

The User's Guide for the Oxford Asylum Jupiter XR Atomic Force Microscope (AFM) in Tapping Mode

The Shortest Possible Version of this Manual

0. Reserve the tool on the LabResources scheduler. Email staff for tip request if needed
1. Log onto Windows with NetID
2. Verify the tool's doors are closed and locked. Launch Jupiter software (RealTime)
3. On the Probe Panel select "none" and click OK
4. Select BlueDrive AC Air Mode from Mode Master panel. Several windows will launch
5. A window will prompt you to home the BlueDrive polarizer. Click yes. More windows will launch
6. Load sample. Turn on vacuum, if needed, by clicking tick box in the bottom left hand corner of the Engage Panel
7. Using the joystick, navigate the sample to the z scanner, and lower the z scanner until it is ~2mm above the sample surface.
 - a. The button that looks like a puff of air moves the stage in the x-y plane
 - b. The button that looks like a stylus with arrows moves the z scanner in the z direction
8. Focus on tip. Set detector laser location to minimize deflection value. Set BlueDrive Laser location. Mark tip location. SET tip focus
9. Focus on sample surface. SET sample focus location
10. Switch back to Tip Focus, and click "Move to Pre-Engage Height"
11. Tune cantilever
 - a. Perform GetReal calibration. When calibration is complete, right click on peak, and select "Fit Thermal Data"
 - b. In the Tuning window, click on Auto Tune
12. Click "Start Tip Approach"
13. Set up Master Panel. Input scan size and adjust scan rate to ≤ 1 Hz. Give file a name and designate a file path for saving data.
14. Click "Frame Up"/"Frame Down" to start tip raster. Optimize data image.
 - a. Lower setpoint, until trace/retrace have good overlap
 - b. Increase Gain as much as possible without inducing "ringing"
 - c. Click "Frame Up"/"Frame Down" to start a new frame with optimized parameters
15. Click "Stop" to end rastering and data collection
16. Scanning a different location?
 - a. In the camera window, use mouse to point to new location. Right click and select "Move Stage to this Location".
 - b. Select focus on tip
 - c. Click "Start tip approach"
 - d. Click "Frame Up"/"Frame Down" to start scanning in new location.
17. Done?
 - a. Click Change Sample to retract z scanner and move stage to unloading position
 - b. Remove sample.
 - c. Turn off pump with tick box in Engage Panel
 - d. Close software, do not save experiment
 - e. Log out of Windows.
 - f. Fill out log book

This tool belongs to Audrey Hammack, PhD. For questions regarding tool operation, please email her at ash107020@utdallas.edu. You may call her at 972.883.5767. You may also call/text her mobile phone at 903.363.8948. There is a dedicated website for obtaining customer support at <https://afm.oxinst.com/support/>. This will lead you through a brief questionnaire about your concerns, which will open up a customer service ticket.

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Introduction and Hardware Overview

Welcome to the UTD Cleanroom's newest characterization tool, the Jupiter AFM. You are probably here because you want to take an image of a sample surface and/or because you want to make some topographic measurements of a sample surface. This tool will help you achieve that. **This guide was written to instruct users on using the AFM in tapping mode microscopy.**

A note for users of the previous tool: There are some ways that this Oxford Asylum Research tool differs from the previous Veeco Dimension V tool. Notably, the old tool achieved the tapping frequency by oscillating the tip with piezo electric elements in the AFM tip holder. This tool achieves the tapping frequency by thermally exciting the tip with a laser. This technology is called BlueDrive, although in this tool, the laser appears red. Another exciting improvement is the capability of a fast scan mode. A surface scan that would take 4-5 minutes in traditional tapping mode takes about 1 minute with fast scan tapping mode. This mode requires a tip especially designed for fast scans, and the tool has some hardware differences that make fast scan possible.

The Hardware

The large module to the left of the desk is the AFM (Fig 1a). The AFM is housed in a noise-blocking hood. The hood is opened by turning the black knob on the left-hand side of the tool and opening the door. The hood has a view port that the user can look through when the hood is closed. The door opens to the right and swings around the tool, and it should not bump into the computer monitors on the table (Figs 1b and 1c).

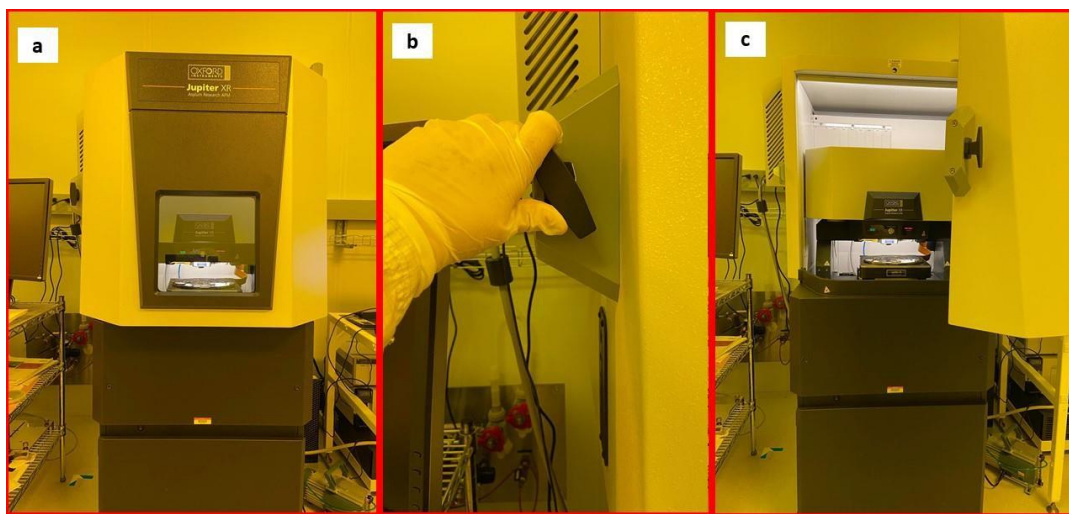


Figure 1. Image of the AFM (a.) with the hood closed; (b.) the hood is unlatched by turning the black knob on the left-hand side of the tool counter clockwise; and (c.) the hood opens by swinging out and to the right

Inside the shielding, the sample stage is housed inside the tool. The stage is mounted on a granite slab that is supported by an air table to reduce noise. The sample stage clamps samples in place during scans. Samples are clamped in place by a vacuum or by magnets that are embedded in the stage (Fig 2b). The stage moves in the x- and y-directions by being floated on a column of air to eliminate noise. Above the sample stage, there is a black module, the AFM head, with a silver box that is labeled "Jupiter XR 12 um AFM Scanner" (Fig 2a). The scanner houses the AFM probe, and can be moved up and down in the z-direction to engage with a sample. Other components of the AFM head not viewable to the user: the optical camera that allows the user to view the AFM tip and the sample surface; the deflection laser; the deflection laser detector; and the BlueDrive laser.

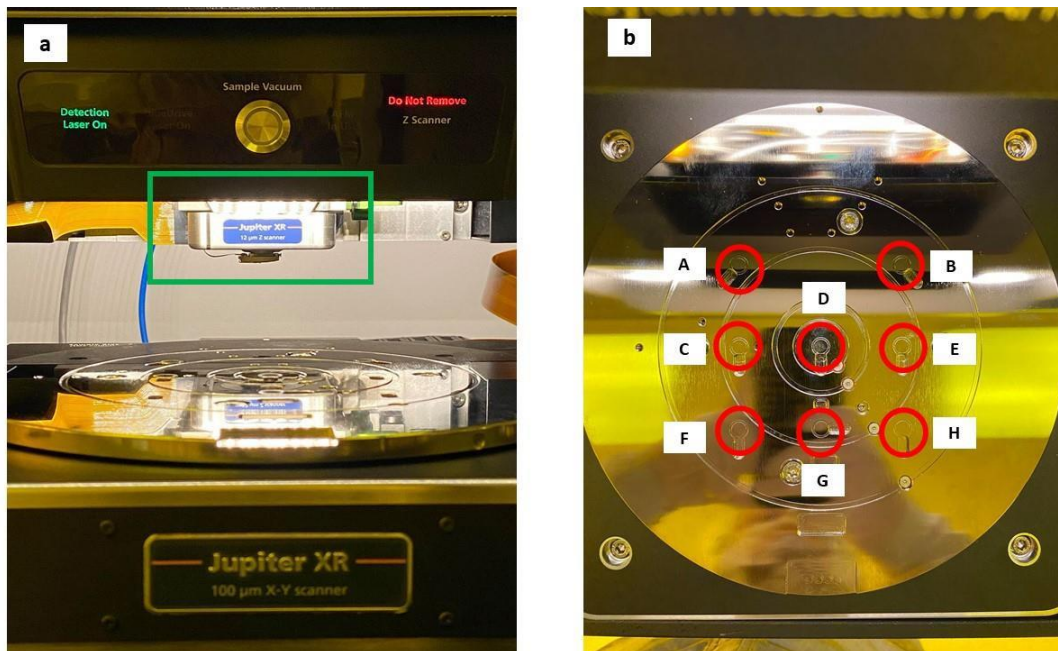


Figure 2. An image of the AFM components viewed with the hood opened. Including (a), an image of the stage in the foreground and the z-scanner head in the background, indicated by a green box. Also pictured (b) is an image of the stage from the top-down. The locations of the embedded sample clamping magnets are indicated by red circles and are labeled with letters that match the labeling in the Jupiter software

Computer components that control the tool are outside of the AFM, also a strategy to minimize/eliminate noise. This includes the "backpack" on the left side of the AFM shielding (Fig 3a), the black CPU (Fig 3b) on the floor to the right of the AFM, and the two white boxes on the floor under the monitors (Fig 3c--these boxes are the AFM and the stage controllers). The "backpack," CPU, and AFM controller operate the tool and perform data processing, while the stage controller moves the stage and controls the column of air that the stage floats on. Additionally, beneath the desk there is an uninterruptible power source (UPS) that powers the instrument in case of a power failure (Figs 3b and 3c).

