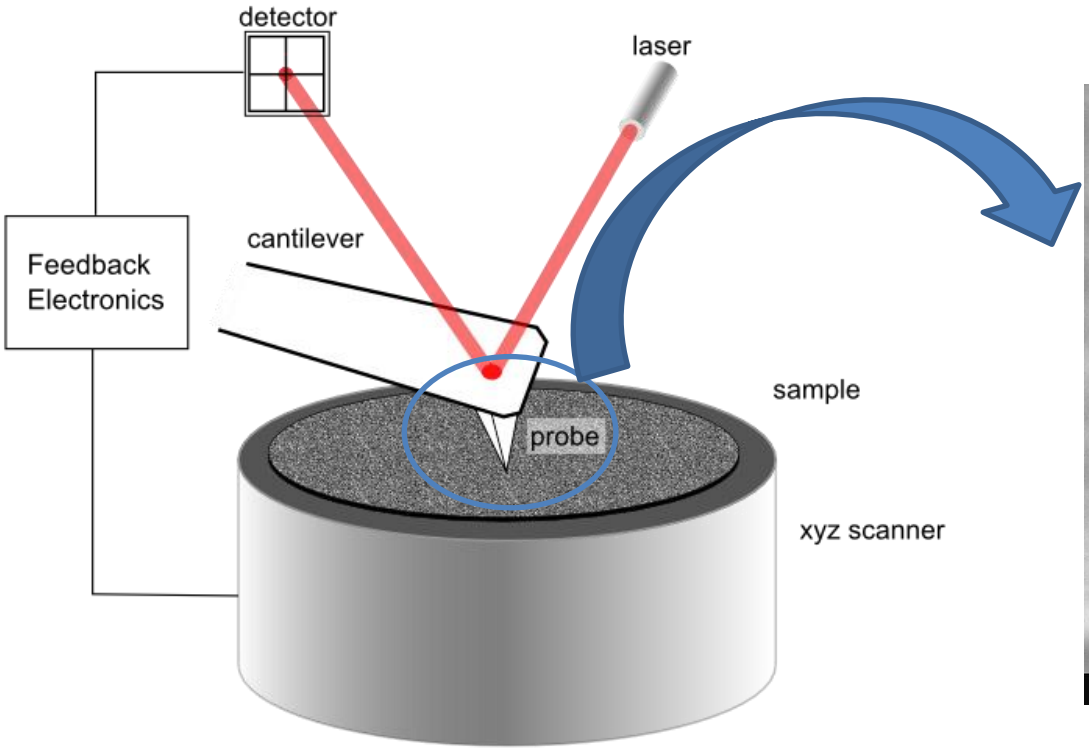
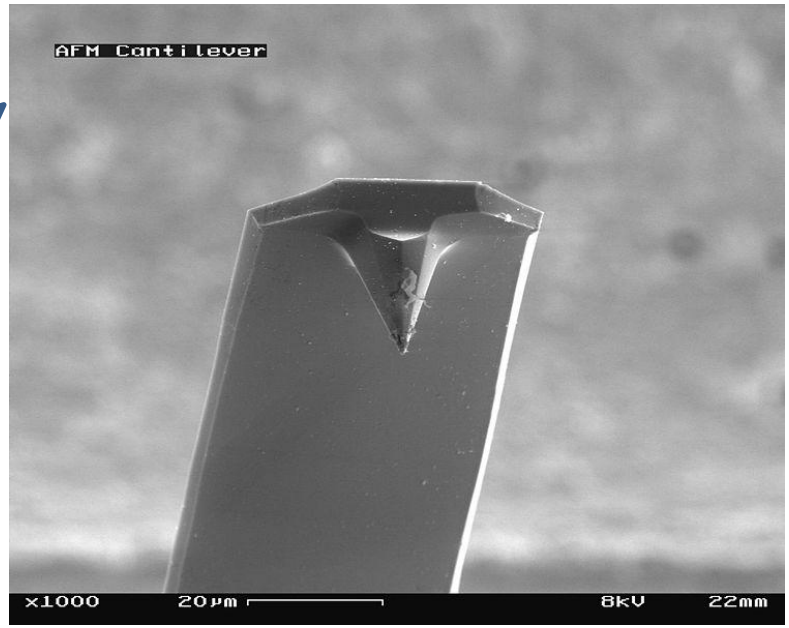
Instrumental Technique:

AFM probe





Azhar

29-03-14

Introduction:

- Atomic force microscopy (AFM) is one of the types of scanning probe microscopy used for imaging, measuring, and manipulating matter at the nanoscale.

