Asylum research MFP-3D AFM troubleshooting guide.

Solutions labelled with an asterix*may require advanced and experienced AFM knowledge.

If problems are occurring with an advanced mode, a complicated set-up, or a difficult sample, it is often a good practise to go back to the basics and tapping mode topography scan a calibration grid to see if problems remain. This will check if the problem is a part of the overall system, or if there is some problem with the specific analysis you are attempting.

Topography scanning

- Computer and controller not connecting (this will be shown in the bottom left hand toolbar)

- Is the controller box turned on? The key should be turned a quarter turn to the right, with the key at the horizontal position.

- Check the connected cables; remove and re-plug.

- Check the controller box fuses. These are at the rear of the controller box; you will need a screwdriver to turn the plastic plugs. Fuse number 2 is usually responsible for computer-controller interaction.*

- Click on the rescan icon. This is on the MFP-3D bottom toolbar, click to rescan the controller bus.

If none of this works, there may be a software problem or a cable fault. (Consult the lab manager and the general lab coordinator to test the cables)

- Cannot find the cantilever in camera window

- Check that camera light box is on and the black intensity setting box is not set too low or too high. Also check the camera focus. This vertical wheel is at the back of the AFM head unit just in front of the black camera movement knobs.

- Check that the MFP-3D camera box window is present and visible. This can be opened by clicking the camera icon on the bottom toolbar of the MFP-3D software. The options menu on the software's camera window should be on the upper composite selection. The screen should be grey/white with static on it or similar. If it is green or black, try selecting another option.

- Check that the AFM controller and photodiode laser are on.

- When the head unit sitting on the x-y scanner, is there the bright camera light visible underneath, if not the camera mirrors may have been moved to an extreme angle. This is visible at the rear of the cantilever head. The circular mirror should have a 45 angle to it. If

the mirror has been moved and there is still no light on the sample with the AFM head unit in place, the camera globe may have blown. It will need to be replaced.

- Move the x and y axis wheels on the head unit from one end to the other, counting the turns. Move one axis at a time. Before moving the other axis, return the just moved axis back to the original position, that is, back the same amount of turns.

- The focal aperture may be closed. This is the wheel in the front of the x-y scanner base. It only turns a small amount. Sometimes it can be bumped or brushed. Turn to see if camera window appears brighter. If not turn back to original position.

- If there is no light emitting from the white light box, the globe may be blown. This requires a specific globe. Replace globe*.

- <u>No cantilever in camera window, even though the end of the cantilever chip is visible (the chip is the big part of the cantilever that is easily visible outside of the cantilever holder)</u>

- This most likely means that the cantilever is broken. Switch off controller box, remove cantilever holder, put into black holder mount and replace cantilever. It is also worthwhile to check that there may be particles or debre under spring clip that may be tilting the cantilever. Turn off controller, remove cantilever holder. Remove cantilever, re-screw in middle screw (so it does not fall out), unscrew the spring clip (be careful not to drop/lose the screws) and wipe underneath using a Kim wipe and Isopropyl alcohol (or Ethanol).

- Try refocusing the camera; this is done with the wheel at the rear of the head unit, just in front of the black camera movement knobs.

- Adjust the intensity on the black intensity light box. The light may be too high or low and is hiding the cantilever.

- Your sample may be very reflective and hiding the cantilever, there may be other camera problems as well. A quick solution is to find roughly the middle of the end of the chip (the big black region with the corners cut off-a trapezoidal shape) and position the laser light close to where the tip should be. Watch the sum and deflection meter. When moving the laser over where the cantilever should be, the sum should increase by a significant value. Ensure that the laser light does not move over the chip as this will increase the sum value. If the sum does not increase the tip is probably broken. Replace with new cantilever.

- <u>Low sum in sum and deflection meter</u>

- The cantilever may not be loaded properly. It may be too far in or out. The cantilever should look black in the camera and not white or transparent. Remove cantilever holder (switch off controller box first), reposition cantilever and re-install cantilever holder.

- There may be particles or debris under spring clip that may be tilting the cantilever. Turn off controller, remove cantilever holder. Remove cantilever, re-screw in middle screw (so it does not fall out), unscrew the spring clip (be careful not to drop/lose the screws) and wipe underneath using a Kim wipe and Isopropyl alcohol (or Ethanol).

- The cantilever may be bad, replace with another cantilever (do not throw out old cantilever, as the cantilever may not be the problem).

- You may be placing the reflection (and not the actual primary light) of the photodiode laser on the rear of the cantilever. The primary laser light should be initially close to the cantilever. Shifting the camera up in the y-axis, there is a secondary laser light and its reflection. These are usually not as focused and sharp as the primary, and will not provide a decent sum vale in the sum and deflection meter.

- If using a new type of cantilever, check that it is not too short or too long, or not suited for the specific cantilever holder. Replace with a standard Nanosensors PPP-NHCR Silicon cantilever as a standard. If the laser is still not able to be placed on the back of the cantilever, consult the Asylum Research forum.

