

BMM1523/BHA1113 ENGINEERING MATERIALS

ADVANCED MATERIALS

by

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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 engineering: 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 ADVANCED 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.

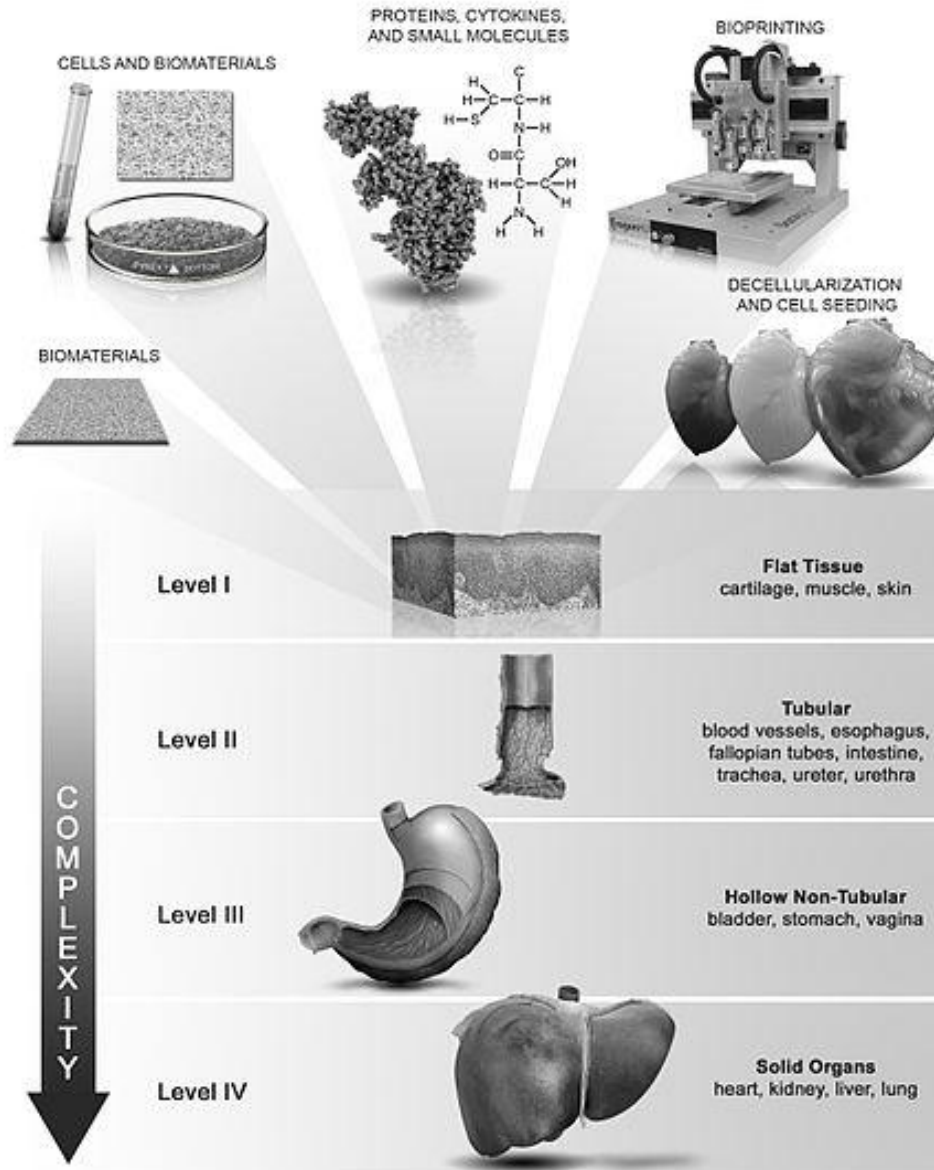
Biocompatibility

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)

