Materials Science

Introduction

- **Materials Science:**
  - Involves investigating the relationship that exist between the structure and properties of materials. By structure we mean the arrangement of its internal components
- **Materials Engineering:**
  - On the basis of structure-property correlations, involves designing or engineering the structure of material to produce a predetermined set of properties

- Property is a material trait in terms of the type and magnitude of response to a specific imposed stimulus. The property of a material is independent of its shape and size
- There are six categories of material properties:

1. **Mechanical properties**

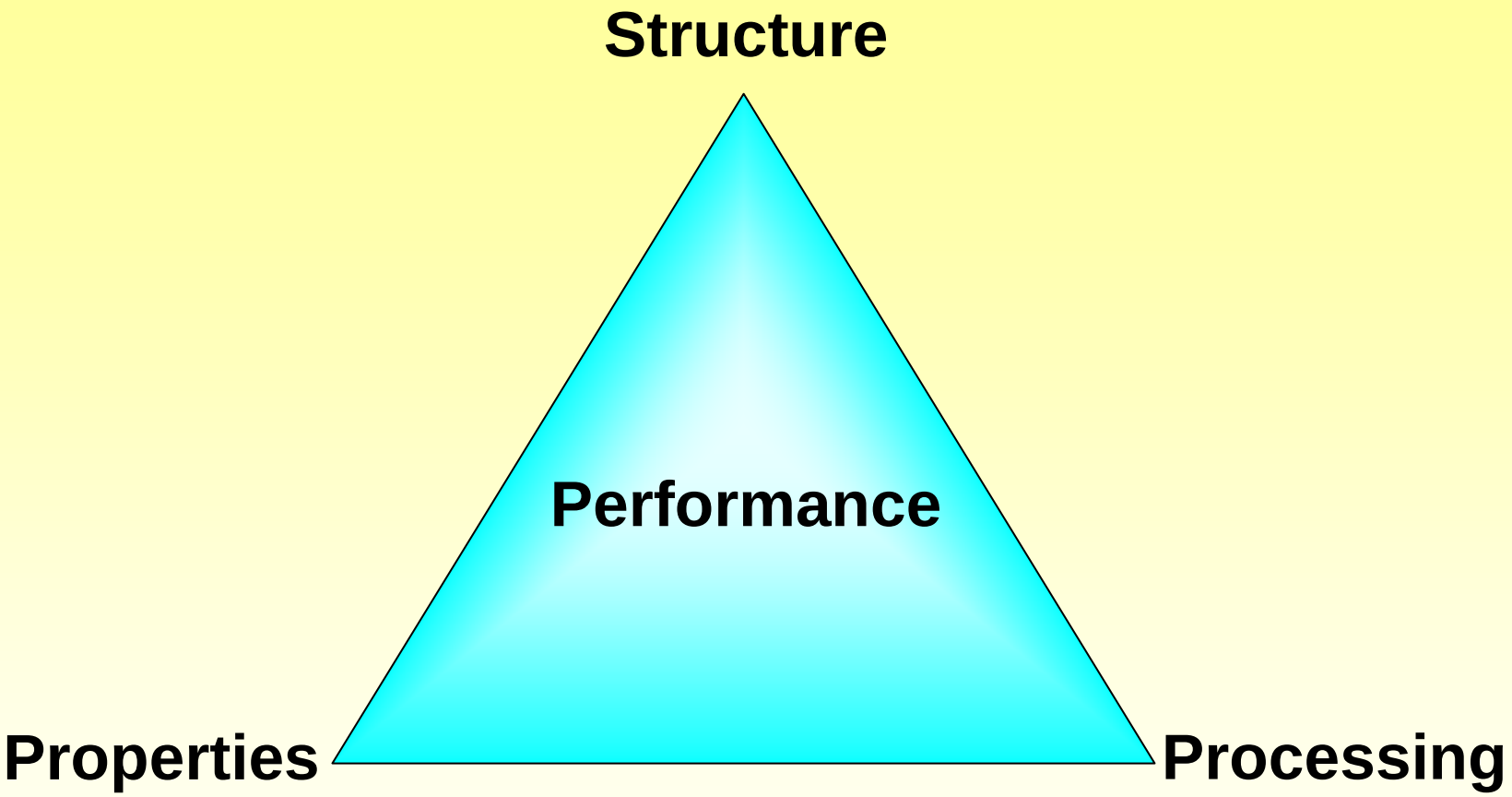
2. **Electrical properties**

3. **Thermal properties**

4. **Magnetic properties**

5. **Optical properties**

6. **Deteriorative properties**



Interrelation between four components of Materials Science

- Why study Materials Science?
  - Engineers, whether mechanical, civil, or electrical will at one time or another be exposed to a design problem involving materials. Examples, gear building, oil refinery component, or an integrated circuit chip.
  - **Adequate knowledge in materials and allows an engineer to properly select the best material for a given design or application.**

