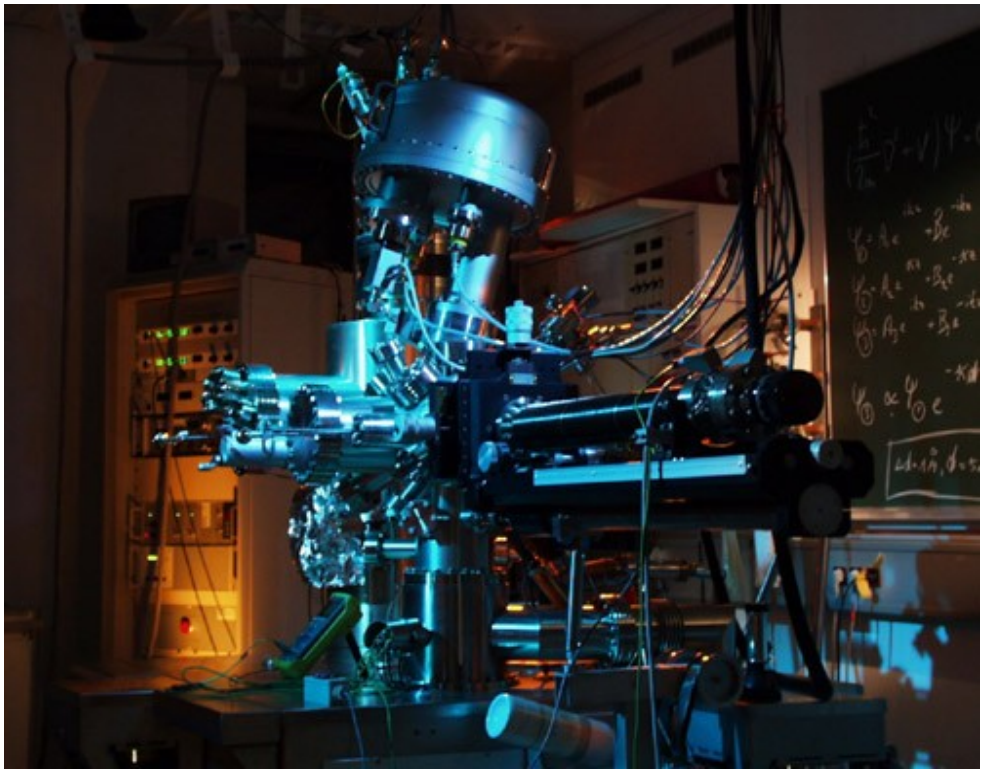
SCANNING TUNNELING MICROSCOPE



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Presentation includes;

- What is STM
- History
- Instrumentation
- How it works?
- Working conditions
- Application areas
- Examples and uses
- Advantages & Disadvantages
- Overview
- References

WHAT IS STM?

A scanning tunneling microscope (STM) is a powerful instrument for imaging surfaces at the atomic level.

