Al-Mustaqbal University-College

Department of medical physics

The Second Stage

Fifth lecture

Nanomaterials Analytical Tools

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Chapter Four

Nanomaterials Analytical Tools

أدوات تحليل المواد النانوية

a) Field Emission Scanning Electron Microscopy (FESEM) مجهر المسح الالكتروني لمجال الانبعاث

b) X-Ray Diffraction (XRD) حيود الاشعة السينية

c) Atomic Force Microscopy (AFM) مجهر القوة الذرية

d) Photoluminescence Spectrum (PL) اطياف اللمعان الضوئي

Field emission scanning electron microscopy (FESEM)

مجهر المسح الالكتروني لمجال الانبعاث

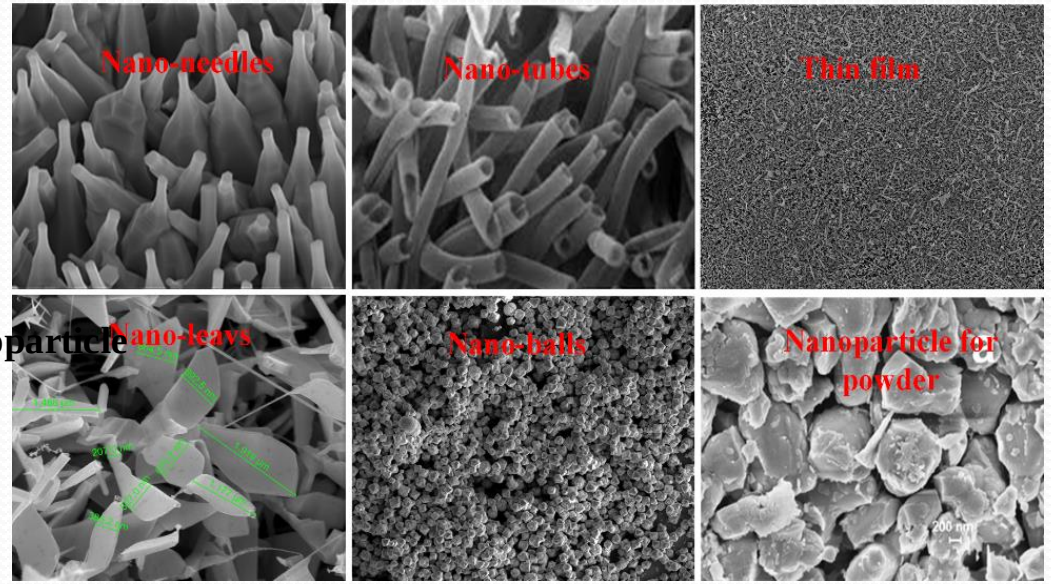
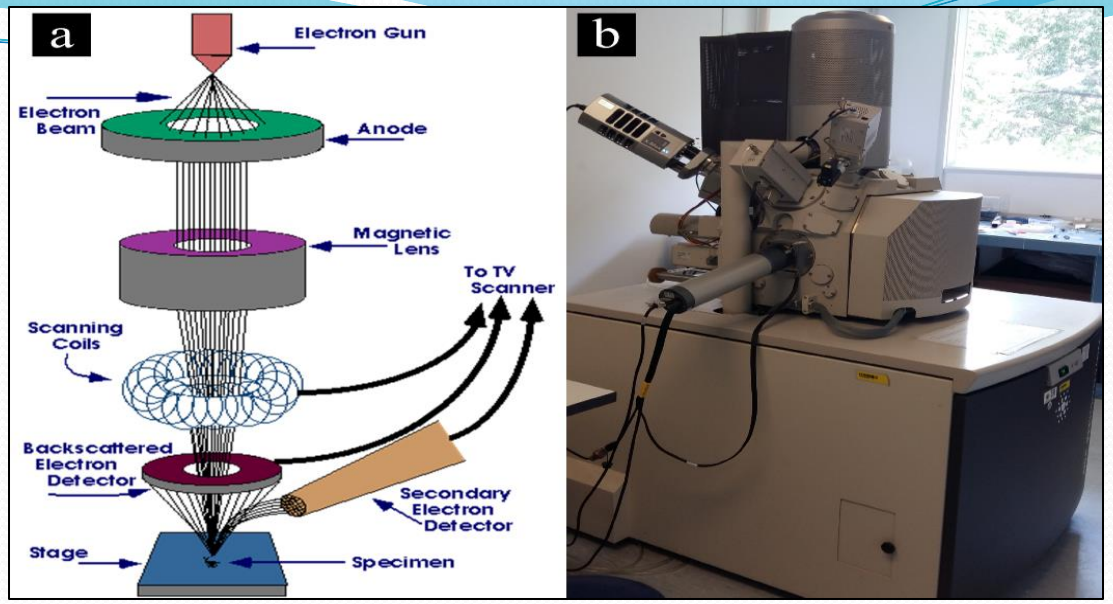


