Veeco Multi-Mode AFM Training Guide

#27

Appropriate Samples and Sample Prep

Samples must fit on a 15mm diameter disk and cannot be more than about 5mm thick. Samples must be flat since the microscope cannot measure features taller than 2µm. The maximum area that can be imaged with the microscope is 10µm by 10µm.

Stuff to Buy:

Description	Vendor	Part no.
Magnetic disks for sample mounting	Ted Pella	16218
Adhesive tabs	Ted Pella	16079
10mm mica disks	Ted Pella	50
Tweezers for handling probes	Ted Pella	5374-NM

Getting Started:

1. Turn on the microscope controller (power strip to the right of the monitor).

2. Turn on the anti-vibration stage (power strip on floor under cabinet).

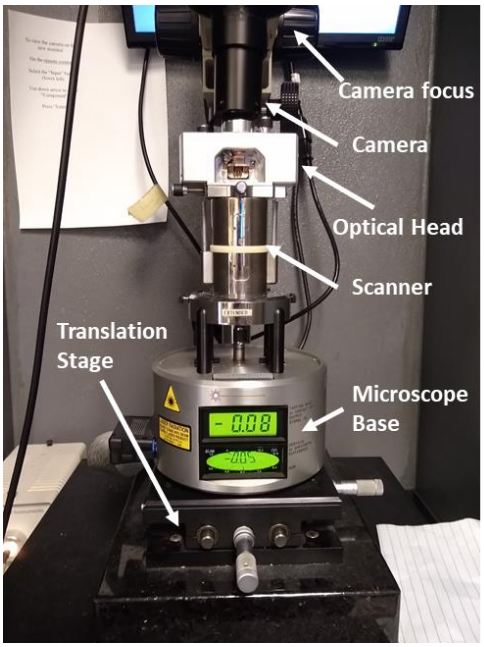
3. Open the cabinet and make sure the switch on the left side of the microscope base is in either the middle (AFM & LFM) or forward (TM AFM) position.

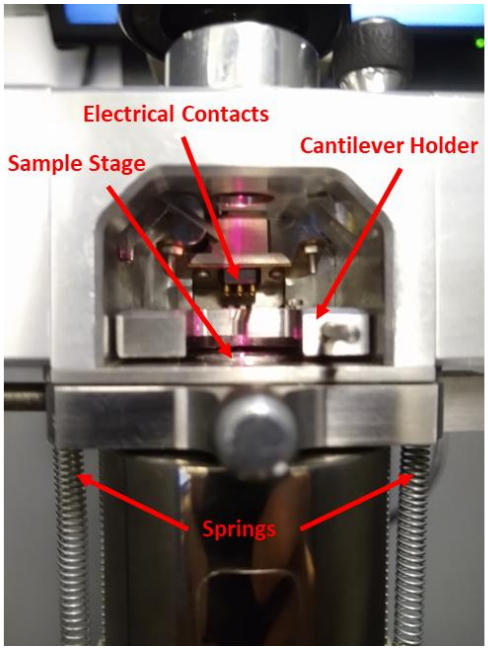
4. Log in to the PC.

Mounting the probe and sample:

1. See pictures below that detail the components of the microscope. The optical head includes many important components so a detailed view is provided. Put the cantilever holder in the optical head and verify that your sample will fit in the gap between the probe tip and the sample stage. If you need to enlarge the gap, push and hold the switch on the right side of the microscope base in the *Up* position. Release the switch when the gap is large enough

Warning: if you hold the switch for two long you will lose the ability to raise and lower the stage and the microscope will require repair.





2. Remove the cantilever holder from the optical head. Place your sample on the stage and mount your probe in the cantilever holder (see picture below). Put the cantilever holder back in the optical head and use the screw on the back of the optical head to lower the 6-pin connector onto the electrical contacts on top of the cantilever holder.

Warning: do not tighten this screw too hard or it will stop working!

3. Press and hold the switch on the right side of the microscope in the *Down* position to lower the probe tip to within a few mm of the sample surface.

Aligning the Laser

1. Start the *Camera Display* software from the desktop. Click *Video Feed* and select *Composite*. A window should appear with a video feed from the camera above the microscope (may be black at this point).

2. Turn on the fiber light in the back left corner of the cabinet (see image below).

3. Find the cantilever on the video image using the micrometers on the translation stage that the microscope is sitting on. Use the large black knobs behind the camera to focus the camera on the tip (see image below).

Warning: turn the large black double knobs to focus the camera not the single black knob below.

