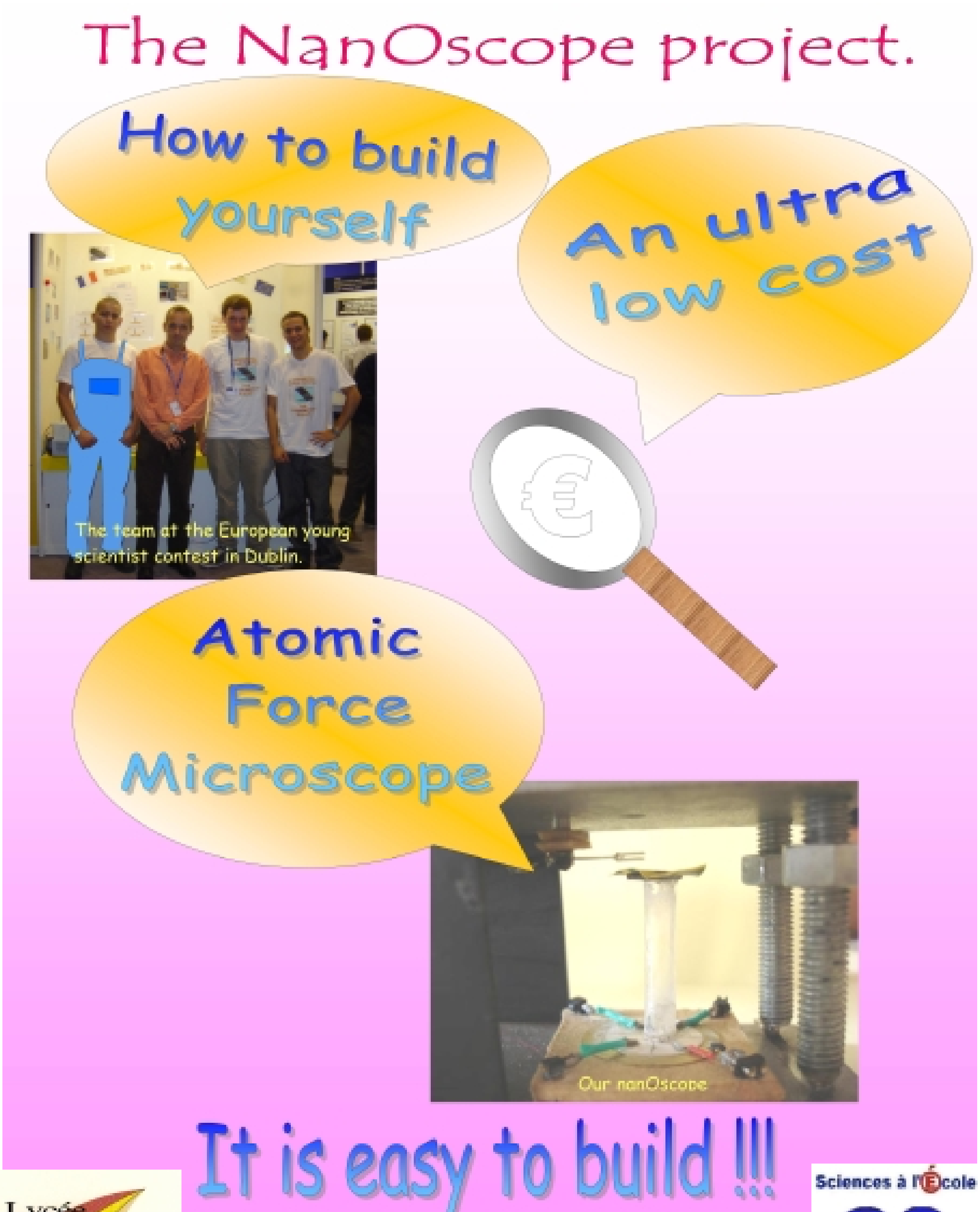
English method



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Décines - France

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Sciences à l'École

Opération "Science en Scène"

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Picture gallery

Summary

A nanometric picture for a nanometric budget
Conception and buildind of a atomic force microscope.

In 1986, the Atomic force microscope (**AFM**) was invented , allowing to « see » individual atoms.

Today, these devices are still expensive (typically more than 15 000 €)
Therefore , we have built a low-cost AFM
We present here the main results of our study.