Fig. 1 : FESEM images of nanostructures and nanoparticle with different surface morphology

FESEM is a tool used to examine and analyse the surface morphology of the nano-materials

هي أداة تستخدم لفحص وتحليل التشكل السطحي (مورفولوجيا السطح) للمواد النانوية FESEM

Fig. 2 : Schematic diagram of field emission scanning electron microscope (FESEM), and (b) photograph of FESEM.



Components of FESEM: Electron gun, electron beam , electro-magnetic lens , scanning coils , TV scanner

- **How the FESEM works?**

The image of FESEM generated as a result of the electron beam from electron gun. This electron beam passes through the electro-magnetic lens and scanning coils which focusing onto the sample surface . As a result of the reflection of the electron beam from the film surface, the FESEM image is generated

X-ray diffraction (XRD) حيود الاشعة السينية

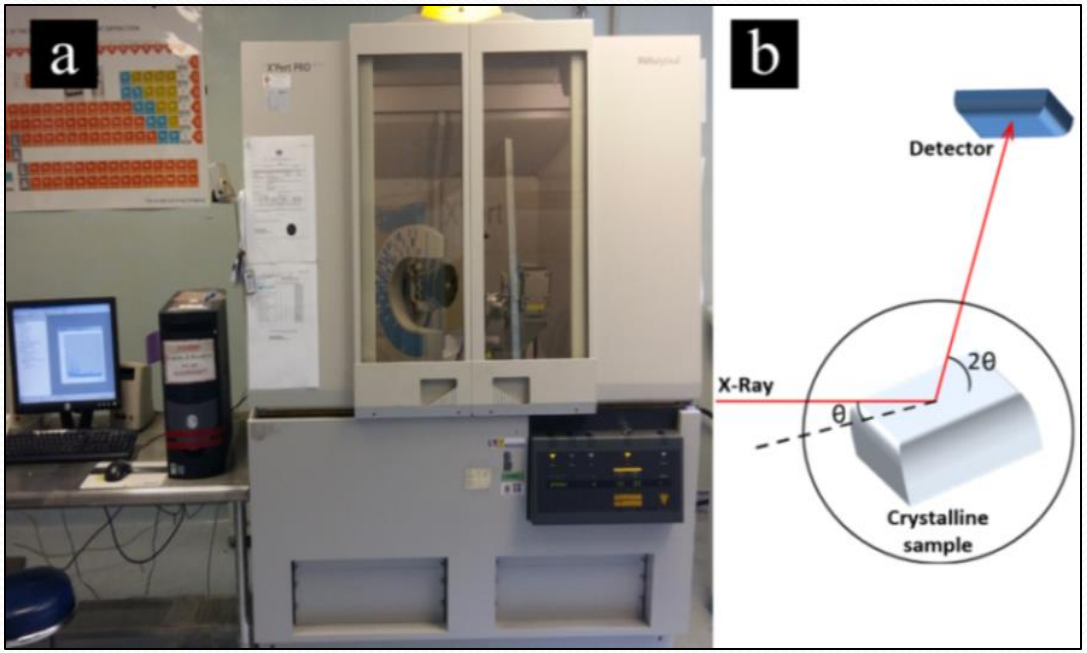


Fig. 3 : Sschematic diagram of an X-ray diffraction experiment.

X-ray diffraction **(XRD)** is a tool used to examine and analyse the quality, structures, orientation, and crystallite size of the nano-materials.

Components of XRD : X-ray tube, a sample holder, and X-ray detector.

