



Integrated Circuit
Scanning Probe Instruments



Atomic Force Microscope User Manual

Version 1.0

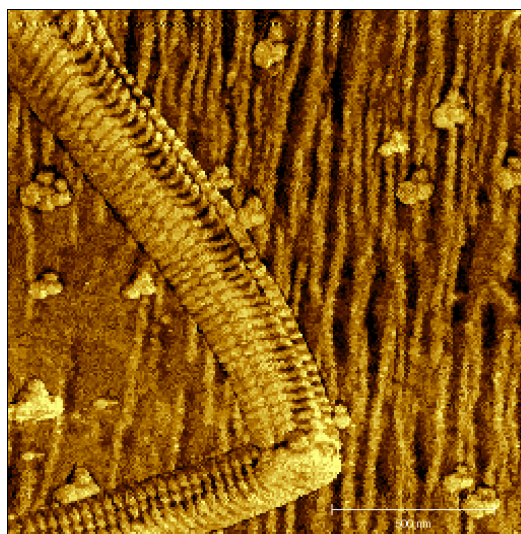
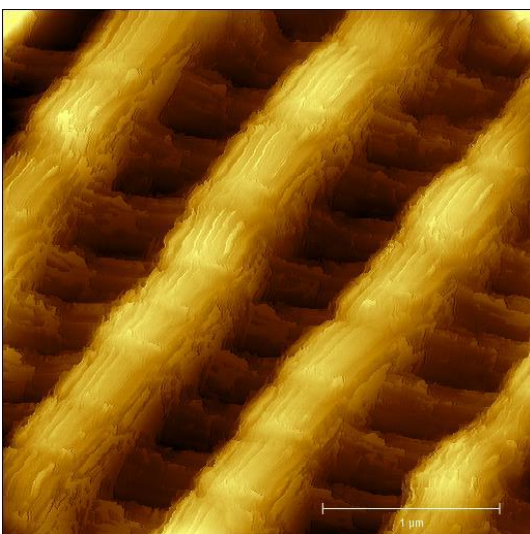


Table of Contents

Introduction	3
1.0 Safety and Precautions	3
2.0 Overview	4
2.1 AFM Basics	4
2.2 sc-AFM Basics.....	5
2.3 nGauge AFM Components	5
2.4 nGauge AFM Capabilities and Limitations	6
3.0 Setup	6
3.1 Where to set it up	6
3.2 How to set it up.....	6
3.3 Installing the Software	9
4.0 Basic Operation.....	10
4.1 Software Overview.....	10
4.2 Preparation and Approach.....	11
4.3 Imaging.....	12
4.4 Analyzing Data	14
5.0 Post-Processing.....	14
5.1 Gwyddion	14
6.0 Troubleshooting.....	15
7.0 Advanced Controls.....	17
7.1 Frequency Sweep - Advanced Controls	17
7.2 Approach - Advanced Controls	18
7.3 Scan - Advanced Controls	18
7.4 Menu Button - Advanced Controls	19

Introduction

Congratulations on purchasing the world's first single-chip Atomic Force Microscope (sc-AFM) system! nGauge achieves magnification that far surpasses that of an optical microscope, so that you may explore the world with nanometer-scale resolution.

The most up-to-date instruction manual can always be downloaded from www.icspicorp.com/resources.

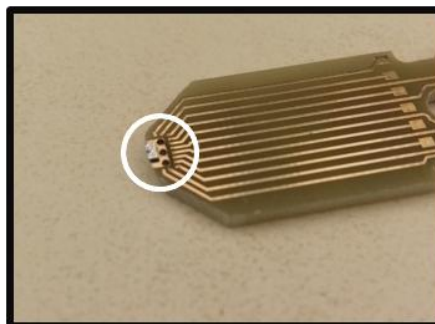
Please read this instruction manual before operating your new instrument to learn how it works, how to set up and operate the hardware and software, how to prepare samples, and how to visualize your data. The nGauge team has made every effort to improve the ease-of-use of AFMs, and we welcome any feedback that may improve your experience.

