Module 1

Introduction to Engineering Materials

Introduction

1960's → Engineering Materials → Metals

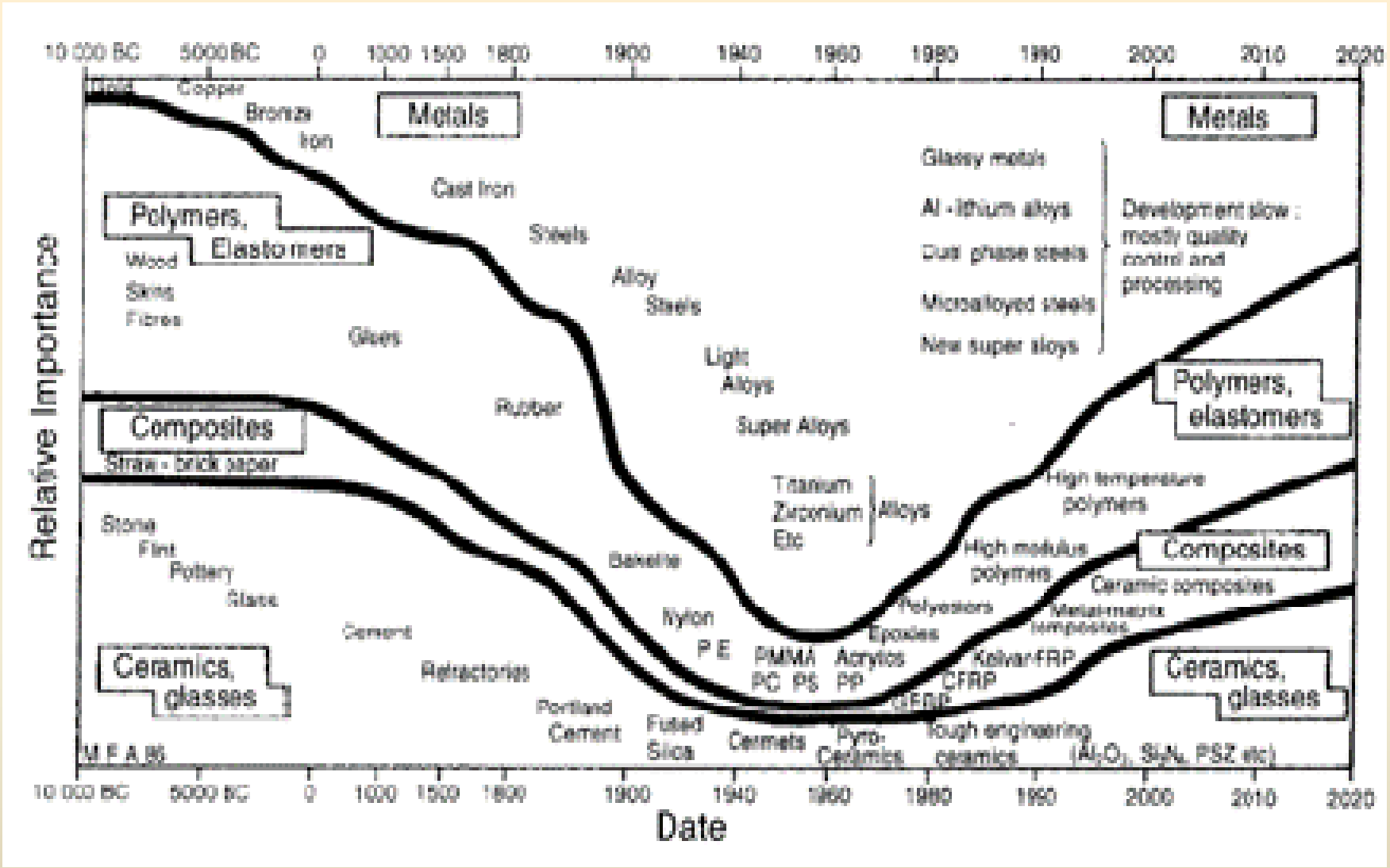
Design → Choice of Material

New Materials → New Products

Number of Materials → 40 – 80,000!

