

VEECO Dimension 3100 Atomic Force Microscope (AFM)

Procedure (Last Update 11/20/06)



Introduction

The Dimension 3100 AFM is an instrument capable of imaging specimens with a horizontal and vertical resolution down to a fraction of a nanometer. The instrument works by measuring the deflection produced by a sharp tip on micron-sized cantilever as it scans across the surface of the specimen. Sample sizes that can be handled by the instrument range from small pieces to 150 mm diameter wafers.

Scanning Modes

The AFM scans on either Tapping Mode or Contact Mode. Each mode should be selected according to the specimen to be scanned and the kind of results desired. When dealing with a new sample, consult the literature available on AFM microscopy to determine which mode better suits your particular application. At any rate, it is recommended that both modes are tested to verify which produces the best results. For more details on the modes and AFM in general, consult the SPM Training Notebook.

AFM Probe Policy

The most common kinds of probes are the RTESP probe and the DNP-20 probe, which are recommended for tapping mode and contact mode respectively. AFM probes are fragile and consumable items; they break on a regular basis, particularly when the probe is being mounted on the AFM head. Extra care should be taken during the mounting operation.

The NRF will keep a store of these two probes and provide them to the users for an extra charge on machine usage. However, it is strongly recommended that the users buy and use their own probes. That will save time and money to the AFM users.

There are many different types of probes that can be mounted on the Dimension 3100 AFM. The most common probes are: for tapping mode the VEECO's RTSP or Applied Nanostructures' ACT50 (both probes are equivalent); for contact mode VEECO's DNP20 or Applied Nanostructures' SICON. These probes must be acquired from either VEECO or Applied Nanostructures only. **DO NOT USE ANY OTHER KIND OF PROBE WITHOUT ASKING THE NRF STAFF.** We will consider other kind of probes on a case to case basis and it will be so provided that there is a good reason to use a probe other than those mentioned above. Customized or home-made probes are not allowed in our Dimension 3100 without permission.

Probes can be purchased from either of these companies:

Applied Nanostructures
1700 Wyatt Dr. Suite 5
Santa Clara, CA 95054
Phone: (408) 567-0115
Fax: (408) 516-4917
<http://www.appnano.com/>

VEECO Probes
5571 Ekwil St.
Santa Barbara, CA
Phone: 1-800-715-8440
Fax: 1-805-696-9003 93111
<http://www.veecoprobes.com/>

Please contact either of these companies directly for pricing and technical questions.