1.0 Safety and Precautions

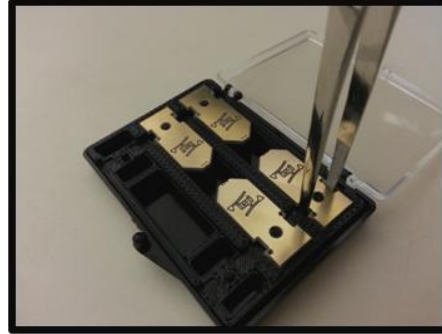
The following warnings and precautions should be observed to ensure the safety of the user and the instrument:

- Use only the power supply provided. The driving electronics are designed to accept 7.5Vdc, and an internal fuse prevents the input current from exceeding 1A.
- The stage contains moving parts that could pinch. To avoid minor injury, be aware of the moving parts.
- Avoid disassembling the system. If not done properly, this could result in damage to the electronics or the mechanical components.
- Be extremely careful when handling an AFM chip. They are very fragile and will break if the tip is touched. AFM chips should be stored in their box with the tip facing DOWN, and removed using the tweezers provided. If necessary, the AFM chip can be placed on a flat surface with the tip facing up. The AFM chip can be picked up by hand by the board as long as you are careful to avoid touching the tip.

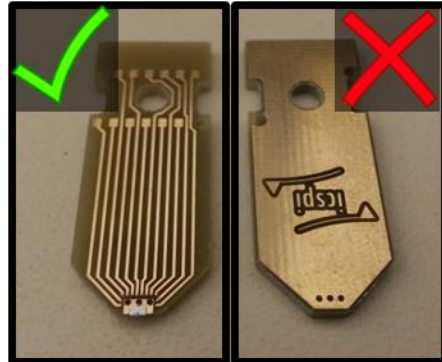
The tip, located at the edge of the board, is extremely fragile.



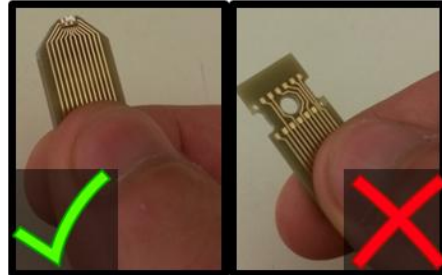
AFM chips should be stored with the tip facing DOWN in the storage box. Use tweezers to pick them up.



The AFM chip can be placed on a flat surface with the tip facing up.



The AFM chip can be picked up by hand as long as you don't touch the tip.



2.0 Overview

2.1 AFM Basics

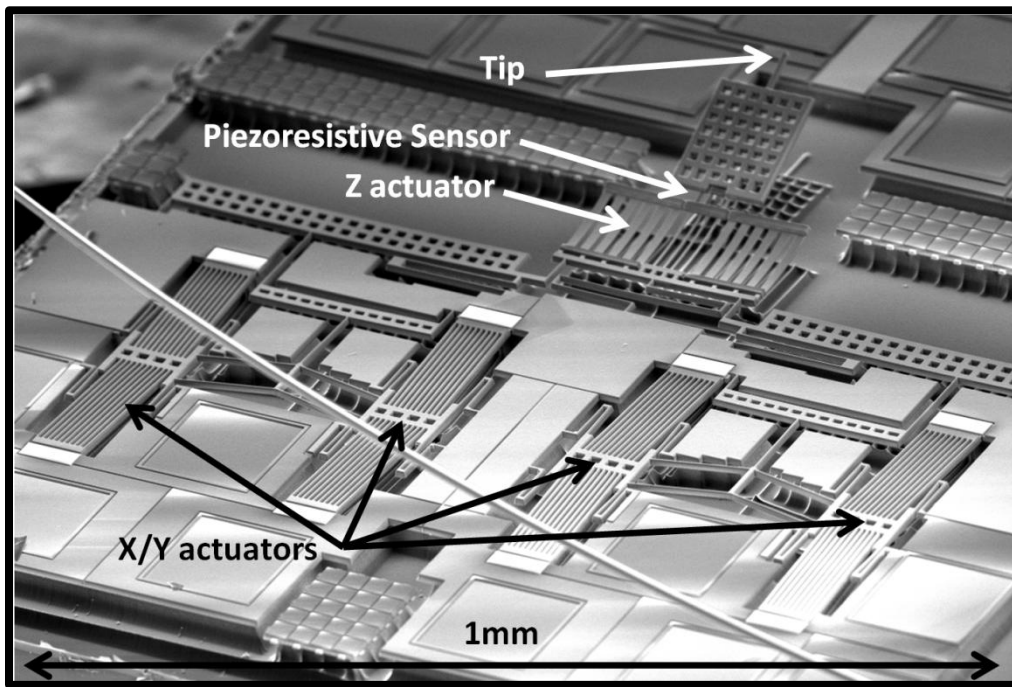
Unlike optical microscopes that use light and lenses to magnify, or electron microscopes which use electron beams to generate an image, Atomic Force Microscopes (AFMs) use a very sharp tip to measure tip-sample interaction forces and generate a 3D reconstruction of a sample surface. The tip is raster scanned over a 2D area while a controller maintains a constant tip-sample force by adjusting the tip's Z height. The control effort then represents the height of the features on the sample.