The industrial AFM costs 15000 € including		We have replaced in our AFM by	
The laser	1000€	Quartz and tungsten tip	1,7 €
The sensor	unknown		
The piezo-electric tube	800 €	Buzzer flat piezo	2,5 €

For our equipment we have to create :

- a dedicated software to scan X ,Y and Z axis
- a dedicated hardware to regulate the Z axis position

Our AFM is composed of :

1) the support
2) adjusting screws to allow the manual approach and to block the system once the approach has been carried out.
3) The Scanner or piezo X,Y,Z is a Buzzer flat piezo
4) a glass tube to obtain movements on X and Y axis
5) a sample support
6) the force sensor composed of a tungsten tip stuck on a quartz using in watch

Our AFM characteristics

We obtain for Maximum sensitivity on Z axis: **0,15 nm** (approaching the atomic scale)
We obtain for Maximum sensitivity on X and Y axis: **0,75 nm**

Our results

Each part works
And we **get a real picture of a graphite sample, quantum dots and calibrated lines**

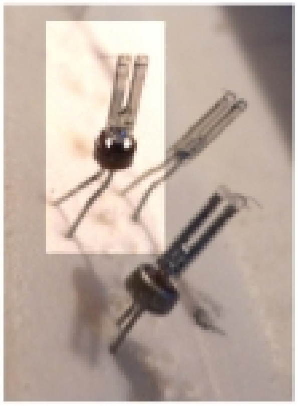
Thanks

- **M. Philippe DUMAS**, directeur de recherche dans le service « microscopie à champ proche » au GPEC de Marseille et toute son équipe de chercheurs :
  ACKERMANN Jörg
  BELLINI Boris
  BATTAGLINI Nicolas
  KLEIN Hubert
- **M. CADETE SANTOS AIRES** et **M. GENET** du CNRS de Lyon.
- **M. BREMOND**, directeur de recherche, INSA de Lyon.
- **M. ROMEU**, artisan chaudronnier
- **M. LOISON**, professeur de BTS au Lycée Charlie Chaplin de Décines.
- **M^me^ MAILLARD** et **M. MASSAULT**, professeurs d'électronique au Lycée Charlie Chaplin.
- **M LE BOURHIS,** Inspecteur de physique chimie et toute l'équipe de **sciences à l'école.**
- **M. JEANNOT**, professeur de physiques appliquées au Lycée Charlie Chaplin.
- **M. FADEL**, Chef du département de Physique au Palais de la découverte.
- **M. BOUGAULT**, proviseur du lycée Charlie chaplin.
- Mairie de Genas et de Décines
- M. le Préfet de Lyon

What have we changed in our AFM

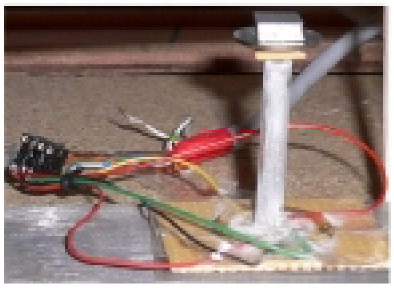
Usual AFM use a laser and a special tip. It is the sensor. It costs more than 2000€. We have replaced them by a quartz (from watch) and a tungsten tip. It costs less than 1€.

Usual sensor is made with a special tip and a laser.

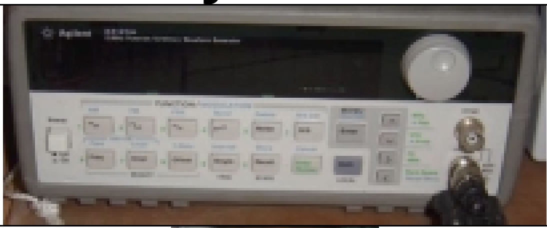
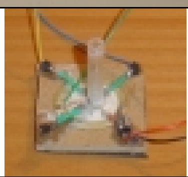
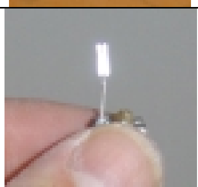
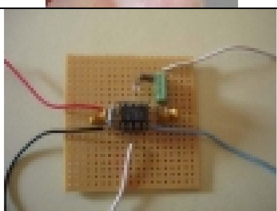
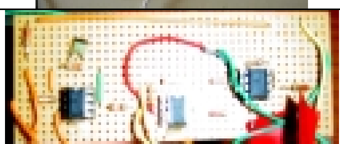


Our quartz and tunsten tip.

Usual AFM scan with a piezo tube. It is the sensor. It costs more than 800€.We have replaced them by a flat piezo (from buzzer) and a glass tube. It cost less than 3€.

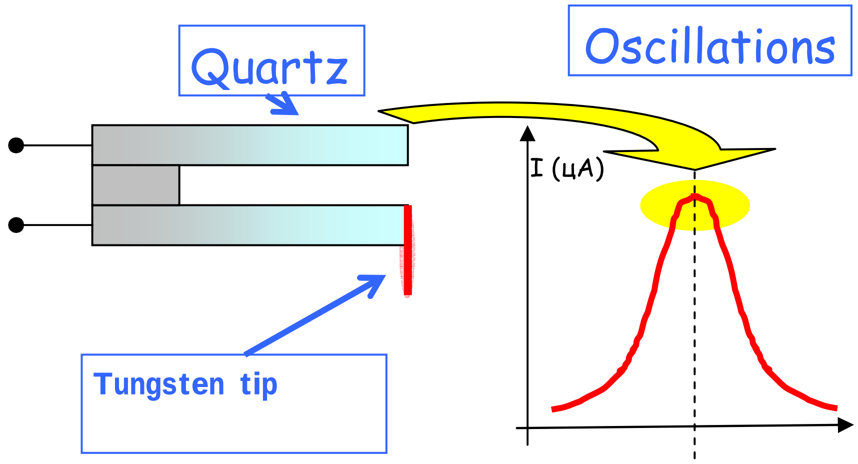


What do you need to build a nanOscope.

