# Scanning Probe Microscope (Veeco Dimension 3100) Training Notebook (Advanced)

*Nanotech User Facility*
*Center for Nanotechnology*
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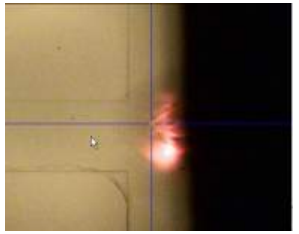
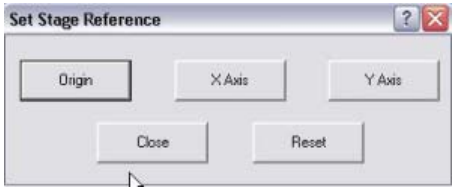
# Advanced Features

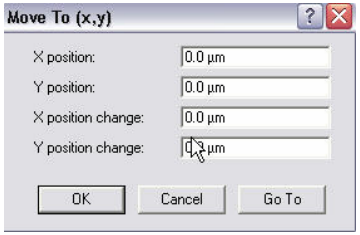
1. Motorized Sample Stage
2. Force Measurement
3. Point-and-Shoot
4. Q-Control
5. Fast Scan
6. Thermal Tune
7. Liquid Cell

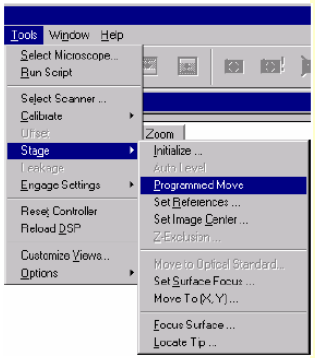
# 1. Motorized Sample Stage

1. Set Origin, X- and Y- Axis.
   - Find a mark on the surface by moving the stage laterally using the arrows. Move the mark to the center of the crosshair.
   - Click on Set Reference… under Tools > Stage. Click on Origin to set the current position as the origin.
   - Move the stage horizontally to another mark and click on X Axis to set the X axis.
   - Bring the stage back to the Origin.
     - Click on Move to (X, Y) under Tools > Stage.
     - Type in 0 in X Position and Y Position.
     - Stage moves back to the Origin.
   - Move the stage vertically to another mark and click on Y Axis to set the Y axis.



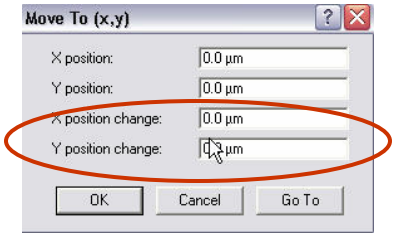


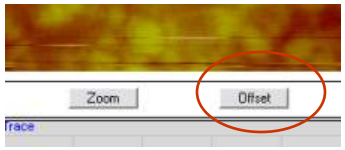



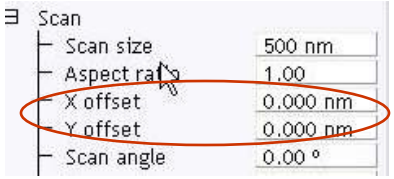



# 1. Motorized Sample Stage (Cont.)

2. Move to a specific point on the sample.
   - Click on Move to (X, Y) under Tools > Stage.
   - Type in estimated values in X Position and Y Position, then click on Go To.
   - Type in values in X Position Change and Y Position Change to move the point to the center of the crosshair.
   - Start a quick scan (128 x128 pixels).
   - Use Offset to move the feature to the center of the image and click on Execute.
   - Adjust the X position and Y Position values according the Offset values and set the Offset values back to zero.
   - Rescan the image, the feature should be in the center.