- Resolution is of the order of fractions of a nanometer, more than 1000 times better than the optical diffraction limit.

- The precursor to the AFM, the scanning tunneling microscope, was developed by Gerd Binnig and Heinrich Rohrer that earned them the Nobel Prize for Physics in 1986.

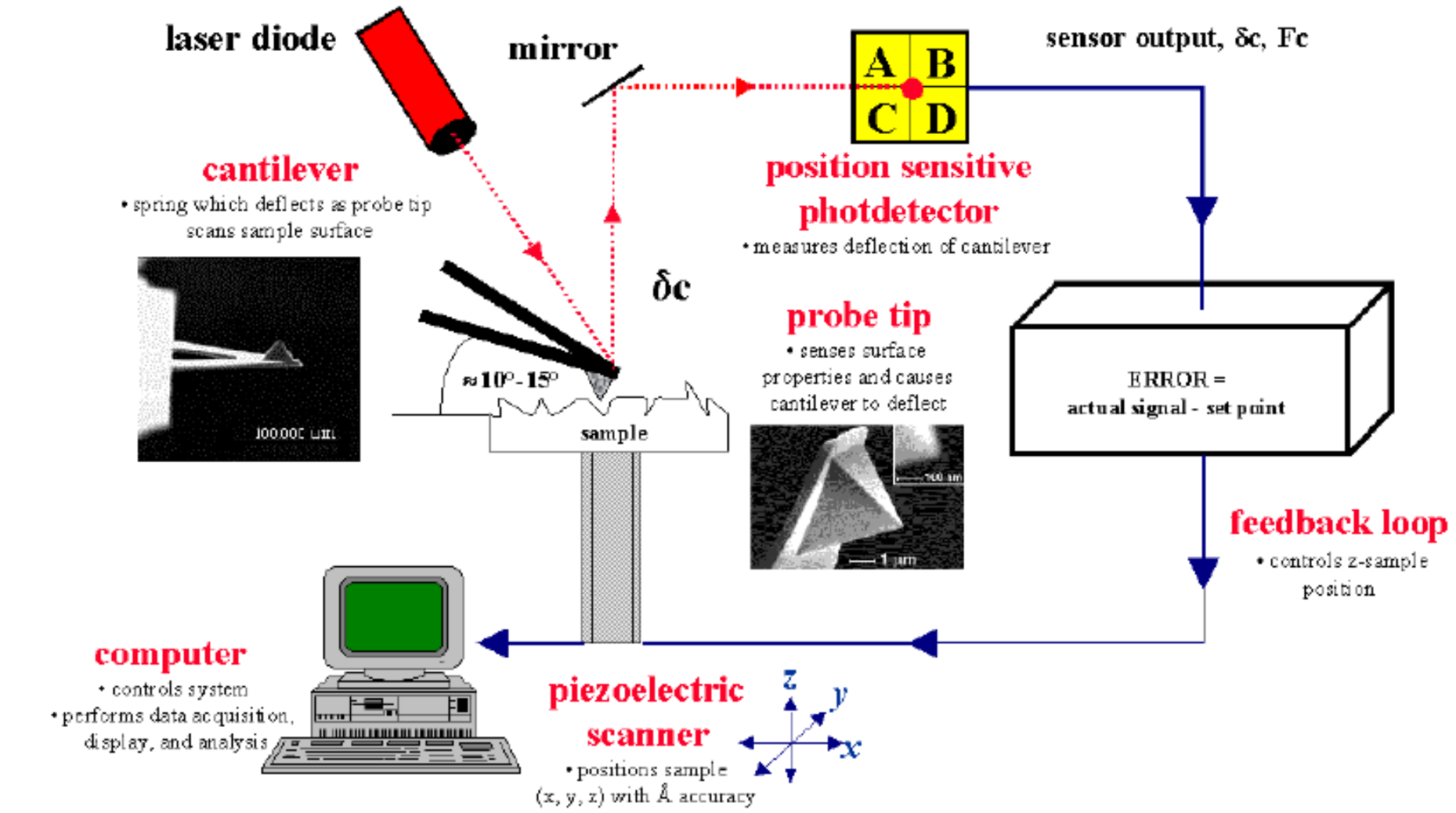
- AFM works by scanning a very sharp probe along the sample surface and the vertical bending (deflection) of the cantilever due to forces acting on the tip is detected by a laser focussed on the back of the cantilever, which is detected by a photodiode detector.