- <u>Cannot shift laser light onto the rear of the cantilever</u>

- Ensure that you are looking at the primary laser light. This should be initially close to the cantilever. Shifting the camera up in the y-axis, there is a secondary laser light and its reflection. These are usually not as focused and sharp as the primary, and will not provide a decent sum vale in the sum and deflection meter.

- Turn off controller, remove the head unit and place upside down on the small raised platform. Check to see if the cantilever holder is in properly by removing and replacing. If you have any wires connected to the cantilever holder circuit chip, these may be blocking an electrical connection.

- The cantilever may not be appropriate for the cantilever holder and system set-up. Replace with a standard Nanosensors PPP-NHCR Silicon cantilever as a standard. If the laser is still not able to be placed on the back of the cantilever, consult the Asylum Research forum.

- Cannot zero deflection

- The PD (photodiode wheel for zeroing the deflection) wheel on the head unit may not be centred. Move the laser off the cantilever and re-centre the PD wheel (~25 turns), then move laser onto cantilever.

- Photodiode may not be completely on cantilever, it may be partially on the sample or on the chip. Reposition laser and retune (autotune). Ensure not too close to sample surface.

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- Your sample may be very reflective and the photodiode detector may not be able to distinguish the laser. If the laser is positioned on the back of the cantilever, lower the light box intensity, or switch off entirely, the attempt to zero deflection.

- Bad autotune or cannot autotune

- Damaged cantilever. Switch off controller and remove cantilever holder and replace cantilever. A brand new cantilever can be faulty, if you have a previously used cantilever that you know is OK, load this cantilever and perform a tune to test if it the cantilever or something else. Do not throw away suspected damaged cantilever, it may not be faulty, there may be another reason it does not tune. There may also be a particle/s attached to the cantilever such as atmospheric impurities. Perform 3-4 autotunes. If this does not help replace cantilever.

- If too close to surface or cantilever is contacting something (such as the sample surface). Raise the AFM head (large wheel on front of head unit-turn clockwise looking down to raise up) or re-check cantilever and cantilever holder is clear of objects.

- Cantilever is not in the cantilever holder spring clip properly or the spring clip screw is not tight enough. Switch off controller, remove cantilever holder, check the position of the cantilever and the screw tightness.

- Debris under cantilever holder spring clip. Turn off controller, remove cantilever holder, remove spring clip and clean underneath with Kim wipe and isopropanol alcohol.

- Laser not on rear of cantilever properly. Reposition cantilever. The highest sum value is not always an indication that the laser is directly on the cantilever. Ensure laser is closer to the tip (the free end) of the cantilever than the base near the chip.

- The sample surface is too reflective. Lower camera light intensity. If this does not work, position the laser light on the back of the cantilever, then switch off the camera light before clicking autotune.

- Too stiff or flexible cantilever for the system or settings. The tuning settings can be altered or a thermal tune can be performed. If unsure how to do this ask your supervisor or the lab manager. Replace with a standard Nanosensors PPP-NHCR Silicon cantilever as a standard and perform a test autotune. If you have a previously used and reliable cantilever, perform a test autotune with this.

- Cantilever too long or short. Use another type of cantilever.

- <u>Z-voltage raises (lowers) when raising drive amplitude</u>

- This will occur to an extent until the tip begins contacting the surface. If the z-voltage rails, the tip was too far from the surface. Disengage the cantilever oscillation on the sum and deflection meter, raise the cantilever head, re-engage and lower onto surface.

- Set drive amplitude to a higher value in Master panel before engaging in sum and deflection meter.

- There may be a very rough or odd surface topography. Disengage cantilever, lift head and move x-y table to place tip at another position on the sample surface.

- There may be something attached to the cantilever. Disengage, lift above surface and engage again. If this does not work try another cantilever.

- There may be static charge on your sample surface. Ground sample to silver bowtie on x-y scanner (silver part).

- Surface may be very reflective and the photodiode detector is drifting values. Turn off the camera and light box.

- Ensure there are no exposed electromagnetic fields too close or under the sample, these can be causing the cantilever to drift. If magnets are holding the sample down, ensure they are not too close to the cantilever or sample. If using a magnetic cantilever (or a cantilever consisting of a magnetic material) it can be attracted to surrounding magnets or the sample. If this is occurring you will need to reposition and rethink set-up, including the type of cantilever you are using.

If all else fails, switch topography mode from AC mode to contact mode.

- Noisy or non-settling scan tracking

- There may be something attached to the cantilever. Stop scan, disengage, lift above surface and engage again. If this does not work, replace the cantilever.

- The drive amplitude or set point may be too high or low. Adjust. These settings can vary for sample-tip dynamics. Most hard surfaces will have a setpoint at 720-790 mV. Also try adjusting the integral gain between the ranges of 3-20.

