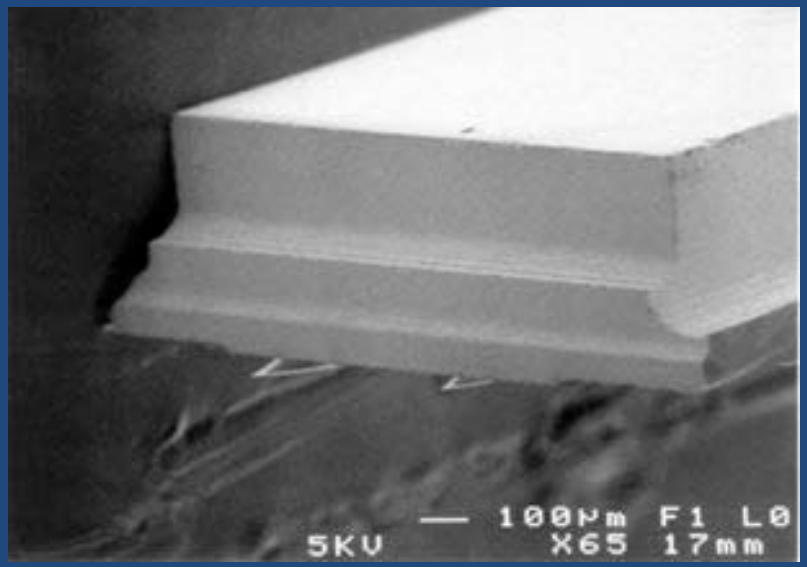
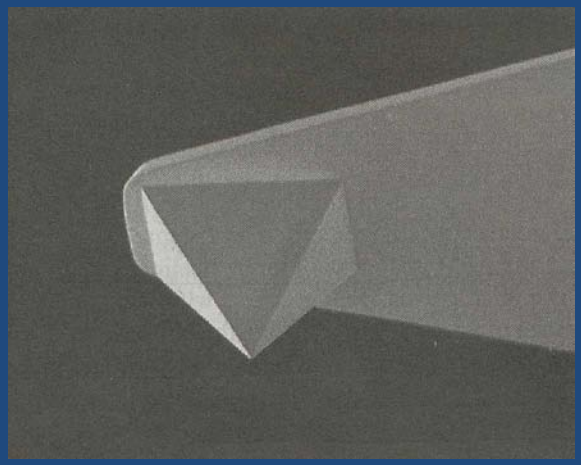
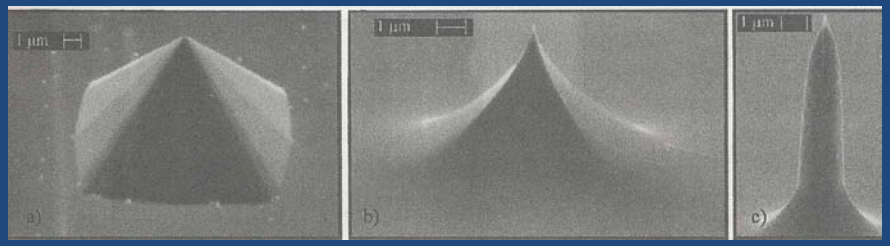
AFM Cantilever/Tip Styles