- The probe is moved over the sample by a scanner, typically a piezoelectric element, which makes extremely precise movements.

- The combination of the sharp tip, the very sensitive optical lever, and the highly precise movements by the scanner, combined with the careful control of probe-sample forces allow the extremely high resolution of AFM.

Atomic Force Microscopy (AFM) :

General Components and Their Functions



Operating Modes:

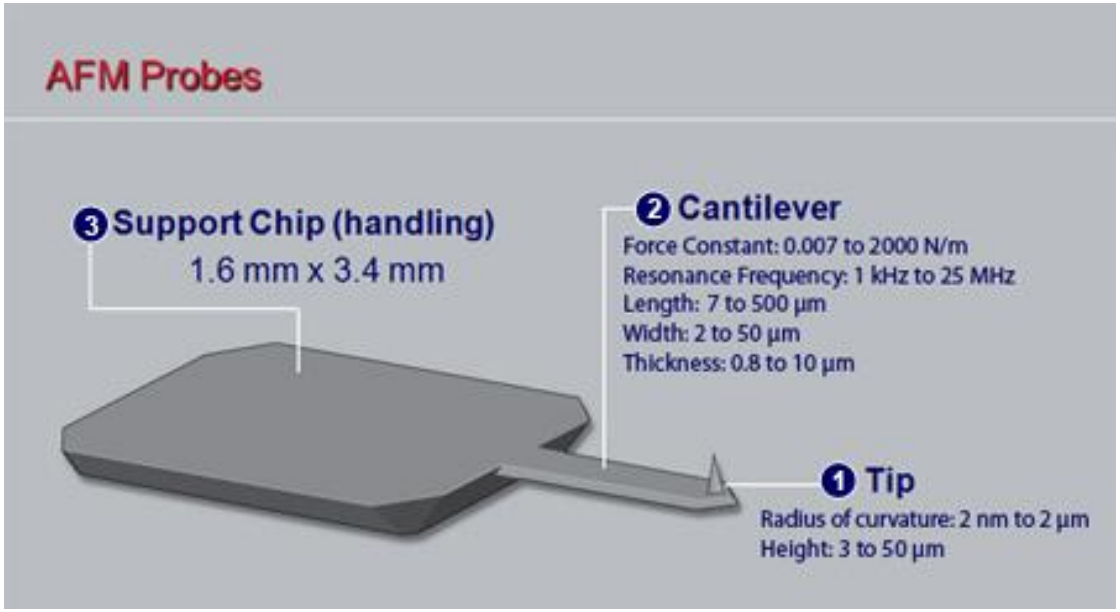
- The AFM can be operated in a number of modes, depending on the application. In general, possible imaging modes are divided into static (also called contact) modes and a variety of dynamic (non-contact or tapping) modes where the cantilever is vibrated:
- Contact mode, also called static mode (as opposed to the other two modes, which are called dynamic modes).
- Tapping mode, also called intermittent contact, ACmode, Amplitude Modulation AFM
- Non-contact mode, or Frequency Modulation AFM
- Non-topographic modes:
- Magnetic Force Microscopy, MFM, measures the distribution of magnetic field in the sample.
- Kelvin Probe Microscopy (KPM) measures contact potential difference across the sample.
- Force Spectroscopy can measure individual molecular interactions.
- Nano-indentation can measure hardness or softness of the sample.
- Thermal modes can measure thermal parameters, for example, thermal conductivity on the nanoscale.

Probe:

❖An AFM probe is a consumable measuring device with a sharp tip on the free-swinging end of a cantilever that is protruding from a holder plate.
❖An AFM probe is a particular type of SPM probe.