Conventional AFMs typically use a probe comprising a sharp tip on a silicon cantilever. A laser beam is reflected off the backside of the cantilever onto a 4-quadrant photodetector that measures any small displacements of the cantilever. A piezoelectric Z-scanner controls the height of the probe while a piezoelectric XY stage raster scans the sample in X and Y.

2.2 sc-AFM Basics

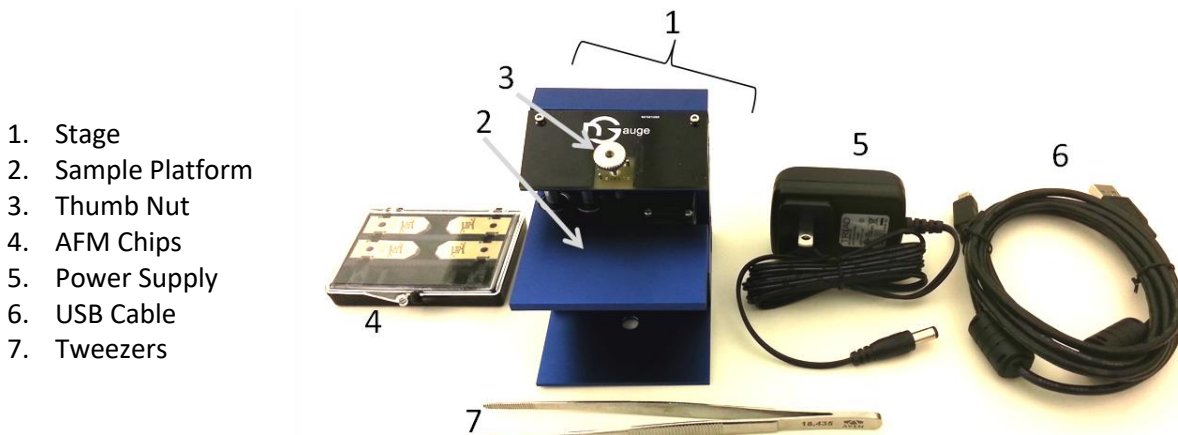
A single-chip AFM (sc-AFM) operates in almost exactly the same manner as a conventional AFM except that all of the essential components are integrated onto a chip. The chip is a MicroElectroMechanical Systems (MEMS) device that uses the most advanced manufacturing process in the world to produce tiny, ultra-precise scanners and sensors on a $\sim 1 \times 1$ mm silicon chip.

An sc-AFM has a cantilever and a sharp tip, but instead of a laser it has an integrated piezoresistive strain sensor to measure tip displacements. The tip and sensor are attached to a MEMS scanner that can position them in X, Y, and Z with sub-nanometer resolution.



2.3 nGauge AFM Components

The nGauge AFM system includes all of the following components. A computer (not included) with a USB port is required.



2.4 nGauge AFM Capabilities and Limitations

The nGauge AFM operates in tapping mode, in which the cantilever oscillates at its resonant frequency and makes intermittent contact, or “taps” the sample surface. It can scan areas of up to 20x20x10um in X, Y, and Z respectively with <2nm RMS Z noise.

Any solid sample can be imaged, including both conductive and non-conductive, but the AFM cannot operate in liquid and cannot image liquid samples. Some samples, particularly polymers, may be difficult to image due to surface charging.

3.0 Setup

3.1 Where to set it up

The nGauge AFM is small, simple, and portable, and can be set up just about anywhere. However, for best results, it is recommended that you adhere to the following guidelines:

- **Flat surface:** The system should be set up on a flat, level surface, like a desk or tabletop, with enough space to ensure that the stage does not get bumped or moved while imaging.
- **Vibrations:** The unique design of the nGauge AFM minimizes the effects of common sources of vibrations, such as those caused by people walking by, doors opening and closing, and building vibrations. However, it is best to set the system up on a solid, stable surface away from as many sources of vibration as possible.
- **Air Drafts:** The system is not immune to air drafts and should be set up away from air vents, drafty windows, etc. If air drafts are unavoidable and present a significant problem, a box or enclosure around the system may be required.
- **Electrical Noise:** The system meets the FCC guidelines for electrical interference, but it is best to avoid setting it up near sources of electrical noise, such as server rooms or rooms operating high-power equipment.

