Introduction to Materials Science & Engineering

Course Objective...

Introduce fundamental concepts in Materials Science

You will learn about:

- material structure
- how structure dictates properties
- how processing can change structure

This course will help you to:

- use materials properly
- realize new design opportunities with materials

Chapter 1 - Introduction

- **What is materials science?**
- **What is materials engineering?**

- **Why should we know about it?**

  → Materials drive our society

  – **Stone Age → Bronze Age → Iron Age →**

    Now → Future?

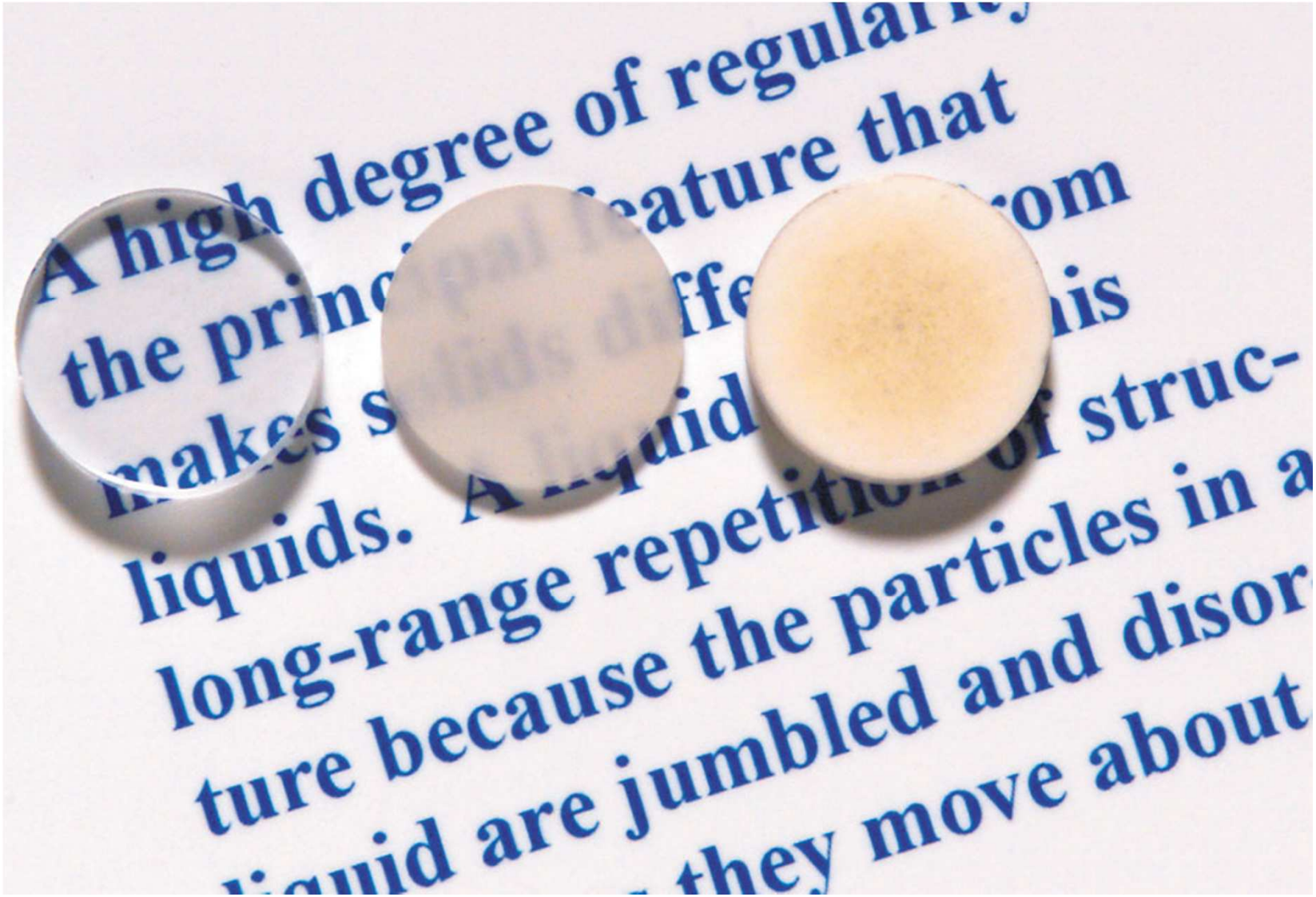

A high degree of regularity
the princ feature that
makes s om
liquids. A liquid is
long-range repetition of struc-
ture because the particles in a
liquid are jumbled and disor
they move about