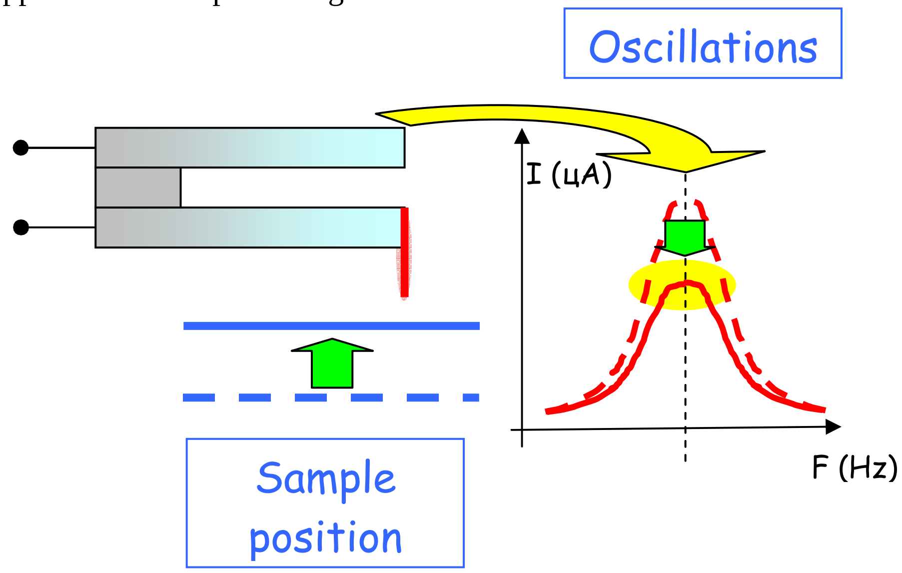
	**Accurate signal wave generator**
	**Power supply**
	**Aquisition card + software+computer**
	**Build a stand with 2 screw and a micrometer**
	**Build a scanner with a glass tube and a flat piezo**
	**Build a sensor with a quartz (from watch) and a tungten tip.**
	**Build a intensity measurement card.**
	**Build a regulation card. (option)**
	**An oscilloscope**

How does the sensor work ?

With the signal wawe generator, we placed the sensor in a resonant state.



When we approach the sample the signal decreases.



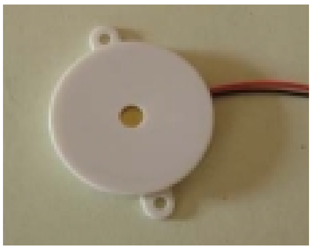
The signal modification is linked with the distance between the tip and the sample (Z). It could be very accurate: less than a nanometer.

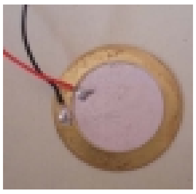
Then we have two possibilities to work:

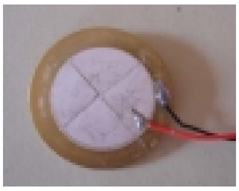
- We can measure directly the “Z” signal.
- We can use a regulation loop and measure the signal to keep Z constant.

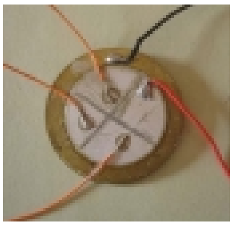
How does the scanner work ?

We have cut a flat piezo in four parts. We have stuck 4 electric wires with a silver conductive glue.

