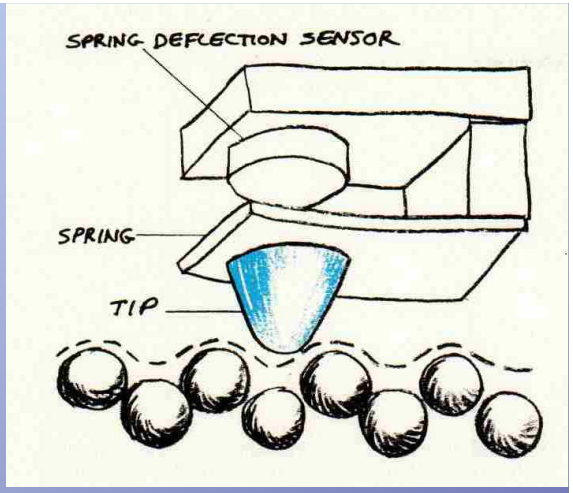
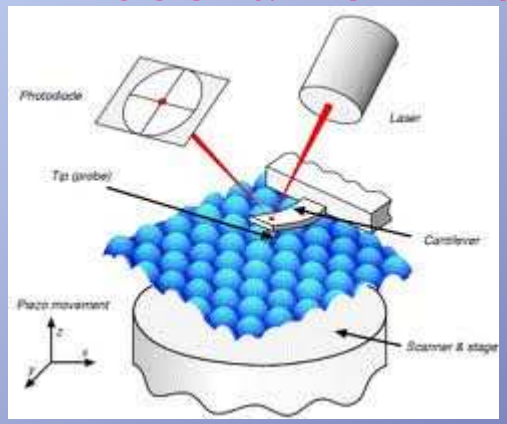
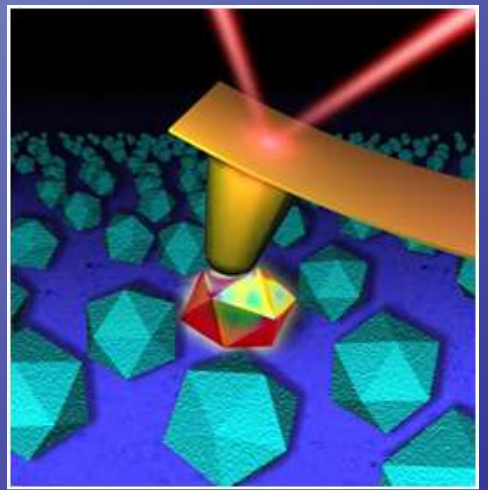
AFM
(Atomic Force Microscope)



The Atomic Force Microscope is an instrument that can analyze and characterize samples at the microscope level. This means we can look at surface characteristics with very accurate resolution less than 1μm.



