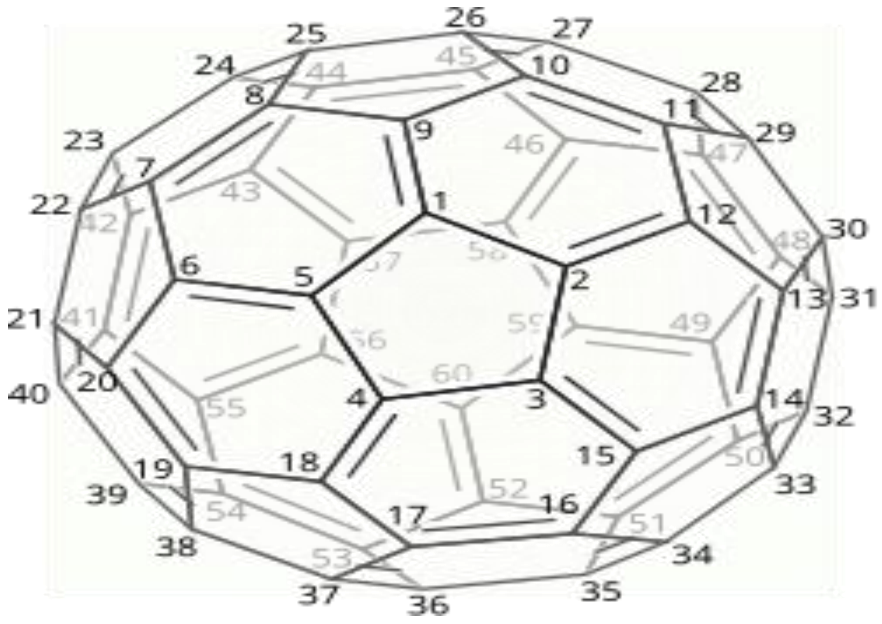


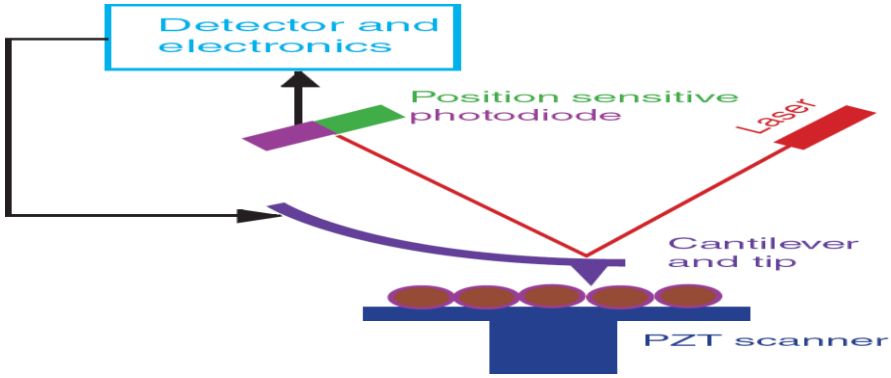
12 - Techniques Used for Nano Structure Studies:

The study of nanostructures requires devices that have the ability to magnify thousands of times to study their structural and surface properties in the finest detail and at the molecular or atomic level. Among these techniques are:(Atomic Force Microscope (AFM) , Scanning Electron Microscope (SEM) , Raman Spectroscopy)

1 - Atomic Force Microscope (AFM) :

Atomic force microscopy is one of the most important techniques used to study surface topography and detect the presence of nanostructures in metallic samples or those characterized by their ability to conduct electricity, as well as to study their structural properties, such as the diameter of carbon nanotubes.
This microscope includes a micro-scale cantilever arm that is characterized by its ability to vibrate, and a tip with a radius of curvature within the nanometers is fixed at one of its ends. The back of this arm consists of a reflective mirror, a laser source, a sensitive laser beam

detector, and a piezoelectric tube scanner that can move in three directions (x, y, z), in addition to electronic circuits to control the microscope.

