BMM1523/BHA1113
ENGINEERING MATERIALS

ADVANCED MATERIALS

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

Chapter Description

- **Aims**

  Students are expected to have basic understanding types of advanced materials and its specific properties

- **Expected Outcomes**
  - identify the specific properties of biomaterials and smart materials
  - Understand the principle of semiconductor and nanomaterials

- **References**

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

What is Advanced Materials?

- Groups of Materials:
  - **Metals**
  - **Ceramics**
  - **Polymer**
  - Advanced Materials
- Their application is usually based on **mechanical** or **structural properties**.
  - Steel : Strong
  - Polymer : lightweight
  - Ceramics: hard and stiff

ADVANCED MATERIALS

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

4 TYPES OF ADVACEND MATERIALS

- **Biomaterials**
- **Smart materials**
- **Semiconductors**
- **Nanomaterials**

BIOMATERIALS

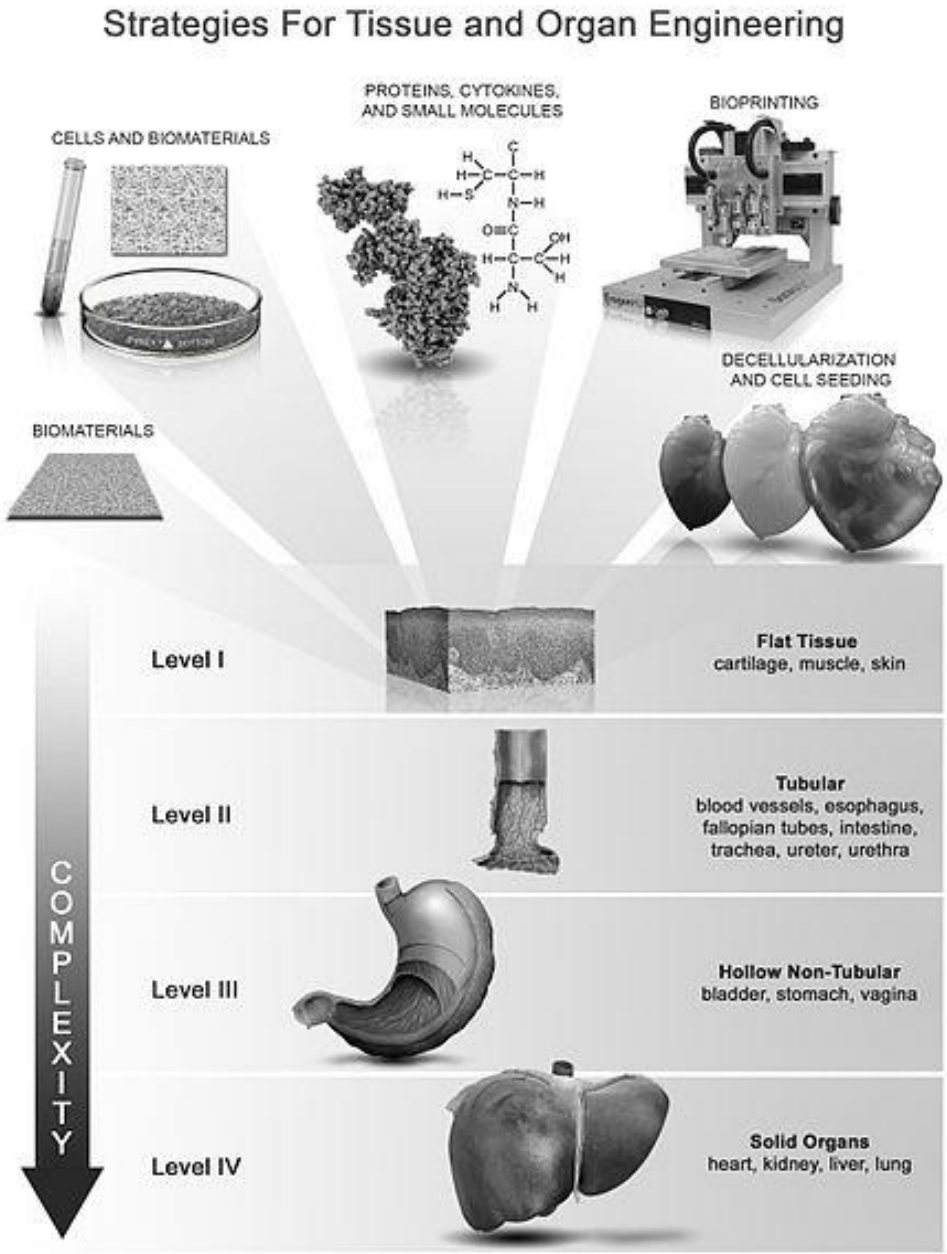
- materials that implanted into human body for medical uses.
- to replace the function of tissue, organ or parts of human body.

