

# Conductive Atomic Force Microscopy (cAFM)

## Our Setup:



# S.O.P

## AC Air Mode (Tapping Mode):

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1. Anti-vibration Table turn on:
2. Computer System turn on:
3. Laser Turn on:
4. Software preparation:
5. Prepare the scanner:
6. Adjust the legs on the head:
7. Software prep:
8. Aligning the laser:
9. Start Imaging:
10. Loading the cantilever Tips and Tricks:
  - Prepare cantilever Mounting Work Area:
  - Remove the cantilever holder from the head:
  - Mount the cantilever Holder:
  - Insert the new cantilever:

### Contact Mode:

### Important steps to be taken care of:

## **1 . Anti-vibration Table turn on:**

- a. Turn on and enable the active vibration isolation platform under your AFM.

## **2. Computer System turn on:**

- a. In **no particular order**, switch on the computer and turn on the MFP-3D AFM by depressing the power switch in front of the

controller. if everything is working properly, then you should see a green light on the face of the controller.

### **3. Laser Turn on:**

- a. Check the the laser key on the controller is on the ON position.
- b. Then check that the red LED light on top of the AFM head is on.

### **4. Software preparation:**

- a. Double click on the Asylum Research 15 software which is located on the desktop.
- b. The software should now be showing The Mode Master window. If not, then click on the Mode Master button at the bottom left of the screen.
- c. Select Mode: *Standard* → *Topography* → *AC Air Topography*.
- d. The screen will now rearrange and present all the controls necessary for this type of AFM imaging.
- e. Following are the list of panels that will appear in the screen.

**Master Channel Panel** (Ctrl + 7) During imaging, multiple data streams, such as height, cantilever amplitude and phase, return from the AFM to the computer. This panel contains information about those data streams and allows for some real time scaling and processing.

**Sum and Deflection Meter** (Ctrl + 6) Also called the S&D Meter. A real time display of various data such as cantilever deflection, amplitude, piezo voltage, and various other user definable channels. Also contains buttons for engaging and withdrawing the AFM tip.

**Image Windows** For each active channel on the Master Channel Panel, one image will appear on the screen. They balloon to proper size as soon as scanning starts. The windows display in real time, line by line, the sample topography (height), phase, amplitude, voltage, or any other

measured quantity, acquired as the sample is scanned. There is usually one such window per active tab in the Master Channel Panel (Lower left hand window). While these windows are primarily a data displays, right clicking with the mouse can activate various commands such as zoom and translate.

## 5. Prepare the scanner:

- a. Remove any sample that may be on the scanner.
- b. Looking from above, turn the XY sample alignment micrometers (thin knobs) until the divots or grooves in the base plate are aligned over the leg holes in the scanner.