- **How the XRD works?**

When the beam of X-ray incident at a certain angle onto parallel planes of atoms in the material . The diffraction pattern produced because of various atom planes. This case provide information related to the atom arrangement unit cell of crystal.

Miller indices (*h*, *k*, and *l*)

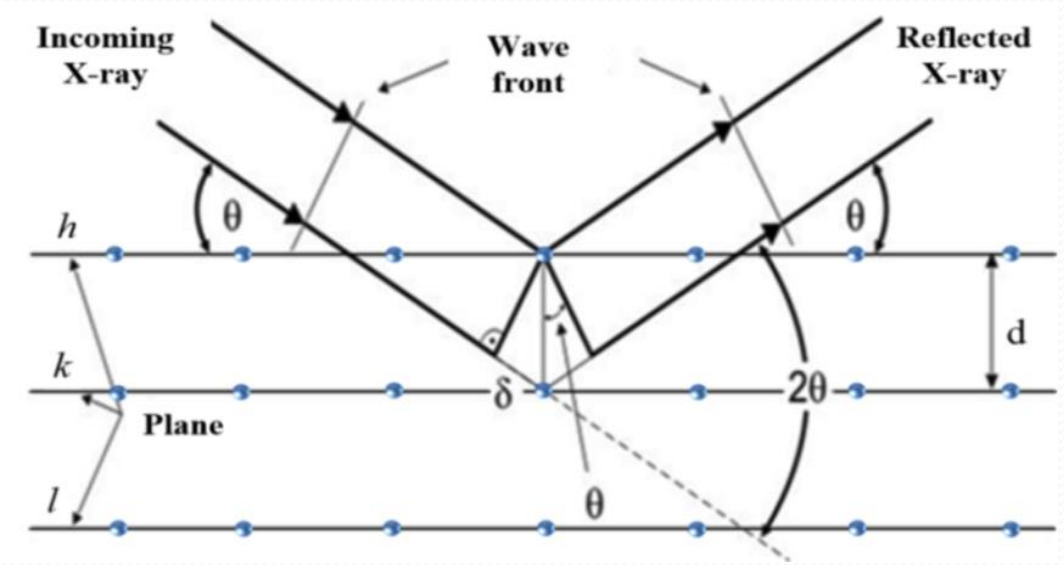


Fig. 4 : Diffraction of an X-ray beam on crystal planes,

Atomic force microscopy (AFM) is a common technique used to examine and analyse surface features of materials, such as surface roughness, agglomeration, and grain size

Components of AFM : probe tip , cantilever , laser diode , detector , scanner .

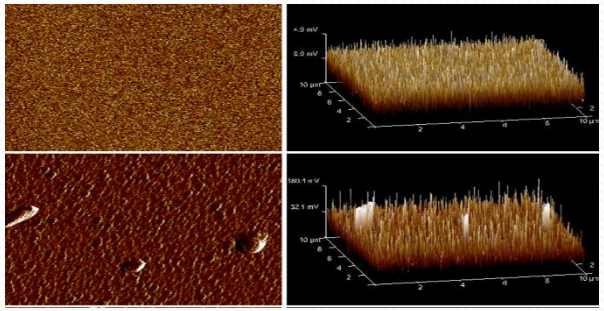


Fig. 5 : AFM images 2D and 3D of nanomaterials

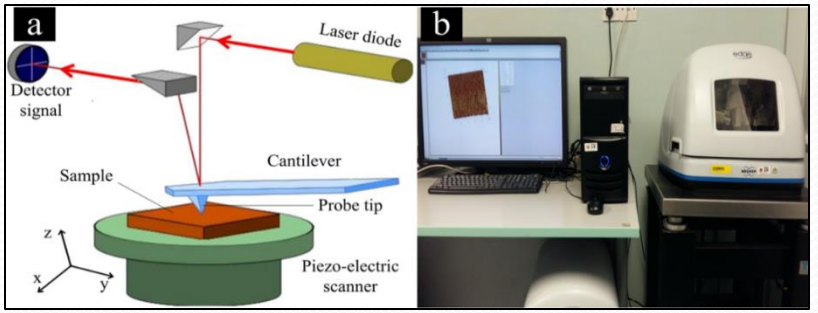


Fig. 6 : photograph of AFM

- **How the AFM works?**

The basis of the AFM system is Van der Waals force between the probe tip and the sample surface.