Figure -1 A type of STM [1]
www.engin.umich.edu/.../linic/laboratory.html

HISTORY

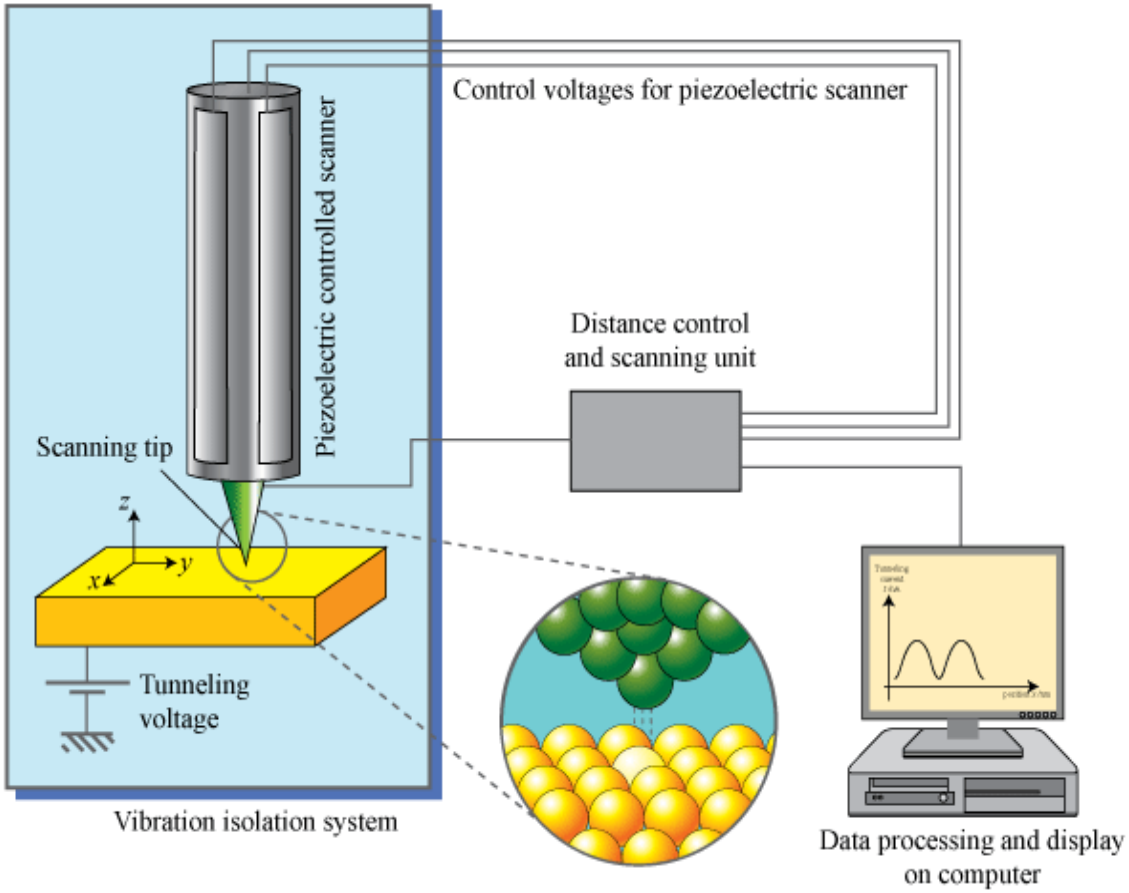
Heinrich Rohrer and Gerd Binnig

http://www.google.com.tr/imgres?imgurl=http://www.nanoforum.org/educationtree/Image

The invention of the scanning tunneling microscope (STM) in 1981 allowed scientists to view the world from an atomic perspective for the first time.

The revolutionary microscope, for which two IBM researchers Gerd Binnig and Heinrich Rohrer received the 1986 Nobel Prize in physics, revealed the topography of surfaces, atom by atom.

INSTRUMENTATION



- Scanning tip,
- Piezoelectric controlled scanner,
- Distance control and scanning unit,
- Vibration isolation system,
- Computer

Figure -2- Simplified structure of a STM.[2]
www.hk-phy.org/atomic_world

How STM works?

- Move tip near the surface
- Apply voltage difference between surface and tip
- Tunneling effect
- Record movement and display moving

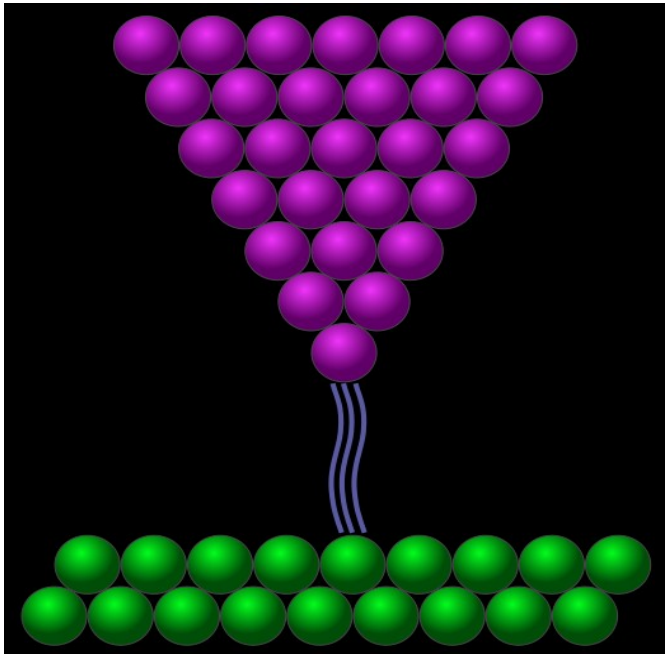
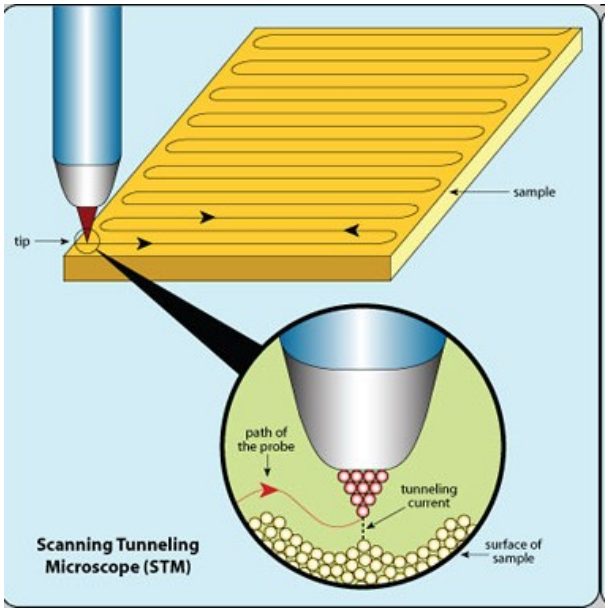