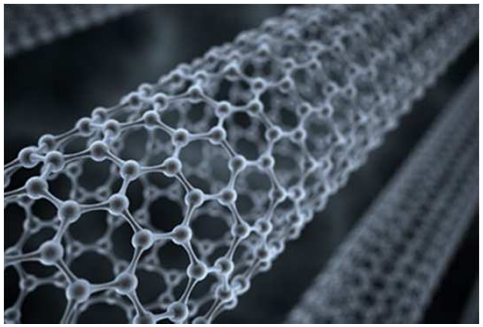
fig_01_02

Glass (ceramic) can

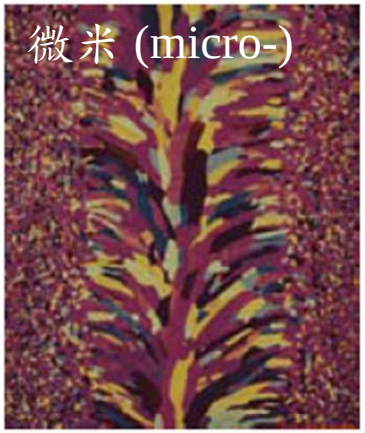
Aluminum (metal) can

Plastic (polymer) can

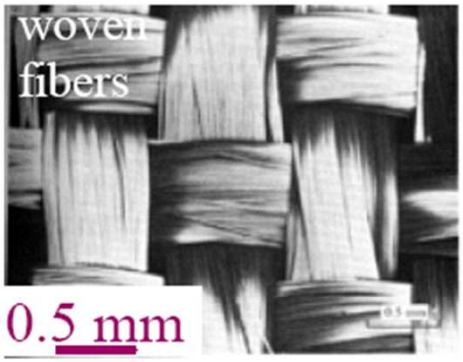
奈米(nano-)



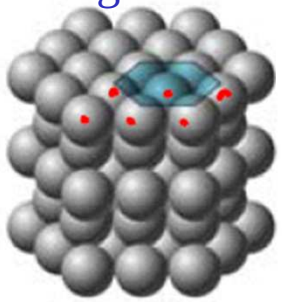
微米 (micro-)



釐米(millii-)



Angstrom



Atomic[a]
Up to 10^{-10} m

0.1nm

Carbon nanotube
10^{-9} m

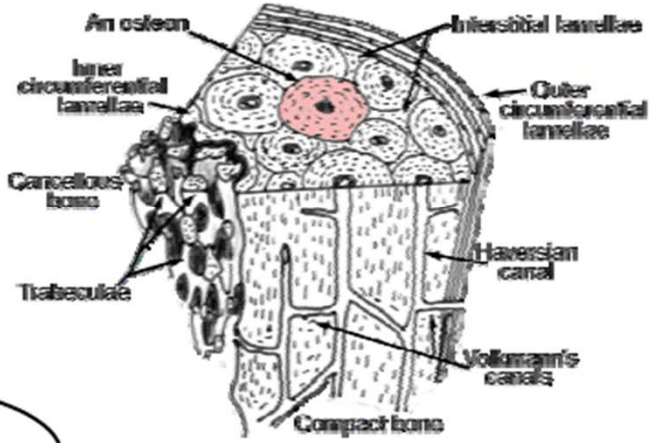
Grain[c]
10^{-9} – 10^{-2} m

Engineered Composite[d]
10^{-4} – 10^{-1} m

Structure

Properties

Processing



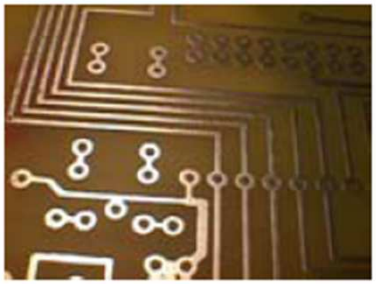
Natural Composite[e]

Bone / Wood ...

