UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2004/2005

October 2004

EBB 524 - Composite Materials

Time : 3 hours

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

This paper contains SEVEN questions.

Answer any 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 answered in English.

1. [a] Explain briefly the classification scheme for the various polymer composites.

(30 marks)

[b] How the fibre orientation and concentration influence the strength of fibre-reinforced polymer composites?

(30 marks)

[c] Discuss the differences between

(i) pultrusion and filament winding

(ii) compression moulding and reinforced reaction moulding (RRIM).

(40 marks)

2. [a] A continuous and aligned glass fibre-reinforced composite consists of 40 vol % of glass fibres having a modulus of elasticity of 69 GPa and 60 vol % of a polyester resin that, when hardened, displays a modulus of 3.4 GPa.

(i) Compute the modulus elasticity of this composite in the longitudinal direction.

(ii) If the cross-sectional area is 250 mm^2 and a stress of 50 MPa is applied in this longitudinal direction, compute the magnitude of the load, carried by each of the fibre and matrix phases.

(iii) Determine the strain that is sustained by each phase when the stress in part (b) is applied.

(60 marks)

[b] A reinforced plastic sheet is to be made from a matrix with a tensile strength of 60 MN/m^2 and continuous glass fibres with a modulus of 76 GN/m^2. If the resin ratio by volume is 70% and the modular ratio of the composite is 25, estimate the tensile strength and modulus of the composite.

(40 marks)

3. [a] What do you know about thermoplastic, elastomer and thermoset?

(30 marks)

[b] A metal carbide matrix composite is made with continues SiC fiber embedded in a metal carbide matrix [Fig 1]. (a) Calculate the elastic modulus of the composite under isostrain condition and (b) calculate the stress σ at which the cracks start to grow. Data are as follows:

Metal carbide matrix	SiC Fiber
E = 94GPa	E = 350 GPa
K_{1C} = 2.4 $MPa(m)^{1/2}$	K_{1C} = 4.8 $MPa(m)^{1/2}$
Largest preexisting flaw is 10 μm	Largest preexisting flaw is 10 μm

(35 marks)

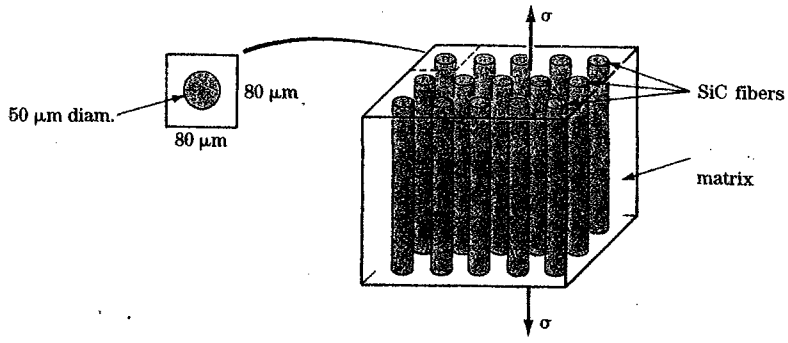

Figure 1

[c] Discuss the processing, properties and applications of SiC whisker reinforced alumina composites.

(35 marks)

4. [a] List and describe briefly with aid of diagrams the fabrication methods for MMCs materials.

(50 marks)

[b] A metal matrix composite is made from a boron (B) fiber reinforced aluminum alloy (Figure 2), to form the boron fiber, a tungsten (W) wire (r=10μm) is coated with boron, giving a final radius of 75μm. The aluminum alloy is then bonded around the boron fibers, given a volume faction of 0.65 for the aluminum alloy. Assuming that the rule of binary mixtures applies also to ternary mixtures, calculate the effective tensile elastic of the composite material under isostrain conditions. Data: E_W = 410 GPa, E_B = 379 GPa and E_{AL} = 68.9 GPa

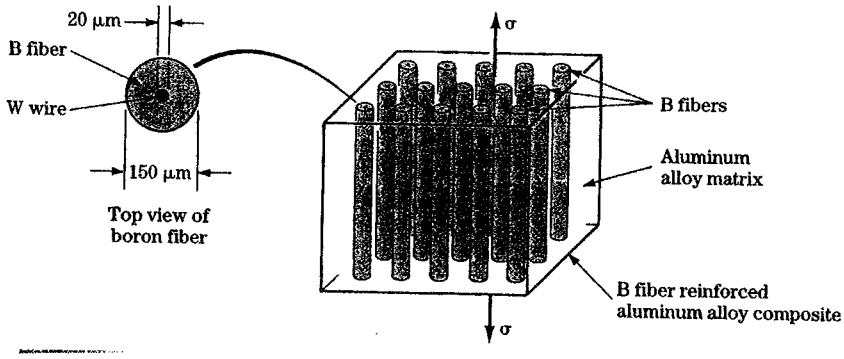

Figure 2

(50 marks)

5. [a] Indicate whether statements 1 to 12 are true or false.

