

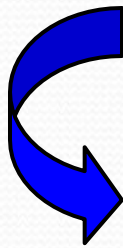
# Introduction to Materials and Manufacturing Processes

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# Session Objectives

- At the end of the session delegates should have understood
  - Overview of materials and manufacturing
  - Importance of Microstructure, Properties, Processing and Performance
    - Example
  - Introduction to design and manufacturing processes

# **Engineering Materials and Manufacturing Technology**

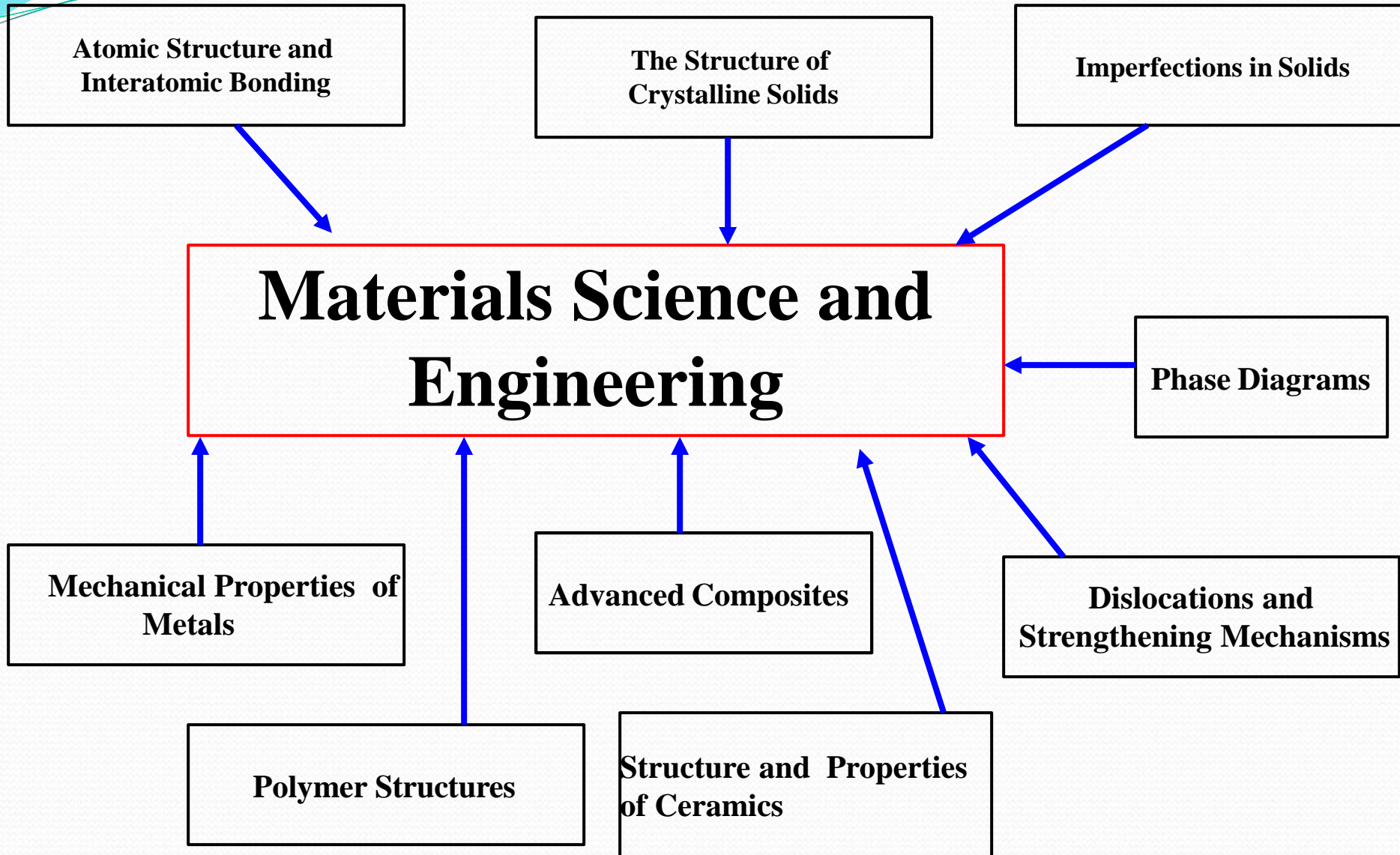


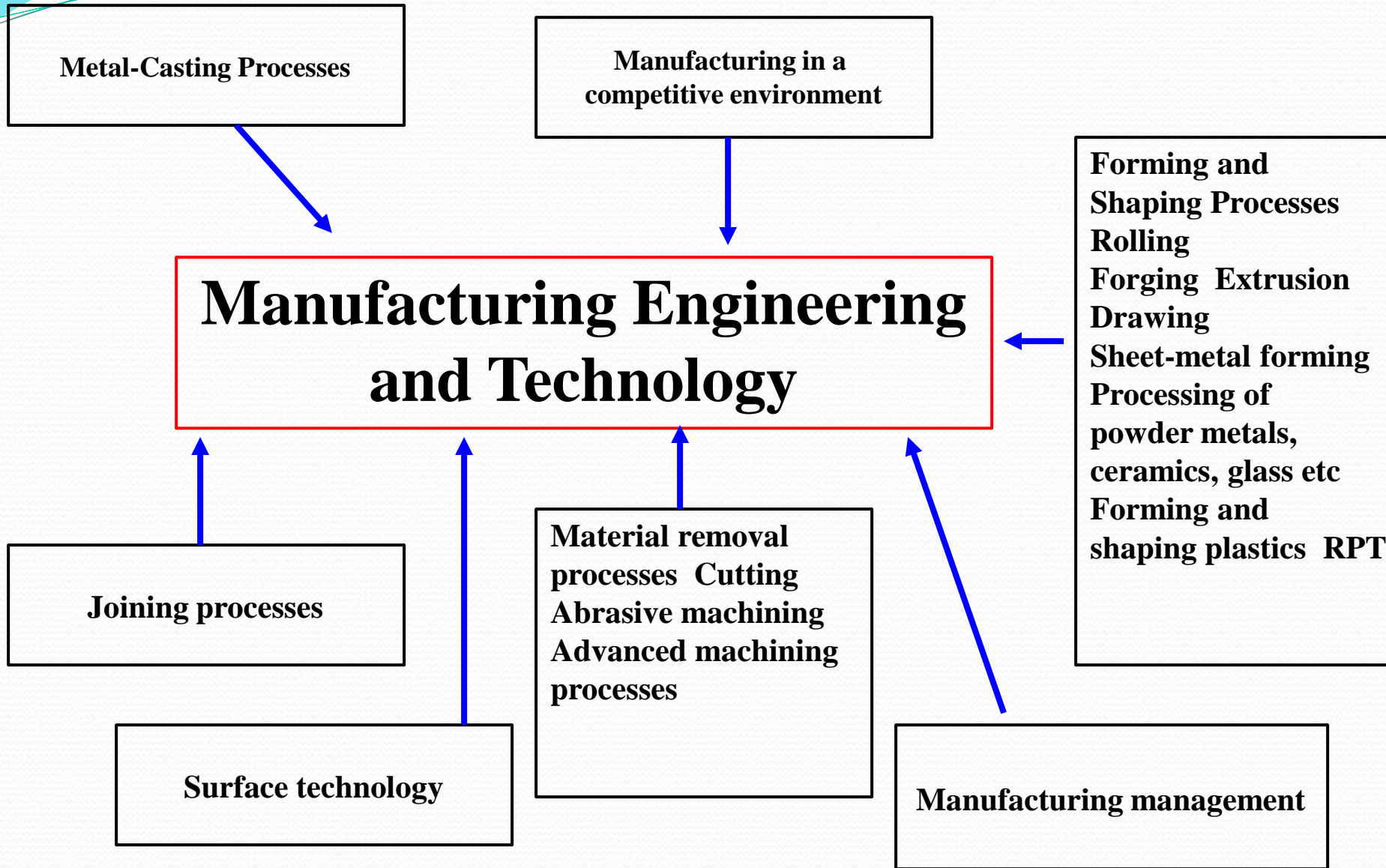
**Materials Science  
and Engineering**



**Manufacturing  
Engineering**







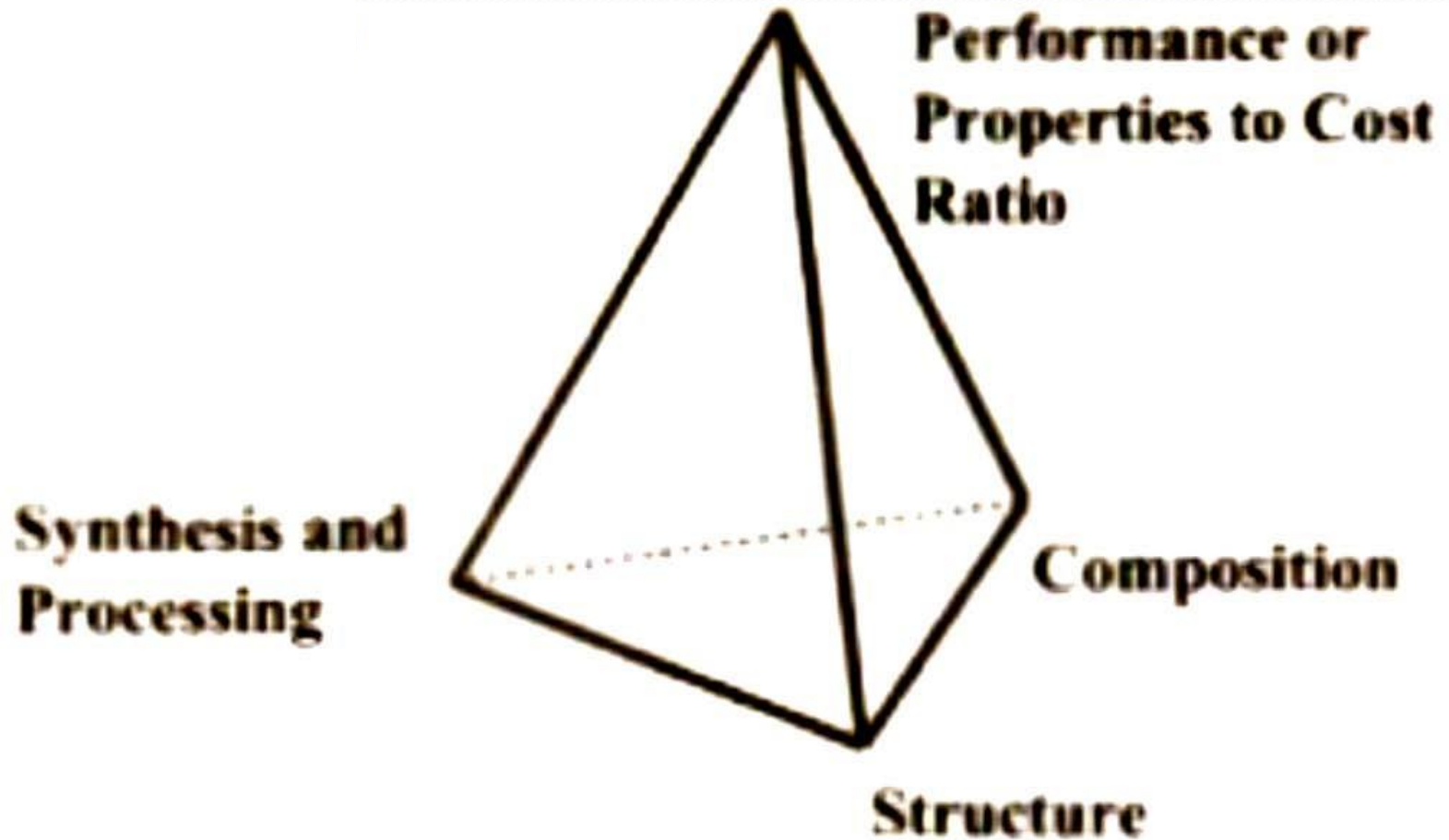


# How to decide the material with the properties required ??

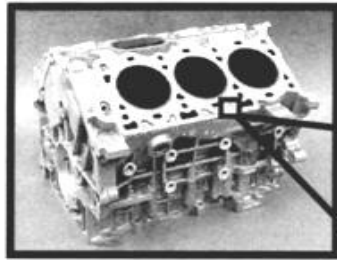
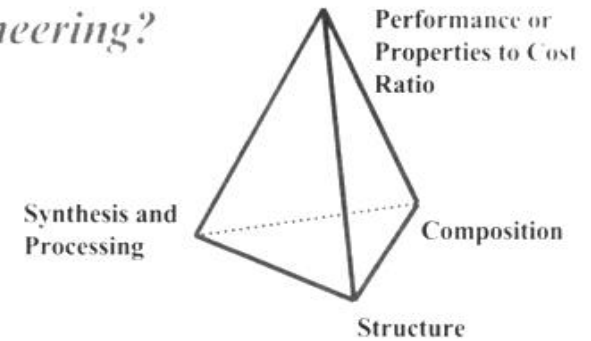
- Use the “right material for the right job”
  - It is impossible to remember the large number of engineering materials.
  - More than a thousand types of steel alone , each with a specific composition, thermal and mechanical history.
  - So, it is better to study the key factors that determine the properties of a material.

# Materials Science

## Tetrahedron



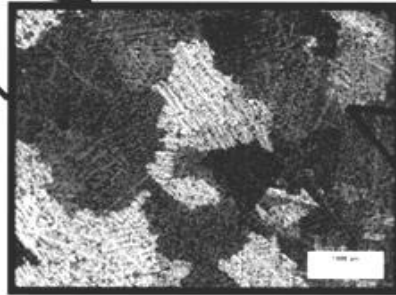
# What is Materials Science and Engineering?



