission.

[a] Explain how a photocatalyst work to remove organic contaminants and microorganisms.

(30 marks)

[b] Decide on a material you wish to use to perform the treatment. State the reasons for your choice.

(30 marks)

[c] Describe how nanostructured materials would be more effective in the use as a photocatalysts.

(10 marks)

[d] By using a suitable illustration, explain how your reactor would look like. Indicate where the position of your nanostructured catalysts.

(30 marks)

5. In the formation of transmission cable to transfer electric current to a housing estate, a conductor and a superconductor could be used.

[a] State three differences in the mechanisms of conduction of a conductor like Cu to that of superconductor like Cuprate based oxide.

(30 marks)

[b] Discuss three advantages of the use of Cu wire as opposed to the cuprate based superconductor.

(30 marks)

[c] Design a typical superconductor cable utilizing the cuprate based oxide (coated conductor). Sketch your conductor to be used in the cable and Indicate why thin film technology is important in realizing your design.

(40 marks)

6. [a] P-type transparent oxides are semiconductors which could be coupled with a transparent n-type to form an all transparent p-n junction.

(i) Explain what happens at the junction when the p type material is placed on the n-type material.

(20 marks)

(ii) State one p-type material which is transparent. Explain the origin of the conductivity of this oxide.

(30 marks)

[b] A piezoelectric spark generator is used in various applications such as for car ignition.

(i) Explain how this spark generator operates.

(10 marks)

(ii) Lead Zirconate Titanate is an example of a piezoelectric material. Explain why leaded piezoelectric material is not desired. Suggest suitable alternative materials and explained how piezoelectric properties occur in these materials.

(40 marks)

PART C

7. [a] Explain why you can see into a store window and see your reflection at the same time, but at night looking out your window from a lighted room you can only see your reflection?

(25 marks)

[b] Consider the interface between a GaAs semiconductor and air. If the index of refractive for GaAs and air are 3.66 and 1.00, respectively, determine how many percents of the light incident from the GaAs-air interface are reflected back into air.

(25 marks)

[c] List down the important processing steps in a sub-micron fabrication technology.

(10 marks)

[d] Explain in detail the purposes of those processes listed in [c].

(40 marks)

- oooOooo -