Figure -3 tunneling current [3]
http://upload.wikimedia.org/wikipedia/commons/thumb/e/e8/Scanning_tunneling_microscope_ideal_tip.svg/520px-Scanning_tunneling_microscope_ideal_tip.svg.png



http://www.nisenet.org/publicbeta/articles/seeing_atoms/index.html

Figure -4 scanning probe [4]

- Scan the surface by the tip

- Piezoelectric materials?
- How do we move the probe?
- Move the tip sensitively in three dimensions

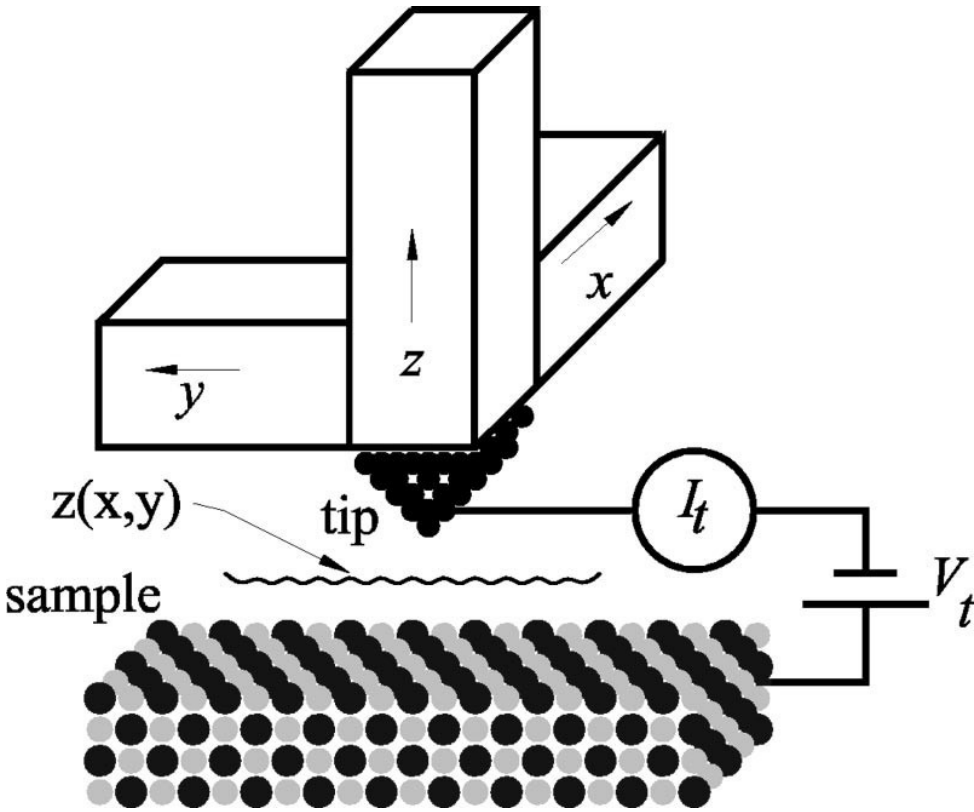


Figure - 7 in the scanner [7]

What are...

- Tunneling effect?
- Tunneling current?

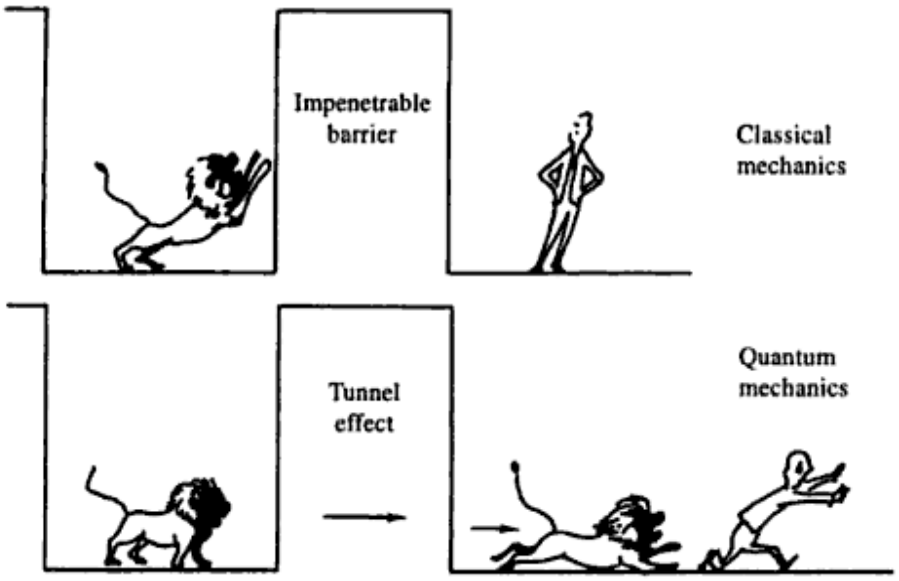


Figure-5 [5]
Surface Sciences.,C.Bai Scanning Tunneling Microscopy and Its Applications,Second Revised Edition,Shanghai Scientific & Technical Publishers