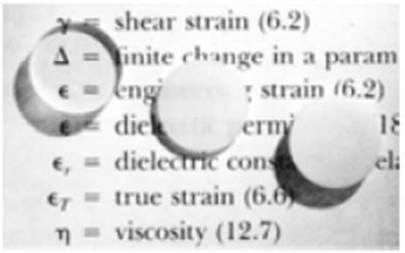
Images obtained from: (a) Fig. 3.3b, *Callister 6e*, (b) fluorapophyllite, from http://www.gc.maricopa.edu/earthsci/imagearchive/apophyllite.htm, downloaded Nov. 15, 2004, (c) Fig. K, color insert to *Callister 4e*,
(d) D. Hull and T.W. Clyne, *An Introduction to Composite Materials*, 2nd ed., Cambridge University Press, New York, 1996, Fig. 3.6, p. 47, (e) https://courses.stu.qmul.ac.uk/smd/kb/microanatomy/bone/, downloaded Nov. 15 2004.

1-9

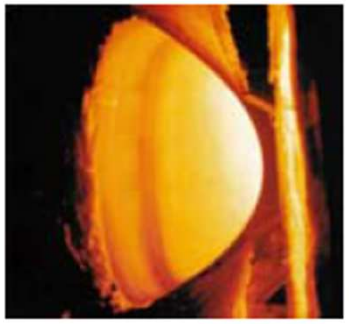
Mechanical[a]
(Strength, etc.)



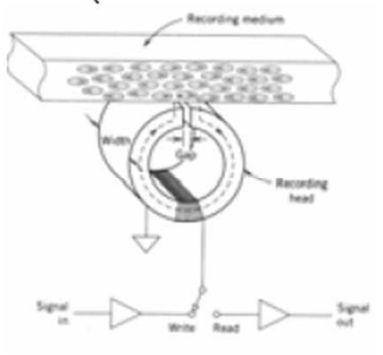
Electrical[b]
(Resistivity, etc.)



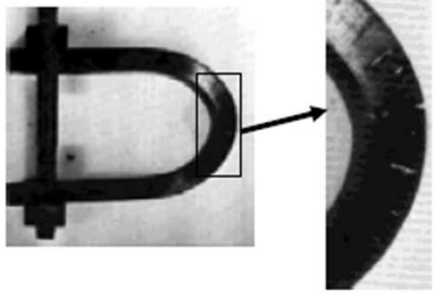
Optical[c]
(Transmittance, etc.)



Thermal[d]
(Conductivity, etc.)



Magnetic[e]
(Permeability, etc.)