Strategies For Tissue and Organ Engineering



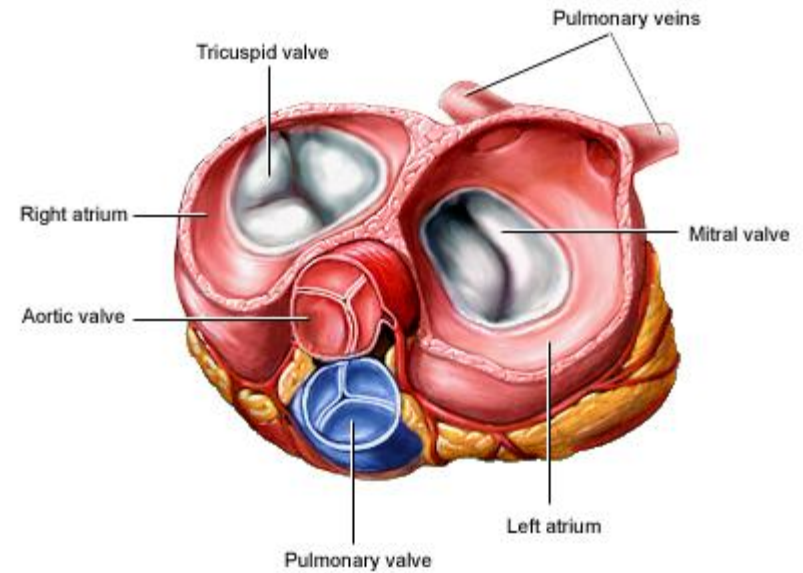
Source: [Community College Consortium for Bioscience Credentials](#)

HIP JOINT



Sources: [Hip Joint](#), [Hip Joint \(2\)](#)

MECHANICAL HEART VALVE



ADAM.

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**.

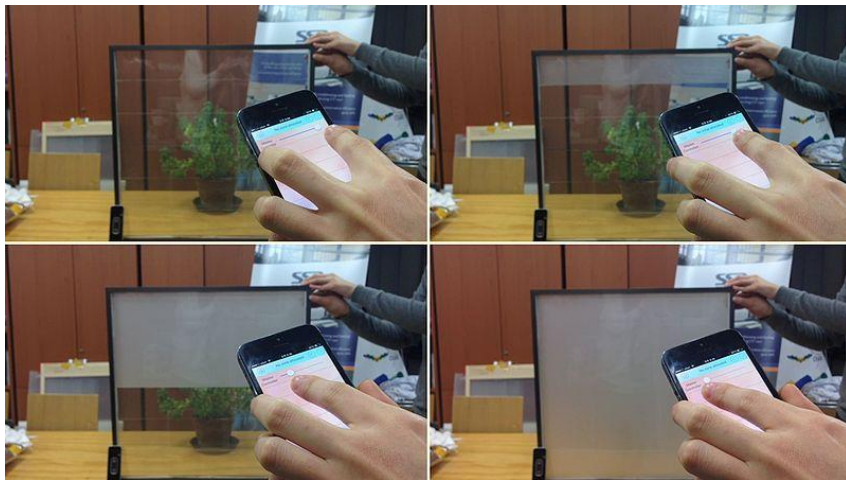
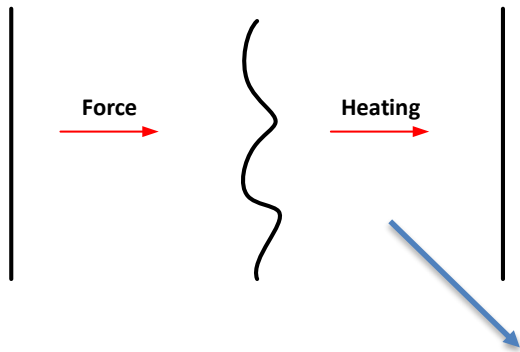
Type of stimulus:

- 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](#)



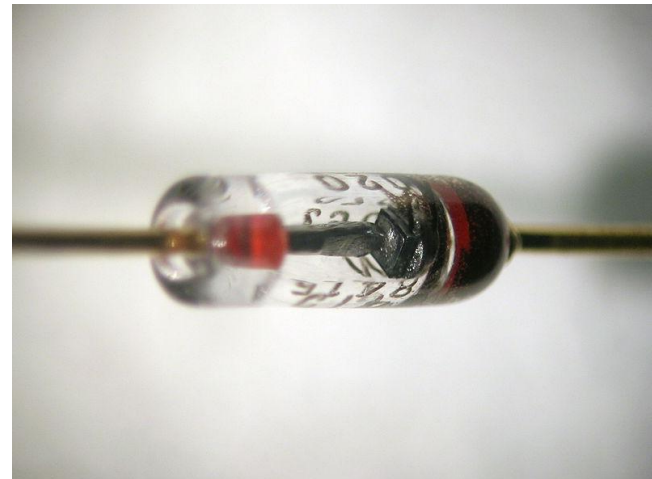
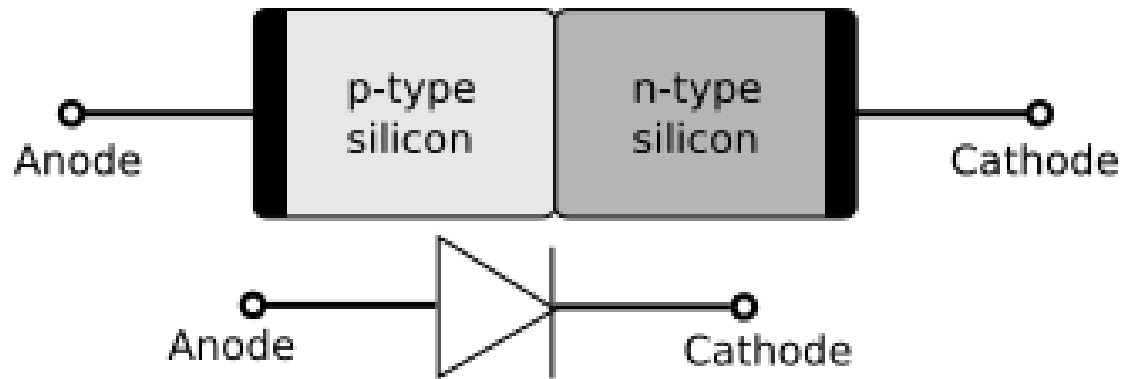
Thermochromic mug
Source: [Damianosullivan](#)