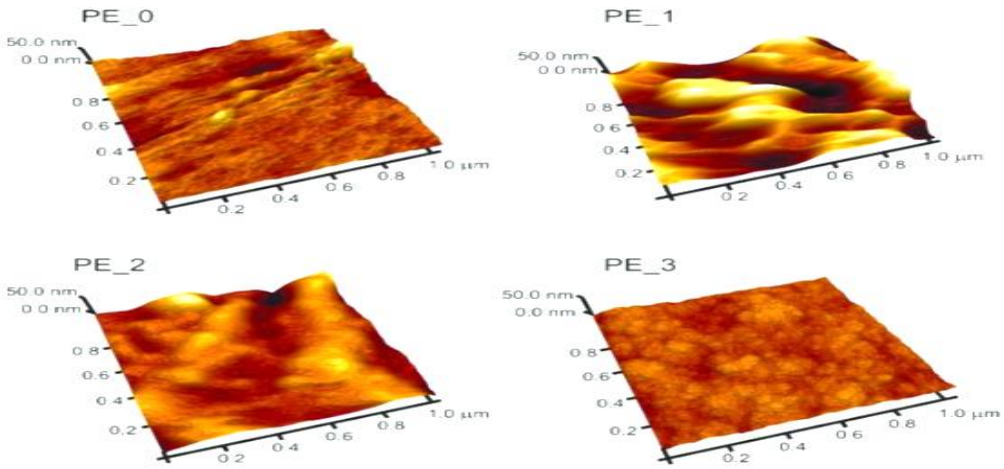


Schematic diagram of an Atomic Force Microscope (AFM)

The basis of the operation of the atomic force microscope generally depends on the van der Waals force (VdW) interactions generated between the atoms of the sample surface and the tip fixed to the arm of the microscope. This force is repulsive if the distance between the tip atoms and the surface atoms is close and attractive if the distance between them is long. [Rouholla Alizadegan et al, 2012].

This generated force will cause the arm to move, which in turn will lead to a change in the laser's reflection point on the detector, according to Hook's law. This is also accompanied by the movement of the scanner in the Z direction, depending on the nature of the force, to avoid any damage to the sample under examination. There are also two movements of the scanner in the x and y directions to move across the sample surface and image it [J. H. Hafner et al., 2001], [Jin Zhng Zhang, 2009].

It is worth noting that the radius of the head is approximately (2-20 nm), which is equal to or greater than the radius of the carbon nanotubes, causing some distortions during the examination and detection of carbon nanotubes, as shown in Figure (39-2) [Ethan Davis Minot, 2004].



The atomic force microscope operates in two modes depending on the nature of the sample to be imaged (Contact Mode , Intermittent or Tapping Mode).

2 - Scanning Electron Microscope (SEM) :

This type of microscope is used to image the surfaces of samples with a resolution of up to 1 nm.

The image resolution in the electron microscope depends on two things: the first is the properties of the electron beam and the second is the nature of the interaction between the electron beam and the sample surface.

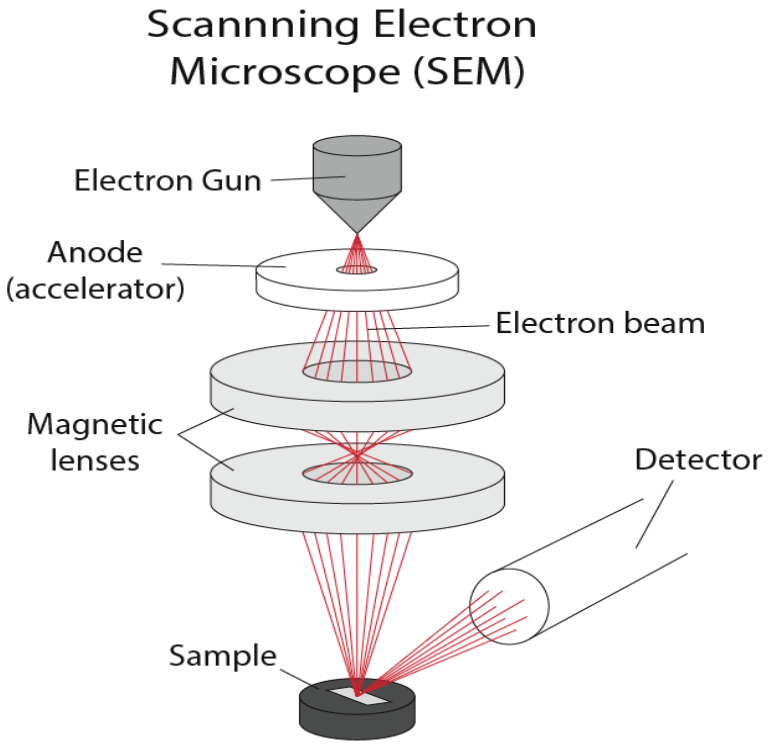
This interaction will lead to the generation of secondary electrons emitted from the sample with energies often less than (50 eV) and depends on the nature of the surface, the nature of the bonding in the sample surface and the elements present in the sample.

