

DIMENSION AFM ICON INSTRUCTIONS

- A. ScanAsyst
- B. Contact Mode AFM
- C. Tapping Mode AFM

I. FACTORS TO TAKE INTO ACCOUNT BEFORE USING THE AFM:-

- a) **DO NOT PLACE ANYTHING ON THE GRANITE STAGE AT ALL!!!!**
- b) **SPM SCANNER COSTS \$25,000, HANDLE IT WITH CARE.**
- c) **DO NOT TOUCH THE LENS ON THE SPM HEAD.**
- d) **DO NOT STARE DIRECTLY AT THE LASER LIGHT**

II. INTRODUCTION TO THE BASIC IMAGING MODES OF AFM

a) ScanAsyst AFM

ScanAsyst imaging mode is the first image-optimization scanning mode for AFM. ScanAsyst continuously monitors image quality, and makes the appropriate parameter adjustments such as setpoints, feedback gains, and scan rates. ScanAsyst is based on Peak Force Tapping mode which collects force curves at every pixel in the image. The peak force of each of the force curves is used as the imaging feedback signal, hence providing direct force control. This enables it to operate at very low forces than Tapping Mode, which helps protect delicate samples and probes. Using ScanAsyst provides faster imaging while retaining high resolution images even for sticky samples.

b) Tapping Mode AFM

The probe is oscillated near its resonance frequency and it intermittently interacts with the sample surface. Constant oscillation amplitude is used as a feedback mechanism to maintain a constant tip-sample interaction. Tapping mode minimizes shear forces, which can damage delicate samples. Topography and phase images are simultaneously acquired with tapping mode AFM. Samples which are delicate as well as with higher adhesive properties can be characterized using tapping mode AFM.

c) Contact Mode AFM

Measures topography and lateral force image/friction by scanning the probe's tip in a raster pattern on the sample surface while monitoring the cantilever deflection. Constant deflection between the cantilever and the sample is therefore used as feedback mechanism. In contact mode, the tip continuously remains in contact with the sample.

- d) For **Magnetic Force Microscopy, Peak Force Quantitative NanoMechanics, Liquid Imaging, Force Imaging, Surface Potential and Peak Force TUNA**:- Please consult Dr. Wilson K. Serem on instructions for these AFM modes.

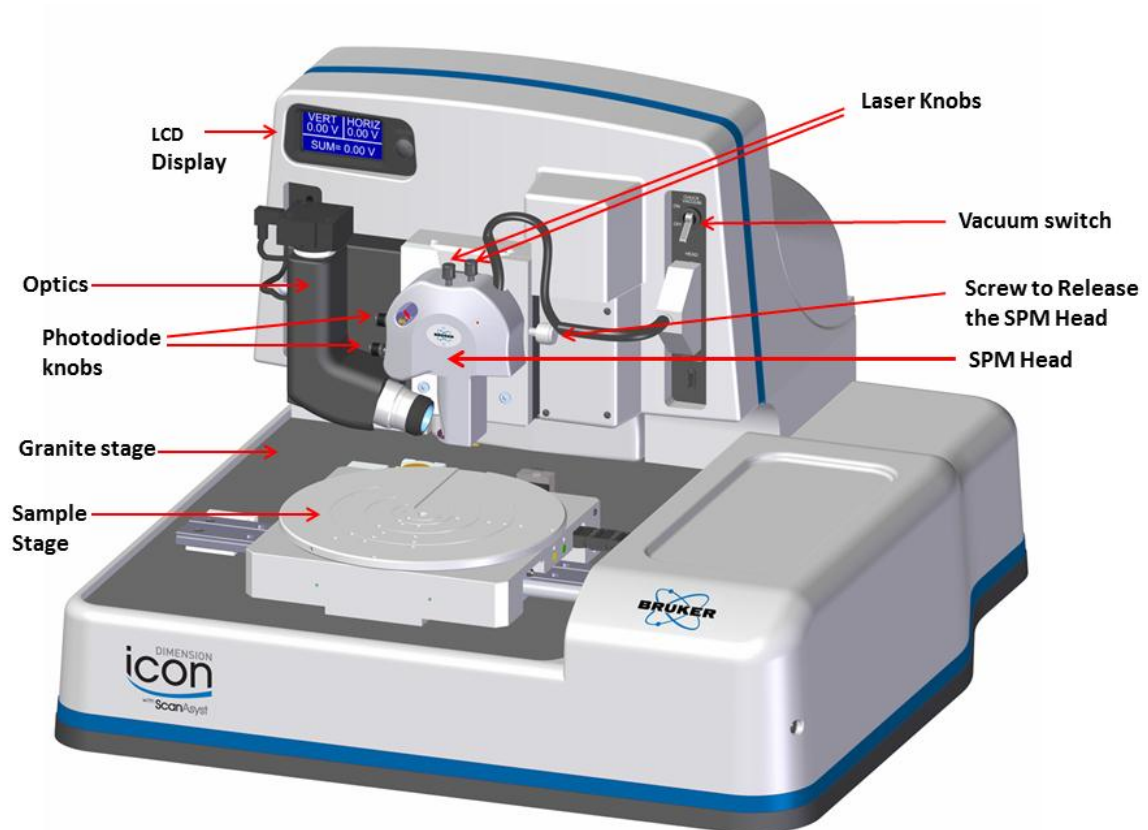


Figure 1. Various components of AFM (*from Icon AFM manual*)

A. ScanAsyst: Step by Step (Nothing on Granite Stage)

1. Tip Loading:

- Place the cantilever holder onto the cantilever holder stand.
- Press down and Pull the probe clip all the way to the back.
- Place the **ScanAsyst AFM probe** into the cantilever holder groove.
- Press down and gently push forward the tip holder clip to hold the cantilever.
- Loosen the screw on the right side of the SPM head to remove the SPM scanner (\$25,000 is the cost of the SPM scanner).
- Carefully mount the AFM probe holder (tip placed) onto the SPM head.