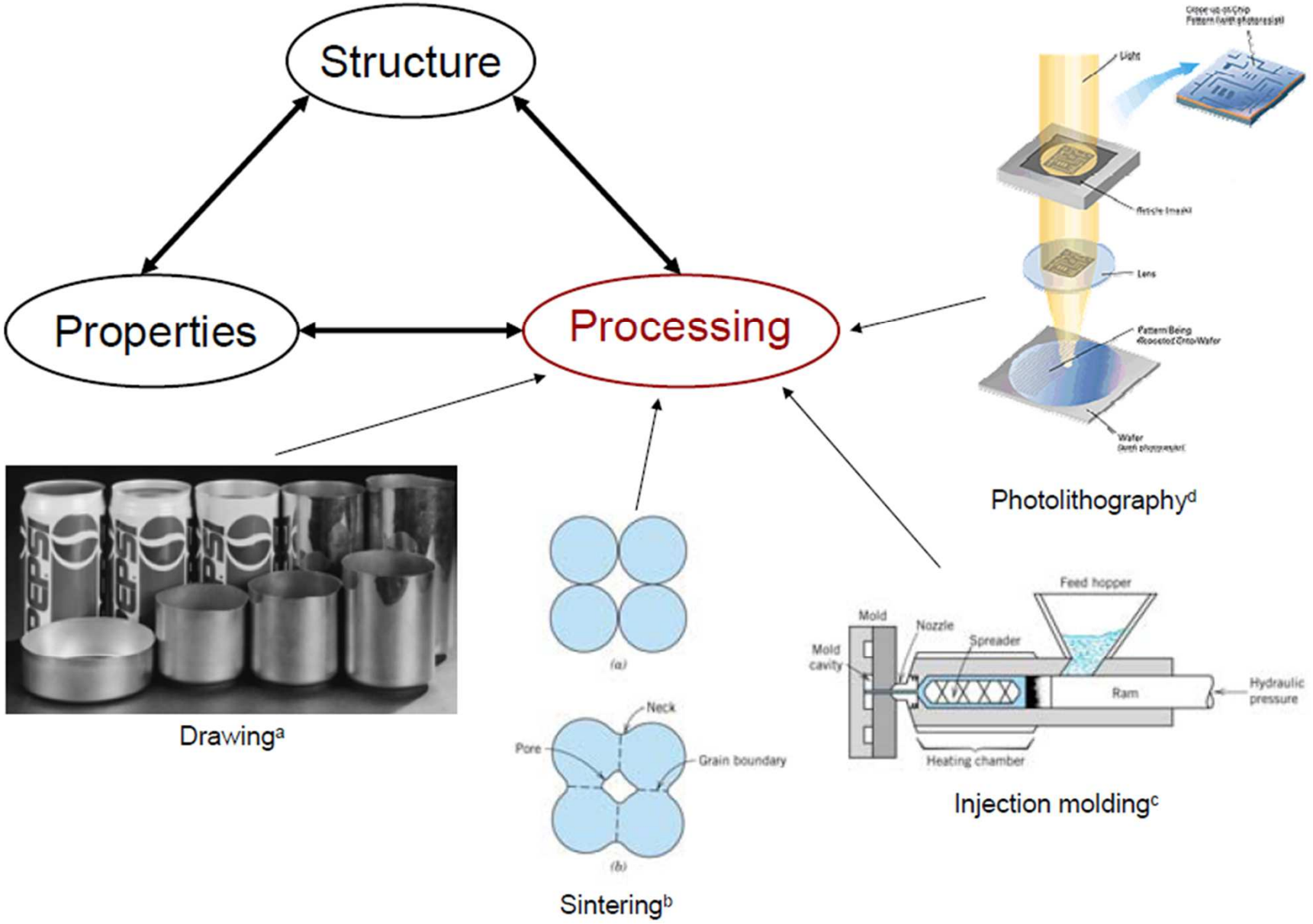
Deteriorative[f]
(Galvanic Potential, etc.)

Structure

Properties

Processing

Images obtained from: (a) http://www.mcshane-enterprises.com/ASL/images/Mitchell/barbendatvastrong.jpg, downloaded Aug. 24, 2004, (b) http://www.netadmintools.com/cabletester/alltinned.jpg, downloaded Aug. 24, 2004, (c) Fig. 1.2, *Callister 6e*, (d) http://www.missilesandfirecontrol.com/our_products/spaceprograms/SHUTTLE/pic01-shuttle.html, downloaded Aug. 24, 2004, (e) Fig. 20.18, *Callister 6e*, (f) Fig. 17.0, *Callister 6e*.



(a) Adapted from opening picture in Ch. 11, *Callister 6e*. PEPSI is a registered trademark of PepsiCo Inc., (b) Adapted from Fig 13.14, *Callister 6e*, (c) Fig. 15.23, *Callister 6e*, (d) **www.just2good.co.uk/ cpuSilicon.htm** downloaded Dec. 21, 2004.

Types of Materials

- **Metals:**
  - Strong, ductile, stiff, dense
  - high thermal & electrical conductivity
  - opaque, reflective.

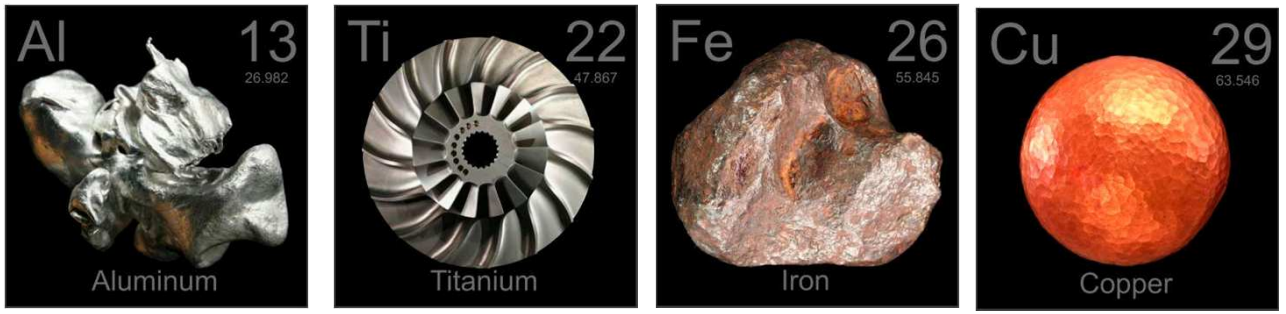
- **Polymers/plastics**: Covalent bonding → sharing of e's
  - Soft, ductile, low strength, low density
  - thermal & electrical insulators
  - Optically translucent or transparent.

