Introduction
Nanotechnology
and Nanomaterials

1 nanometer =
1×10^{-9} meter
1×10^{-3} µm
3.281×10^{-9} feet
39.37×10^{-9} inches

Contents

Introduction

is science, engineering, and technology conducted at the nanoscale (about 1 to 100 nanometers)
Nano can refer to technologies, materials, particles, objects

To manipulate the size and shape of materials at the nanometer scale (atomic, molecular, and macromolecular scale) , in order to produce materials with at least one novel/superior characteristic or property

Why nanoscale

People are interested in the nanoscale because at this scale physical and chemical properties of materials differ significantly from those at a larger scale.

What is Nanoscale?

atom

0.1 nm

carbon nanotube diameter

5-10 nm

transistor

35 nm

red blood cell

10 µm

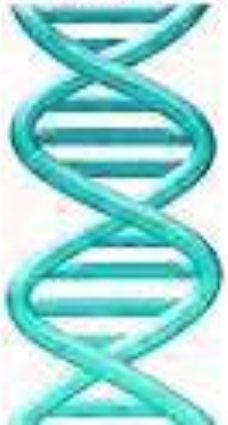
grain of sand

1 mm

10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6} nm

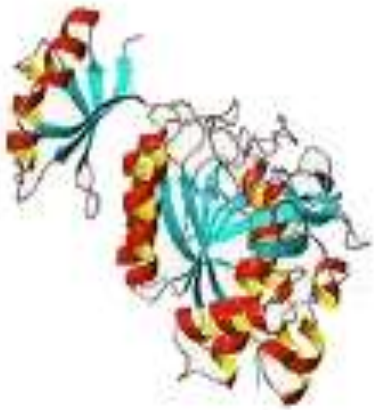
1 nm

DNA diameter



10 nm

protein



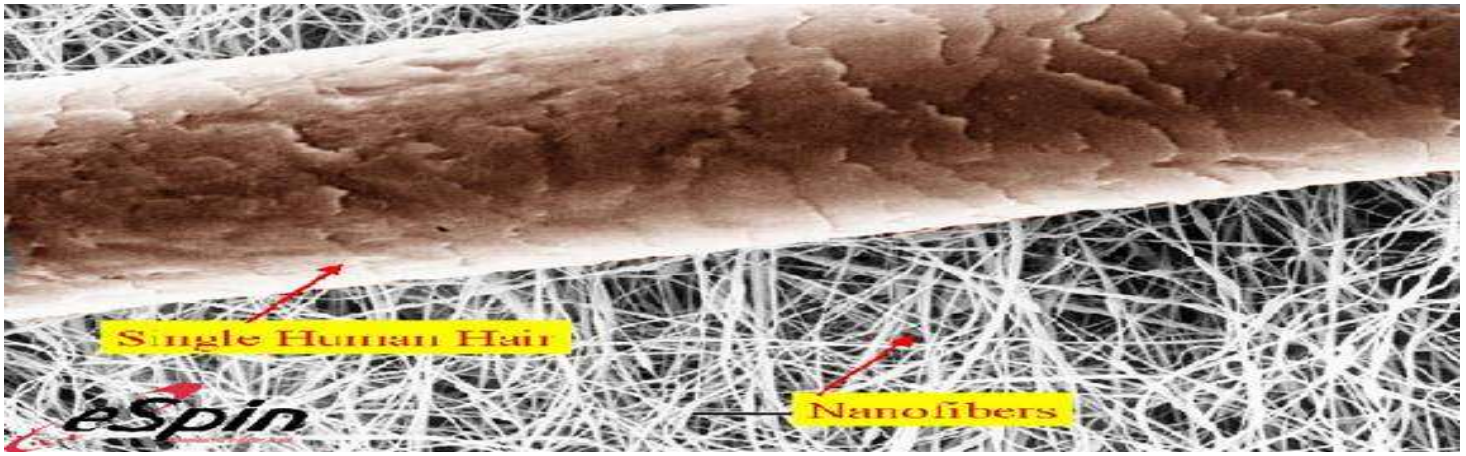
150 µm

human hair diameter

1 nanometer = one billionth of a meter

What is Nanoscale?