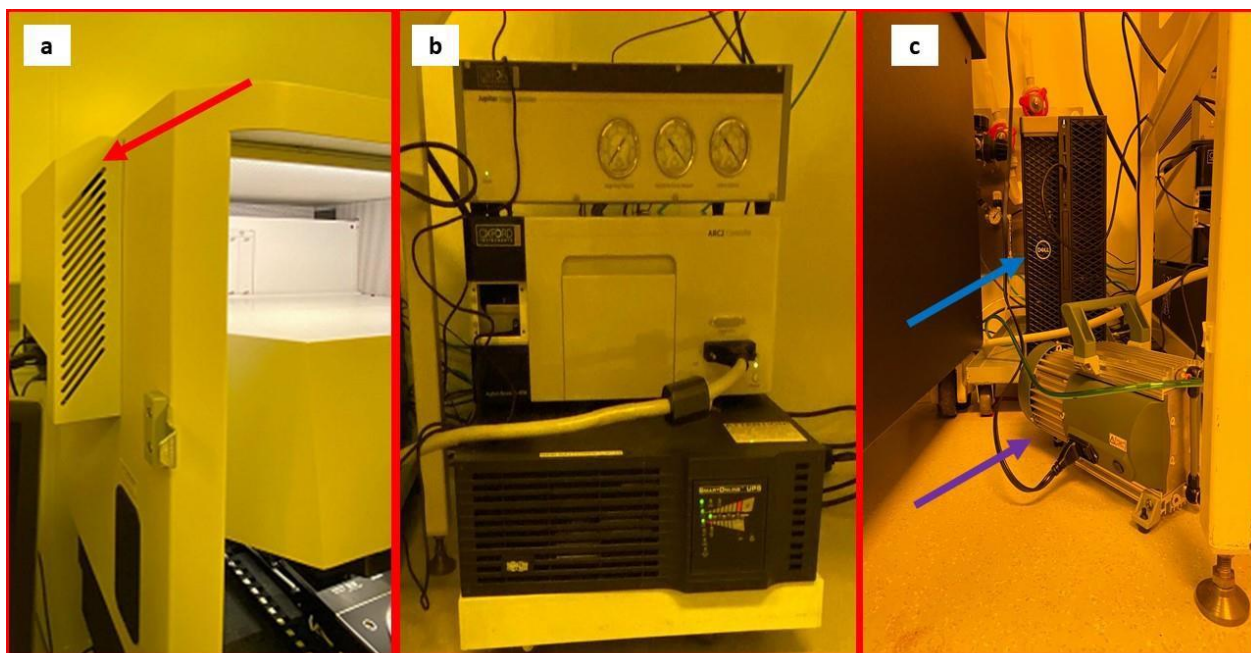


Figure 3. Images of external components. This includes (a) the “backpack” on the left-hand side of the AFM hood, indicated with a red arrow. Image (b) includes, from top to bottom, the stage controller, the AFM controller, and the black UPS box. Image (c) shows the CPU, indicated by a blue arrow, and the sample stage pump, indicated by a purple arrow. The pump was removed in Spring of 2022 and the tool was moved to house vacuum.

On the desk, there are 2 pieces of hardware. One is the joystick (Fig 4a). The other piece of hardware is a dark blue box with silver wheels, referred to as the “hamster wheel;” it has 2 wheels, inner and outer, that move independently of each other (Figs 4b and 4c). The hamster wheel is useful in the software to optimize data scanning parameters.

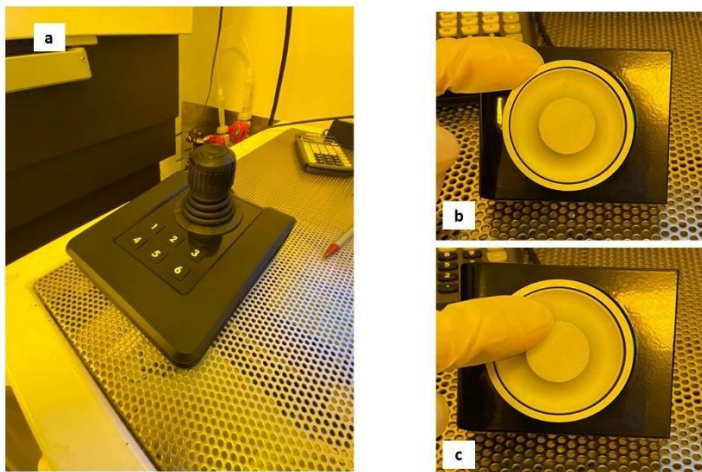


Figure 4. Images of the desktop hardware, including (a) the joystick. In (b) the user’s finger is manipulating the outer ring of the “hamster wheel” and in (c) the user’s finger is manipulating the inner ring. The rings can be moved clockwise or counterclockwise and independently of each other.

Before you get started

You need an account on the UTD Cleanroom Scheduler, Lab Resources. This system is the scheduler for time on the tool, and manages billing for tool usage. AFM tips are also available for purchase through the scheduler as an accessory, although staff need to be notified when they need to supply the tip. A user may buy their own tips and learn how to install them in the z-scanner as well.

Determine the type of AFM scanning you will perform and select the appropriate probe (“tip”). Most people will be satisfied with tapping mode AFM using a relatively “stiff” probe. Some people may be interested in performing a “fast scan”. Performing fast scan microscopy with a tip that is not designed for the method will break the tip and potentially damage your sample. You may supply your own tips, or they are available for purchase from our lab.

Determine the sample size and how it will be clamped into place on the sample holder. There are 2 methods for clamping a sample in place on the tool’s sample holder: vacuum clamping or magnetic force. The vacuum clamping force is provided by house vacuum and is delivered through circular channels on the sample stage. The smallest sample that can be clamped by the vacuum is 2 cm x 2 cm. Additional screws may be removed from the stage to expand the clamping area to accommodate an 8” wafer. If your sample is too small to be clamped by the vacuum, we recommend mounting the sample to a magnetic disk with paste. Magnetic disks and paste are available for purchase from various vendors, or they are available for purchase from our lab.

Performing Tapping Mode AFM

Log into Windows

Check into Lab Resources reservation.

Launch Jupiter software (Fig 5a). The software is called “RealTime” and is located on the desktop. Wait for tool to initialize and close any windows related to the status of the software/providing feedback about the software. The bottom of the software window should read “Ready” with 2 green check marks. There will be 2 windows open. One window is the Probe Panel. On this window, select “none” and click ok. The remaining window is the Mode Master. **Select BlueDrive AC Air Topography mode**, located in the Standard tab (Fig 5b). There will be a pop-up window regarding “homing the BlueDrive polarizer.” Click the option that will enable this action. Note that the homing action will not proceed if the AFM hood is open and/or unlocked.

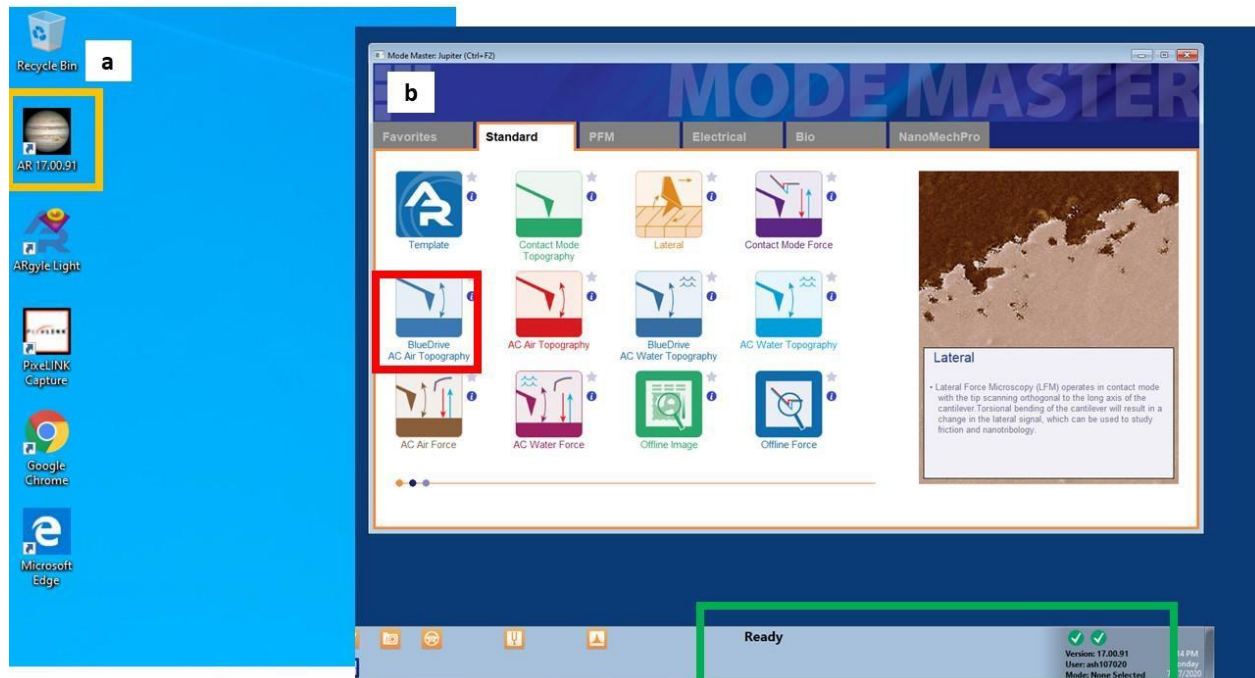


Figure 5. Launching the Jupiter software (a) from the icon indicated by the orange square. When the software launches (b), wait for the “Ready” message and check marks, indicated by the green rectangle. In the Standard tab of the Mode Master panel, select BlueDrive AC Air Topography