Van der Waals forces include attraction and repulsions between atoms, molecules, and surfaces

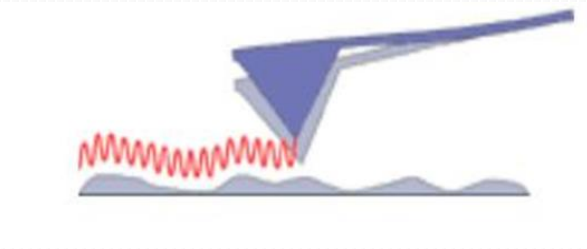


Fig. 7 : Non-contact mode

when the probe tip approaches the surface, the sensor between probe tip and film surface is generate (Van der Waals forces), which leads to move the probe tip and then the cantilever depending on surface of film (Fig. 7).

By use a reflection of laser spot from the top surface of the cantilever into an array of photodiode to detect the deflection of probe tip and cantilever . This case will generate the AFM image

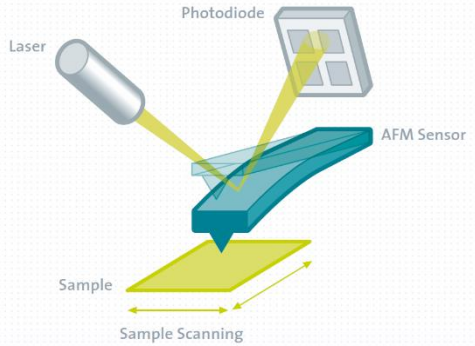
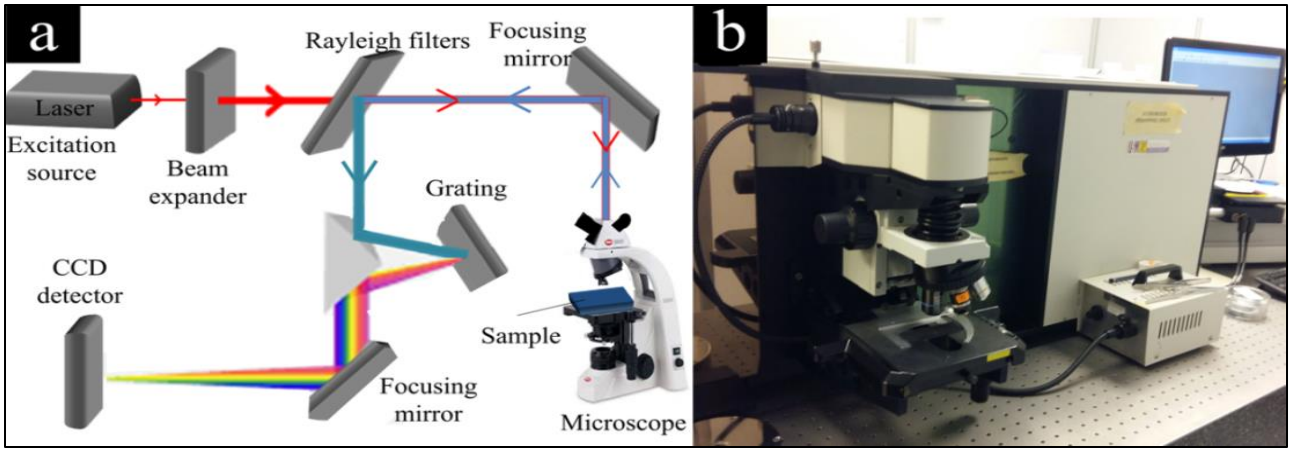


Fig. 8 : Schematic diagram of AFM tool

Photoluminescence spectroscopy (PL) is a powerful tool used to examine and analyse the optical properties of materials; this method provides information about the energy band gap value *Eg*, impurity densities, and possible presence of defect.

Components of PL : laser , beam expander , detector , microscope .



When a laser beam incident in the material, the laser photons ($Eexc > Eg$) encourage electrons to transport from valence band (VB) to conduction band (CB) leaving holes within the material. The excess energy after recombination of the excited electrons with the holes can emit photons that have the same energy of the tested sample energy band gap. The CCD detector collects these photon emissions, and the intensity is recorded as a function of emission energy to produce a PL spectrum