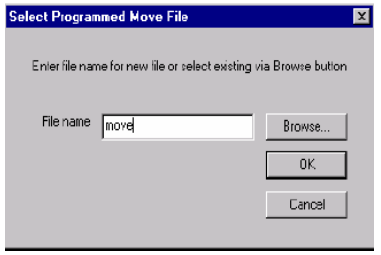



# 1. Motorized Sample Stage (Cont.)

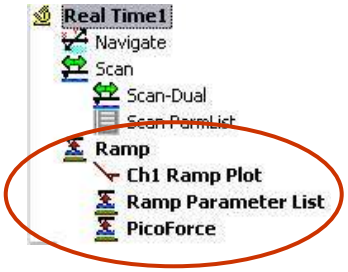
3. Programmed Move.
   - Click on Programmed Move under Tools > Stage.
   - Type in a new file name or browse an existing file.
   - Add Step.
     - Click on Add Step. Step number changes.
     - Type in values in X Position and Y Position, then click on Move. Stage moves to the new position.
     - Click on Add Step and then Move To Selected, Step X and Step Y values change.
     - Repeat these steps to add new steps.
   - Remove Step.
     - Type in the number of the step to be removed.
     - Click on Remove Step.
   - Click on Run to run programmed moves.

(To capture images, click Scan Parm List window to active the tool bar. Use Capture Continuous…)



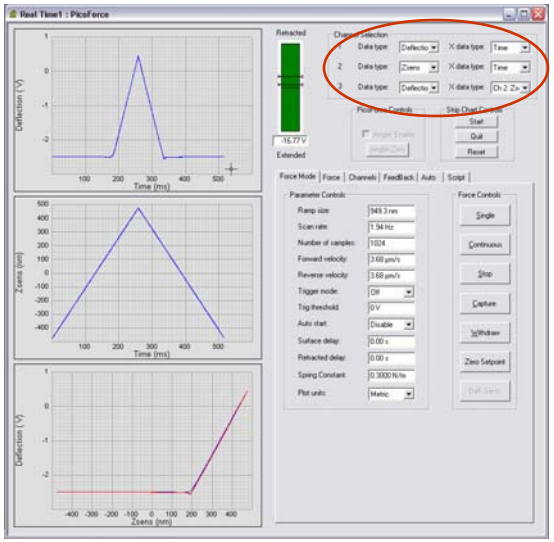

# 2. Force Measurement

1. Add Ramp…, Ramp Parameters List…, and PicoForce… to the workspace from the drop-down menu of RealTime.




2. Click on Ramp icon. 

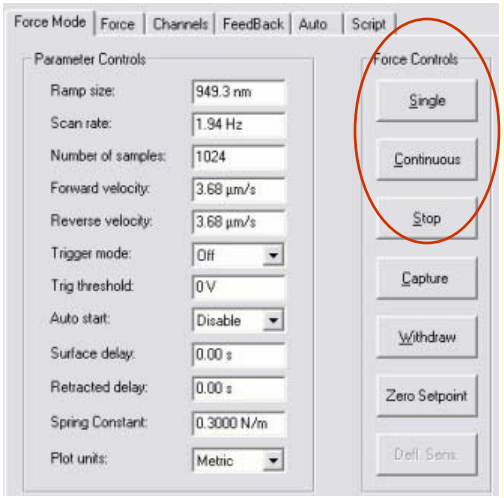

3. Set Data Type and X Data Type in three channels as:
   Defl. Vs. Time (or Z)
   Z Sens. Vs. Time
   Defl. Vs. Z Sens.



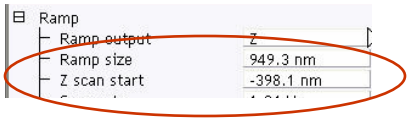
# 2. Force Measurement (Cont.)

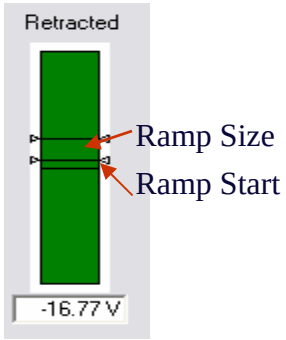
Measure force on a single point once, or continuous.