Configure screen. Drag the Jupiter software window in the bottom right-hand corner to expand the Jupiter software into both monitors. Left click on any panel and drag it to move it to a new location. A useful configuration would be to put the Engage Panel, Video Panel, the Sum and Deflection meter, and the Master Panel on the left, and to put the Height Retrace, Amplitude Retrace, Phase Retrace, Z sensor retrace, and the Master Channel Panel on the right.

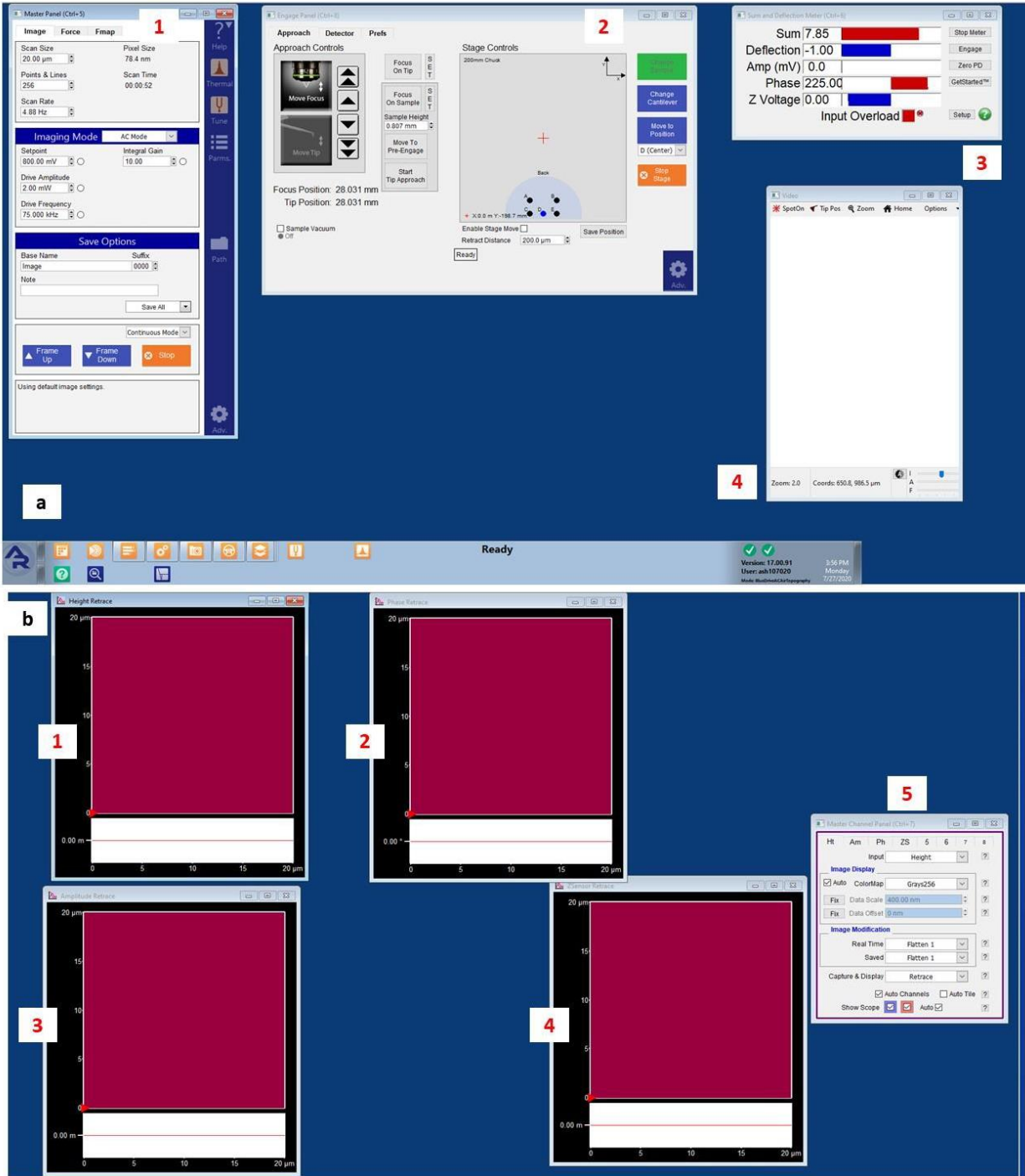


Figure 6. Images of a dual screen configuration. In (a), an image of the left-hand screen is shown with 4 numbered panels; these panels are the Master panel, the Engage panel, the Sum and Deflection panel, and the Video panel. In (b), an image of the right-hand screen is shown with 5 numbered panels, including the Height Retrace, Phase Retrace, Z Sensor Retrace, Amplitude Retrace, and the Master Channel panel.

Load probe. On the Engage panel, click on “Change Cantilever” (Fig 7). Wait for this button to turn green. On the AFM head, the “Ok to Remove” light will come on. At this point, reach into the AFM and grab the green lever to the right of the z-scanner. Push the lever down to disengage, and push it back. At the end of the travel path, a magnet locks the lever in place. With a thumb and index finger, use one hand to carefully grab and pull the AFM head out. Install a new probe. Refer to another section of this manual for detailed instruction on installation. Replace the z-scanner in the AFM head, carefully lining up the z-scanner with the dovetail channels on the AFM head. Lock the z-scanner in place with the green lever.

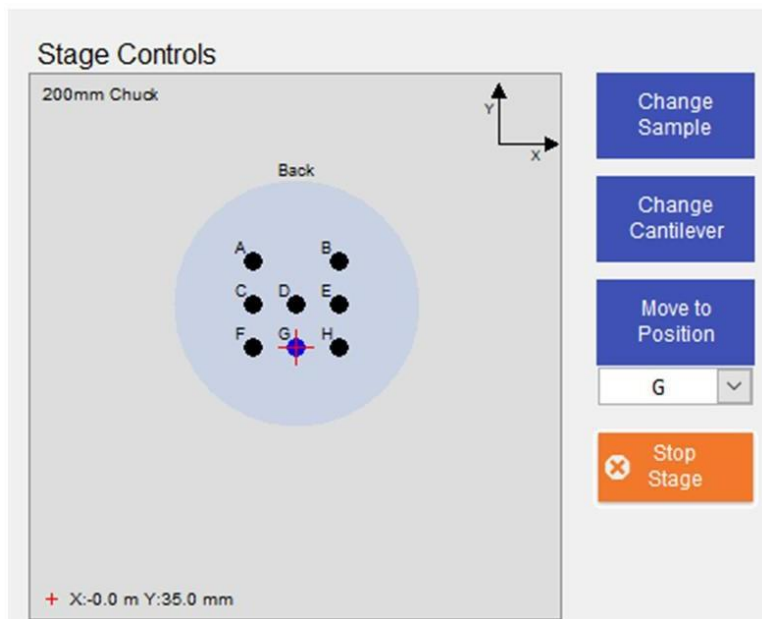


Figure 7. The “Stage Control” section of the Engage panel that shows the locations of the “Change Cantilever” and “Move to Position” buttons

Load sample. In the Engage panel, click on “Change Sample.” This moves the sample stage from beneath the AFM head and toward front of the tool where the user can access it. Open the hood. If the sample is mounted to a magnetic disk, clamp it to one of the stage-embedded magnets. Or, use the vacuum clamping force to clamp a sample to the stage. An Allen key can be used to remove additional stage screws to expand the vacuum clamping force (Fig 8). **DO NOT LOSE THESE SCREWS.** Enable the house vacuum by clicking the tick box in the lower left hand corner of the Engage Panel. When the sample is loaded and clamped, close and lock the AFM hood.