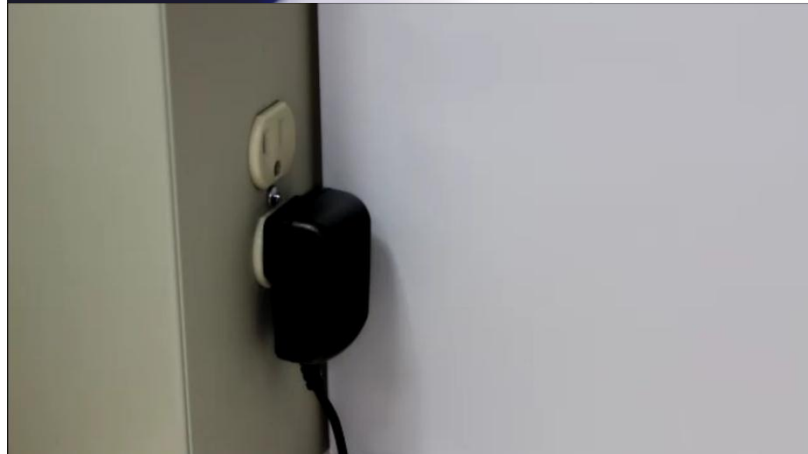
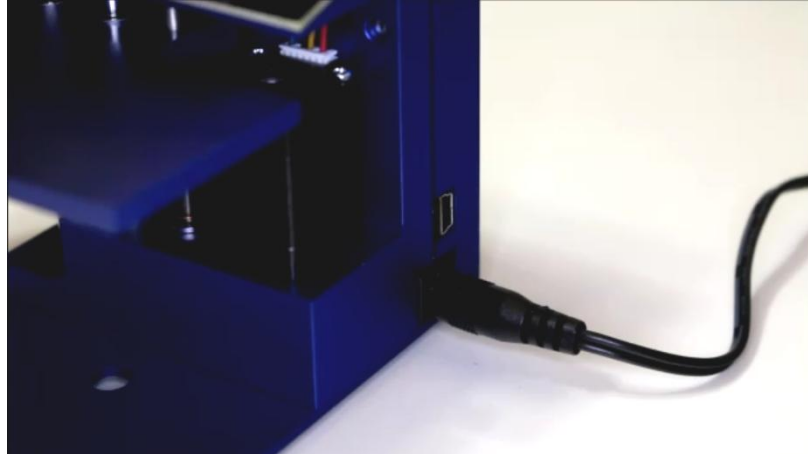
3.2 How to set it up

Setup of the nGauge AFM is very simple.

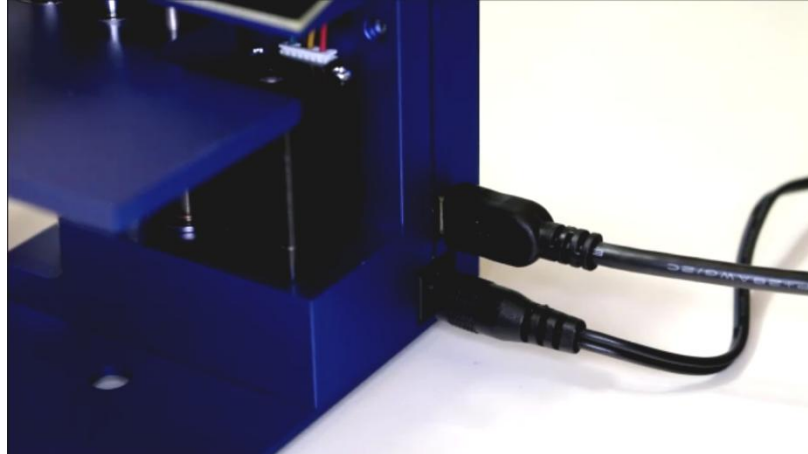
-
1. Remove the components from the carrying case. Set the stage upright on a flat surface.



2. Plug the power supply into a wall outlet and into the power connector in the stage.



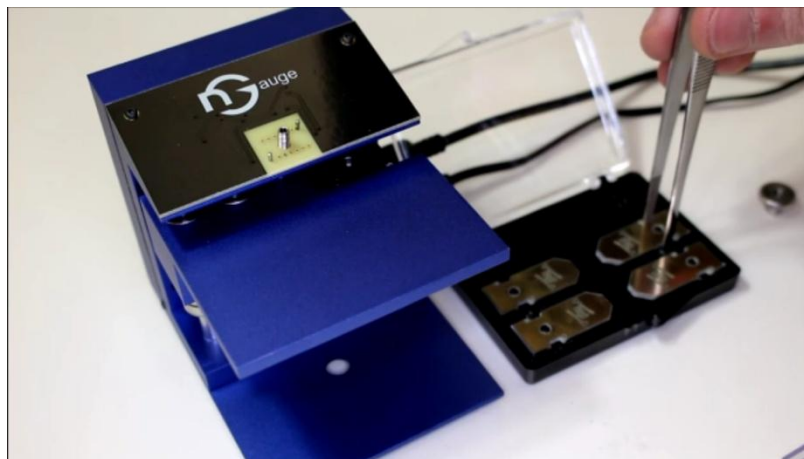
-
3. Connect the USB cable to a computer and to the USB connector in the stage.