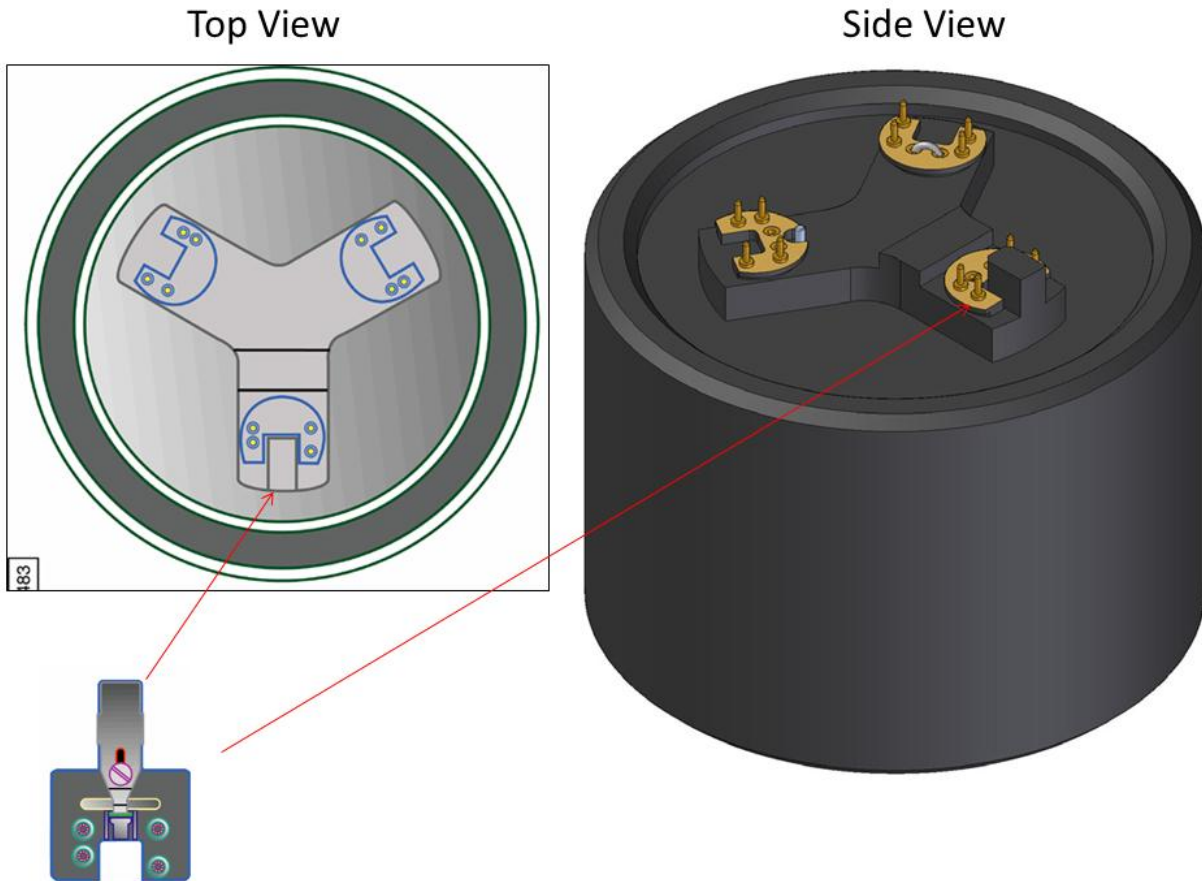


Figure 2. Loading AFM tip onto the Cantilever Holder (*from Icon AFM manual*)

- ### 2. Sample Mounting:
- Mount your sample on the magnetic discs using scotch double-sided tape OR put it on the vacuum stage and turn on the vacuum by toggling the VACUUM switch.

3. CAMERA ALIGNMENT and LASER ALIGNMENT



- Double click the **NanoScope** icon on the desktop and Select **SCANASYST** (Figure 3)



Figure 3. Experiment window showing different modes of AFM (taken from Bruker manual)

- Select **SCANASYST IN AIR** or **SCANASYST IN FLUID** in the **Select Experiment Group**.

