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Lab. 6: Nanomaterials characterization

2. Imaging of Nanomaterials

Electron Microscopy:

- Uses some type of probe that generates an image by physically scanning the sample surface in a horizontal scan pattern

- Depending on the type of microscope, several different surface characteristics can be analyzed.

Some types of electron microscope

1. Scanning Electron Microscope (SEM)

2. Transmission Electron Microscope (TEM)

3. Atomic Force Microscope (AFM)

4. The Scanning Transmission Electron Microscope (STEM)

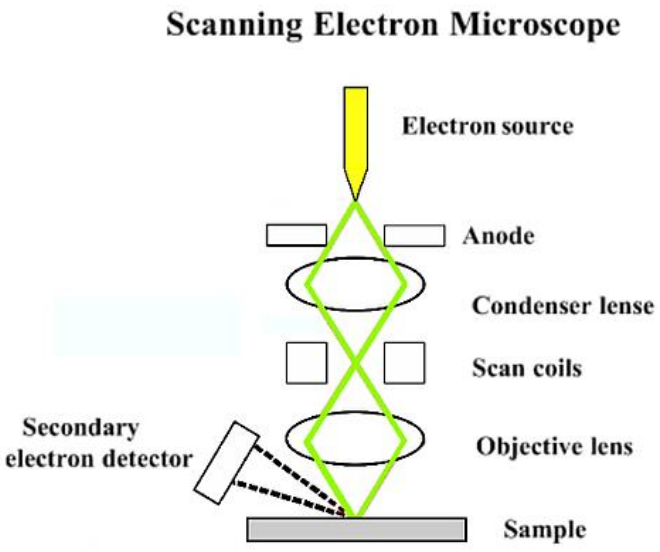
1. Scanning Electron Microscope (SEM)

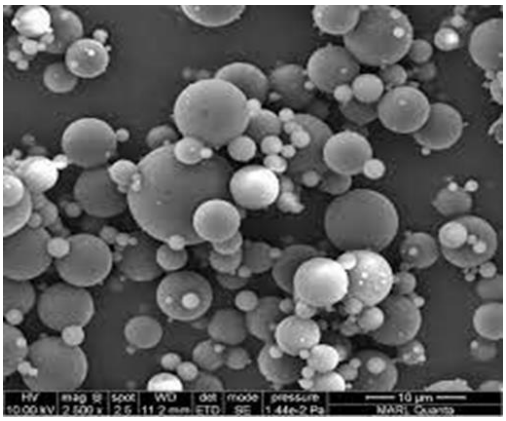
- Type of Electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons.

- The electrons interact with atoms in the sample.

- Producing various signals that contain information about the surface topography and composition of the sample

- Generates photo-like images.





Limitations:

1- Samples must have surface electrical conductivity.

2- Non-conductive samples need to be coated with a conductive layer (Like silver paste).

2. Transmission Electron Microscope (TEM)

Image is generated based on the interaction pattern of electrons that transmit through the specimen.

Advantages:

- High-resolution, 3-D image construction possible but aberrant.

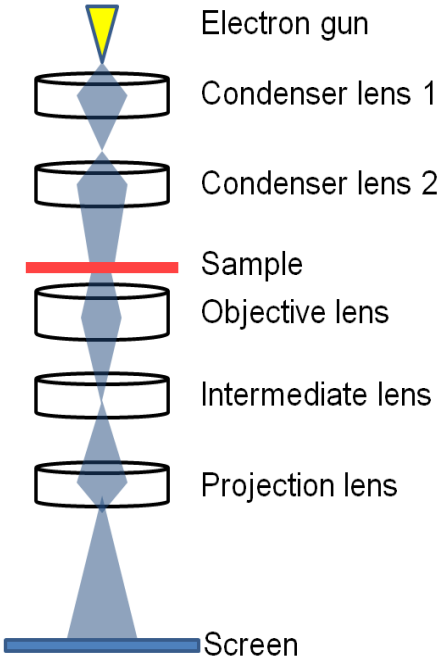
- Additional analysis techniques like X-ray spectrometry are possible.

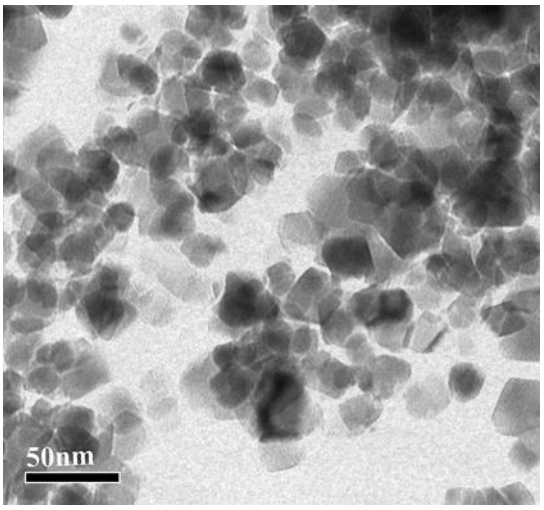
Limitations:

1- Needs high-vacuum chamber

2- Sample preparation necessary

3- Mostly used for 2-D images





Classification of Nanomaterials

Nanomaterials can be classified dimension wise into following categories.

