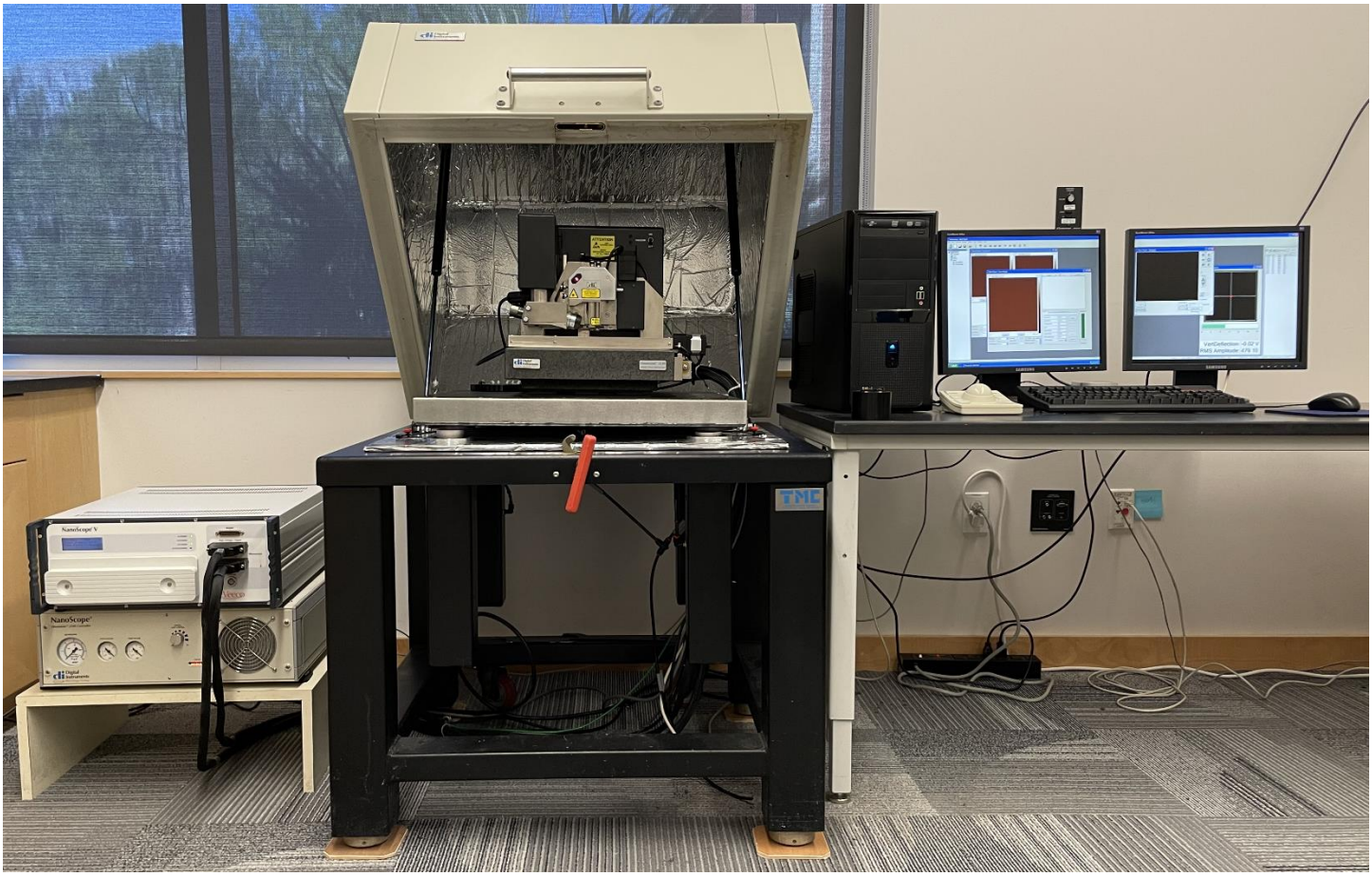
Dimension 3100 AFM SOP

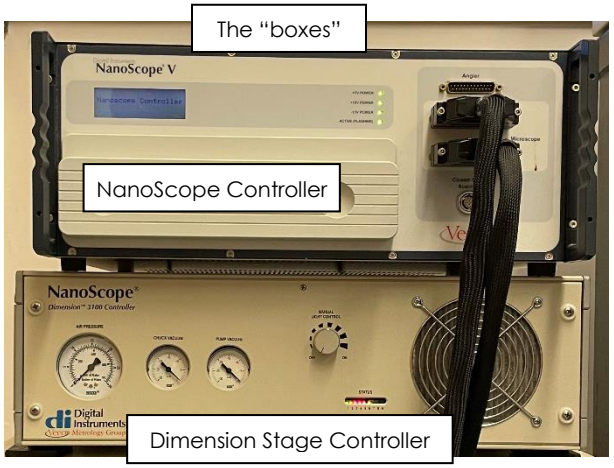
RSC Standard Operating Procedure (SOP)

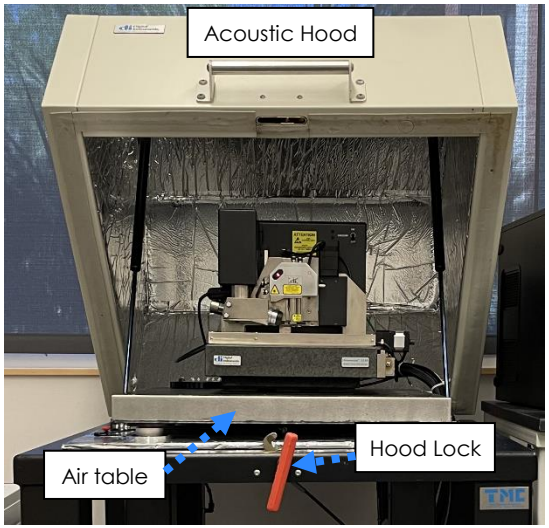


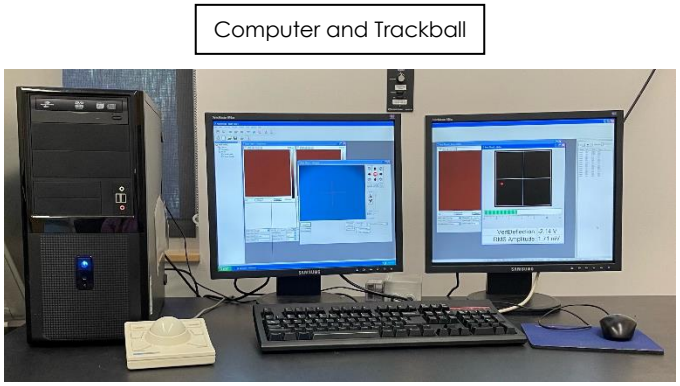
Details:	Dimension 3100 AFM with Nanoscope V Controller Nanoscope Software Version 7.3 NanoScope Analysis Version 2.0		
Location:	NRF 283	**Room Phone:**	352-273-0016
Contact:	Alison Trachet aat425@ufl.edu	Kristy Schepker kschepker@ufl.edu	
RSC Equipment Page	https://rsc.aux.eng.ufl.edu/ccb/resource.asp?id=23		

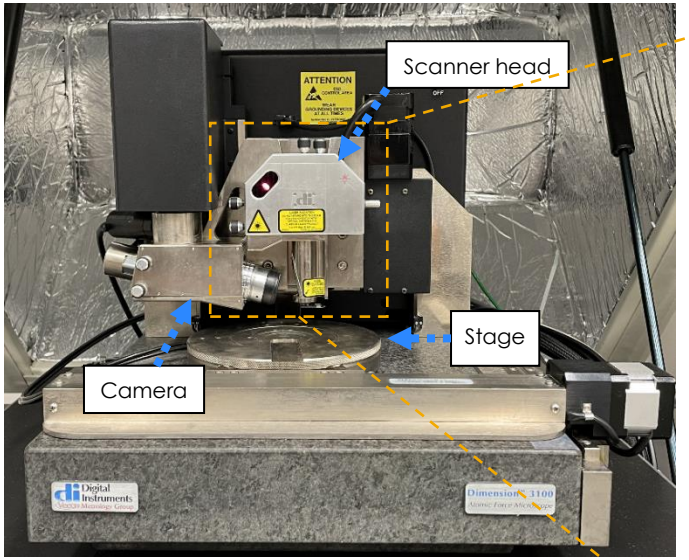
1. Equipment Overview

1.1 HARDWARE









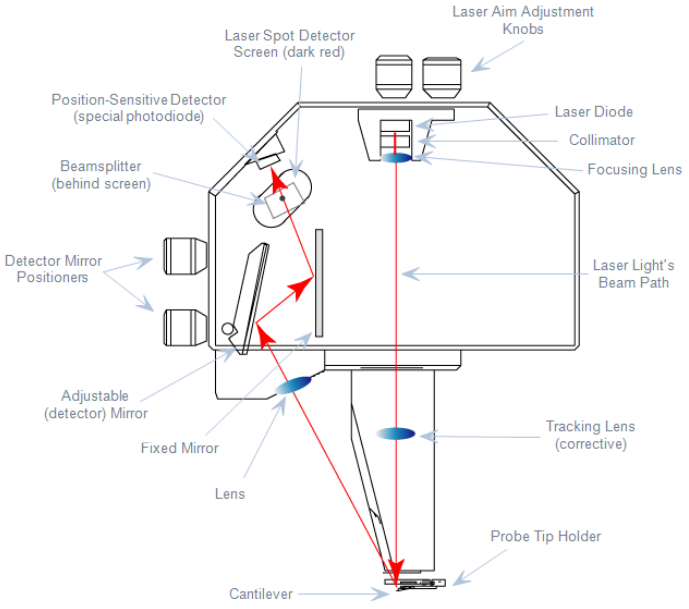
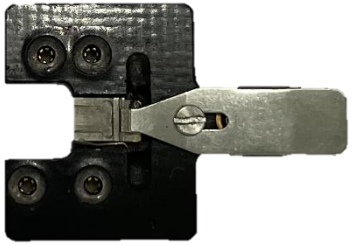


Image from [1]

1.2 PROBE TIP HOLDER AND AFM TIPS

"Probe holder", "cantilever holder", "tip holder"



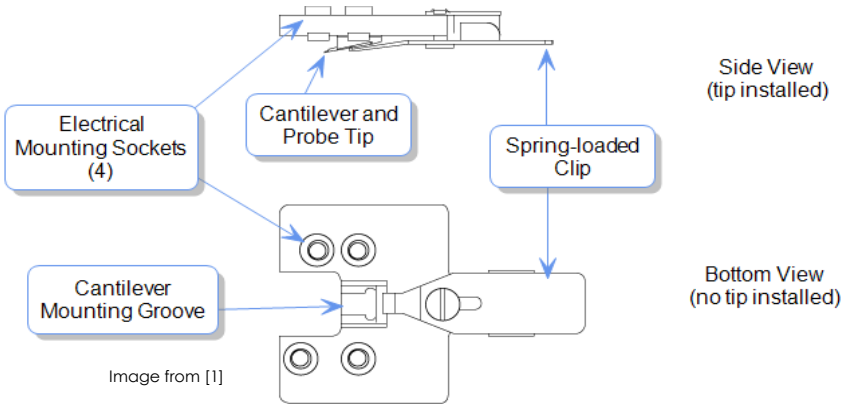


Image from [1]

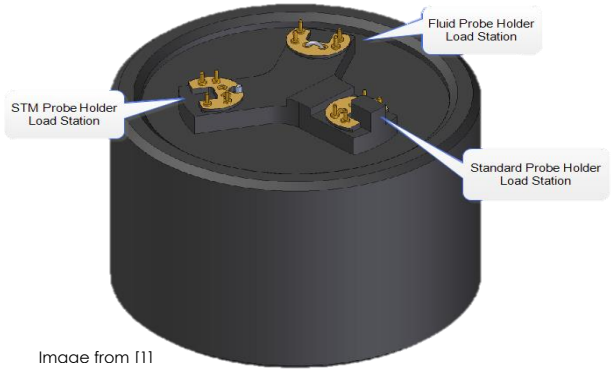
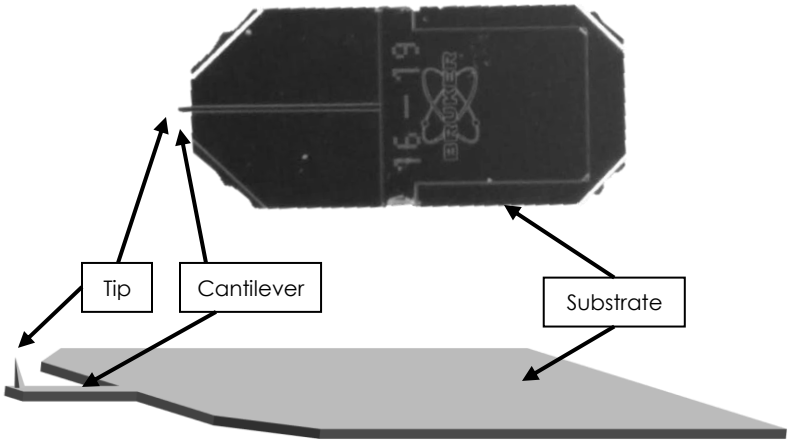
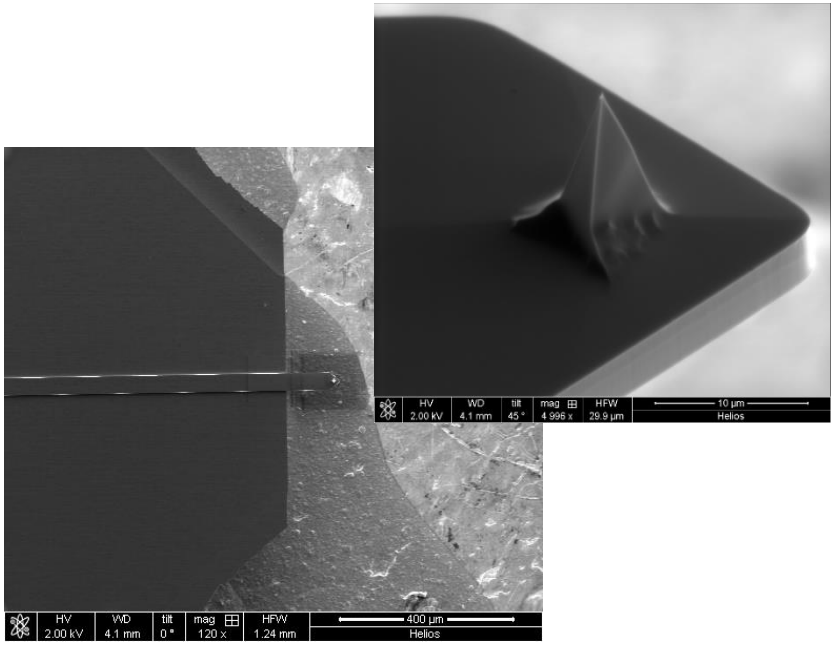


Image from [1]

"AFM probe" or "tip" or "cantilever"





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1.3 CAPABILITIES OF EQUIPMENT

Z goes from 0 to -15253.3 um- total range about 15 mm.

Stage has approximately 200 mm range in x direction and 100 mm in y direction. Origin is set to halfway between these two extremes (not at the center of the stage).

Maximum scan size is 110 um and minimum is ~1 nm.

Scanner head z-range	~ 15 mm
Stage X-direction range	~200 mm
Stage Y-direction range	~100 mm
Maximum scan size	110 um (under 50 um is usual)
Minimum scan size	~1 nm

"The minimum possible value for the Aspect Ratio is 1, meaning the fast axis is always equal to or longer than the slow axis" [1].