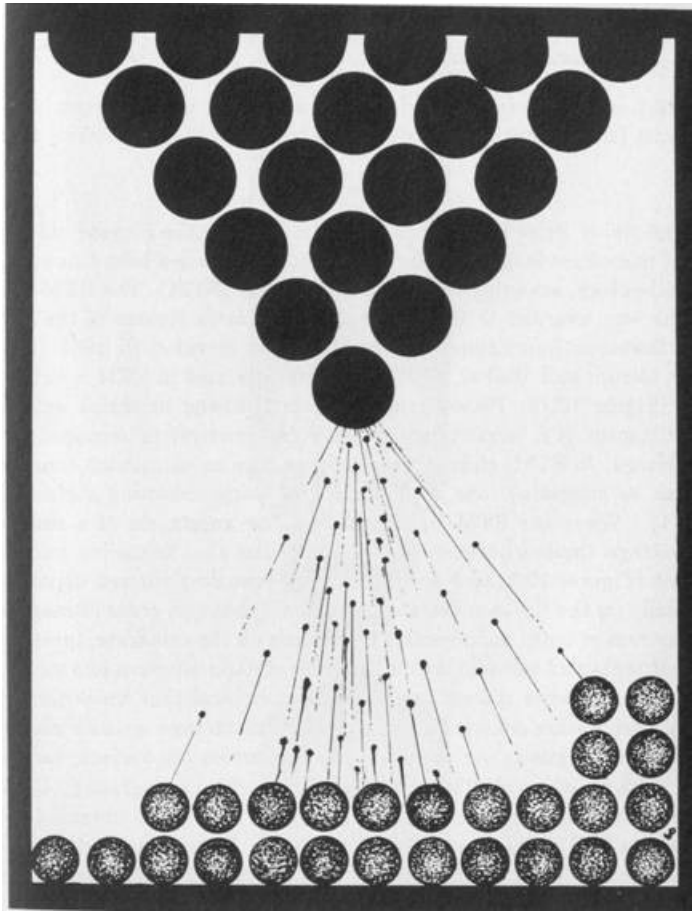


Figure -18 tunneling current
http://www.quantumconsciousness.org/ultimatecomputing/ulti_files/image083.jpg

- Constant current mode
- Constant distance mode (for topography)
  ⟶ Faster.

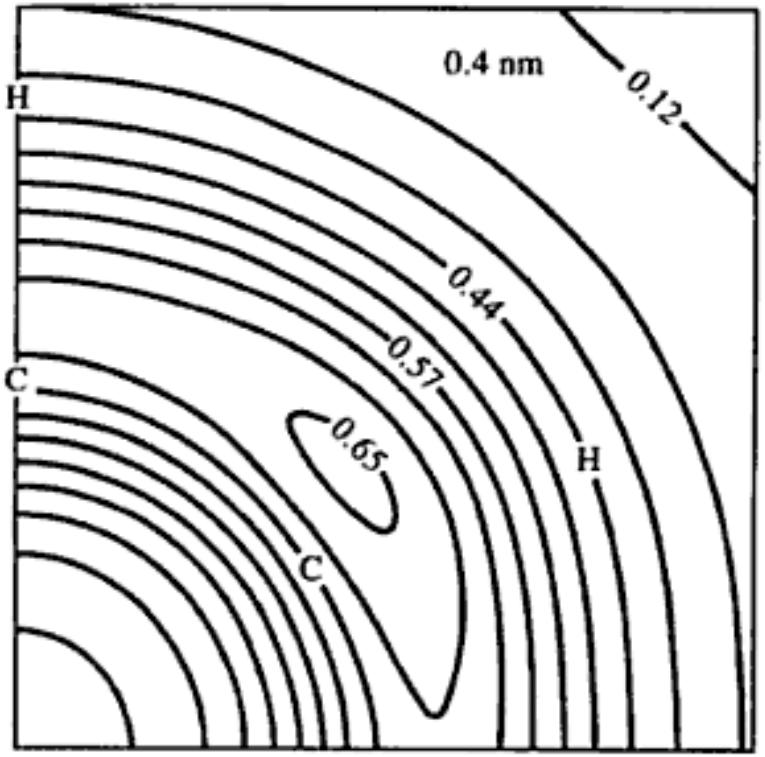


Figure-6- A constant distance mode output [6]