DNP Silicon Nitride Probes

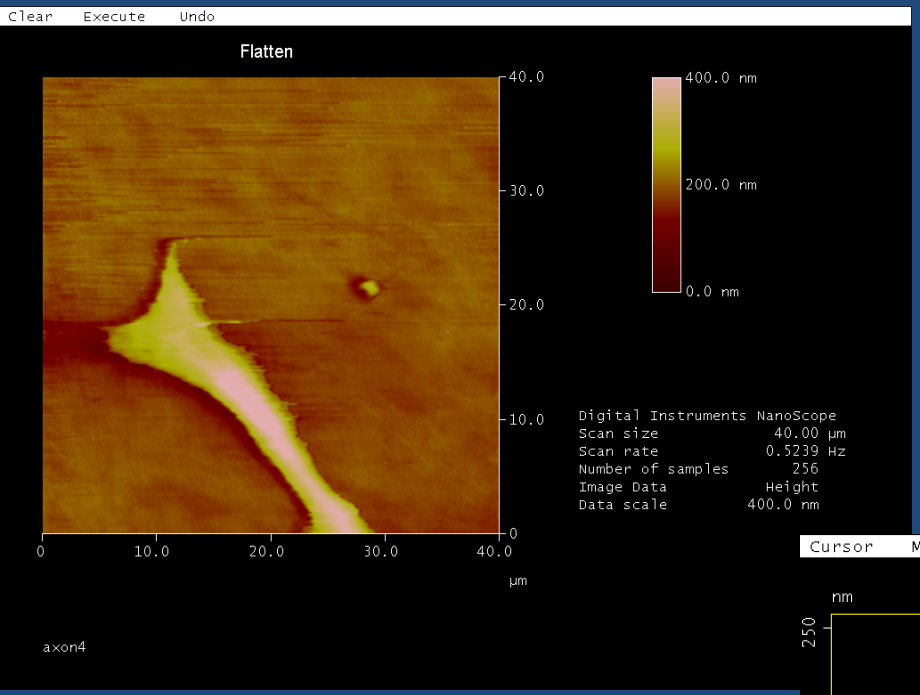
spring constants: 0.58, 0.32, 0.12, 0.06 N/m
tip radius of curvature: 20-60nm
cantilever length: 100 & 200µm
reflective coating: gold
shape of tip: square pyramidal
tip half angle: 35



Carbon nanotubes as AFM tips?