Biocompatibility

The compatibility of a material with the human body to perform a specific application and without causing toxicity or immunological reaction.

Types of Biomaterials

- Metal-based biomaterials **(Metallic biomaterials)**
- Ceramic-based biomaterials **(bioceramics)**
- Polymer-based biomaterials **(polymeric biomaterials)**
- Composite-based biomaterials **(biocomposite)**

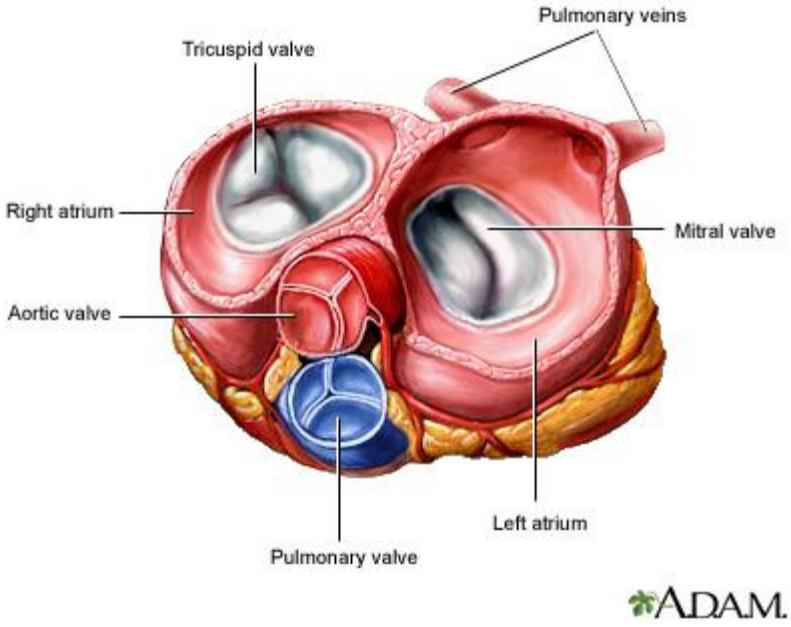


Source: [Community College Consortium for Bioscience Credentials]

HIP JOINT

Sources: Hip Joint, Hip Joint (2)

MECHANICAL HEART VALVE



Sources:

- Z22
- http://www.nlm.nih.gov/medlineplus/ency/imagepages/18093.htm

SMART Materials

- Change shape when heat applied
- Produce electricity when stress applied
- Change in color when heat or electricity applied.

✓ React to a **stimulus** by its environment by its self

✓ Fast respond!

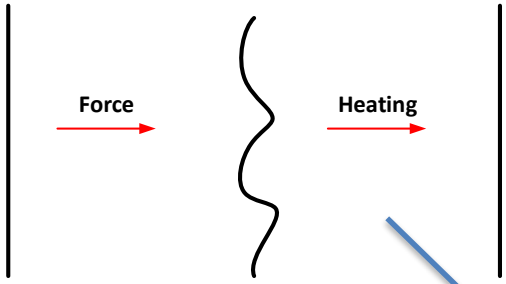
✓ Other than structural function, smart materials may functioning as sensor, actuator and microprocessor.