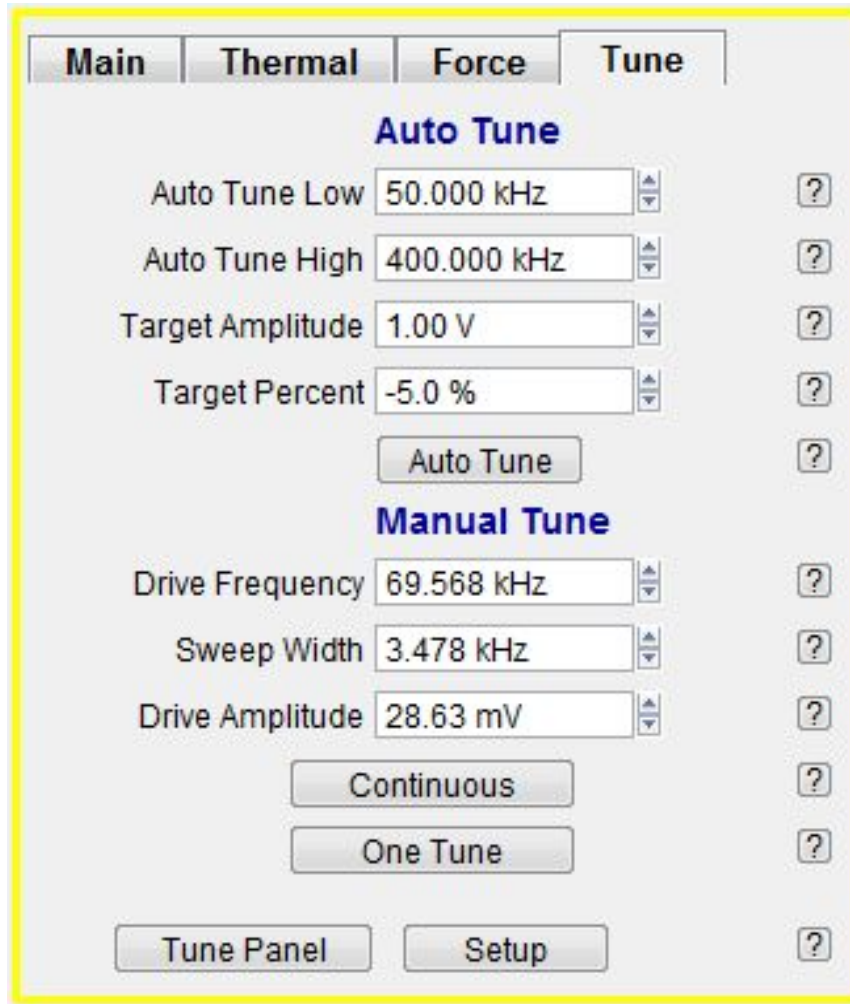
- c. Firmly grip the head and place it on the base. Each leg goes through one of the leg holes in the scanner.
- d. Since no sample is present there is no worry about crashing the cantilever into anything.

## **6. Adjust the legs on the head:**

- a. Look for clearance between the scanner top plate and cantilever.
- b. Turn the thumb wheels that control the legs to create sufficient space for the sample. Seen from above, clockwise motion raises the head; see the arrow on the top of the head for guidance.
  
- c. The goal is to have at least 1mm of clearance for the cantilever when the head is first set down over the actual sample. Be conservative on your first attempts. If you are worried, wheel the legs all the way up.
- d. In the process try to end up with the head reasonably level.

## 7. Software Prep:

| Main  | Thermal             | Force                            | Tune                  |
|---|---------------------|----------------------------------|-----------------------|
| Scan Size                                       | 20.00 $\mu\text{m}$ | <input type="radio"/>            | <input type="radio"/> |
| Scan Rate                                       | 1.00 Hz             | <input type="radio"/>            | <input type="radio"/> |
| X Offset  | 0 nm                | <input type="radio"/>            | <input type="radio"/> |
| Y Offset  | 0 nm                | <input type="radio"/>            | <input type="radio"/> |
| Scan Angle                                      | 0.00 $^{\circ}$     | <input type="radio"/>            | <input type="radio"/> |
| Points & Lines                                  | 256                 | <input type="radio"/>            | <input type="radio"/> |
| Set Point                                       | 700.00 mV           | <input checked="" type="radio"/> | <input type="radio"/> |
| Integral Gain                                   | 10.00               | <input type="radio"/>            | <input type="radio"/> |
| Drive Amplitude                                 | 28.63 mV            | <input type="radio"/>            | <input type="radio"/> |
| Imaging Mode                                    | AC Mode             | <input type="radio"/>            | <input type="radio"/> |
| Auto Tune                                       | Engage              | <input type="radio"/>            | <input type="radio"/> |
| Do Scan   | Stop!!!             | <input type="radio"/>            | <input type="radio"/> |
| Frame Up  | Frame Down          | <input type="radio"/>            | <input type="radio"/> |
| Base Name                                       | Image               | <input type="radio"/>            | <input type="radio"/> |
| Base Suffix                                     | 0006                | <input type="radio"/>            | <input type="radio"/> |
| Save Images <input checked="" type="checkbox"/> | Path...             | Save Image                       | <input type="radio"/> |
| Save Status: <input type="checkbox"/>           | Save Current        | Save Prev.                       | <input type="radio"/> |
| Main Panel                                      | Setup               | <input type="radio"/>            | <input type="radio"/> |