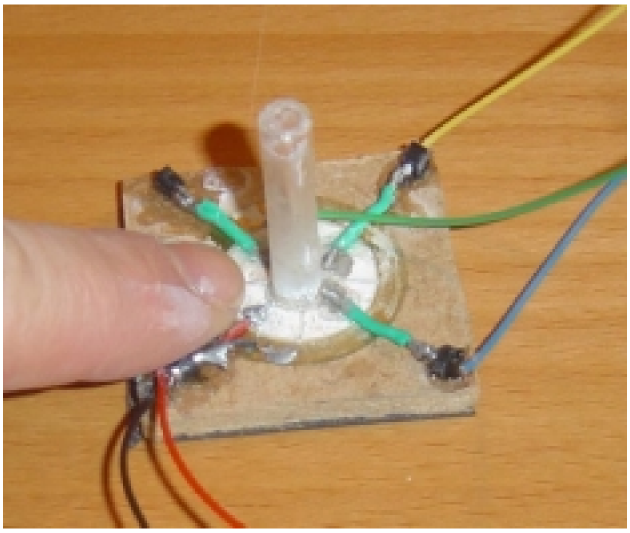




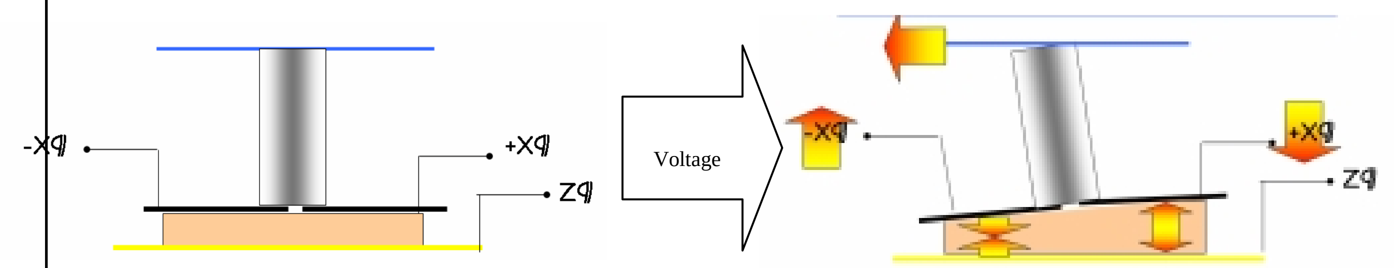




We have stuck the glass tube



We change the voltage between two opposite quadrants of the piezo. The thickness of one part increases and the thickness of the other quadrants decreases.
The glass tube and the sample move on X or Y axis.



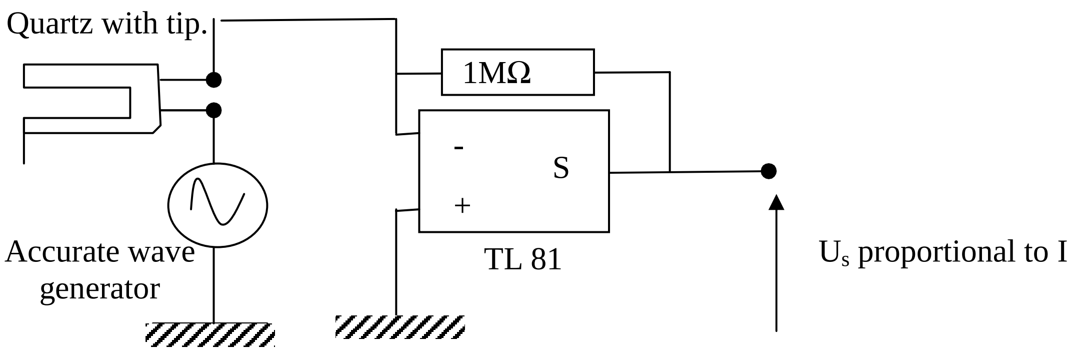
We have measured the maximal scale: For 10 V we have approximately 1µm scan.

Accuracy

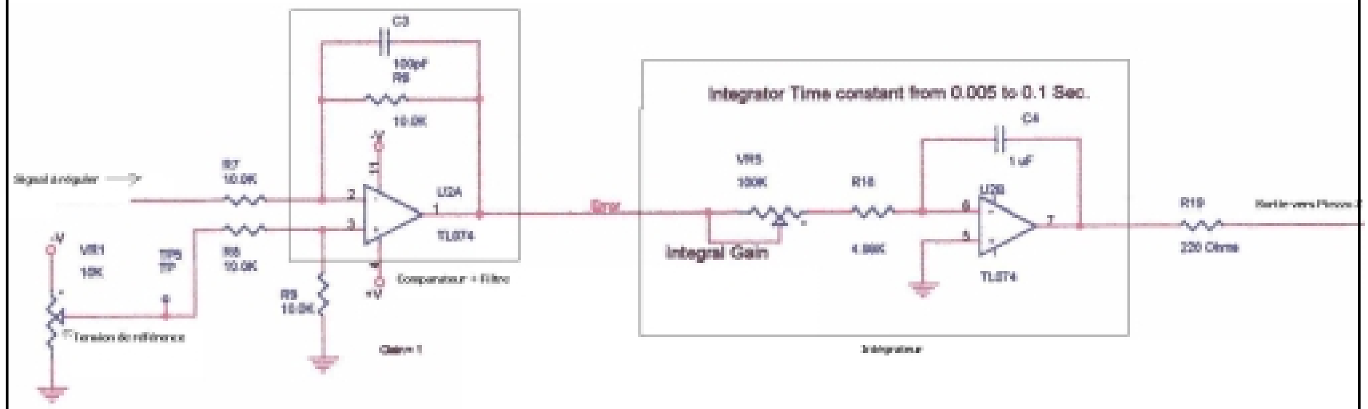
It is easy to split this scale in 100 and get a step of almost **10nm** on X, Y axis and **1nm** on Z Axis.