Definition

Engineering materials are that part of inanimate matter, which are useful to the engineer in the practice of his profession



Evolution of Engineering Materials

Classification

It is the systematic arrangement or division of materials into groups on the basis of some common characteristic

1. According to General Properties

2. According to Nature of Materials

3. According to Applications

1. According to General Properties

(a). Metals **(*e.g.* iron, aluminium, copper, zinc, lead, etc)**

Iron as the base metal, and range from plain carbon (> 98 % Fe) to

(i). Ferrous: **high alloy steel (< 50 % alloying elements), e.g. cast iron, wrought iron, steel, alloys like high-speed steel, spring steel, etc**

(ii). Non-Ferrous: **Rest of the all other metals and their alloys, e.g. copper, aluminium, zinc lead, alloys like brass, bronze, duralumin, etc**

(b). Non-Metals **(e.g. leather, rubber, asbestos, plastics, etc)**

2. According to Nature of Materials

(a). Metals: **e.g. Iron & Steel, Alloys & Superalloys, Intermetallic Compounds, etc**

(b). Ceramics: **e.g. Structural Ceramics (high-temperature load bearing), Refractories (corrosion-resistant, insulating), Whitewares (porcelains), Glass, Electrical Ceramics (capacitors, insulators, transducers), Chemically Bonded Ceramics (cement & concrete)**

(c).Polymers: **e.g. Plastics, Liquid Crystals, Adhesives**

(d). Electronic Materials: **e.g. Silicon, Germanium, Photonic materials (solid-state lasers, LEDs)**

(e). Composites: **e.g. Particulate composites (small particles embedded in a different material), Laminate composites (golf club shafts, tennis rackets), Fiber reinforced composites (fiberglass)**

(f). Biomaterials: e.g. Man-made proteins (artificial bacterium), Biosensors, etc

(g). Advanced / Smart Materials: **e.g. materials in computers (VCRs, CD Players, etc), fibreoptic systems, spacecrafts, aircrafts, rockets, shape-memory alloys, piezoelectric ceramics, magnetostrictive materials, optical fibres, microelectromechanical (MEMs) devices, electrorheological / magnetorheological fluids, Nanomaterials, etc**

3. According to Applications

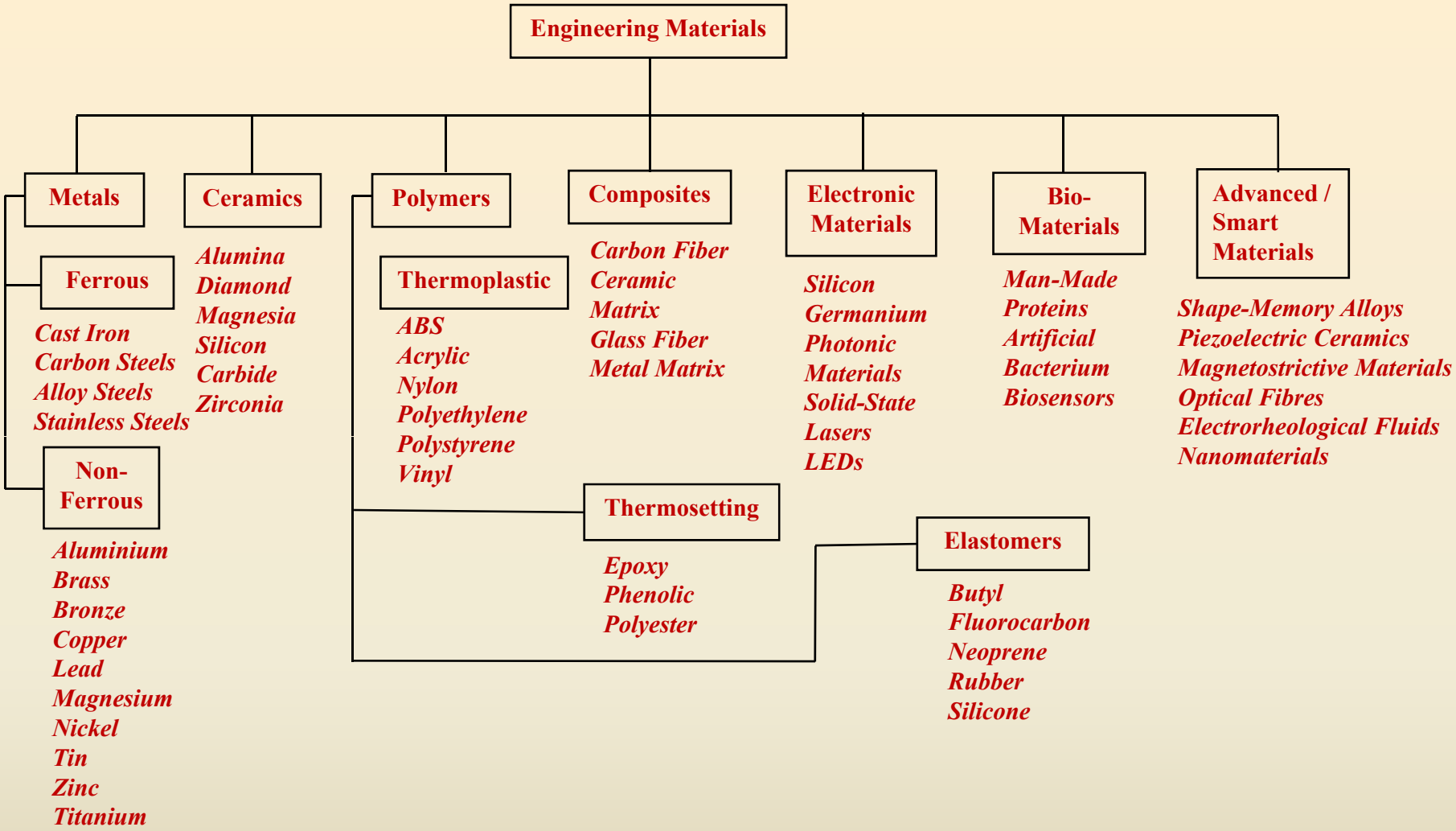
(a). Electrical Materials: **e.g. conductors, insulators, dielectrics, etc**