- Click **Load Experiment** to open the **Workflow Toolbar, Scan Parameters List Scan One Channel** and **Force Monitor**.
- Click **SETUP** in the Workflow Toolbar. Click **Change probe** and select the tip you want to use in the database or other/unknown cantilever if it is not in the database.
- It is easier to align the laser on the tip in the **ALIGNMENT STATION**. Click the **ALIGNMENT STATION** icon in the **Align** window. Zoom out as far as possible in case you cannot see the laser spot as well as the tip in the optical field of view. Align the laser using the laser control knobs.
- Click **FOCUS UP** or **FOCUS DOWN** to focus the cantilever. Adjust the illumination for better view. Move crosshair on the tip and move the laser position using the laser knobs on the tip of the cantilever to maximize the **SUM** value on the LCD display. Zoom out as far as possible.

4. DETECTOR ALIGNMENT

Adjust the photodetector using the two photodetector knobs so that the red dot is at the center of the Dimension head filter screen. Do fine adjustment to attain (0,0) for vertical and horizontal deflections respectively.

5. Click **Return from the Alignment Station** and click **"Yes"** when prompted.

6. FOCUSING THE SAMPLE:

- In the **Workflow Toolbar**, click **NAVIGATE. RAISE THE SPM HEAD** using SPM "up arrow" to make sure that there is enough space between the tip holder and the sample before the stage is rotated.
- Rotate the sample stage so that the laser light is falling on your sample. Use the trackball to position your sample if necessary. Focus on the surface by moving the SPM head up or down using the SPM "up arrow" or "down arrow". **CAUTION: be careful not to crash the SPM head into your sample.**

7. SCANNING PARAMETERS:

Click **CHECK PARAMETERS** and set the initial scan parameters to match Figure 4:-

| | |
|------------------------------|----------|
| [-] Scan | |
| Scan Size | 500 nm |
| Aspect Ratio | 1.00 |
| X Offset | 0.000 nm |
| Y Offset | 0.000 nm |
| Scan Angle | 0.00 ° |
| Scan Rate | 0.977 Hz |
| Samples/Line | 512 |
| [-] Feedback | |
| Peak Force Setpoint | 0.1001 V |
| Feedback Gain | 5.000 |
| ScanAsyst Auto Config Frames | 0 |
| ScanAsyst Auto Control | On |
| [-] Limits | |
| Z Range | 7.67 µm |
| [-] Other | |
| Units | Metric |

Figure 4. Initial scan parameter list for ScanAsyst AFM (taken from Bruker manual)

- 8.** Click **Engage** to achieve “smart” approach of the tip.
- 9.** Set Channels 1 and 2 to **HEIGHT SENSOR, PEAK FORCE ERROR** respectively.
- 10.** Click **AUTOSCALE icon** or set the **Data Scale** to a reasonable value.
- 11. CAPTURING THE IMAGES**
 - Create your folder in the “E” directory under the Capture/USERS. Capture the AFM image by clicking **Capture** and choose **Capture file name**, write your name here to save the data. Capture the images by clicking on the camera icon, **Capture on** will be shown at the bottom right of the monitor window. All your saved images can be found in the “E” directory using the nanoscope offline analysis.
 - **Withdraw** the tip first if you want to move to a different area. Use the trackball to locate the area you want to image.
- 12. OFFLINE IMAGE ANALYSIS**
 - Click on the **nanoscope analysis** icon on the desktop to open and selected the image of interest.
 - Modify the image by using plane fit and or by flattening.
 - Export your images by right clicking on the image. Click **TIFF Export** and move your data to your folder.

B. Tapping Mode AFM: (Nothing on Granite Stage)

1. Tip Loading:

- Place the cantilever holder onto the cantilever holder stand.
- Press down and Pull the probe clip all the way to the back.
- Place the **Tapping Mode probe** into the cantilever holder groove.
- Press down and gently push forward the tip holder clip to hold the cantilever.
- Loosen the screw on the right side of the SPM head to remove the SPM scanner (**\$25,000 is the cost of the SPM scanner**).
- Carefully mount the AFM probe holder (tip placed) onto the SPM head.