AFM Tip Manufacturing Process

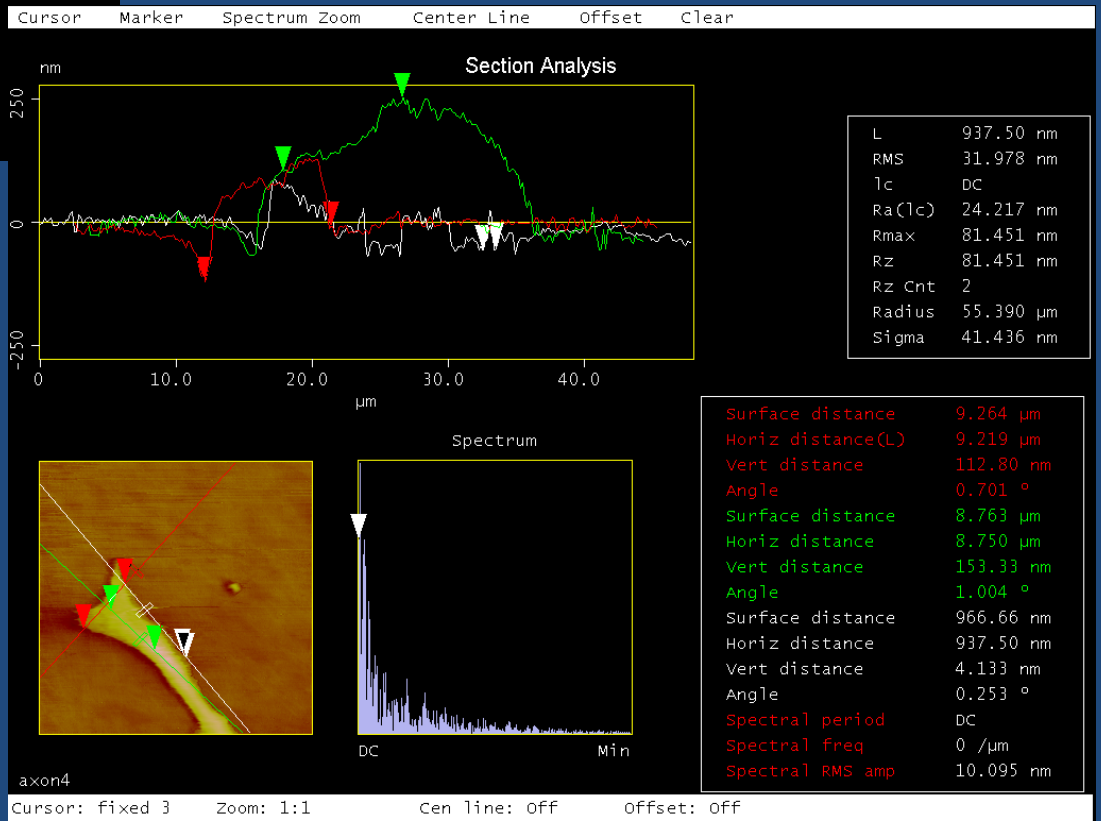
AFM Image Acquisition and Analysis



Original image

- 40X40µm (variable)
- scale bar (variable)
- image parameters –
  - ✓P&I gains
  - ✓ scan rate
  - ✓ set point
  - ✓ # samples/line
  - ✓ scan angle