**Macro-Scale Structure**  
Engine Block  
≡ upto 1 meter

## Performance Criteria

- Power generated
- Efficiency
- Durability
- Cost



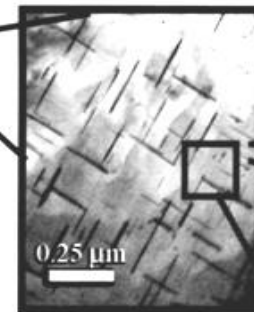
**Microstructure**  
- Grains  
≡ 1 – 10 millimeters

- Properties affected*
- High cycle fatigue
  - Ductility



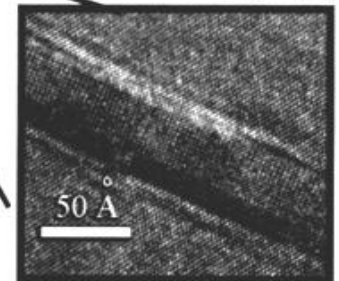
**Microstructure**  
- Dendrites & Phases  
≡ 50 – 500 micrometers

- Properties affected*
- Yield strength
  - Ultimate tensile strength
  - High cycle fatigue
  - Low cycle fatigue
  - Thermal Growth
  - Ductility



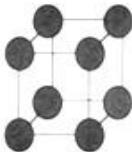
**Nano-structure**  
- Precipitates  
≡ 3-100 nanometers

- Properties affected*
- Yield strength
  - Ultimate tensile strength
  - Low cycle fatigue
  - Ductility