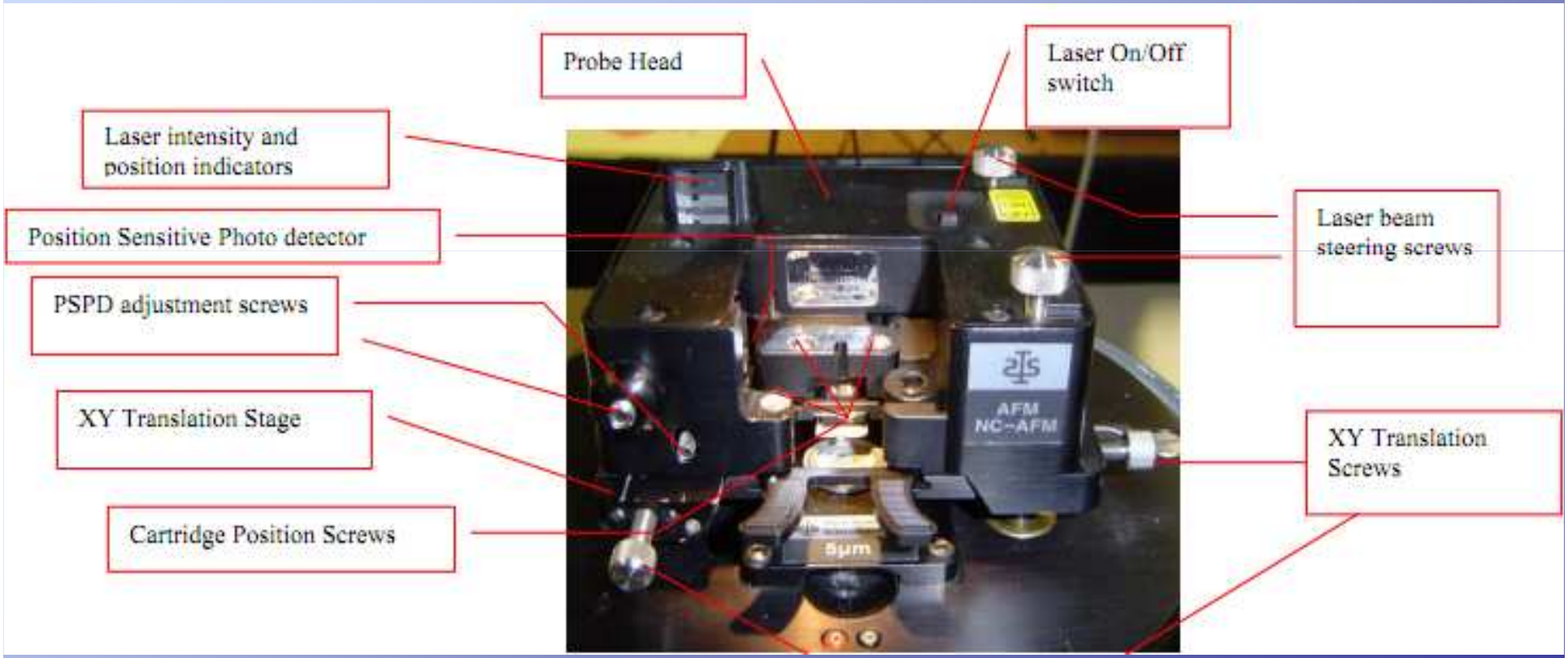


The Atomic Force Microscope (AFM) is being used of technologies affecting the electronics, telecommunications, biological, chemical, and energy industries. Also the AFM is being applied to studies of phenomena such as abrasion, adhesion, cleaning, corrosion, etching, friction, and polishing.

History of AFM

- In the fall of 1985 the first AFM was made by Gerd Binnig and Christoph Gerber who used the cantilever to examine insulating surfaces. A small hook at the end of the cantilever was pressed against the surface while the sample was scanned beneath the tip. The force between tip and sample was measured by tracking the deflection of the cantilever.

Components of AFM



Components of AFM

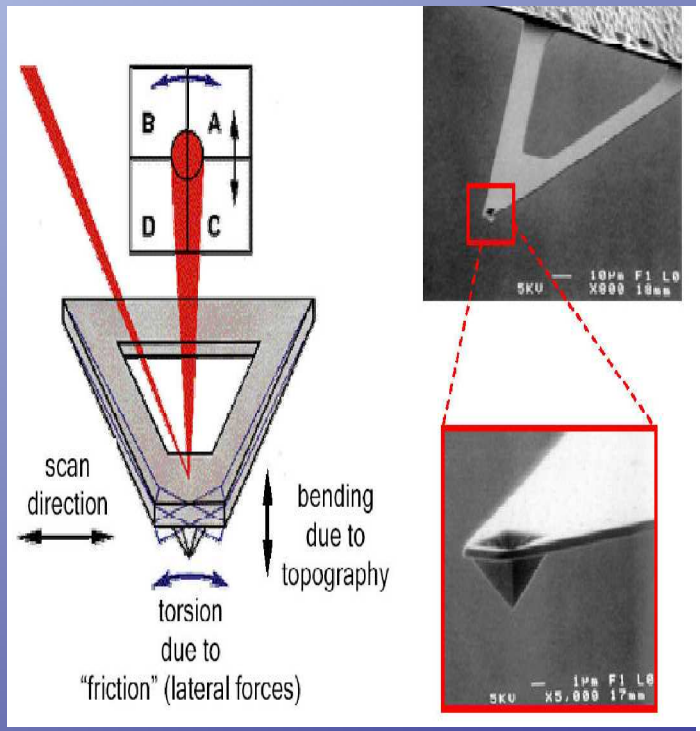
- Piezocrystals
- Piezocrystals are ceramic materials that expand or contract in the presence of voltage gradient and conversely, they develop an electrical potential in response to mechanical pressure. In this way, movements in x, y and z direction are possible.

