UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2006/2007

October/November 2006

EBB 524/3 – Composite Materials

Time : 3 hours

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

This paper contains SEVEN questions.

Answer 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.

1. [a] Write a short note about the following polymer composites:

    (i) Particle reinforced composites.

    (ii) Fibre reinforced composites

    (iii) Structural composites.

(30 marks)

[b] Using a suitable diagram, discuss the differences between:

    (i) Pultrusion and filament winding.

    (ii) Hand lay-up and hand spray-up.

    (iii) Compression moulding and reinforced reaction injection moulding.

(40 marks)

[c] In a unidirectional carbon fibre/epoxy composites, the modular ratio is 40 and the fibres take up 50% of the cross-section. What percentage of the applied forced is taken by the fibres?

(30 marks)

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2. [a] (i) For a short fibre reinforced polymer composites, load transfer length, ℓ_{τ} is given by:

$$\ell_{\tau} = \frac{(\sigma_F)_{\max} d}{2\tau_y} \qquad \text{———————} \qquad (1)$$

Explain briefly the meaning of each term in the above equation.

(20 marks)

(ii) Short carbon fibres with a diameter of 10 μm are to be used to reinforced nylon 66. If the design stress for the composite is 400 MN/m^2 and the following data is available on the fibres and nylon, calculate the load transfer length for the fibres and also the critical length. The volume fraction of the fibres is to be 0.3.

	Modulus (GN/m^2)	Strength (GN/m^2)
Carbon fibres	230	2.9
Nylon 66	2.8	-

The interfacial shear strength for carbon/nylon may be taken as 4 MN/m^2.

(50 marks)

[b] Show that when a polymer is reinforced with uni-directional continuous aligned fibres at longitudinal direction, the following relationship can be obtained:

$$E_{cL} = E_f V_f + E_m V_m \qquad \text{———————} \qquad (2)$$

(30 marks)

3. [a] With the aid of appropriate diagrams, explain the principle toughening mechanisms in:

    (i) continuous fiber reinforced CMCs and

    (ii) ductile particle and fiber reinforced CMCs.

(60 marks)

[b] Explain the principle of CMC machining by using electro discharge machining (EDM).

(40 marks)

4. [a] Describe the fabrication of CMC, with the help of diagrams, using the following process:

    (i) Directed Oxidation or the Lanxide Processes

    (ii) Vapor Deposition Techniques

(60 marks)

[b] What is the definition of interface? Why interface region is crucial in determining the ultimate properties of CMCs?

(40 marks)

5. [a] Explain with aid of diagrams in full detail the interfacial bonding between the reinforcement and the matrix.

(50 marks)

[b] Boron is pre-deposited on SiC fibers with an initial concentration of $5x10^{15}$ atoms cm^{-3} in development of metal matrix composite. Conditions are 30 minutes at 1223 K and constant surface concentration of Boron at this temperature is Cs = $4.5x10^{20}$ atoms.cm^{-3} and diffusion coefficients = 1.6x 10^{-3} μm^2h^{-1}. Calculate (a) the amount of Boron deposited; b) the diffusion length; c) the concentration at the diffusion length. (d). After pre-deposition step SiC subjected to drive in at 1423 K for 2 h, D at this temperature = $1.6x10^{-1}$ μm^2h^{-1} calculate the junction depth. (e). The concentration on that depth. (f) The surface concentration.

(50 marks)

6. [a] Three-point bend specimens were produced from an aligned continuous tungsten fibers in metal matrix composite of 5 mm thickness. The dimensions of the specimens were 5x10x120 mm (sample A) and 5x 10x50 mm (sample B). The span between the lower loading points was 10mm less than the sample length. Account the failure mode and what is the value of failure stress for the following experimental observation.

(i) Specimen A failed by tensile fracture from a line midway between the lower loading points at a force of 2910 N.

(ii) Specimen B failed by shear at the mid plane at a force of 2670N

(50 marks)

[b] Discuss the Squeeze casting method in processing of metal matrix composite with aid of diagrams.

(50 marks)

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7. [a] Using a suitable diagram explain the differences between polymer microcomposites and polymer nanocomposites. What are the advantages and disadvantages using nanosize fillers in polymer composites.

(30 marks)

[b] Derive a mathematical equation to correlate the interfacial area of fiber and the fiber diameter in fiber reinforced CMCs.

(30 marks)

[c] State, giving your reason, which composite materials you would select for the following applications:

(i) A tie-rod carrying a tensile load for a room temperature transport application.

(ii) A tool to cut wood at high speeds.

(iii) A component to operate within a vacuum furnace at 2100°C.

(iv) A component of diesel engine which is subject to wear.

(40 marks)

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First Semester Examination
Academic Session of 2006/2007

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EBB 525/3 – Electronic Materials & Optical Devices

Time : 3 hours

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1. [a] Discuss the behavior of electron(s) in an atom and in a square well with the help of Schrödinger's equation and Bohr's model.