2. Safety & Prerequisites for Equipment Use

2.1 PERSONAL SAFETY

Do not look directly at the laser light.

Do not point the laser at anyone. (If the head is removed and turned 90°, the laser will shut off automatically.)

Wear static discharge device when loading aligning laser and putting on probe tip holder.

2.2 PROCESS & EQUIPMENT SAFETY

Do not drop the head while handling it.

Do not drive the head into the stage.

Be careful when putting the tip holder onto the scanner head. Do not bend the pins.

2.3 FACILITY SAFETY: N/A

2.4 PREREQUISITES FOR USE

User of the RSC facilities.

Up-to-date hazardous waste training.

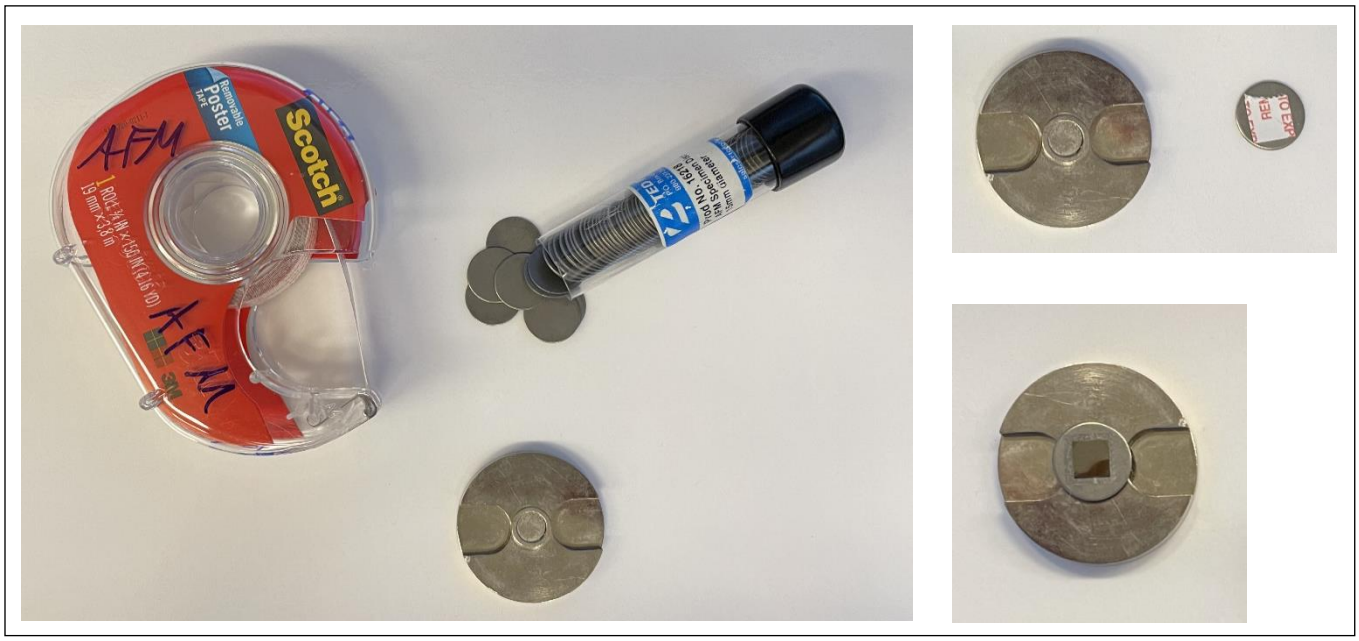
Training by staff.

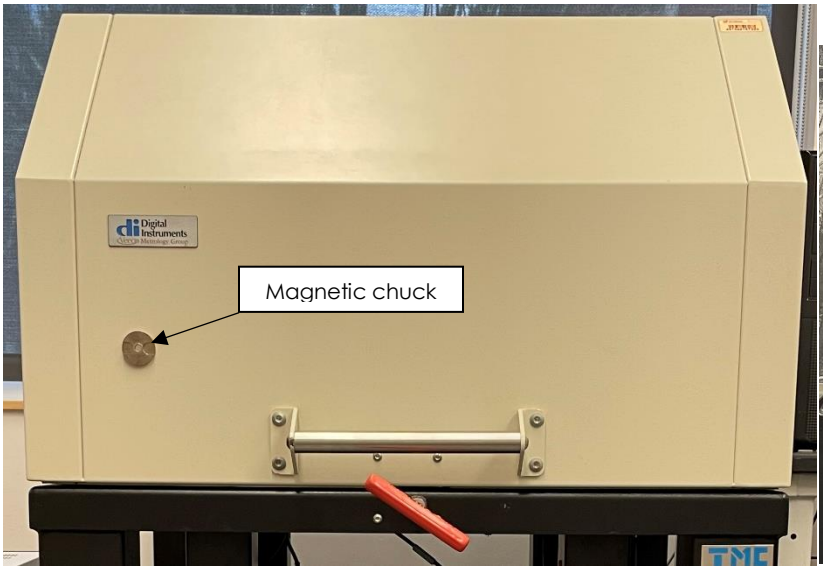
User will be responsible for lost or damaged equipment due to negligence. Negligence means not following the SOP, not asking staff for assistance, intentionally damaging items, etc.

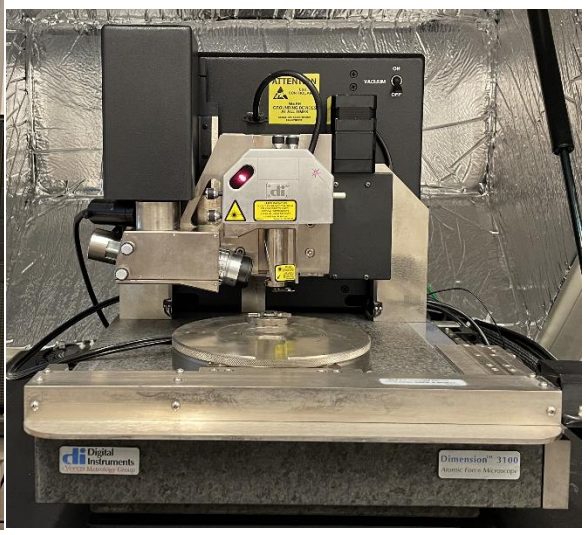
3. Sample Preparation

Use double-stick tape or super glue to adhere sample to magnetic disc. Superglue will be stiffer and a more permanent adhesive.

Put magnetic disc on top of magnetic chuck. The chuck should be stuck to the acoustic hood.







Place chuck on stage beneath scanner head. If you have a large or tall sample, you can place it directly on the stage. (However, if you have a thin wafer, you may need to raise it so that the z-range of the scanner head is sufficient). Use double-stick tape to adhere your sample to the stage if necessary (you don't want your sample moving during the scan).

4. Procedure

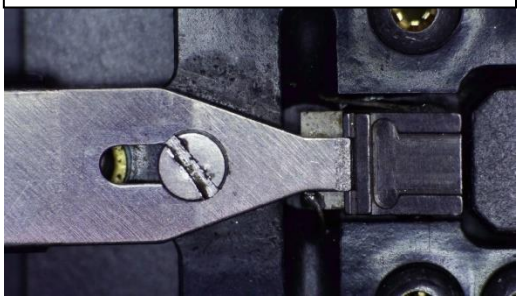
4.1 LOADING TIP

4.1.1 Putting tip in probe tip holder

Put the probe holder on the loading block if not already there. Pull back probe holder clamp if not already retracted.

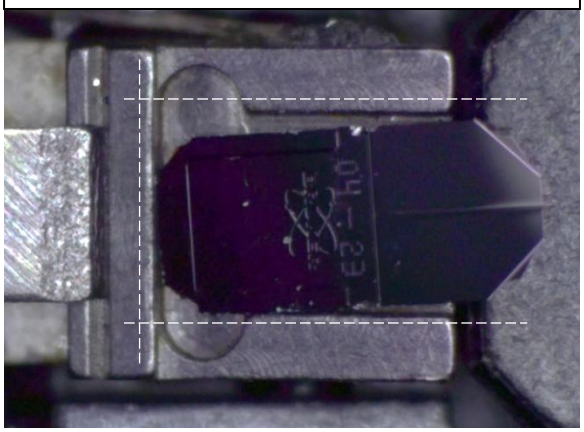
Probe holder on loading block.

Clamp retracted.

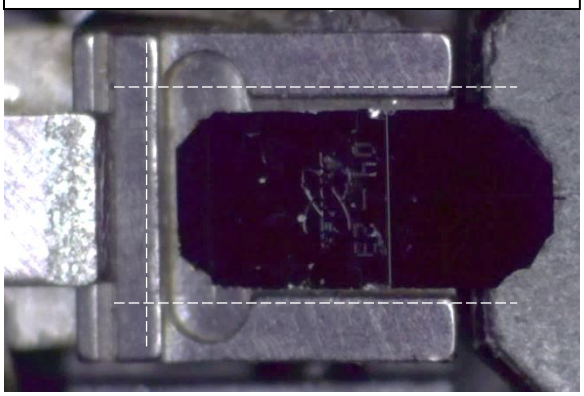


Place AFM probe in middle of slot and just a hair away from the back. Adjust probe with tweezers or micro needles until probe is relatively centered, straight, and slightly away from the back end of the slot.

Probe is crooked in slot. It is also butted up against the end of the channel. The probe cannot sit flat/flush against the bottom of the probe holder if it is too close to the back of the holder. The cantilever end of the probe will kick up.

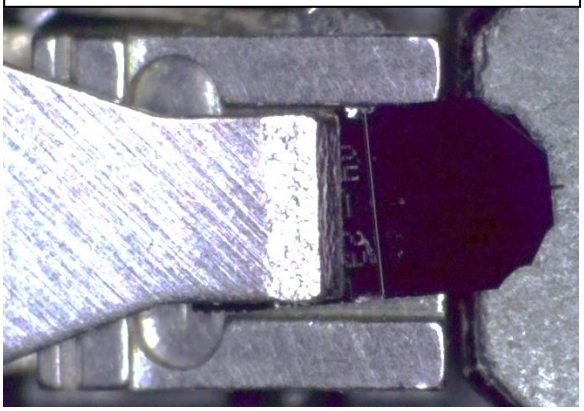


Probe is aligned in slot. It is also not butted up against end of slot.

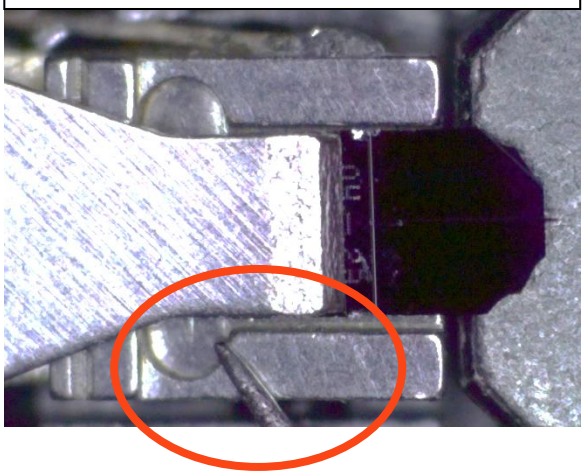


Clamp down probe.

The probe will likely move around when you clamp it.



Straighten the probe with fine micro needles.



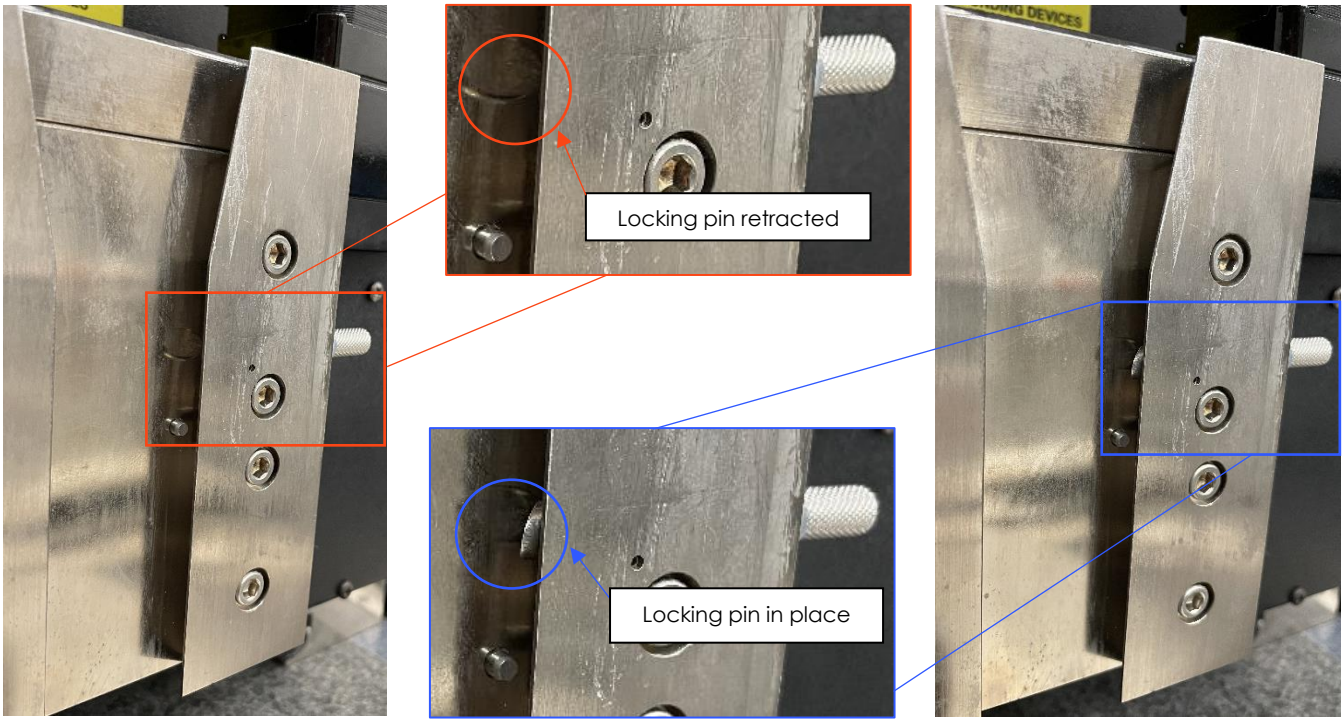
After adjusting probe, move entire loading block to scanner.

4.1.2 Putting probe tip holder on scanner head

Unlock the scanner head by turning the locking pin clockwise (opposite of what you expect).

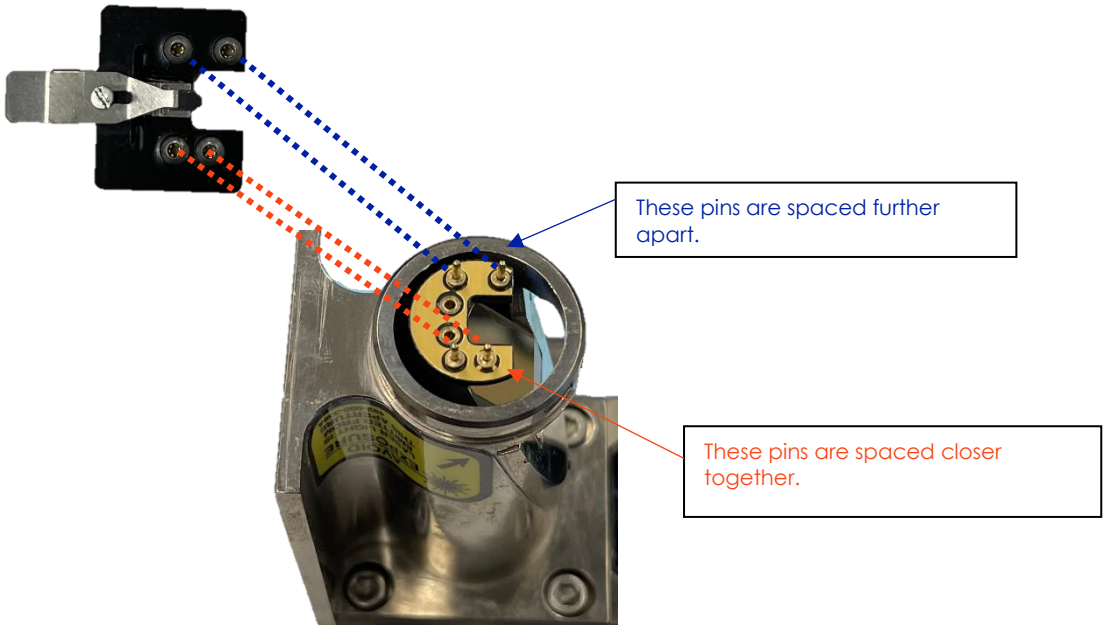
Turn knob clockwise to retract the locking pin.