Human hair: 50,000 nm across
Bacteria: About 200 nm across
10 Hydrogen atoms lined up: 10 nm
Nanotechnology: Build structures from1 to 100 nm



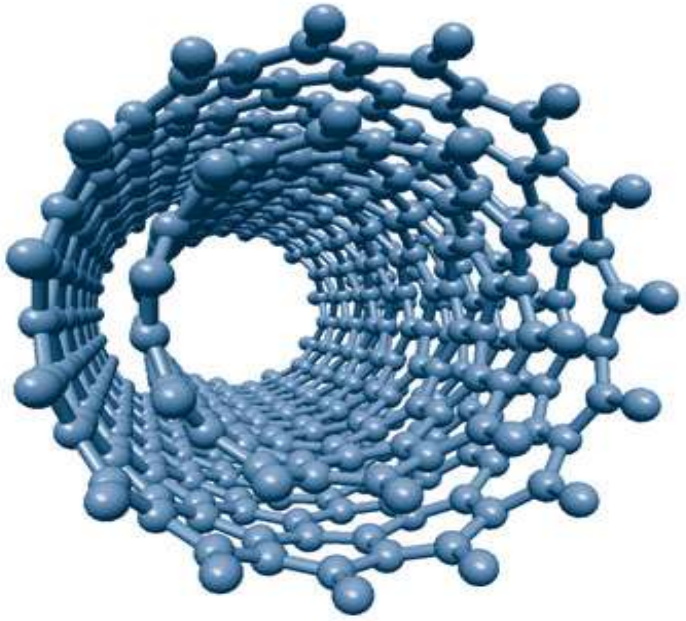
What is Nanomaterial?

Is defined as **any material that has unique or novel properties, due to the nanoscale (nano metre- scale) structuring**.

They are subdivided into nanocrystals, nanopowders, and nanotubes:

Nanotubes are extremely strong mechanically and very pure conductors of electric current. Applications of the nanotube,include resistors, capacitors, i nductors, diodes and transistors

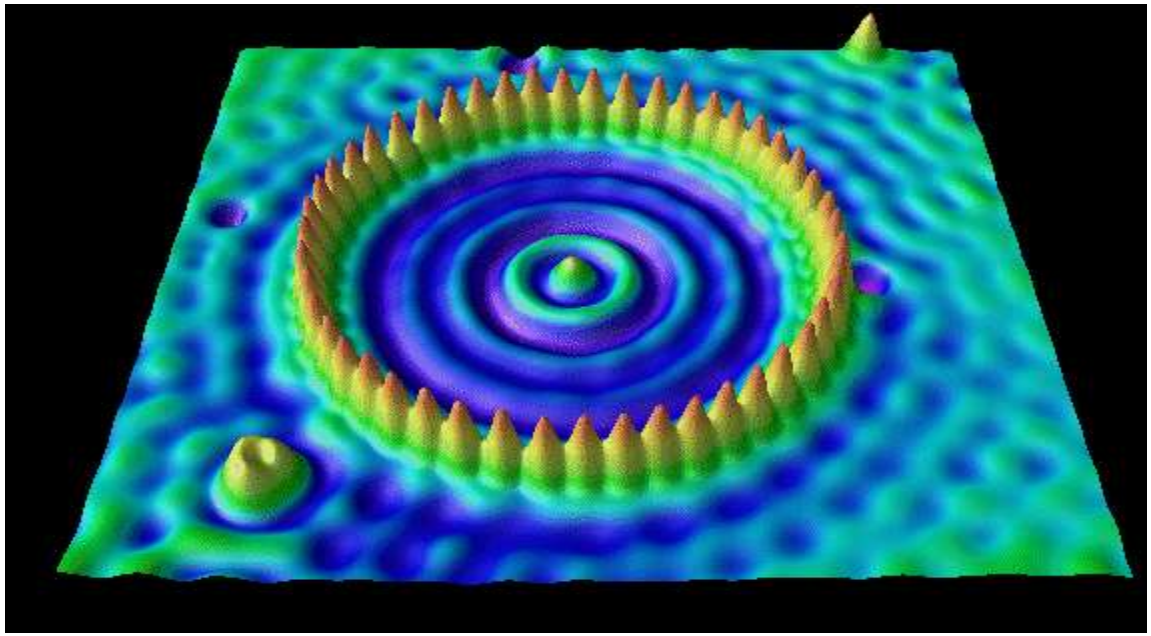
nanopowder



carbon nanotubes

Nanomaterials are interesting because at the small scale, materials have fundamentally **different properties than at the bulk due to increased surface area to volume ratios**