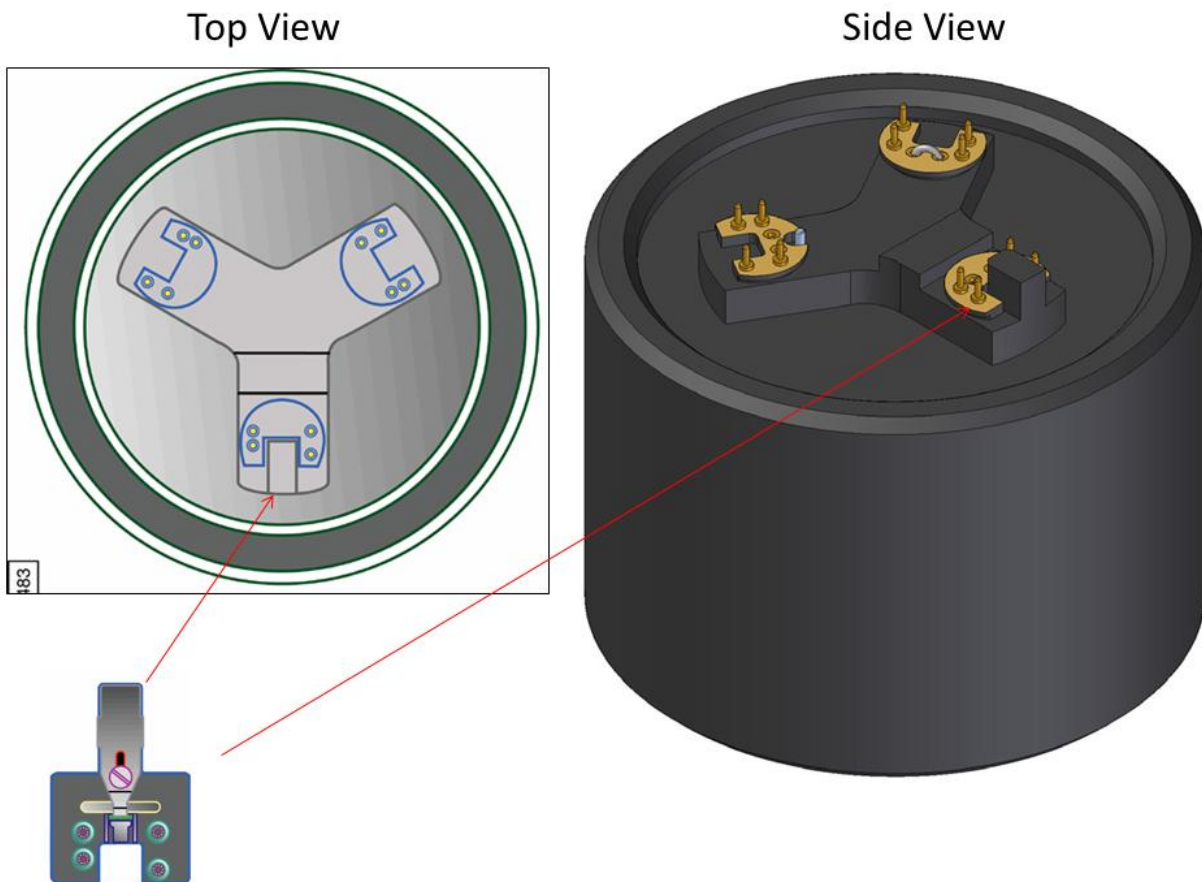


Figure 3. Loading AFM tip onto the Cantilever Holder (*from Icon AFM manual*)

- ### 2. Sample Mounting:
- Mount your sample on the magnetic discs using scotch double-sided tape OR put it on the vacuum stage and turn on the vacuum by toggling the VACUUM switch.

3. CAMERA ALIGNMENT and LASER ALIGNMENT

- Double click the **NanoScope** icon  on the desktop and Select **Tapping Mode** (Figure 3)