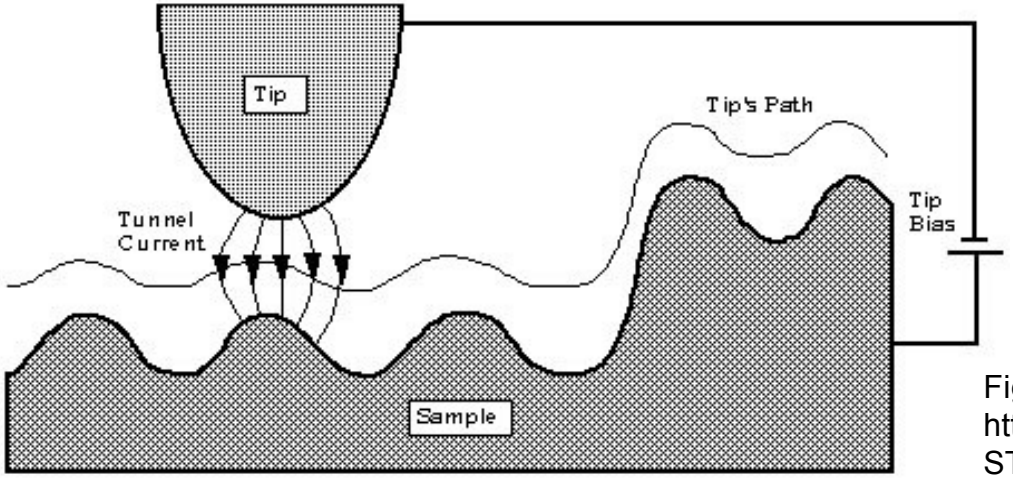


Figure- 19- constant current mode http://www.sljus.lu.se/stm/NonTech/STM_sch.jpg

Working conditions

- Must be highly vacuumed
- No vibrations
- Clean and stable surface
- Stable probe (Pt , W)
- Tip-to-surface distance in Å
- Can be applied to conductors and semi-conductors

