

Nanomaterials Characterization

By Atomic Force Microscopy

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Principle

The tip

The Scanner

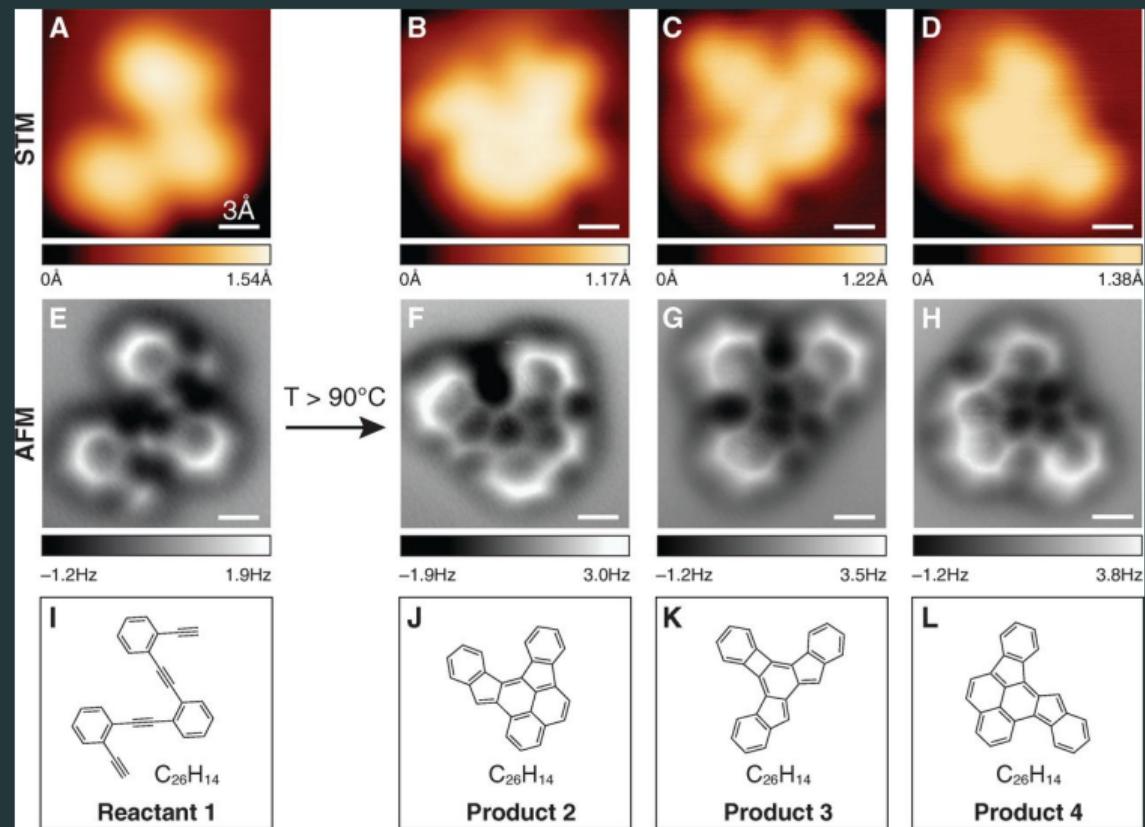
Imaging

Spectroscopy

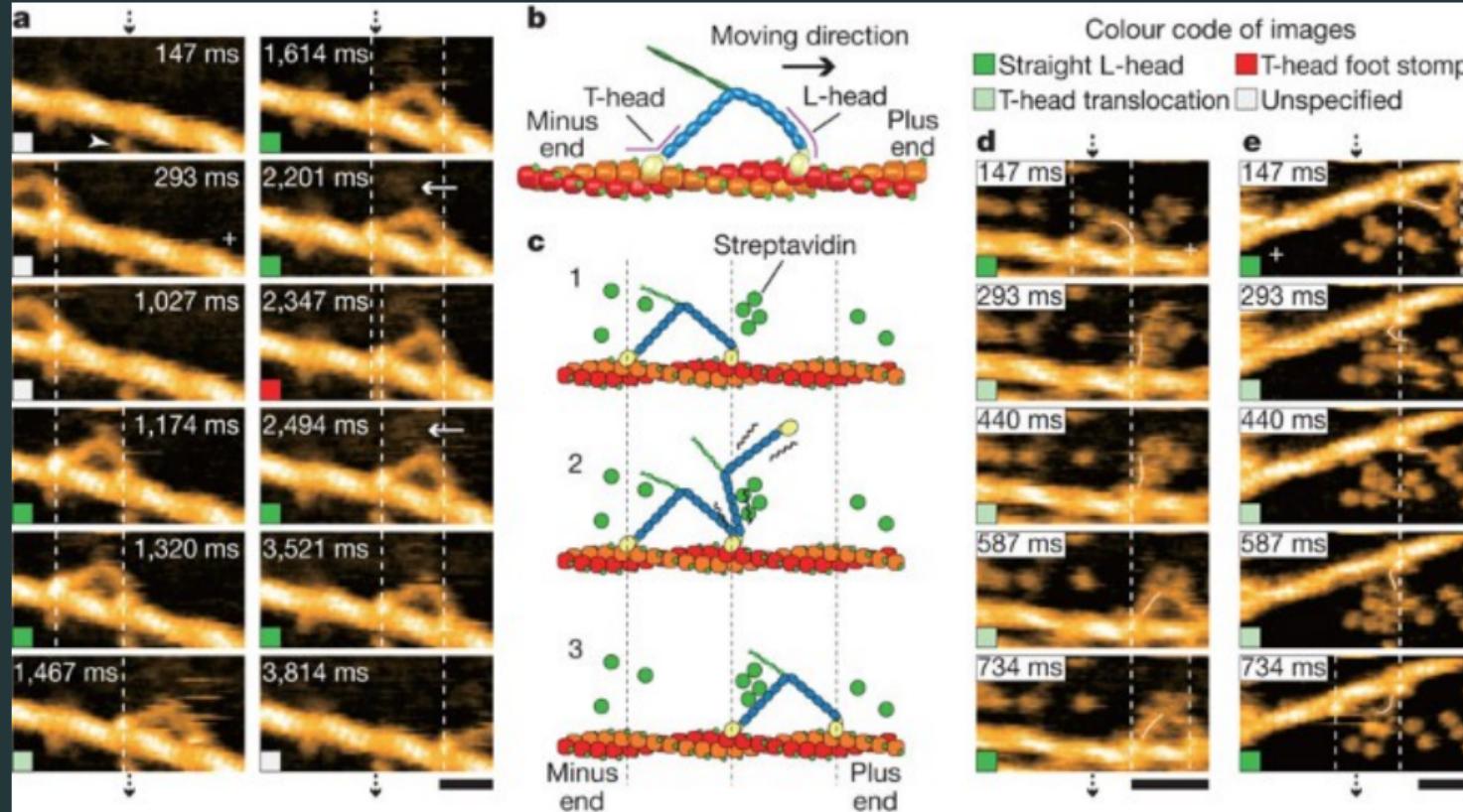
Summary

AFM:

Atomic Force Microscopy



Oteyza et al. 2013



Myosin walking on Actin. Kodera et al. 2010

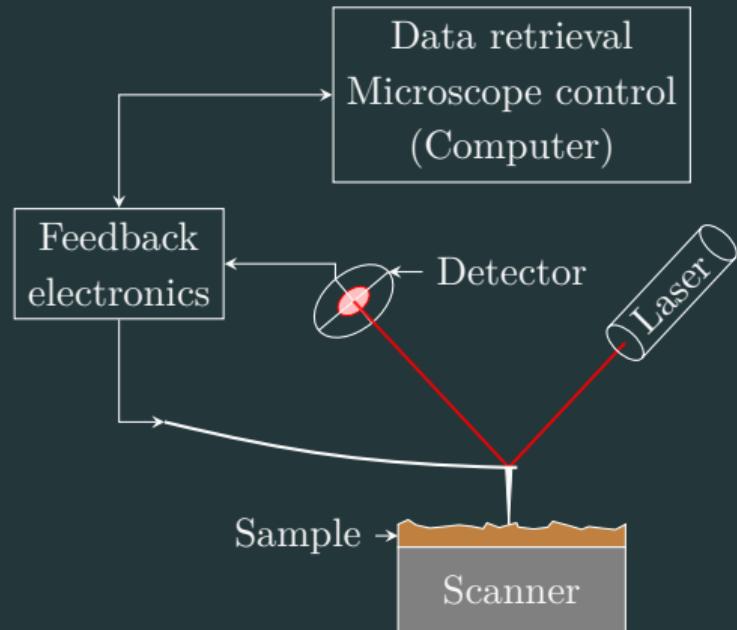
AFM:

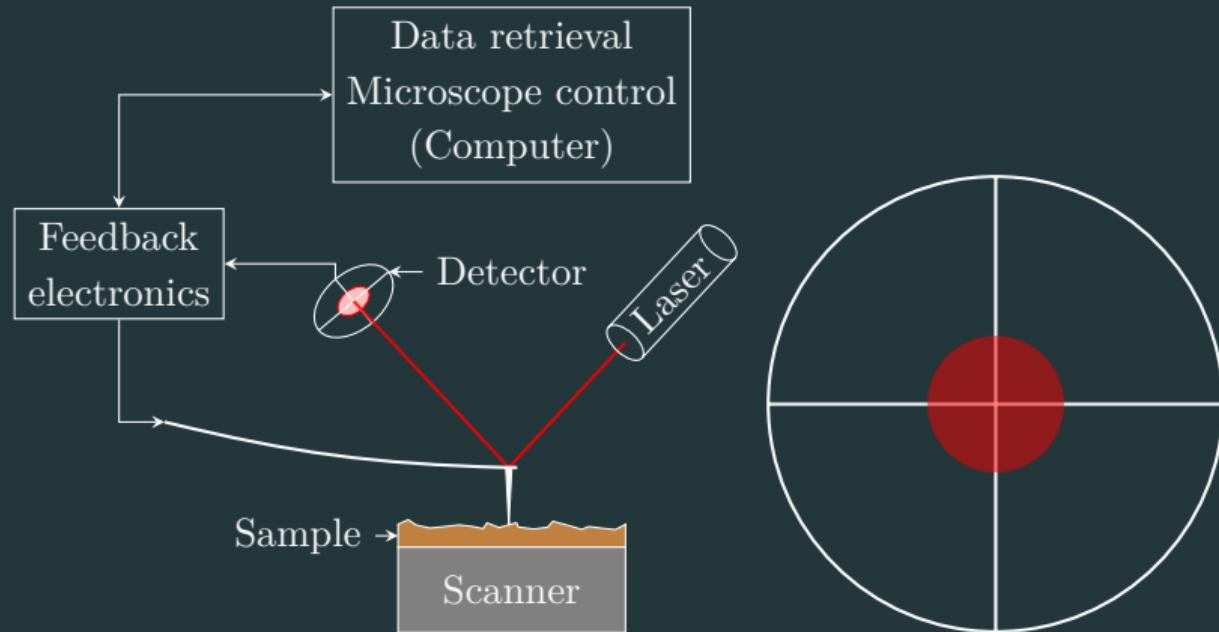
Atomic Force Microscopy

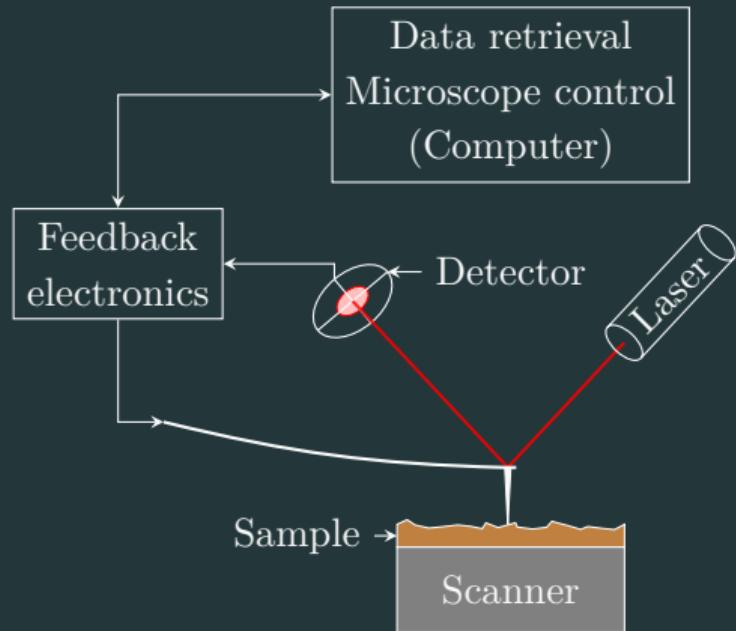
OR:

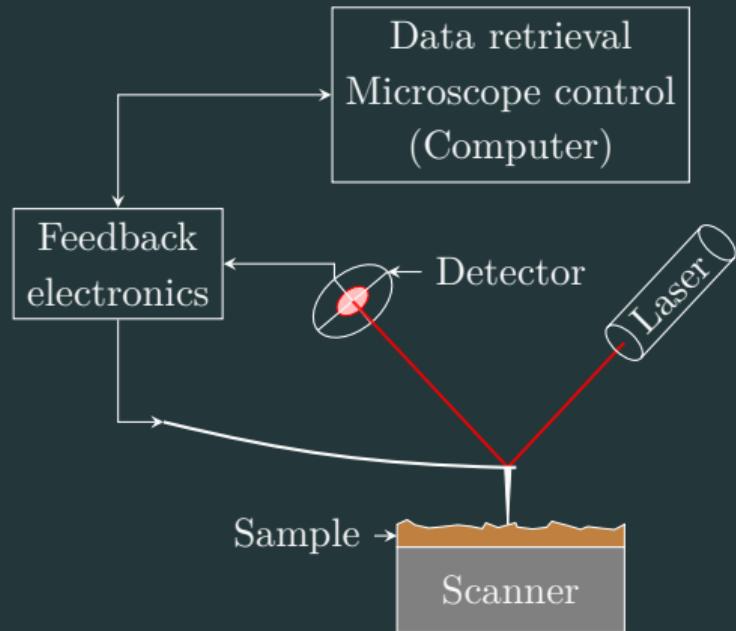
Artifact Fabrication Machine

Principle

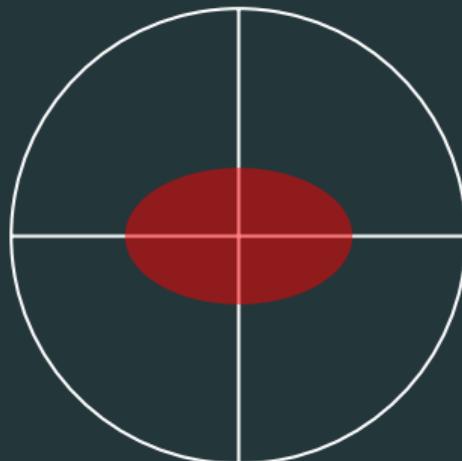








displacement in x

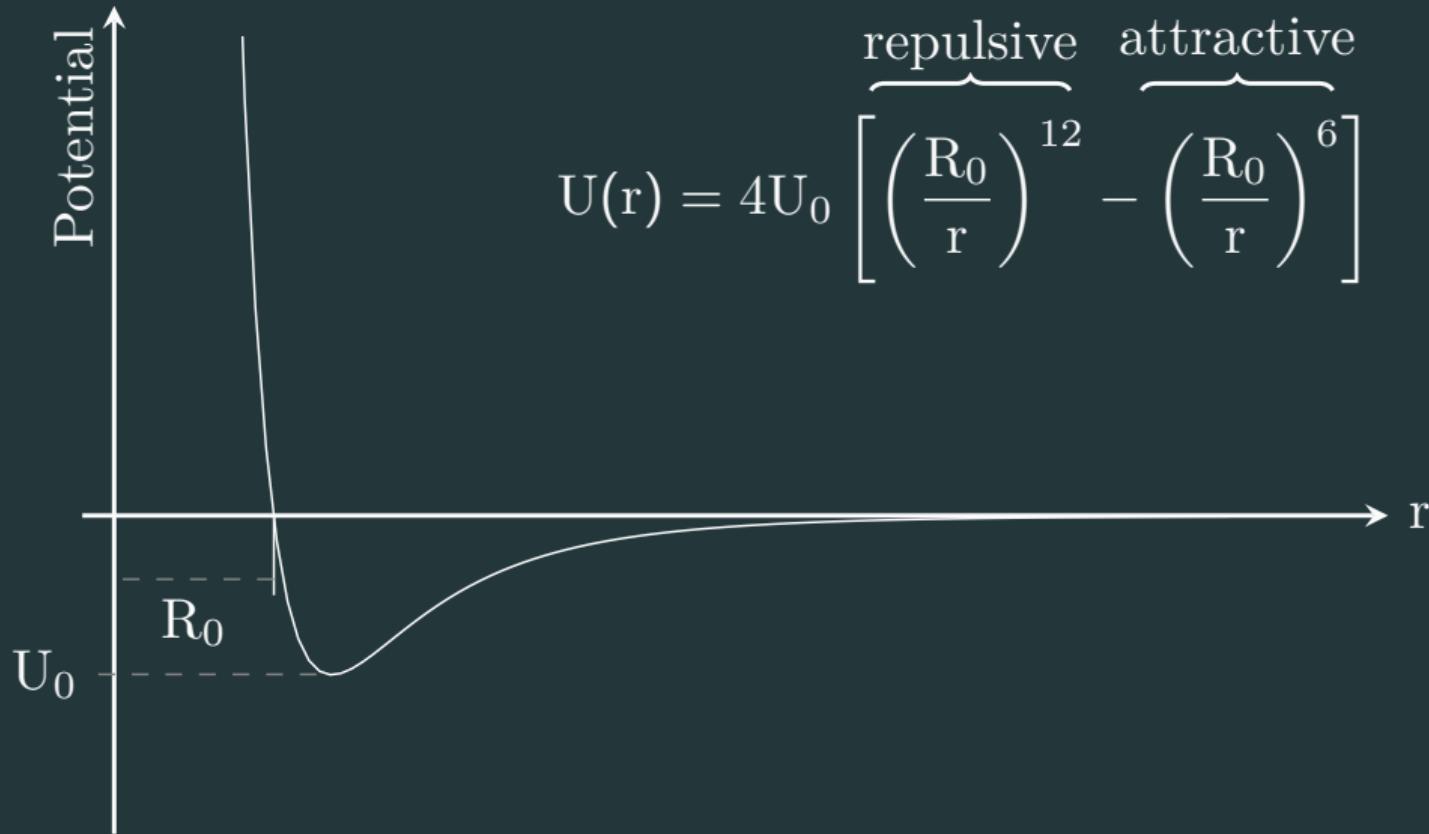


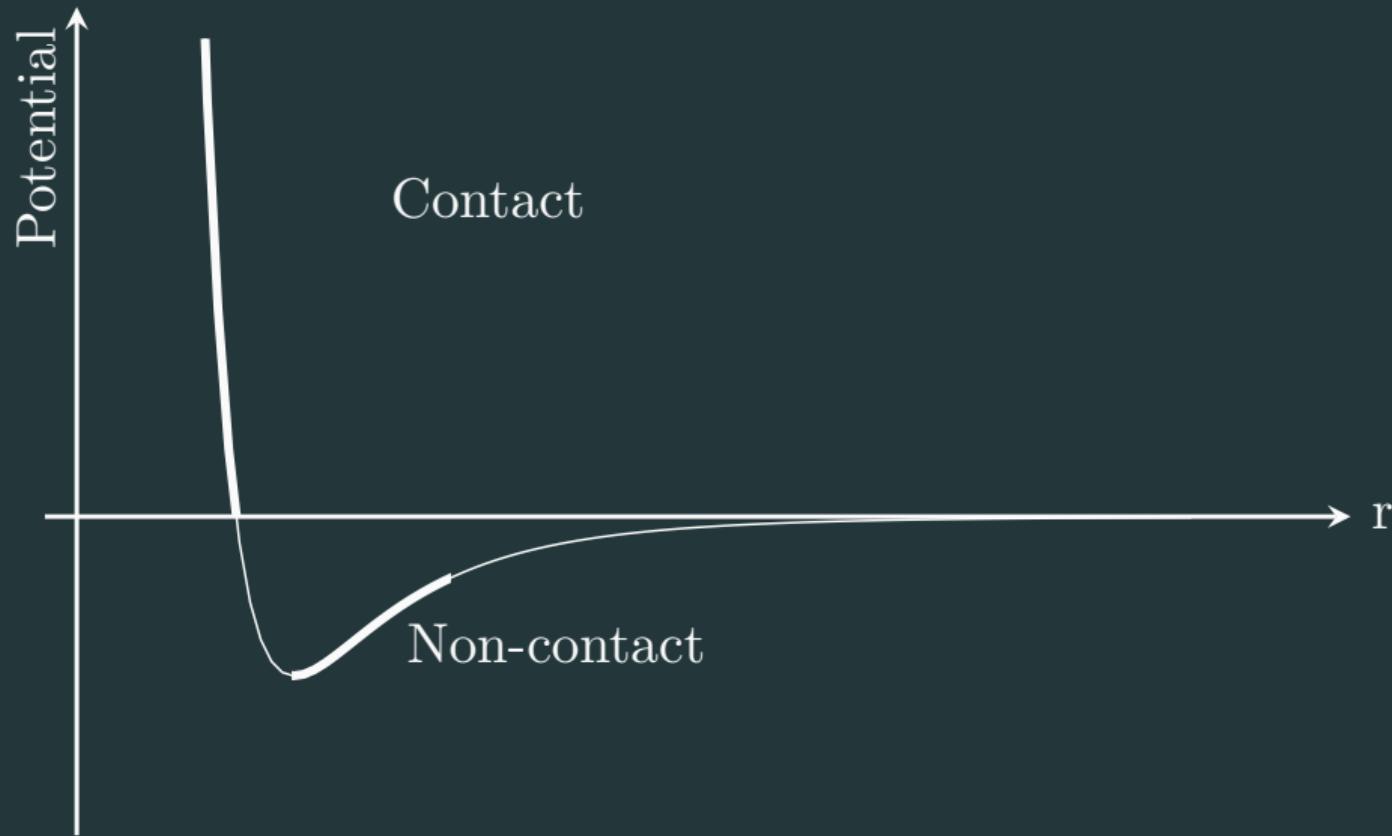
Vacuum, air, liquid

- Topography
- Mechanical properties
- Chemistry
- Magnetism
- Electrical/semiconductors
- Lithography
- +++

Typically slow BUT: fast AFM can image proteins in action

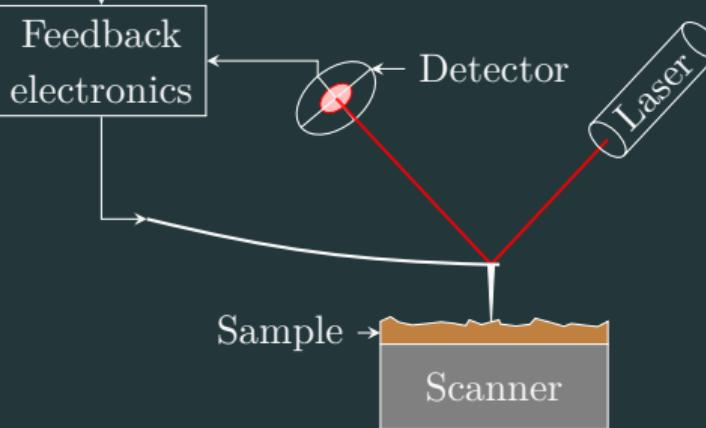
Achievable resolution: Below atomic scale.





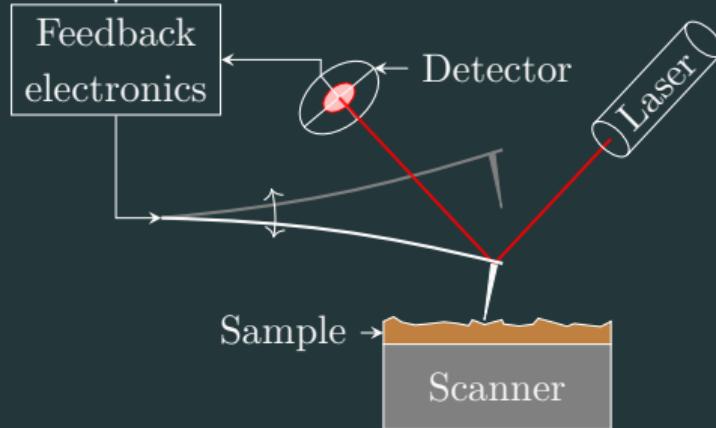
Contact

Data retrieval
Microscope control
(Computer)



Tapping/non-contact

Data retrieval
Microscope control
(Computer)



Contact

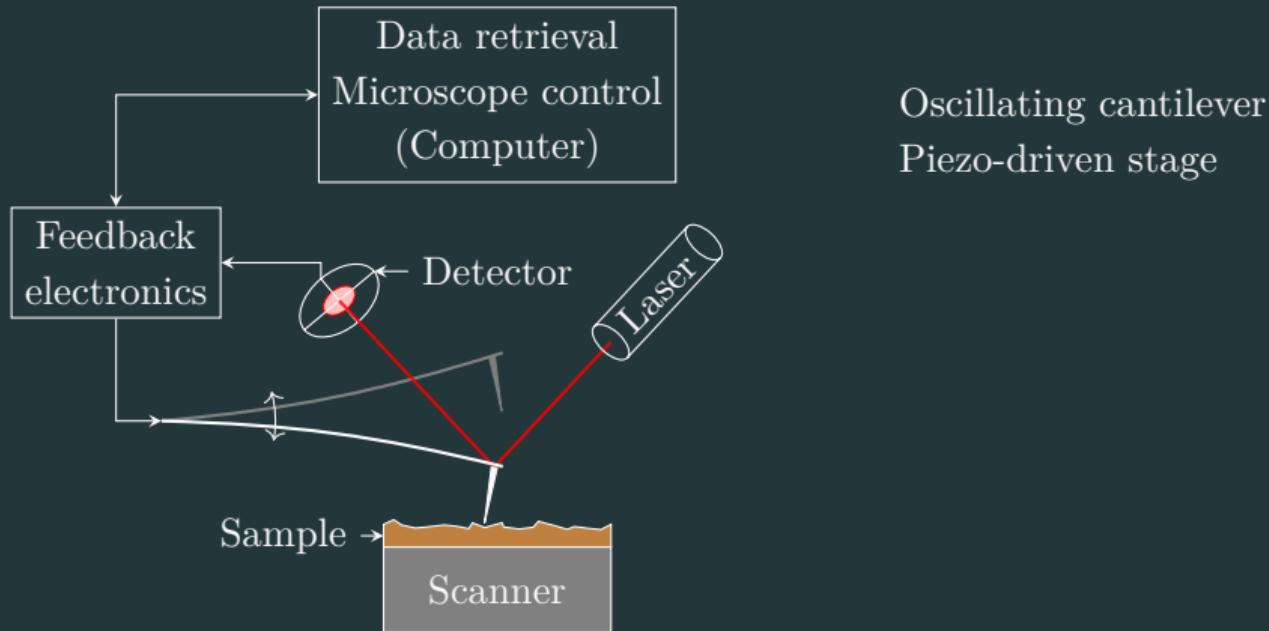
- Harsh
- Any environment
- Simple
- Lithography