1. Click on Single  or Continuous  force measurement icon.
   Or, Single or Continuous in the panel.




2. Adjust tip travel distance (Ramp Size) and tip-surface interaction intensity (Ramp Start).



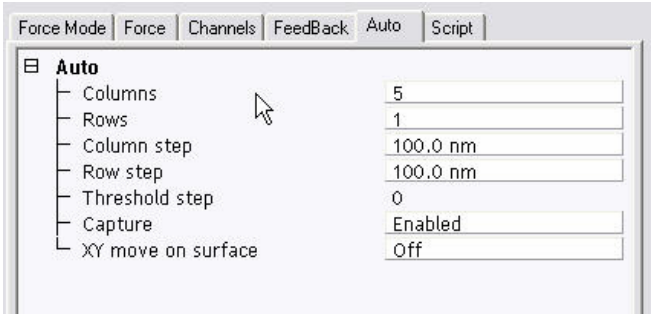



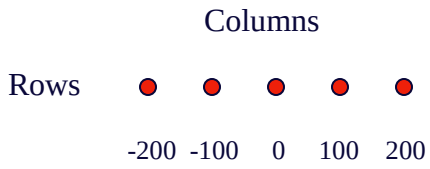

3. Click on Stop or  to stop the measurement.
4. Click on Capture to save force curves.

# 2. Force Measurement (Cont.)

Measure force on different points automatically.

1. Click on Auto tab to set up parameters.



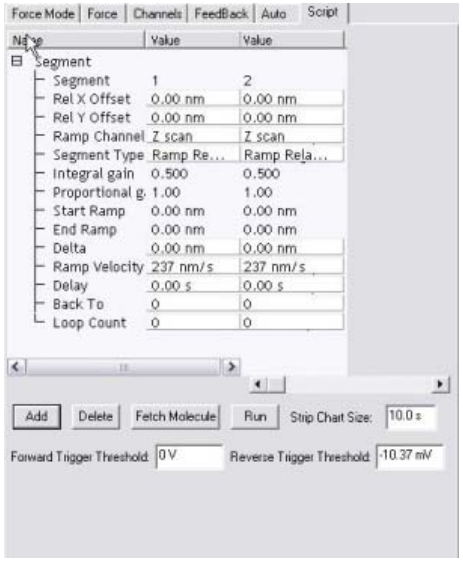



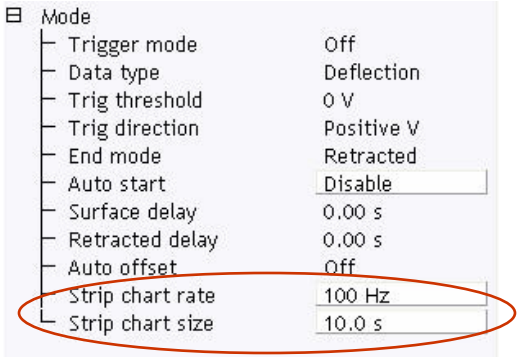

2. Click on Auto Force Measurement icon  to start the measurement.

# 2. Force Measurement (Cont.)

Measure forces on a single point according to the script.

