UVA's Hands-on Introduction to Nanoscience

Instructions for easyScan Atomic Force Microscope

(revision 8 November 2012)

NOTE: Instructions assume software is pre-configured per "UVA Instructor Guide for easyScan 2 STM and AFM"

Start up Electronics and Software (manual pages 27 & 37):

1) Open the log book and record your Name(s), Date, Time, and a short sample description. Initial and date.

All Users MUST use the log books or face removal from lab

2) Turn on the control electronics (long hexagonal black box).

Indicator lights should blink yellow

3) After the controller lights have settled, on the laptop PC click the "Nanosurf easyScan2" icon.

Indicator lights on controller should then become steady yellow, except:

- "STM scan head" = dark (because it instead sees an AFM scan head)
- "Video Module" (unless are using AFM #4 which DOES have video)
- "Probe Status" may remain red at this point

White light should go on at AFM cantilever position

4) Click Menu: File / Workspace / Load

Go to the folder: C:/Program Files/Nanosurf easyScan2/Config

Select and load the file: **"UVA_AFM.gui"**

By this point the bottom margin of the program must have these entries:

Online	UVA_AFM.chart	UVA_AFM.par	10-06-172.hed	Standard Level

The numbers in the 4th entry (##-##-###.hed) MUST match the label on top of the ATM

If your entries are different, the software is confused as to if it is controlling an AFM or STM, or it lacks vital calibration and control data - ASK THE INSTRUCTOR TO FIX!!

The preloaded files SHOULD set most of the required AFM parameters. But, because these files are easily corrupted, it is essential that you verify settings:

For dynamic (tapping) mode, find the cantilever resonant frequency:

5) In the "Operating Mode Panel"

In the "Operating Mode" sub-bar:

5a) Following your AFM's label/tag verify that "Mounted Cantilever" is set to EITHER NCLR or ACLA

5b) Verify that "Operating Mode" = Dynamic Force

5c) Expand the "Mode Properties" sub-bar which should have appeared

5d) Verify that "Free vibration amplitude" = 100-300 mV (preset = 199 mV)

Use 50-100 mV for relatively flat samples

Use 200-300 mV for rough, steep or deep samples (e.g., CD, IC . . .)

IMPORTANT: Later if you change this amplitude setting, you must **stop** data collection, **withdraw** the cantilever (for ~ 5 seconds), then re-**approach** the sample. This allows the unit to detect the cantilever's new free vibration resonant frequency (which changes with amplitude).

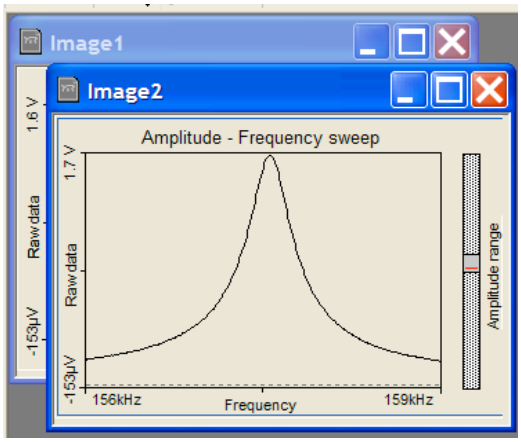
WARNING: Later indication of improper setting: Uniform orange image + absolutely flat/smooth line scan + red or blinking red "Probe Status" light on black electronics module.

5e) Verify that box is checked for "Display Sweep Chart"

5f) Click the "Set" button

The AFM will now search for resonant frequency of the cantilever of the type specified in step 5a.

If it succeeds you will see two charts pop up, first with a sharp peak, and then a second chart with a greatly expanded peak



IF PLOT IS NOT AS ABOVE and "Probe Status" LED is not now green: STOP!

The cantilever is not oscillating as expected and required due to:

Wrong operating mode ***Wrong cantilever type***

Improperly mounted cantilever ***Damaged cantilever***

Optimize feedback loop for type of sample you are examining:

6) In the "Z-controller Panel"

6a) Verify that Set point" = 50%

6b) Verify that "P gain" = 10000

6c) Verify "I gain" = 1000

Approach the sample to be measured (manual page 39):

7) In the "Positioning Window"

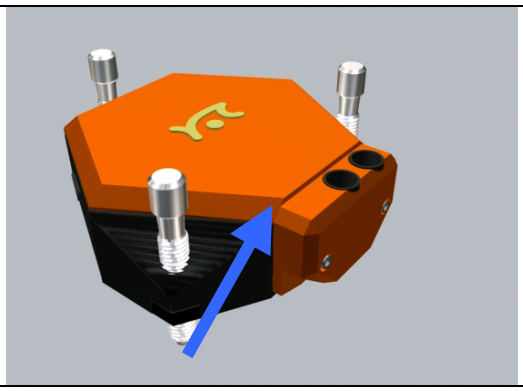
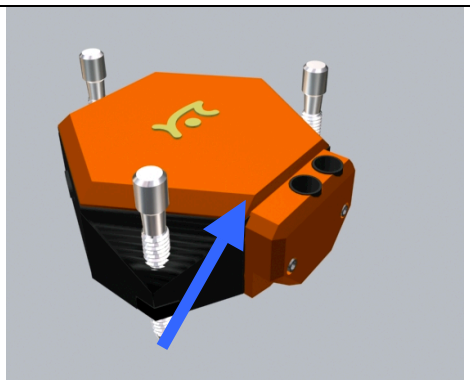
7a) If necessary expand the "Approach" sub bar to read full wording of buttons:

7b) With no sample in place OR with the AFM well above the sample:

Use 

and 

buttons to raise or lower the head to a starting position flush to 1mm below body of AFM (as shown at left below)

	
CORRECT: Head flush to 1mm below body	**WRONG: Head several mm below body**

SAMPLE LOADING:

8a) Turn micrometers to pull X-Y sample stage out from under AFM (as far as it will go)

8b) Place sample on stage but DO NOT PUSH TWEEZERS OR SAMPLE UNDER AFM

8c) INSTEAD use X-Y stage micrometers to move sample back under AFM

(Later also remove sample using stage instead of placing tweezers under AFM)

COARSE MANUAL APPROACH: *CRITICAL THAT FOLLOWING IS DONE RIGHT!*

9a) <u>WHILE PRESSING DOWN ON AFM body so that is does not move</u>:

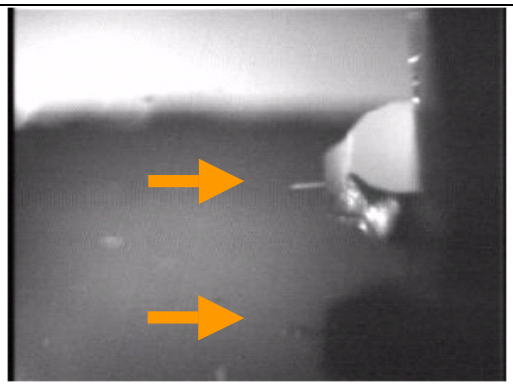
Take turns adjusting the three screws on top until the cantilever is 1-2 mm from sample surface and the head is level (judge this by eye view from the front of unit)

As AFM is lowered, keep its body ~ level (a bubble level is provided to check)

9b) Get a side view of cantilever in right lens (or with AFM #4 Click: 

for TV image)

9c) Using this side view, continue adjusting the three screws until the shadow of cantilever enters the view as shown below:



Upper arrow at right: Side view of cantilever

Lower arrow at right:

Reflected image of cantilever

Vague dark shadow of cantilever assembly

DON"T GO ANY CLOSER THAN THIS MANUALLY!!

MOTORIZED FINE APPROACH (using buttons to control motor)

YOU controlling AFM (fairly coarse):

Advance = Turn on motor (while button is depressed) to move closer to sample

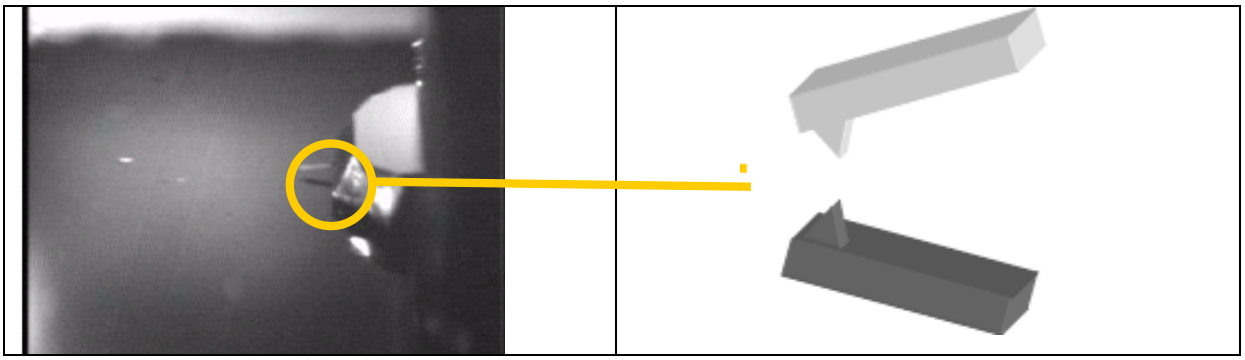
Retract = Turn on motor (while button is depressed) to move away from sample

AFM doing things automatically (very fine and slow):

Approach = An automatic slow final approach to sample with AFM sensing contact

Withdraw = Automatic slow movement away from sample

10a) Use Advance button to move toward sample until cantilever tip ALMOST meets its reflection



DON'T LEAVE THE MOUSE CURSOR OVER 

Or tip may start moving even when the mouse button not pushed

RESULT: Crashes cantilever into sample, breaking it!