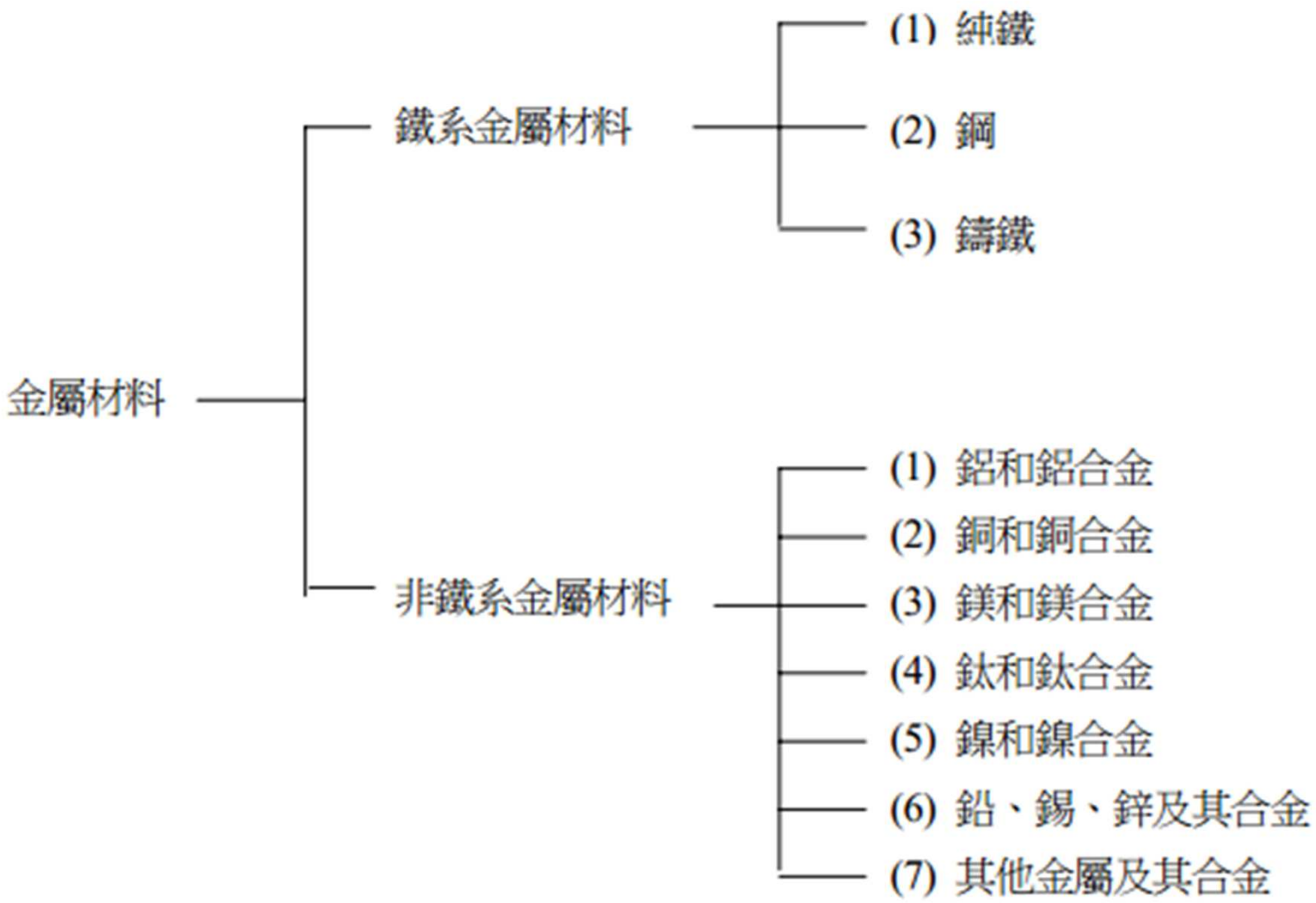
- **Ceramics**: ionic bonding (refractory) – compounds of metallic & non-metallic elements (oxides, carbides, nitrides, sulfides)
  - Brittle, glassy, elastic, stiff, strong, hard
  - non-conducting (insulators)