(b). Electronic Materials: **e.g. conductors, semi-conductors, etc**

(c). Magnetic Materials: **e.g. ferromagnetic, paramagnetic & diamagnetic materials, etc**

(d). Optical Materials: **e.g. glass, quartz, etc**

(e). Bio Materials: **e.g. man-made proteins, artificial bacterium**



Classification of Engineering Materials

Difference between Metals & Non-Metals

Sr. No.	Property	Metals	Non-Metals
1.	Structure	Crystalline	Amorphic
2.	State	Generally solids at room temp.	Gaseous & solid at ordinary temp.
3.	Luster	Metallic luster	No metallic luster (except iodine & graphite)
4.	Conductivity	Good conductors of heat & electricity	Bad conductors
5.	Malleability	Malleable	Not malleable
6.	Ductility	Ductile	Not ductile
7.	Hardness	Generally hard	Hardness varies
8.	Electrolysis	Form anions	Form anioins
9.	Excitation of valence electron by e.m.f.	Easy	Difficult
10.	Density	High	Low

Procedure for Selection of Materials (Engineering Applications)

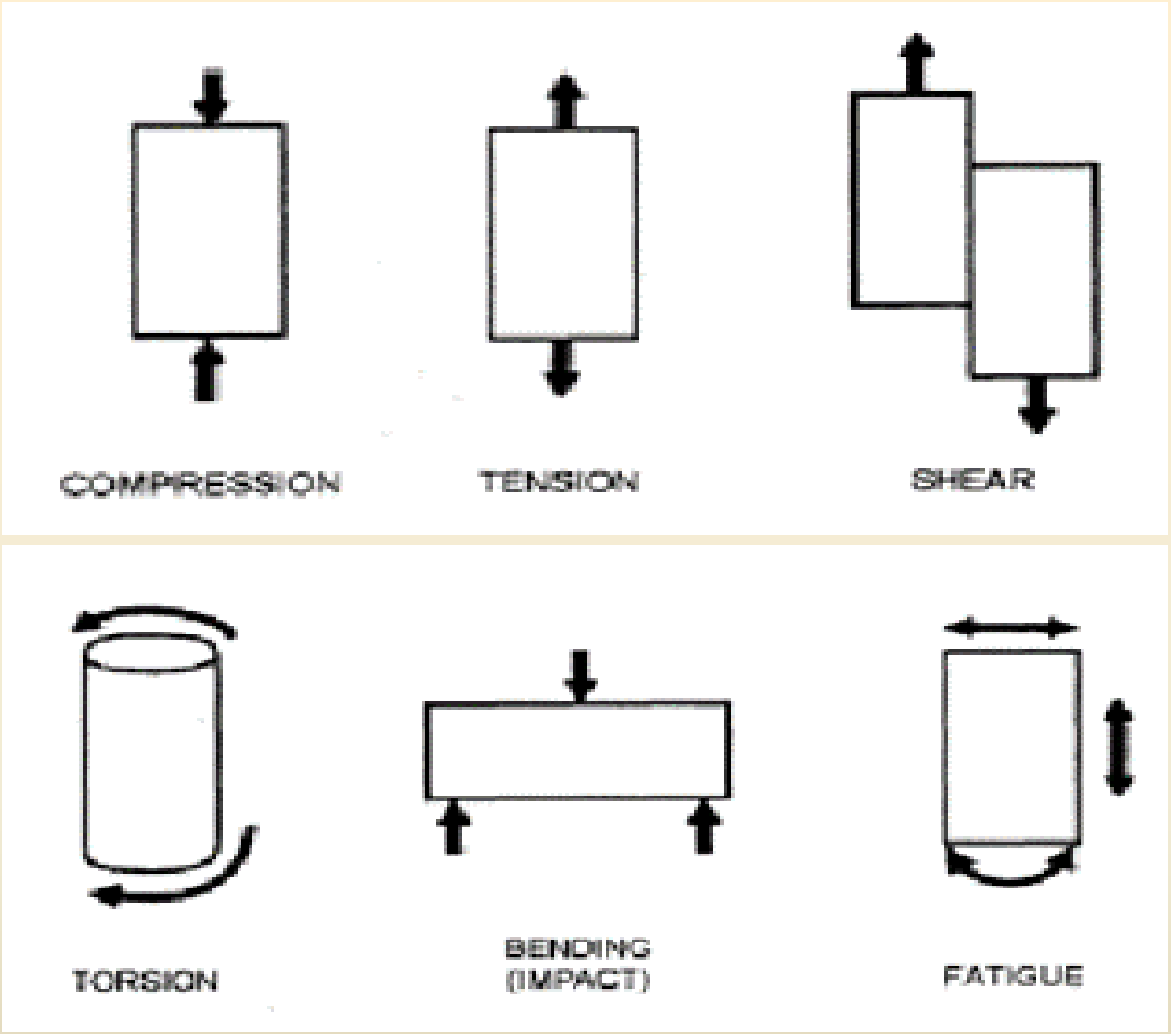
- Analysis of material application problem
- Translation of material application requirements to material property values
- Selection of candidate materials
- Evaluation of candidate materials
- Decision making