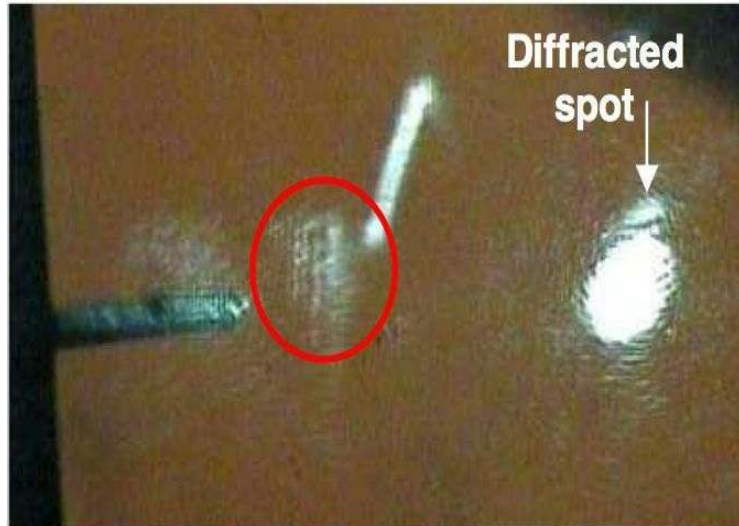


Open the live video window:

- a. Turn on the computer, and open the Asylum Research AFM software.
- b. In the software, click the *Camera*.
- c. From the menu bar at the top, select AFM Controls < Other < Live Video.

## 8. Aligning the Laser:

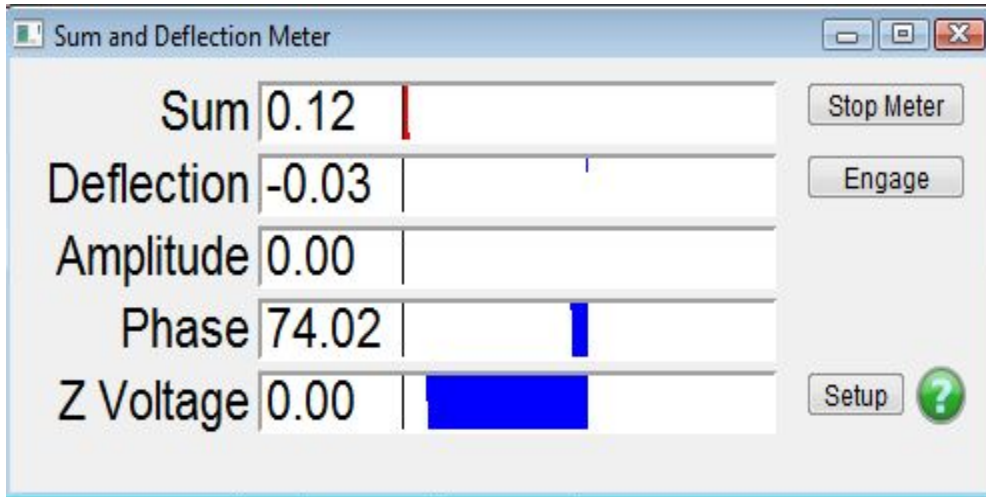
- a. Observe the live video screen while doing the following:



- b. Rotate LDY clockwise (CW) until it reaches the end of its range and you feel some resistance. Then, while counting the number of turns, go completely counterclockwise (CCW) to the other end. Now go CW again, but half the counted number of turns. The laser is now near the center of its Y range.