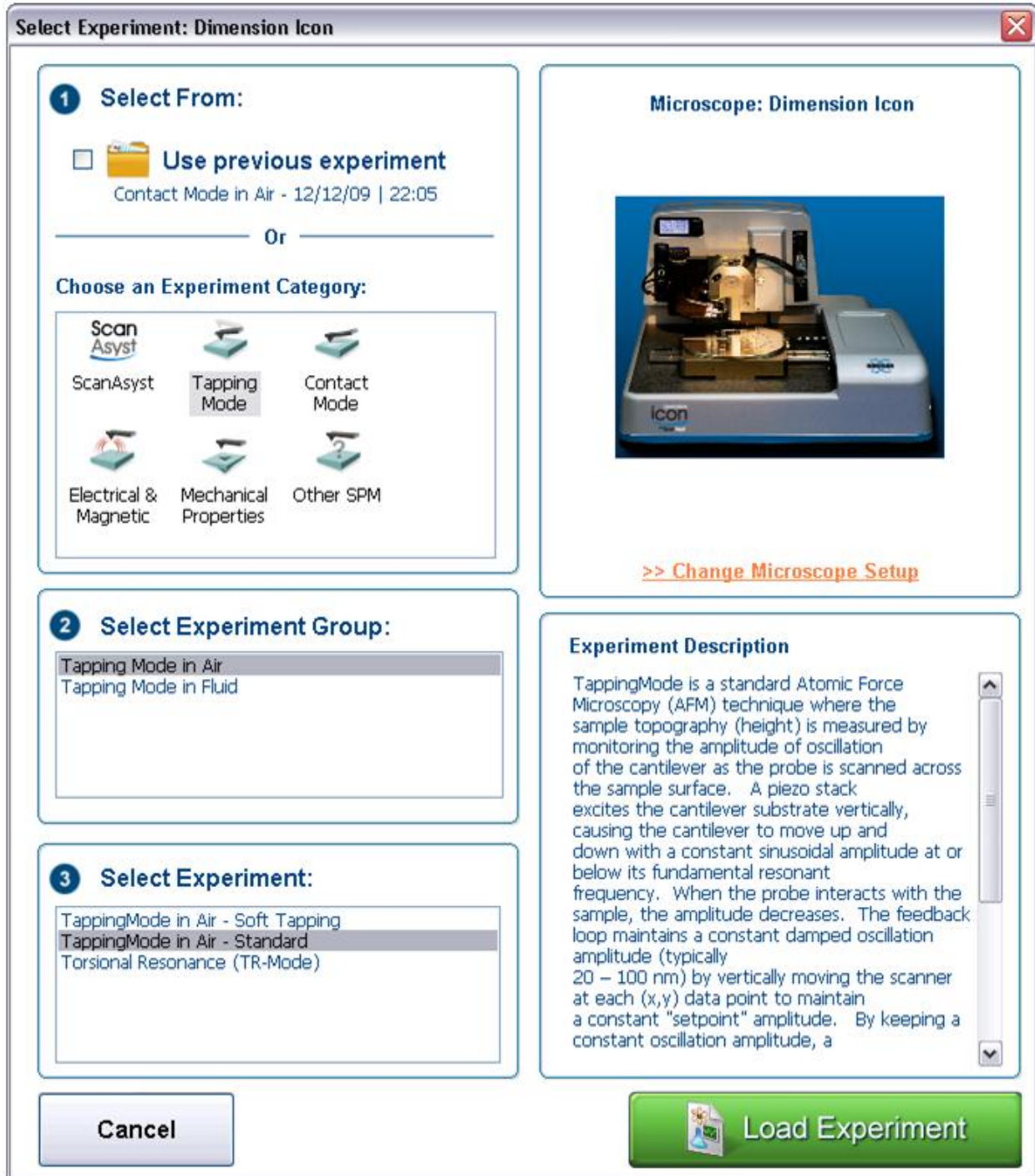


Figure 3. Experiment window showing different modes of AFM (taken from Bruker manual)

- Select **Tapping Mode in Air (soft)** in the **Select Experiment Group**.
- Click **Load Experiment** to open the **Workflow Toolbar, Scan Parameters List Scan One Channel** and **Force Monitor**.
- Click **SETUP** in the Workflow Toolbar. Click **Change probe** and select the tip you want to use in the database or other/unknown cantilever if it is not in the database.
- It is easier to align the laser on the tip in the **ALIGNMENT STATION**. Click the **ALIGNMENT STATION** icon in the **Align** window. Zoom out as far as possible in case you cannot see the laser spot as well as the tip in the optical field of view. Align the laser using the laser control knobs.
- Click **FOCUS UP** or **FOCUS DOWN** to focus the cantilever. Adjust the illumination for better view. Move crosshair on the tip and move the laser position using the laser knobs on the tip of the cantilever to maximize the **SUM** value on the monitor. Zoom out as far as possible.

4. DETECTOR ALIGNMENT

Adjust the photodetector using the two photodetector knobs so that the red dot is at the center of the Dimension head filter screen. Do fine adjustment to attain (0,0) for vertical and horizontal deflections respectively.

5. Click **Return from the Alignment Station** and click **"Yes"** when prompted.

6. FOCUSING THE SAMPLE:


- In the **Workflow Toolbar**, click **NAVIGATE. RAISE THE SPM HEAD** using SPM "up arrow" to make sure that there is enough space between the tip holder and the sample before the stage is rotated.
- Rotate the sample stage so that the laser light is falling on your sample. Use the trackball to position your sample if necessary. Focus on the surface by moving the SPM head up or down using the SPM "up arrow" or "down arrow". **CAUTION: be careful not to crash the SPM head into your sample.**

7. SCANNING PARAMETERS:

Click **CHECK PARAMETERS** and set the initial scan parameters to match Figure 4:-

| | |
|----------------------|---------------|
| ☐ Scan | |
| └ Scan Size | 500 nm |
| └ Aspect Ratio | 1.00 |
| └ X Offset | 0.000 nm |
| └ Y Offset | 0.000 nm |
| └ Scan Angle | 0.00 ° |
| └ Scan Rate | 1.00 Hz |
| └ Samples/Line | 256 |
| ☐ Feedback | |
| └ Integral Gain | 0.5000 |
| └ Proportional Gain | 5.000 |
| └ Amplitude Setpoint | 371.2 mV |
| └ Drive Frequency | 171.426 kHz |
| └ Drive Amplitude | 167.5 mV |
| ☐ Limits | |
| └ Z Limit | 9.557 μ m |
| ☐ Other | |
| └ Units | Metric |

Figure 4. Initial scan parameter list for Tapping Mode AFM (taken from Bruker manual)

- 8.** Tune the cantilever to find the resonance frequency of the probe. This is done by clicking the TUNE icon  in the Workflow Toolbar. Click **Auto Tune** to begin automatic tuning. A graph should appear with both amplitude and phase charts similar to Figure 5. Click **EXIT** after tuning.