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

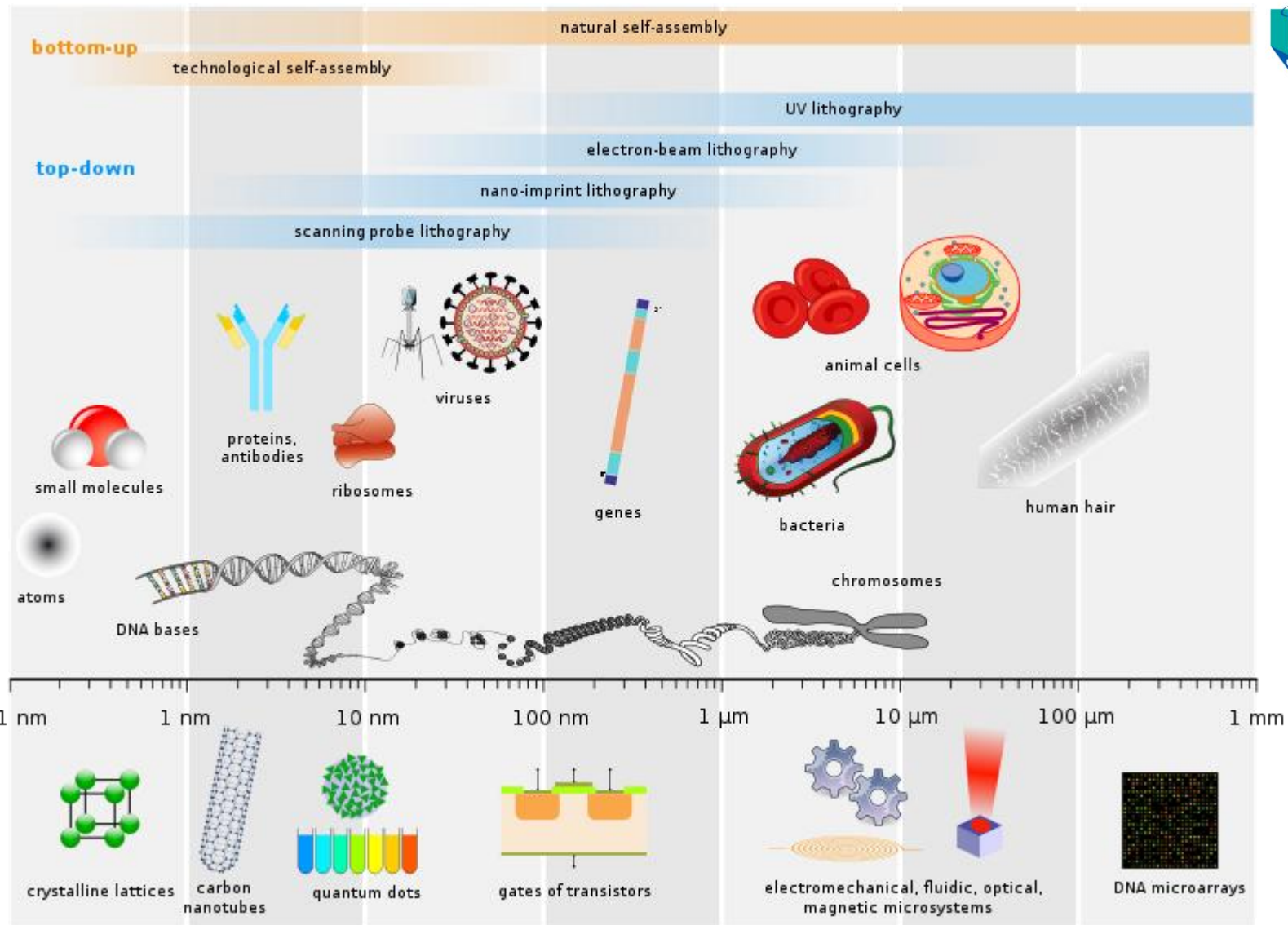
Electronic devices that combine p-type and n-type regions of semiconductor, which create two-terminals and conduct current in one direction.