Tapping

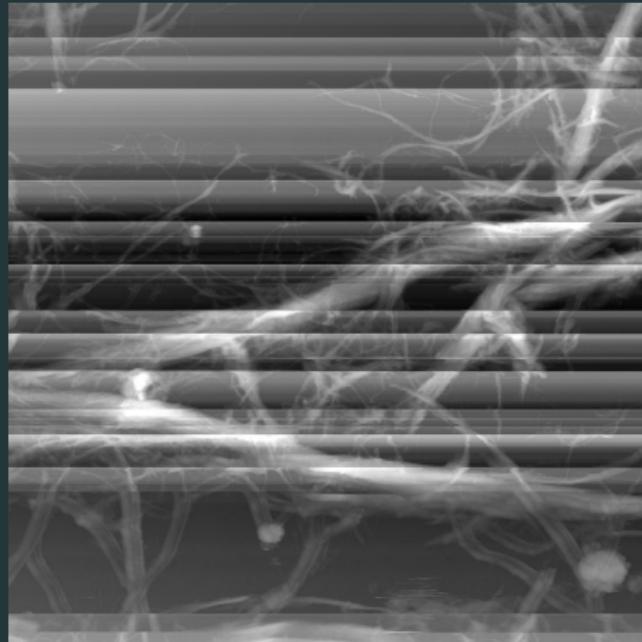
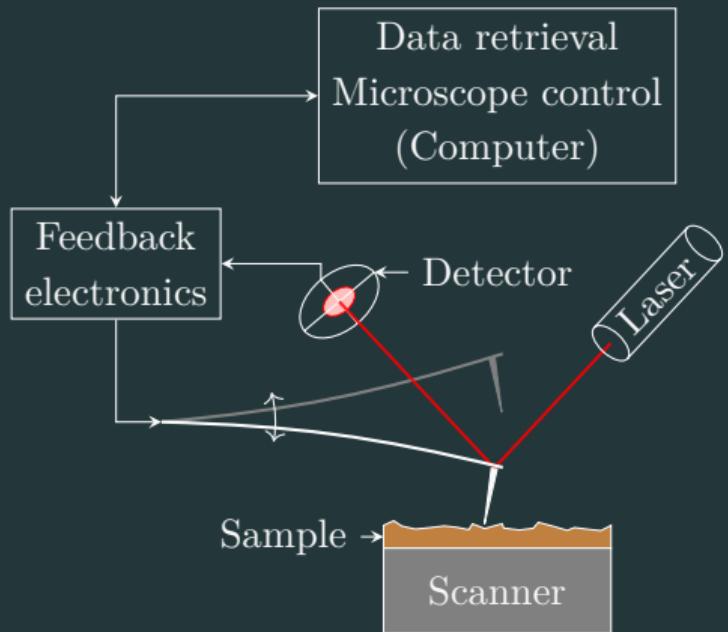
- Gentle
- Any environment
- Less simple
- Most common

Non-Contact

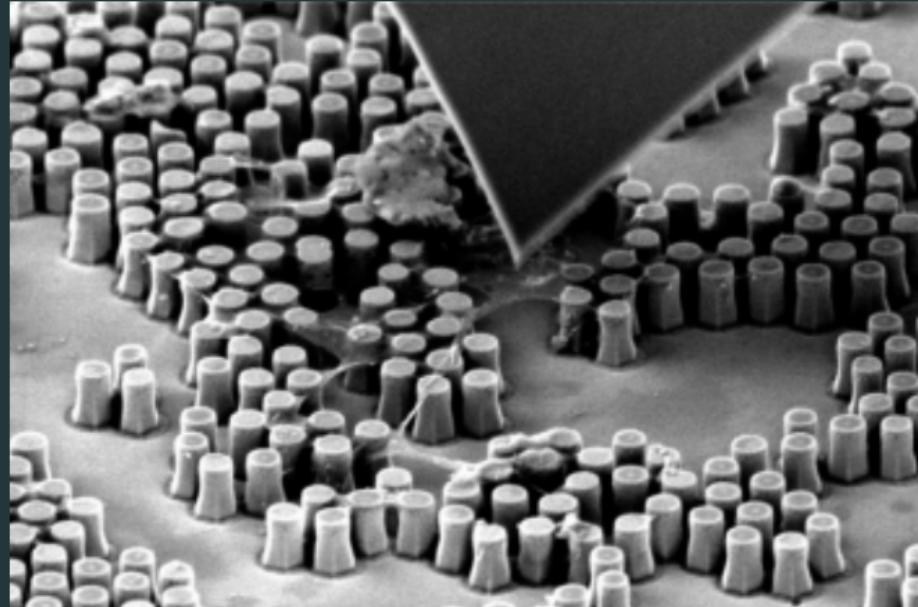
- Very Gentle
- Not liquid
- Not simple
- Forces, not topography



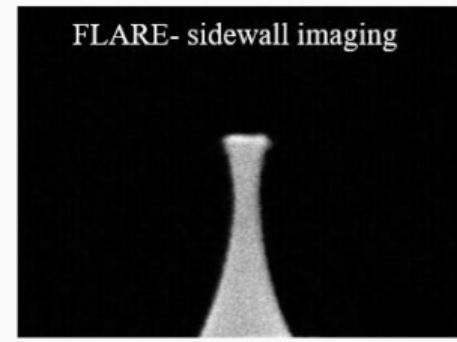
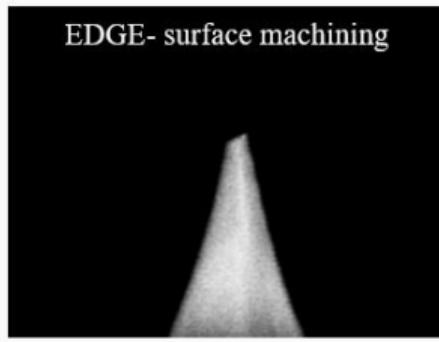
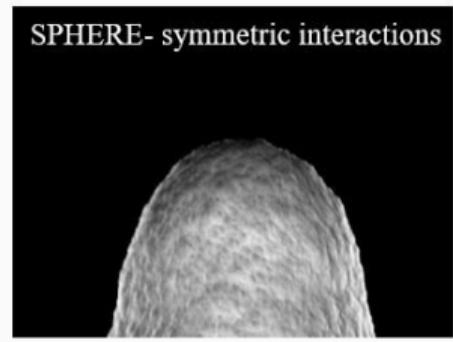
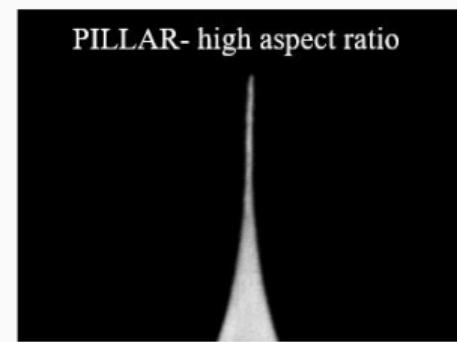
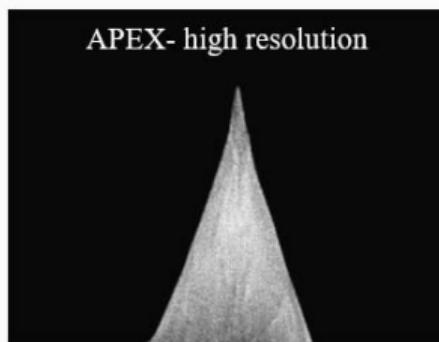
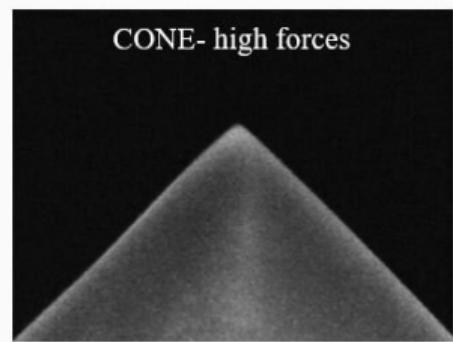
Oscillating cantilever
Piezo-driven stage