- **Composites, semiconductors**, biomaterials, smart materials, nanomaterials

Types of Materials

- **Metals**:
  - Composed of one or more metallic elements (Fe, Al, Cu, Ti, Au and Ni…..) and often also nonmetallic elements (C, O, N).
  - Crystalline structure.
  - Strong, ductile, stiff, dense
  - High thermal & electrical conductivity
  - Divided into two classes ：Ferrous and nonferrous metals.




金屬材料
鐵系金屬材料
(1) 純鐵
(2) 鋼
(3) 鑄鐵
非鐵系金屬材料
(1) 鋁和鋁合金
(2) 銅和銅合金
(3) 鎂和鎂合金
(4) 鈦和鈦合金
(5) 鎳和鎳合金
(6) 鉛、錫、鋅及其合金
(7) 其他金屬及其合金

全鋁合金車型 EvaGT

航太交通工具

鋁合金輪圈

MOSSO 700C27速鋁合金自行車

MOSSO 7005航太鋁合金車架
前、後培林花鼓
微轉27速變速系統

3期0利率 31家	18期0利率 18家
6期0利率 31家	24期0利率 15家
10期0利率 25家	30期0利率 1家
12期0利率 10家	12期 分期 15家

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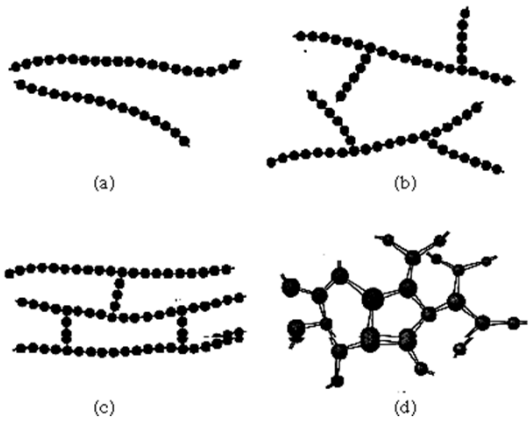
建議售價 $19999
網路價 $16800

鋁合金自行車

Types of Materials

- **Polymers/plastics**:
  - **Organic compounds** chemically based on **C**, H and other nonmetallic elements (O, N and Si).
  - Soft, ductile, low strength, low density.
  - thermal & electrical insulators
  - Optically translucent or transparent.



Types of Materials

- **Ceramics**: ionic bonding (refractory)
  - – Compounds of metallic & non-metallic elements (oxides, carbides, nitrides, sulfides) (ex: Al_2O_3, SiO_2).
  - – **Inorganic**
  - – Brittle, glassy, elastic, stiff, strong, hard
  - – non-conducting (insulators)

Types of Materials

- **Composites**

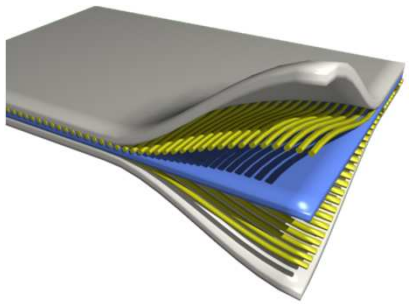
  Mixture of two or more materials.

  Polymer base composite, Metal base composite, Ceramic base composite.

  纖維強化高分子複合材料 (Fiber Reinforced Plastic, FRP)

- **Semiconductors**

- Biomaterials, smart materials, nanomaterials



The Materials Selection Process

1. Pick Application ⟶ Determine required Properties

   Properties: mechanical, electrical, thermal,
   magnetic, optical, deteriorative.

2. Properties ⟶ Identify candidate Material(s)

   Material: structure, composition.

3. Material ⟶ Identify required Processing

   Processing: changes *structure* and overall *shape*
   ex: casting, sintering, vapor deposition, doping
   forming, joining, annealing.