Quick Instructional Manual

Warning: Keep fiber optic light always off, when performing your experiments. When it is on, it creates acoustic noise and ground vibrations.

Introduction:
Scanning Probe Microscopy (SPM) is a general term referring to surface characterization techniques that utilize probes in close proximity to the sample surface. Surface topographical characterization is perhaps the most common use of SPM techniques. These devices are capable of characterizing the topography of a sample with vertical features ranging in size from $10^{-10}$ to $10^{-6}$ meters. The lateral dimensions of the scanned region may be on the order of $10^{-10}$ to $10^{-4}$ meters.

Various SPM techniques are being developed; among these are Lateral Force Microscopy, Magnetic Force Microscopy, and this manual is designed to serve as a supplement to training on the SPM and is not intended as a replacement for formal training sessions. To schedule training on the SPM, contact Gajendra Shekhawat (g.shekhawat@northwestern.edu, 1-3204/847-650-2918).

Peoples who can assist you in DI AFM if you don’t find Manager:
Mirela Mustata (g.mustata@northwestern.edu, Ph:1-5809).

General Start up
• Computer and monitor are always on and should not be turned off
• Turn on SPM control electronics. Switch is on the bottom left in the cabinet underneath
• Start the WinSPM scan software for data acquisition. There should be no login-in and password
• Go to the SPM PULL down menu
• Choose “Reset SPM/controller”
• Click OK
• Go to the SPM PULL down menu again and click on calibrate scanner
• Choose scanner number 2 option as it is default scanner with scan size up to 65 μm
• If you need high resolution scanner for scan area less than 500 nm, please ask the manager for that.
• Go to the SPM PULL down menu again and choose scan
• Choose operational mode
• Contact mode tapping mode (AC mode), STM, options and advanced modes are available on this system.
• If you need MFM, Kelvin probe, STM, conducting AFM, Liquid Cell, Hot and cold stage options, please ask the manager for details and specific training
• For AC mode operation (tapping mode), click on AC tab
• For contact mode, click on contact tab
• In either mode, check the Z stage location (look for triangle sign). If the triangle is near to IN side, please check out and then click on start. It should be ¼ distance from the IN side.
• If triangle touch down the IN side, the stepper motor will interlock the piezo movement in upward direction and you will not able to approach forever.
• Minimize the scan software and open up PCX DRAW1 software from Desktop. This will open up the monitor for video optical microscope to see cantilever sample location
• Turn on the CCD on optical microscope and click on S-VIDEO tap on the PXCdrow video screen.
• Turn on the lamp. Switch is on the front panel and moves it to CCD. Don’t keep the lamp turned on while doing imaging

Sample Preparation and Cantilever
• Insert the cantilever in the cantilever holder precisely in the center and fully inserted in the tip carrier.
• Glue the sample on the pucks (use two pucks sample holder; otherwise you will not be able to approach). Use sticky dots to stick your samples and press firmly to ensure its flatness and proper sticking
• Put down the sample very carefully on the scanner. The magnetic holder on the piezo will hold the sample. Sample should not fall in the open spaces near the scanner; otherwise it will block the vacuum valve.
• Insert the cantilever holder in side the AFM head and ensure that it is fully insert in it. Make sure that it is fully inserted.
• Use THUMB WHEEL at the bottom to bring the sample is very close proximity to the cantilever. Use cantilever reflection as a reference point in brings it closer.
• Put the AFM amplifier knob on the SUM. Sum signal will increase if laser is on the cantilever. Normally for Si cantilevers, it is generally around –6 to -8.
• If you are confident of laser on cantilever and still don’t see any SUM signal, try adjusting the mirror by looking into the photodiode inside AFM head. If the cross lit up, laser is properly falling on the detector.