- c. Turn LDX CCW until the end of its range, which will put the spot beyond the right end of the screen.
  - d. You may see some spots moving around on the live video window. Get a feel for how they move while you rotate the wheels.
- 
- Maximize the Sum located on Sum deflection meter with the help of two knobs e.i LDX and LDY.
  - Make Deflection zero with the help of Deflection knob.
  - Now press *Auto tune* icon located on Master channel panel. The system will automatically tune the cantilever.
  - Set the Setpoint value to 80% of the free air amplitude. Typically the amplitude away from the surface is 1 volt, after a standard auto tune, which would call for an initial setpoint of 800 mV.
  - All the other parameters should already be set from tuning the cantilever.



- After tuning, press *Engage* icon, Z

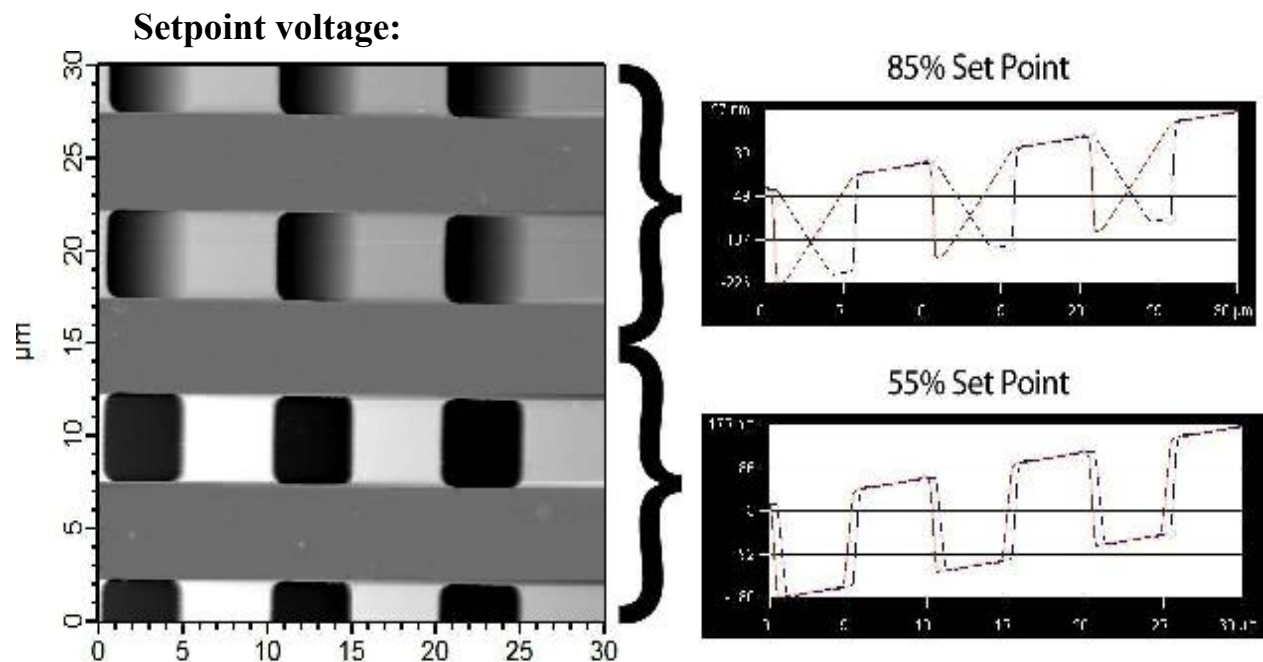


Voltage will move from 0 to 150.

- Slowly approach the tip towards the sample manually by turning the front wheel knob till the computer produces a beep sound.
- Bring the Z Voltage to 70.