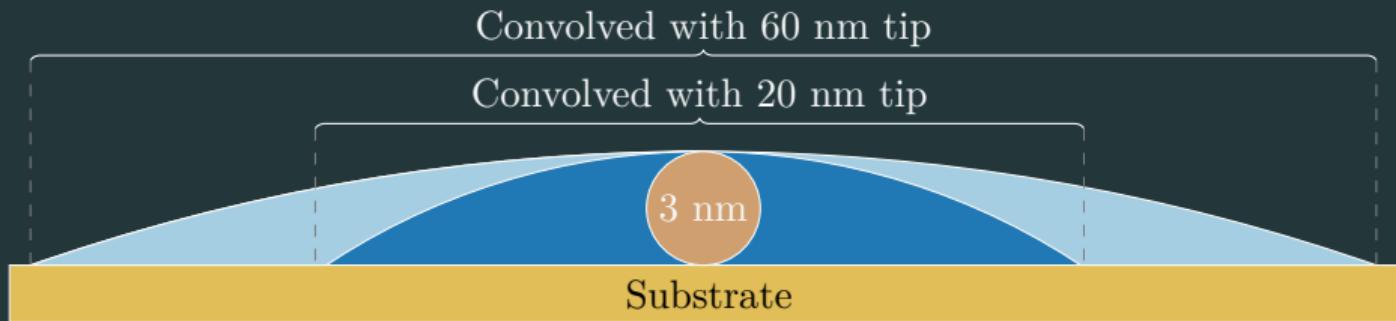
The tip

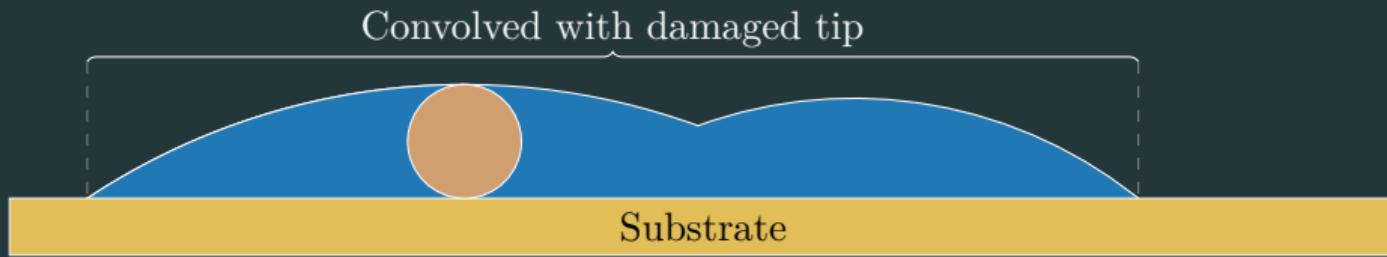


Source: Azo materials

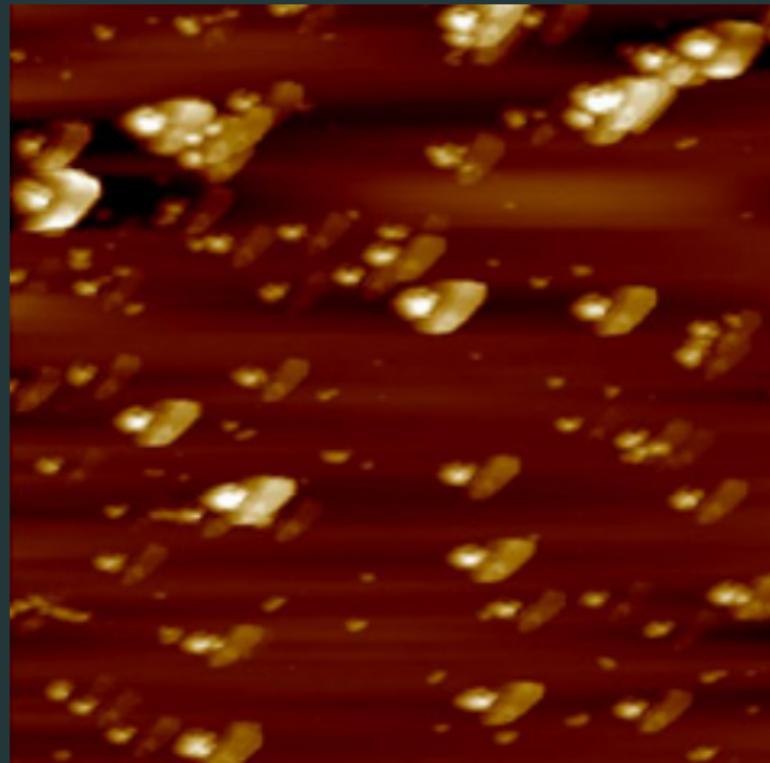


Source: Adama Innovations

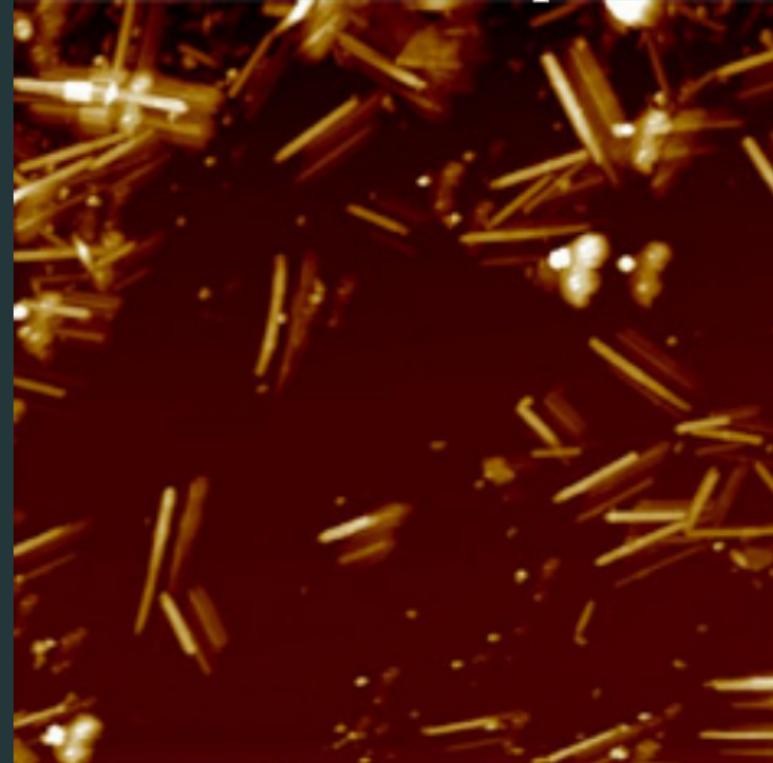




Contamination

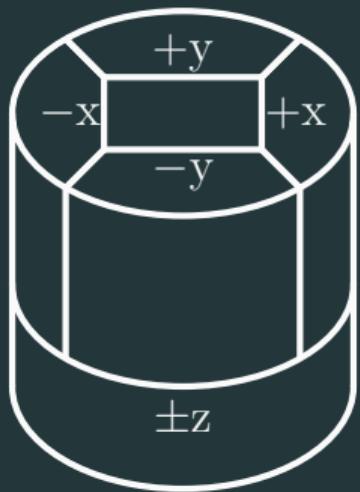


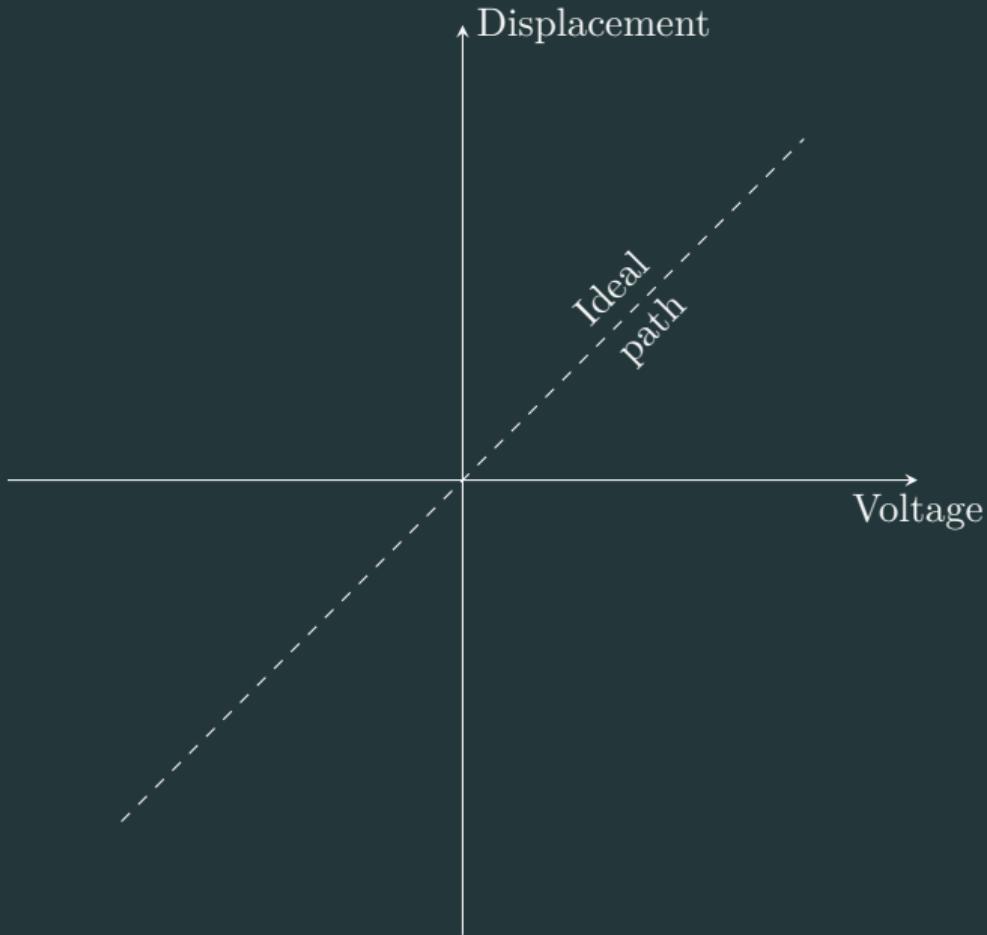
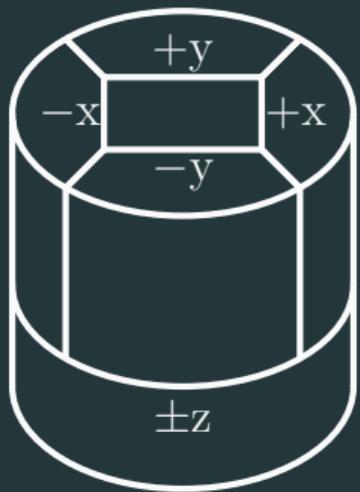
Double tip