1. Set Strip Chart parameters.
2. Click on Scrip tab to write script.

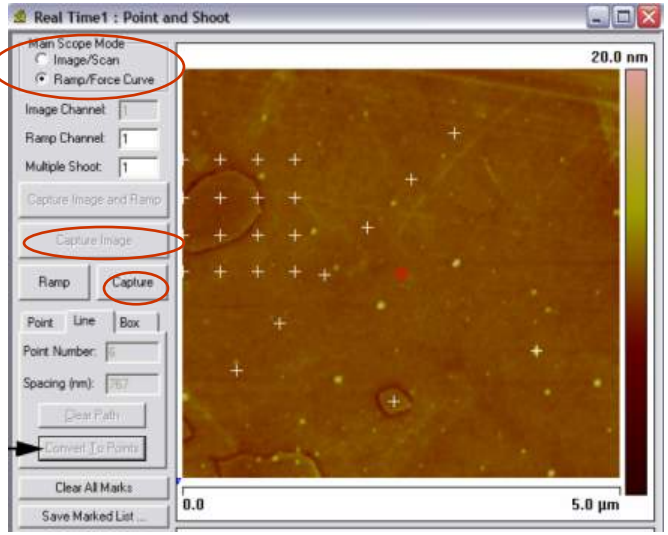


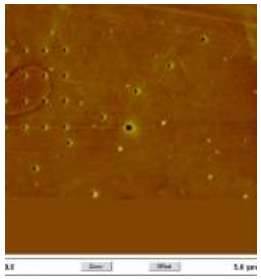




(See Dimension Hybrid XYZ Scanning Probe Microscope Head manual, pp. 31 – 77, for detailed force measurement and analysis.)

# 3. Point-and-Shoot

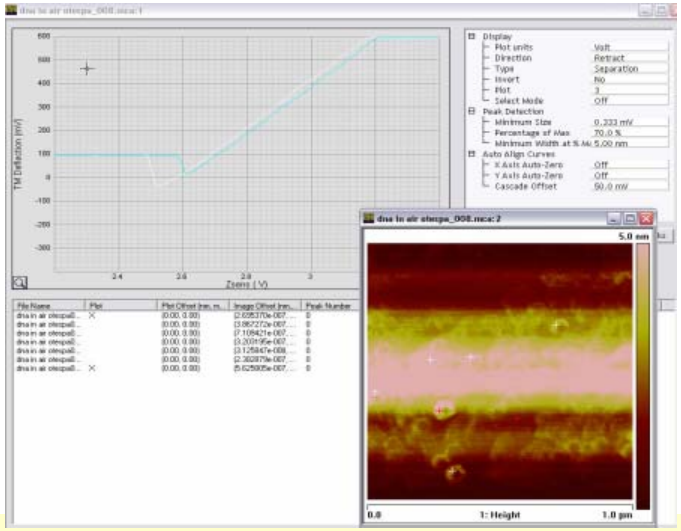
1. Click Point and Shoot under RealTime.
2. Click on Image/Scan and Capture Image to pre-scan and save an image.
3. Click on Point, or Line, or Box tab to draw points, a line, or a box in the image. Click on Convert To Points.
4. Click Capture by Ramp for performing Ramp and Capture. (A subdirectory is created and the "before" image and force curves are saved in it.)
5. In the normal scan mode, scan and capture marked surface image after Point-and-Shoot.



# 3. Point-and-Shoot (Cont.)

6. Compare the point-and-shoot force curves with “after” image.
   - Rename “before” image.
   - Copy “after” image into the subdirectory and rename it as “before”.
7. Analyze forces.
   - Double click on folder icon.
   - Mark any force file.

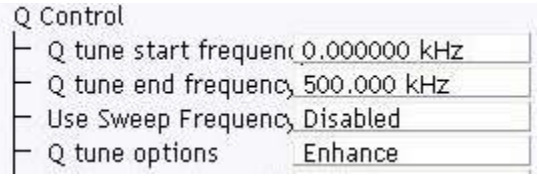


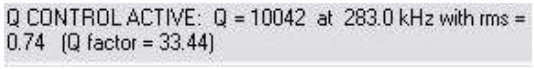
(Dimension Hybrid XYZ Scanning Probe Microscope Head manual, pp. 40 – 52.)

# 4. Q Control

1. Click on Tune icon. 
2. Click on Auto Tune.
   - Click on Compute Q to get a Q value before Q control.


3. Set Q Control parameters.
4. Click on More and then Adjust Q.




5. Turn off Q control before Engage.
   - More > Turn Off QC
   (Engage is very slow or false engagement if QC is on.)
6. Click on Engage icon.

# 4. Q Control (Cont.)

7. Click on Tune icon  once Engage finishes.
8. In the pop-out window type in 1 μm to lift the cantilever 1 μm away from the surface.
9. Tune window pops out. Click More > Restore QC, then Exit.
10. Scan images under Q control.

NanoScope IVa Controller Manual, Software Version 6.13, Sections 7.5 -7.6, pp. 73 – 78.