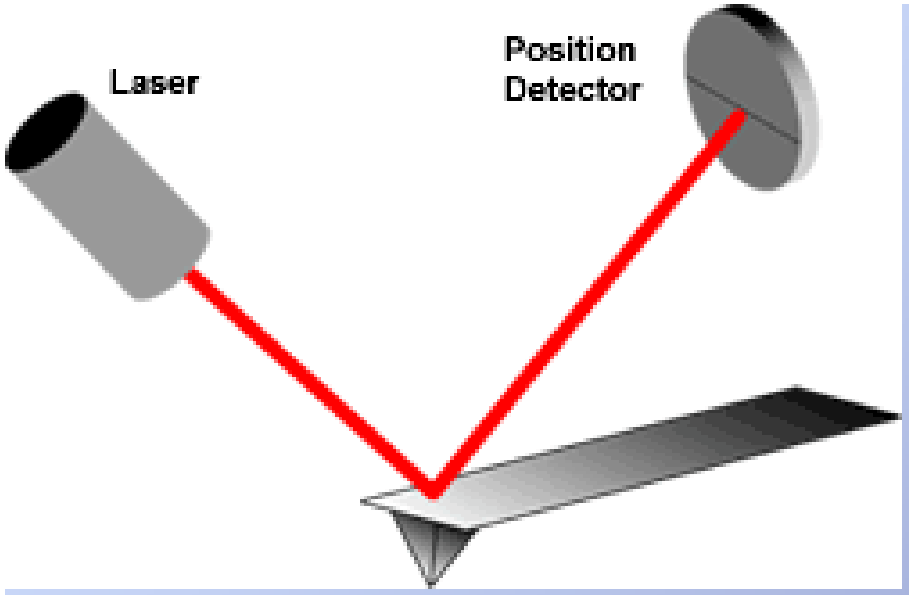
Components of AFM

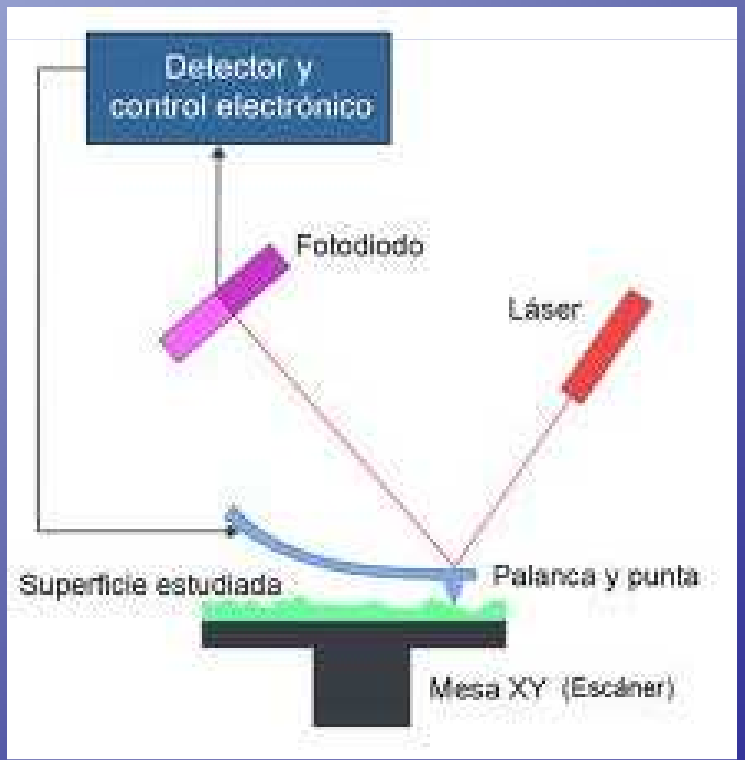
- Probe
- The probe represents a micromachined cantilever with a sharp tip at one end, which is brought into interaction with the sample surface. They are characterized by their force constant and resonant frequency.

Components of AFM

- Beam Deflection Detection
- To detect the displacement of the cantilever, a laser is reflected off the back of the cantilever and collected in a photodiode. When the laser is displaced horizontal along the positions top (B-A) and bottom (D-C), there exists a bending due to topography, while if this movement is vertically left (B-D) and right (A-C), it produces a torsion due to "friction" (lateral force).




Laser
Position
Detector


Detector y
control electrónico
Fotodiodo
Láser
Superficie estudiada
Palanca y punta
Mesa XY (Escáner)

How to Work?

- A sharp tip is scanned over a surface with feedback mechanisms that enable the piezo-electric scanners to maintain the tip at a constant force or height. Tips are typically made from Si3N4 or Si. AFM has an optical detection system in which the tip is attached to the underside of a reflective cantilever. A diode laser is focused onto the back of a reflective cantilever. The photodetector measures the difference between the upper and lower photodetectors, and then converts to voltage.