Increased interaction and reactivity is one of the by products of materials that are nanoscale, which means potentially using less of the material or that even on the nanoscale the properties are so utterly different from that of the bulk scale



Quantum corral: ***Fe atoms on Cu(111) (r=7.3 nm)***

Nanomaterials' characteristics

The properties of materials with nanometer dimensions are significantly different from those of atoms and bulks materials

This is mainly due to the nanometer size of the materials which render them:

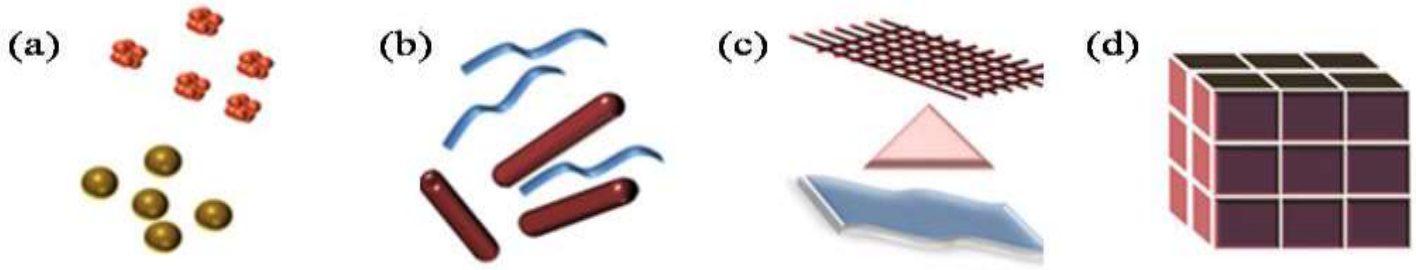
I. **large fraction of surface atoms;** have extremely large surface area to volume ratio
II. **high surface energy.**
III. **spatial confinement.**
IV. **reduced imperfections, which do not exist in the corresponding bulk material**

This in turn greatly enhanced all other properties such as electrical, magnetic, mechanical and optical.

Classification of Nanomaterials

Nanomaterials have extremely small size which having at least one dimension 100 nm or less.Nanostructured materials are classified as

1) **Zero dimensional**,
2) **one dimensional**
3) **two dimensional**
4) **three dimensional nanostructures**



(a) 0D spheres and clusters, (b) 1D nanofibers, wires, and rods, (c) 2D films, plates, and networks, (d) 3D nanomaterials

Nanomaterial - synthesis and processing

Nanomaterials deal with very fine structures: a nanometer is a billionth of a meter. This indeed allows us to think in both;