- Tip may be damaged. Stop scan, turn off controller, remove cantilever holder, replace cantilever. Do not throw out cantilever it may still be OK.

- Surface may be very rough. Slow scan speed or switch to contact mode.

- There may be lose particulates or a surface with large variances in elastic consistency. Slow scan speed, adjust drive amplitude. Try a stiffer cantilever type or move to another region on the sample surface.

- There may be static build up on surface. Ground sample temporarily or use anti-static brush on surface.

- 'Bent' scan image

- This is usually due to thermal drift. It is due to thermal effect of the laser on the back of the cantilever and the camera light on the sample. This causes expansion and distortions of the materials over time. Initial scan bending will minimise or disappear over a few scan passes.

- Ensure there are no reasonable magnetic or electric fields that may be influencing measurement electronics or the cantilever.

  If all else fails perform a noise test to test the x and y piezos.*

- Scan anomalies

- The tip geometry can be a factor in image resolution and scan anomalies depending on surface roughness, etc. Try a different cantilever brand/construction.

- There may be static build up on surface. Ground sample temporarily or use anti-static brush on surface.

- There may be something attached to the cantilever. Stop scan, disengage, lift above surface and engage again. If this does not work try another cantilever.

- Tip may be damaged or blunt. Stop scan, turn off controller, remove cantilever holder, replace cantilever. Do not throw out cantilever, it may still be OK.

- Surface may be very rough. Slow scan speed or switch to contact mode.

- There may be loose particulates or a surface with large variances in elastic consistency. Slow scan speed, adjust drive amplitude. Try a stiffer cantilever type or move to another region on the sample surface.

- There can be electrical noise. Remove all external connections that are unnecessary. Ensure there are no magnets or magnetic fields close to cantilever.

- Ensure sample is not moving, this can be seen by careful observation in the camera window while scanning. The tip and sample will be moving as one.

If all else fails perform a noise test, there may be a faulty piezo, additional noise or feedback noise.*

- Scans not saving

- Unclick save scan box near the bottom of the Master panel, then re-click box and browse to your folder. Select your folder or create a new one.

- Make sure that the selected folder is correct.

- If saving a partial scan, click save partial, near the bottom of the Master panel. Then save scan again. When the pop-up appears with the correct folder directory, click that's it.

If all this fails, it may be a software fault. Try restarting MFP-3D.

SKPFM

- Potential scan not scanning/tracking properly

- Nap Channel panel: Check ‘capture What’ and ‘Save image’ is set to ‘Retrace’.
- Check Master Channel panel scan tabs are all set to ‘Trace’, not ‘Retrace’.
- Electric tune panel: Drive amplitude “Normal’ and ‘Parm Swap’ values are the same. Set them the same by clicking the arrow in-between the two drive amplitudes.
- Are you using a conductive cantilever? These include Nanosensors doped Silicon and metal coated cantilevers. If using Cr/Co coated cantilevers, magnetic coupling may occur.
- Is the delta height value large enough to ensure non-contact of surface but not too high to not measure the surface properly. Minimum delta height with reasonable scan value settings is 50 nm and maximum at 200 nm.
- SKPFM can scan insulating samples, but it can be difficult to due to surface static build up and capacitance problems. Grounding sample to the bow tie (silver part on x-y scanner; can assist some of these problems).

EFM

- No or bad Nap phase scan

- Nap panel: Ensure positive tip voltage and drive amplitude on Parm Swap side.
- Ensure delta height is between 50 nm and 200 nm. 50-100 nm is usually ideal.
- On mostly insulating samples, surface static build up can affect the cantilever, ground sample to bow tie (silvery part of x-y scan table).

MFM

- No or bad Nap phase scan

- Ensure you are using a MFM cantilever. Common MFM cantilevers are Cr/Co coated cantilevers. These cantilevers require magnetising before use by holding a strong magnet around 5 mm from the cantilever for 10-15 seconds.

- Nap Panel: Ensure tip voltage on the Parm Swap side should be zero.

- If your sample has no magnetic features, there will be no features present. Therefore this mode is not designed for your sample.

- On mostly insulating samples, surface static build up can affect the cantilever, ground sample to bow tie (silvery part of x-y scan table).

- Ensure there are no other magnets close to the sample or cantilever. Using the Black anodised sample holder or probe station is OK.

- Ensure delta height is between 50 nm and 200 nm. 50-100 nm is usually ideal.

CAFM

- Need to use the ORCA cantilever holder and a conductive cantilever such as the Nanosensors doped Silicon cantilever. Use the ORCA sample holder. The pogo out connection needs to be connected.

- Nap Panel: Tip voltage needs a positive value on the Parm Swap side (in volts, using not mV)

- Mode in Masters Panel should be in Contact mode NOT AC mode.

- This mode will not work on insulating samples. If sample is partly insulating there may be static build up.