Instrument Parts

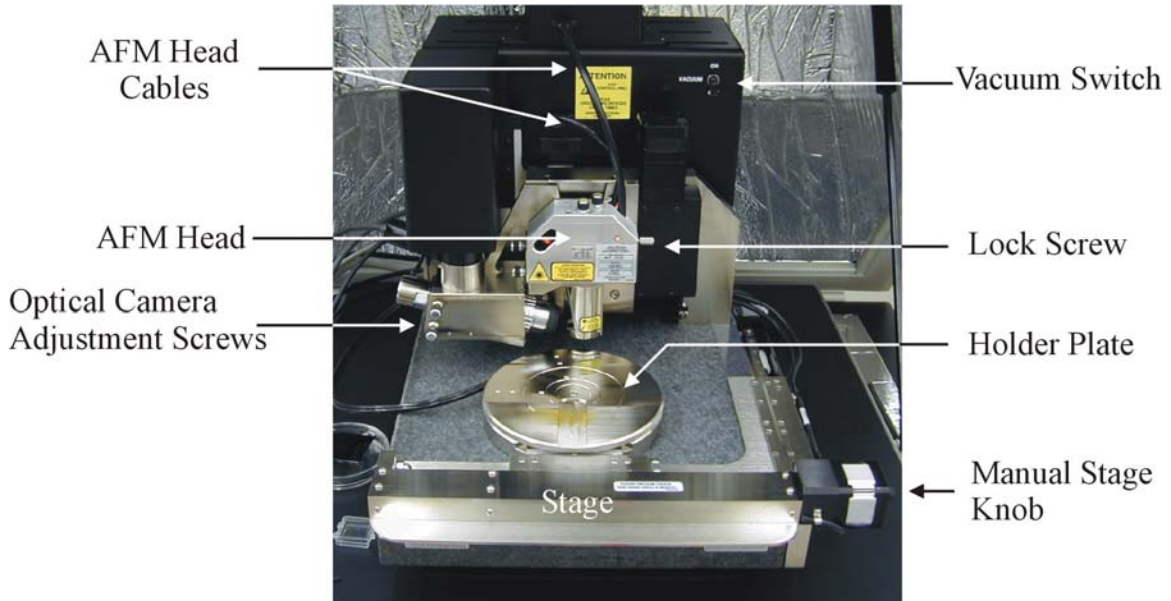


Fig. 1: Overall Instrument View

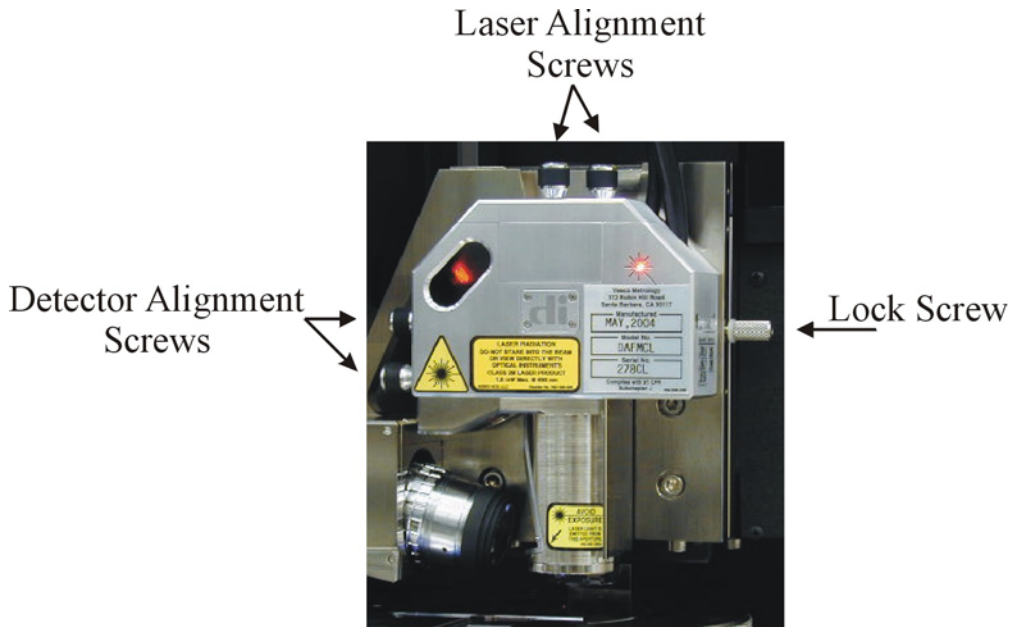


Fig. 2: AFM Head

Abbreviated Instructions for Dimension 3100 AFM

Initial Setup

1. Open program on computer (Nanoscope 6.12r1).
2. Open your Workspace file. If you do not have one, you create it and save it in your own folder. Do not open someone else's workspace file. To create a new workspace, select File/Open Workspace and, under the folder D:/CAPTURE select generic.wks. Select File/Save Workspace As and save it as <yourname>.wks under your own folder on D:/users.

Probe Mounting on AFM Head

WARNING: While performing this operation, handle the AFM head with extreme care. Impacting the head against a solid surface or dropping it will cause severe damage. Also be careful not to touch the windows placed on the AFM head as this will obstruct the passage of the laser to the detector.

3. Open Hood.
4. Unlock AFM head by tightening the lock screw.
5. Disconnect the head cables.
6. Pull out head completely and place it on the table. Be careful of not dropping the head.
7. If probe carrier is on AFM head, remove and place it on the carrier holder.