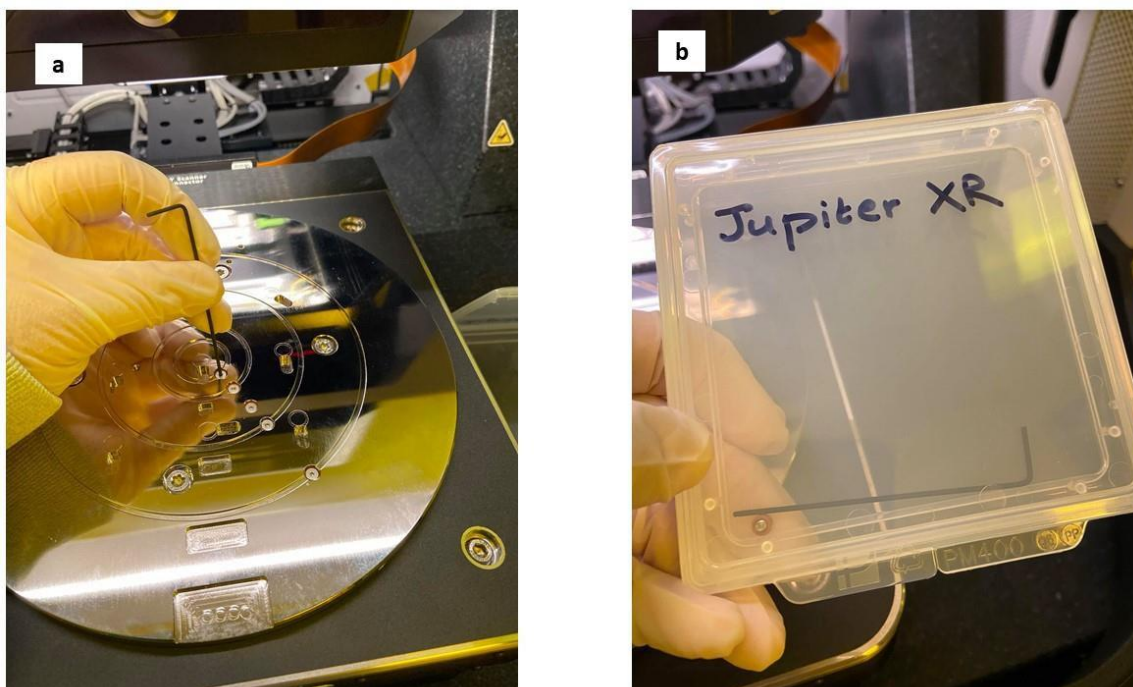


Figure 8 (a) using the Allen key to remove screw from the sample stage to access the vacuum clamping force. In (b), please note that there is a sample box in the tool. The Allen key should be kept here, along with any screws that are temporarily removed for a user's work.

Drive stage to sample location. *If the sample is on a magnetic disk, the stage can be automatically driven to the locations of the magnetic sample holders in the Engage panel* (Fig 7). In this panel, select the lettered location in the drop-down menu under the "Move to Position" button. When the correct location is selected, clicking "Move to Position" will move the stage in the x- and y- directions to a position where the tip is roughly over the center of this lettered location.

If the sample is not mounted to a magnetic disk, use the joystick. Position yourself where you can see inside the hood view port and hold the joystick. Press the button with the "puff of air" icon on the joystick to engage the stage float. Use the joystick to move the sample stage in the x- and y- directions. The goal here is to get the AFM head in a general location relative to the sample. Finding a location for scanning and fine tuning the location is done later. Press "puff of air" button on the joystick when you are satisfied with the location to disengage the stage.

Lower AFM head to ~2mm above sample surface while looking into the hood viewport. Continually hold the button with the "stylus" icon to lower the AFM head with the joystick. This is just to get the AFM head close enough to the surface for the instrument's optics to be able to locate the surface, finer adjustments to the height and location on the sample surface are made later

Adjust optical focus to focus on the tip, adjust lasers, and mark tip position. This is accomplished with the "Approach Controls" in the Engage panel (Fig 9a), and the visual feedback from the Video panel (Fig 9b). In the Engage panel, click on "Move Focus". To the right of this button the single- and double-arrow buttons will jog the focus of the optical microscope up and down slowly or quickly. The user will focus down to visualize the tip in the Video panel. As focus changes, the user may adjust illumination intensity in the video panel (Fig 9b); using the mouse, left click on the "I" slider at the bottom of the video panel and drag to the left or right. Also, the user may zoom in/out of the view using the slider on

the lower left-hand corner of the Video panel.

In the Video panel (Fig 9b), use the mouse pointer to indicate a location on the tip. At this location, right click to **“spot on” the laser location**. This is the detector laser. This laser spot should be close to the tip, without spilling over the edges of the cantilever. Adjusting the light intensity will help to view this. To make very fine adjustments to the laser location, use the buttons in the crosshair on the top left-hand corner of this panel; holding the Shift key+clicking a button moves the laser in the smallest possible increment. When the laser location is satisfactory, zero the detector by clicking the red dot in the center of the crosshair on the left-hand side of the Engage Panel. You should see the Deflection value in the Sum and Deflection panel decrease to 0-0.10 (Fig 10)

In the Video panel (Fig 9b), use the mouse pointer to indicate a location very close to the base of the cantilever, and right click in this location to **“spot on” the BlueDrive laser**. This laser is not blue; it is red and appears larger than the detector laser. Small adjustments to the BlueDrive laser location can be made with the crosshair on the top right-hand corner of the Video panel.

In the Video panel (Fig 9b), use the mouse pointer to indicate a location very, very close to the tip and **right click to select “tip position”**. This action marks the location of the tip in the Video panel with a green crosshair. The green crosshair remains in the video panel to indicate to the user where the tip will land on a sample surface. In the Engage panel, find the “Focus on Tip” button and click the “SET” button to the immediate right. This completes all the steps for locating and marking tip locations.

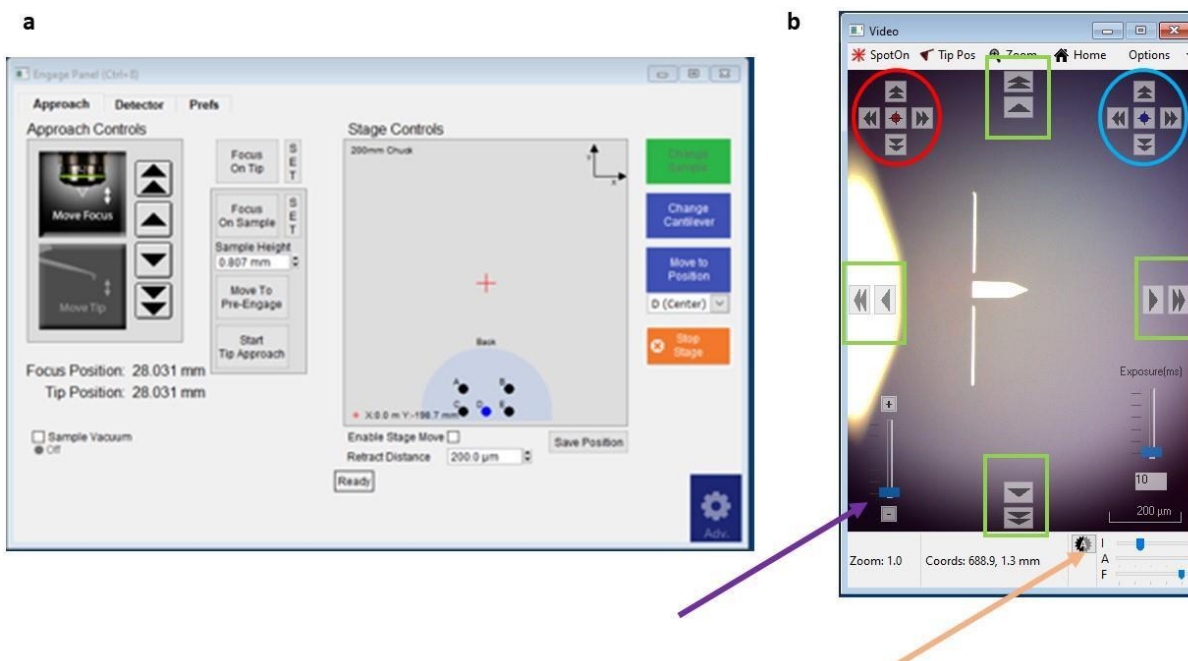


Figure 9. Images of the (a) Engage panel and (b) the Video panel that are useful for locating the tip and the sample surface. In the Video panel (b), the crosshair for moving the red detector laser are circled in red; the crosshair for moving the BlueDrive laser are circled in blue; the arrow keys for moving the sample stage are indicated by green boxes; the light intensity slider “I” is indicated with an orange arrow; and the image zoom in/out slider is indicated with a purple arrow.

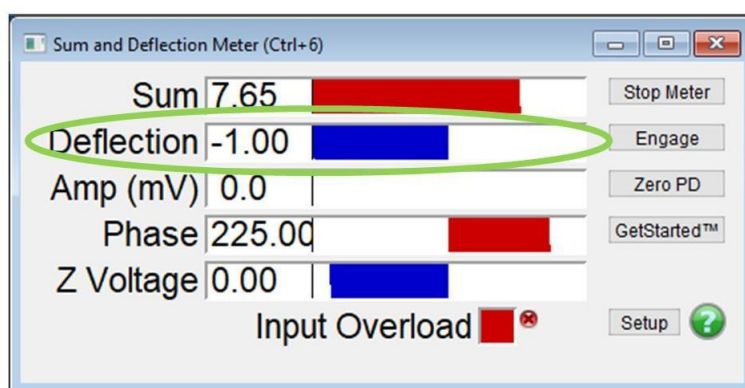


Figure 10. An image of the Sum and Deflection Meter panel. The Deflection value is circled in green. When the detector laser is in the correct location, this can be “zeroed” and a deflection of 0-0.10 can be obtained.