10b) Complete approach by clicking 

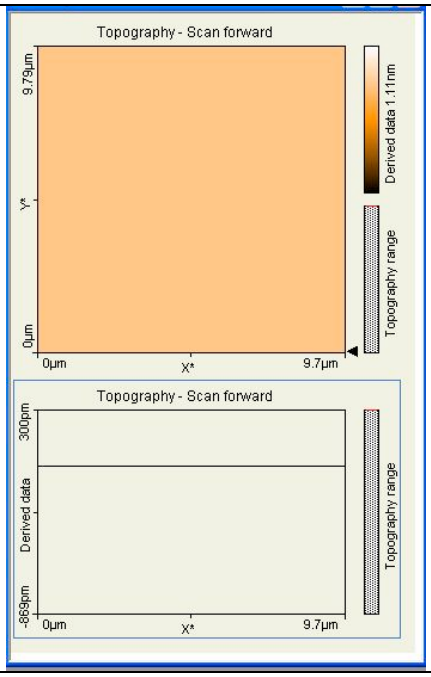
automatic final approach button

False Approach:

Sometimes the AFM "thinks" it sensed a change in the cantilever's resonant frequency - and thus sample contact - before it has actually occurred (due to electrical noise).

If this occurs you get data like that to the right:

To fix: 1) "Stop" the scan; 2) Click the "Approach" button again.



Starting a measurement (manual page 43):

11) In the "Imaging Window" use START, STOP buttons as with STM

Use the data fitting parameters to your advantage:

For the best images we have set up the program to use DERIVED DATA

But RAW DATA and LINE FIT might work better for certain samples.

MOVE the scanned area by clicking the image in the "Topography – Scan Forward" pane.

- Then click the MOVE button immediately above the image.

- Click on image and draw an arrow giving the direction and distance you wish to move

- Finally, under the "Tool Results Panel" on the left, click the MOVE button

ZOOM into a portion of your current image using one or the other of these techniques:

1) To zoom into the **center** of your current image area, in the “Imaging Panel” click the down arrow next to the “Image Size” box. This will zoom in to ½ the scan size (i.e. magnify by two).

2) Should you instead need to zoom into a specific non-center area:

a) Click on the developing image in the “Topography – Scan Forward” window pane

b) Click the ZOOM button immediately above the image

c) Click and drag a box around the area of interest

d) Under the “Tool Results Panel” on the left, click the ZOOM button

Capturing and saving your images:

1) During any measurement, click on the “Topography – Scan Forward” window

2) Click on the “Photo” button immediately above/right of this image (it will turn blue)

When scan reaches the top or the bottom, a new window with that saved image will pop up

Program will continue saving images as long as "Photo" button is blue

LATER, to save your data to a file, click on its pop-up window:

- To save ALL information: Go to FILE / Save (as an "nid" Nanoscience Inc. format file)

- To save ONLY a bitmap image (which cannot later be reprocessed, e.g. in 3D):

Go to FILE, then EXPORT, then CURRENT DOCUMENT AS bmp, png or tiff file

For a crude 3D map of your image, select its window then:

1) On the top outermost program bar, click "Line Graph" icon and switch "3D View"

2) Rotate 3D view as desired

3) Under the Tools menu you can also apply "Glitch" and "Noise" filters to smooth the data

4) Go to FILE, then EXPORT, then CURRENT DOCUMENT AS in the format you want

For a FAR BETTER 3D map with noise filtering, smoothing & other enhancements:

1) Load your nid format file into program **Nanosurf Reports** by clicking "File/Open a Studiable"

2) Apply "Operators / Level" to level an image higher at one edge (i.e. different color / lighter)

3) Click "Studies/ Continuous Axonometric" (and rotate 3D plot as desired)

Click OK in window that pops up

4) Adjust "Height Amplification" (rainbow colored volcano icon, below "Reserves" and "Options")

5) Try adjusting color "Palette" (icon at far left, under the menu bar)

6) Try applying other "Operators," for instance:

- "Waviness / Roughness" to filter out higher frequency noise

- "Threshold" to cut out regions of low signal

7) Try applying "Studies / Photo Simulation"

8) To save EVERYTHING (in proprietary format): File / Save the Document (mmt format file)

9) To export the currently selected image: File / Export Reserve Image (choose tiff, gif, jpeg . . .)

FOR CARBON NANOTUBE SAMPLES:

For all of our other measurements you should use “Dynamic Force” (tapping) mode measurement – as detailed above.

However, for the carbon nanotube sample you will instead need to use “Static Force” (continuous contact) mode.

1) Have the instructor install a different static force type of AFM probe

2) Enter that probe’s description into the AFM software

3) Change the operating mode to “Static Force.”

4) For the approach, set the force to 10 nN.

5) When the probe contacts the sample (and begins to scan), change the force setting to 2 nN.

Ending a Measurement

- Click “Withdraw” button to automatically pull back a little ways from sample.

- Click 

to then pull farther back

Final Notes & Cantilever Replacement

- Before shutting down AFM software & collecting tools, record all required information in log book

- Under no circumstances are students to replace cantilevers.

- Nor are you to modify or enable hardware/software settings in order to access the Internet

- Immediately notify an instructor of any damage to the equipment

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