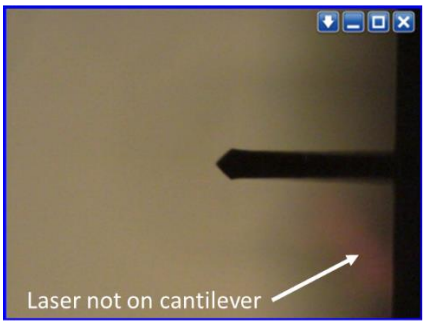
Warning: make sure you are focused on the tip and not its shadow, which appears below the plan of the sample.

4. Move the camera focus down until you are focused on your sample surface.

5. Press and hold the switch on the right side of the microscope in the *Down* position. On the video image you should see the tip slowly coming into focus. Release the switch when the tip is almost, but not quite, in focus (see image below).

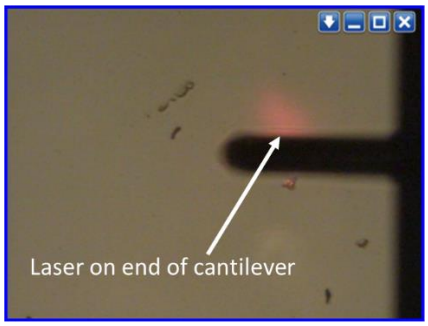
Warning: if you are not actually focused on the sample surface, or if you move the tip down too far, you can crash the probe tip into the sample.

Tip in focus (far above surface)

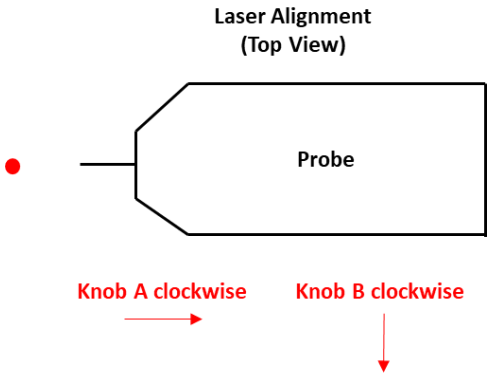


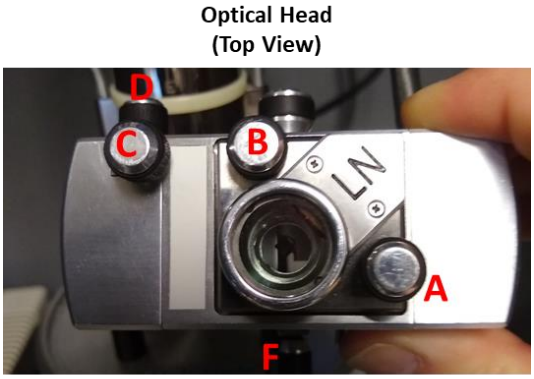
Surface in focus (tip far above)

Surface in focus (tip very close)

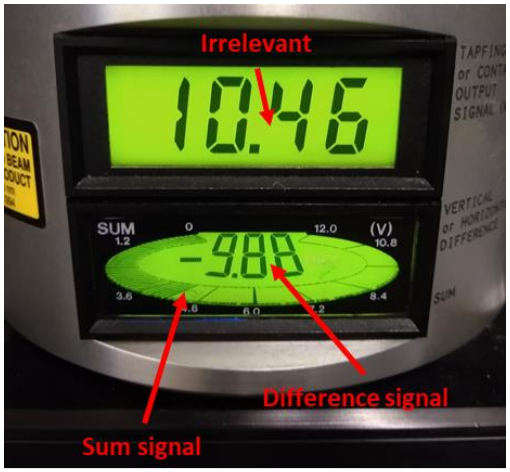


6. While watching the video image, use the two knobs A and B on top of the optical head (see image below) to move the laser spot onto the cantilever. Knob A moves the laser spot left to right on the video image while knob B moves the laser spot up and down.





7. When the laser is on the cantilever you will see the sum signal increase on the microscope's bottom display (see picture below). The sum signal is NOT the large number in the center of the display, but is instead shown by the number of hash marks around the perimeter of the oval. Once you find the cantilever, turn knob B back and forth to move the laser over the cantilever until the sum signal is maximized.

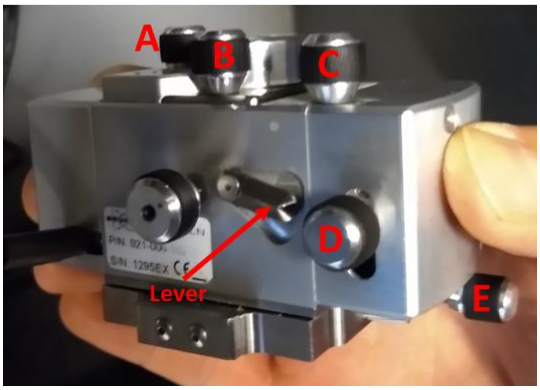


8. Turn knob A counterclockwise to move the laser along the length of the cantilever until it drops off the end. You will see the sum signal drop. Turn knob A clockwise slightly to move the laser onto the tip of the cantilever where the sum signal is maximum. If necessary slightly adjust knob B to maximize sum signal. The laser spot is now on the end of the cantilever.