Focus on sample surface. For some samples, this may be as easy as bringing the focus down beyond the tip using the same down arrows in the Engage panel that were used to locate the tip. In the Engage panel (Fig 9a), there are 2 values called “Focus Position” and “Tip Position.” The user can bring the focus position down below the tip position by about 1 mm. If the user notices that the focus is not able to lower, this indicates that the user has approached the 1 mm difference. Now, the user must move the AFM head. In the Engage panel, click on “Move Tip”, and use the arrow buttons to slowly lower the AFM head until the sample surface comes into view and then into focus. At this location, the user may move the stage in small increments in the x- and y-directions to locate a place to scan on the sample surface. Using the joystick for this is not recommended. There are a few ways of making small movements using the Video panel that are helpful at this step. In the Video panel, the user may right click on a location in the image of the sample surface, and click on “Move Here.” The tool will jog the stage to the indicated location. If the user wishes to manually move the stage, there are arrow buttons on the top, bottom, left and right edges of the video feed (Fig 9b). Again, the shift+click command on these buttons will move the stage in the smallest possible increment in the x- and y-directions. The green crosshair used to mark the tip location indicates to the user where the AFM tip will land during the scan. When the user is satisfied with the location, click on the “SET” button to the right of the “Focus on Sample” button in the Engage panel.

The user should click on “Focus on Tip” to toggle back to the tip view, and check that the tip is still in focus. Then, the user should click “Focus on Surface” to toggle back to the surface view, and verify that the surface is in focus at the correct location. **The user should verify they are in tip view before proceeding to the next steps.**

In the Engage panel, toggle to the tip view and click on “Move to Pre-Engage.”

Tune the cantilever. Note: the user cannot tune if the camera is not in tip view. Click on Tune on the right-hand side of the Master panel. This opens a Cantilever tune window. Verify that the “target amplitude” field has 1.00 V (Fig 11). In this window, click on “Get Real.” This opens a menu of commonly used probes. The user will select the type of probe that is loaded in the tool, then click on Get Real Calibrate. This opens a new window of Thermal Fit Data (Fig 12). As the computer calibrates, this particular window will fill in with a Gaussian peak. The user will right click on the apex of the peak, and select “Fit Thermal Data” from the drop-down menu that opens. Switching back to the Cantilever tune window, the user will click on “Auto Tune” (Fig 13). The computer calculates a resonance frequency based on parameters from the selected probe and the thermal data. The tuning is complete when a black trace (frequency) and teal trace (phase) appear in the window.

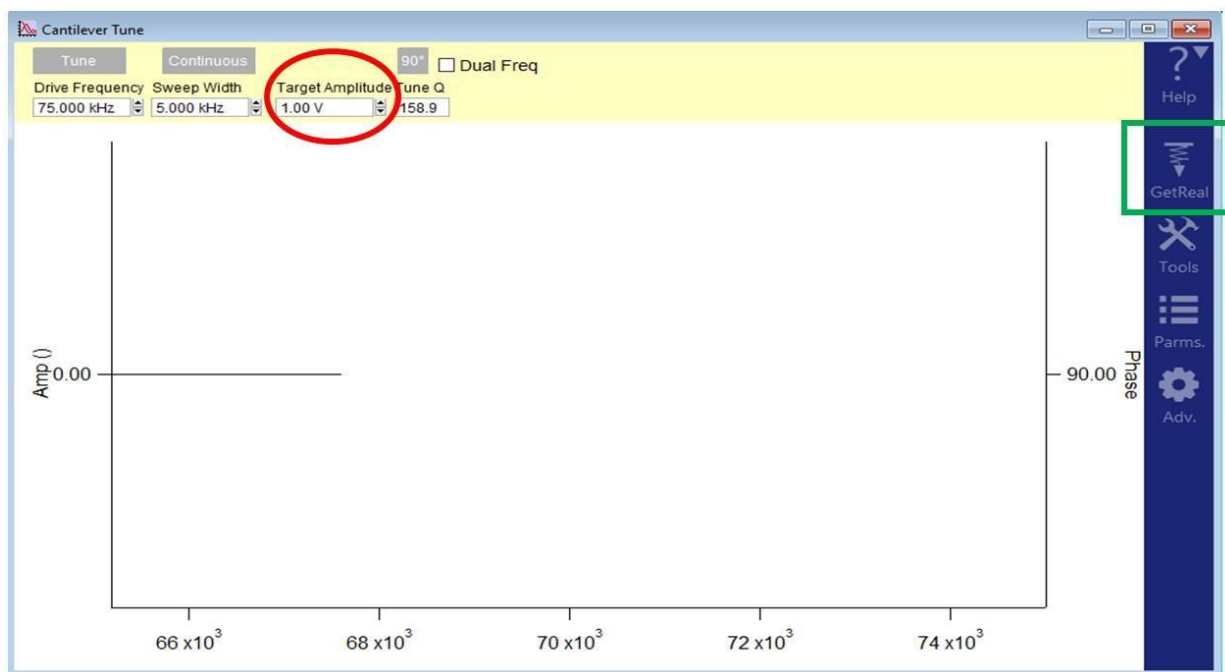


Figure 11. The cantilever tune window has no data when initially opened. Verify the Target Amplitude, indicated by the red circle is set to 1.00 V. The GetReal button indicated by the green square opens a menu of commonly used AFM probes.

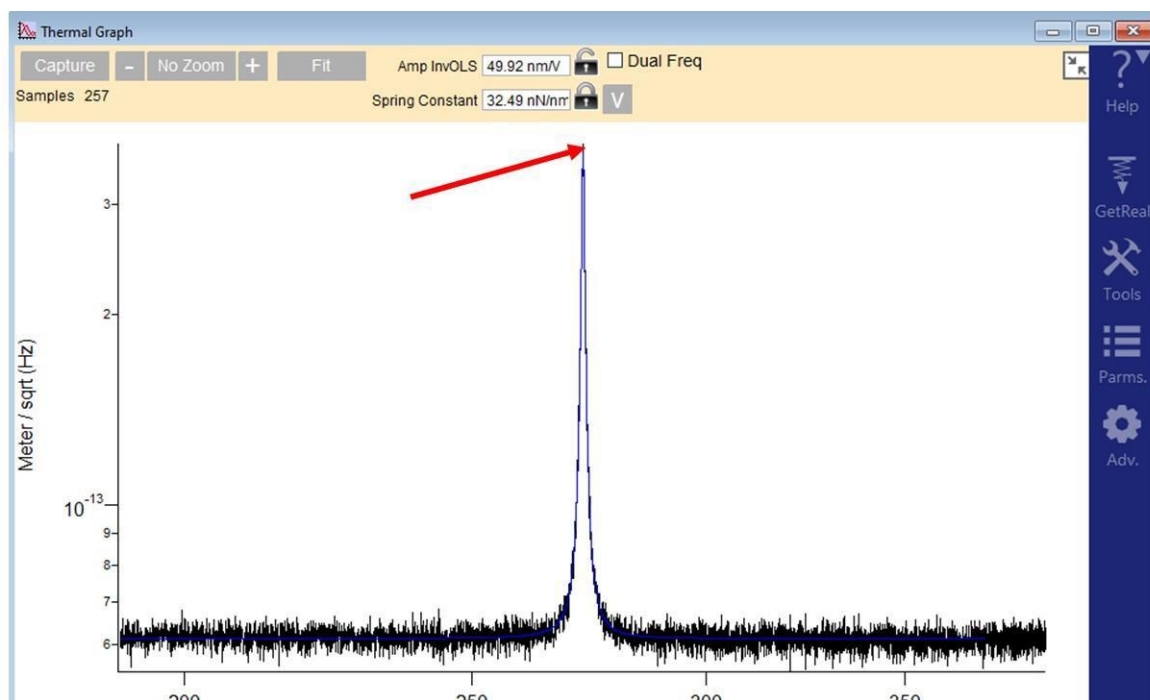


Figure 12. The thermal tune window, with a Gaussian curve. Right click on the apex of the curve, as indicated with the red arrow, and select "Fit Thermal Data"