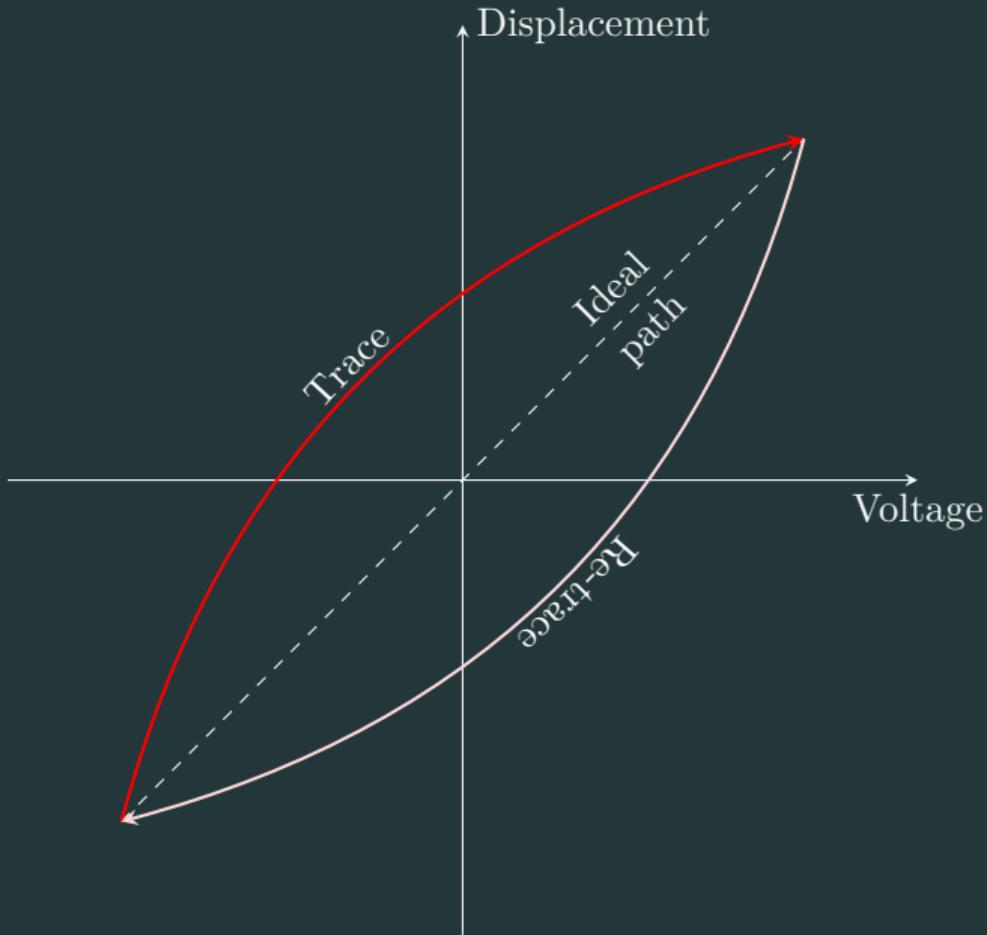
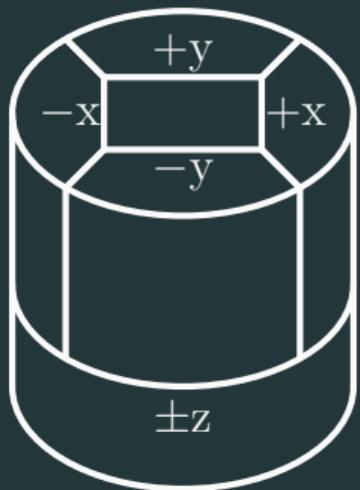


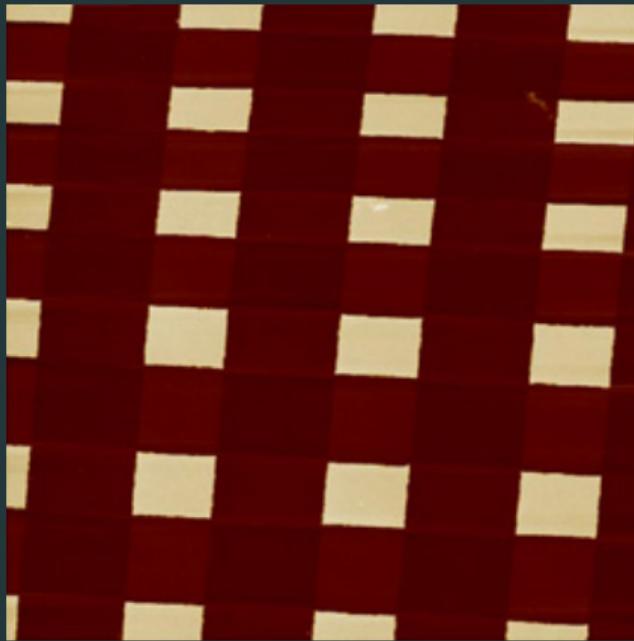
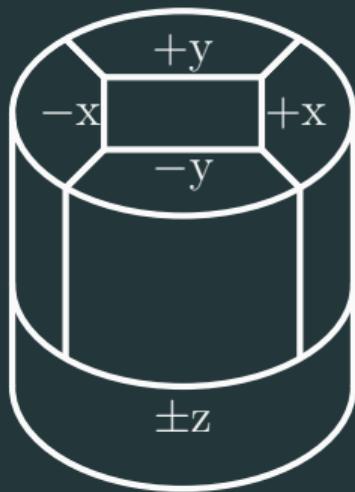
Geometry is essential

The Scanner

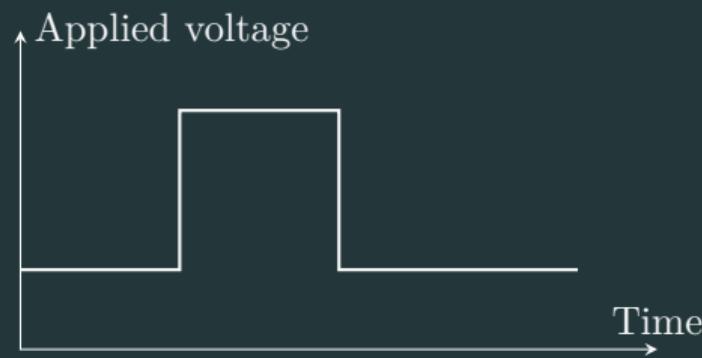
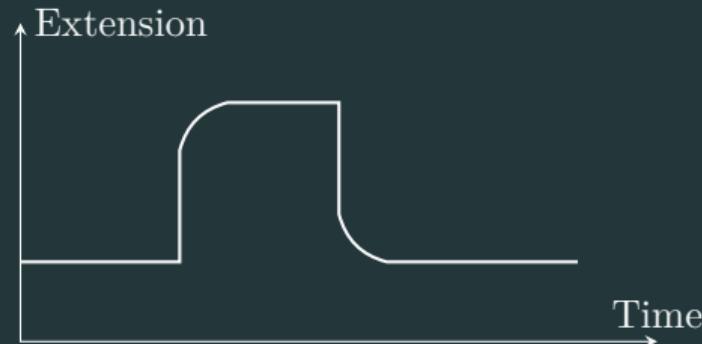
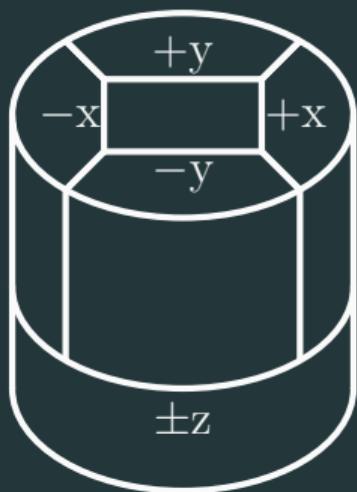


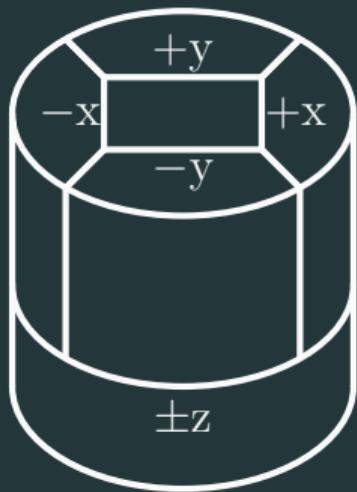






Myscope.com





Software correction (to an extent)

Imaging

Channels

Error

Height

Inphase

Horizontal

Adhesion

Dissipation

Young modulus

Conductivity

...

Channels

Error

Height

Inphase

Horizontal

Dissipation

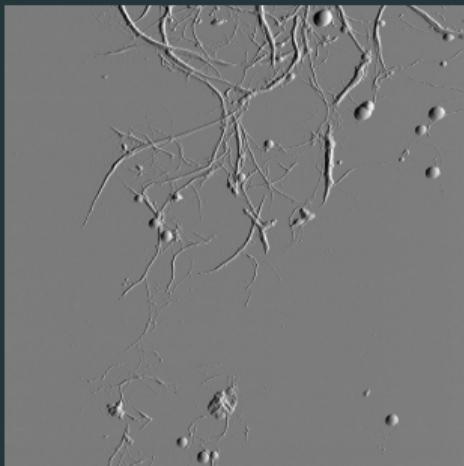
Dissipation

Young modulus

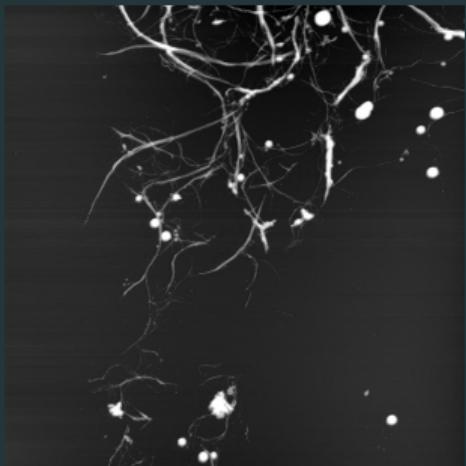
Conductivity

...

