

BMM1523/BHA1113 ENGINEERING MATERIALS

INTRODUCTION TO MSE

by

Dr. Tedi Kurniawan
Faculty of Mechanical Engineering
tedikurniawan@ump.edu.my

Chapter Description

- **Aims**

Students are expected to have basic understanding of materials science and engineering together with its classification and main components.

- **Expected Outcomes**

- Understand the meaning of materials science and materials engineering
- Differentiate the types of engineering materials and gives their examples
- Understand the relation of four main component in materials science and engineering: processing, structure, properties and performance

- **References**

1. William D. Callister and David G. Rethwisch. Materials science and engineering: An Introduction, 9th Ed. Wiley, 2014.

What is MSE ?

- **Materials Science**

Study the relationship between structure and properties of materials.

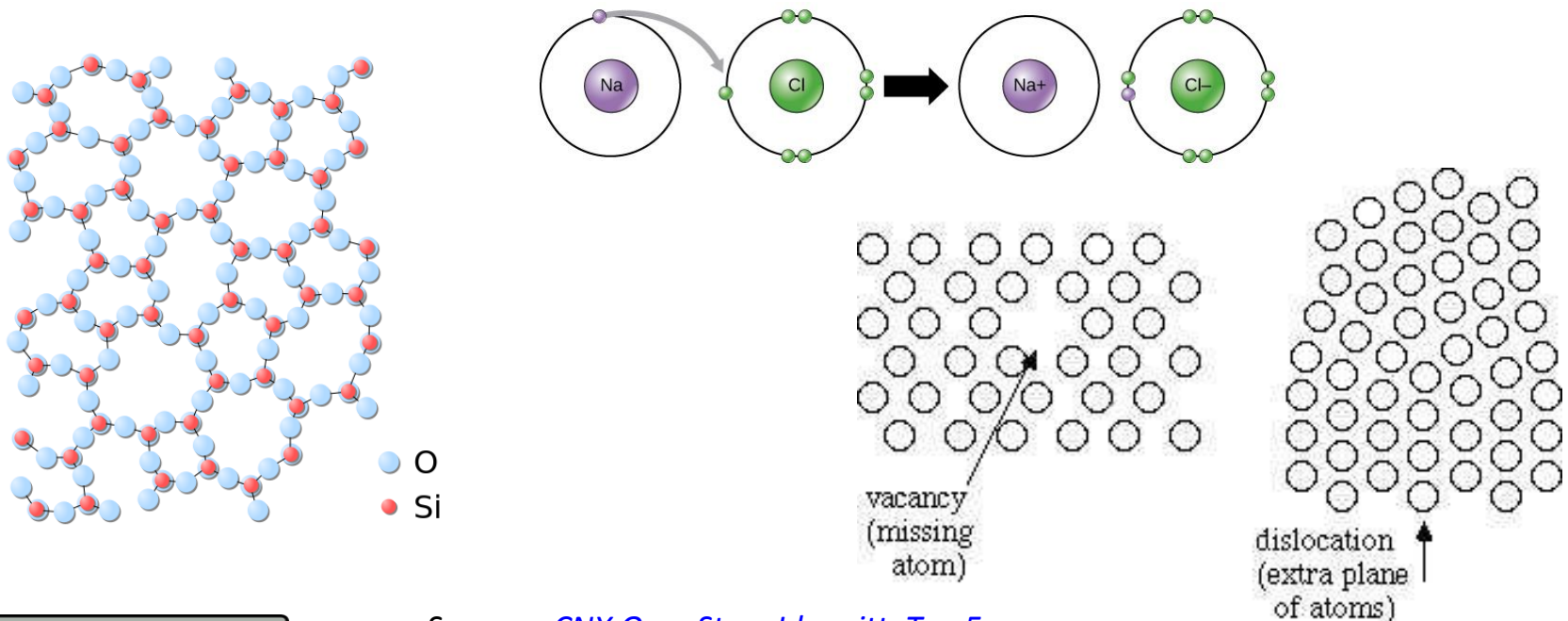
- **Materials Engineering**

The apply the fundamental relation of structure-properties of materials to convert it into product.