Section analysis
height and width measurements of interesting features

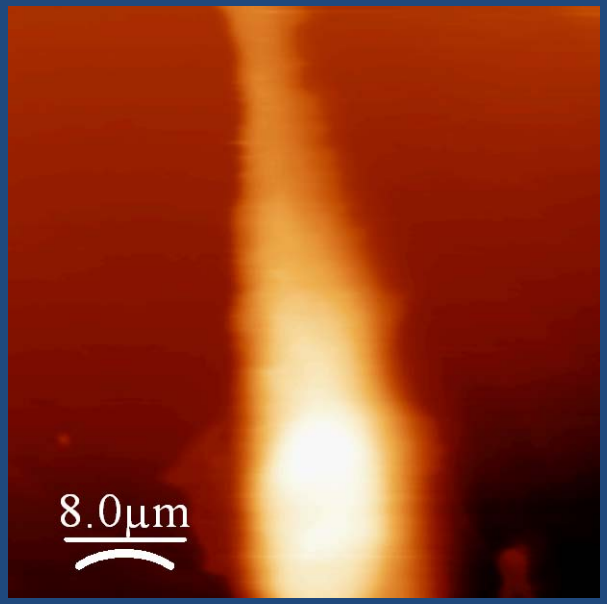


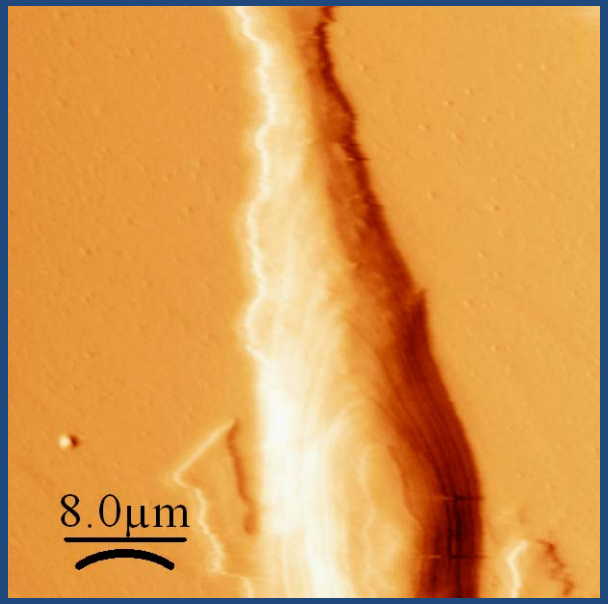
AFM Image Acquisition and Analysis

Channel selection

Height Mode

Error Mode



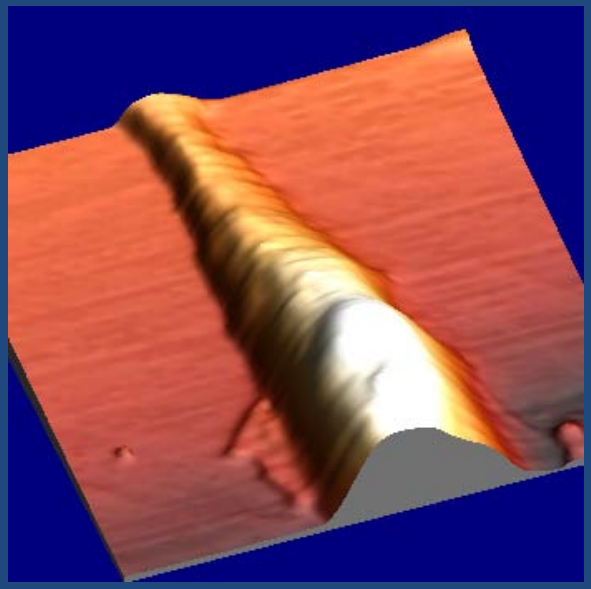


Offline Analysis

http://www.nanotec.es/index_noticias.html

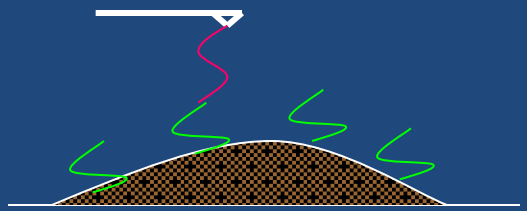
http://nanoprobenetwork.org/

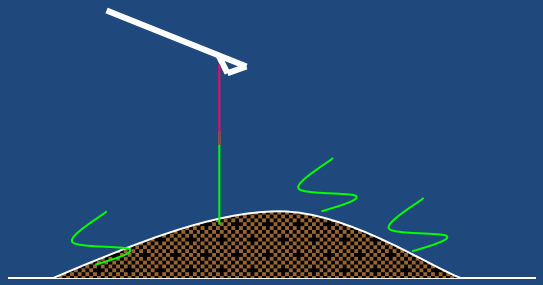
Free WSxM software

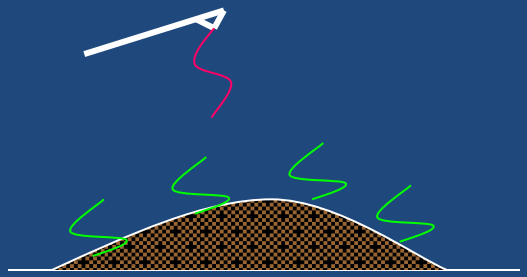


AFM Force Measurements

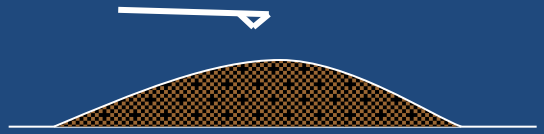
Pulling







Pushing



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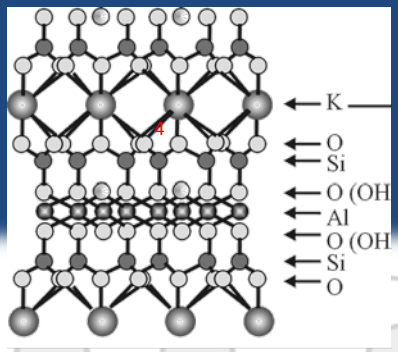
Sample Preparation

Flat Substrate
Free of Contaminants
Securely attached to the surface (or not?)
Size
Separation of particles/dilution
Vacuum, dry, fluids
Other Environmental conditions

What is your sample and what are it's characteristics?

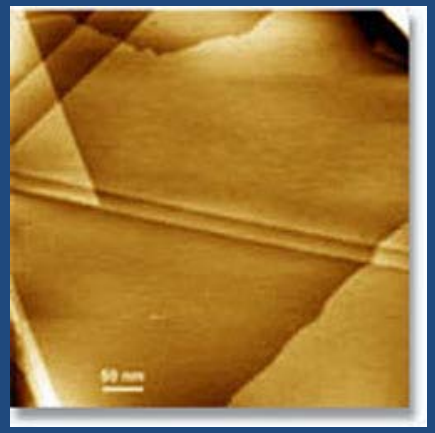


Mica

- An example of an atomically flat surface is Mica.
- Mica has flat layers surface that comprises of Aluminum, Silicon, Oxygen and Potassium.
- Mica has highly perfect basal cleavage.
  - Cleavage - tendency of crystalline materials to split along definite planes, creating smooth surfaces
    - Basal cleavage: cleavage parallel to the base of a crystal, or to the plane of the lateral axes
- Cleaved easily with the help of adhesive tape
- The area around the two planes have not been exposed to air making it extremely clean.
- Can be modified with silanes either to promote absorption or covalent bonding of bio molecules