## 9. Start Imaging: Start the scan:

a. Click the Do Scan button (or Frame Up or frame down) On the main Tab in the master panel. The tip will begin scanning from the top or bottom of scan area. the red marker to the left of each image window indicates the current scan line.



b. The Setpoint Voltage generally needs adjustment:  
c. Decrease the Setpoint Voltage value to increase the force applied to the sample, and to improve the tracking between

red and blue lines (trace and retrace).

d. Higher Setpoint voltages may help preserve the tip apex, but may not allow proper tracking of the surface.

e. For this example, use a Setpoint between 600-750 mV.

f. Practically speaking, amplitude set points from 20-75% of the free air amplitude will put you in repulsive mode, which tend to track well, but may wear down your tip.

Increase the *integral gain* to improve the tracking, but at a certain level the signal will start to ring.

g. Decrease gain until ringing ceases in trace and retrace.

Images will be saved automatically.

## 10. Loading the Cantilever Tips & Tricks:



### **Prepare cantilever mounting work area:**

- a. Set out your cantilever changing stand, tweezers, and box of cantilevers on a clear work surface, preferably close to the AFM so you can easily wheel your chair over.
- b. A low power binocular dissection microscope with light source is recommended.

### **Remove the cantilever holder from the head:**

- a. Place the AFM head upside down (usually on the metal platform or “head stand” next to the AFM.) Depress the button on the head.
- b. Gently lift the cantilever holder straight up out of the head and carry it to your cantilever changing area.

### **Mount the cantilever holder:**

- a. Orient the cantilever holder with



the

clip's screws towards the lever on the stand.

- b. Press the lever on the stand down, as shown.
- c. At the same time, angle the cantilever holder into the stand. Two fixed balls in the stand, opposite the lever, must match up with the two matching kinematic mounting points on the cantilever holder.
- d. Lower the cantilever holder so the final kinematic mounting point lines up with the ball on the stand's lever, then release the lever.
- e. Inspect that the cantilever holder sits flat in the stand and that all the balls sit properly in the mounting points.

### **Insert the new cantilever:**

- a. With tweezers, slide the cantilever chip under the clip.
- b. Gently, tighten the clip's screw.

- c. The chip should not be able to move if nudged with the tweezers. firmly mounted probes will perform best during AC mode imaging.

## Contact mode:

In Contact mode, All the steps are similar to AC Mode, except the tuning step.

Here we skip the step of Auto tune.

## **Important steps to be taken care of :**

1. Respect the weight of the AFM head as you handle it, the original model heads weighs 14 pounds, and can be difficult to lift with one hand. Get a good grip on the head with both hands when removing it or carrying it around. If dropped on your hand or foot (even from a small height) it could cause injury.
2. The AFM's XYZ piezos operate on voltages up to 165 V<sub>DC</sub>, and with sufficient current to be harmful to human life. Note that the cables connecting the controller to the base and the head and scanner to the base carry these voltages. Do not pinch or cut these cables. Turn off the controller before disconnecting any of these cables. It is safest to plug them all in and then turn on the controller. Also do not remove any covers from the controller or other instrument components while the controller is turned on or plugged into an AC outlet. Dangerous voltages are exposed with the covers removed.
3. When approaching the sample, there are two stages of approach.
  - a. First look under the scanner to ensure that the tip is >2mm away from the surface. At this point, you should not see an image/shadow of the tip on the surface.
  - b. When the tip is far as mentioned above, then keep looking at the monitor and begin to turn the knob 1/8 turns at a time until an image/shadow of the tip can be seen on the surface.
  - c. Then turn 1/16 turns at a time, while still monitoring the image on the monitor. Your wafer patterns will come into focus at this time. As it comes towards the distance set point, "amplitude" shown on the monitor will decrease to 0.80. When it reaches the set point, you will hear a beep. Then stop. Final amplitude will be 0.8+/-0.01.



4. While loading the cantilever, do not push the cantilever chip too far back. this can cause misalignment. Instead, align the line on the AFM tip to the edge of the clip.
5. Tighten gently with thumb and index finger hold on the screw driver. Do not over tighten the clamp on the cantilever holder, as this can crush the AFM tip.
6. While approaching the tip towards the sample, move the 'head' knob slowly. it should be taken care that we do not crush the tip while bring down.