• Zero dimension nanomaterials: all three dimensions are compressed into nanoscale, such as nanoparticles.

• One dimension nanomaterials: this group includes materials with two dimensions in nanoscale like polymer chains.

• Two dimensions nanomaterials: one of their three dimensions is pressed in nanoscale such as thin films

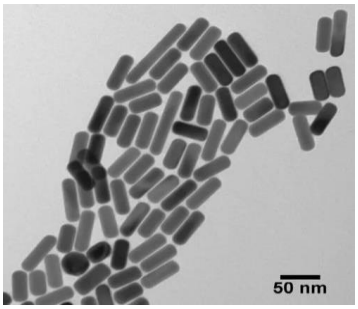
• Three dimensions nanomaterials: all of their three dimensions is pressed in nanoscale such as nanoflowers.

Nanomaterials shapes

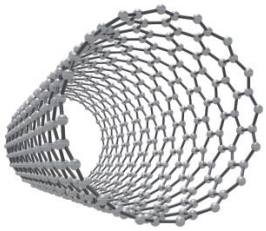
Nanofibres

Nanofibre is the generic term describing nano – objects with two external dimensions in the nanoscale.

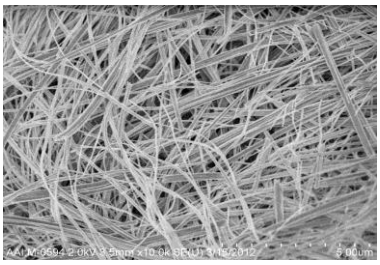
1. Nanorod: is a rigid nanofibre



2. Nanotube: is a hollow nanofibre.



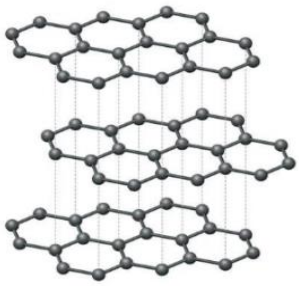
3. Nanowire: is an electrically conducting nanofibre



Graphene – based materials

• Graphene is an allotrope (different structural modification of an element) of carbon in the form of two dimensional, atomic –scale, hexagonal lattice in which one atom forms each vertex.

• It is the basic structural element of other allotropes including graphite, charcoal, carbon nanotubes and fullerenes (carbon in a hollow sphere, tube or other shapes.



Graphite structure

a) Graphene:

the graphene lamellae stacked to make bulk graphite were from the ease of their detachment (like writing with graphite on paper) known to be only weakly bound to each other.

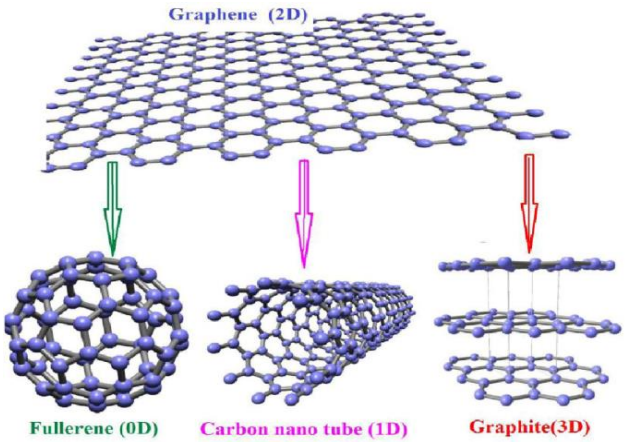
b) Carbon nanoparticles:

Fullerenes can be a graphene curled up to form an enclosed spherical shell (exist as C^{60}, C^{70}).

They can have made in carbon arc or burning hydrocarbons methods.

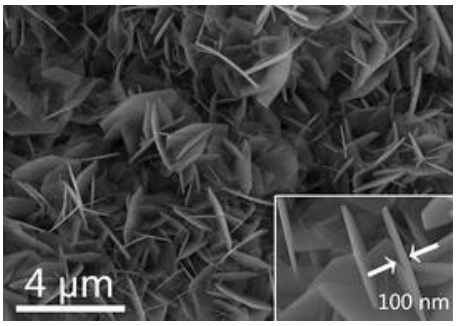
c) Carbon nanotubes (CNT):

The carbon nanotube is a seamless tube made by rolling up graphene. Carbon filaments are formed by passing hydrocarbons over hot metal surface.



Nanoplates

Thin coating on a substratum have not been consider as nano- objects, but simply as a thin film, because typically they have been more than 100 nm thick.



Aggregation and Agglomeration of nanomaterials

► Aggregation: Attraction of nanomaterials by weak forces such as Van der Waals forces.

► Agglomeration: Attraction of nanomaterials by stronger forces like covalent bonds and ionic bonds.

● This concept explained by classical DLVO theory (Derjaguin, Landau, Verwey and Overbeek theory) which assume that the balance between repulsion and attraction potential energies control dispersed particles interaction, particles with the same charge propagation layer and particles-solvent interaction causes repulsive force, the type of interaction between particles defined by the sum of these two forces.