Turn knob counterclockwise to insert the locking pin



Tilt the head slightly toward you and pull up the head.

Put probe holder on bottom of scanner head. There is only one way this will fit on the scanner head. Please be careful to not bend the pins.



Slide head back onto holder. Make sure head goes all the way to the bottom of the groove- sometimes the locking pin is not retracted the entire way and will prevent the head from going all the way down.

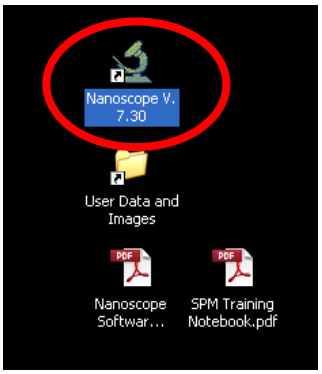
Locking pin retracted entirely. Scanner head sits in correct position.

Locking pin slightly inserted. Scanner head will not reach bottom of groove.

Lock pin by turning counterclockwise. Pull up gently on head to make sure it's locked in place. Turn on boxes (power strip on floor) and log into the TUMI system.

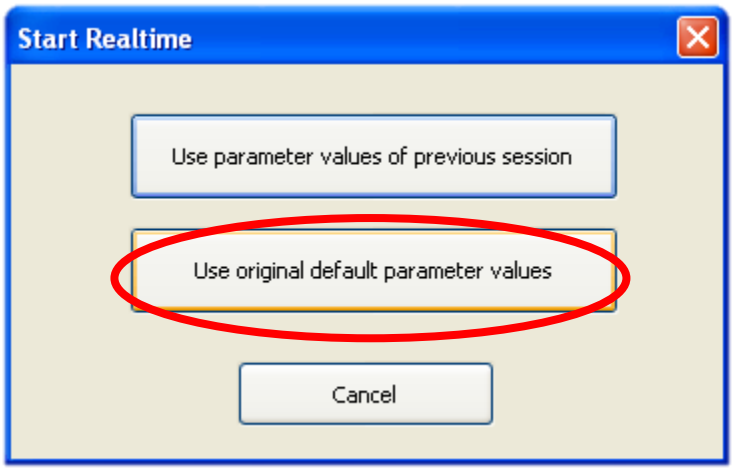
4.1.3 Setting up Real Time Workspace

Open NanoScope software (microscope icon on desktop).

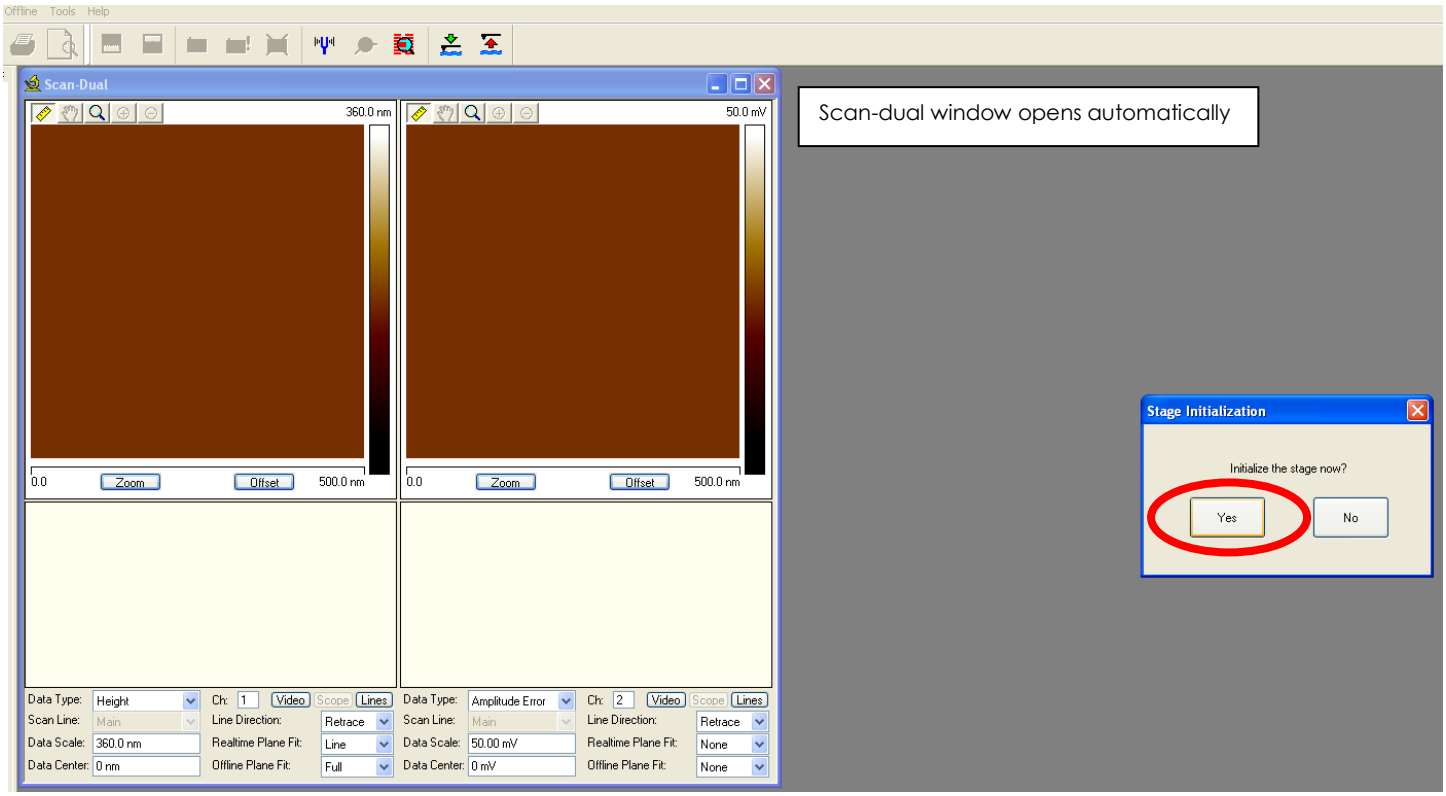


Once the software is open, click on the microscope icon (Real Time).

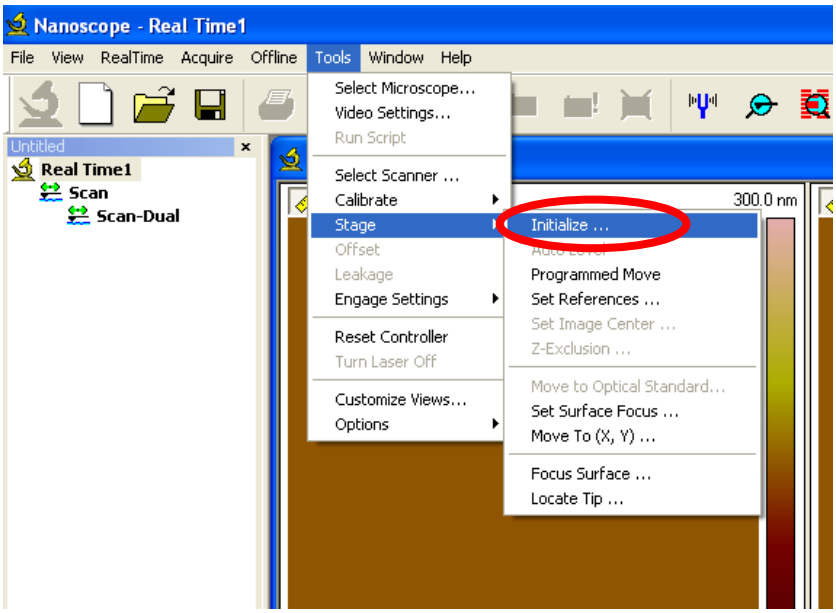
In the pop-up box, click "Use original default parameters." This resets any conditions from previous users.



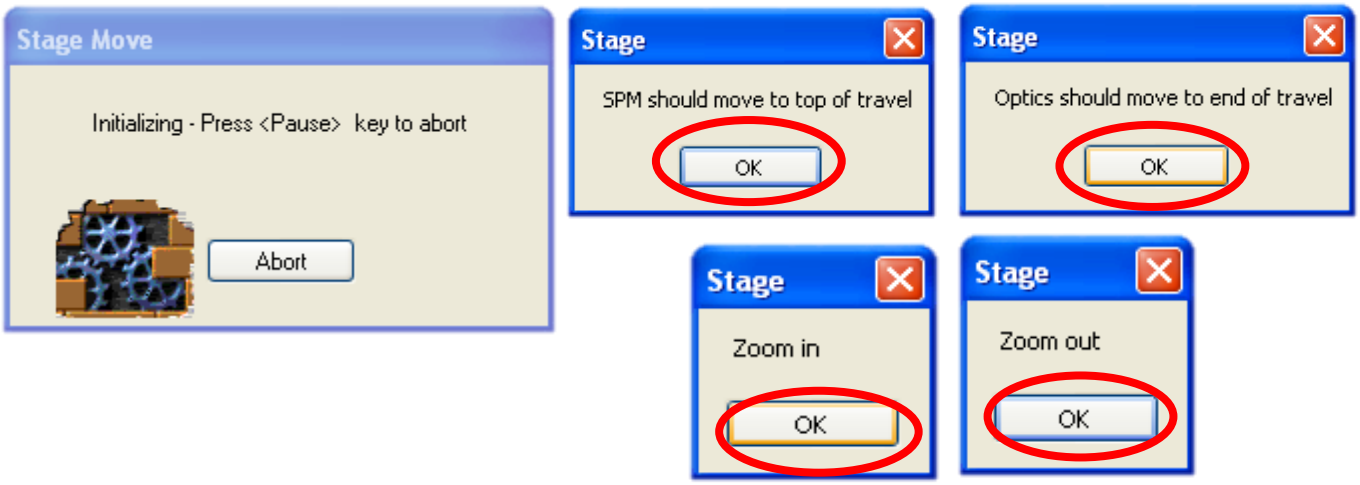
After Real Time opens, you will likely be prompted to initialize the stage. Click "yes" to home the stage.



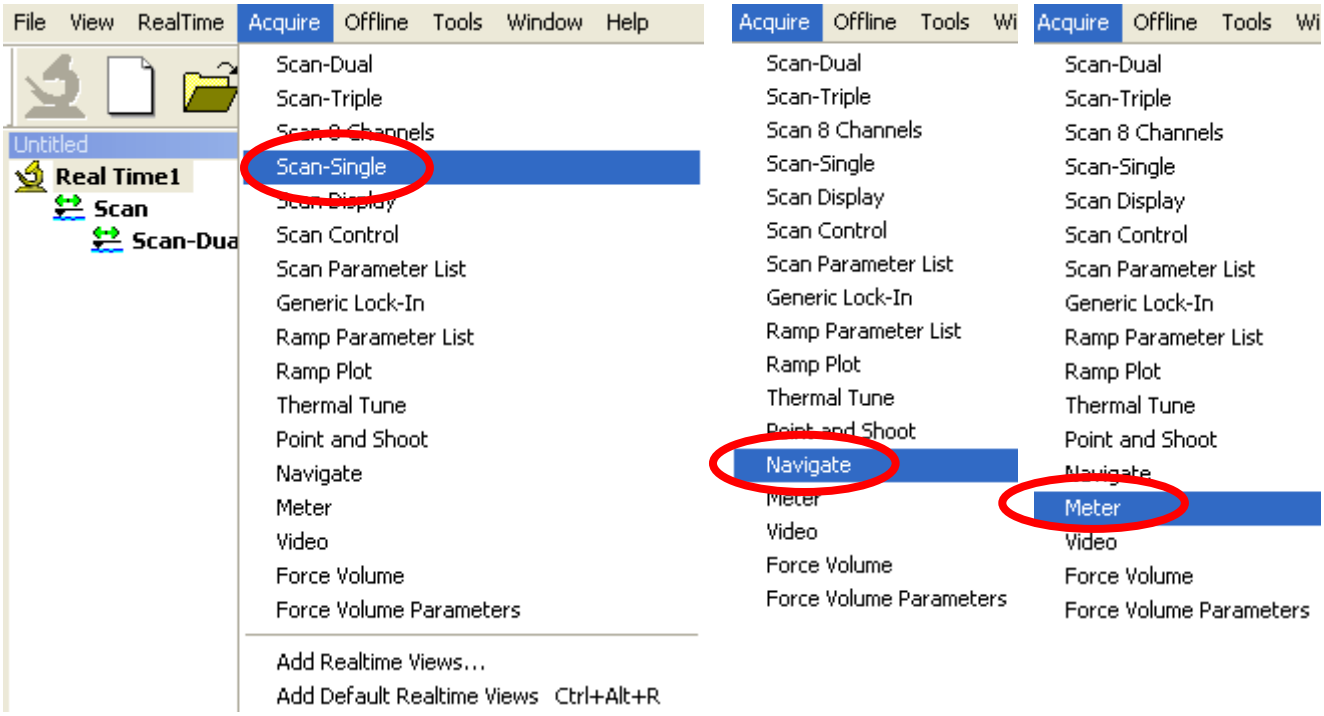
If you are not prompted, go to Tools→Stage→Initialize.