Hardware to build

The intensity measurement card:

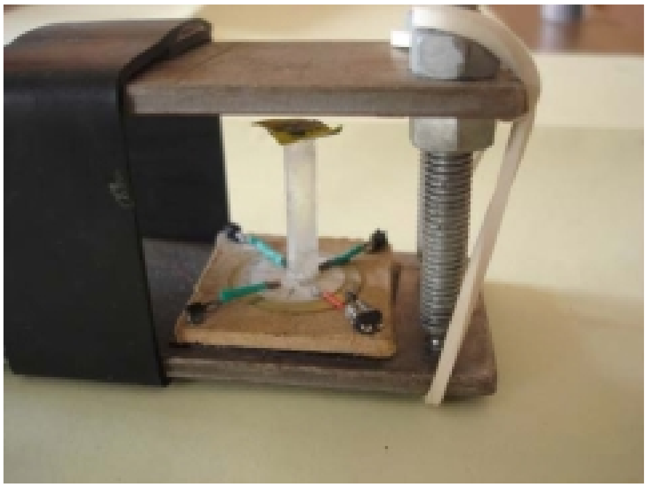


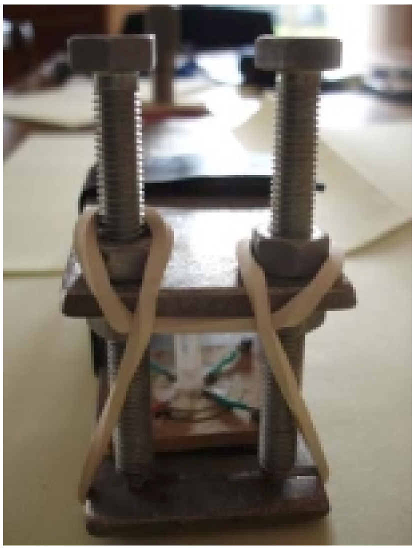
This is the regulation loop. We use a Scanning tunnelling microscope card.

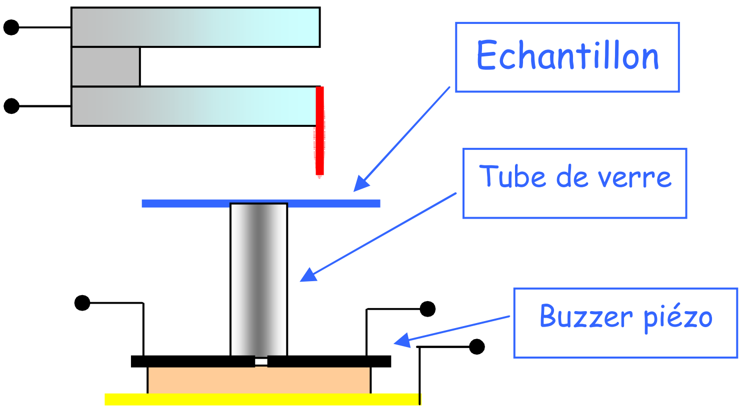


The stand, scanner and sensor building

The scanner and the sensor are stick on the stand with magnets.







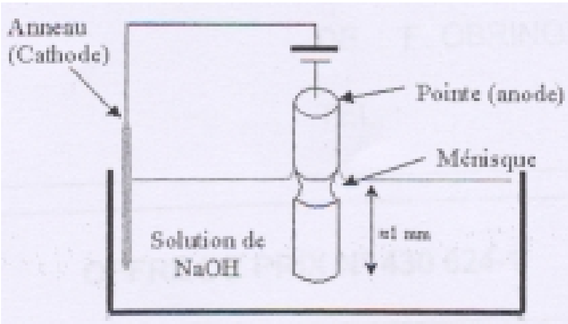
4

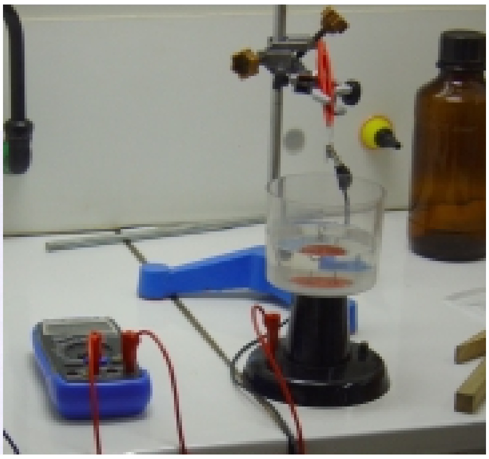
How to cut the tip

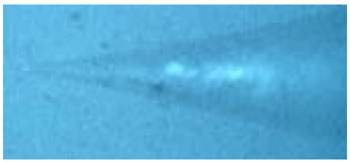
There are two methods:

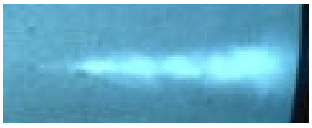
<u>**With an electrolyser**</u>**.**

It is very long but the tip end is very sharp.