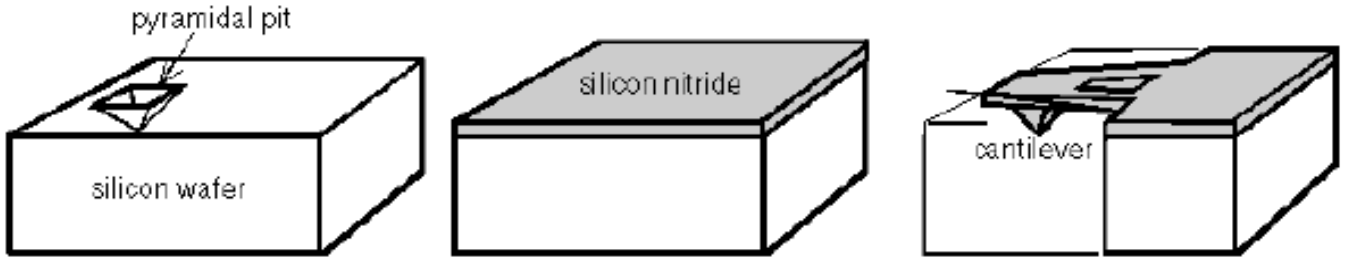
❖Dimensions:

❖The dimensions of the cantilever are in the scale of micrometers. The radius of the tip is in the scale of a few nanometers. The holder plate, also called holder chip, - often 1.6 mm by 3.4 mm in size - allows the operator to hold the AFM probe with tweezers and fit it into the corresponding holder clips on the scanning head of the Atomic force microscope.



Fabrication of AFM probes:

✓AFM probes are manufactured with MEMS technology.
✓The basic procedure is deposition of material layers, patterning by lithography and etching to produce the required shapes.



Pit etching in Si Si_3N_4 coating Si underetching

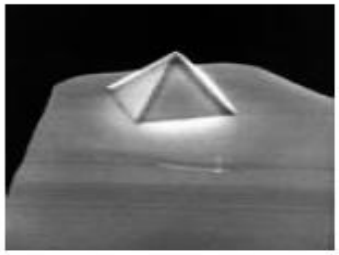
✓Most AFM probes used are made from silicon (Si), but borosilicate glass and silicon nitride are also used.

Working:

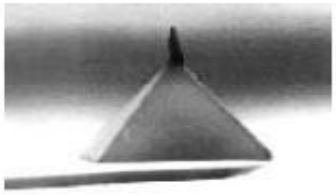
✓As the tip is brought very close to the surface of the object under investigation, the cantilever is deflected by the interaction between the tip and the surface, which is the what the AFM is designed to measure. A spatial map of the interaction can be made by measuring the deflection at many points of a 2D surface

Types of probes:

- Several types of interaction can be detected. Depending on the interaction under investigation, the surface of the tip of the AFM probe needs to be modified with a coating. Among the coatings used are gold - for covalent bonding of biological molecules and the detection of their interaction with a surface, diamond for increased wear resistance and magnetic coatings for detecting the magnetic properties of the investigated surface etc.
- The surface of the cantilevers can also be modified. These coatings are mostly applied in order to increase the reflectance of the cantilever and to improve the deflection signal.

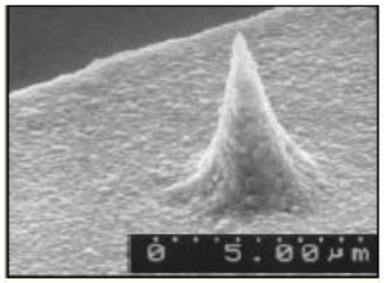


Normal Tip

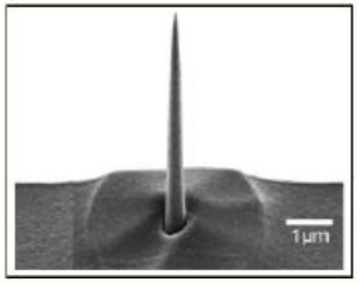


Supertip

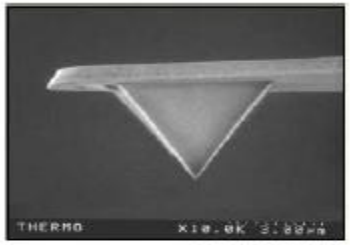
Ultralever



Diamond-coated tip



FIB-sharpened tip



Gold-coated Si_3N_4 tip

Probes in our lab:

Contact Mode:

In contact mode, the tip is "dragged" across the surface of the sample and the contours of the surface are measured either using the deflection of the cantilever using the feedback signal required to keep the cantilever at a constant position.

Non-Contact Mode:

Non contact mode is the most popular AFM technique. In this mode, the tip of the cantilever does not contact the sample surface. The cantilever is instead oscillated at either its resonant frequency (frequency modulation) or just above (amplitude modulation) where the amplitude of oscillation is typically a few nanometers (<10 nm) down to a few picometers.