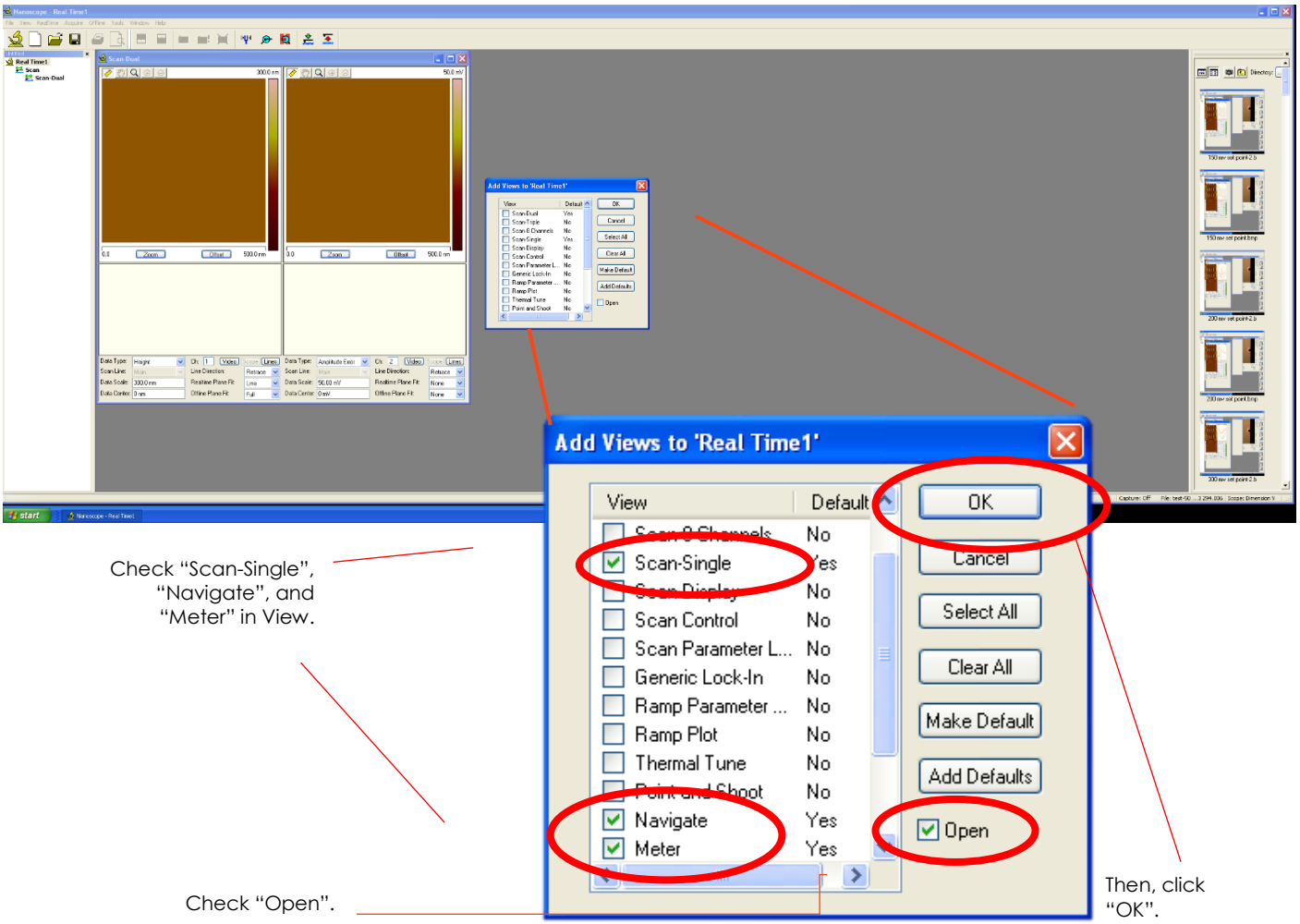
You will see a pop-up box that says “Stage Move”, and there will be multiple pop-up boxes as the stage homes itself. Keep clicking OK.

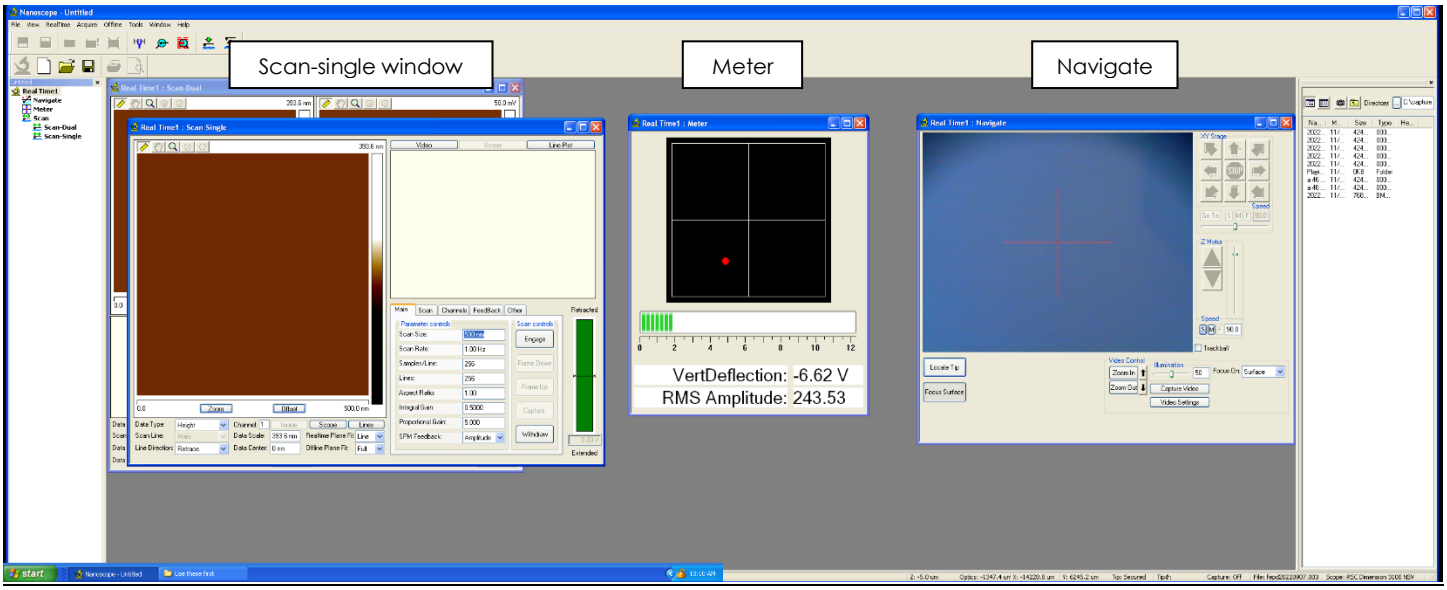


Next, open the “Scan Single”, “Navigate”, and “Meter” windows from the “Acquire” drop-down menu.



If this window pops up instead:

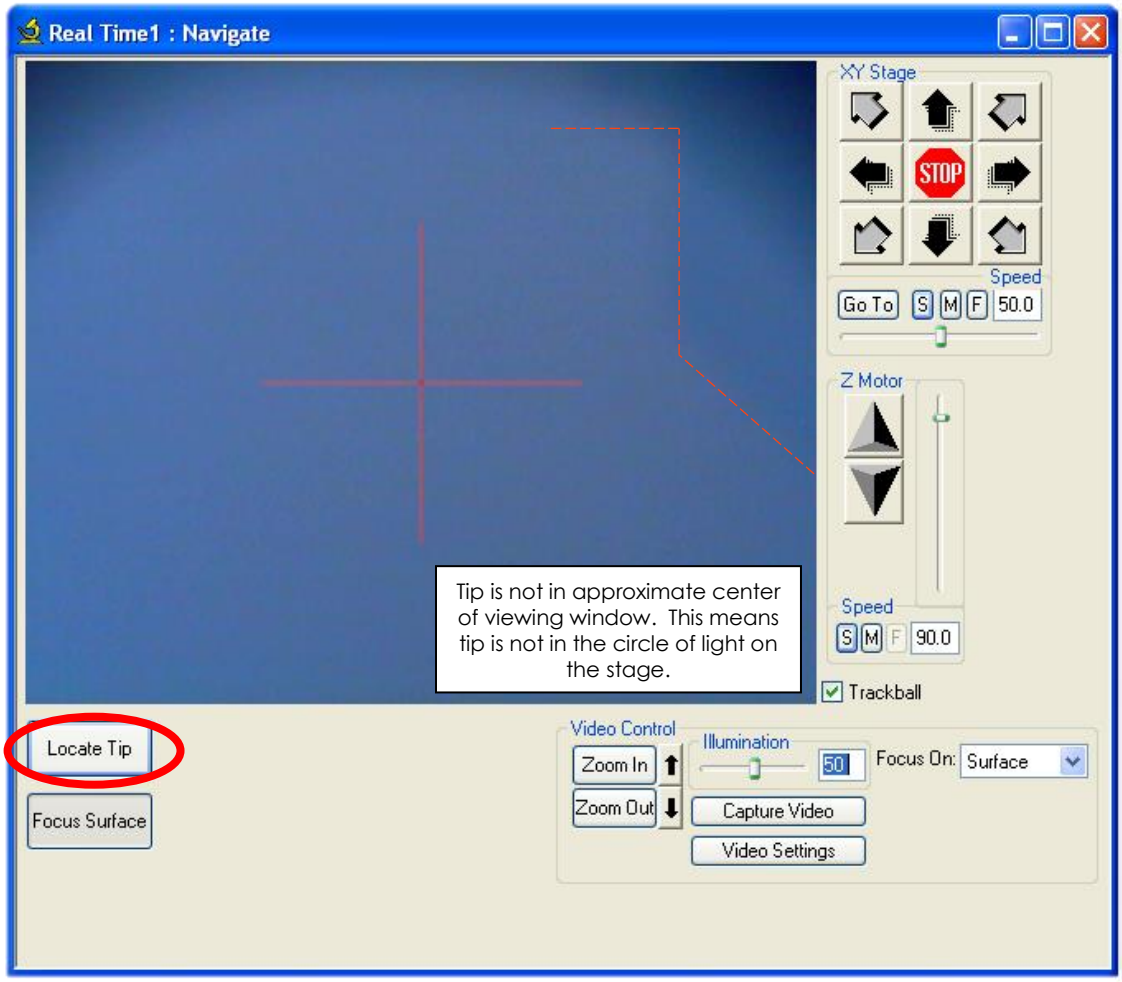




4.2 ALIGNMENTS

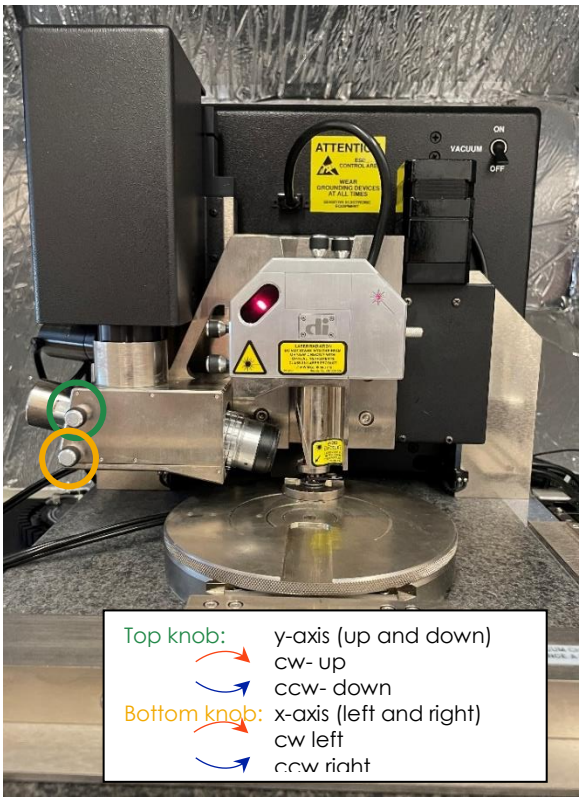
4.2.1 Align the laser

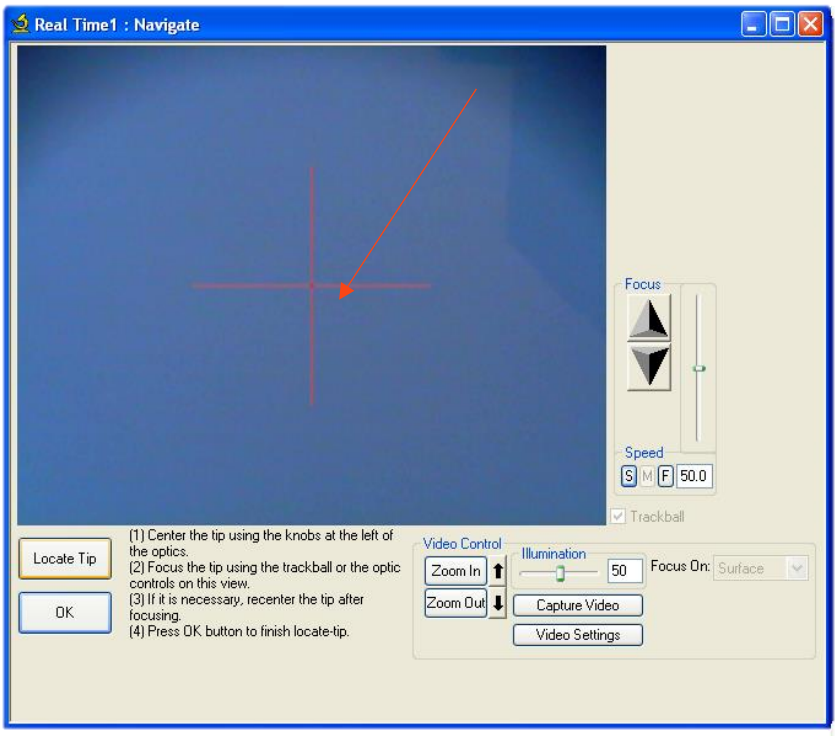
Make sure the tip is visible in the navigate window. Approximate tip location is outlined in orange dashes. Making sure the tip is centered in the window means that it is centered in the microscope light, making laser alignment much simpler and repeatable.



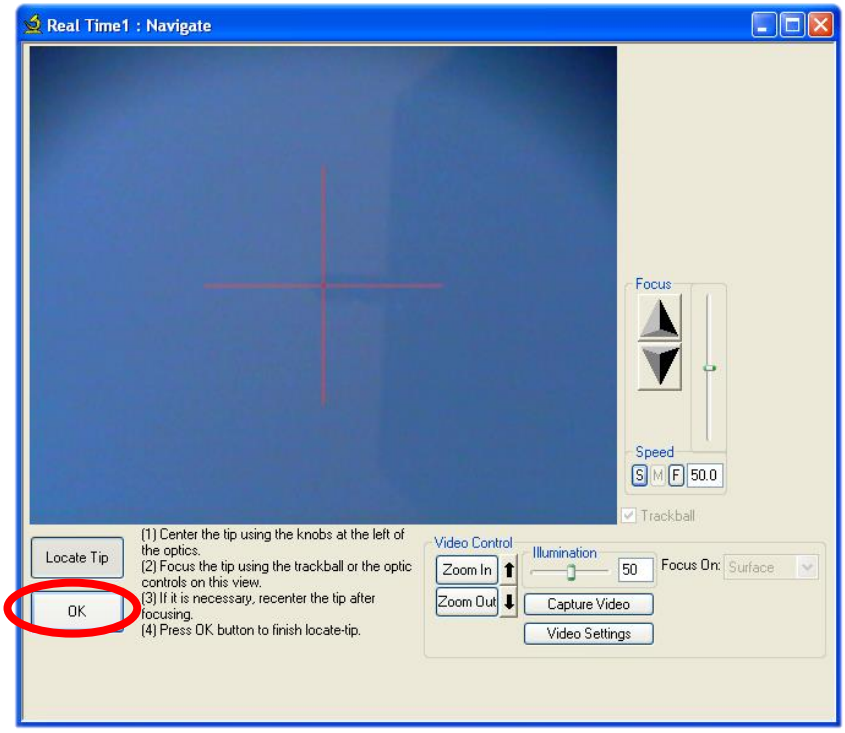
Click "locate tip". The tip will move around in the image. You can see that it is near the upper right corner of the navigate window.

Use the camera adjustment knobs to bring the cantilever into the middle of the screen.