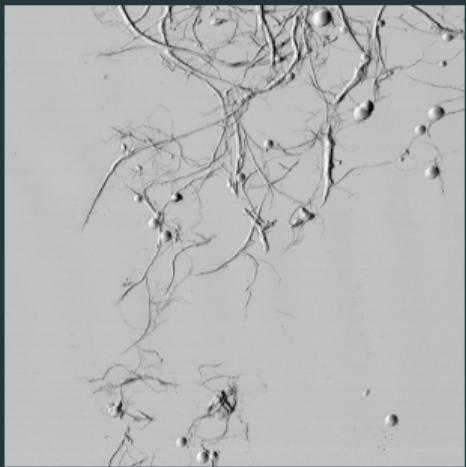
Error



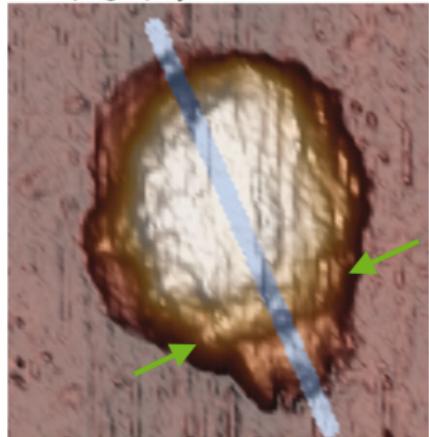
Height



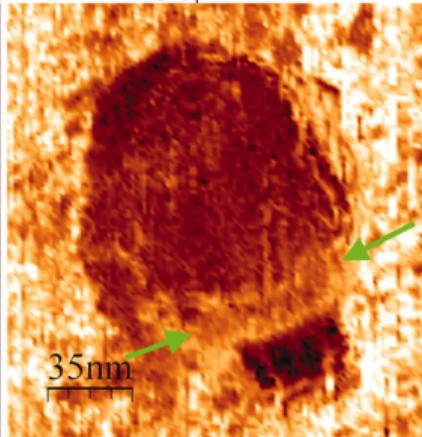
Phase



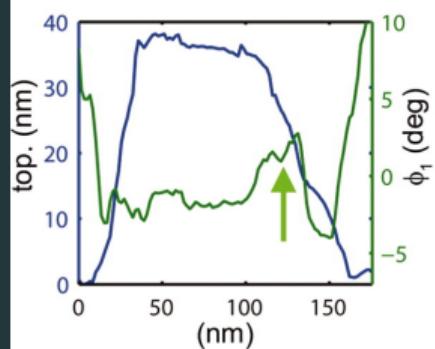
A topography



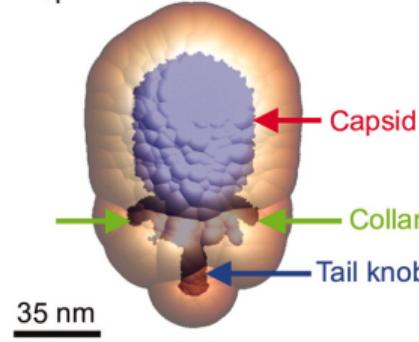
B phase lag ϕ_1



C Profiles

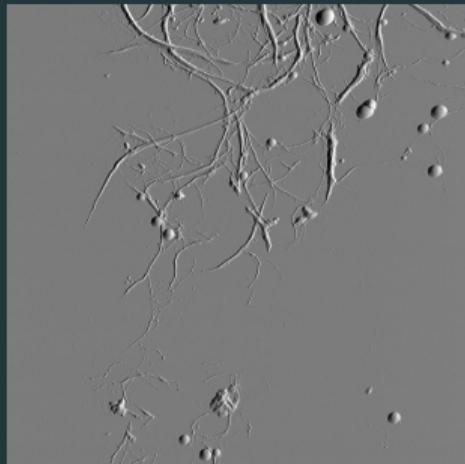


D Cryo-EM model with AFM tip dialation

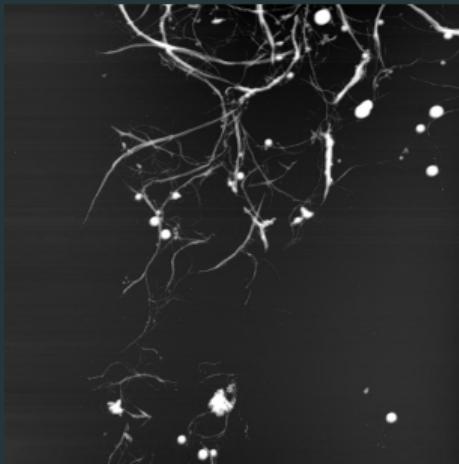


From Melcher et al. 2009

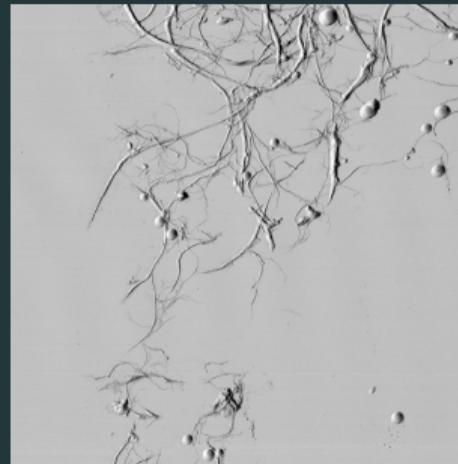
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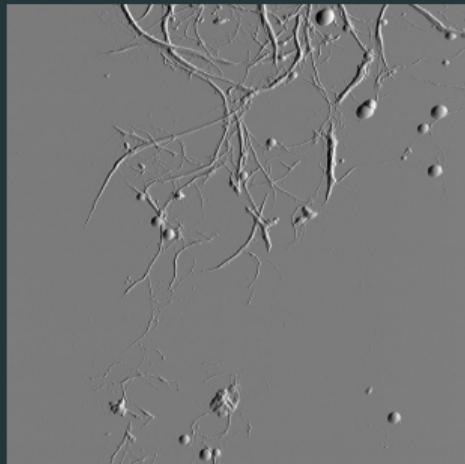
Height