# 5. Fast scan

See NanoScope IVa Controller Manual, Software Version 6.13, Section 7.4, pp. 61-72, for detail.

# 6. Thermal Tune

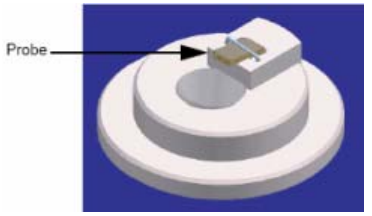
- It only works for cantilever resonance frequency less than 32 kHz.
  Usually works for soft cantilevers or in-liquid.
- See Atomic Force Microscope Thermal Tune Adapter manual for detail.

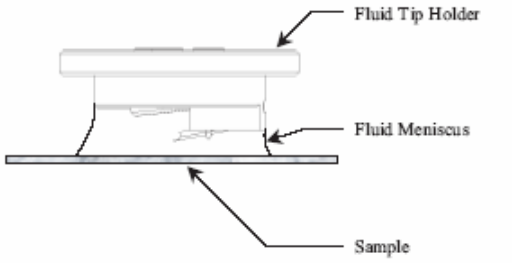
# 7. Liquid Cell

1. Choose a probe for scanning in liquid. (Si single crystal, FESP)
2. Mount the probe onto the in-liquid probe holder.
   - Put the holder on the liquid cell docking station.
   - Push the holder down to lift the spring
   - Insert the probe underneath the spring, align the probe against the back end of the groove.
3. Preparation.
   - Follow all steps in B.

   (Note: More clearance between the bottom of the head and the sample stage is needed for in-liquid probe holder.)
4. Add liquid.
   - Take off the head.
   - Add a drop of liquid between the cantilever and the glass window of the in-liquid probe holder.
   - Add a drop of liquid onto the sample.
   - Put the head back to the dovetail trail.

   (Note: The liquid should form a meniscus around the in-liquid probe holder.)

# 7. Liquid Cell (cont.)

5. Realignment.
   - Realign laser to the free end of the cantilever.
   - Readjust reflected laser to the center of the photo detector.
   - Relocate the tip.

6. Contact Mode.
   - Set Vertical Deflection to -1 V.
   - Set Setpoint to 0 V.
   - Set Integral Gain and Proportional Gain to 2.0 and 3.0.

# 7. Liquid Cell (cont.)

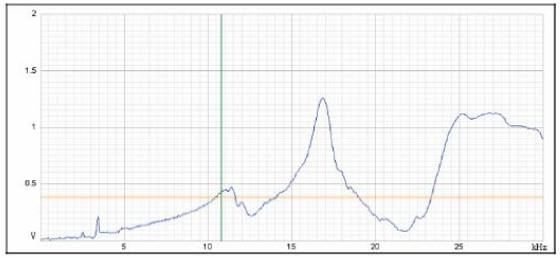
7. Tapping Mode.

- Set Vertical Deflection to 0 V, Integral Gain and Proportional Gain to 0.5 and 0.7.
- Tune cantilever *manually*.
  - Click on Tune icon. 
  - In the **Feedback Controls** panel, set **Z MODULATION** to DISABLED.
  - Set Sweep Control parameters.

| Drive Frequency | Sweep Width | Drive Amplitude | Amplitude Set Point | Amplitude Limit |
|---|---|---|---|---|
| 10 kHz | 20 kHz | 2000 mV | 0 | 2.5 V |

- Use Zoom In and Offset to center the peak in the sweep plot.


- Adjust Drive Amplitude to get appropriate RMS Amplitude.
  - 0.3 -0.6 V for proteins.
  - 2 V for cells.



(Note: Two frequency ranges commonly used are 16-19 kHz and 8-12 kHz.)

# 7. Liquid Cell (cont.)

8. Engagement is the same as in-air.
9. Scan.
    - Adjust Setpoint to get better image.
    - Set Scan Rate slower in liquid.
10. Follow all steps in G. Shut Down.
11. Clean and dry the in-liquid probe holder.