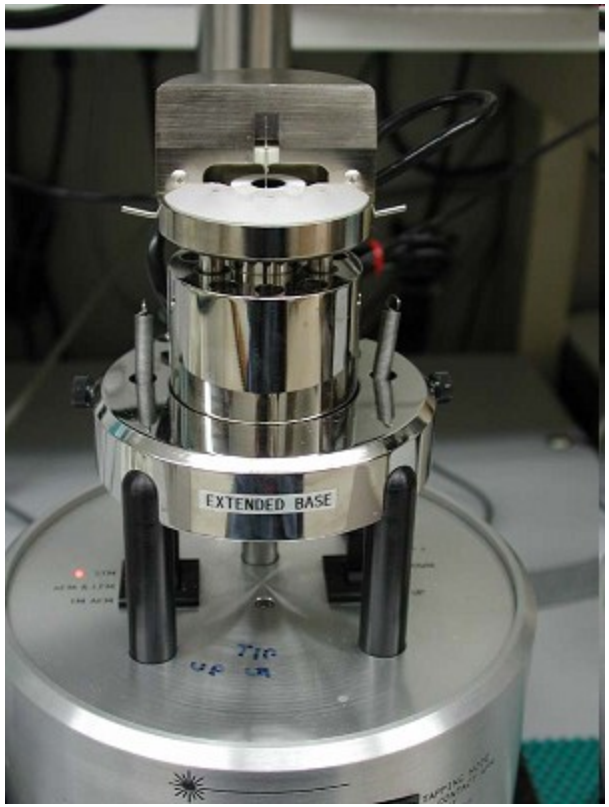


Figure-8 [8]
http://web.iitd.ac.in/~tryst/stm.htm

Other STM Related Applications

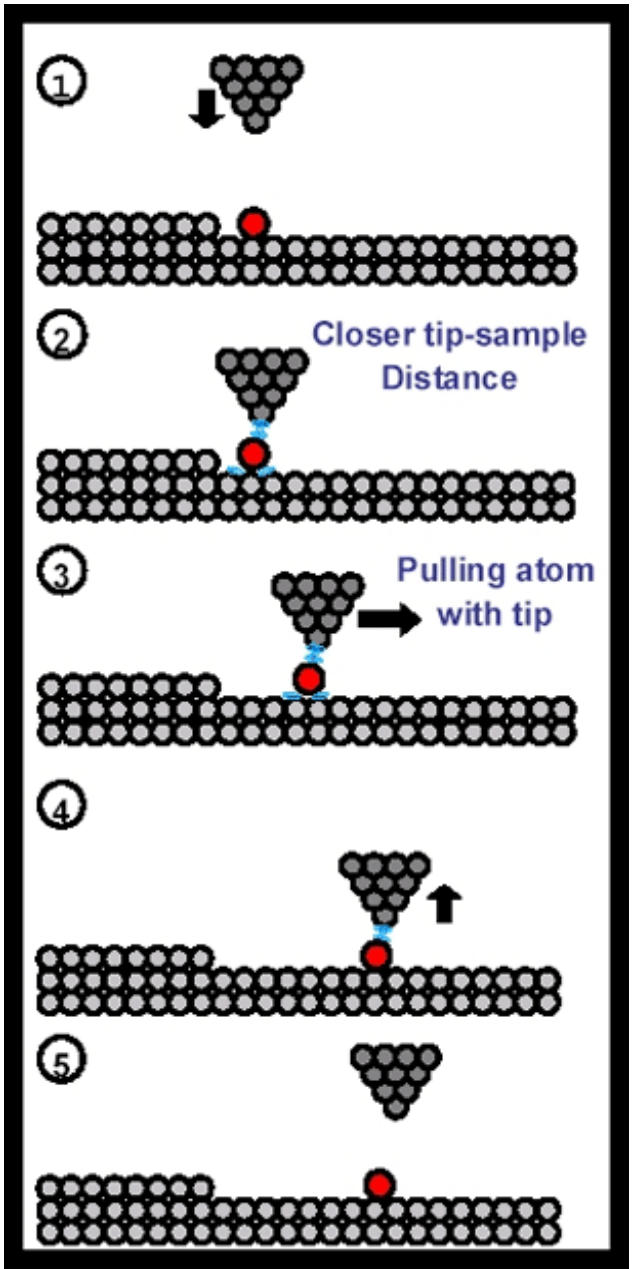


Figure10 - manipulating atoms with stm

- We can manipulate individual atoms.
- Very thin film used in nano devices.

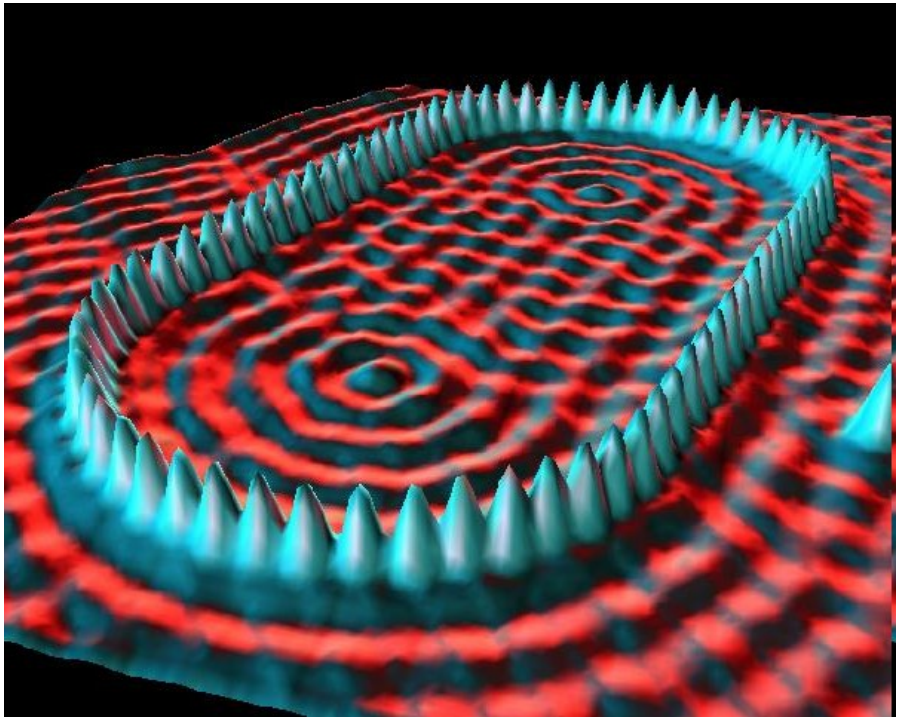


Figure9 - Positioned iron atoms on a copper surface [9]
http://images.google.com.tr/imgres

Advantages

- Conceptually simple but complexities in use.
- Can even move atoms
- Can be used in variety of temperatures.

  (VT-STM in variety of temp.) UHV-STM in low temp.