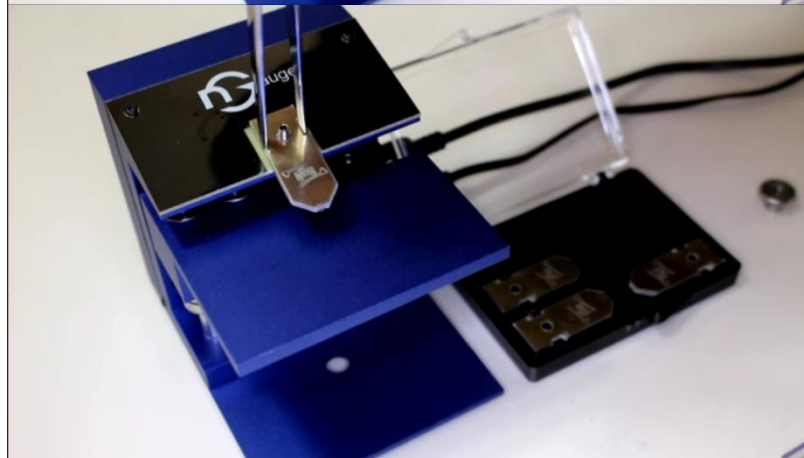
4. Completely unscrew and remove the thumb nut from the stage



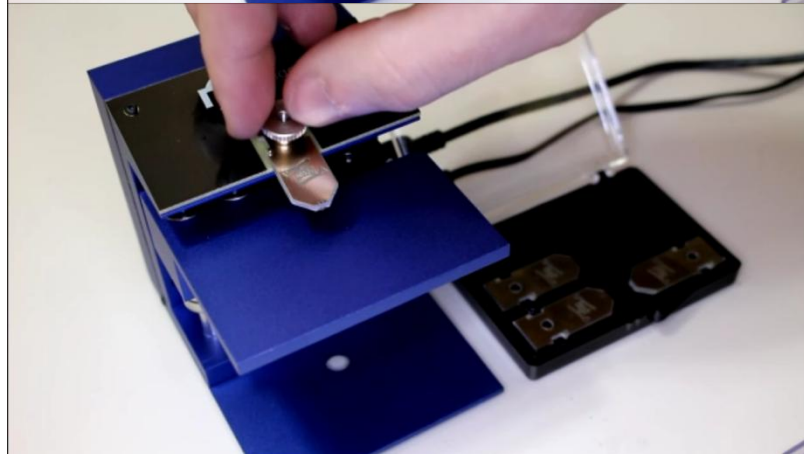
5. Open up the AFM chip box and pick up an AFM chip using the tweezers



6. Carefully place the AFM chip onto the alignment pins on the stage with the tip facing down. During this step, the sample platform should be retracted sufficiently to avoid any contact between the tip and platform.



7. Replace the thumb nut and firmly tighten it.

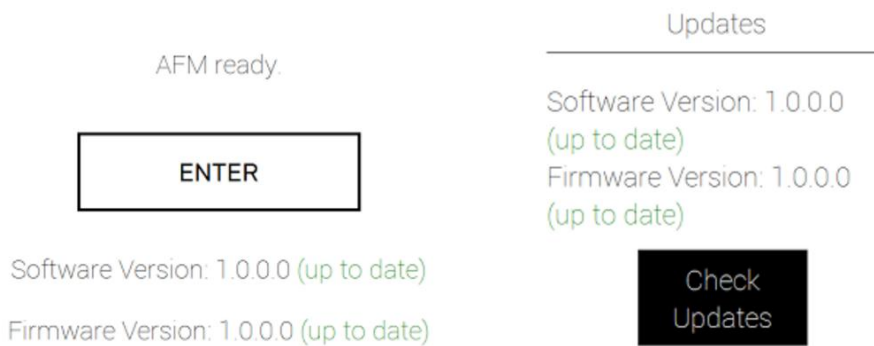


3.3 Installing the Software

The software required to operate the AFM can be found on the USB stick provided, or downloaded from www.icspicorp.com/resources. To install the software for windows, run the executable installer “nGauge_setup_x.x.x.x_windows.exe”. To install the software on Mac OS, simply mount the disk image “nGauge_setup_x.x.x.x_mac.dmg” and drag the nGauge application into the applications folder.