Factors Affecting Material Selection

1. ***Material Performance*** **(depend upon material properties): Adequate properties for anticipated operating conditions / performance**
2. ***Constraints*** **: Design, Availability, Cost etc**

1. Material Performance

- ***Physical:*** **e.g. appearance, shape, weight, boiling point, melting point, freezing point, density, glass transition temperature, permeability**
- ***Mechanical:*** **e.g. strength (tensile, compressive, shear, torsion, bending), elasticity, plasticity, ductility, malleability, rigidity, toughness, hardness, brittleness, impact, fatigue, creep, strain hardening, Bauschinger effect, strain rate effect, vibration resistance, wear**
- ***Thermal:*** **e.g. thermal conductivity, expansion coefficient, resistivity, thermal shock resistance, thermal diffusivity**



Types of Force / Stress System

- ***Electrical:*** **e.g. conductivity, resistivity, dielectric strength, thermoelectricity, superconductivity, electric hysteresis**
- ***Magnetic:*** **e.g. ferromagnetism, paramagnetism, diamagnetism, magnetic permeability, coercive force, curie temperature, magnetic hysteresis**
- ***Chemical:*** **e.g. reactivity, corrosion resistance, polymerization, composition, acidity, alkalinity**
- ***Optical:*** **e.g. reflectivity, refractivity, absorptivity, transparency, opaqueness, color, luster**
- ***Metallurgical:*** **e.g. grain size, heat treatment done / required, anisotropy, hardenability**

2. Constraints

- **Design Requirements**
- **Existing Facilities**
- **Availability**
- **Compatibility**
- **Marketability**
- **Manufacturability (Fabricability / Castability / Formability / Machinability / Weldability)**
- **Cost (Material + Fabrication / Manufacturing)**

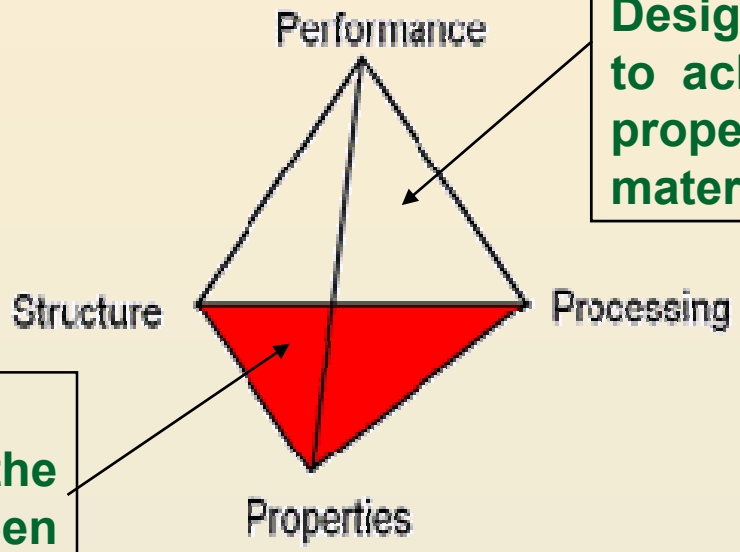
Others Factors Affecting Material Performance

- Structure-property -Processing Relationships
- Hot Work, Cold Work,
- Solid Solution Strengthening
- Precipitation Hardening
- Inclusions
- Imperfections (Number of Dislocations)
- Crystal structures: Crystalline vs Amorphous
- Toughening
- Heat treatment (Annealing, Normalizing, Quenching)
- Residual Stresses

Investigating relationship between Structure & Properties

Materials Engineering

Designing the structure to achieve the specific properties of the materials



Materials Science

Investigating the relationship between structure and properties of the materials

Processing → Structure → Properties → Performance