Tapping Mode (AC MODE)
• Turn on the laser diode using the LD ON switch on the AFM preamplifier.
• Align the laser to the cantilever using the top knobs on the SPM head
  o Right knob is for left-right adjustment
  o Left knob is for the up-down adjustment
• Best way to align is that bring cantilever in very close proximity to the surface using reflection cantilever image as an reference point and then put the laser towards you.
- Slowly move the laser spot and you will notice the laser coming on the cantilever surface.
- Make sure that the spring loaded X- and Y- adjustment knobs of the laser alignment should not move too much. In such instance, the laser will be completely misaligned and laser stage will be tilted.
- When properly aligned, SUM signal should be around -7 to -8 for current cantilevers. Some cantilevers may not have reflective aluminum coating on their back side. In that case, SUM signal will be lower (-4 to -5). It is ok to operate the system under such conditions.
- Higher SUM signal indicates laser spot in on the detector. Now, use the X and Y-detector knobs to move the laser spot in the center of the detector.
- To do this, click on ADJUST PD tab in the software and a four quadrant window will appear on the screen. You will also see red dot somewhere in that quadrant.
- Move the X-detector knob to bring the red dot along the center of Y-axis. If you turn the knob in correct direction, SUM signal will not fall down. If other way, then SUM signal will fall down.
- Similarly, turn the Y Knob to bring the red dot in the center of the quadrant by adjusting the Y-knob. You will notice that increase in SUM signal after doing this step.
- Move the AFM selector knob to RMS now. RMS indicates the free space amplitude of vibrating cantilever when tuned.
- Click on Tune. Go ahead and auto tune it. You will see a peak in the frequency spectrum and resonance freq. will be displayed on the screen.
- If you did not see peak at this point, then click on cantilever and check the HIGH VCO OUTPUT
- Tune it again and you will see a nice peak. Cantilever free space amplitude will now be displayed on the RMS.
- Click on the cantilever and reduce the freq. by pressing the arrow keys (avoid changing the freq. by side bar) until the RMS amplitude (free space cantilever oscillation amplitude) is around 3-4.5 (In your system, it may around 2). In this way, we can operate in the high sensitive amplitude region. Higher the amplitude, higher will be the tapping and you can easily control that during the scanning by looking at your images.
- If the image features looks the way you are not expecting (like extended triangular features), increase your reference amplitude by moving the side bar using arrow keys towards zero. This is one of the important parameter in getting quality images, so avoid changing the amplitude very fast. Change in steps by looking at your image.
- Adjust your scan size according to your requirements. If you don’t see the scan size you wanted to scan, please put your own values in there.
- Work properly with scan speed. Slower is always the better. For larger scans such as more than 10 micron, use scan speed of 167 µs and for over 20 micron, use 333 µs. For smaller scan size (say less than 1-2 microns), you can use higher scan speed (100 or even 66µs).
- Filter should be set at 1 KHz and
- Loop gain should be in between 4 and 8
- Select topography, phase or amplitude according to your choice and application
- Reference voltage should be 70-80% of the actual free space amplitude. For example, if the free space amplitude is 4, then ref. should be around 3.
- Keep track of the signs.
- You can easily adjust the reference set point while you are scanning. If you increase the reference amplitude (towards positive side), you are tapping much harder.

**Scanning and Data Acquisition**

- Click on retract knob and then approach.
- If your tip-sample distance is very large, it will take lot of time to approach.
- Try to bring the sample in close proximity to the cantilever.
- Hit the scan button and you will start getting images. Left image is topography and right scan is either amplitude/phase.
- Hit the grab button to save your image on the temp folder on the desktop.
- All the images that you grab will be saved in temporary folder.
- .When you are done with specific region of the sample and want to scan at another location, retract the cantilever and hit the start button which moves the Z stage out (make sure that out should be checked). Move about 100 micron and then stop.
- Use the coarse knobs on the AFM head and move the sample to another location and just repeat the scan. Like, hit retract off, click on Approach and repeat scan.
- You can change your scan size while you are scanning.
- If you want to change your sample, then bring down the stage using the thumb wheel located on the bottom of AFM head and bring it all the way down. Carefully move the sample without touching the cantilever.
- Put new sample and bring the sample in close proximity in same way when you started. In this way, you need not to tune the cantilever and etc. It saves time.

**NOTE:** Images are saved in shortcut to Temp folder on the desktop when you captured these images. They will be there temporarily and please, move in to your own folder under USER directory.

**Image Processing**

Click on the WinSPM processing software to process your images.
- I generally use the process→substrate background→ line averaging. This will make a flat background and image will look uniform and flat.
- Use LUT→brightness/contrast adjustment.
- Play with software and save your image in TIF format by creating your folder in user directly on the desktop.
- The processing software is user friendly and users are encouraged to learn it on their own. Please contact the manager if there is any problem with it.
**Shut Down Process**

- When you are done with your experiments, hit the retract off and use thumb wheel to bring the sample all the way down.
- Take out the cantilever holder and sample.
- Remove the cantilever and put the holder in its proper place.
- Switch off the CCD light, VOM switch and the controller as you did in the beginning.
- Close the image and processing software.
- Switch off the optical fiber light.

**Suggestive Notes**

**Looking For Imaging Problems**

- When looking at the topography scan, one can determine if the image is real or if it has tip or scanning artifacts. If the image has high frequency noise (seen as small repeating squiggly lines), the integral gain is most likely too high. Generally, for very flat surface, it is necessary to decrease the integral gain dramatically (usually to 0.5 Hz under Filter/Loop gain). Keep loop gain around 4.
- If there are dark Vertical lines (usually after larger peaks on the surface), it is possible that the tip is tapping too hard. Increase the reference amplitude until the lines decrease.
- Tip Artifacts. If there are objects in the image that all look the same (have the same shape but different sizes such as triangles or parallelograms), then the AFM may be imaging the tip instead of the surface. If this is the case, stop the scan by pressing on the icon with the red arrow to disengage the tip. It is necessary to change tips and re-image the surface.