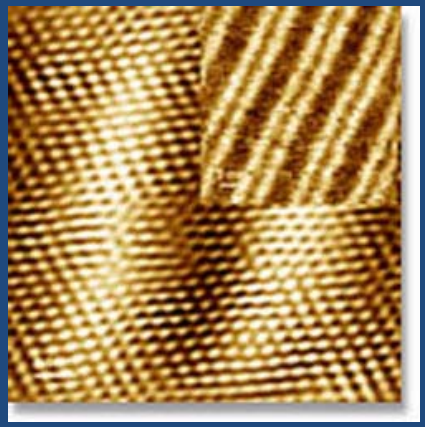
Evaporated Gold (Au 111)

- Used to immobilize samples because the metal surface can attract different molecules.
- Drawback is that gold can be exposed to the air and get contaminated.
- However using a flame based on hydrogen gas can clean the gold surface making it clean and flatter



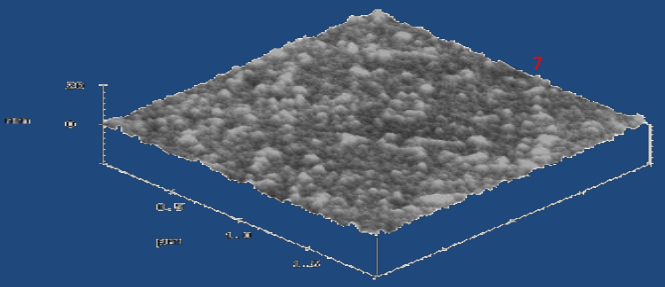
Low resolution scan of Au (111) surface, showing atomic steps.
Scan size: 500 nm

http://mnelab.com/p.htm



High resolution scan of Au (111) surface, with reconstruction strips (inset) hexagonal atomic structure.
Scan size: 5 nm; inset: 20 nm

Glass



- Before use the glass is cleaned by washing with concentrated Hydrochloric Acid of Nitric Acid about 5 times for 1 min with Millipore water in an ultrasonic bath running at 50 kHz. This process makes the glass slides clean and smooth.
- Can also be modified with silane molecules bringing new chemical functions at the surface for further covalent modification
- Good for imaging cells and other large structures, but too rough to image of absorbed molecules

Immobilization

- If the mechanical touch force is larger then the immobilization force then the AFM tip can simply sweep away the sample as observed with the dust particles in AFM lab.
- Ideas to keep the sample firmly on the substrate.

  Biological Immobilization
  Tape the edges of the sample
  Use a small drop of glue or wax to fix the sample on.
  Avoid using a material that would cause drifting, contamination or peeling.

SPM Manufacturers

Veeco

Agilent Technologies

NANOTEC ELECTRONICA

ASYLUM RESEARCH

JPK Instruments

Park SYSTEMS

RHK Technology
Imaging the Future of Nanoscience

HYSITRON™

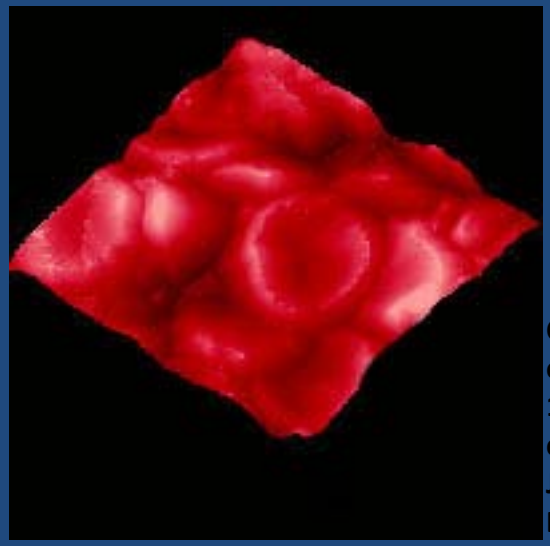
References

Ron Reifenberger, **A Primer on Scanning Tunneling Microscopy (STM),**
http://www.nanohub.org/resources/1185/