If network connection is available, the software will automatically check for updates from the ICSPi server. This information is displayed on both the home screen and in the updates section of the menu. To manually query the ICSPi update server for new updates, click **Check Updates** under the updates section of the menu.

Welcome to nGauge.



The open source AFM post-processing software called Gwyddion is a very useful tool and should also be installed. You can download it from the Gwyddion website: <http://gwyddion.net/download.php>. See section 5.1 Gwyddion for more details.

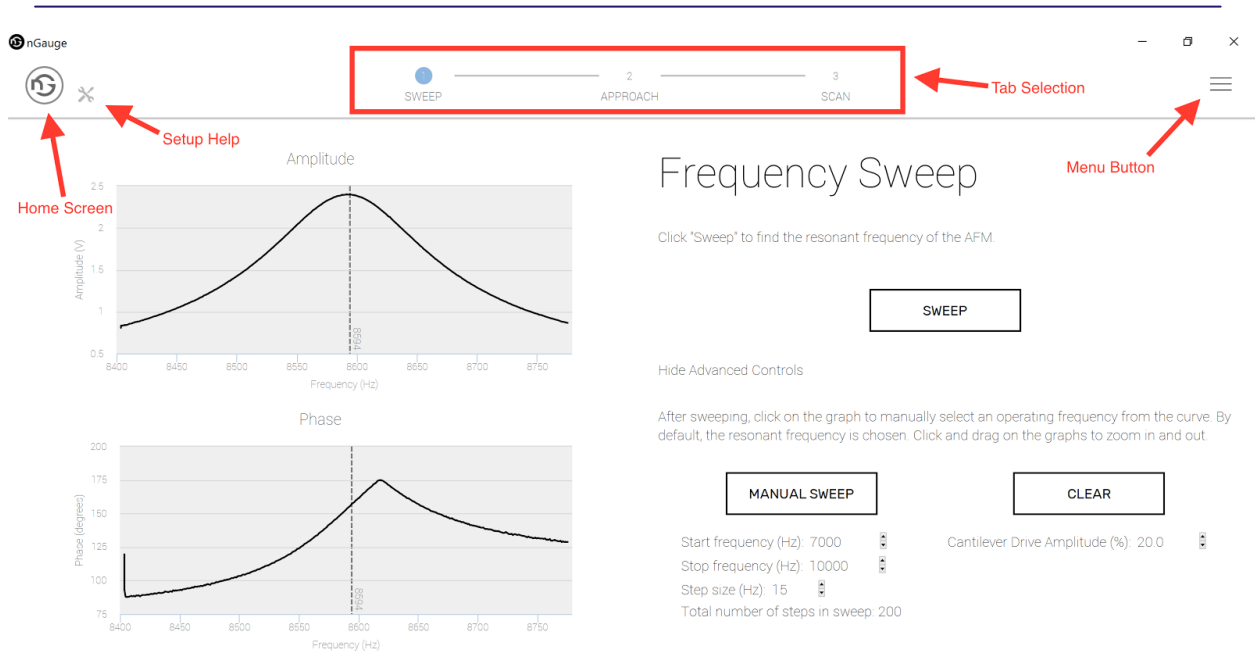
4.0 Basic Operation

4.1 Software Overview

Launch the software by double-clicking on the nGauge program on your desktop or searching for nGauge in start menu. If the AFM is powered up and connected to the computer with the USB cable, the splash screen should display the message "AFM Ready". If not, refer to section 6.0 Troubleshooting.

The setup and imaging workflow is divided into three ordered tabs: **Sweep**, **Approach**, and **Scan**. To navigate between the three tabs, click on the desired tab in the progress bar at the top of the page. The menu button at top-right of the page brings out a detailed settings menu for all aspect of AFM configuration. Please review section

7.4 Menu Button - Advanced Controls for details.



4.2 Preparation and Approach

Once the AFM has been set up and the software installed, you are ready to start imaging. Launch the software, wait for the message "AFM ready", and click the **Enter** button. Place your sample on the sample platform, making sure you don't touch the tip. If the sample will not fit under the tip, lower the sample platform by clicking on the **Approach** tab, then clicking and holding down the **Retract** button until the platform is low enough. Position the sample so that the area to be scanned is directly under the tip. Ensure the sample is stable on the sample platform, and that it won't tilt, roll, flutter, drift, or otherwise move while imaging.