- **Chapters Covered**
  - Introduction
  - Atomic Structures and Bonding
  - Crystalline Structures
  - Defects in Solids
  - Mechanical Properties
  - Material Failure
  - Phase Diagrams
  - Engineering Alloys
  - Polymers
  - Corrosion
  - Non Destructive Testing

- Basic Classifications of Materials:
  - Classification are mostly based on chemical makeup and atomic structure
    1. **Metal**
    2. **Ceramic**
    3. **Polymer**

- Additional Classifications of Materials:
  1. **Composites**
  2. **Advanced materials**

- **Metals**
  - Composed of one or more metallic elements, and often non-metallic elements in small amounts.
  - Atoms are arranged in more orderly manner.
  - Posses good stiffness, strength and fracture resistance.
  - Lustrous appearance.
  - Not transparent to visible light.
  - Higher density compared to polymers and ceramics.

- Superior electrical and thermal conductivity.
- Lacks corrosion resistance.
- High melting point.
- Some metals are magnetic.

- **Some Application of Metals**
  - Electrical wiring
  - Building and bridge structures
  - Automobile: body, chassis, engine block, springs
  - Air planes: engines, fuselage, landing gear
  - Trains: rails, engine body, wheels
  - Industrial machinery
  - Machining tools: drills, hammers, saw blade
  - Magnets

- **Ceramics**
  - Compounds of metallic and non metallic elements.
  - **Engineering ceramics** are mostly oxides, nitrides and carbides e.g. aluminium oxide, silicon dioxide, silicon carbide, silicon nitride.
  - **Traditional ceramics** include clay, cement and glass.
  - Stiffness and strengths that are comparable to metals.

- Hard and brittle and very susceptible to fracture.
- There are ceramics which are transparent, translucent and opaque.
- Low electrical conductivity.
- Good resistance to high temperatures.
- Good corrosion resistance.
- Some are magnetic.
- Lower density than metals.

- Some Application of Ceramics
  - Electrical insulators
  - Thermal insulation and coating
  - Abrasives
  - Glasses: windows, TV screens, optical fiber
  - Cement, concrete
  - Ceramic tiles
  - Furnace lining bricks

- Polymers
  - Organic compounds that are chemically based on carbon , hydrogen and other non-metallic elements.
  - They have large molecular structures, often chain like.
  - Common polymers include polyethylene, nylon, polyvinyl chloride, polycarbonate and polystyrene.
  - Lower density than metals and ceramics.
  - Lacks stiffness and strength.
  - Extremely ductile

- Good corrosion resistance.
- Lower melting point – easily softens or decomposes.
- Low electrical conductivities.
- Not magnetic.
- Some polymers are transparent but most are opaque.

- **Some Applications of Polymers**
  - Adhesive and glue
  - Plastic products
  - Coating and paints
  - Solid lubricants: Teflon
  - Sealing: gasket, o-rings, liquid seals
  - Clothing and furniture covering

- **Composites**
  - Composed of two or more individual materials i.e. metal, ceramic or polymer.
  - Designed to achieve a combination of properties not possessed by a single material.
  - Some naturally occurring composites include wood and bone.
  - Common composite includes fibreglass (small glass fibres embedded within polymeric material)

- The glass fibres are relatively strong, stiff and brittle but the polymer is ductile, weak and flexible. Thus the composite of the two is a relatively stiff, strong, flexible and ductile fibreglass.

- Some Application of Composites
  - Aerospace, Marine, Automotive
  - Sporting goods
  - Storage tanks
  - Coating
  - Piping for oil, seawater, sewage

- **Advanced Materials**
  - Materials that are utilized in high-technology applications are sometimes termed advanced materials.
  - High technology: a device or product that operates using relatively complex and sophisticated principles. E.g. electronic equipment (VCRs, CD players, etc.), computers, fiberoptic systems, spacecraft, aircraft, and military rocketry.

- Typically traditional materials whose properties have been enhanced *OR* newly developed, high-performance materials.
- They may be of all material types (e.g., metals, ceramics, polymers).
- Normally relatively expensive.

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