Zeroing the photodiode:

1. Tilt the small lever on the back of the optical head up and down until sum signal is maximized (see pic below).

Optical Head
(Rear View)



2. Put the switch on the left side of the microscope in the middle position. Turn knob D on the back left side of the optical head in while watching the difference value in the center of the microscope's bottom display. If the number passes through zero, turn the knob in the opposite direction until the difference value is near zero. If you turn the knob all the way in and it does not pass through zero, turn the knob the other way until it does. If you see the sum signal starting to go down, you are turning the knob the wrong way.

Warning: if you turn a screw counterclockwise too much, it will come completely out of the optical head and repair will be required.

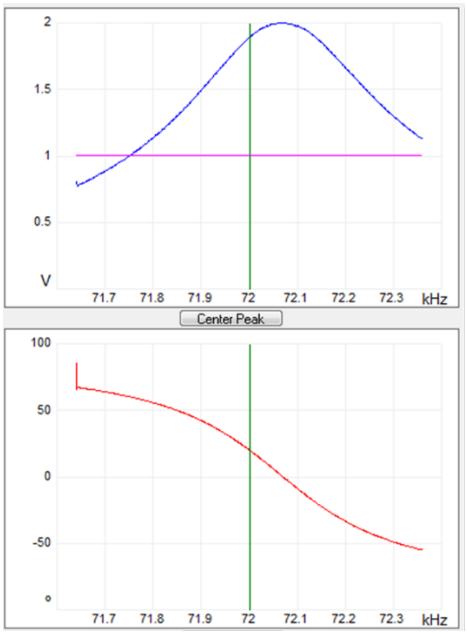
3. Move the switch on the left side of the microscope to the forward position. Repeat the zeroing process using knob C on top of the optical head.

4. Repeat steps 2 and 3 until the difference values are near zero with the switch in both positions.

5. At this point you can use knobs E and F to move the cantilever around the sample surface to find your region of interest. You may need to adjust the micrometers on the translation stage to keep the tip in view.

Landing the tip on the surface

1. Start the *Nanoscope* software from the desktop (yellow microscope icon). Click the yellow microscope icon in the top left corner of the *Nanoscope* software to connect the software to the microscope. In the window that pops up, choose *Use original default parameter values*. In the *Add Views to Real Time1* window that pops up, check *Scan Triple* and *Scan Control* then click *OK*.
2. In the *Nanoscope* software, click *Tune*  . In the *Start Frequency* and *End Frequency* boxes enter values that are 25% below and above your cantilever's expected resonant frequency. Set the *Target amplitude* to 1000mV (1V). Click *Auto Tune*. The cantilever should tune to a frequency near its expected resonance. See figure below for typical tune output. *Exit* the *Cantilever Tune* window.

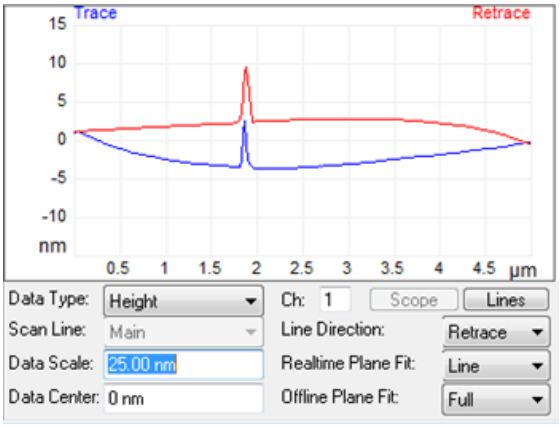


3. On the Menu Bar click *Acquire* → *Scan Control*. Enter your desired parameters in the *Main* tab. Set *Integral Gain* to 0.5 and *Proportional Gain* to 0.7.

4. On the *Main* tab click *Engage*. The microscope will move the tip down very slowly until it touches the surface. You should see the tip slowly come into focus on the video image. Once the tip is on the surface, the microscope will automatically begin acquiring an image. At this point it is often desirable to close the cabinet door.

Acquiring Data

1. In the *Scan-Dual* (or *Scan-Triple*) window, shrink or expand the *Data Scale* to suit your data. In the height data, you should see the trace and retrace lines tracking each other closely. Features should show up in both traces and there should not be a lot of noise on the baseline.