<u>**With a scissor.**</u>

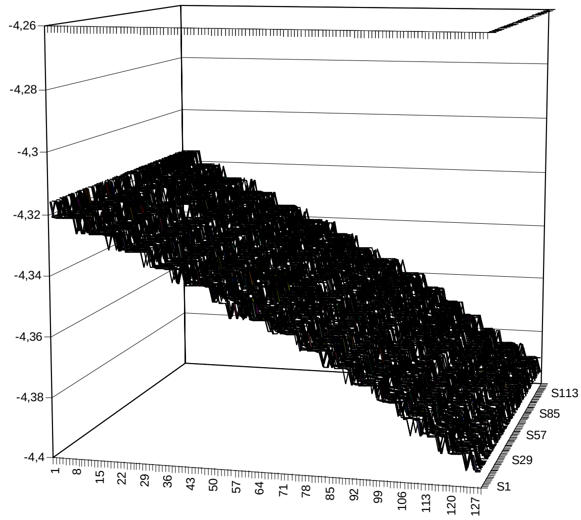
It is easy and prompt to do. It is used in the laboratories. The end of the tip is sufficiently sharp for a 1nm accurate picture.

How to stick the tip to the quartz.

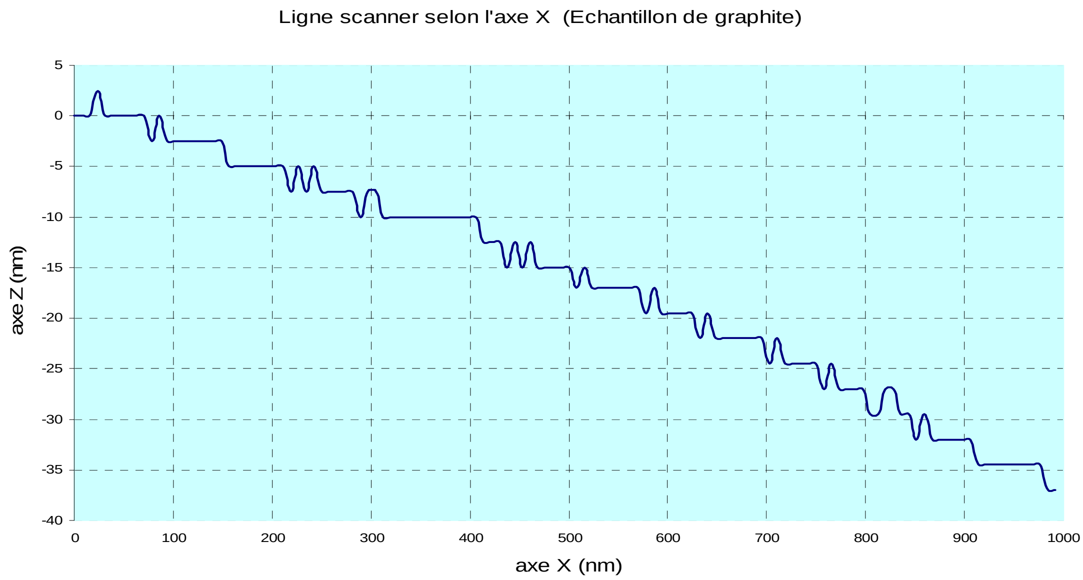
We stick it with a very strong glue.

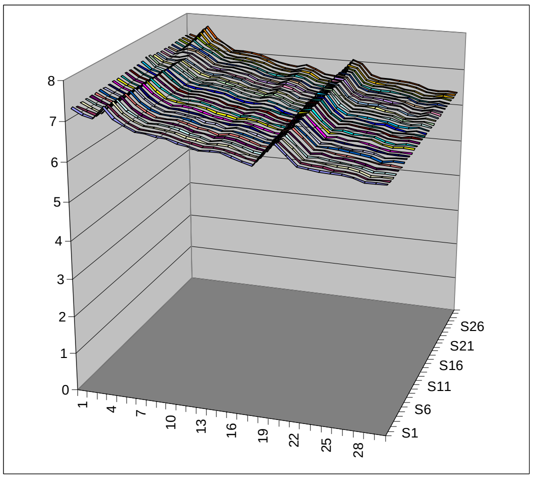
Our nanOscope results

First results: with a graphite sample.



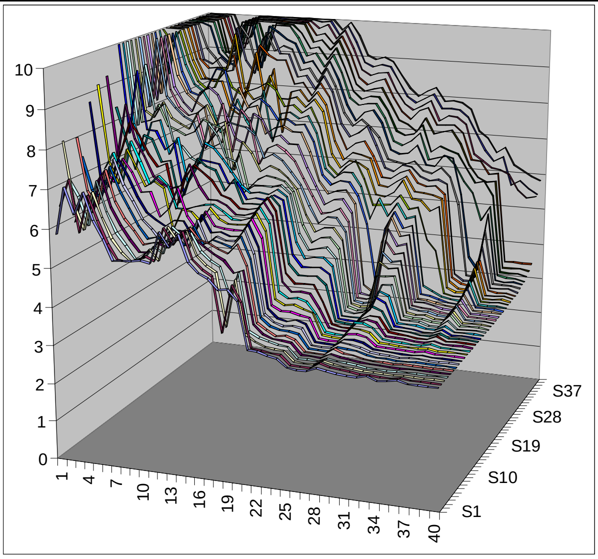
128 lines aquisition (graphite sample)