**Atomic-scale structure**  
≡ 1-100 Angstroms  
*Property affected*

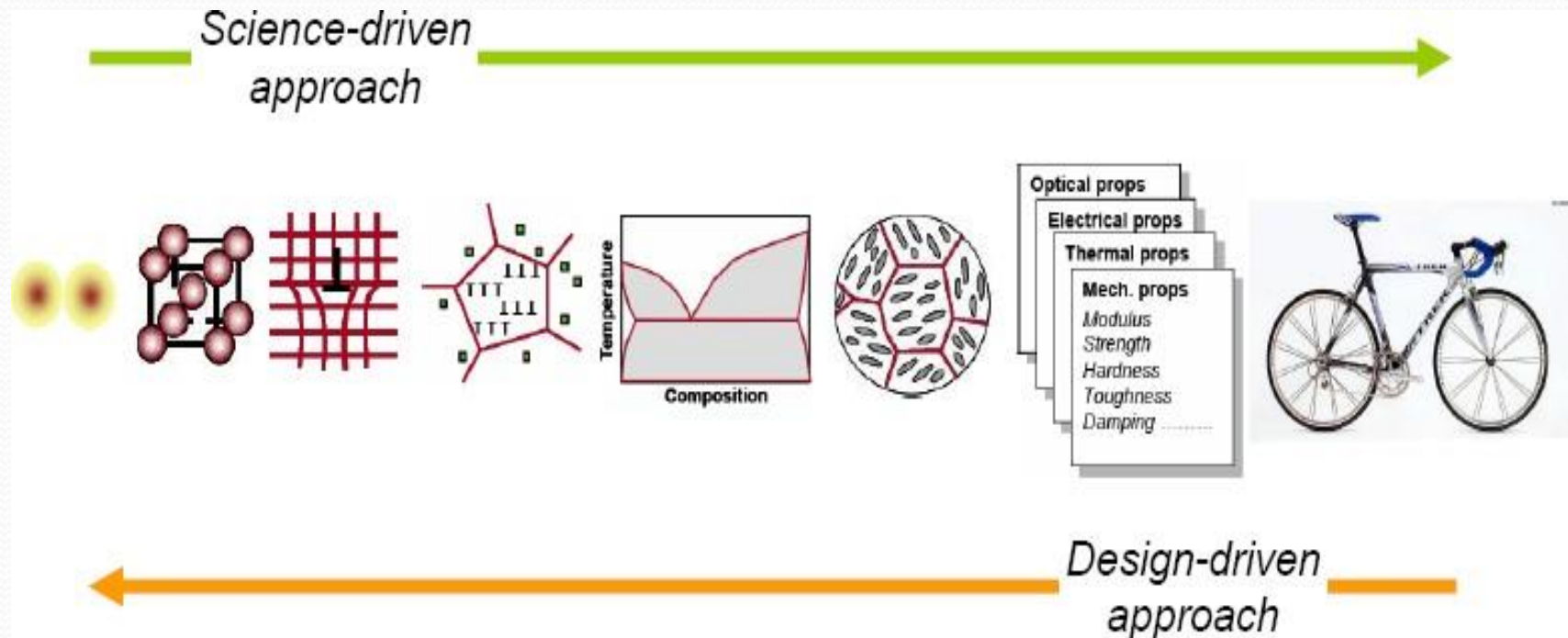
- Young's modulus
- Thermal Growth



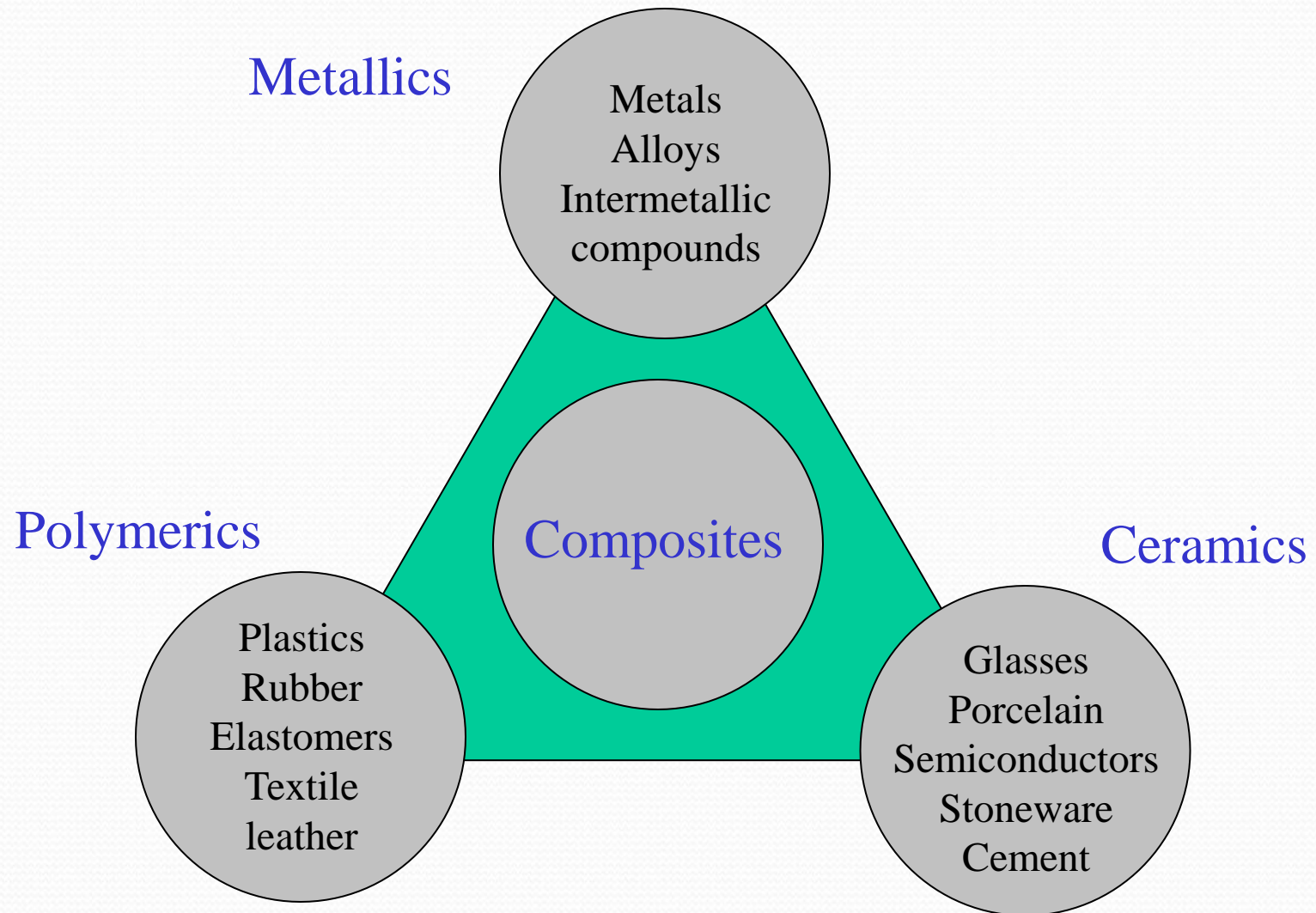
## Multiple Length Scales Critical in Engineering