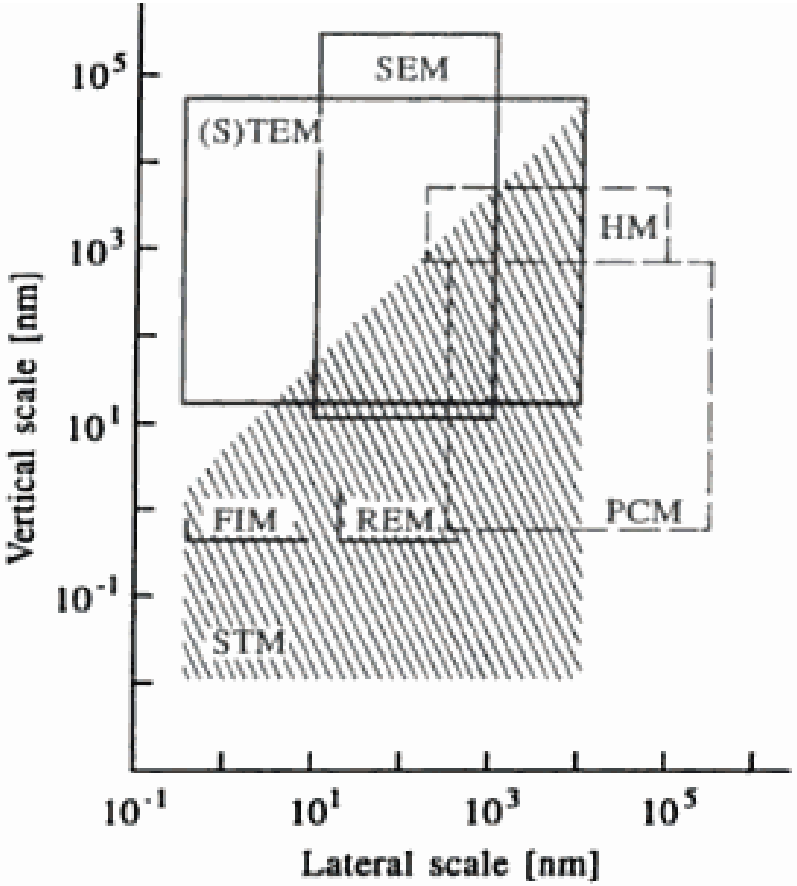


Figure 16 Comparison of the resolution range of STM with that of other microscopes [1.1]. [HM: High-resolution optical Microscope. PCM: Phase Contrast Microscope. (S)TEM: (Scanning) Transmission Electron Microscope. FIM: Field Ion Microscope. REM: Reflection Electron Microscope]

[16] Surface Sciences.,C.Bai Scanning Tunneling Microscopy and Its Applications,Second Revised Edition,Shanghai Scientific & Technical Publishers

Examples

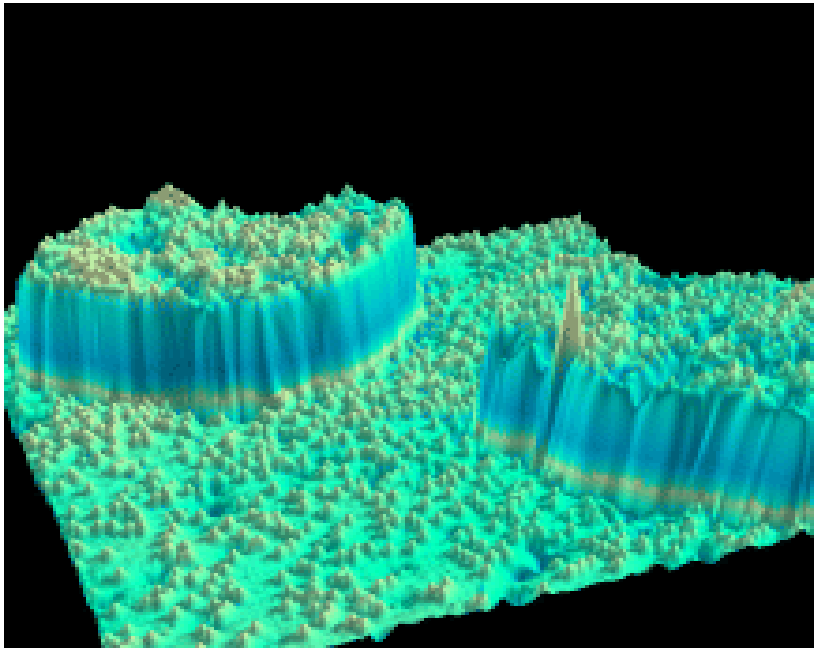


Figure 11 -STM image, 35 nm x 35 nm, of single substitutional Cr impurities (small bumps) in the Fe(001) surface.[11]
www.nist.gov/physlab/general/stm/index.cfm

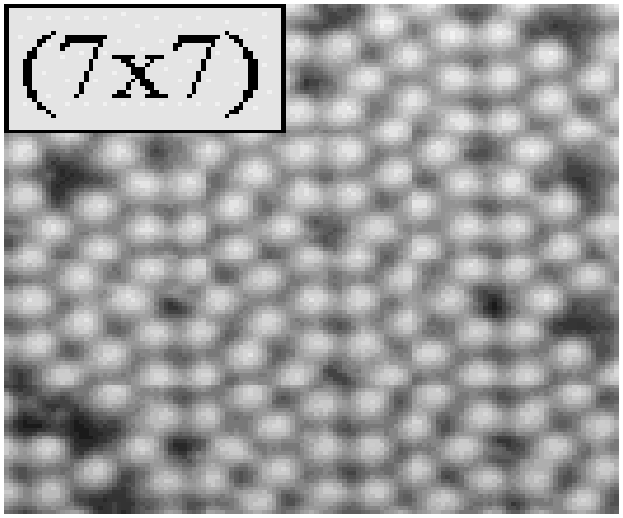


Figure 12-Si(111)7x7
www.fkp.uni-erlangen.de/methoden/stmtutor/stmpage.html

Advantages

- Can achieve atomic-level resolution.
- Can perform in different environments. (air, water etc.)
- Directly analyze sample and 3D output.
- No need for any lenses or unique light source.