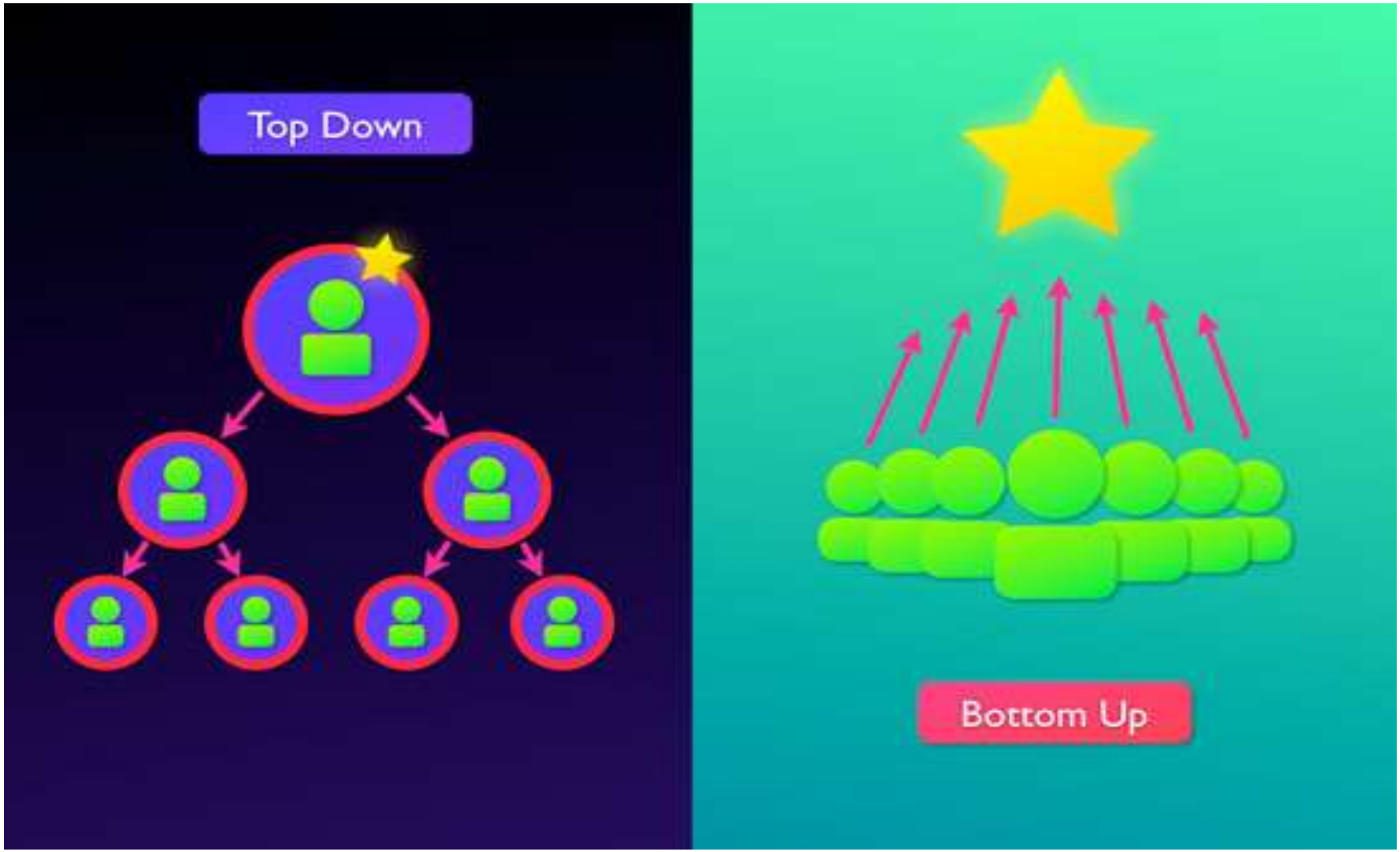
1. Bottom up approach:

To assemble atoms together which consisting of sol-gel method, precipitation. Bottom-up