Arvind Raman, Atomic Force Microscopy
http://www.nanohub.org/resource_files/2005/11/00522/2005.11.28-raman.pdf

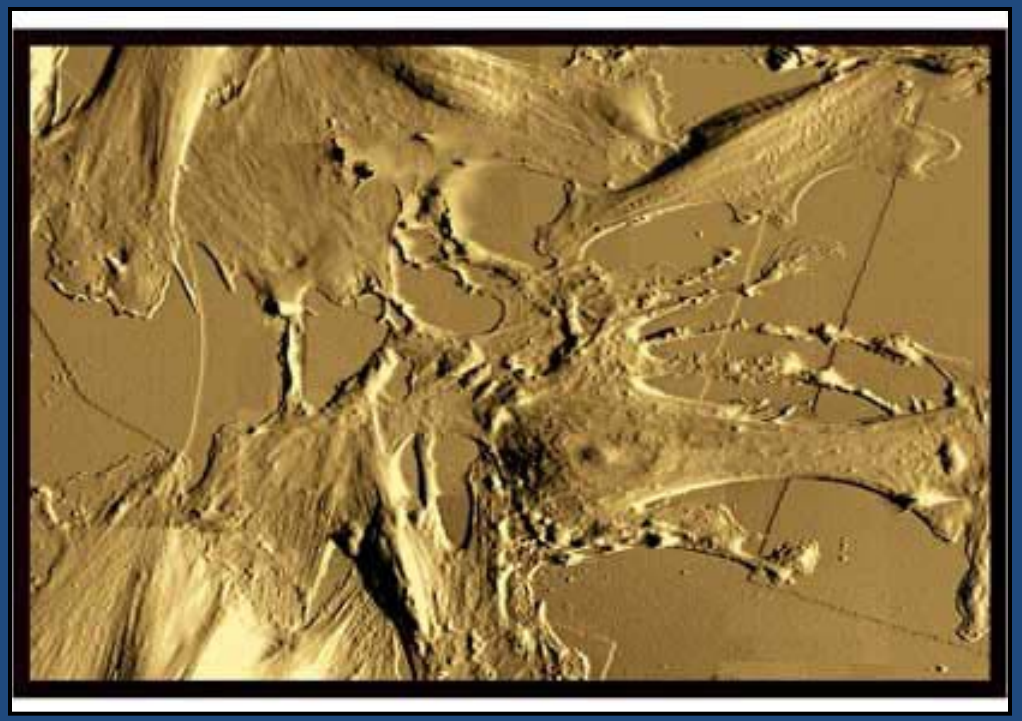
Ron Reifenberger, Nanometrology Room Design:
The Performance and Characterization of the Kevin G. Hall Nanometrology Laboratory,
http://www.nanohub.org/resources/3779/

