UNIVERSITI SAINS MALAYSIA

KSCP Examination
Academic Session 2006/2007

June 2007

EBB 524/3 - Composite Materials

Time : 3 hours

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

This paper contains SEVEN questions.

Answer any FIVE questions. If a candidate answers more than five questions, only the first five answers 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] Discuss various forming processes which can be used to manufacture polymer composite.

(50 marks)

[b] By referring to specific examples, discuss how the interface interaction between filler/fibre and polymer matrix can be enhanced.

(50 marks)

2. [a] By considering a polymer composite with uni-directional continuous aligned fibres at longitudinal and transverse direction, show that the resultant modulus is:

$$E_{cL} = E_f V_f + E_m V_m \quad \text{and}$$
$$E_{cT} = E_f E_m / (V_f E_m + V_m E_f)$$

(50 marks)

[b] In a unidirections Kevlar/epoxy composite the modular ratio is 20 and the epoxy occupies 60% of the volume. Calculate the modulus of the composite and the stresses in the fibres and the matrix when a stress of 50 MN/m^2 is applied to the composite. The modulus of the epoxy is 6 GN/m^2.

(50 marks)

3. [a] There are 4 type polymeric materials which can be used in polymer composite, i.e.:

(i) Rubber

(ii) Thermoplastic

(iii) Elastomer thermoplastic

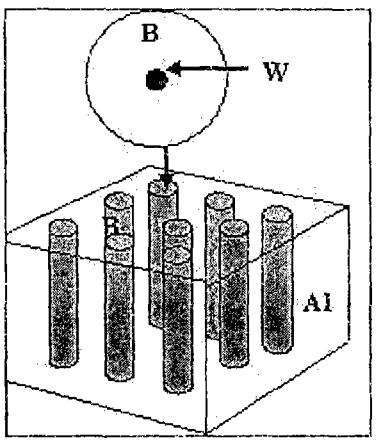
(iv) Thermoset

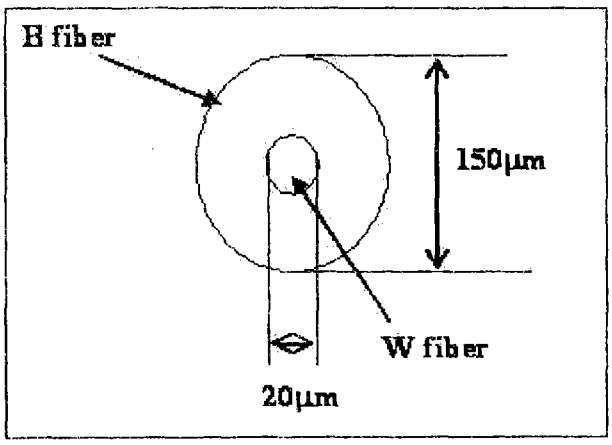
By selecting on example for each polymeric material, discuss how they can be used to produce polymer composite.

(30 marks)

[b] A metal matrix composite is made from a boron (B) fiber reinforced aluminum alloy. To form the boron fiber, a tungsten (W) wire (r = 10um) is coated with boron, giving a final radius of 75 um. The aluminum alloy is then bonded a round the boron fiber, giving a volume fraction of 0.65 for the aluminum alloy. Assuming that rule of mixture is applied also to ternary mixture, calculate the effective tensile elastic modulus of the composite material under isostrain contions. Data E_w = 410 GPa; E_B = 379 GPa; E_{Al} = 68.9 GPa.

(40 marks)





[c] Discuss why interface region is crucial in determining the ultimate properties of CMCs?

(30 marks)

4. [a] Describe the fabrication of continuous fiber reinforced glass composite via slurry infiltration method. Give the advantage and disadvantage of this process.

(40 marks)

[b] List down the advantages and disadvantages of ceramic matric composite processing via directed oxidation and chemical vapor infiltration techniques.

(30 marks)

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

(30 marks)

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

(40 marks)

[b] Describe crack bowing and crack deflection mechanisms in ceramic materials. The principle of ceramic toughening based on the following mechanisms:

(60 marks)

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

1. 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

2. 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

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 transerve directions
(D) is greater in the longitudinal direction
(E) is greater in the transverse direction

4. 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 slength
(D) is the highest, tensile strength
(E) depends mainly on the properties of the matrix and of the fibrematrix interface
(F) depends mainly on the properties of the fibres

5. 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

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. Bone

(A) is a natural composite
(B) consists of spirally wound cellulose fibres
(C) contains hydroxyapatite
(D) contains inorganic crystals
(E) contains the organic fibre, collagen

8. The specific modulus

(A) is given by I/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

9. 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 composites
(E) are usually multilayered composites

10. Micrograph

(A) Multi phase material
(B) Single phase material
(C) Continuous fiber composite
(D) Cross-ply composite

11. 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

(50 marks)

[b] Indicate whether statements 1 to 13 are true or false.

1. Usually the matrix has a lower Young's modulus than the reinforcement.

(A) True (B) False

2. The most widely used composites are metal matrix composites.

(A) True (B) False

3. The performance indicator $E^{½}/\rho$ is applicable when considering the possibility of buckling under the action of a compressive force.

(A) True (B) False

4. A hybrid has a mixed metal and ceramic matrix reinforced with polymer.

(A) True (B) False

5. The main objective in reinforcing a metal is to lower the Young's modulus.

(A) True (B) False

6. A laminate is an example of a particle reinforced composite.

(A) True (B) False

7. The properties of a composite are essentially isotropic when the reinforcement is randomly orientated, equiaxed particles.

(A) True (B) False

8. Materials property charts always have Young's modulus for one of the axes.

(A) True (B) False

9. Powder metallurgy is commonly employed for the fabrication of MMCs, but only if the reinforcement is continuous fibre.

(A) True (B) False

10. In the squeeze casting process molten metal is forced by mechanical pressure into a perform.

(A) True (B) False

11. The electrical conductivity of an MMC is usually less than that of the matrix.

(A) True (B) False

12. Although an MMC has a higher room temperature strength than the matrix the converse is true at elevated temperatures.

(A) True (B) False

13. The superconducting properties of a multifilamentary superconductor are determined by the Nb_3 Sn layer thickness and grain size.

(A) True (B) False

(50 marks)

7. Explain in full detail with aid of diagrams the metal matrix composite processing techniques.

(100 marks)

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