4 Components of Materials: Structure

- **Structure of materials**

Relates to the arrangement of internal components of materials, such as: valence electron, atomic bonding, crystal structure, and defects.



Sources: [CNX OpenStax](#), [Jdrewitt](#), [Tem5psu](#)

4 Components of Materials: Properties

Properties of materials: Response to external stimuli

Properties	Stimulus	Examples
Mechanical	Load	Strength; elasticity; modulus of elasticity
Electrical	Electric field	Electrical conductivity; dielectric constant
Thermal	Heat	Thermal conductivity; heat capacity
Optical	Electromagnetic or light radiation	Index of refraction; reflectivity
Magnetic	Magnetic field	Ferromagnetic; paramagnetic; diamagnetic
Deteriorative	Environment: moisture, oxygen, etc.	Corrosiveness in metals; degradation in polymer.

4 Components of materials: Processing and Performance

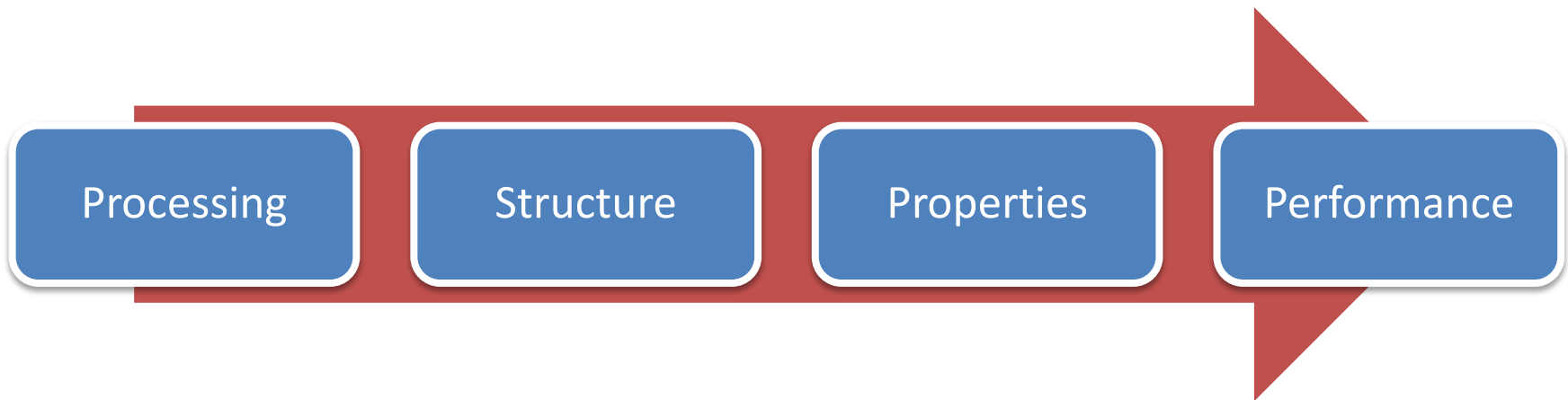
- **Processing of materials**

Ways of producing materials will effect on what kind structure will be made.

- **Performance of materials**

Functionality of properties materials

4 Component of materials



Types of Engineering Materials

- ☐ Metals
- ☐ Ceramics
- ☐ Polymers
- ☐ Composites
- ☐ Advanced Materials

Types of Engineering Materials: Metals

- **Structure:**

- Compose of metallic element(s) or metallic element plus small percentage of non-metallic element.
- Atomic arrangement usually in ordered manner (crystalline) and dense.