Type of stimulus:

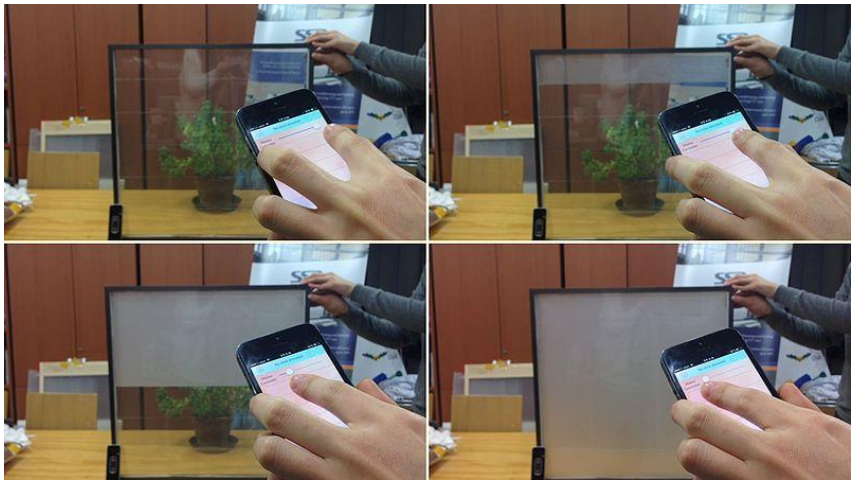
➢ Stress, temperature, magnetic, electric, etc.

Examples of Smart Materials

- Shape Memory Alloys
- Piezoelectric Materials
- Photochromic Materials
- Thermochromics Materials
- Electrochromic Materials



Transformation of Ni-Ti SMA wire: “plastically” deform then return back to original shape by heating



Smart window
Source: Vitswell

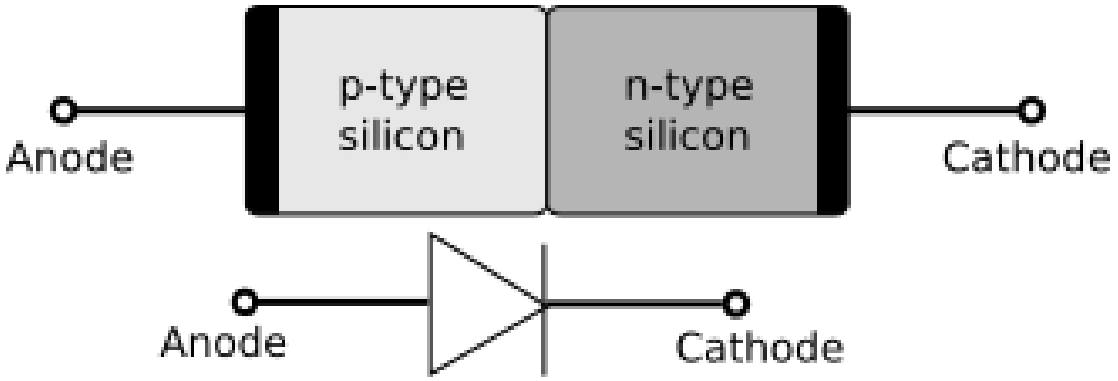
Thermochromic mug
Source: Damianosullivan

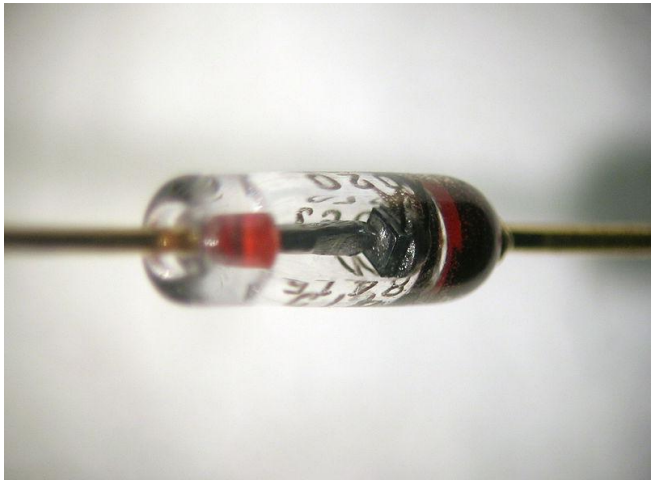
SEMICONDUCTORS

- Materials with electrical properties in between insulator and conductor and can be modify by the existence of impurities (dopant).
- Classified into **P-type** and **N-type** semiconductor
  - P-type: positively charged semiconductor; holes as majority carrier
  - N-type: negatively charged semiconductor; electrons as majority carrier.