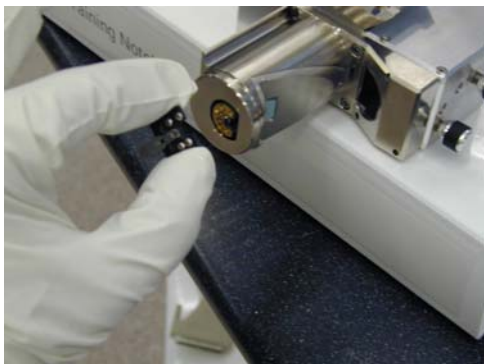


Fig 3

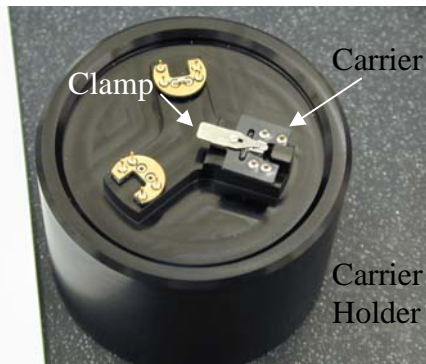


Fig 4

8. Place probe using tweezers and fix it to the carrier with the clamp.
9. Insert carrier back on AFM head. Be careful not to touch the AFM probe.

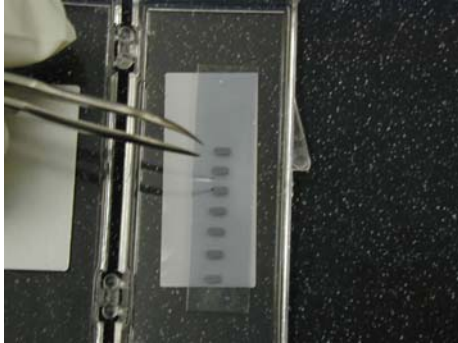


Fig 5

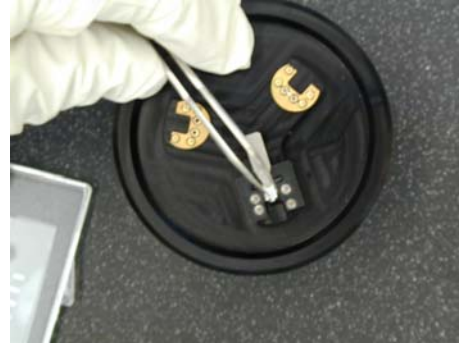



Fig 6

10. Loosen the lock screw and slide head back into the dovetail groove. It will not go all the way down.
11. Plug cables back in.
12. Single click on  Meter on the computer console. The system takes a few minutes to start. The window below will display on one of the computer screens:

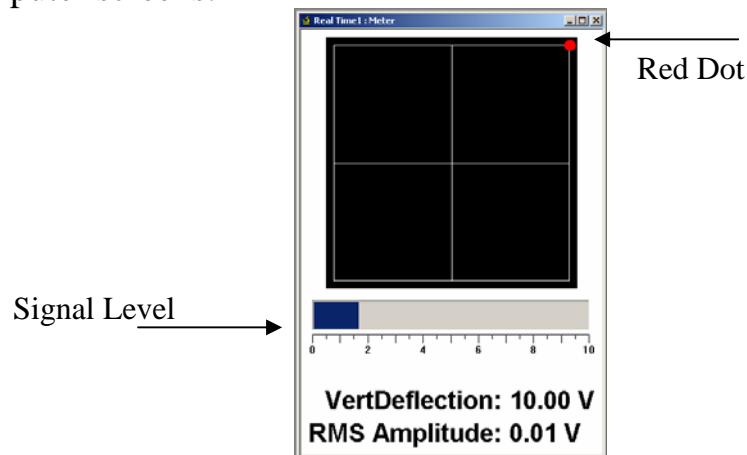


Fig 7

13. Pull out the AFM head one more time without disconnecting the cables and hold it upright while observing the laser beam that is projected down (see Fig. below). Be careful not to drop the head.

