Tutorial 7&8 – Week 8

Aims:

Upon successfully completing these tutorial exercises, students should be able to:

- Demonstrate an understanding of composite materials including their mechanical properties and how they relate to physical structure
- Perform calculations related to mechanical properties of composite materials

Exercise 7.1 Carbon fibre reinforced polymer (CFRP)

A continuous and aligned carbon fibre reinforced polymer (CFRP) composite consists of **60 vol%** carbon fibres having a modulus of elasticity of **265 GPa** and **40 vol%** polyester resin that, when hardened, has an elastic modulus of **3.8 GPa**.

(a) Calculate the modulus of elasticity of this composite where loading is applied in the longitudinal direction of the fibres
(b) If a component with cross sectional area **180 mm^2** is subjected to a normal tensile stress of **90 MPa** in the longitudinal direction of the fibres, determine the force carried by each of the fibre and matrix phases
(c) Calculate the strain sustained by each phase under the loading described in part (b)

Theory

Elastic Modulus of aligned composite loaded longitudinally:

$$E_{comp,long} = E_{matrix}V_{matrix} + E_{fibre}V_{fibre}$$

Distribution of load in aligned composite loaded longitudinally:

$$\frac{F_{fibre}}{F_{matrix}} = \frac{E_{fibre}V_{fibre}}{E_{matrix}V_{matrix}}$$

Strains (Hooke's Law)

$$\varepsilon_{fibre} = \frac{\sigma_{fibre}}{E_{fibre}}$$

$$\varepsilon_{matrix} = \frac{\sigma_{matrix}}{E_{matrix}}$$

Area fractions

$$A_{fibre} = V_{fibre}A$$

$$A_{matrix} = V_{matrix}A$$

Exercise 7.2 Carbon fibre reinforced polymer (CFRP)

How would the elastic modulus of the CFRP calculated in Exercise 1 differ if the loading was not applied along the longitudinal axis of the fibres? How would it differ if the fibres were randomly oriented in the polyester matrix?

Exercise 7.3 Ceramics

a) What are ceramics

Ceramics

Ceramics generally can withstand very high temperatures such as temperatures that range from [ ] °C to [ ] °C

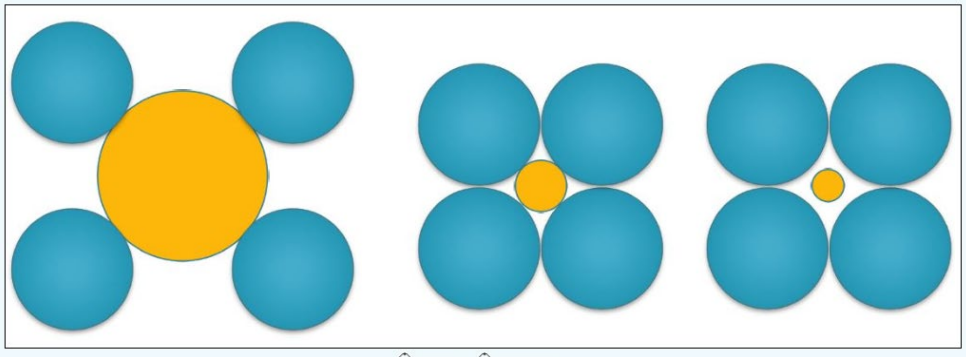
2000 | 1000

1600 | 2500

b) Match the ionic crystal structure's stability. Pauling's rules for ionic crystals

Ceramics

Match the ionic crystal structure's stability

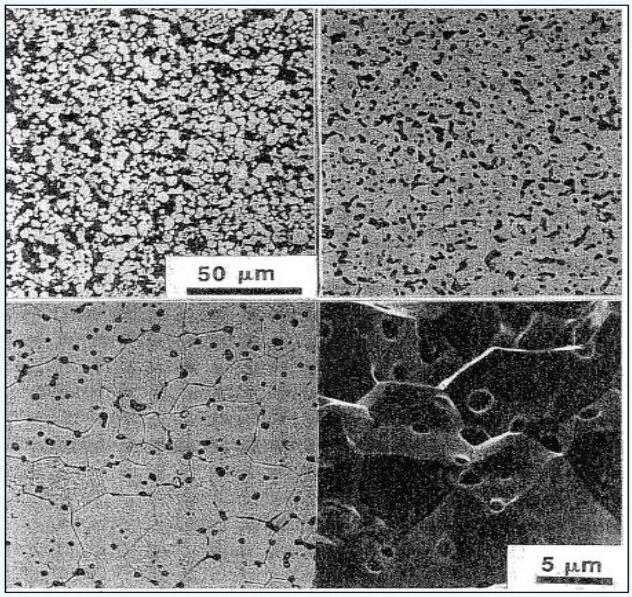


Stable | Unstable

c) Stages of solid state sintering

Ceramics

Match the correct stage in Solid State Sintering in the image shown



Intermediate | Fracture | Initial | Final