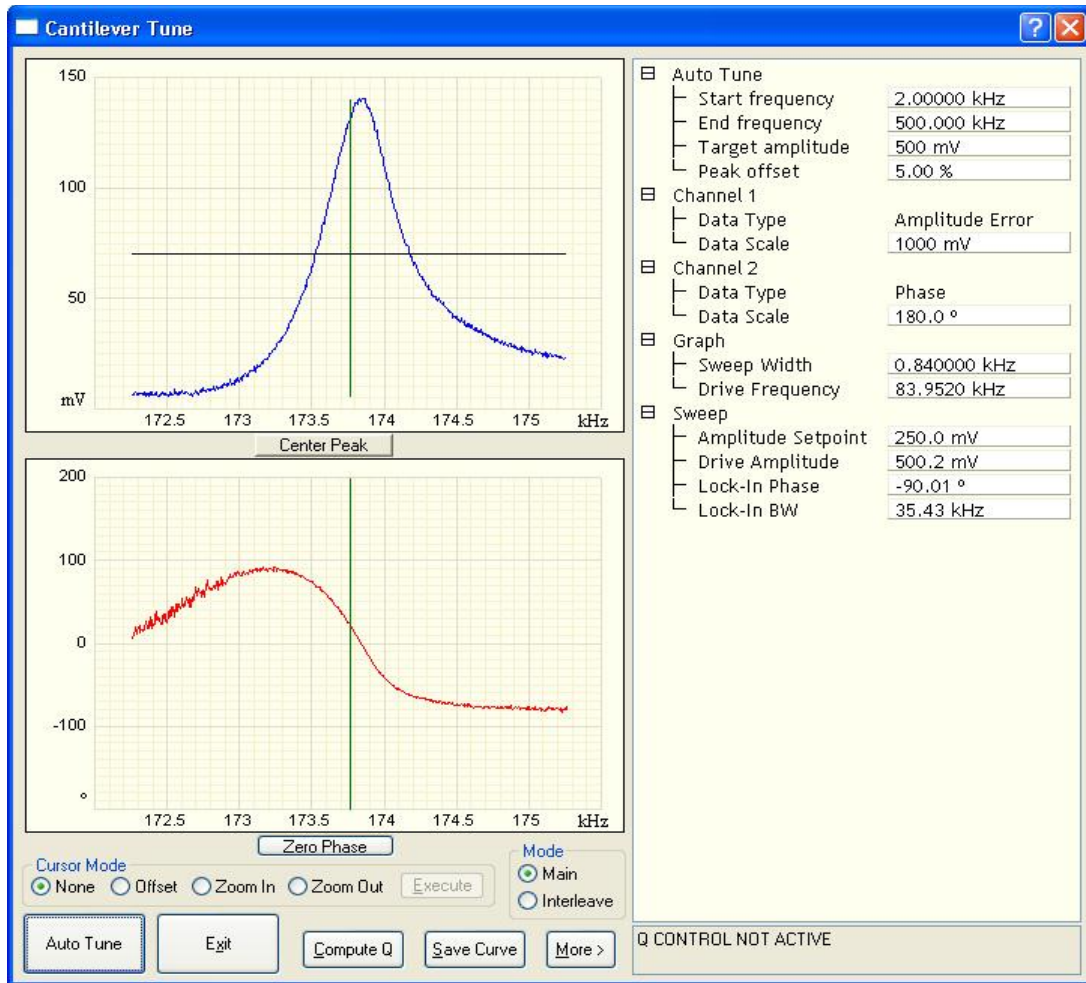


Figure 5. Auto tune control panel for AFM tapping (taken from Bruker manual)

- 9.** Lower the **SPM head** until the sample surface is in focus. **CAUTION: be careful not to crash the SPM head into your sample.** Click **Engage** to approach the tip.
- 10.** Set Channels 1, 2, 3 to **HEIGHT SENSOR, AMPLITUDE ERROR** and **PHASE** respectively.
- 11.** Click **AUTOSCALE icon** or set the **Data Scale** to a reasonable value.
- 12.** Adjust the **Amplitude Setpoint** in Feedback controls to optimize (smallest) the force during imaging by:-
 - Start by gradually increasing the **Setpoint** using the right arrow until the blue and red lines are completely different.

- Then slowly reduce the **Setpoint** using the left arrow key until the blue and the red lines are very close or similar.

13. Increase **Integral Gain** and **Proportional Gain** (30 % more than **Integral Gain**) as well until you begin to see noise in the trace and retrace lines. Reduce both the **Integral Gain** and **Proportional Gain a little bit until the noise disappears.**

14. CAPTURING THE IMAGES

- Create your folder in the "E" directory under the Capture/USERS. Capture the AFM image by clicking **Capture** and choose **Capture file name**, write your name here to save the data. Capture the images by clicking on the camera icon, **Capture on** will be shown at the bottom right of the monitor window. All your saved images can be found in the "E" directory using the nanoscope offline analysis.
- **Withdraw** the tip first if you want to move to a different area. Use the trackball to locate the area you want to image.

15. OFFLINE IMAGE ANALYSIS

- Click on the **nanoscope analysis** icon on the desktop to open and selected the image of interest.
- Modify the image by using plane fit and or by flattening.
- Export your images by right clicking on the image. Click TIFF Export and move your data to your folder.

C. Contact Mode AFM: (Nothing on Granite Stage)

1. Tip Loading:

- Place the cantilever holder onto the cantilever holder stand.
- Press down and Pull the probe clip all the way to the back.
- Place the **Contact Mode probe** into the cantilever holder groove.
- Press down and gently push forward the tip holder clip to hold the cantilever.
- Loosen the screw on the right side of the SPM head to remove the SPM scanner (**\$25,000 is the cost of the SPM scanner**).
- Carefully mount the AFM probe holder (tip placed) onto the SPM head.