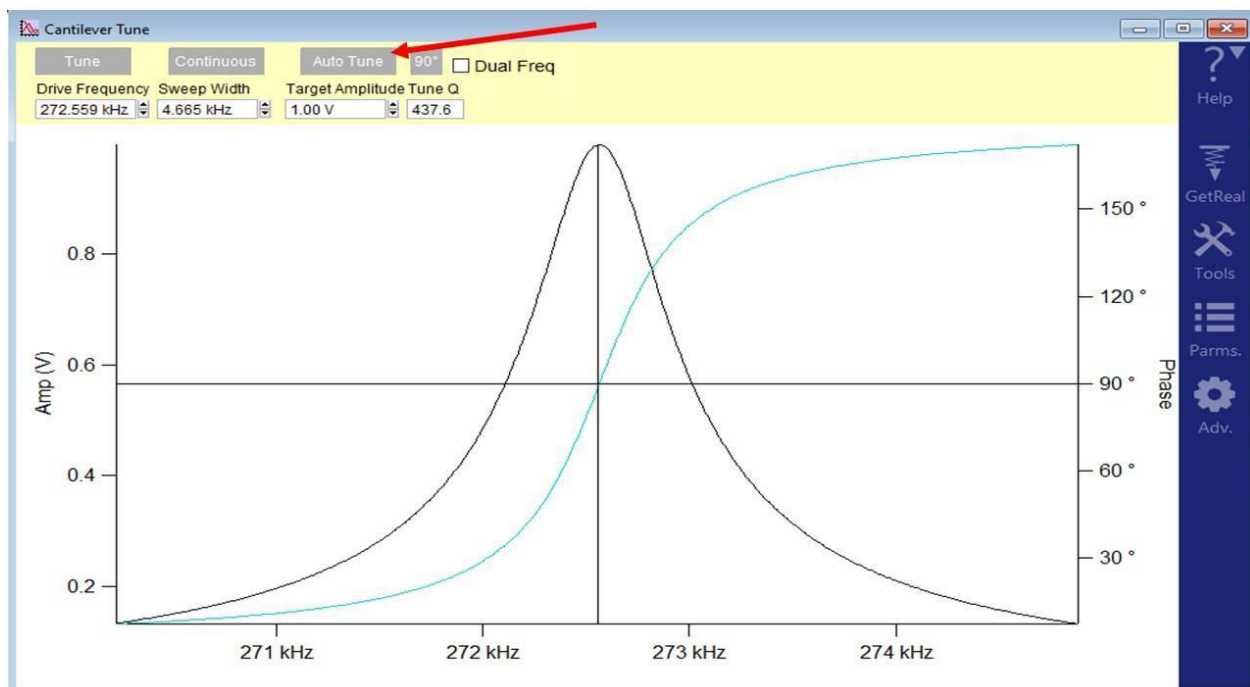


Figure 13. The Cantilever tune window after clicking Auto Tune, indicated by the red arrow. The computer calculates the resonance frequency of the cantilever (black trace)

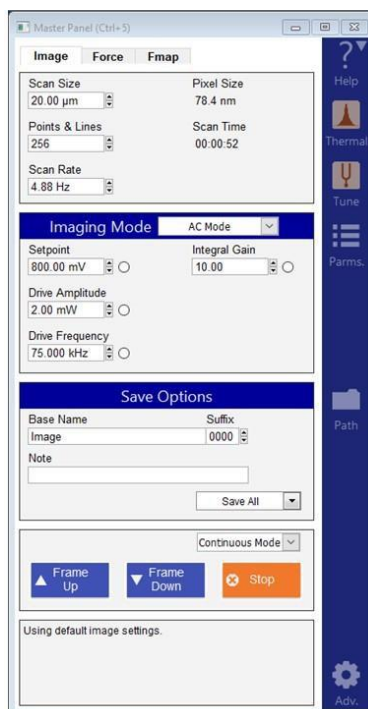


Figure 14. An image of the Master Panel

In the Engage panel, click on “Start Tip Approach.” The user will now fill in some values in the Master panel before collecting data (Fig 14)

The Master panel is divided into a few grey sections with parameters that will be adjusted and set by the user before the scan starts. The top-most section has fields for scan size, points and lines, and a scan rate. These factors determine the amount of time a scan will take, which is calculated and displayed in this panel. **The maximum scan size is 100 μm . Scan sizes that are smaller than the tip dimensions are nonsense; for an AC160 tip, this limit is on the order of 7 nm. Most users will find 256 points and lines to be acceptable. The maximum scan rate for traditional tapping AFM is 1 Hz. With a fast scan tip, rates up to 4 Hz are accessible.**

In the “Imaging Mode” tab of **the Master panel, modify the setpoint to a value that is 80% of what was indicated in the tuning voltage. For a tuning voltage of 1 V, the setpoint should be set to 800 mV.** This is a good starting point for this value. It will be adjusted when data collection begins.

In the “Save Options” tab of the Master Panel, the user inputs an image name and designates a file path. There is a field for the user to input notes, but this information is not a part of the file name. Note that the software will append a number to the end of the file name, starting with 000. As the tip rasters and the tool collects frames of data, every new frame will be sequentially numbered (the next frame will be 001, then 002, etc.). This continues until the user stops the tip raster. Note that the computer is connected to the UTD network and the internet. Users have the capability of storing data on remote servers on campus, or transferring data to cloud drives. **The cleanroom does not permit using external media (USB sticks or flash drives) to retrieve data from the computer.**

When the user is satisfied with the initial changes to the Master panel, **begin the tip raster and data collection by clicking “Frame Up” or “Frame Down” in the Master panel.**

As data fills in in the data windows on the right-hand side of the screen, the user will modify image parameters to visualize and optimize the data. First, lower the setpoint in order to bring the tip closer to the surface to a point where the tip is physically interacting with the surface. **In the Master panel, click on the radio button to the right of the “Setpoint” field. Slowly decrease the setpoint by turning the inner ring of the hamster wheel counter clockwise** (NOTE: increasing the setpoint above the initial tuning voltage does not make any sense here). Decrease the setpoint until topographic data begins to fill in in the data windows; specifically, pay attention to the blue and red trace/re-trace and image that fills in the Height Retrace window.

The user will further optimize the image by modulating the “Gain”. Turn the outer ring of the hamster wheel to toggle from “Setpoint” to “Gain”. **Once in the “Gain” field, turn the inner ring of the hamster wheel clockwise to slowly increase the gain.** As the gain increases the blue trace and retrace lines in the Height retrace data windows will approach and eventually overlap with minimal noise. If “ringing” in data occurs, adjust the gain back down.

Now that the image is optimized, the user may make note of the new number that is appended on the data when a new frame is started. The user may wait for the tool to complete the raster and start a new frame, or force a new one to start with “Frame Up” or “Frame Down”, or the user may give the file a new name. It is up to the user to develop a file naming convention that will help them determine which files will contain the most useful optimized images.

When a frame is complete and the user is satisfied with data collection, click on “Stop” in the Master panel. This ends data collection and tip raster.

In the Engage panel, on “Change Sample”. This raises the AFM head far above the sample stage, and moves the sample stage out of the tool toward the user. In the Engage Panel, click the tick box to turn off the vacuum if it was used. The user will remove their sample from the stage. If screws were removed from the stage, please replace them.

If desired, the user may unload the tip and reclaim it.

Fill out the log book.

Log out of Windows.

Turn off the pump if it was in use; replace screws in sample stage

Saving data as an image, and image processing

Data is saved in an .ibw (Igor binary wave) file extension. This data format is not an image or surface measurement file. The user will use some software, either the Asylum program on the tool or image processing software such as Gwiddon, to manipulate the .ibw file to obtain useful data. Here, the user will find some useful information on **how to export data as a 2D image in a JPEG or TIFF format, how to generate a 3D rendering of data, and how to obtain surface roughness measurements from an image.**

Close all other windows, or drag them out of the way. The user will be opening other windows to locate data and perform image processing.

Open the Data from the Windows file explorer. Locate the desired .ibw file. Left click on the file name and drag it from the File Explorer into the Asylum software.

A window with the user's collected image appears. The user can toggle between the height data, amplitude data, phase data, and the Z sensor data by toggling between the "HtR," "AmR," "PhR," and "ZSr", respectively, tabs in this window.

The user may be curious about the difference between height and z sensor data. The shortest explanation is that for data in the micron range down to 100 nm, the z sensor data tends to be the best image with less noise. For images with height data that is less than 100 nm, the height channel is the best. The other data channels are not useless. Users may also find that they can generate impressive images with phase data, provided they can tune the scan parameters to optimize phase contrast. At this point, that is an exercise left up to the user.

At any rate, the data that appears in the window is not truly raw data. The software automatically saves the data with a 1st order flattening algorithm; the algorithm corrects for distortions in the image that arise from the nature of the tapping mode raster. To view the raw data, click on the M button in the data window. **This opens a Modify panel that is open to a "Flatten" tab (Fig 16a). Click the "ultra-restore" option to restore the data to its raw form.** There are additional forms of data filtering and correction that are available, but not yet discussed here.