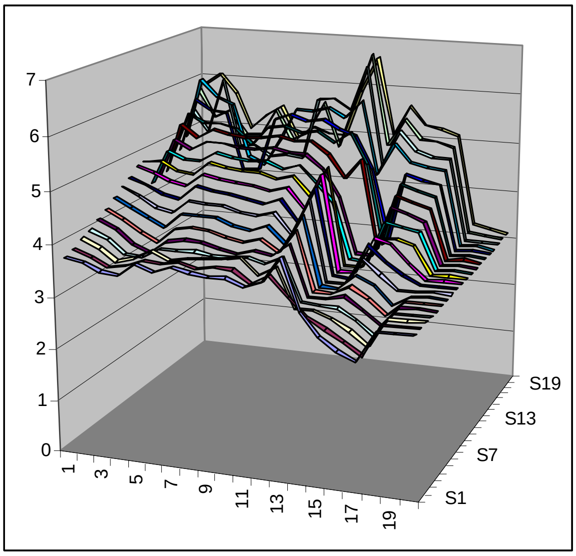


Echantillon de graphite (30 X 30)

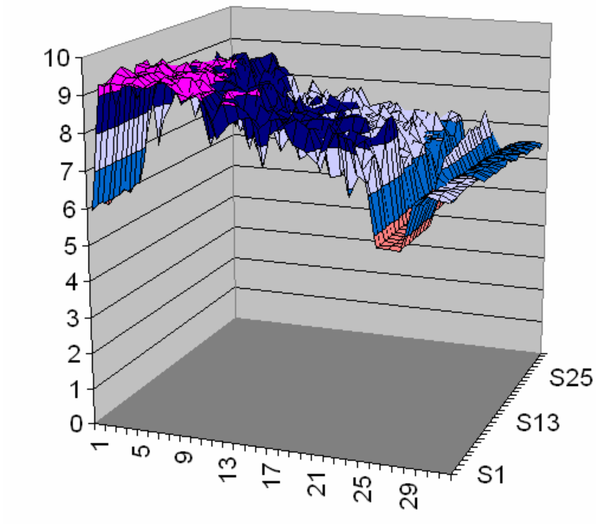
Other results with our nanoscope.



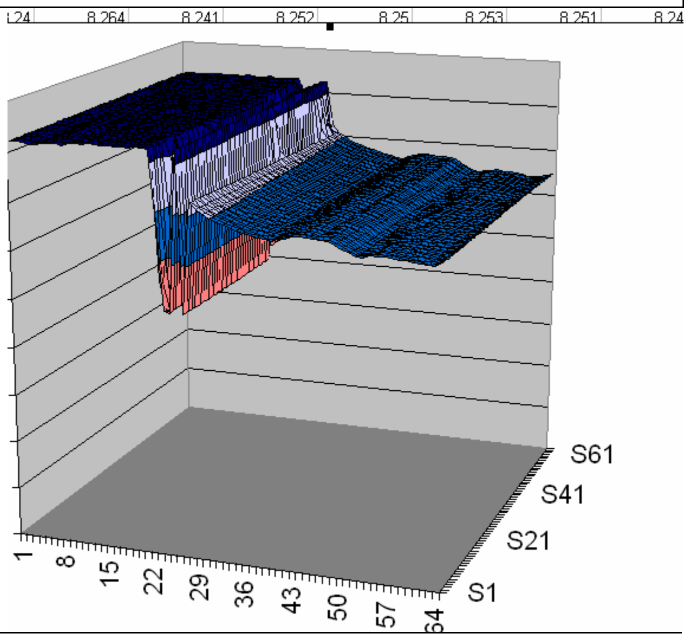
Alumiium paper (40 X 40)



Alumiium paper (20 X 20)