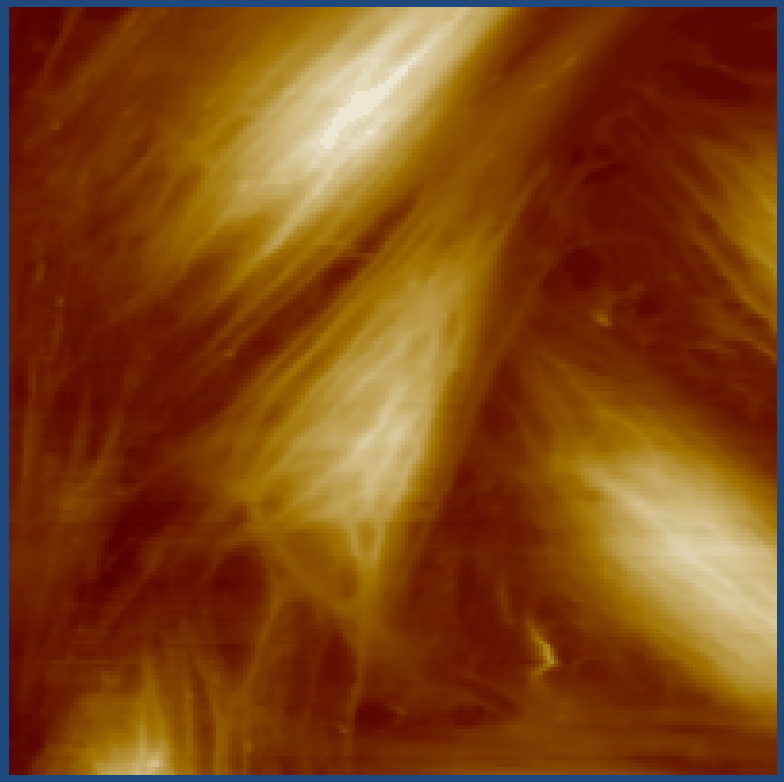
VEDA as a simulation resource



Contact mode image
of human red blood cells
15µm scan
courtesy M. Miles and
J. Ashmore, University of
Bristol, U.K.

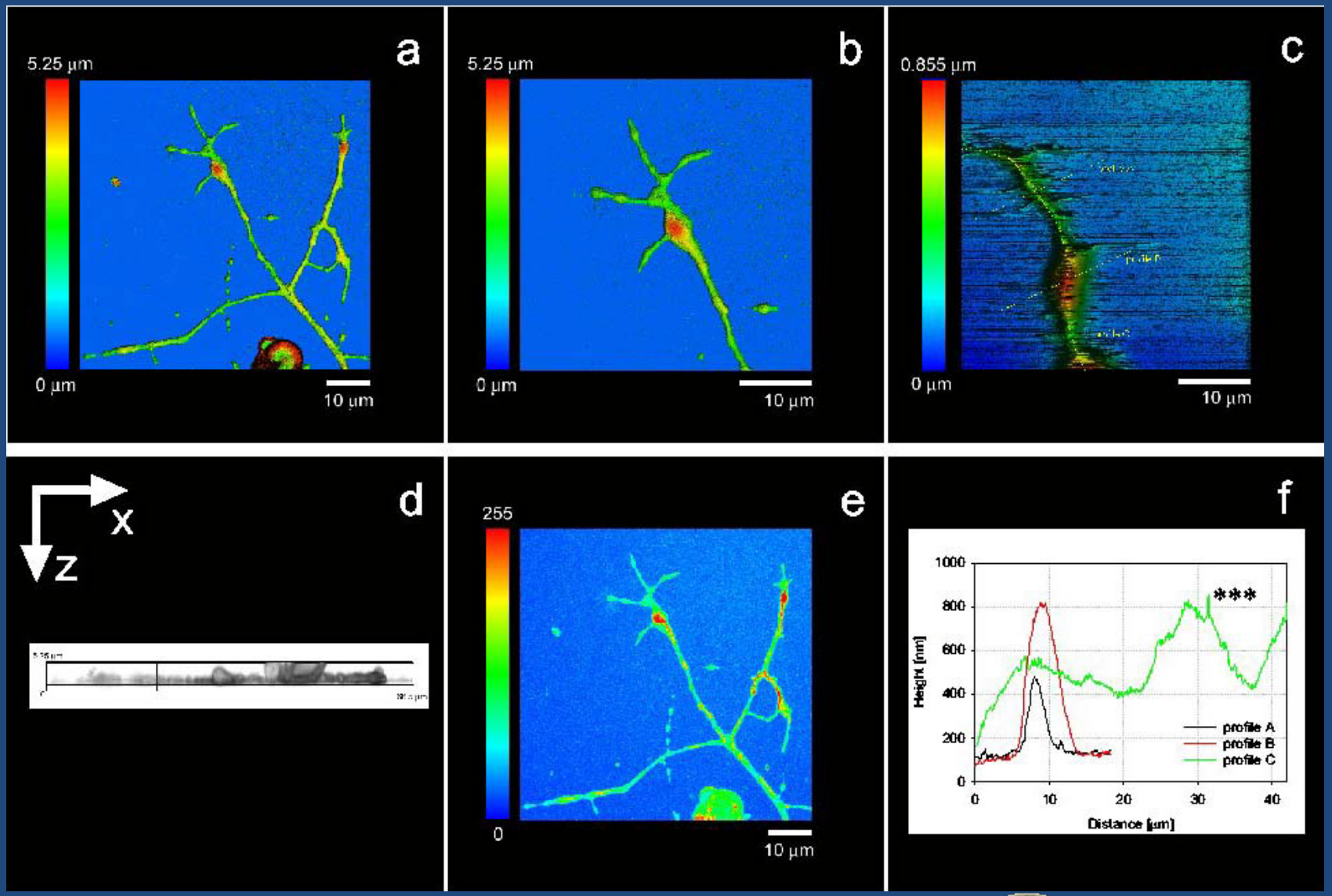
Field of view Mosaic of 10 Images taken each at 100µm x 100µm
Liquid AFM image of fibroblast-like cultured cells chemically fixed with glutaraldahyde on a glass cover slip. From this image one can see the cell-to-cell contacts, cell division, and the formation of stress fibers.
Image Courtesy of M. Drechler, LS Pharm Tech - FSU Jena, Germany





