

Lecture 2



Materials for Engineering



- Types
 - Metals
 - Ceramics and glasses
 - Polymers
 - Composites
 - Semi-conductors
- Selection of materials

Selection of Materials - Metals



- High Moduli
- Strong if alloyed
- Ductile
 - Partly results in fatigue sensitivities
 - Formability
- Subject to corrosion

Ceramics



- High Moduli
- Brittle ---
 - 15 times the strength in crushing than tension
 - Sensitive to stress concentrations (hole)/contact stress
- Strength depends on size of sample -- argg
- Stiff, hard, abrasion resistant and resist corrosion
 - only game at very high temperatures

Polymers and Elastomers



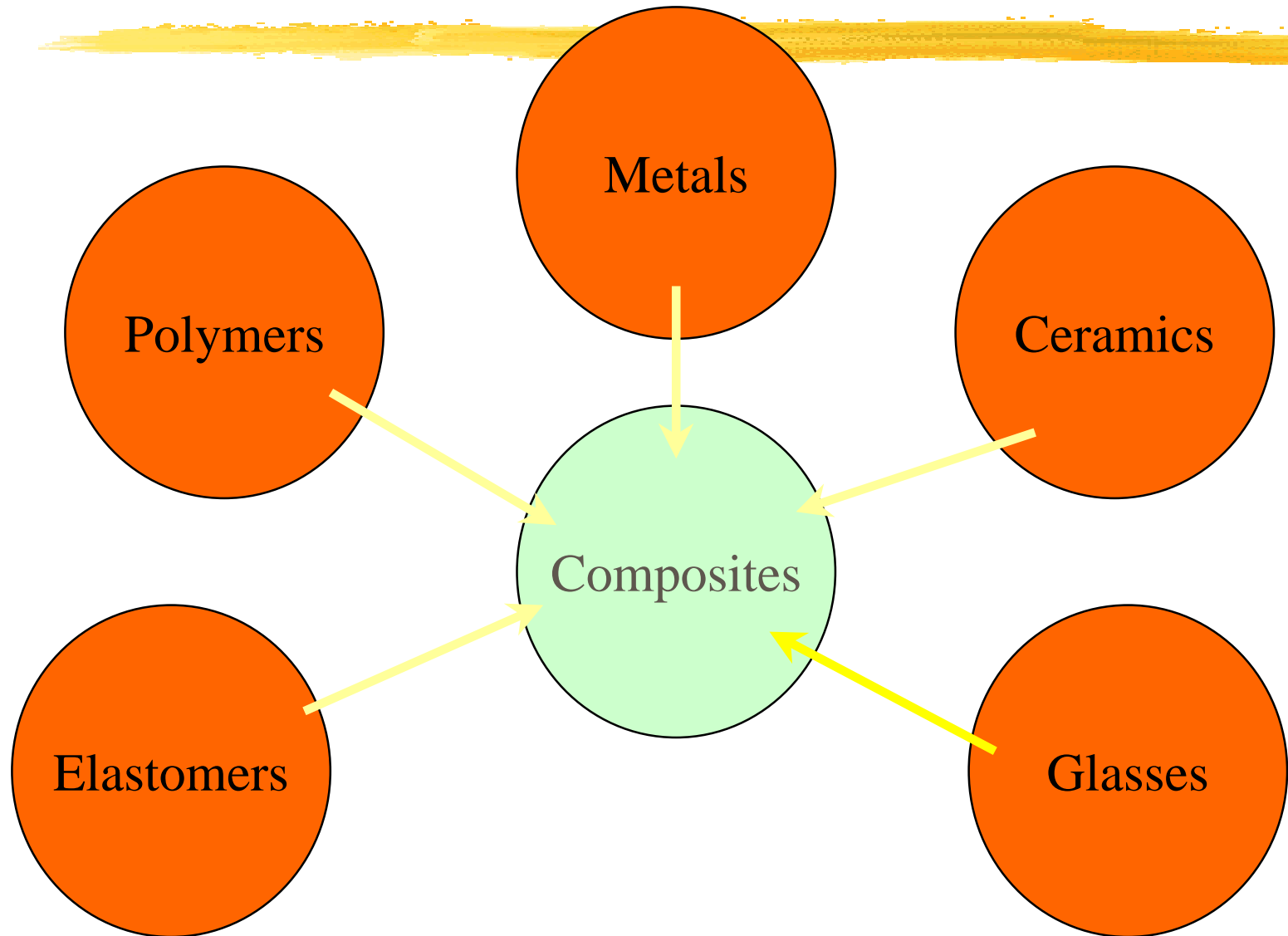
- Low moduli (1/50 x metals)
- Strength ~ metals
- Creep - even at room temp (car tires)
- Properties are temperature dependent
- Strength per unit weight -- impressive
- Easy to form (near net shape)
- Corrosion resistant -- low frictional coef.

Composites



- Combine properties of other classes of materials
- Usually polymer matrix
 - Epoxy or polyester
- Reinforced by fibers
 - glass, carbon or Kevlar
- Matrix limits operational temp

Engineered Materials



Properties we care about



- Mechanical
 - Strength
 - Ductility
 - Toughness
 - Hardness
- Thermal
- Electrical

Properties we care about (cont.)



- Optical
- Magnetic
- Chemical
- Melting point (glass transition)

Properties are determined by



- Microstructure
- Crystal structure
- Atomic structure and bonding

STRUCTURE



- Microscopic structural features which can be observed using optical or electron microscope -- dimensions $>$ nm
- Atomic level
Arrangement of individual atoms, ions or molecules
 - Crystalline -- regular repeating
 - Non-crystalline

Crystal Structure



The crystal structure of a material is determined by the types of bonding between the atoms and hence the actual atomic structure

Material Properties for Design

- General
 - Cost
 - Density
- Thermal
 - Conductivity
 - Melting point
 - Thermal Expansion Coef
 - Glass transition
- Wear
- Corrosion/Oxidation
- Mechanical
 - Elastic moduli
 - Young's
 - Shear
 - Bulk
 - Toughness
 - Fracture Toughness
 - Strength
 - Yield
 - Ultimate
 - Fracture
 - Damping
 - Fatigue endurance limit

Picking a class of materials



- A ladder -- for use at home in removing ice dams
 - Function
 - Objective
 - Constraints