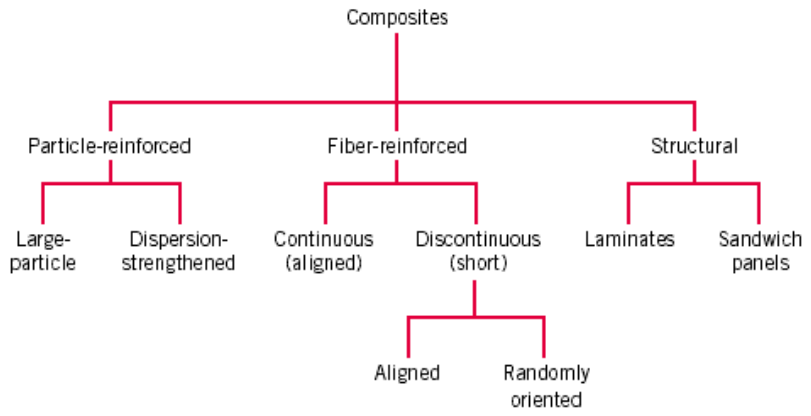
Chapter 16 Composites

- Basic concepts
- Particle-reinforced composites
- Fiber-reinforced composites
- Structural composites

Basic concepts

- Composite
  - a multiphase material with significant proportions of each phase
  - made artificially
- Matrix
  - continuous phase that surrounds the dispersed phase
- Dispersed phase
  - non-continuous

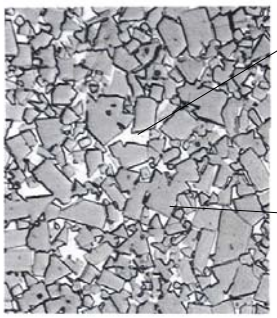
Composite classification



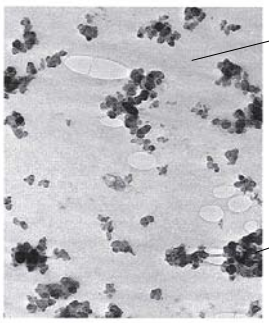
Particle-reinforced composites

- Dispersed phase: large size of particles
- Improve strength by reinforcement action
- Examples

WC-Co cemented carbide

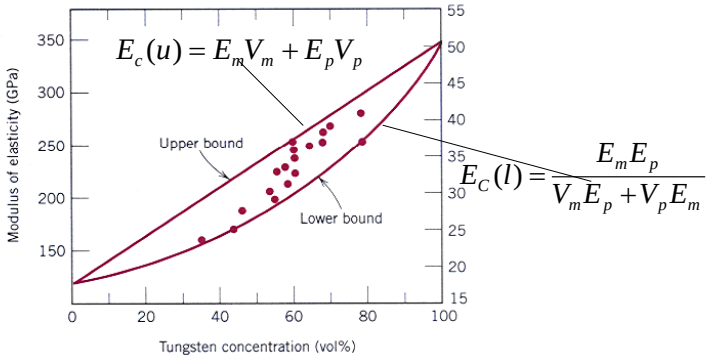


Carbon black particles in rubber



Particle-reinforced: elastic modulus

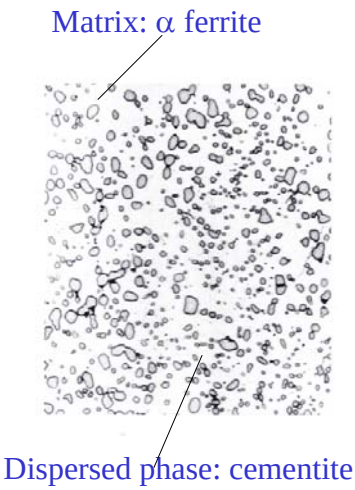
- Elastic modulus depends on volume fractions Vp and Vm



Copper matrix/dispersed tungsten

Dispersion-strengthened composites

- Improve strength by extremely small particles of the dispersed phase



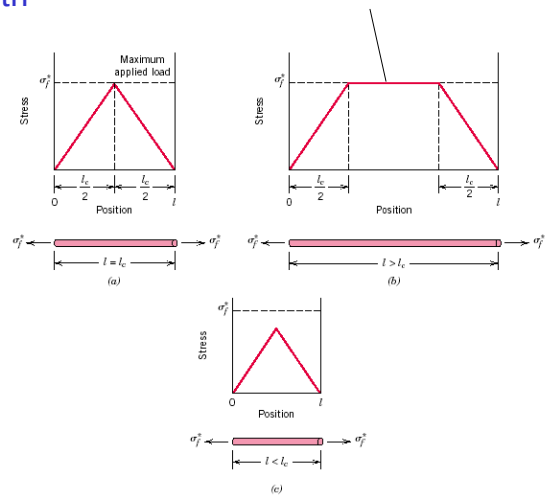
Fiber-reinforced composites

- Influence of fiber length
  - Critical fiber length

Ultimate strength

$$l_c = \frac{\sigma_f d}{2\tau_c}$$

Fiber-matrix bond strength



Fiber-reinforced composites (continue)