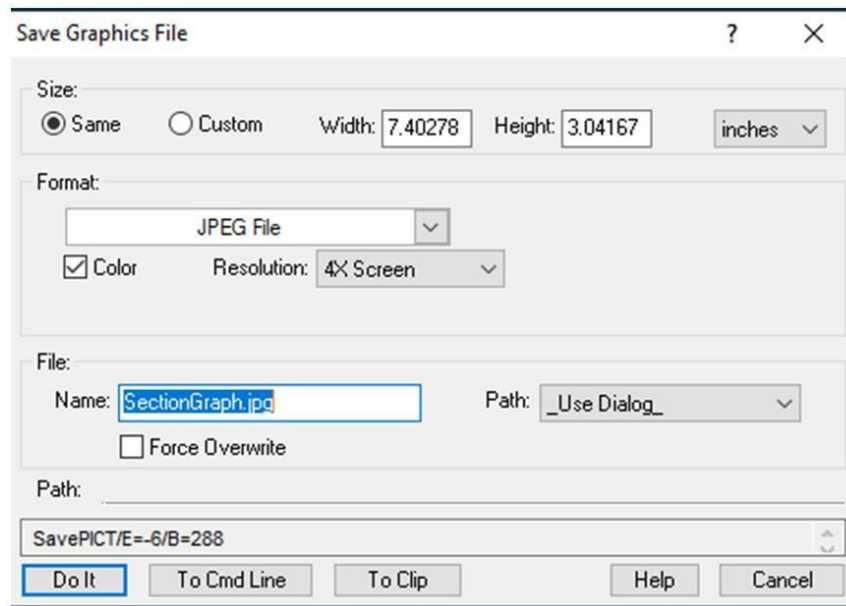


Figure 15. An image of the Save Graphics File window that allows the user to export data as an image

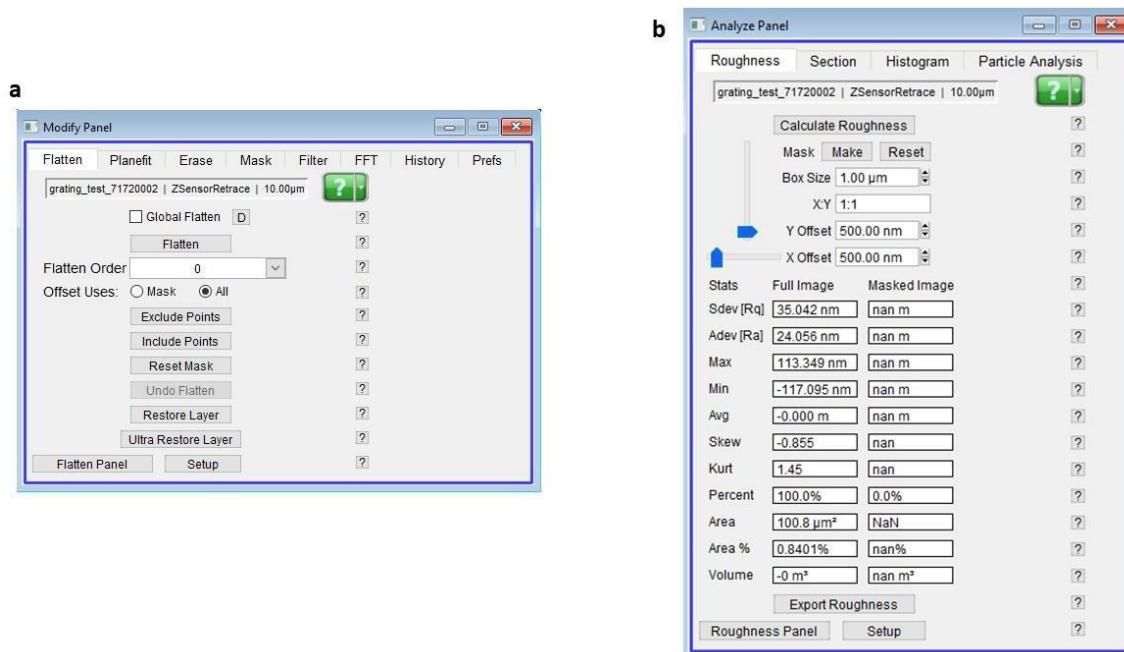


Figure 16. An image of the Modify panel (a), in which the user may “ultra restore” data back to the raw format. An image of the Analyze panel (b) is also included, where the user may obtain useful information about the surface roughness of a sample.

To save data as an image (flattened or not), the user will open the main File menu in the software, and click on “Save Graphics”. This opens a Save Graphics File window (Fig 15), where the user can define the size of the image, choose the file extension from a drop down menu (including JPEG and TIFF), and indicate a file name and path. Click “Do It” to execute. Alternatively, from the data window, clicking on “Command” opens a drop down menu with an option to export the file as a TIFF. This drop down menu also has the option to toggle between a “classic” and “new” appearance, which may be helpful to meet the formatting demands of a technical journal or a PI.

To analyze the sample surface, click on the A button in the data window. This opens the Analyze panel to the “Roughness” tab (Fig 16b). The fields are automatically populated with surface roughness data related to the full image. The user can define a box-shaped mask to calculate roughness of a box-shaped subsection of the image. The “Section” tab of this window allows the user to draw a line on the data image, and the software will calculate the length of the line, or cursors may be dropped on the line in order to measure a subsegment of the line. The line is a minimum of one pixel thick, but the user may make the line thicker in order to average more data points on the line.

To see a 3D plot of the data, click the 3D button on the data window. This opens a new window with a 3-dimensional rendering of the data with scales on the x-, y-, and z-axes (Fig 17). The user may click on the image and drag to rotate and view the rendering from other angles. This image can be saved and exported to a JPEG or TIFF as previously discussed.

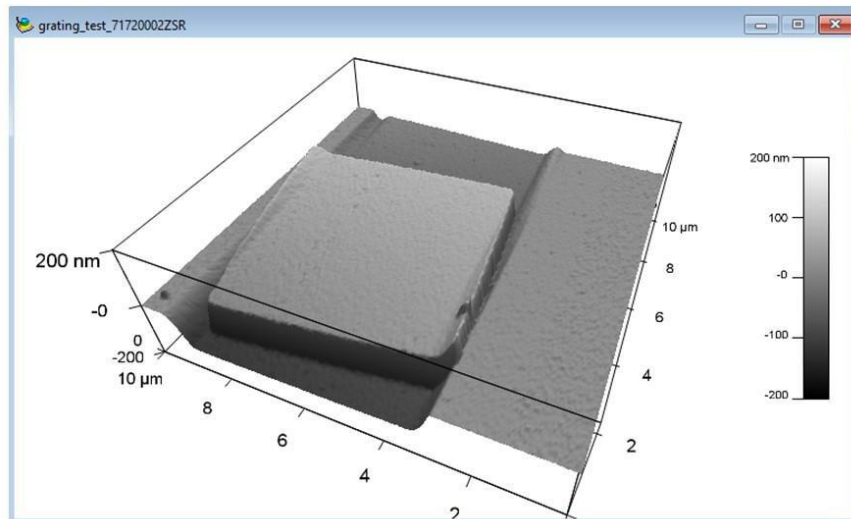


Figure 17. An image of a 3D rendering of data

Changing the AFM Probe

The user will want to learn how to change the AFM probe (aka “tip” or “cantilever”) for many reasons: to install a new probe at the beginning of the user’s session, to replace a probe that is broken or dull in the middle of a user’s session, or to install different tips that allow the user to access multiple modes of AFM during a session. Installing a fresh probe at the beginning of the session is the only way that the user can be for certain that the tip is unbroken, sharp, and free of contamination (i.e., do not rely on the previous user’s probe in the tool as a way to save money, as it might also be a waste of time). **This guide demonstrates how to remove and replace a probe from the AFM z-scanner.**

The user will need to provide a new probe and a pair of sharp-tipped tweezers. The user will also need a very small Phillips head screwdriver; this is provided in the small clear toolbox on the control desk (Figure 18a).

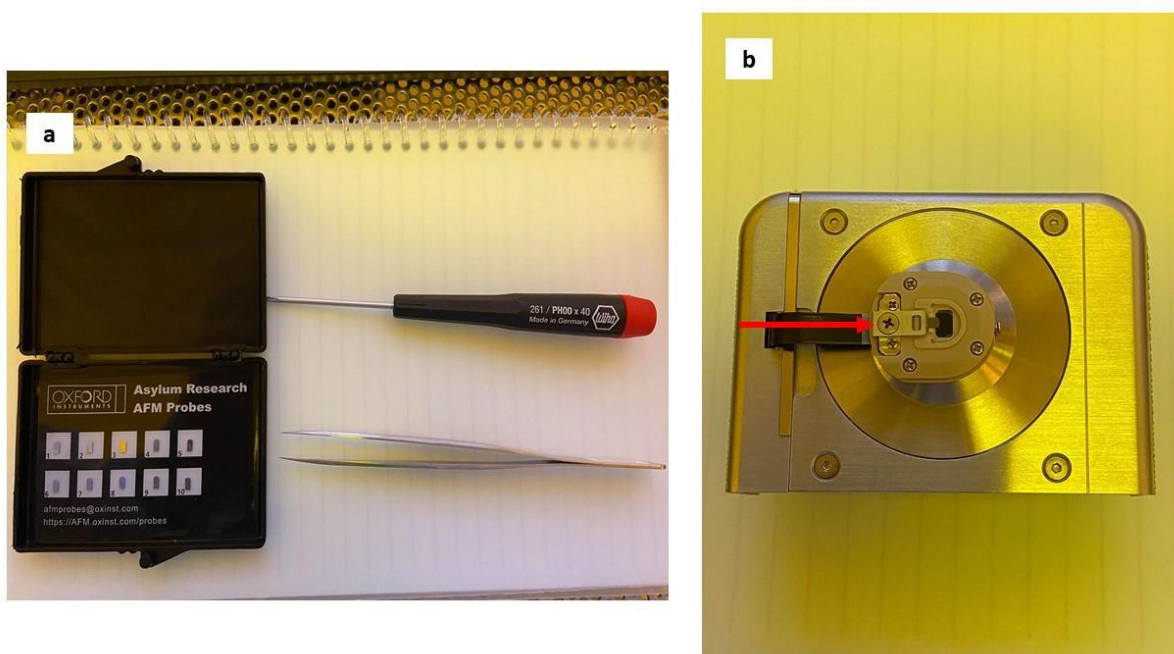


Figure 18. Image of (a) the tools of the trade, including a box of fresh tips, sharp-tipped tweezers, and a small Phillips head screwdriver; and (b) and image of the z-scanner resting on a tabletop with the beige tip holder facing upward. **Notice the red arrow that points to the ONLY SCREW THAT THE USER WILL LOOSEN/TIGHTEN**

From the Jupiter software, in the Engage panel, click on “Change Cantilever,” and wait for the button to turn green in color (Fig 7). This moves the stage to a location where it is out of the way of the user, and this also disengages the AFM lasers. On the AFM head, a light that says “Ok to Remove” will be illuminated.