Living endothelial cells grown directly on a petri dish and imaged by AFM on a Digital Instruments BioScopeTM using contact mode in liquid. The image shows the interaction between multiple cells and between the cells and the substrate. Scan time was 35 min and scan size = 65µm.
Imaged by I. Revenko, M.D., Applications Scientist, Digital Instruments.
Sample courtesy of Georges Primbs, Miravant Inc.

AFM Compared to Confocal Microscopy



H.McNally, B. Rajwa, and J.P. Robinson, accepted for publication in the Journal of Neuroscience Methods, April 2003

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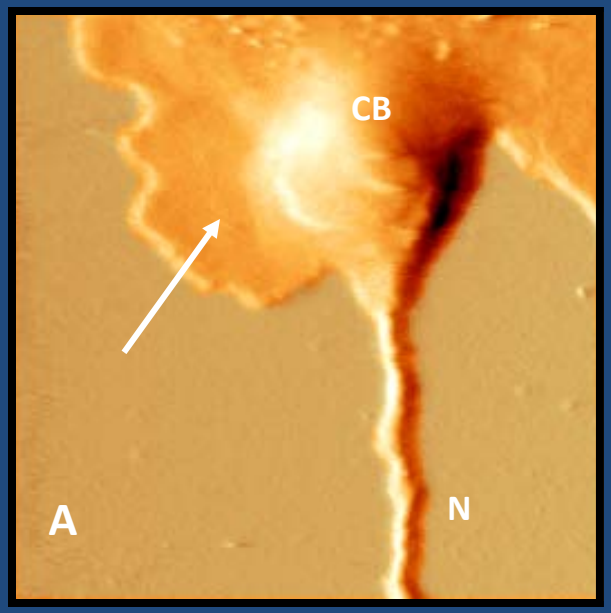
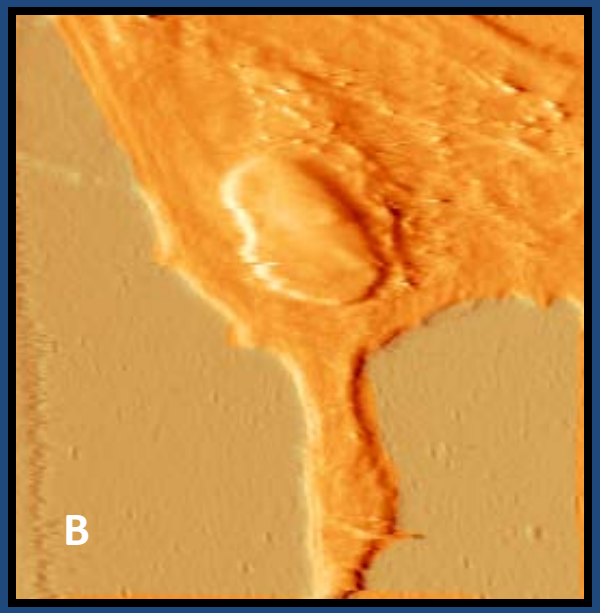
Cell Death by AFM Probe





time