Working Modes of AFM

- Contact Mode
- In this mode, the tip makes soft “physical contact” with the surface of the sample. In contact force mode the deflection of the cantilever is fixed and the motion of the scanner in z-direction is recorded. By using contact-mode AFM, even “atomic resolution” images are obtained.

Working Modes of AFM

- Advantages:
- - High scan speeds.
- -“Atomic resolution” is possible.
- -Easier scanning of rough samples with extreme changes in vertical topography.

- Disadvantages:
- -Lateral forces can distort the image.
- -Capillary forces from a fluid layer can cause large forces normal to the tip-sample interaction.
- -Combination of these forces reduces spatial resolution and can cause damage to soft samples.

Working Modes of AFM

- Non-Contact Mode
- In this mode, the probe operates in the attractive force region and the tip-sample interaction is minimized. The use of non-contact mode allowed scanning without influencing the shape of the sample by the tip-sample forces. In most cases, the cantilever of choice for this mode is the one having high spring constant of 20-100 N/m so that it does not stick to the sample surface at small amplitudes.

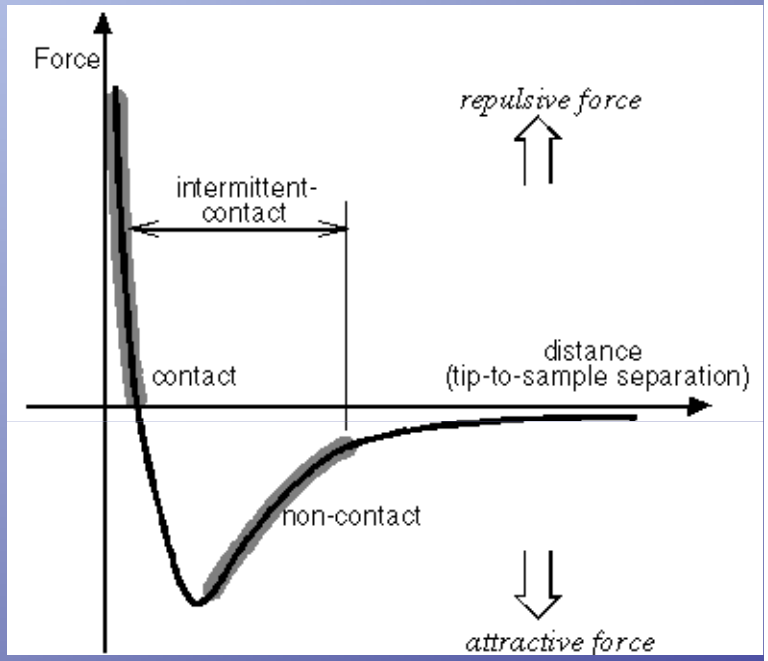
Working Modes of AFM

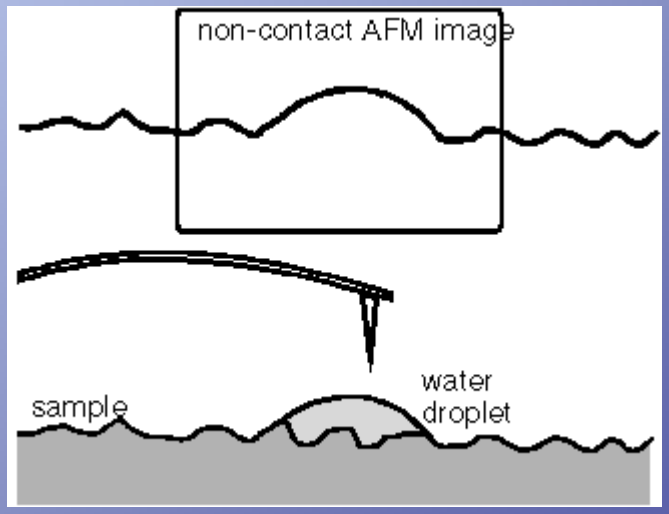
- Advantage:
- - Low force is exerted on the sample surface and no damage is caused to soft samples

- Disadvantages:
- - Lower lateral resolution, limited by tip-sample separation.
- -Slower scan speed to avoid contact with fluid layer.
- -Usually only applicable in extremely hydrophobic samples with a minimal fluid layer.