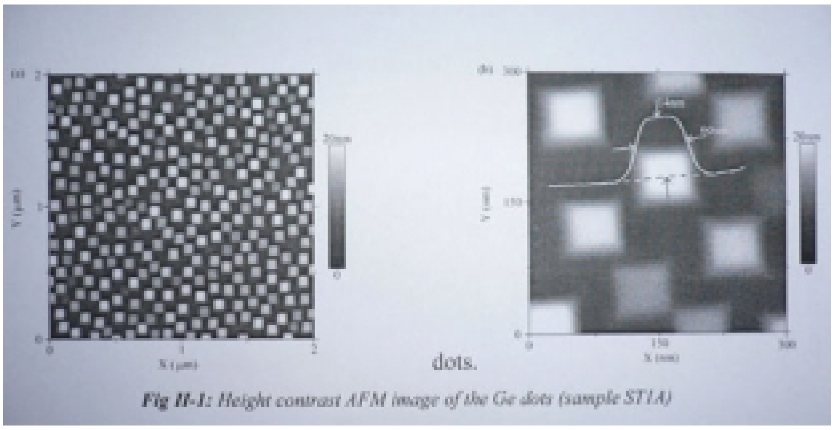
Calibrated lined sample



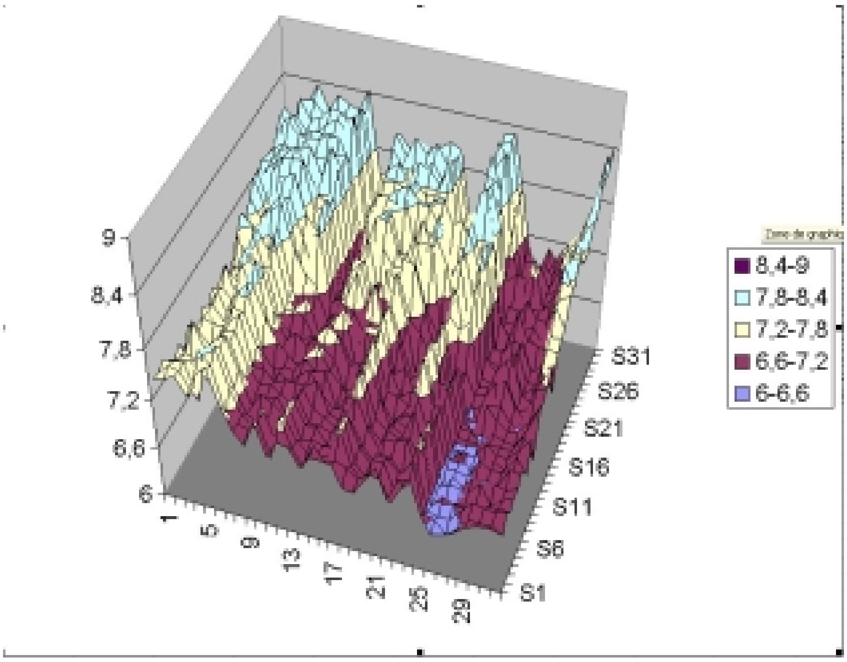
Calibrated lined sample

Comparison with other AFM

Quatum dots sample.(INSA lending)

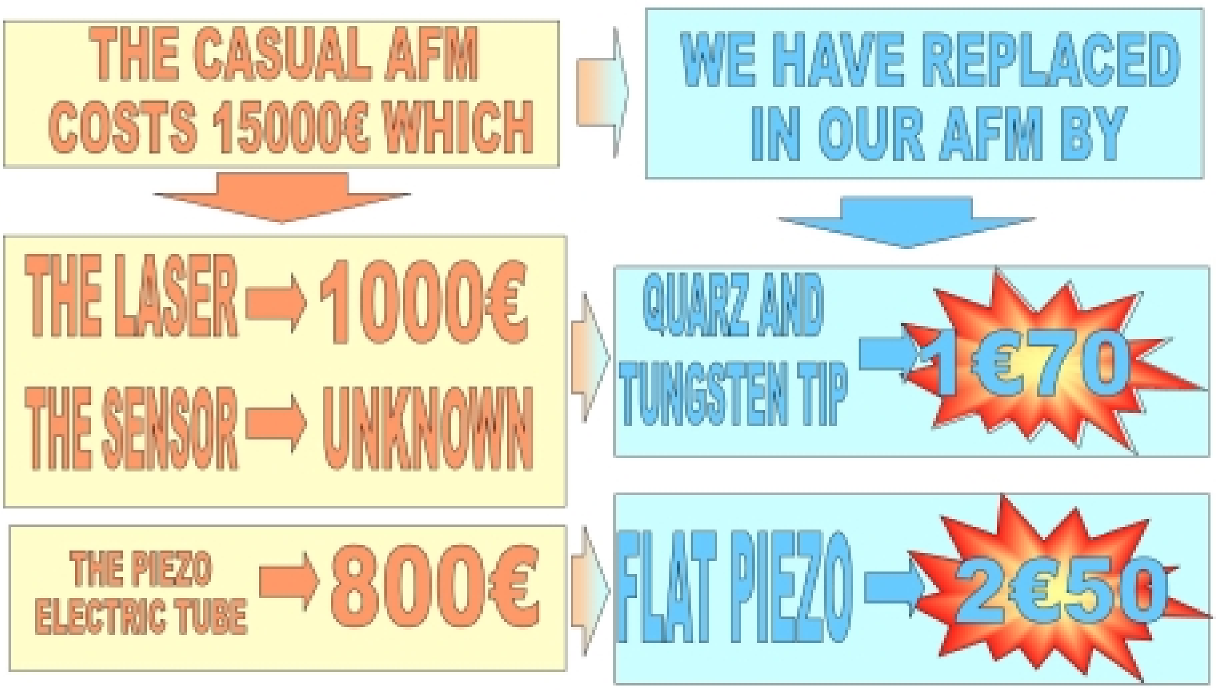


Height contrast AFM image (from Mr Bremond and al. LPM INSA Lyon)



1 µm scare image with our nanOscope

Conclusion



We have reached our challenge. We have built an ultra low cost AFM.

It could be used for teaching in high school or university. We can imagine workshop or practical works.

With our nanOscope, everybody could travel in the nanOworld, any country could begin research in nanotechnology.

We can improve our equipment with more tests, more samples.

We can reduce the price by changing the signal wave generator and acquisition card.

Be with us and:

Welcome to the nanOworld