2. If the height data is a flat line at zero even when zoomed in to single digit nanometers, the probe tip is likely not touching the surface. In the *Scan Control* window, try reducing the *Amplitude Setpoint* 20mV at a time until the tip lands on the surface.

3. If the tip appears to be moving on/off the surface while scanning, for example you are seeing features in the trace but not the retrace, try increasing the *proportional gain* and/or *integral gain*. You may need to reduce the *scan rate* especially if you have tall, sharp features that the microscope has trouble tracking or if you are scanning a large area.

4. If the height data is very noisy try decreasing the gains.

5. Obtaining good images is often a matter of trial and error while adjusting parameters such as the gains, scan rate, and amplitude setpoint.

6. While the microscope is scanning you can click *Frame up*  or *Frame down*  to start a new image from the bottom or top, respectively.

7. To designate the directory where your data will be saved, on the menu bar click *RealTime* → *Capture Filename*. Browse to your folder in the e:\capture\ directory. Enter your desired *Filename*. Consecutive saved images will have numbers appended after the filename.

8. Click *Capture*  to save the next image once it is completed. If you later decide you don't want to save the image, you can click *Abort Capture*  . You can see whether or not capture is active by looking in the lower right corner of the software. If you want to save the image as it appears right now, click *Capture Now*  .

Data Analysis:

1. To open an image, on the menu bar click *File* → *Open*, select *Captured Data File* then click *OK*.

    a. You can use the tools in the top left corner of each image  to zoom in on features and measure distances between features in the XY plane.

    b. Right clicking on the color scale and selecting *Color Scale* brings up the *Color Scale* window. Here you can change the height scale in order to view/hide small features in the data.

    c. You can export any of your images as pictures by right clicking it and selecting *Export* → *Screen Display*.

2. Flattening is used to correct common artifacts in the images such as streaking, curvature, and tilt. Click on the image you wish to flatten and click *Flatten*  .

    a. In the *Flatten* window choose appropriate *Thresholding Direction*: Use *Z <* for features that stick up from the substrate, Use *Z >=* when features are pits/valleys in the substrate.

    b. *Flatten Z Threshold %* should be set such that the substrate is flattened but not the features. Use the image height scale to determine a boundary percentage between substrate and features.

    c. You can choose to define the threshold for the *whole image* or *line-by-line*. The latter is useful if there is a lot of height variations within the image.

    d. You can vary the *Flatten Order* to see which gives the best results.

    e. Click *Execute* when you are ready to flatten. If you don't like the results, you can click *Reload* and make adjustments. You can even flatten multiple times in succession using different parameters.

3. You can use the section tool to measure properties of features such as height/depth, size, and shape. You can also measure distances between features. To use the section tool click  .

    a. Click and drag on the image to create a line. To the right of the image you will see a graph showing the signal (often height) as a function of position along the line. The two crosshairs on the image are represented on this graph as dashed vertical lines. You can drag the dashed lines to move the crosshairs on the image along the line to features of interest.

b. The table below the image shows various measurements that are made between the two points on the line. To export this data you can right click the table and select *Copy Text*. You can then paste this text into another program such as notepad.

c. The above steps can be repeated two more times to create up to three different colored lines on the image.

d. The image including lines and crosshairs can be exported as a picture by right clicking the image and selecting *Export* → *Screen Display*. You can also export the data plot by right clicking it and selecting *Export* → *Graphic* or *Export* → *XZ Data*.

4. You can see a 3D rendering of an image by clicking *3D Surface Plot*  .

    a. You can right click the Color Scale and select *Color Scale* to bring up the *Color Scale* window. Here you can adjust the *Data Scale* to zoom in the Z direction.

    b. You can also click and drag the plot to change the viewing angle.

    c. When you are finished setting up the image you can use the *Export* button to save it as a picture.

5. You can use the roughness tool  to get various roughness parameters calculated from the image.

    a. To export the parameters, right click on the parameter list and select *Copy Text*. The parameters and their values can then be pasted into another program such as notepad.

When you are finished:

1. To stop data acquisition click *Withdraw* in the *Scan Control* window → *Main* tab.

2. Use the switch on the right side of the microscope to raise the tip at least 1mm.

3. Remove the cantilever holder from the optical head and remove your probe.

4. Remove your sample from the stage (you may need to remove the optical head). Replace optical head if necessary.

5. Close the *Nanoscope* software.

6. Turn off the monitor in the cabinet, the light source, the anti-vibration stage, and the microscope controller.

7. Log out of the PC.

8. Close the cabinet.