Working Modes of AFM

- Non-contact AFM (NC-AFM) is one of several vibrating cantilever techniques in which an AFM cantilever is vibrated near the surface of a sample. The spacing between the tip and the sample for NC-AFM is on the order of tens to hundreds of angstroms. This spacing is indicated on the van der Waals curve of Figure





Working Modes of AFM

- Because the force between the tip and the sample in the non-contact regime is low, it is more difficult to measure than the force in the contact regime, which can be several orders of magnitude greater. In addition, cantilevers used for NC-AFM must be stiffer than those used for contact AFM because soft cantilevers can be pulled into contact with the sample surface. The small force values in the non-contact regime and the greater stiffness of the cantilevers used for NC-AFM are both factors that make the NC-AFM signal small, and therefore difficult to measure. Thus, a sensitive, AC detection scheme is used for NC-AFM operation.
- In non-contact mode, the system vibrates a stiff cantilever near its resonant frequency (typically from 100 to 400 kHz) with an amplitude of a few tens of angstroms. Then it detects changes in the resonant frequency or vibration amplitude as the tip comes near the sample surface. The sensitivity of this detection scheme provides sub-angstrom vertical resolution in the image, as with contact AFM.

Working Modes of AFM

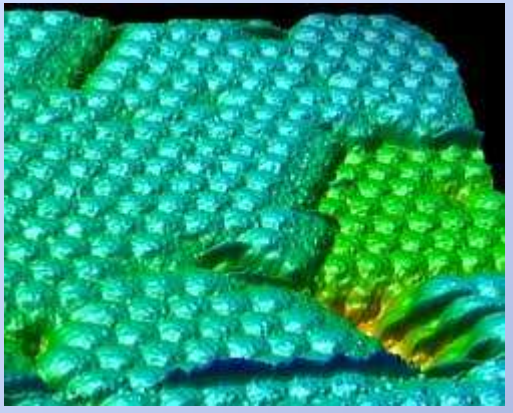
- Tapping Mode
- In tapping mode AFM the cantilever is oscillating close to its resonance frequency. An electronic feedback loop ensures that the oscillation amplitude remains constant, such that a constant tip-sample interaction is maintained during scanning. Forces that act between the sample and the tip will not only cause a change in the oscillation amplitude, but also change in the resonant frequency and phase of the cantilever. The amplitude is used for the feedback and the vertical adjustments of the piezoscanner are recorded as a height image. Simultaneously, the phase changes are presented in the phase image (topography).

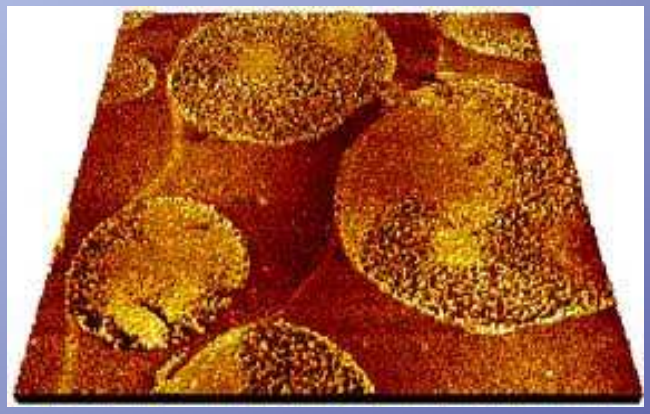
Working Modes of AFM

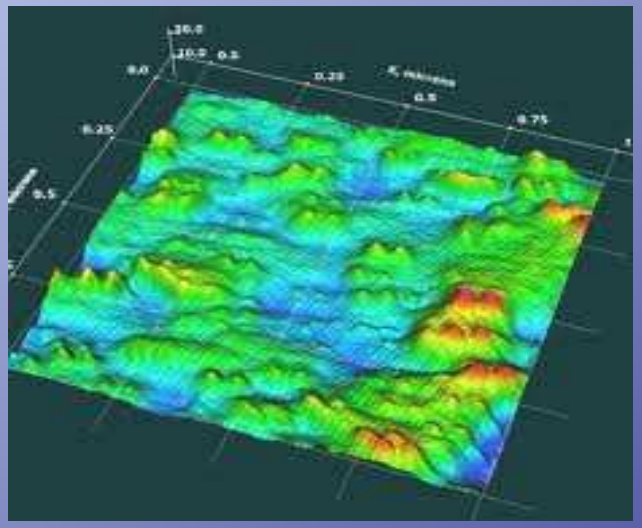
- Advantages:
- -Higher lateral resolution (1 nm to 5 nm).
- -Lower forces and less damage to soft samples in air.
- -Almost no lateral forces.

- Disadvantage:
- -Slower scan speed than in contact mode.

Images







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- Thanks for listening…

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