(30 marks)

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

(40 marks)

[c] Explain the challenges of using low dielectric constant material as the Inter-level Dielectric (ILD) in a deep-submicron CMOS structure.

(30 marks)

2. [a] How do electrons conduct in a conductor, semiconductor, and insulator at 0 K?

(30 marks)

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

(40 marks)

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

(30 marks)

3. [a] Briefly explain the solution of Schrödinger's equation based on the following cases. (i) Free electron, (ii) Electron in a potential well, (iii) Electron in a periodic field.

(40 marks)

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

(60 marks)

4. [a] In light-emitting diodes (LEDs), we need electrons and holes to recombine so that photon can be emitted. Explain why it is necessary to dope n-type dopant heavily to increase conduction?

(25 marks)

[b] Is there the energy gap, Eg of the optical materials corresponds to the refractive index?

(25 marks)

[c] How does a dielectric mirror differ from a standard mirror? Why a regular mirror cannot be used in the design of semiconductor lasers?

(25 marks)

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

(25 marks)

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

[a] Explain the reason why the 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 pn junction LED, as shown in Figure 1. (*A sketch might help*).

(50 marks)

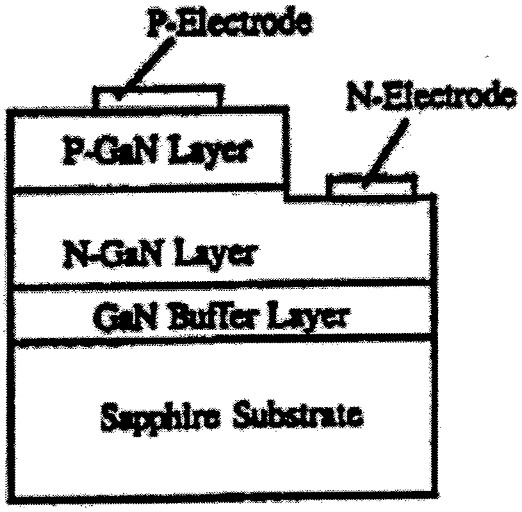

Figure 1: The structure of the GaN pn junction LEDs.

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 device. Assume that $h\nu = E_g$ and use the data given in Figures 2. *(Please don't use band gap data from other references!).*

(60 marks)

[b] Why are double heterostructure LED (DH-LED) devices more efficient if compared to a conventional pn junction LED?

(40 marks)

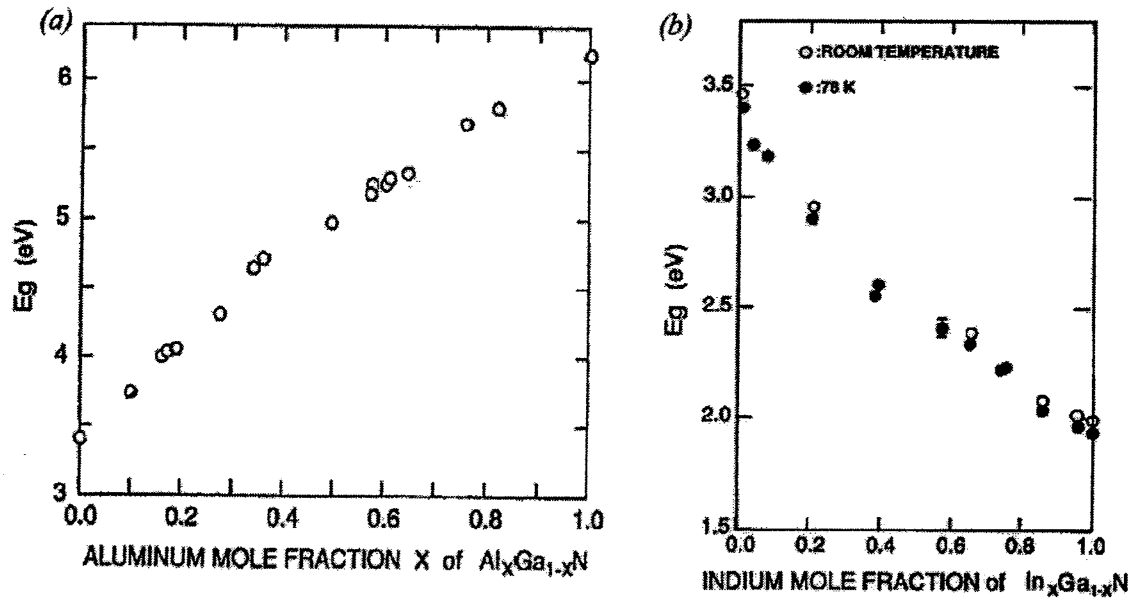

Figure 2: Composition dependence of the direct energy gap E_g of (a) $Al_xGa_{1-x}N$ alloys, and (b) $In_xGa_{1-x}N$ alloys.