Examples

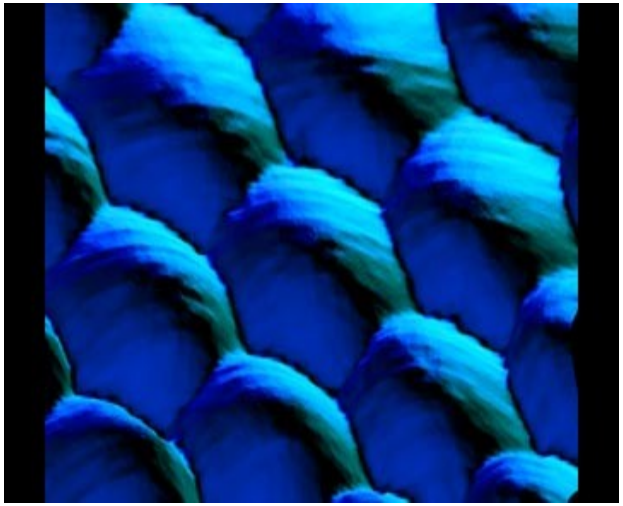


Figure 13-Blue Platinum
The surface of Platinum.[14]
Courtesy: IBM Research, Almaden Research Center

Figure 14-In 1989, Eigler and Schweizer spelled “IBM” by positioning thirty-five xenon atoms on a nickel surface. [15]
Courtesy: IBM Research, Almaden Research Center

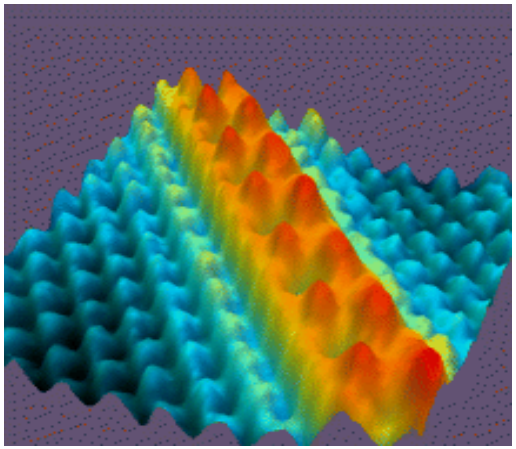


Figure -15- STM image, 7 nm x 7 nm, of a single zig-zag chain of Cs atoms (red) on the GaAs(110) surface (blue).[15]
www.nist.gov/physlab/general/stm/index.cfm

Disadvantages

- Needs extremely clean surface.
- A single dust particle can damage needle.
- Needs sophisticated electronics.
- Sharp tips. (Pt, W)
- Noise problems.
- Vibration.

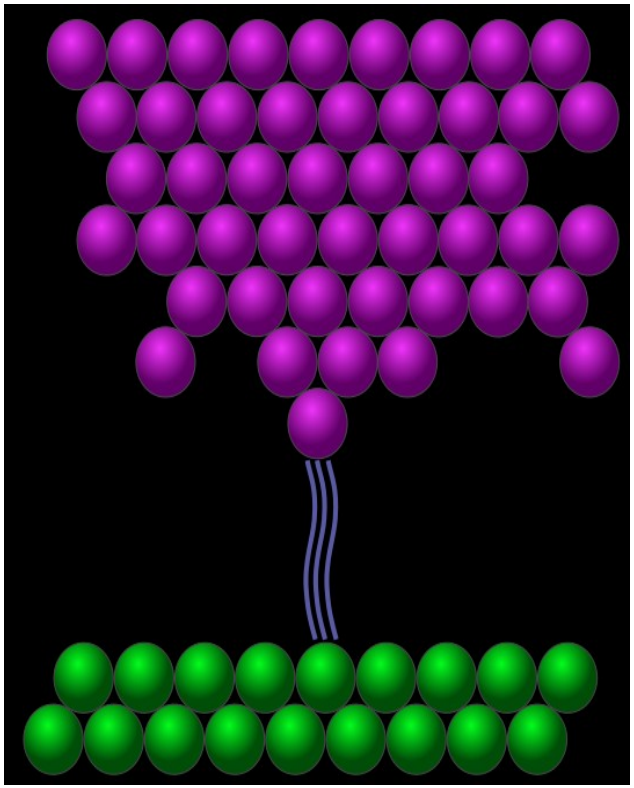


Figure -17 Damaged tip [17]
http://upload.wikimedia.org/wikipedia/commons/thumb/e/e8/Scanning_tunneling_microscope_ideal_tip.svg/520px-Scanning_tunneling_microscope_ideal_tip.svg.png

Important in Many Sciences

- In physics, semiconductor physics and microelectronics.
- In chemistry, surface reactions in catalysis.
- In biology, in the study of DNA molecules.
- In nanoscale chemistry labs, synthetic chemical compounds.

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