Therefore, this microscope gives us information about the surface topology and morphology of the samples and their chemical composition.

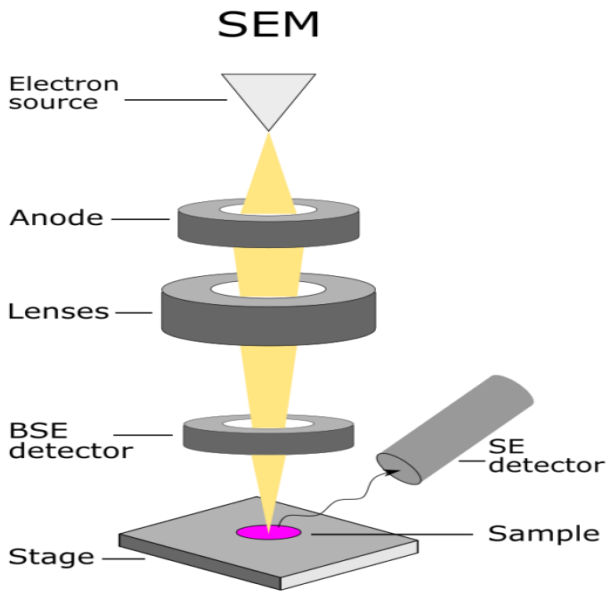
The microscope consists of an electron gun, a set of condensed lenses, and scanning coils.

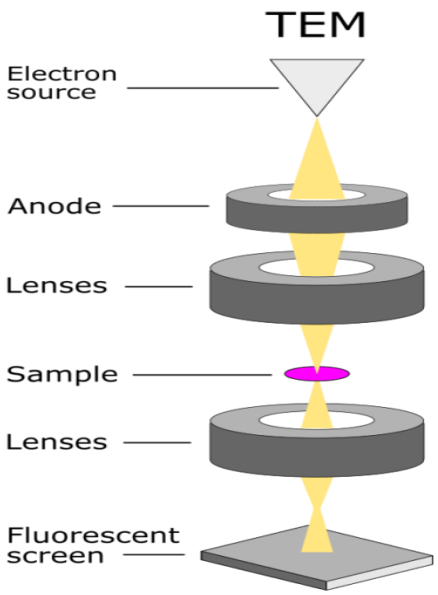
The electron gun generates a cloud of electrons that is focused using the condensing lenses, which reduce the width of the electron beam incident

on the specimen. The coils move the electron beam across the surface of the specimen for imaging.



When the electron beam hits the sample, secondary electrons, rays, scattered electrons, and Auger electrons are emitted. By studying the X-rays using a technique known as energy dispersive X-ray (EDX) spectroscopy, we can identify the elements that make up the sample [Jin Zhng Zhang, 2009]. This type of electron microscope is used to detect the diameters of carbon nanotubes and distinguish between single- and multi-walled tubes .


SEM
Electron source
Anode
Lenses
BSE detector
SE detector
Stage
Sample


TEM
Electron source
Anode
Lenses
Sample
Lenses
Fluorescent screen