- Critical fiber length for effective stiffening & strengthening:

fiber strength in tension

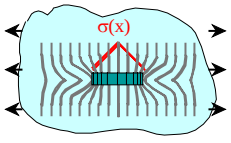
$$\text{fiber length} > 15\,\frac{\sigma_f d}{\tau_c}$$

fiber diameter

shear strength of fiber-matrix interface

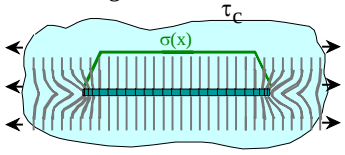
- Shorter, thicker fiber:

$$\text{fiber length} < 15\,\frac{\sigma_f d}{\tau_c}$$



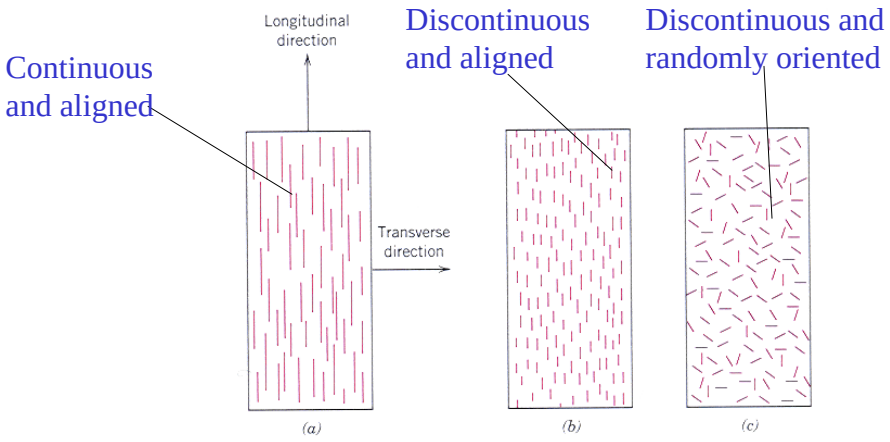
- Longer, thinner fiber:

$$\text{fiber length} > 15\,\frac{\sigma_f d}{\tau_c}$$



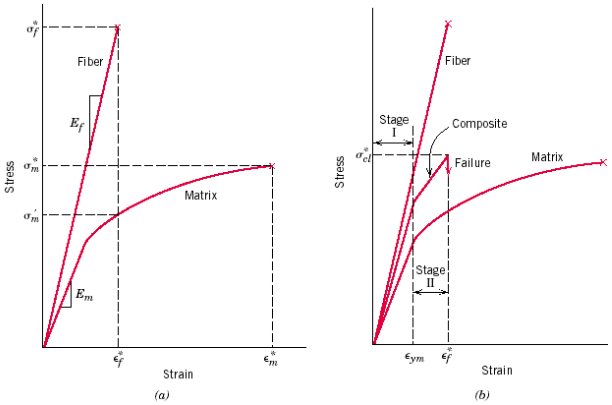
Fiber-reinforced composites (continue)

- Fiber orientation and concentration



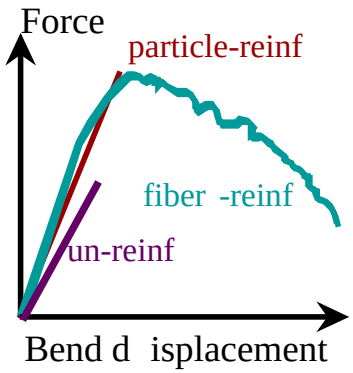
Fiber-reinforced composites (continue)

- Stress-strain relation for brittle fiber and ductile matrix
- Elastic modular in longitudinal
- Elastic modular for transverse loading



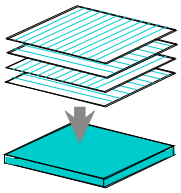
Fiber-reinforced composites (continue)

- Ceramic metal composites: Increased toughness

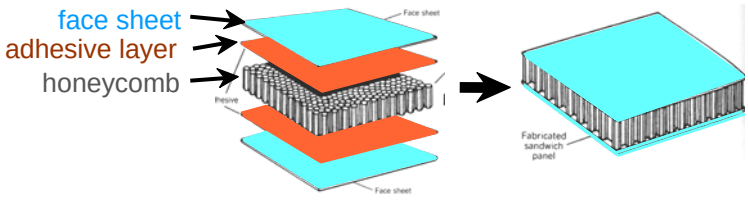


Structural composites

- Stacked and bonded fiber-reinforced sheets



- Sandwich panels



Summary

- Composites are classified according to:
  -- the matrix material (CMC, MMC, PMC)

- Particulate-reinforced:
  -- Elastic modulus can be estimated.

- Fiber-reinforced:
  -- Elastic modulus and TS can be estimated along fiber dir.

- Structural:
  -- Based on build-up of sandwiches in layered form.