- **Properties:**

- Strong and ductile, high fracture toughness
- Good electrical and thermal conductivity
- Non-transparent and shine when polished

- **Example:**

- Iron (Fe), Aluminum (Al), Cupper (Cu), Gold (Au), Mercury (Hg)
- Steel (Fe-C), Stainless steel (Fe-Cr-Ni-C), Bronze (Cu-Sn), Brass (Cu-Zn),

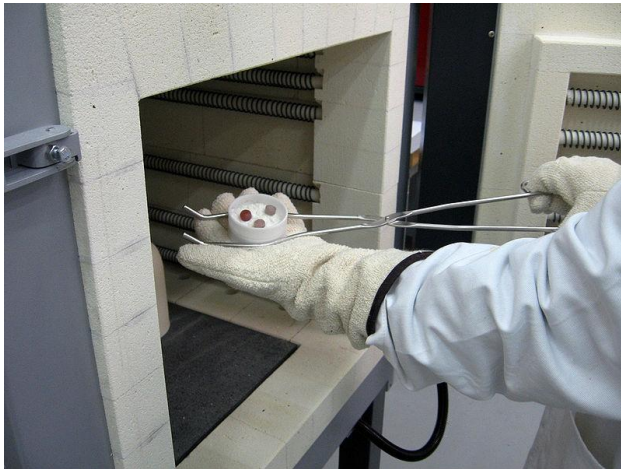
Types of Engineering Materials: Metals



Types of Engineering Materials: Ceramics

- **Structure:**
 - Compound between metallic and non-metallic element(s)
 - Most frequently oxides, nitrides, and carbide
- **Properties:**
 - Stiff, strong, hard, brittle and susceptible for fracture.
 - Low electrical and thermal conductivity
 - Resistance to high temperature and harsh environment
- **Example:**
 - Aluminum oxide (alumina, Al_2O_3), silicon oxide (silica, SiO_2), silicon carbide (SiC), silicon nitride (Si_3N_4), porcelain (clay), cement, and glass.

Types of Engineering Materials: Ceramics



Types of Engineering Materials: Polymers

- **Structure:**
 - Compose of organic compounds based on carbon, hydrogen, and other non metallic elements.
 - Large molecular chain structures mostly carbon-chain.
- **Properties:**
 - Low strength and stiffness, yet ductile and pliable.
 - Low electrical and thermal conductivity
 - Low density, soften at modest temperature, good chemical inertness
- **Example:**
 - polycarbonate (PC), polyethylene (PE), polystyrene (PS), poly vinyl chloride (PVC), nylon, and rubber.

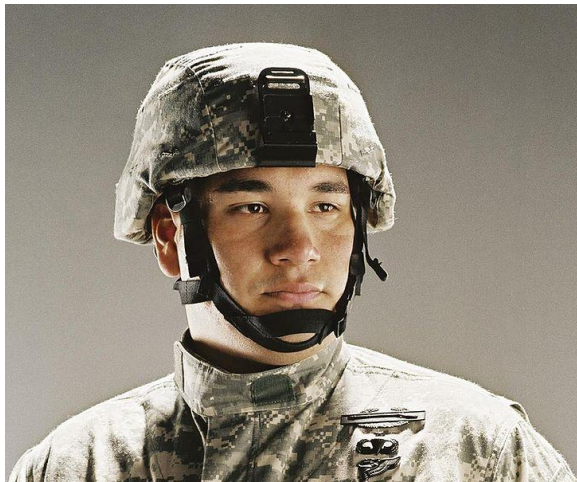
Types of Engineering Materials: Polymers



Types of Engineering Materials: Composites

- **Structure:**
 - Compose of two or more components of metals, ceramics or polymers, to combine the properties of each individual.
 - Natural components can be added as composite components and named as bio-composite or natural-composite.
- **Properties:**
 - High stiffness, strong and flexible.
 - Low electrical and thermal conductivity
 - Low density
- **Example:**
 - Carbon fiber-reinforced polymer (CFRP), fiberglass, concrete (cement+sand).