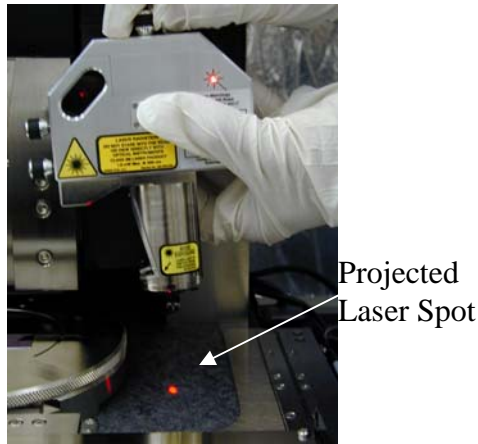


Fig 8

Laser Alignment
Screws

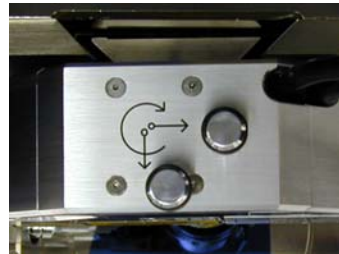



Fig 9

14. Find tip by looking at the projected laser spot and turning the alignment screws located at the top of the head. The goal is to place the laser beam at the top of the cantilever.
15. Once the tip has been found using the laser, put the head back into the dovetail groove. Since the lock screw is in place, the head should not go all the way down.
16. Check the meter on the computer screen (Fig 7). The signal level should be above zero. Maximize signal by slowly turning the laser alignment screws.
17. Center the red dot on the meter window crosshairs using the detector alignment screws located on the left side of the head.
18. While holding the head, tight the lock screw and carefully slide the head all the way down the groove making sure that it does not hit the substrate holder plate.
19. Loose the lock screw to fix the AFM head to the rest of the system.

Substrate Loading

20. Click on  **Navigate** on console. This will display the Real Time Navigate window. Move stage out so that it completely clears the AFM head. Use the track ball and lock button to move the stage faster. The Navigate window should be active in order to move the stage.
21. Set vacuum-set screws on holder plate according to the substrate to be loaded as follows (refer to Fig. 10):
 - If substrate is a piece, remove the first screw, which is the furthest from the center of the plate. Make sure that all the

other screws are in place and that the substrate is centered on plate.

- If substrate is a 4inch wafer or larger, remove the second screw and the center screw on the plate. Make sure all the other screws are in place and that the substrate is centered on plate.
- If substrate is a 2inch wafer, then remove the third screw and the center screw on the plate. Make sure all the other screws are in place and that the substrate is centered on plate.
- If substrate is a 1inch wafer, then remove the fourth screw and the center screw on the plate. Make sure all the other screws are in place and that the substrate is centered on plate.

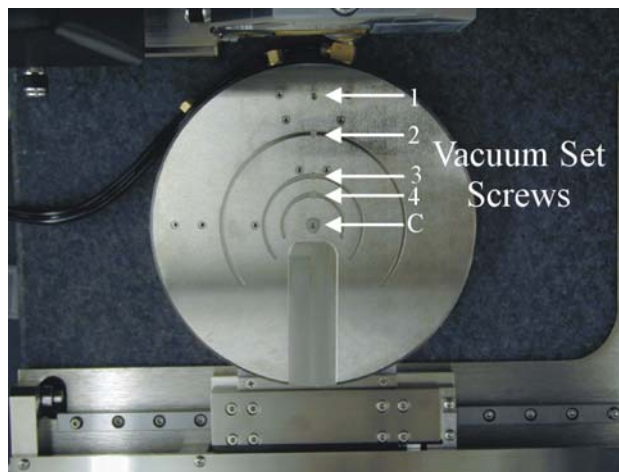



Fig 10: AFM holder plate and vacuum-set screws.

22. Once the vacuum screws are set, place the substrate on the plate and turn the vacuum on. The vacuum switch is located in the top right corner (see Fig. 1). Make sure that the sample is fixed on the plate.

Setting up the instrument for substrate imaging

23. Go to the window “Real Time: Navigate”. If it is not open, double click on  **Navigate**. The following window should be displayed on the screen:

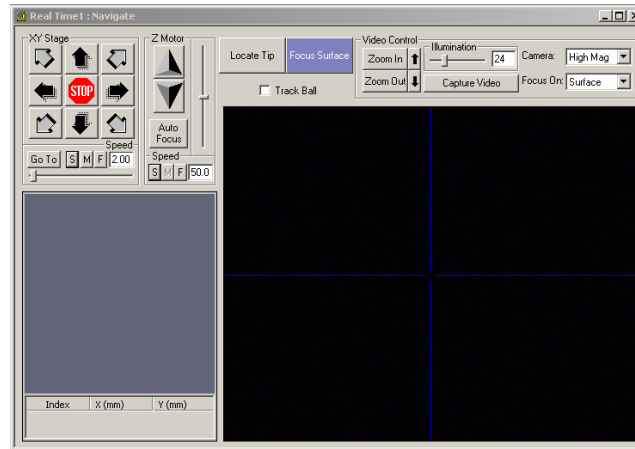


Fig 11: Normal Navigate Window

24. Move stage so that substrate is directly underneath the AFM head. Verify that there is enough vertical clearance; if not, click on Up Arrowhead on Z Motor under the Navigate window. **WARNING:** if there is not enough vertical clearance, the probe will break upon moving substrate under AFM head.
25. Click on the LOCATE TIP button. The cantilever should be now visible on the screen inside the window. If not, click on the ZOOM OUT button and/or increase/decrease the illumination. Center tip on crosshairs using the optical camera adjustment screws. The image of the tip should look similar to the image below:

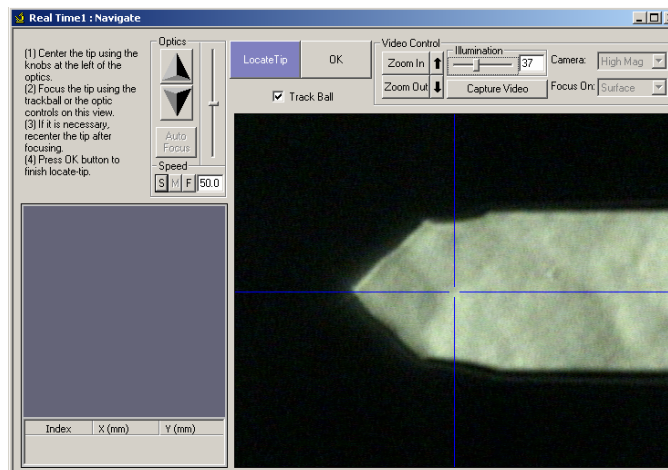




Fig 12: Locate-Tip Navigate window


26. Once the tip is located, click on ZOOM IN and center the tip on the cantilever under the cross hairs using the optical camera adjustment screws to the left of the optical objective on the microscope.


27. Focus the tip end of the cantilever using the trackball while holding down the FOCUS button. Click OK when done.
28. Focus surface on substrate. Use Z-motor arrows on Navigate window to move the optics and AFM up or down until an acceptable focus is achieved. Notice that this requires visible features on your substrate that will help focusing. To move the substrate horizontally, use the trackball. To properly focus on the substrate, click on ZOOM OUT and adjust the illumination to a proper level. Care must be taken when making this adjustment to ensure that the tip does not hit the substrate. The surface should be in focus at the highest optical magnification (ZOOM IN). WARNING: the probe may break during this operation.
29. Move to the desired measurement point under the cross hairs. To move the stage, use either the trackball or the XY Stage control in the Navigate window.

Cantilever Tune (Tapping Mode Only)

30. Click on  Scan-Dual and set Microscope Mode as Tapping.
31. Click on the Tune icon . Make sure that the Start Frequency is at 100 kHz and the End Frequency is at 500 kHz.
32. Click on AUTO TUNE. Wait until the cantilever tuning is completed.
33. Write down the drive frequency.
34. Click on ZERO PHASE.
35. Make sure that the peak offset is between 3 to 10%.
36. Exit window.

Initial Scan Parameters

37. Click on  Scan-Dual
38. In the scan parameters on the right on the Scan-dual window, set the initial Scan size to 5um, X and Y offsets to 0, and Scan Angle to 0. Tapping or contact modes can be selected under the Microscope mode entry.
 - Tapping: In the Feedback Controls panel, set Integral Gain to 0.4, Proportional Gain to 0.6, Scan Rate to 1 Hz, and Microscope Mode to Tapping.
 - Contact: In the Feedback Control panel, set the Setpoint to 0V, Integral Gain to 2.0, Proportional Gain to 3.0, Scan Rate to 2Hz, and Microscope Mode to Contact.

39. Click on the Engage icon . It takes a few minutes for the microscope to engage. For Engage to work, the Scan-Dual window should be active. Once the probe engages, the AFM will start scanning.
40. Close the hood and lock it to minimize acoustic and electromagnetic noise.

Imaging Adjustments

The following is a brief list of pointers on how to adjust the instrument in order to obtain a good AFM image. For more details and information, consult the SPM Training Notebook.