1. Materials property charts always have Young's modulus for one of the axes.
2. The properties of a composite are essentially isotropic when the reinforcement is randomly orientated, equiaxed particles.
3. A laminate is an example of a particle reinforced composite.
4. The main objective in reinforcing a metal is to lower the Young's modulus.
5. A hybrid has a mixed metal and ceramic matrix reinforced with polymer fibres.
6. The performance indicator $E^{1/2}/p$ is applicable when considering the possibility of buckling under the action of a compressive force.
7. The most widely used composites are metal matrix composites.
8. Usually the matrix has a lower Young's modulus than the reinforcement.
9. The superconducting properties of a multifilamentary superconductor are determined by the Nb_3 Sn layer thickness and grain size.
10. Although MMC has higher room temperature strength than the matrix the converse is true at elevated temperatures.
11. The electrical conductivity of an MMC is usually less than that of the matrix.
12. In the squeeze casting process molten metal is forced by mechanical pressure into a perform.
13. Powder metallurgy is commonly employed for the fabrication of MMCs, but only if the reinforcement is continuous fiber.

(40 marks)

5. [b] For each of the statements of questions 1 to 11, one or more of the completions given are correct. Mark the correct completions.

1. The creep curve of a metal reinforced with continuous ceramic fibres
   (A) asymptopically approaches a zero creep rate,
   (B) exhibits a marked monotonically increasing tertiary creep regime,
   (C) is a classical three-stage creep curve,
   (D) is identical to that of a continuous in situ composite,
   (E) is a consequence of significant creep of the ceramic fibres.

2. The transverse tensile strength of an aligned continuous fibre composite
   (A) is obtained when testing normal to the fibre axis,
   (B) is obtained when testing parallel to the fibre axis,
   (C) is the lowest tensile strength,
   (D) is the highest tensile strength,
   (E) depends mainly on the properties of the matrix and of the fibre matrix interface,

3. The Young's modulus of an aligned continuous fibre metal matrix composite
   (A) increases with increasing volume fraction of fibre,
   (B) is independent of volume fraction of fibre,
   (C) is the same in the longitudinal and transverse directions,
   (D) is greater in the longitudinal direction,
   (E) is greater in the transverse direction.

4. In situ MMCs

(A) are produced by squeeze casting,

(B) are produced by unidirectional solidification,

(C) are produced by spray co-deposition,

(D) have an aligned microstructure,

(E) usually have a two-phase eutectic microstructure.

5. Rheocasting

(A) is a solid state technique,

(B) can only be employed for in situ composites,

(C) involves mixing the reinforcement with solid-liquid metal,

(D) is a modification of melt stirring,

(E) involves applying a mechanical pressure during casting.

6. The matrix

(A) is always fibrous,

(B) transfers the load to the reinforcement,

(C) separates and protects the surface of the reinforcement,

(D) is usually stronger than the reinforcement,

(E) is never a ceramic.

7. The specific modulus

(A) is given by l/E where E is Young's modulus,

(B) is given by $E\rho$ where ρ is density,

(C) is given by E/ρ,

(D) is generally low for polymer matrix composites,

(E) is generally low for metallic materials.

8. Hybrids

(A) are composites with two matrix materials,

(B) are composites with mixed fibres,

(C) always have a metallic constituent,

(D) are also known as bidirectional woven

(E) are usually multilayered composites.

9. Metal matrix composites usually

(A) have a heavy metal for the matrix,

(B) have a poorer ductility than the matrix,

(C) retain their strength to higher temperatures than the matrix,

(D) have a lower Young's modulus than the matrix,

(E) are reinforced by polymer fibres.

10. Stress on composite

(A) is the total load on a component,

(B) is a normalized measure of load,

(C) arises only from the application of a couple,

(D) always exists as two components at right angles,

(E) has units of force/length.

11. Strain

(A) is an alternative term for displacement,

(B) has units of 1/length,

(C) is a non-dimensional measure of deformation,

(D) is caused by the application of a stress,

(E) can be related to curvature of a bent beam.

(60 marks)

6. [a] Give your comment on the following sentence. Thermal stresses due to coefficient of expansion differences between the matrix and the reinforcement are important in ceramic matrix composites.

(40 marks)

[b] Consider a fiber reinforced composite, explain and derive the correlation between the area of the fiber/matrix interface, l_A, and the fiber diameter (d).

(30 marks)

[c] With the aid of diagram (s), write a short note on the fiber reinforced ceramic matrix composites.

(30 marks)

7. [a] With the aid of diagram (s), describe the processing and structure of glasses and glass-ceramics materials.

(35 marks)

[b] List the processing techniques of ceramic matrix composites? Describe the sol-gel processing in ceramic matrix composites.

(30 marks)

[c] Describe the applications of ceramic matrix composite in aerospace area. Explain one example of ceramic matrix composite system which is used in aerospace applications.

(35 marks)

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