# Materials Teaching



# Classification of Engineering Materials





# Properties of Materials

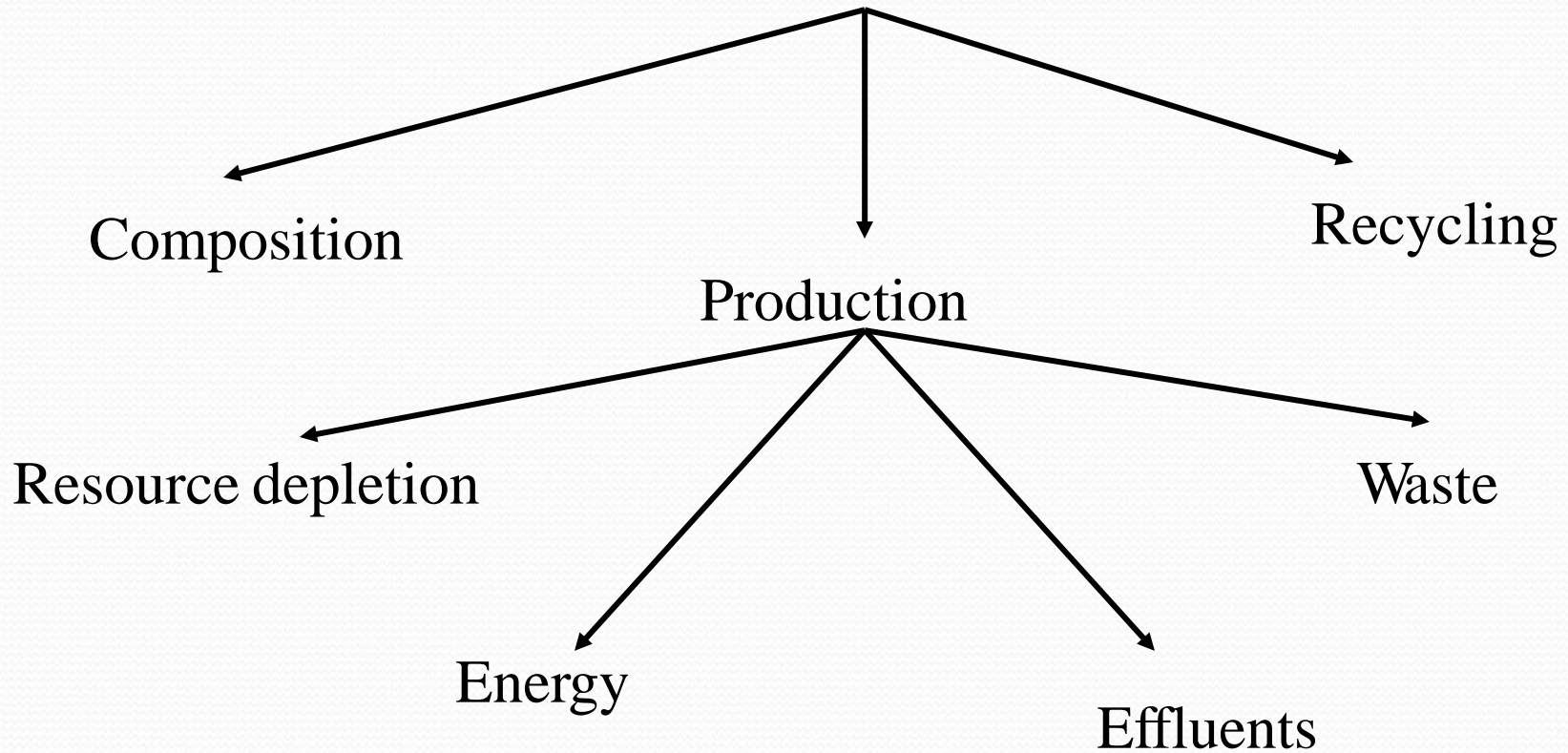
- Mechanical properties: strength, toughness, ductility, hardness, elasticity, fatigue, and creep
- Physical properties: density, thermal expansion, conductivity, specific heat, melting point, and electrical and magnetic properties
- Chemical properties: oxidation, corrosion, toxicity, and flammability
- Manufacturing properties: castability, formability, machinability, weldability, and hardenability by heat treatment.



# Properties of Materials (cont.)

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## Environmental Aspects



# Controlling :- Processing - Structure - Properties

- Performance of materials

- **Realistically engineering materials: Trade-off between**

- properties (what do we need or want?)
- deterioration (how long will it last?)
- cost (what's the biggest bang for the buck?)
- resources depletion (how to find new reserves, develop new environmentally-friendly materials, and increase recycling)