Diode

Electronic devices that combine p-type and n-type regions of semiconductor, which create two-terminals and conduct current in one direction.

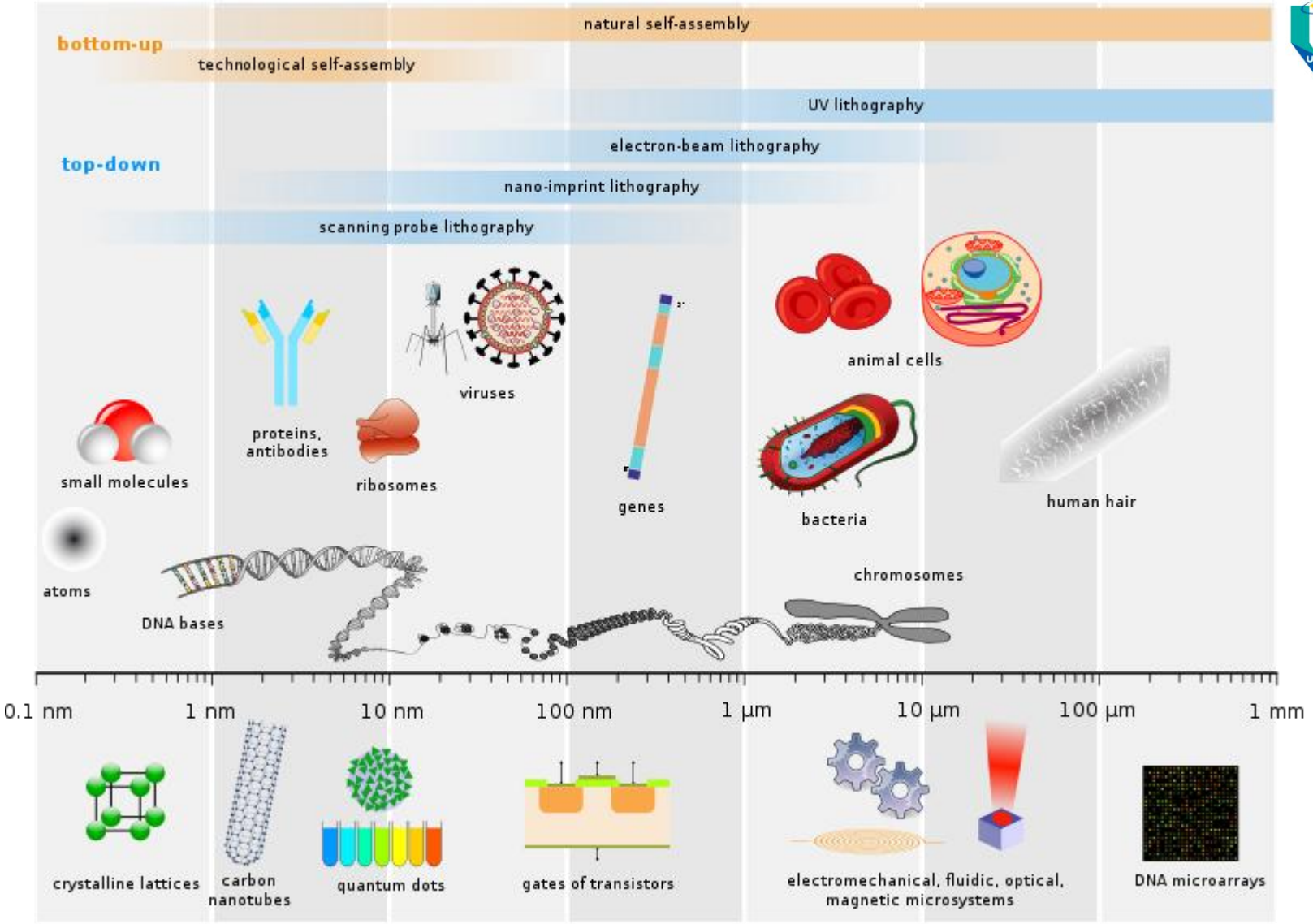




Sources: Raffamaiden; Morcheeba

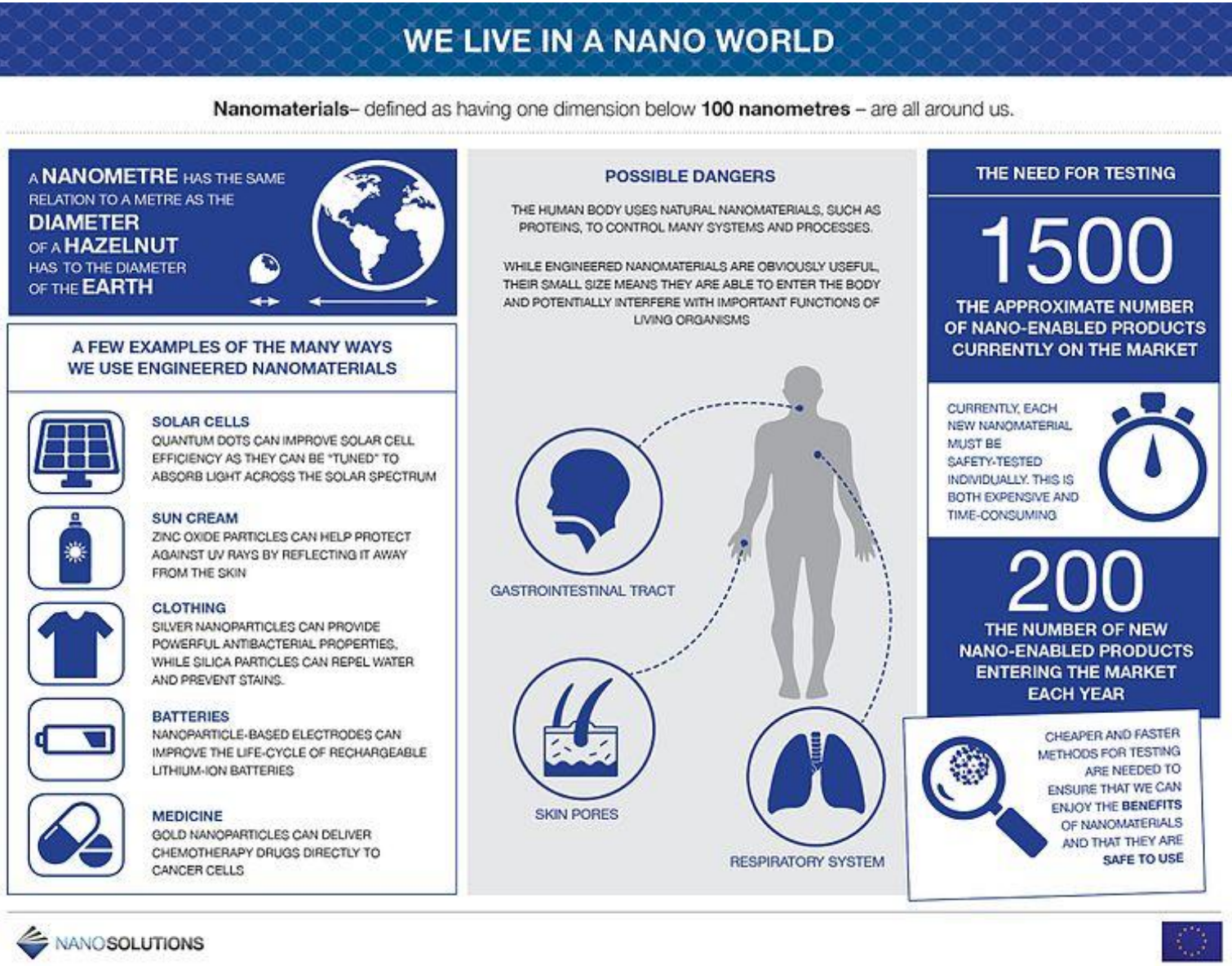
NANOMATERIALS

NANOMATERIALS are materials with the dimension on the order of nanometer (less than 100 nm)



Biological and technological scales compared

Source: [Guillaume Paumier]



Infographic on nanomaterials
Source: [InsightPublishers]

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