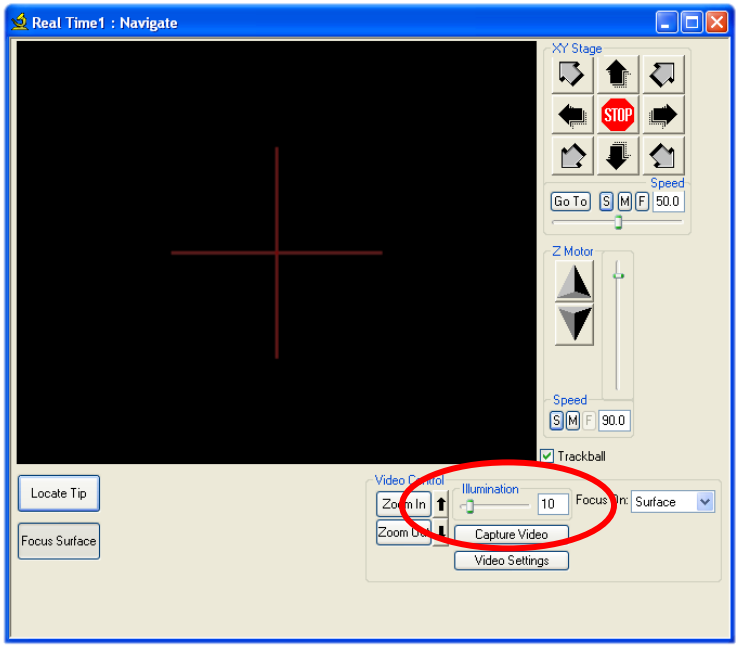




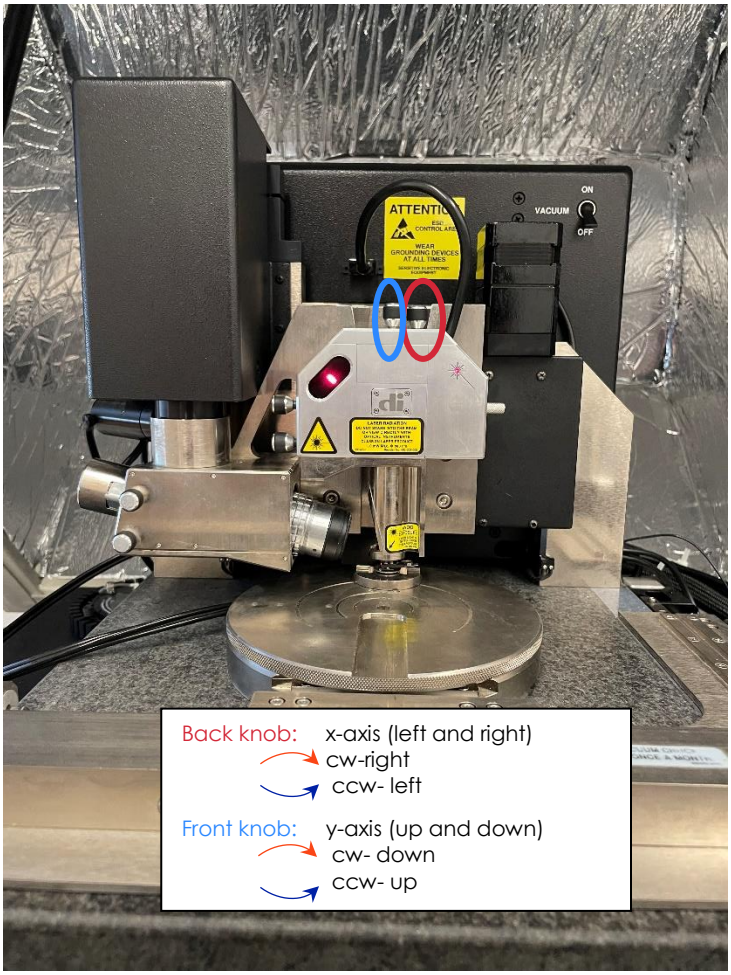
After moving the tip to the approximate center of the navigate window, click "Okay." This returns the navigate window to surface focus.



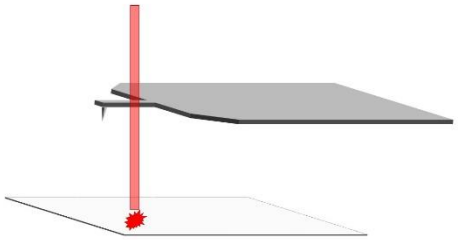
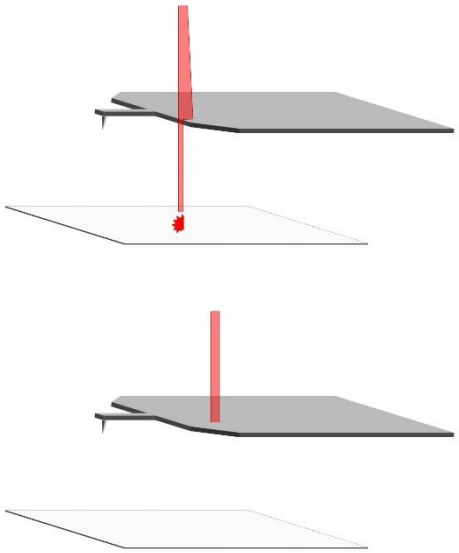
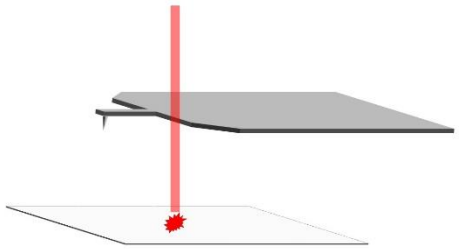
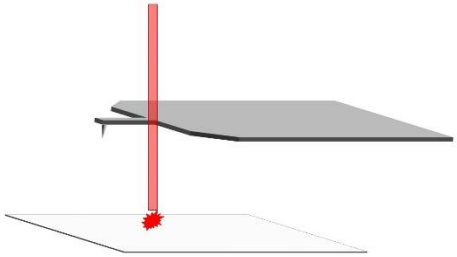
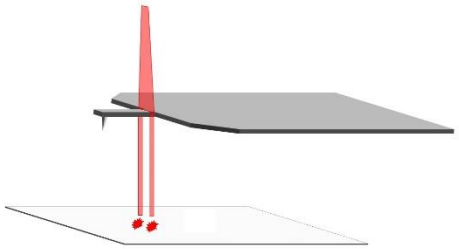
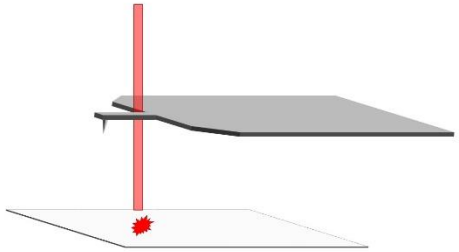
Place a white piece of paper under the laser. Make sure the laser is within the circle of light. You might want to turn off the room lights and dim the light intensity to better see the laser.

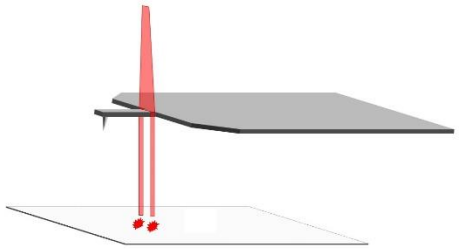
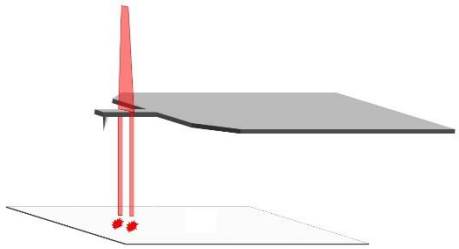
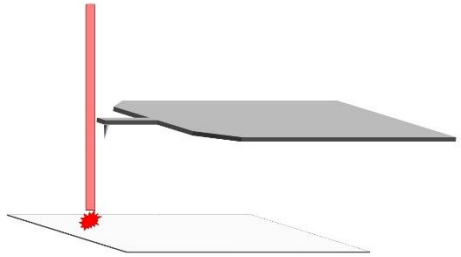


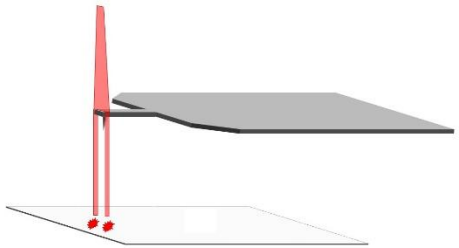
Use the knobs on top of the scanner head to adjust the laser position.


VACUUM
ON
OFF
Back knob: x-axis (left and right)
cw-right
ccw- left
Front knob: y-axis (up and down)
cw- down
ccw- up

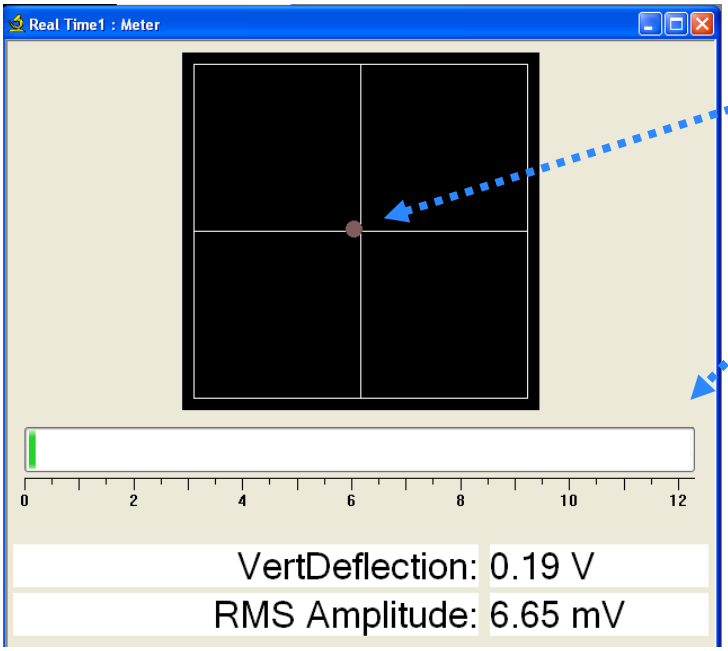
The following sketches show how the laser should look shining on a piece of paper.

Find the edge of the substrate by moving the laser to the right (x-direction). Ignore reflected laser lights.	Keep moving laser to the right until it disappears.	Back off laser (move slightly left) until it is visible again. You have just found the edge of the substrate.
		
Move laser up and down (y-direction) to find the cantilever.	When you see a "blip" in the laser (it's being blocked by the cantilever), you've found the cantilever. The laser might also be split in two.	If you go past the cantilever, you will see the entire laser again.
		

Move laser back down until you see the "blip" or split laser. You might also see a strong sum signal (this will depend on if the photodetector is already aligned).	Now move the laser from the base of the cantilever to the end.	Move the laser left until you see the whole laser again and/or the sum signal drops.
		

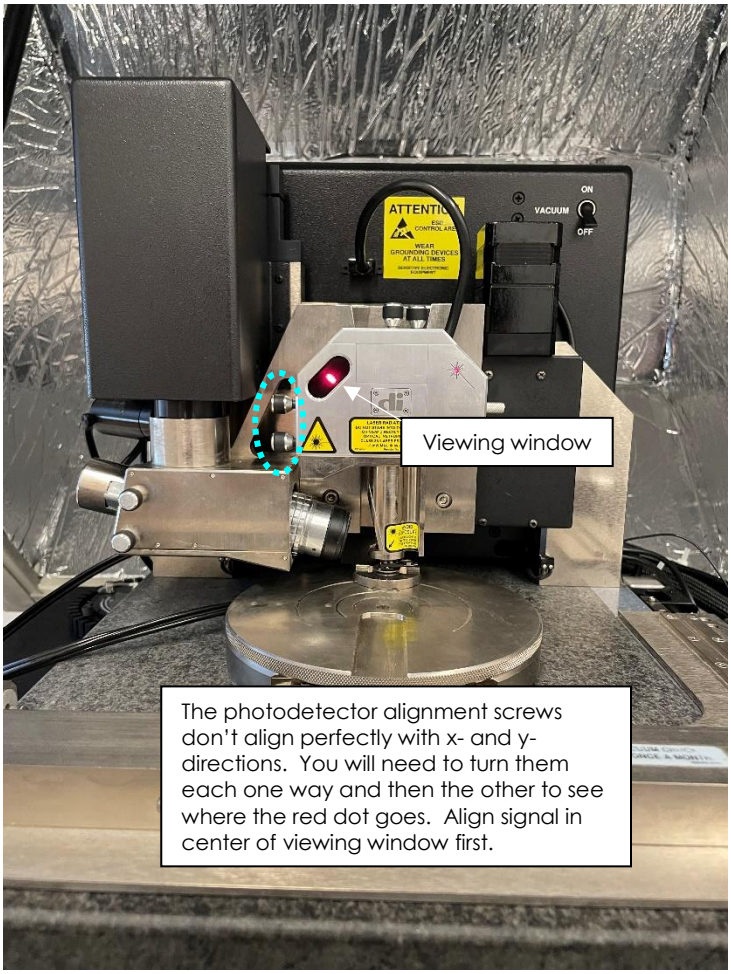
Move the laser back to the right until you see a maximum sum signal. The laser should now be on the back on the cantilever.


If the dot is gray, there is no signal on photodetector. The goal is to have the dot be red, in the center, and with a VertDeflection less than ±0.10 V.

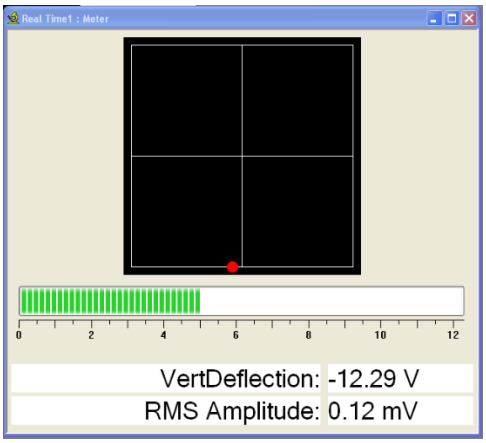


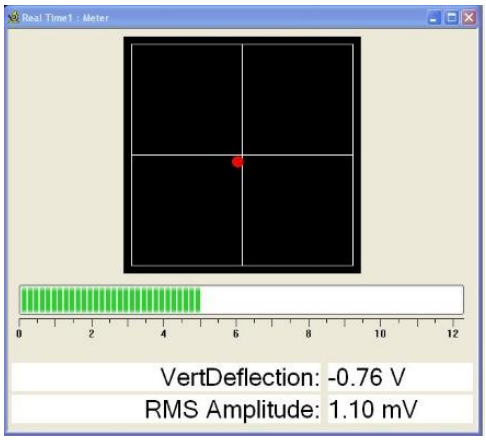
Photodetector signal. Dot is gray; stage is locked.

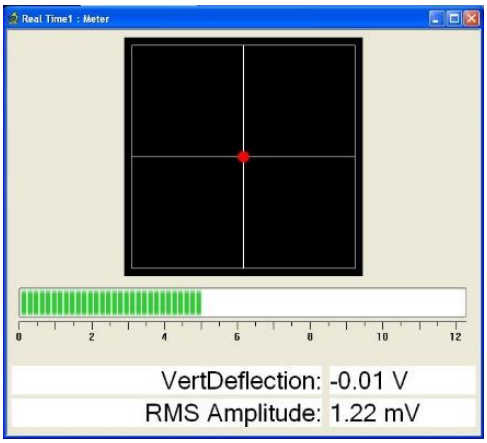
Sum signal (usually around 5 for Bruker TESPA-V2 AFM tips) is basically zero.