Force Modulation:

Force modulation is an AFM mode where probe properties of materials are understood through tip and sample interactions. The modulation data can be acquired in tandem with topography, allowing for comparison of both height and material properties.

Nanoworld
www.nanoworld.com

Bruker
www.brukerafmprobes.com

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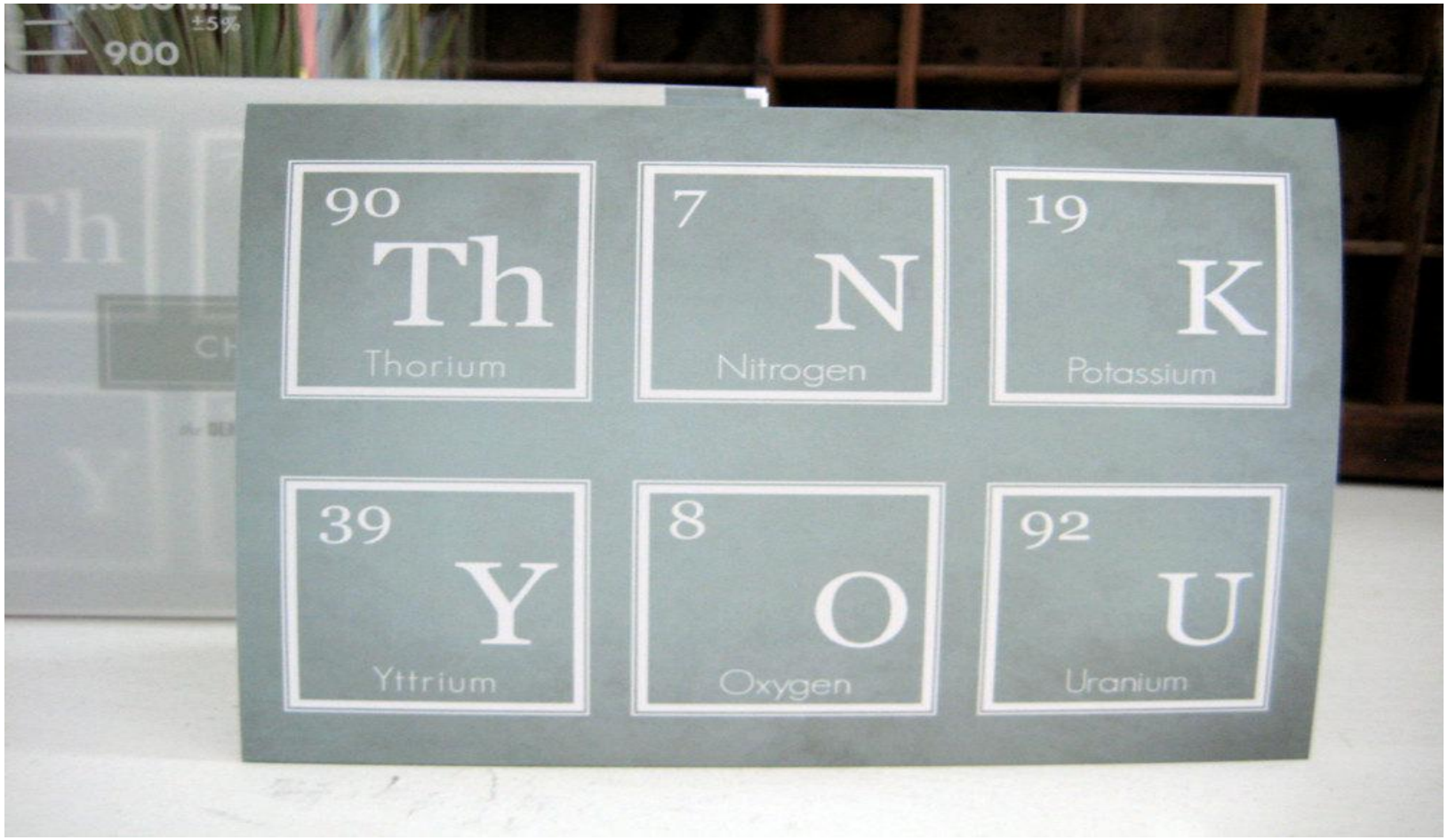
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O
Oxygen
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