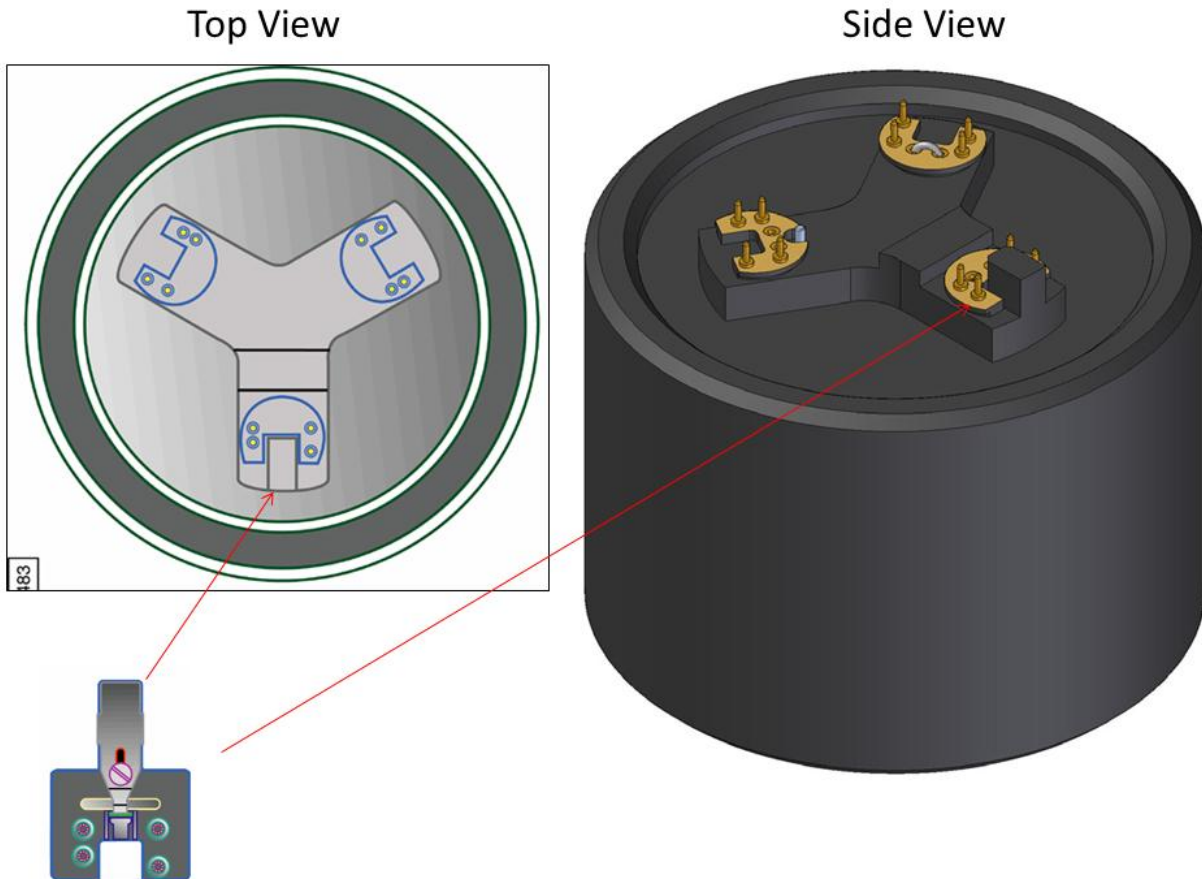


Figure 1. Loading AFM tip onto the Cantilever Holder (*from Icon AFM manual*)

- ### 2. Sample Mounting:
- Mount your sample on the magnetic discs using scotch double-sided tape OR put it on the vacuum stage and turn on the vacuum by toggling the VACUUM switch.

3. CAMERA ALIGNMENT and LASER ALIGNMENT

- Double click the **NanoScope** icon  on the desktop and Select **Contact Mode** (Figure 2)