Types of Engineering Materials: Composites



Types of Engineering Materials: Advanced Materials

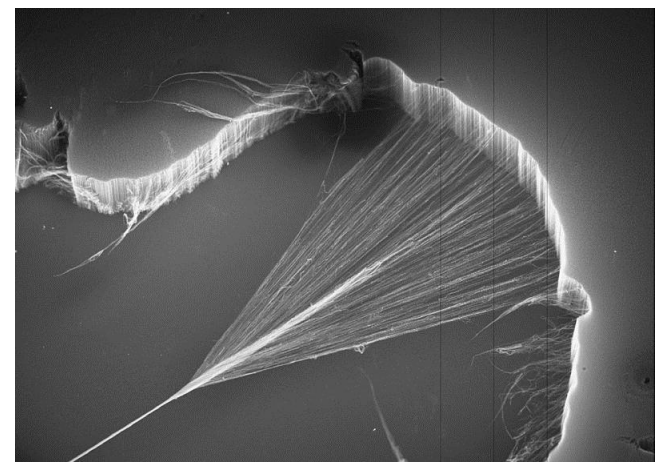
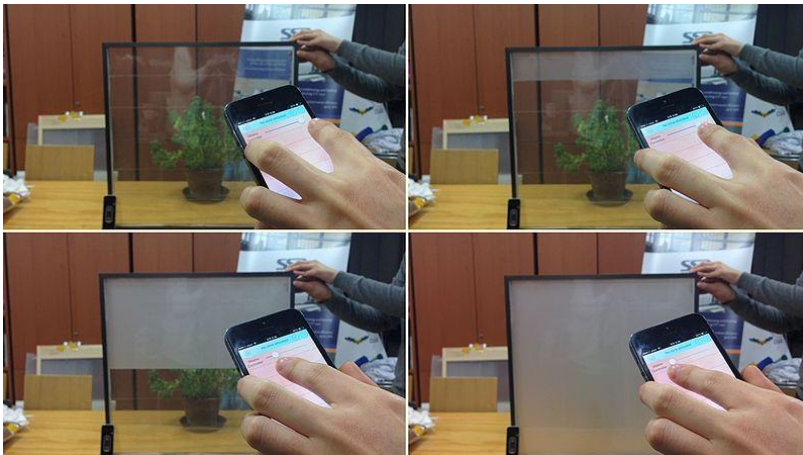
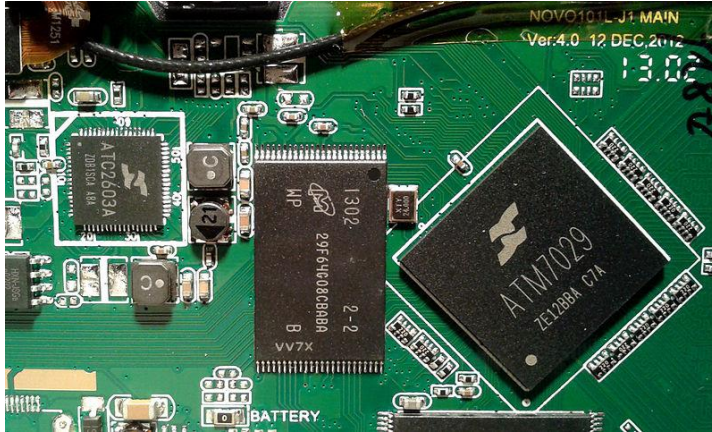
- **Structure:**

- Traditional materials (metals, ceramics or polymers) that newly developed to enhance its properties for high-technology application (operates using sophisticated principles).

- **Example:**

- **Semiconductors:** electrical properties in between insulator and conductor and can be modify by the existence of impurities (dopant).
- **Biomaterials:** materials that implanted into human body for medical uses.
- **Smart materials:** able to respond the change of environment (temperature, electricity, magnet, etc) by itself
- **Nanomaterials:** materials with the dimension on the order of nanometer (less than 100 nm)

Types of Engineering Materials: Advanced Materials



Summary

- Materials science related to structure and properties of materials, meanwhile materials engineering related to use the information of materials science to make a usable product.
- The components of materials science and engineering consist of processing, structure, properties and performance.
- Five types of engineering materials are metals, ceramics, polymers, composites, and advanced materials.

Dr. Tedi Kurniawan

Affiliation:

Structural Materials and Degradation (SMD) Focus Group
Faculty of Mechanical Engineering
University Malaysia Pahang
Pekan 26600 Pahang, Malaysia.

Research Interest:

- ☐ High Temperature Physical Chemistry
- ☐ Thin Films Technology
- ☐ Metals and Alloys.

Contact:

- Email: tedikurniawan@ump.edu.my