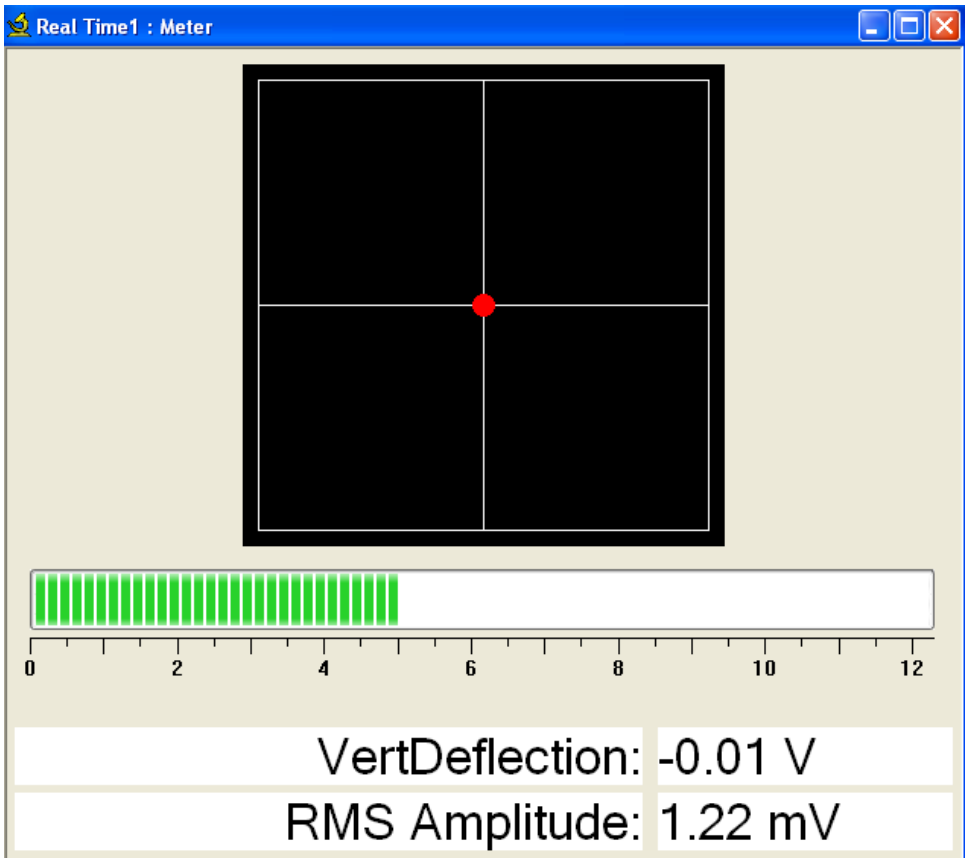
Getting red dot to center of photodetector split screen and decreasing VertDeflection to less than ±0.1 V.



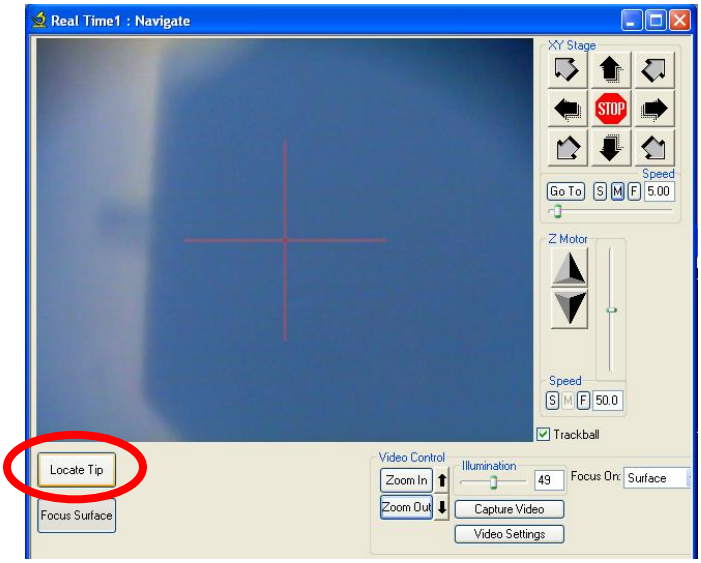




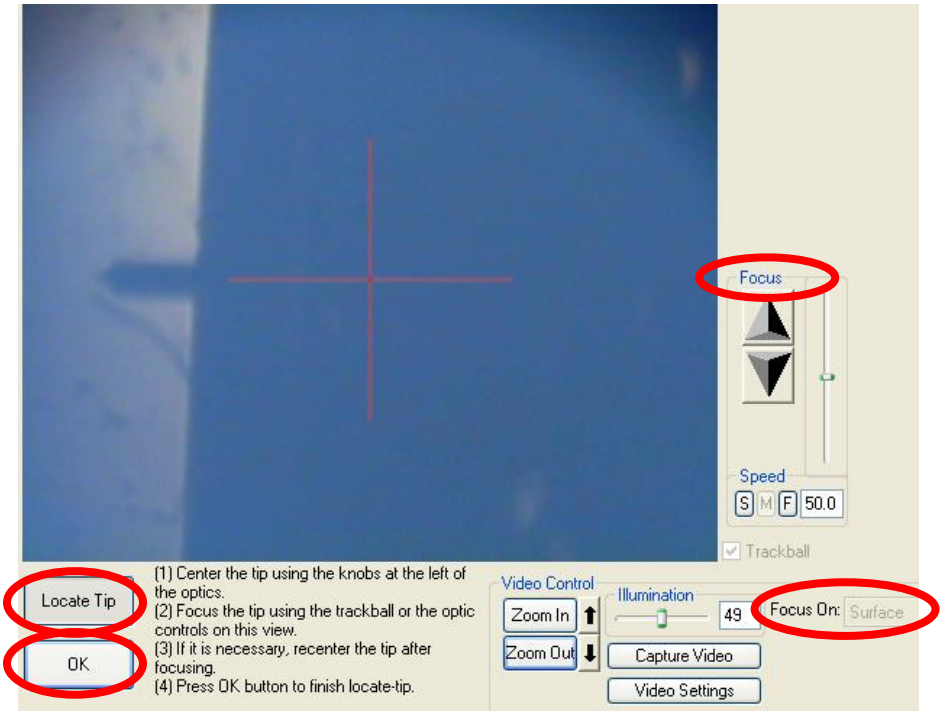
After the laser is aligned and photodetector adjusted, the dot is red and centered, the sum signal is high, and the VertDeflection is <±0.1 V.



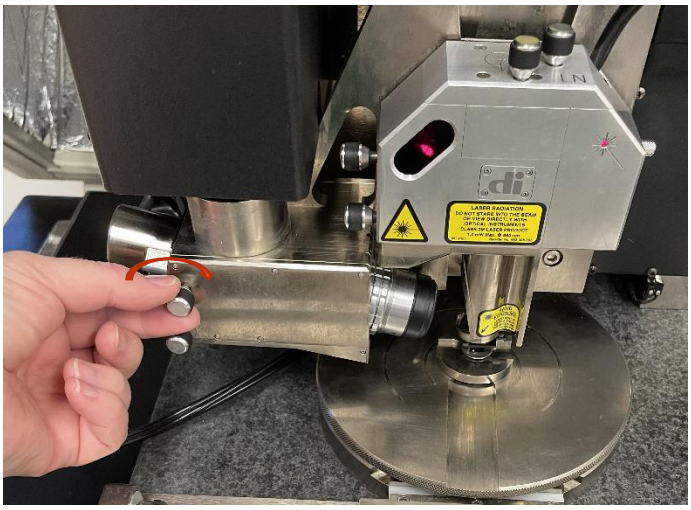
If your sample is shiny, put your sample on the stage. Otherwise, use the piece of silicon to focus the tip. Click "Locate Tip". Head moves tip automatically to help you find it. Image is blurry because it is moving.

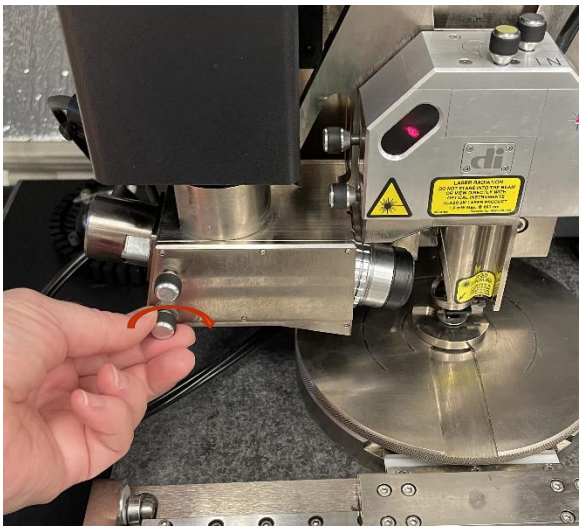


"Z Motor" changes to "Focus". The head is no longer moving downward to focus on the surface. Instead, the camera is moving in and out to focus on the tip. Making sure the tip and surface are in focus at their heights lets the head know where the tip is in relation to the surface. "Focus on" is grayed out. "Focus Surface" has changed to "OK".

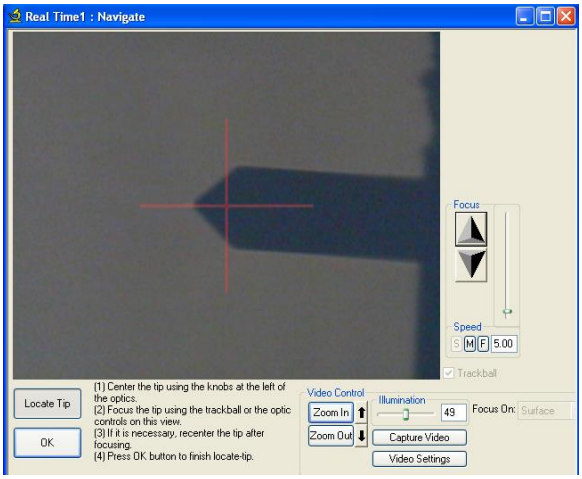


Adjust camera using knobs to center cross hairs on tip.

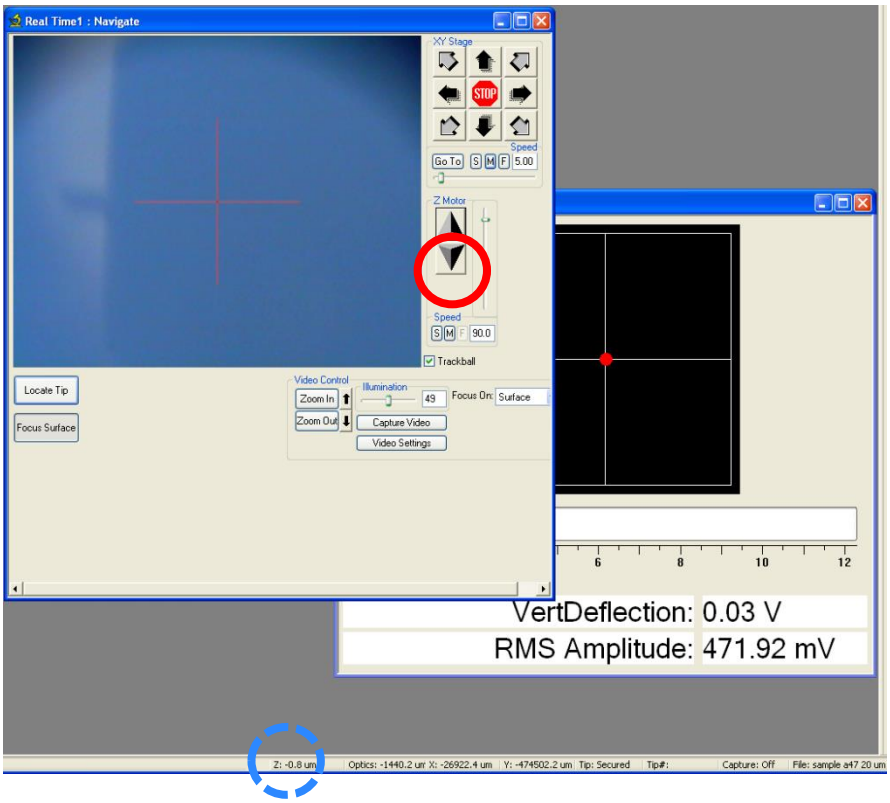


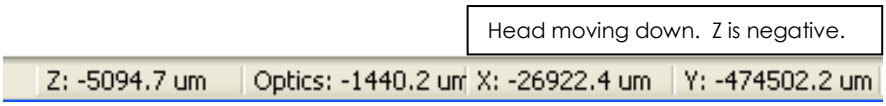


Cross hairs aligned on tip and tip in focus.

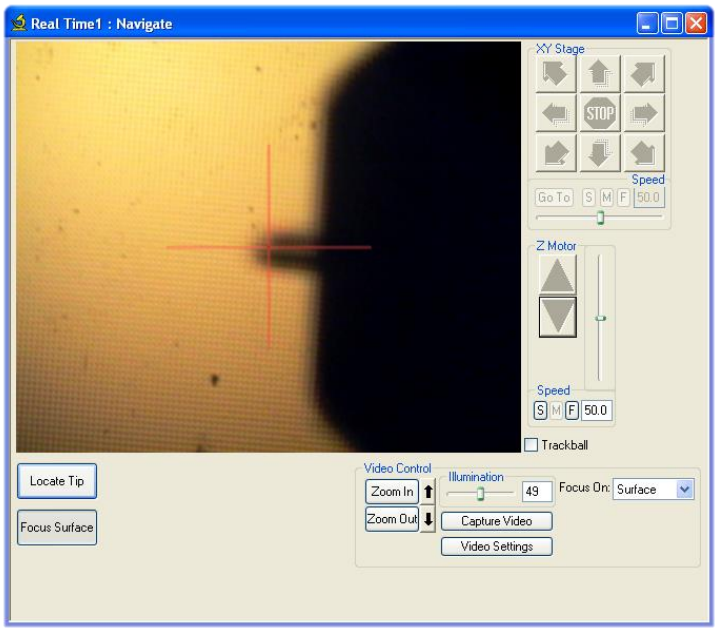


Focus on sample surface using the z-motor arrows. This moves the head up and down. Note the Z value in the bottom bar.





Surface in focus. For the standard sample mounted on a magnetic disc on top of the magnetic chuck, the surface is in focus around Z=-7700 um.

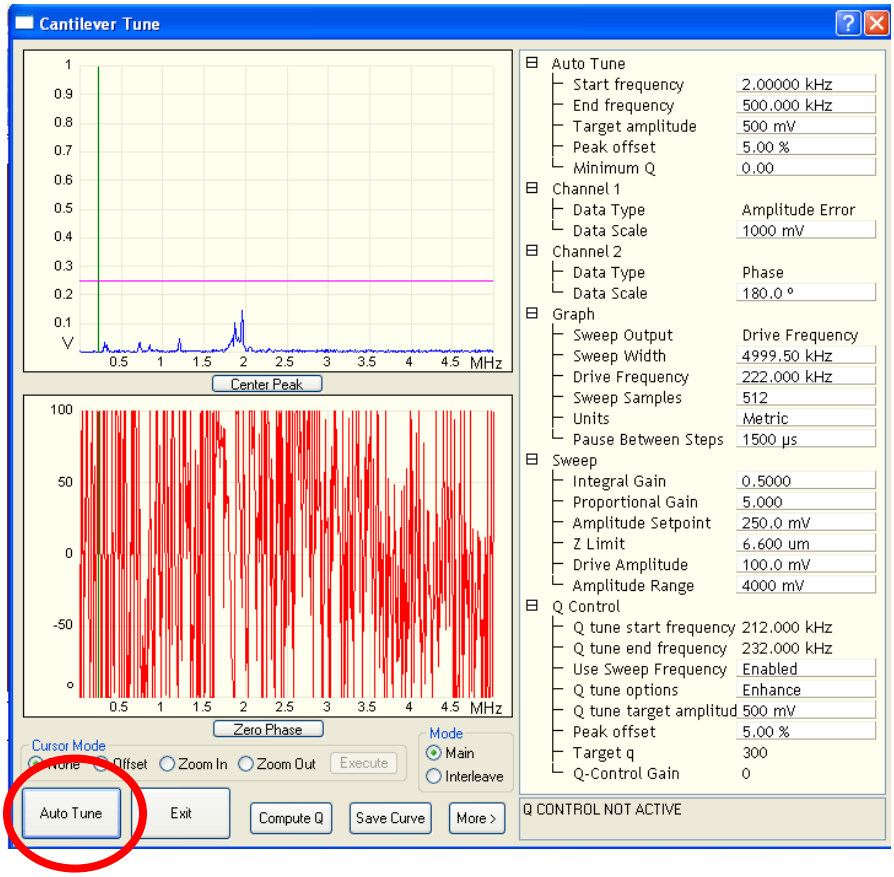


The sample should be in focus when the tip is 1 mm (1000 μm) above the surface [1].