Navigate to the Sweep tab and click the **Sweep** button to perform a frequency sweep of the cantilever. This may take a few seconds. The Amplitude graph should display a smooth curve with a maximum value greater than 1. If not, refer to section 6.0 Troubleshooting. Click the **Approach** tab to proceed.

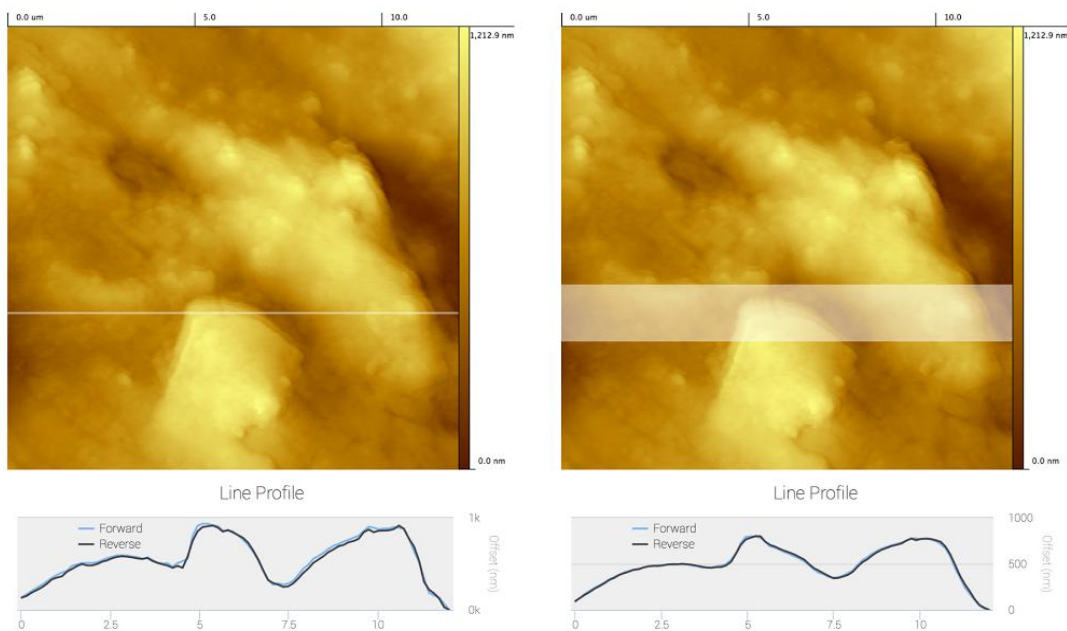


In the Approach tab, click the **Approach** button to initiate the auto-approach. The sample platform will rise quickly and then slow down for a final approach once the sample gets very close. The data being streamed on the graph represents the cantilever oscillation amplitude, and it will begin to decrease as the sample gets close and tip-sample interaction is observed. When the auto-approach is complete, the tip will be engaged with the sample and you can proceed to imaging. If the cantilever oscillation amplitude does not track the setpoint or the amplitude oscillates, please refer to section 6.0 Troubleshooting.

4.3 Imaging

In the **Scan** tab, choose the image resolution you would like by selecting the **number of pixels per line** and the **number of lines** per image. The higher the resolution, the longer it will take to complete a scan. The **Time spent at each point** field indicates the amount of time that the tip dwells above each point of the scan and ultimately determines the scan speed. A smaller number in this field increases the scan speed, but if the scan is too fast the resulting image may be blurry or distorted.

Click **Scan** to begin imaging. The image will begin to build up line by line. The color in the image represents the height of the features, and some minor corrections (line leveling, plane leveling) can be applied to the raw data to display a clearer image by checking the **Level Image** checkbox on the left side of the screen. There you will also find the options to display the topography, phase, or error images in both the forward and reverse directions. A profile view can be found below the image that displays the cross-section (height) of the current line being scanned. When the scan is completed, the line under your cursor would be displayed on the line profile plot. You can widen or narrow the line profile by using the scroll wheel.