approach to manufacturing is analogous to the way biological systems are made, i.e. proteins

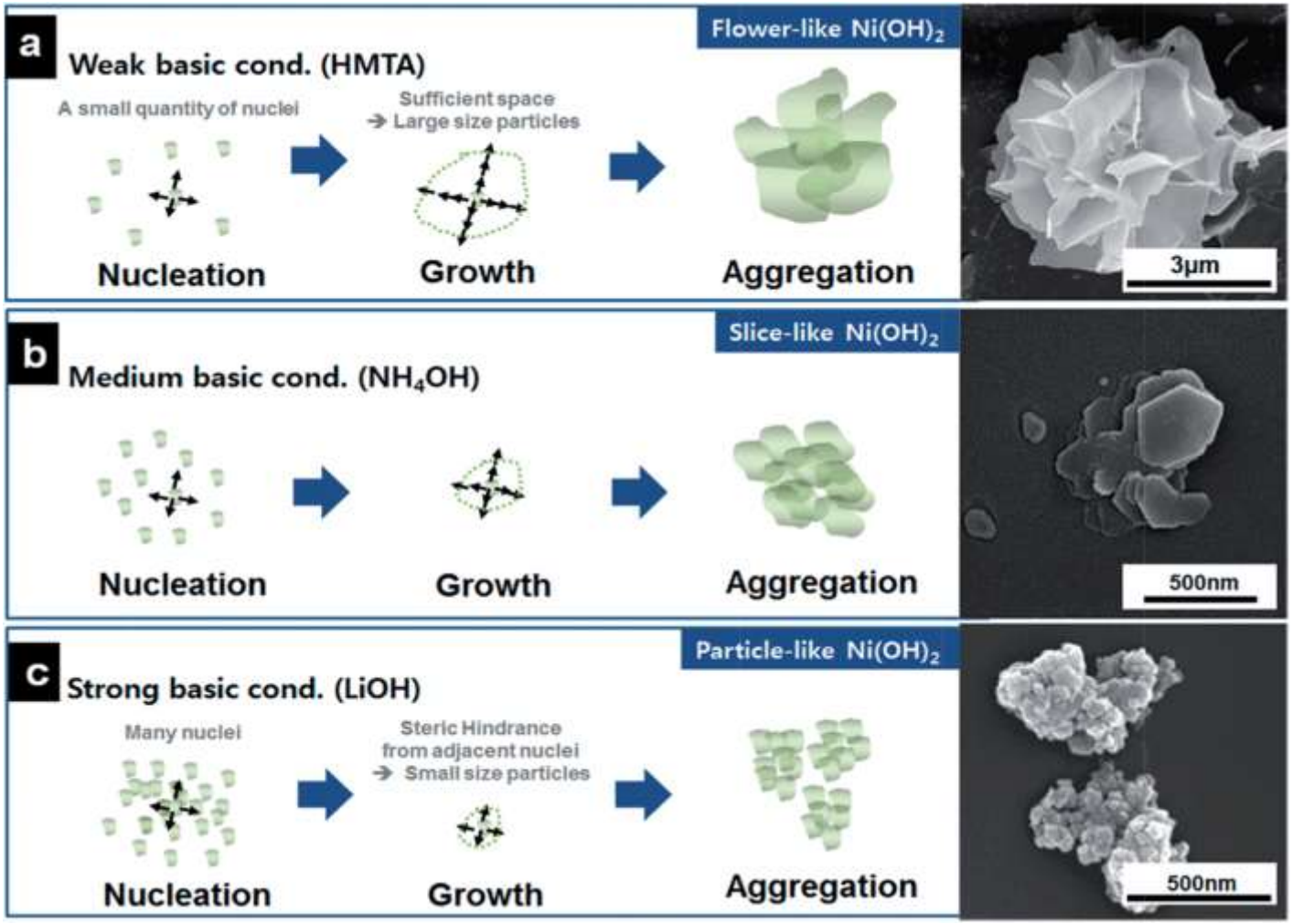
2. Top down:

To dis-assemble (break, or dissociate) bulk solids into finer pieces until they are constituted of only a few atoms. This could be achieved via mechanical grinding.

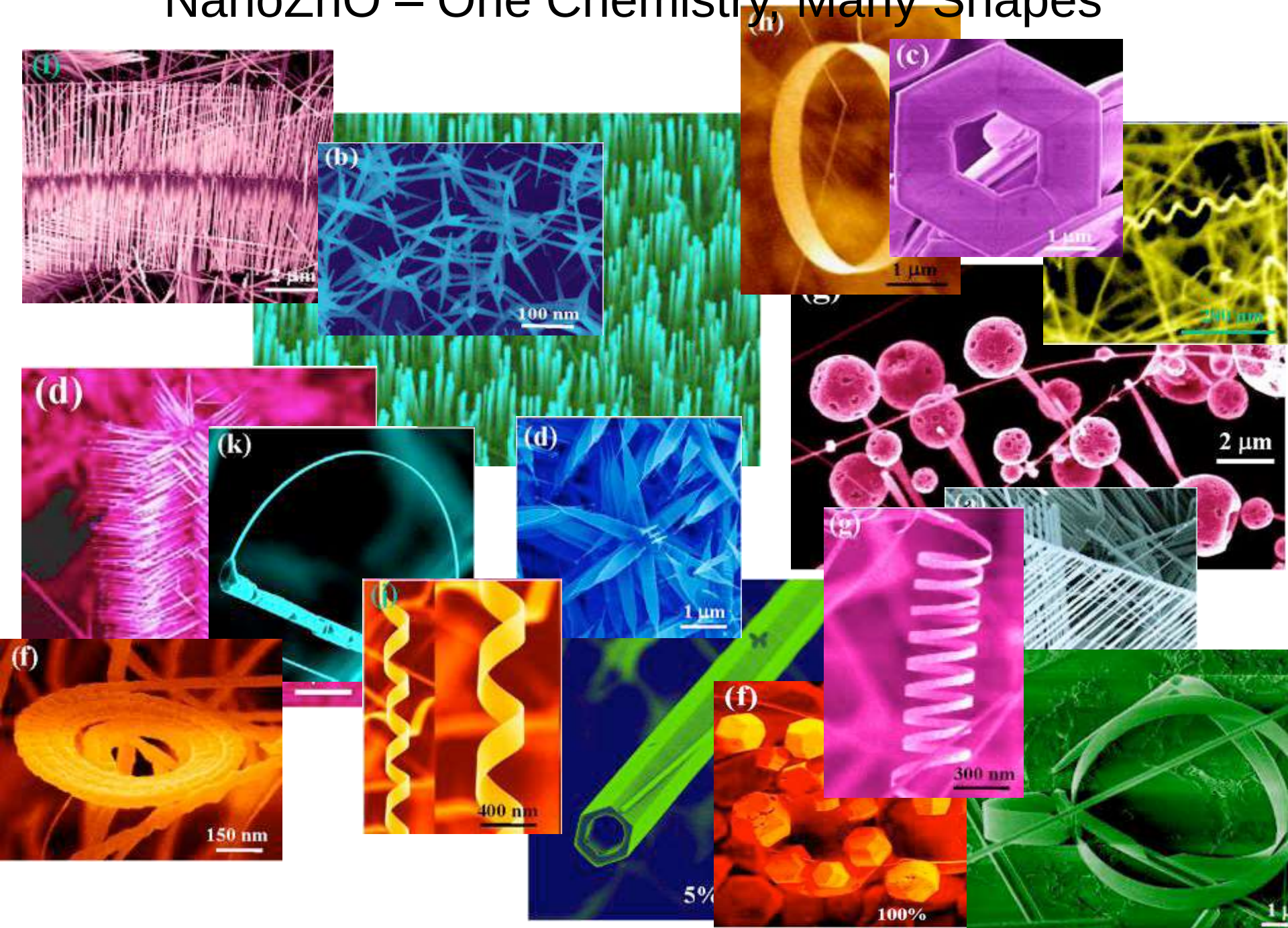
Synthesis of nanomaterials



Different Nanostructures Obtained by controlling the reaction parameters



NanoZnO – One Chemistry, Many Shapes

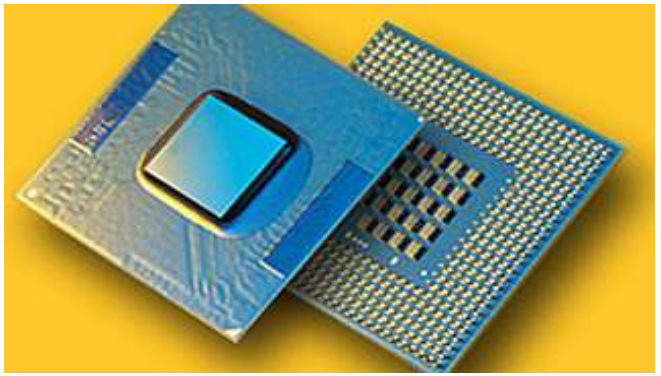


Examples

Top-down

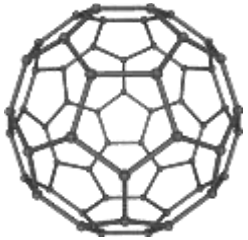
Etching a block of material down to the desired shape.