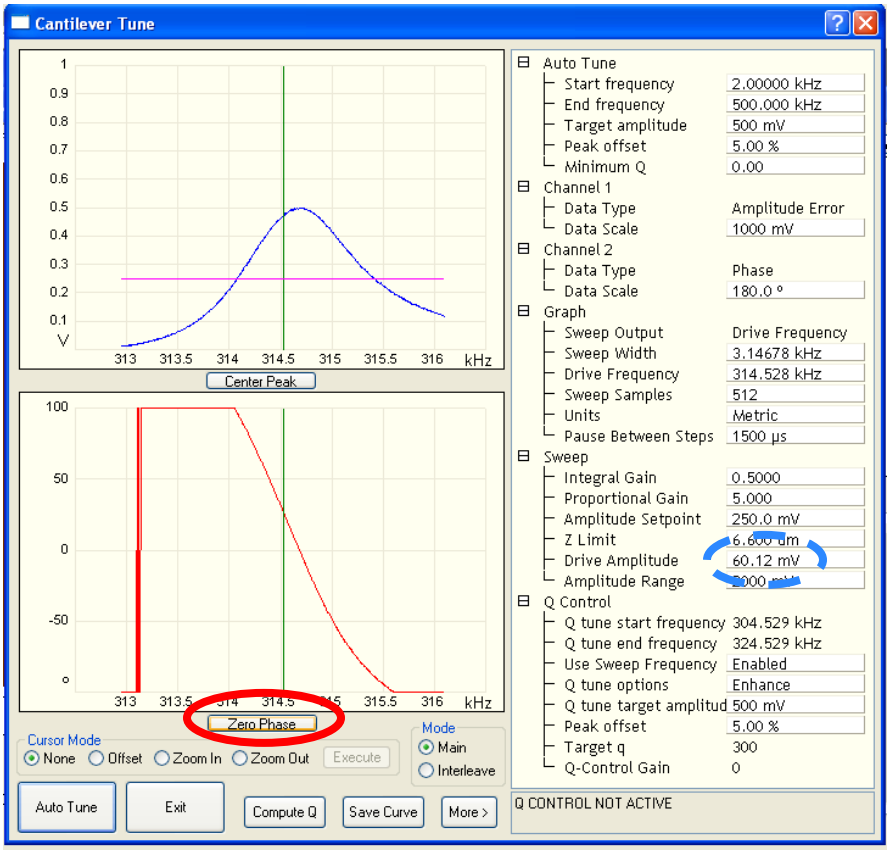
4.3 TUNE THE TIP

Select "Tune". It is the tuning fork icon.

Click "Auto Tune"

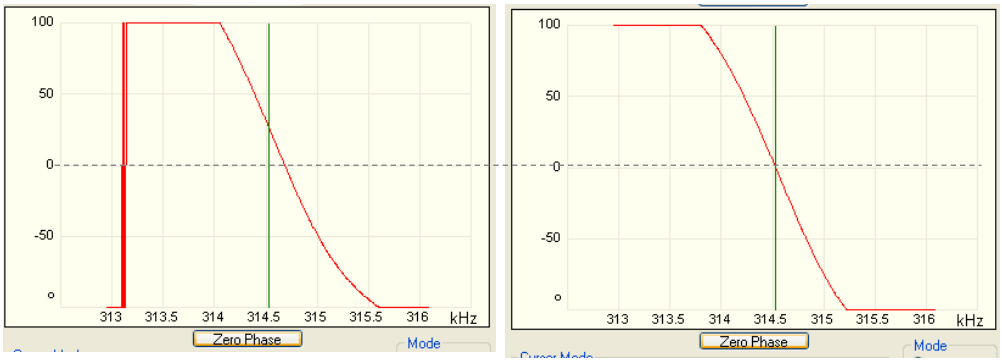


Drive amplitude: keep less than 100 mV if possible. If really high (>300 mV), consider reloading tip and realign. Example of good tip tuning. Click "Zero Phase." This centers the phase shift line. Important if you are doing phase contrast.



Before phase is zeroed.

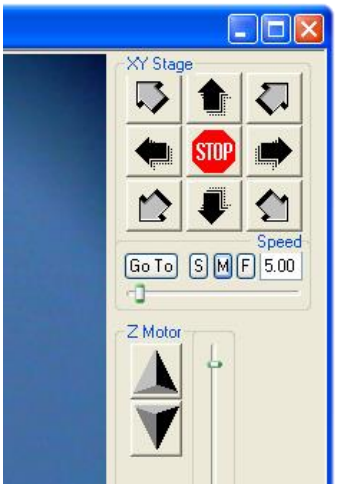
After phase has been zeroed.



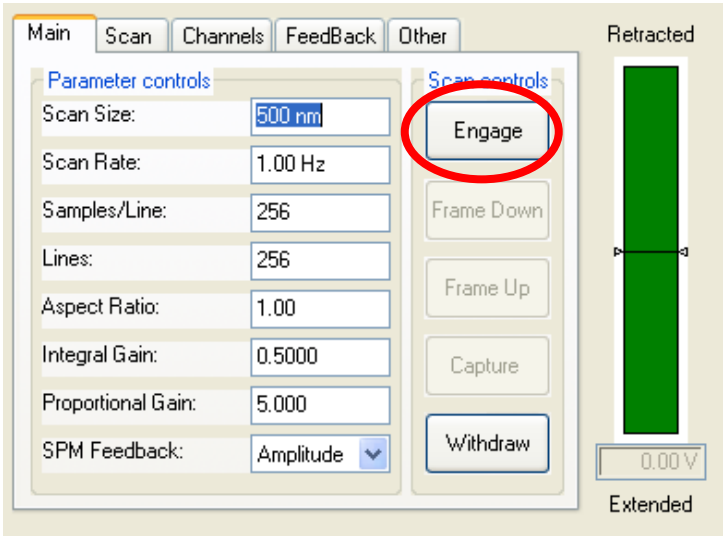
Click "Exit".

4.4 START SCANNING

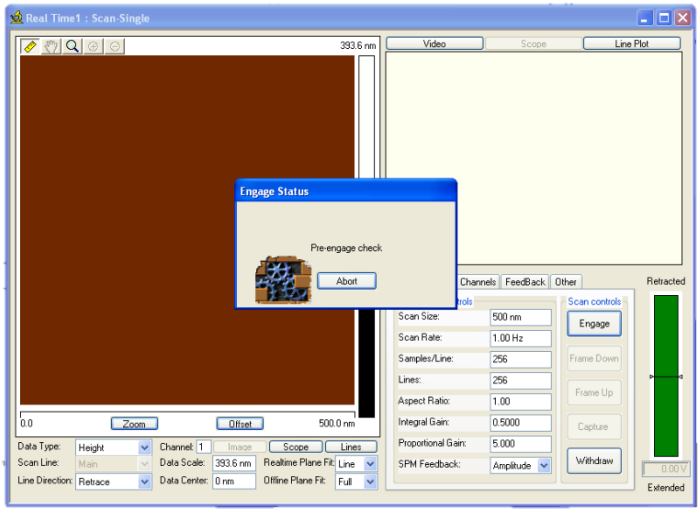
After the tip is tuned, find the region of interest (ROI) on sample by moving stage.

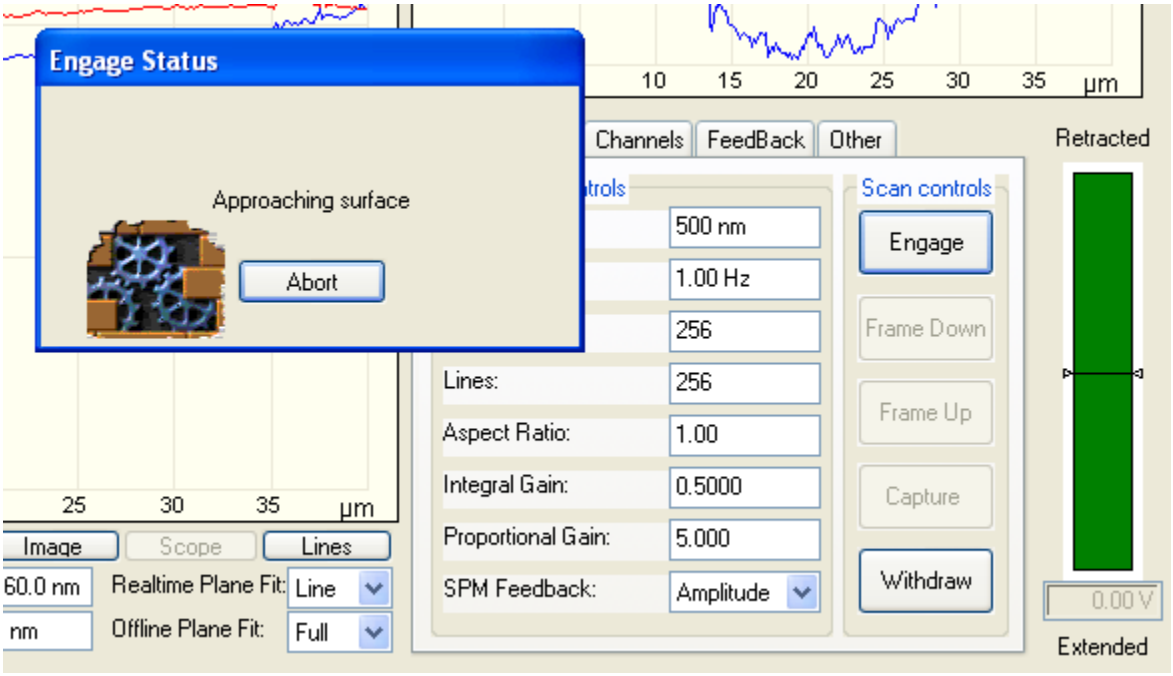


Once ROI is located, click "engage" in single-scan window.

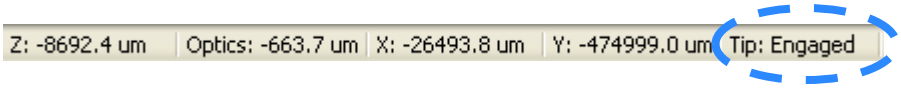


The scanner head will move down to make contact with the surface.



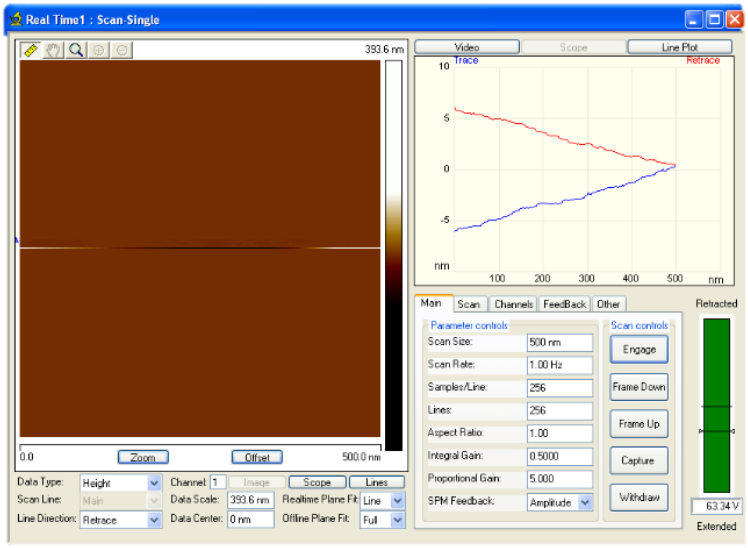


After the tip has reached the surface, it should say "Engaged" at the lower right.

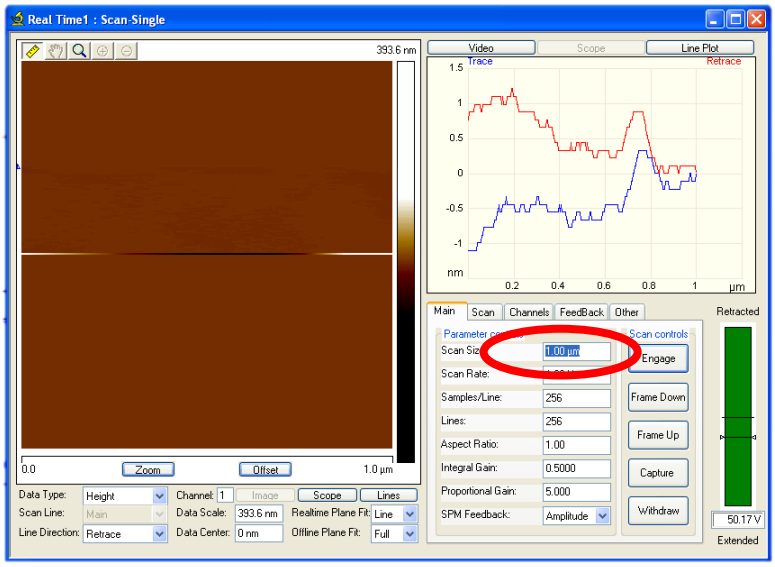


4.5 OPTIMIZE SCAN PARAMETERS

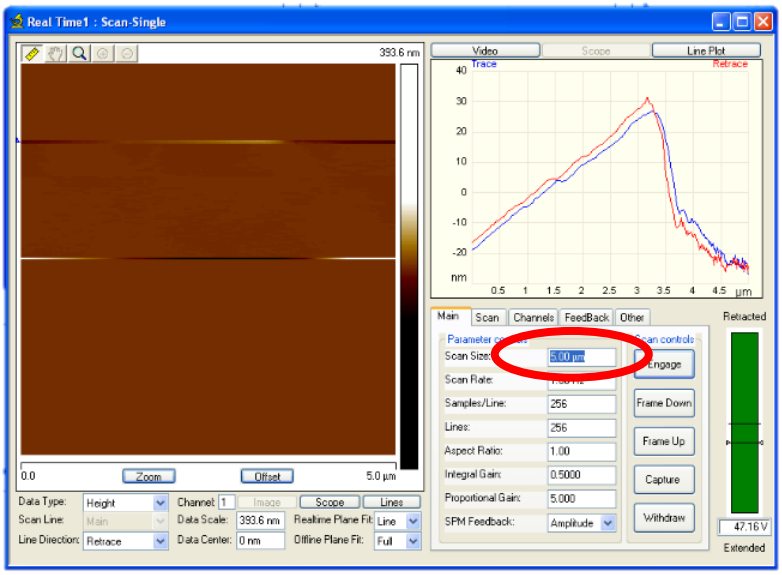
Once the tip is engaged, start changing the scan parameters. You may want to get a larger, rougher scan of an area and then use the "Zoom" button to focus on an area. The maximum scan size possible is 110 um, but you're better off doing several smaller scans (below 50 um) or using the profilometer if you need to analyze a large area.