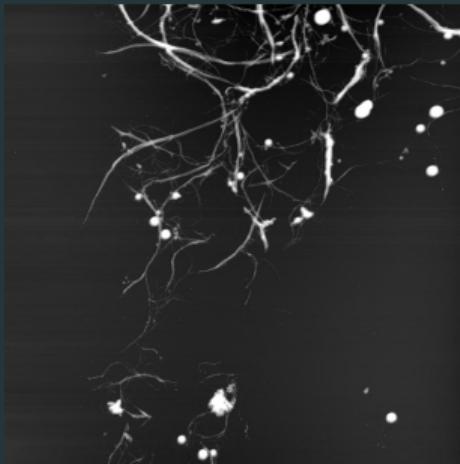
Phase



Error



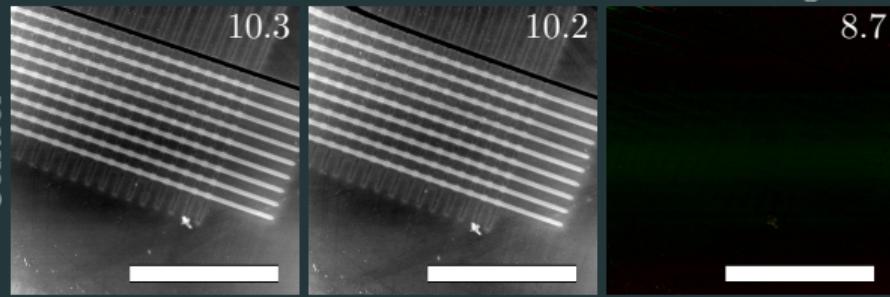
Height



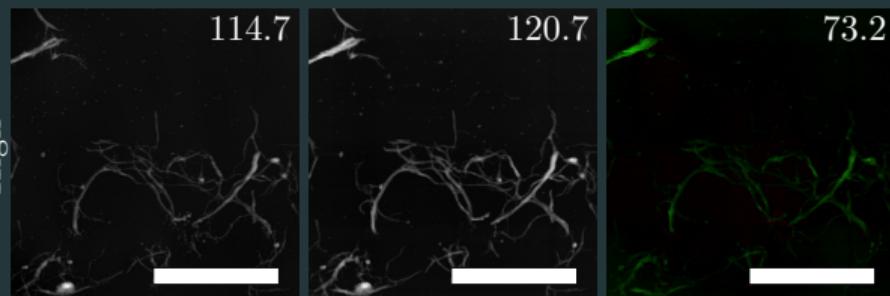
Phase



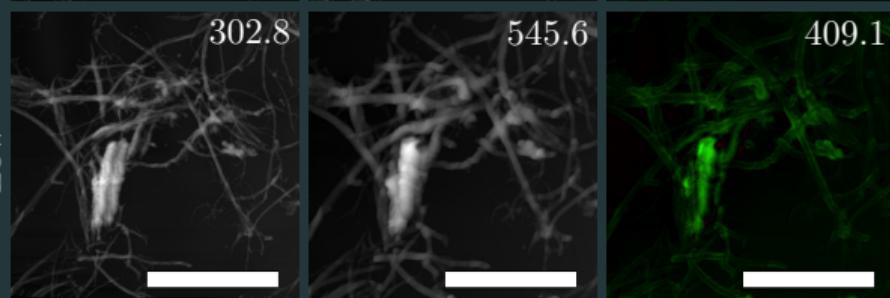
Control



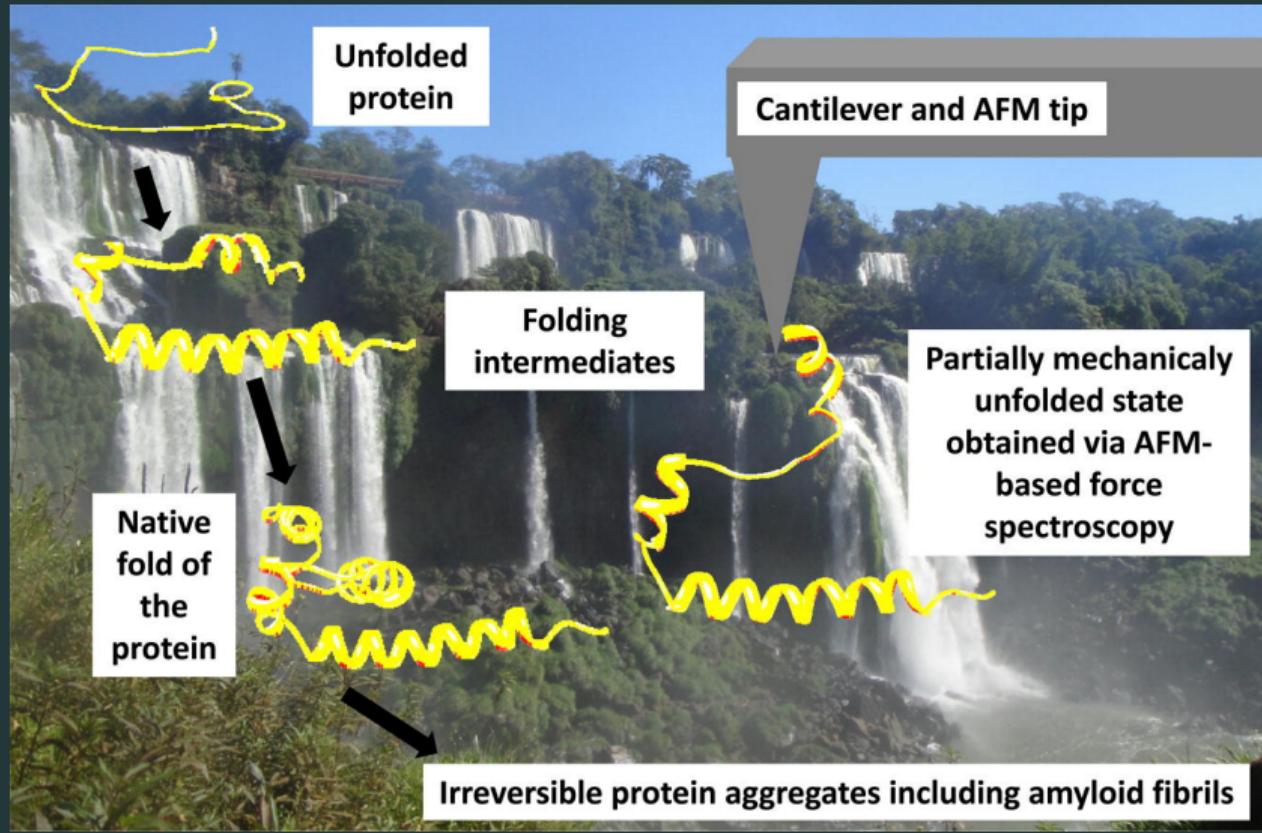
High



Low

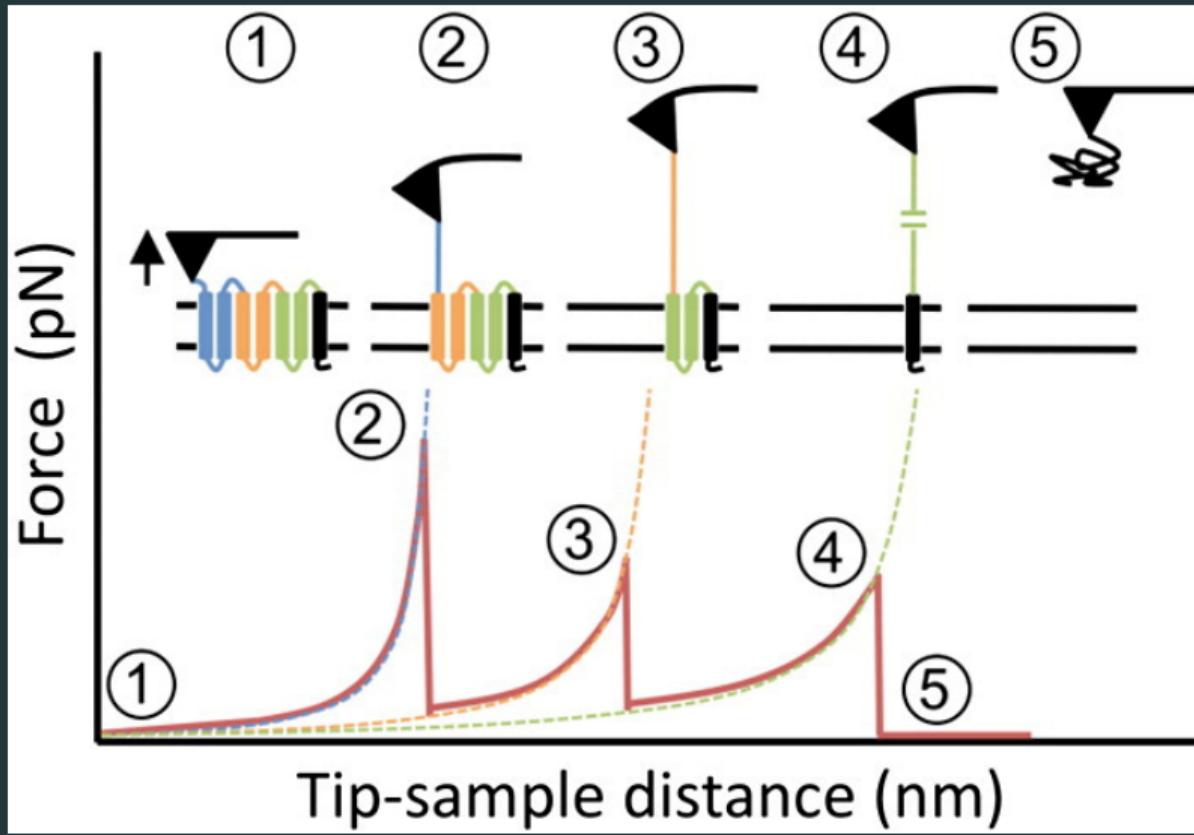


Spectroscopy

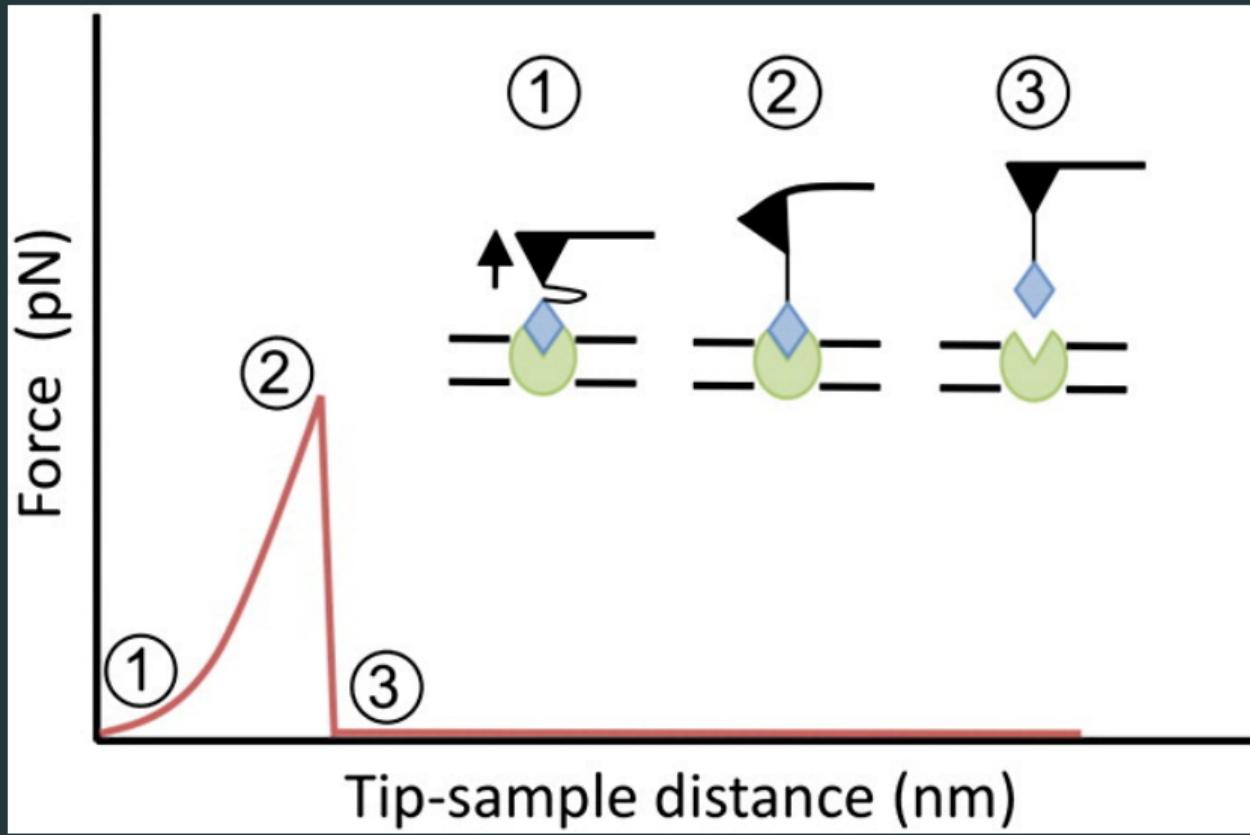


et al. 2013

//Carvalo



Whithed & Park, 2014



Whithed & Park, 2014

Summary

AFM: Atomic Force Microscopy

Sharp tip rastered across sample

Deflection, twist, oscillation: Basis for signal

Works in air, liquid, vacuum

Can resolve even covalent bonds

Contact, Tapping, Non-contact

Tip

Sharp tip affixed to larger cantilever

Tip geometry affects resolution

Tip geometry/chemistry must fit experiment

Tip care essential

Scanner

Piezo-electric, often below sample

Hysteresis, creep, scanner geometry may skew image

Mostly software corrected

Imaging

Various channels w. different data

Available channels depend on setup

Spectroscopy

Functional tip, test molecular interactions

Examples: Protein folding, protein interactions

General:

Versatile surface technique

Supreme resolution

Easy to use, difficult to master

?