Chips and processors



Bottom-up

Building materials atom by atom such as C60, carbon nanotubes, quantum dots

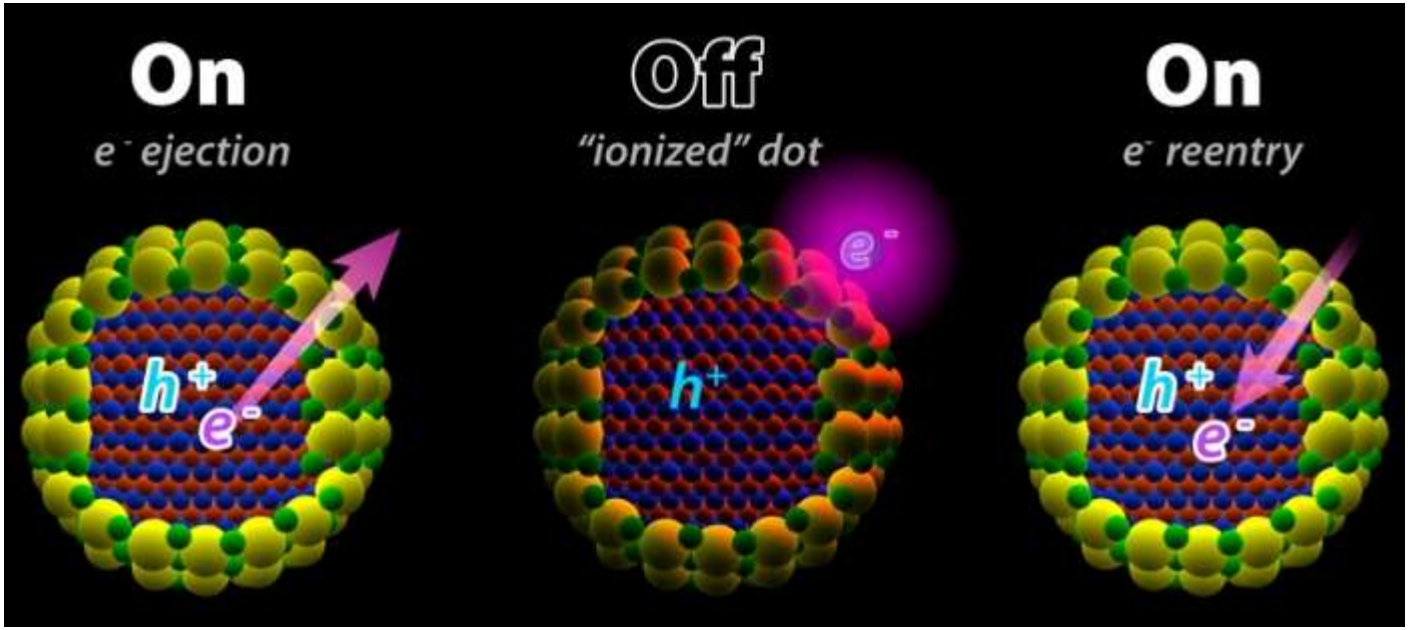


C60

Applications

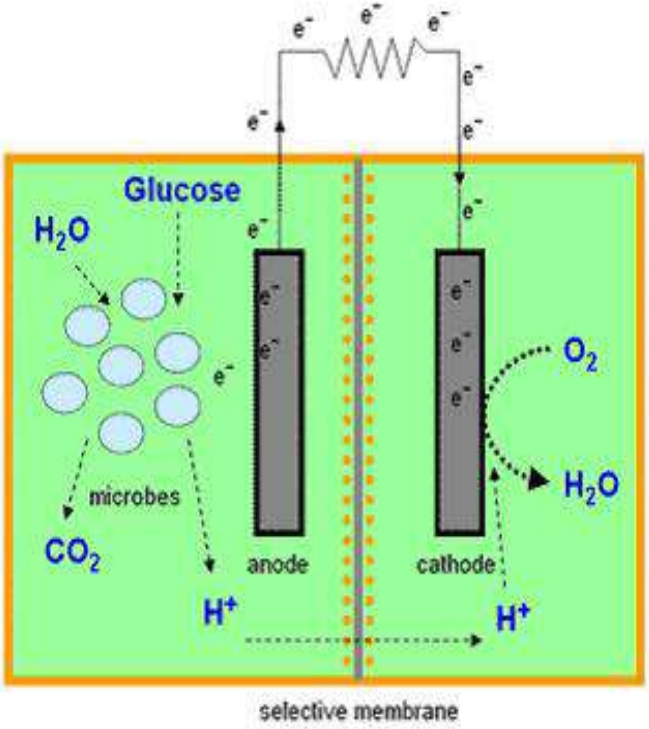
Quantum dots

(**QD**) are very small semiconductor particles, only several nanometres in size, so small that their optical and electronic properties differ from those of larger particles. They are a central theme in nanotechnology.



Microbial fuel cell

Is a device in which bacteria consume water-soluble waste such as sugar, starch and alcohols and produces electricity plus clean water. This technology will make it possible to generate electricity while treating domestic or industrial wastewater



Carbon nanotubes (CNTs) have chemical stability, good mechanical properties and high surface area, making them ideal for the design of sensors and provide very high surface area due to its structural network. Since carbon nanotubes are also suitablesupports for cell growth, electrodes of microbial fuel cells can be built using of CNT

Phosphors for High-Definition TV

The resolution of a television, or a monitor, depends greatly on the size of the pixel.
These pixels are essentially made of materials called "phosphors," which glow when struck by a stream of electrons inside the cathode ray tube (CRT). The resolution improves with a reduction in the size of the pixel, or the phosphors. Nanocrystalline zinc selenide, zinc sulfide, cadmium sulfide, and lead telluride synthesized by the sol-gel techniques are candidates for improving the resolution of monitors

Next-Generation Computer Chips

The microprocessors, which contain transistors, resistors, and capacitors, , can run much faster, thereby enabling computations at far greater speeds by achieving a significant reduction in their size,