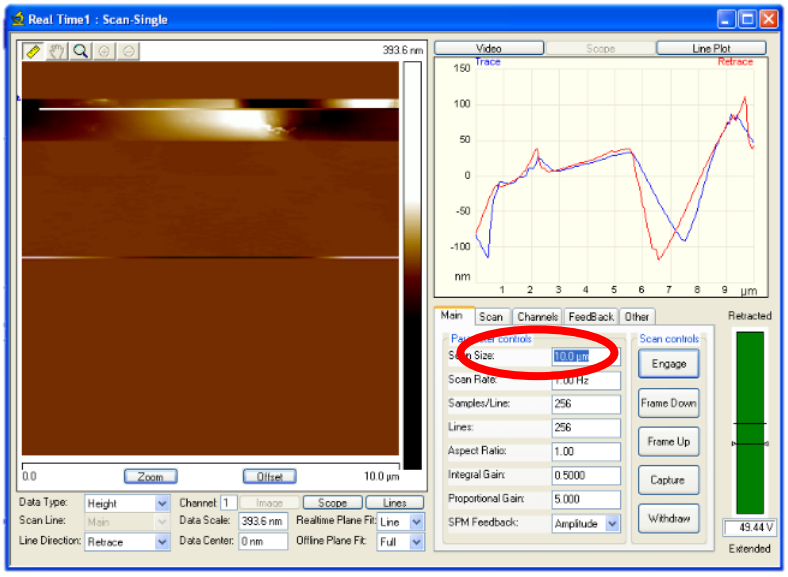
Change scan size to 1 µm. Increase the scan size by small increments. 500 nm, 1000 nm, 5 um, 10 um, 20 um, 30 um etc. We want to slowly increase the scan size to avoid damaging the tip.



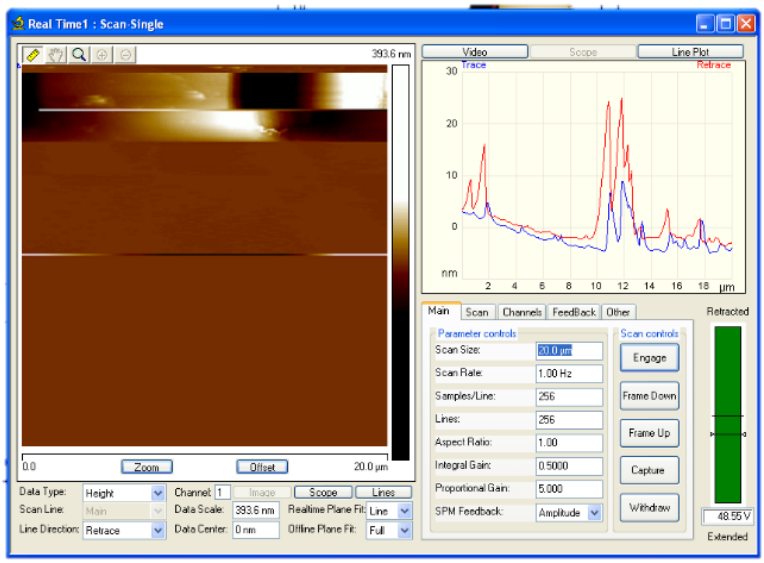
Change scan size to 5 µm.



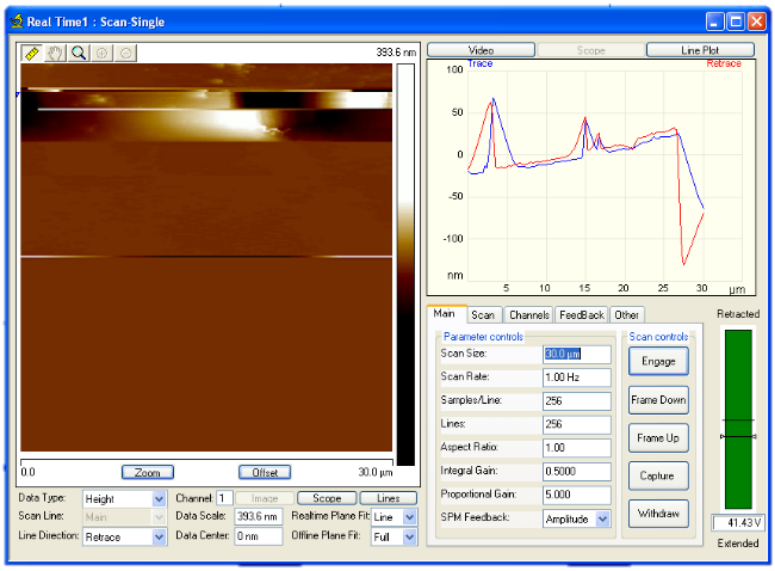
And then to 10 µm.



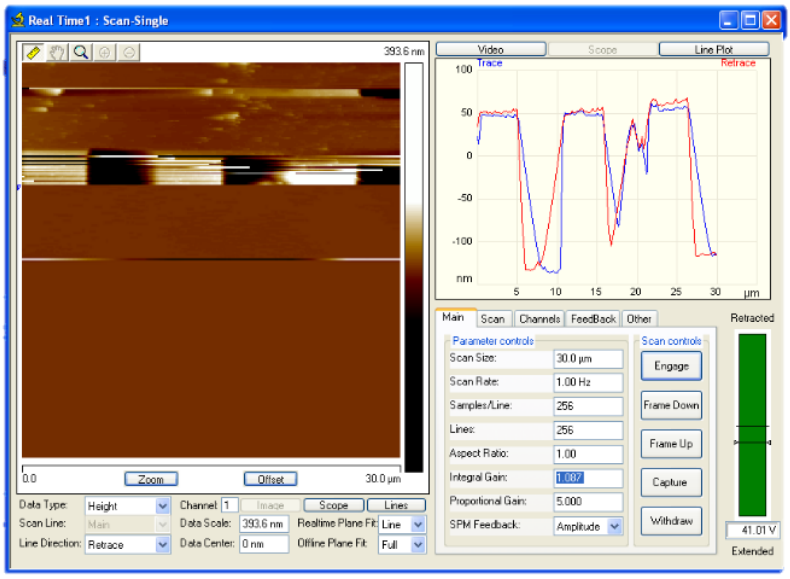
And then to 20 µm.



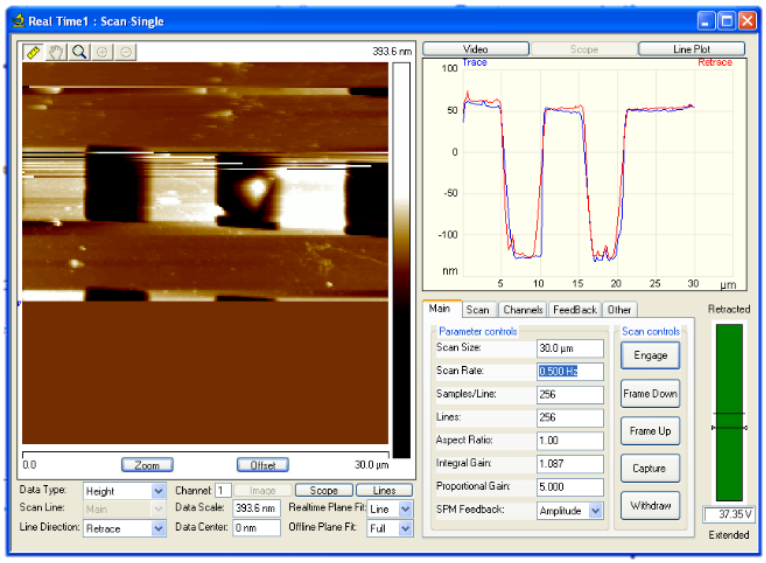
And then to 30 µm.



Once the scan size is set, increase integral gain to improve tracking between trace and retrace.



To further improve tracking, decrease the scan rate.

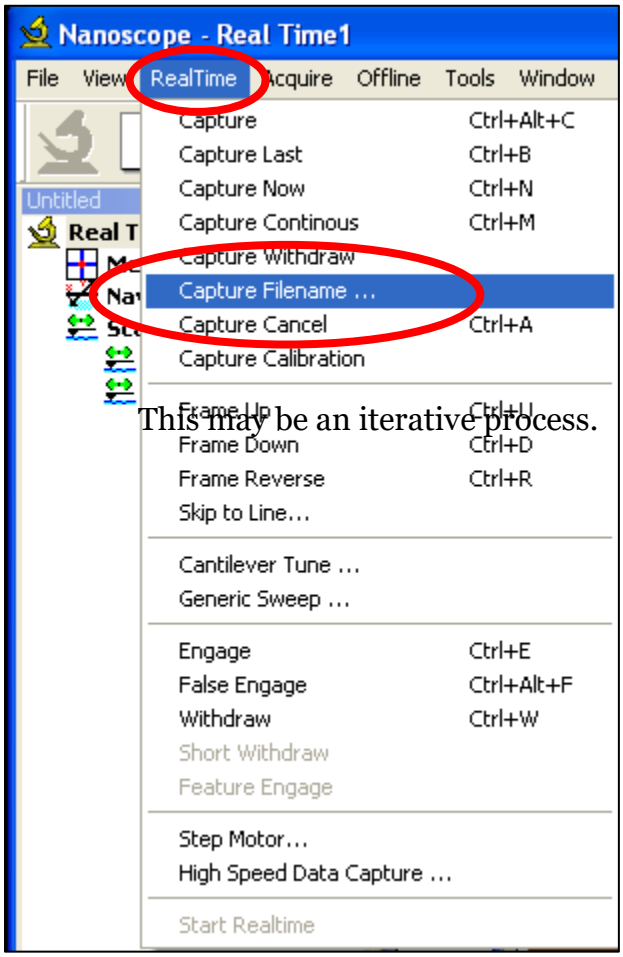


You can also change the resolution if needed.

> Resolution Example: If you are acquiring a 50 µm x 50 µm image with the Samples per Line parameter set to 512, then the pixel size is 98 nm (50 µm ÷ 512 = 0.098 µm, or 98 nm). Thus, you will not be able to resolve features smaller than 98 nm at a 50 µm scan size. If you want to be able to see 10 nm-sized features, you will need to choose a scan size <5.12 µm (preferably 1 or 2 µm) since 5.12 µm ÷ 512 = 0.010 µm or 10 nm [1].

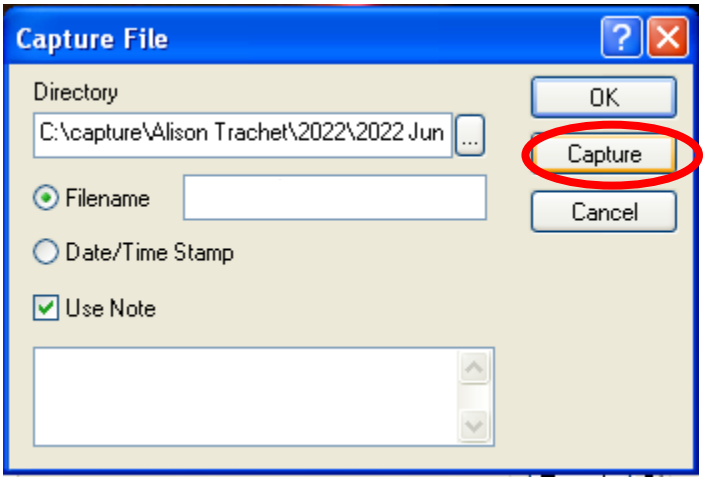
4.6 SAVING YOUR SCAN

Once you are happy with the scan parameters, you will need to save the scan. Open "RealTime" and click "Capture Filename".

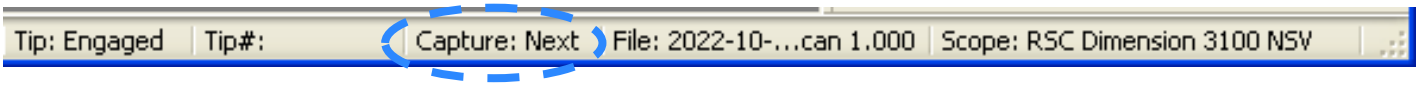


This may be an iterative process.

Navigate to the proper folder. Enter filename. Add any notes (e.g., integral gain, proportional gain, etc.). Then click "Capture". Clicking "OK" will close the window but not set the software to capture the image.

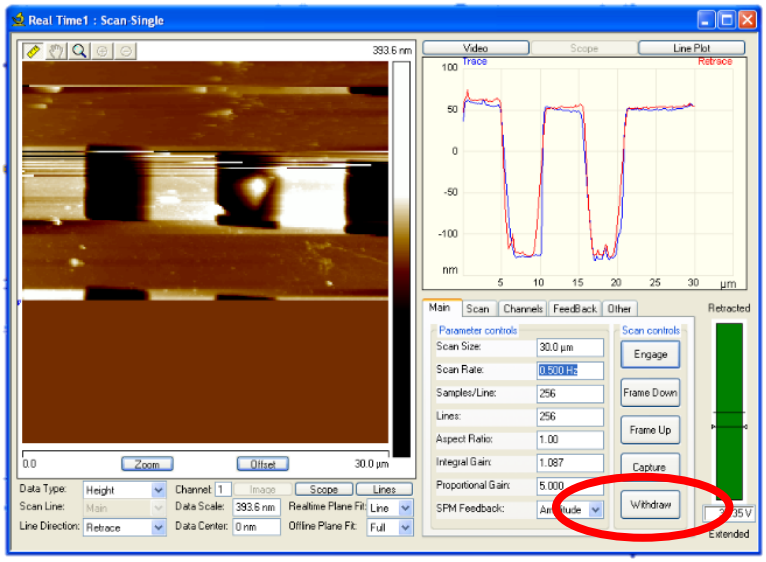


Check lower right corner. Capture should say "Next" or "On." If it says "Off", scan will not be saved.

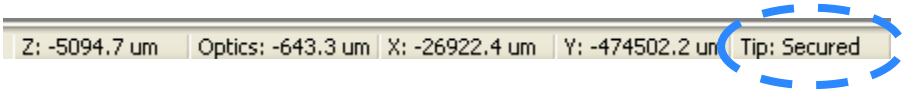


After scan is complete, check that the file is saved. You can process your scans in NanoScope, but Nanoscope Analysis is available on the computer on the 2nd floor area.

If you would like to take additional scans on the same sample, click "Withdraw".



If the tip says "Secured", it means that the tip is not interacting with the surface. It is also safe to move the stage to find another location to scan.



5. Processing, Exporting, and Copying Data

Files are saved in a proprietary file format that can be opened in Nanoscope, Nanoscope Analysis, and the open-source software, Gwyddion. To get your data off the computer, you will need a USB to copy files.

6. Equipment Shutdown

After you have collected your data and are finished scanning, raise the head of the scanner to the very top. Click stage→move to→ origin to return the stage to its home position.

Close the software. Click "no" to saving the workspace.

Remove your sample from the stage and magnetic chuck. Put the magnetic chuck back on the outside of the acoustic hood.

Remove the tip from the scanner head. Put the scanner head back in place and lock it. Close the acoustic hood.

7. Waste Disposal

Broken tips can placed in the practice tip boxes. If you would like to throw the broken tip away, please put it in the sharps box in Room 239.

In the unlikely case that your sample is hazardous, please dispose of the used tape and magnetic disk in accordance with EHS guidelines.

8. References

1. https://www.nanophys.kth.se/nanolab/afm/icon/bruker-help/DIcon_webhelp.htm
2. Veeco SPM Training Notebook
3. Veeco diNanoScope V Controller Manual
4. https://www.usherbrooke.ca/3it/fileadmin/sites/3it/documents/3IT.Nano/Manuels_equipements/AFM_user_guide.pdf
5.