Disengage the green lever that locks the z-scanner in place (Fig 19a). Using a thumb and a forefinger, use one hand to carefully grasp the z-scanner on either side and pull it out of the tool (Fig 19b)

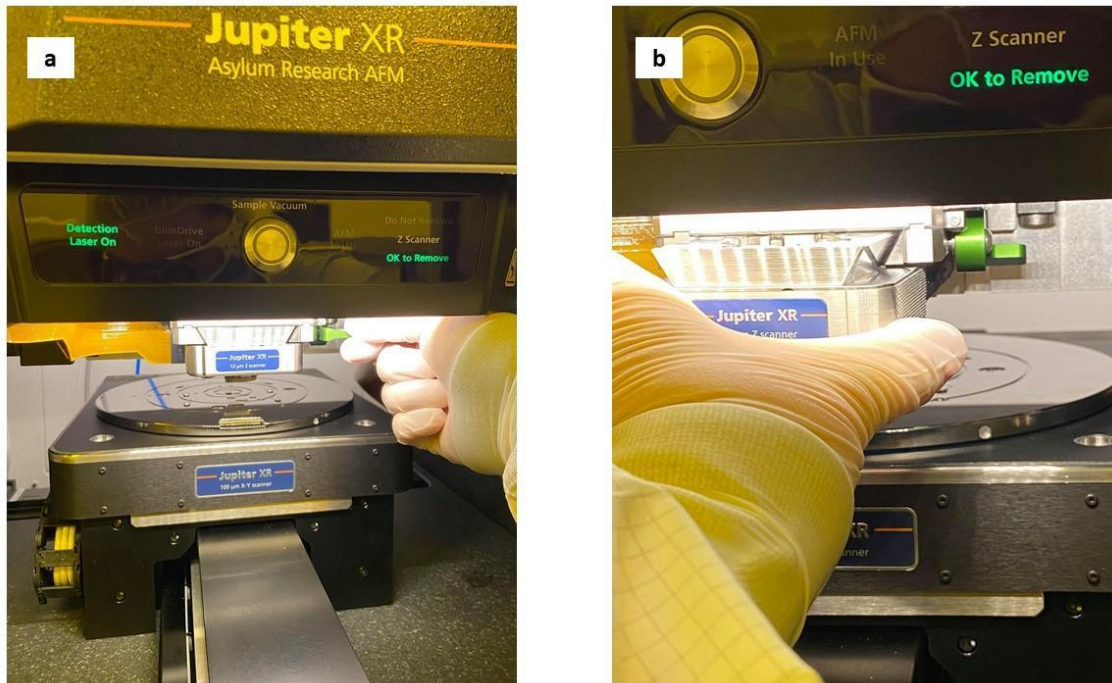


Figure 19. Images of (a) the user disengaging the green lever on the AFM head and (b) the correct technique for grasping and removing the z-scanner

Carefully, carry the z-scanner over to the stereoscope, and place it on the table. The beige disk that forms the tip holder should face upward (Fig 18b). Use the Phillips head screwdriver to loosen the central screw by a few turns, **BUT DO NOT REMOVE IT COMPLETELY** (Fig 20a)

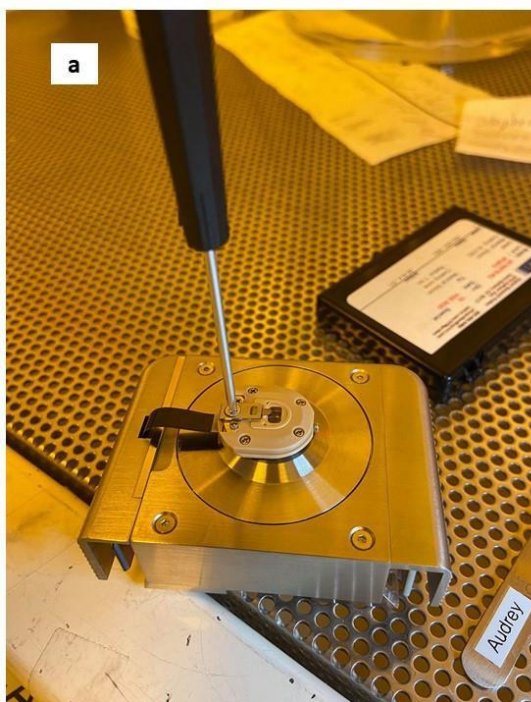


Figure 20. Images of steps to remove the old probe, including (a) using the Phillips head screwdriver to loosen the central screw and (b) viewing the z-scanner under the stereoscope in bay 5.

Place the z-scanner under the stereoscope (Fig 20b). Turn on the stereoscope light, and adjust and focus the stereoscope until the probe is visible in the eyepieces. Notice that on the beige probe holder, there are 2 vertical pillars and a flat back wall that form a channel in which the probe is situated. Note that the probe sits squarely between the 2 pillars and is equidistant from each one, and the back flat edge of the probe is positioned evenly and flat against the back wall (Fig 21a).

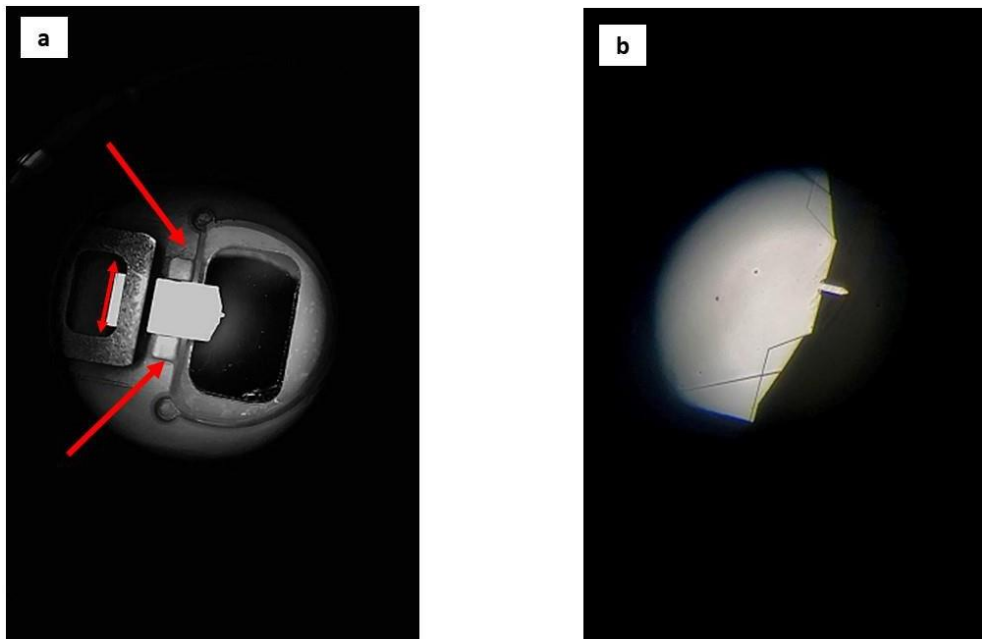


Figure 21. Image of a cantilever in the tip holder. Notice the channel created by the two square pillars and the back wall, indicated by red arrows. An image of (b), a sharp, fresh tip as viewed at high magnification under the stereoscope.

Using the tweezers, grasp the old probe by the sides, and pull it out of the channel. Discard the old probe. Look at the empty channel under the stereoscope. The channel should be free of any silicon shards or debris left behind from the previous tip.

Grasp a fresh probe by the side edges, and carefully slide the probe into the channel of the tip holder.

Use the sharp tips of the tweezers to make very fine adjustments of the probe position. Again, the flat edge of the probe shall lie flush and square against the back wall of the channel and equidistant from either pillar (Fig 21a). **Use one hand to manipulate the tweezers, and steady the hand with the opposite hand. This step is where viewing the tip holder under the stereoscope is the most helpful.**

Tighten the Phillips head screw. The screw should be tight enough that the probe will not move when gently bumped by the tip of the tweezer, but not so tight as to crush and break the base of the probe.

Return the z-scanner to the AFM and lock into place with the green lever. Return the screwdriver to the tool box. Secure the user's supplies in a safe storage place.