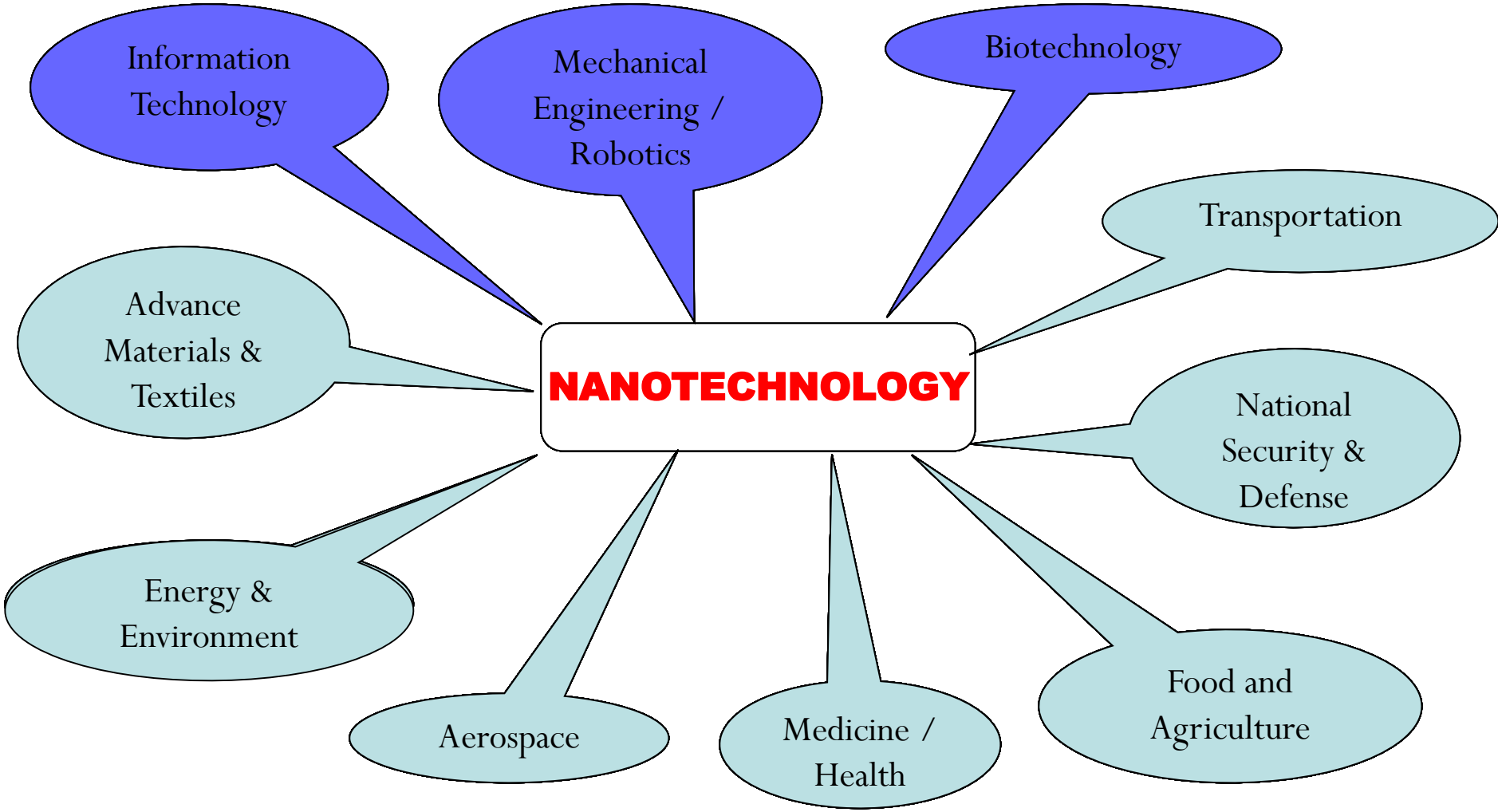
However, there are several technological challenging to these advancements, including:

1. **lack of the ultrafine precursors to manufacture these components.**
2. **poor dissipation of tremendous amount of heat generated by these microprocessors due to faster speeds.**
3. **short mean time to failures (poor reliability).**

Nanomaterials help the industry break these barriers

down by providing the manufacturers with nanocrystalline starting materials, ultra-high purity materials, materials with better thermal conductivity, and longer-lasting, durable interconnections (connections between various components in the microprocessors). **Example:** Nanowires for junctionless transistors

Nanotechnology spans many Areas



More applications?

To Where your imagination can take you