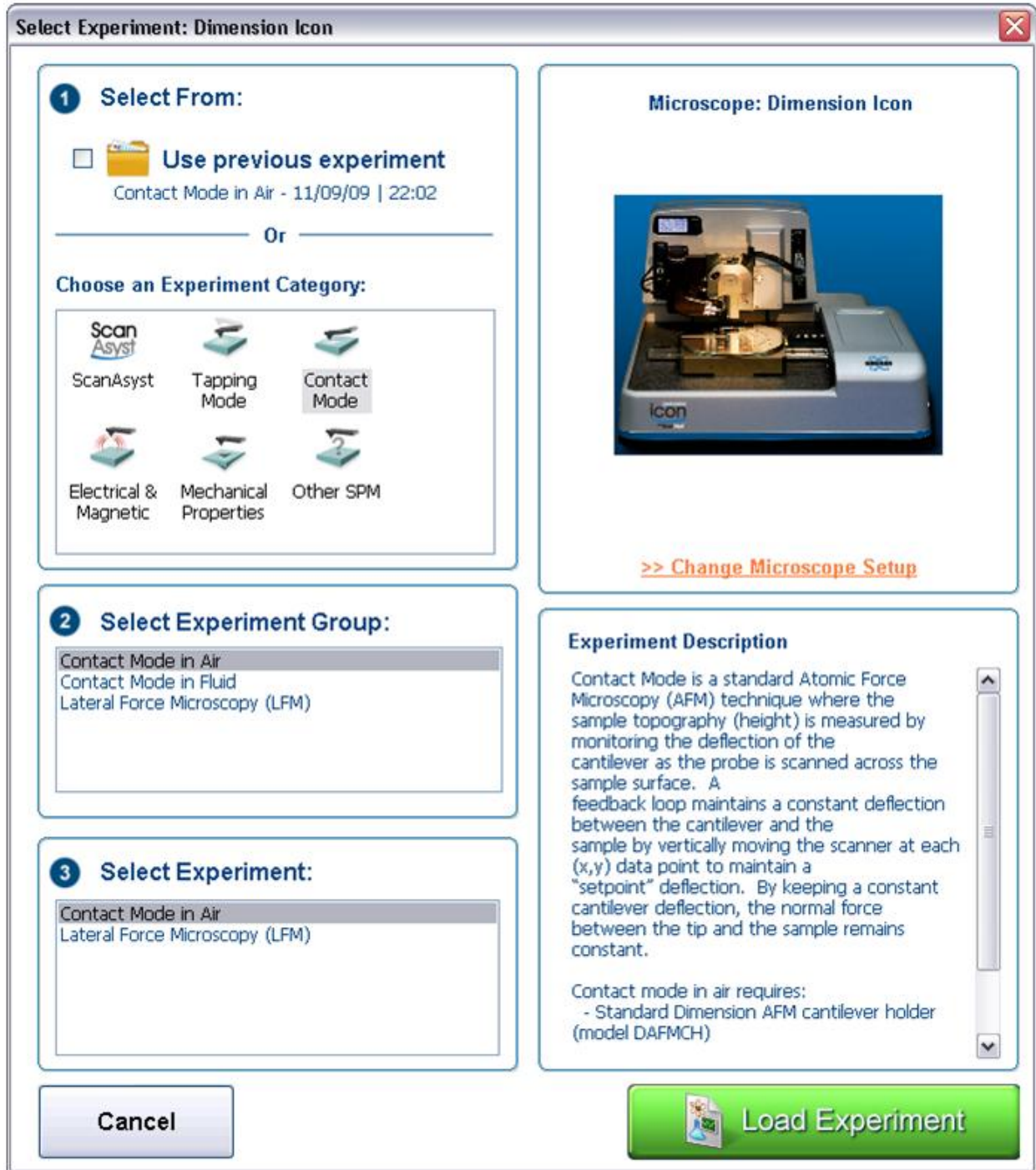


Figure 2. Experiment window showing different modes of AFM (taken from Bruker manual)

- Select **Contact Mode in Air** in the **Select Experiment Group**.
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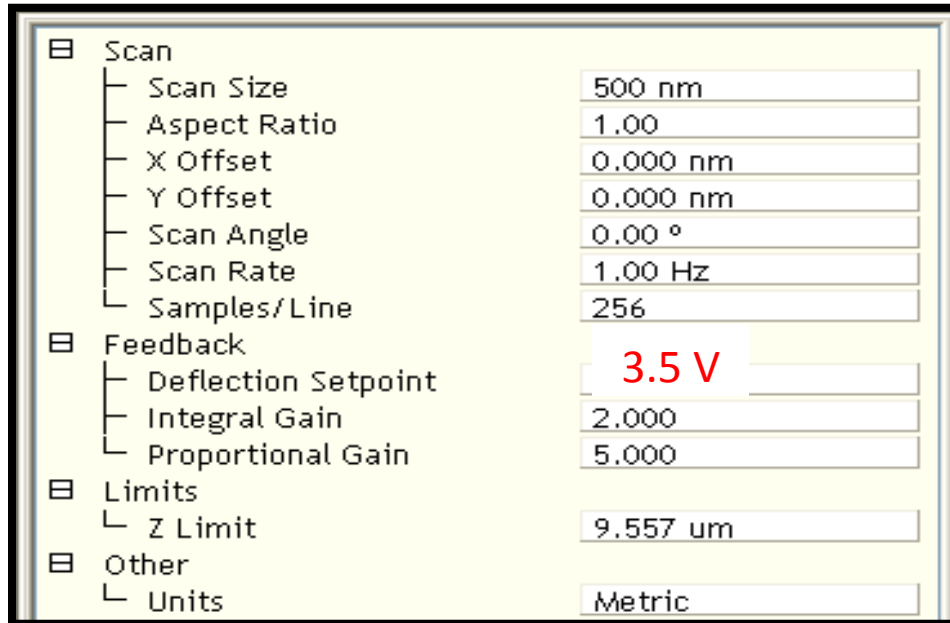


Figure 3. Initial scan parameter list for Contact Mode AFM *(taken from Bruker manual)*

1. Lower the **SPM head** until the sample surface is in focus. **CAUTION: be careful not to crash the SPM head into your sample.** Click **Engage** to do a final approach of the tip.
2. Set Channels 1, 2, 3 to **HEIGHT SENSOR, DEFLECTION ERROR and Friction** respectively.
3. Click **AUTOSCALE icon** or set the **Data Scale** to a reasonable value.
4. Adjust the **Setpoint** in Feedback controls to optimize (smallest) the force during imaging by:-
 - Start by gradually increasing the **Setpoint** using the right arrow until the blue and red lines are completely different.
 - Then slowly reduce the **Setpoint** using the left arrow key until the blue and the red lines are very close or similar.

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