Sources: [Raffamaiden](#); [Morcheeba](#)

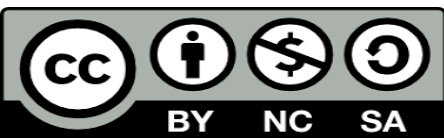
NANOMATERIALS

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



Biological and technological scales compared

Source: [Guillaume Paumier](#)



WE LIVE IN A NANO WORLD

Nanomaterials– defined as having one dimension below **100 nanometres** – are all around us.

A **NANOMETRE** HAS THE SAME RELATION TO A METRE AS THE **DIAMETER** OF A **HAZELNUT** HAS TO THE DIAMETER OF THE **EARTH**



A FEW EXAMPLES OF THE MANY WAYS WE USE ENGINEERED NANOMATERIALS



SOLAR CELLS

QUANTUM DOTS CAN IMPROVE SOLAR CELL EFFICIENCY AS THEY CAN BE "TUNED" TO ABSORB LIGHT ACROSS THE SOLAR SPECTRUM



SUN CREAM

ZINC OXIDE PARTICLES CAN HELP PROTECT AGAINST UV RAYS BY REFLECTING IT AWAY FROM THE SKIN



CLOTHING

SILVER NANOPARTICLES CAN PROVIDE POWERFUL ANTIBACTERIAL PROPERTIES, WHILE SILICA PARTICLES CAN REPEL WATER AND PREVENT STAINS.



BATTERIES

NANOPARTICLE-BASED ELECTRODES CAN IMPROVE THE LIFE-CYCLE OF RECHARGEABLE LITHIUM-ION BATTERIES



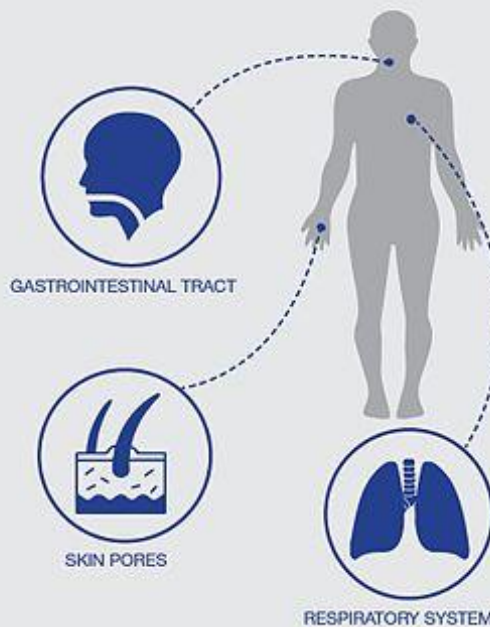
MEDICINE

GOLD NANOPARTICLES CAN DELIVER CHEMOTHERAPY DRUGS DIRECTLY TO CANCER CELLS

POSSIBLE DANGERS

THE HUMAN BODY USES NATURAL NANOMATERIALS, SUCH AS PROTEINS, TO CONTROL MANY SYSTEMS AND PROCESSES.

WHILE ENGINEERED NANOMATERIALS ARE OBVIOUSLY USEFUL, THEIR SMALL SIZE MEANS THEY ARE ABLE TO ENTER THE BODY AND POTENTIALLY INTERFERE WITH IMPORTANT FUNCTIONS OF LIVING ORGANISMS



THE NEED FOR TESTING

1500

THE APPROXIMATE NUMBER OF NANO-ENABLED PRODUCTS CURRENTLY ON THE MARKET

CURRENTLY, EACH NEW NANOMATERIAL MUST BE SAFETY-TESTED INDIVIDUALLY. THIS IS BOTH EXPENSIVE AND TIME-CONSUMING



200

THE NUMBER OF NEW NANO-ENABLED PRODUCTS ENTERING THE MARKET EACH YEAR



CHEAPER AND FASTER METHODS FOR TESTING ARE NEEDED TO ENSURE THAT WE CAN ENJOY THE BENEFITS OF NANOMATERIALS AND THAT THEY ARE SAFE TO USE

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Research Interest:

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- Metals and Alloys.

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