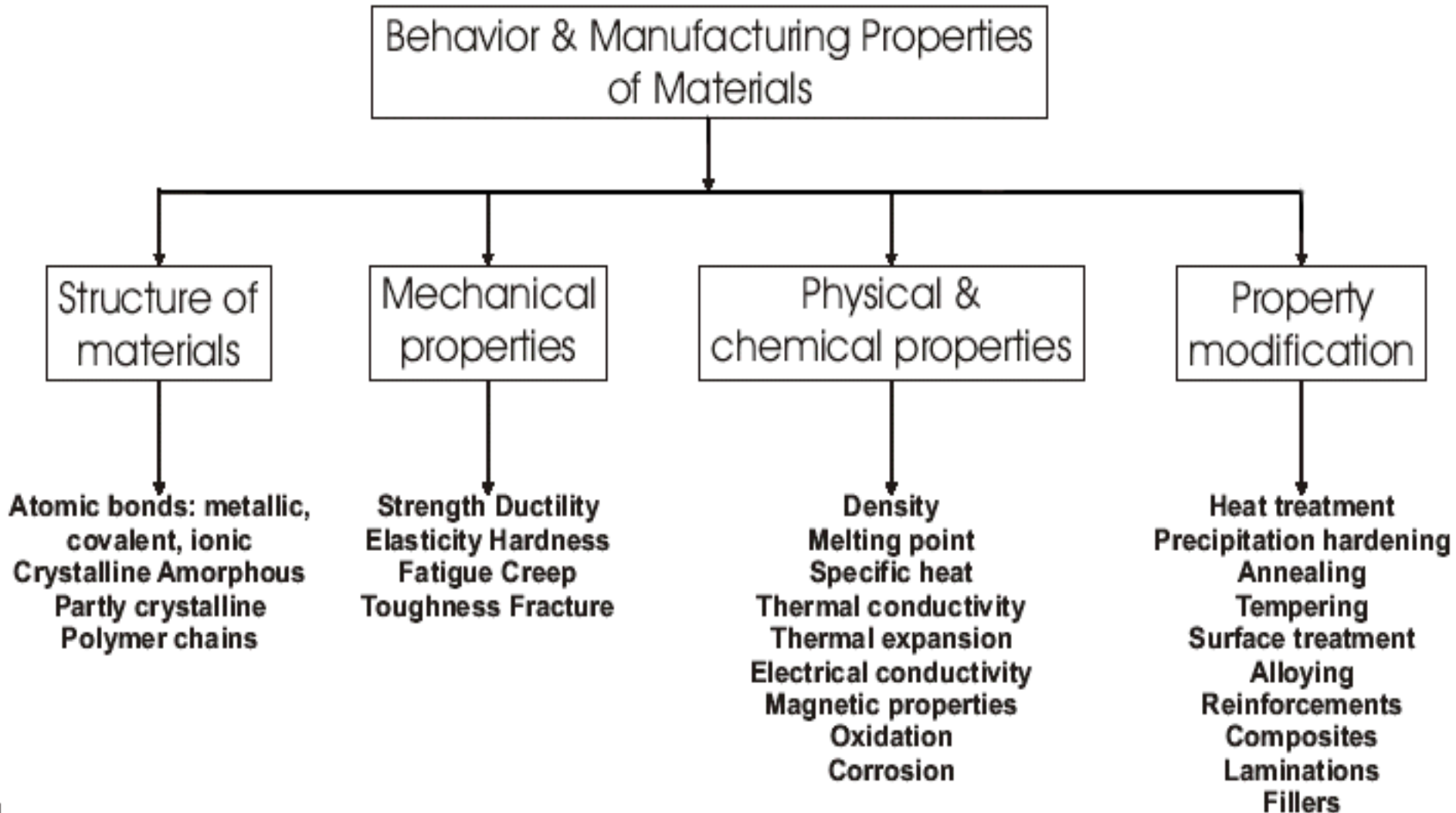


# Key Relationships

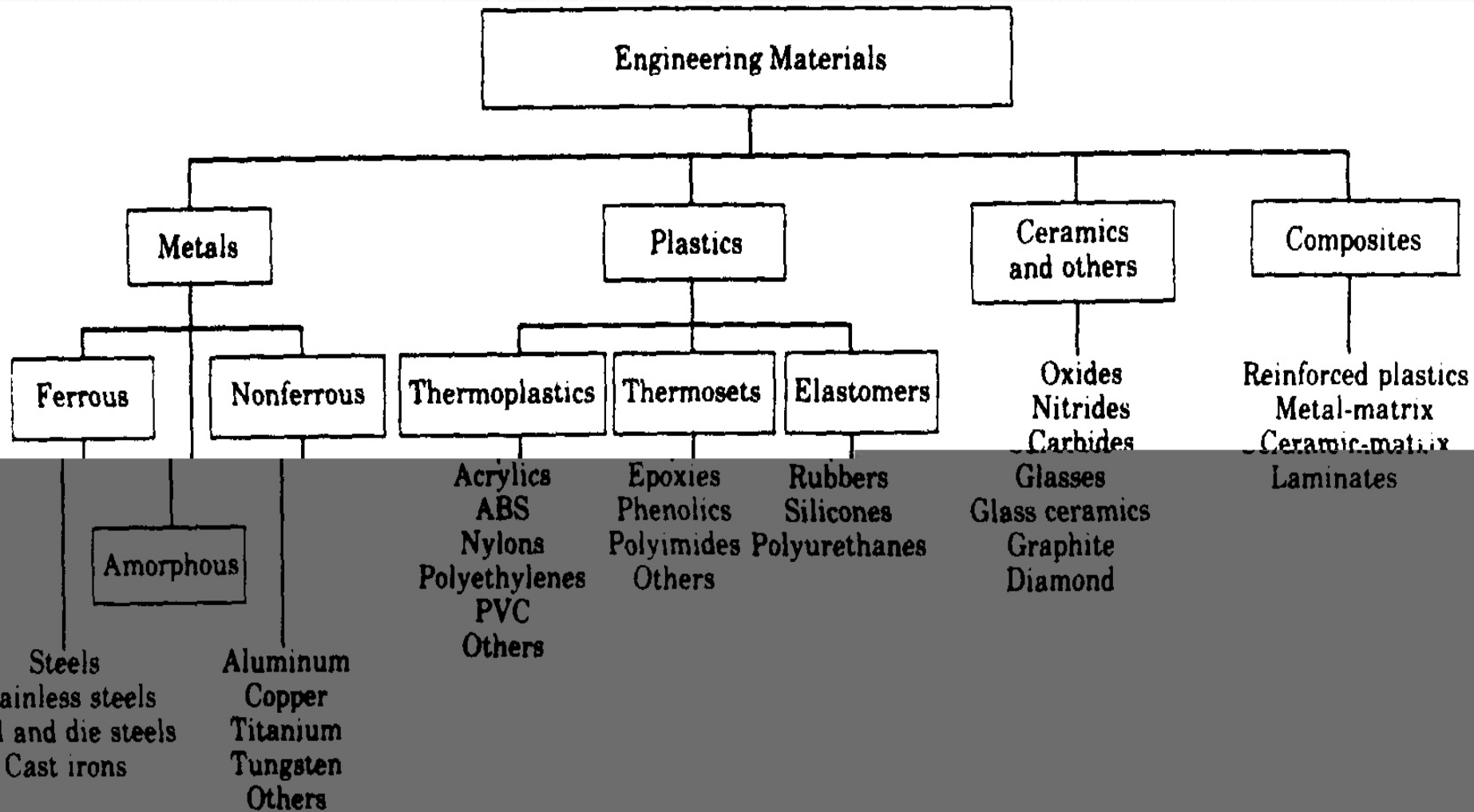
- Properties ← Microstructure ← Processing
- Microstructure : Structure as observed under the optical microscope. Magnification by about 1500 times.
- Substructure: Structure observed under electron microscope . Magnification upto 1,00,000 is possible.
- Crystal structure : tells us the details of the atomic arrangement within the crystal.



# An Outline of the behavior and the manufacturing properties of Materials



# TYPES OF ENGINEERING MATERIALS



# WHAT IS MANUFACTURING?

- Transformed from various raw materials and assembled into the shapes
- Manufacturing: - PROCESSES OF CONVERTING RAW MATERIALS INTO PRODUCTS.
- Encompasses of
  - the design of the product
  - selection of raw materials, and
  - sequence of processes.
- Country level of manufacturing directly related with economic health



# Why study Manufacturing?

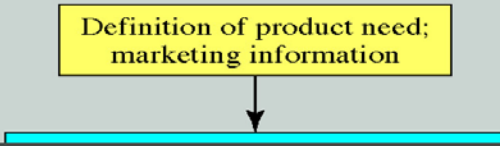
- Manufacturing is the core to economic activity!
- As a *designer*: understand the limitations available
  - Tolerances
  - Production rates
  - Economic issues

# Design Issues

- Designer must consider:
  - What processes are available/relevant for the product?
  - What tolerances can be achieved, and are these sufficient?
  - Are there any design features that need to be incorporated (eg webbing, round edges, etc)?
  - Can the expected production rate be met?
  - How will the product be assembled?

(a)

Definition of product need;  
marketing information



## Design Steps

- (a) Chart showing various steps involved in designing and manufacturing a product. Depending on the complexity of the product and the type of materials used, the time span between the original concept and the marketing of a product may range from a few months to many years.





Market

(b) Chart showing general product flow, from market analysis to selling the product, and depicting concurrent engineering.

**Concurrent engineering or simultaneous engineering**

# Summary

- Interrelationship between processing, microstructure, properties and performance with example have been illustrated
- Design steps and issues have been discussed
- Significance of materials and manufacturing used in critical engineering environment have been emphasized



# THANK YOU