Tapping Mode

41. Under the Scan-Dual window, check to see if **Trace** and **Retrace** are tracking each other well (i.e. look similar). If they are tracking, the lines should look the same, but they will not necessarily overlap each other, either horizontally or vertically. Under some circumstances, it is recommended to **Disable the Slow-Axis** so that the probes scans along one particular line only.
42. If they are tracking well, then your tip is scanning on the sample surface. You may want to try keeping a minimum force between the tip and sample by clicking on **Setpoint** and using the right arrow key to increase the Setpoint value gradually, until the tip lifts off the surface (at this point the Trace and Retrace will no longer track each other). Then decrease the Setpoint with the left arrow key until the Trace and Retrace follow each other again. Decrease the **Setpoint** one or two arrow clicks more to make sure that the tip will continue to track the surface.
43. If they are not tracking well, adjust the **Scan Rate**, **Gains** and/or **Setpoint** to improve the tracking. If Trace and Retrace look completely different, you may need to decrease the setpoint one or two clicks with the left arrow key until they start having common features in both scan directions. Then, reduce **Scan Rate** to the lowest speed with which you feel comfortable. For scan sizes of 1-3 μm try scanning at 2Hz; for 5-10 μm , try 1Hz; and for large scans, try 1.0-0.5Hz. Next, try increasing the **Integral Gain** using the right arrow key. As you increase the **Integral Gain**, increase the **Proportional**

Gain as well (Proportional Gain can usually be 30-100% more than Integral Gain). The tracking should improve as the gains increase, although you will reach a value beyond which the noise will increase as the feedback loop starts to oscillate. If this happens reduce the gains until the noise goes away. If Trace and Retrace still do not track satisfactorily, the last thing to try is to reduce the **Setpoint**.

Contact Mode

44. Once engaged, increase the **Setpoint** by using the right arrow key and observe the **Z-Center Position**. If the line in the Z-Center Position moves far to the extended end, the tip has false engaged. Increase the setpoint by +2 volts and execute the engage command again. If the Z-Center Position does not change greatly, you are probably on the sample surface. Under the Scan-dual window, see how well Trace and Retrace are tracking each other. Adjust the **Gains**, **Scan Rate**, and **Setpoint** if needed. Remember that in Contact mode, increasing the Setpoint increases the force on the sample. Minimizing the imaging force is recommended for most applications.



Set Desired Scan Size, Scan Angle, and Offsets

45. Once the scan parameters are optimized, scan size and other features may be adjusted for capturing images for analysis. When changing the scan size value, keep in mind that the scan rate will need to be lowered for larger scan sizes.

Image Handling

46. Change the capture filename under Real Time/Capture Filename. Make sure that the destination folder is yours.

47. Images can be captured in two ways:


- Capture button  will capture the image until the scan is completed in the vertical direction.
- Capture Now! button  will capture the image at any point during the scan.

48. The images can be accessed on the same Workspace by clicking the following icons located at the left of the screen.



49. The images can be processed and viewed in different ways. Take some time and explore the different options available for image processing. The images can ultimately be exported into the JPEG format under File/Export/View. Save all the images under your own folder in the hard drive.
50. The settings used during the scan along with all the images captured can be saved under your workspace.

Instrument Shutdown

51. It is recommended that you save the Workspace for your future reference. Save it under your own directory in the hard drive.
52. Click on  to withdraw microscope.
53. Open hood.
54. Move the stage fully away from the AFM head using the trackball and the lock button. The Navigate window should be active in order to move the stage.
55. Turn off the vacuum and remove the substrate.
56. Move stage back under the AFM head using the trackball and the lock button.
57. Unlock AFM head by tightening the lock screw.
58. Disconnect the head cables.
59. Pull out head completely and place it on the table. Be careful of not dropping the head.
60. Remove probe carrier from the head and place it on the carrier holder.
61. Loose carrier clamp and remove the probe with the tweezers.
62. Slide head back into the dovetail groove of the microscope.
63. Loose the Lock Screw to fix the head to the microscope.
64. Plug cables back in.
65. Close hood.
66. Close the Nanoscope program window.
67. Fill out logbook.

Software Download

<http://www.nanolab.ucla.edu/downloads/afm-installation.zip>