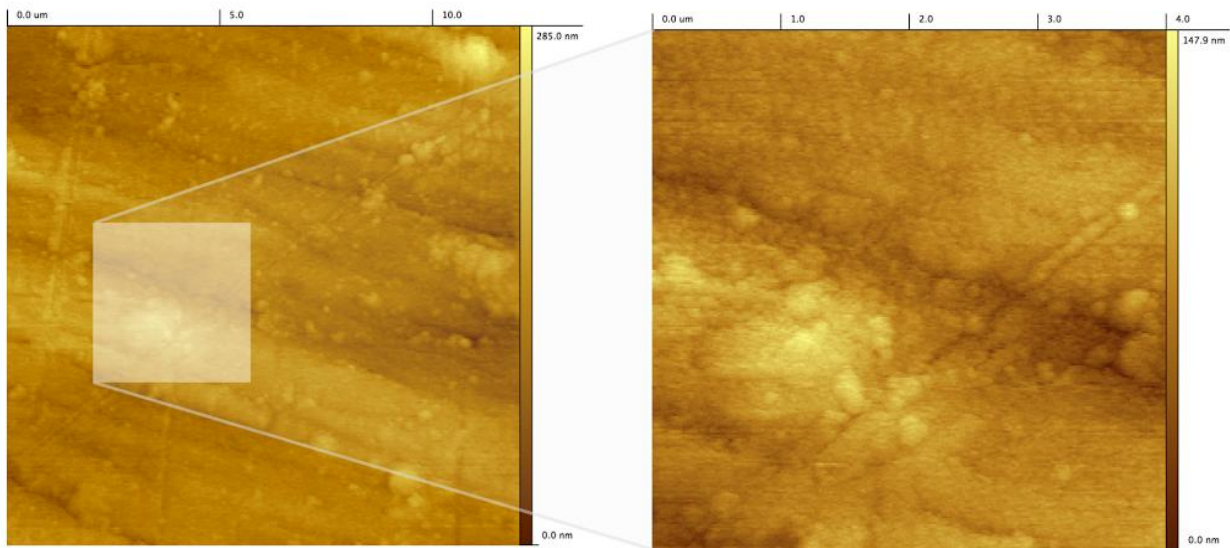
The Z actuator is split into Coarse Z and Fine Z controls. The Fine Z has a smaller range, and it's the control that is used to track sample topology while scanning. If a sample has tall features that extend

beyond the range of the Fine Z control, the image will get clipped. To increase or decrease the Fine Z scan range, click on the **Menu**, then under PGAs, adjust the Fine Z. For maximum imaging resolution, the smallest Fine Z range should be used. It is also possible that the sample topology is not centered around the middle of the Fine Z range, which could result in image clipping. The Approach tab displays a graph with the Fine Z position. If it appears that most of the image data is at the lower or higher end of the Fine Z range, you can click **Show Advanced Controls** and increase or decrease the Coarse Z to center the data. In some cases, you may even need to **Disengage** and then re-**Approach**.

There are several parameters that you can control to improve the imaging performance. The **Time spent at each point** is the number of microseconds that the tip will dwell above each data point. As you decrease this value, the scan speed will increase and the controller will have less time to track the sample topology, leading to poor image results. The **Set Point** is the tip oscillation amplitude that the controller will try to maintain as the tip scans over the sample surface. It can be thought of as the amount of force that the tip exerts as it taps the surface, where a lower setpoint exerts more force. A lower setpoint can often give better results, but is also more likely to damage the tip or sample, and when the setpoint gets too low the imaging performance may suffer. A PI controller is used to maintain a constant tip oscillation amplitude throughout the scan by adjusting the Fine Z height. The **Proportional** and **Integral** control in the advanced controls section are used to adjust the response of the controller, and can be tuned to give the best sample tracking performance. See section 6.0 Troubleshooting for more details for PI tuning.

At any time you can click **Pause** and **Resume** to temporarily halt and then resume the current scan, or you can **Pause** and then **Reset** to re-start the current scan at the beginning. When the scan is complete, you will be able to click **Save** to save the image as a .gwy file which is native to Gwyddion (a post-processing software), and as a .png image. You can also save the data as a .tsv file where the data points are arranged in a 2-d tab and line separated table. The image will be saved in the folder specified by **Path**, which you can click on to change.

To zoom into a region of interest, you can drag across the displayed image to select an area to zoom in. Click **Scan** again after the selection has been made to scan the region of interest. To reset to the original scan area, click **Reset Zoom**. If **Reset Zoom** button is disabled, the AFM will scan the default area.



When you are finished with the AFM, go to the **Approach** tab and click **Disengage** to safely disengage the tip from the sample. After the disengage routine is completed (a few seconds), hold the **Retract** button to rapidly move the sample downwards to the point where there is sufficient separation between the sample and the tip to safely remove the sample. It is advisable to **always disengage and retract** when finished with the AFM lest any external disturbances (such as accidentally bumping into the stage) cause the tip to crash into the sample. **Caution:** the tip is extremely fragile so please avoid crashing the tip into the sample while removing the sample.

4.4 Analyzing Data

Once a scan is complete, users often want to extract some quantitative data about the sample, like the height or width of a specific feature, or the RMS roughness of the surface. These measurements are best acquired using Gwyddion, a powerful AFM post-processing program that is explained in section 5.0 Post-Processing.

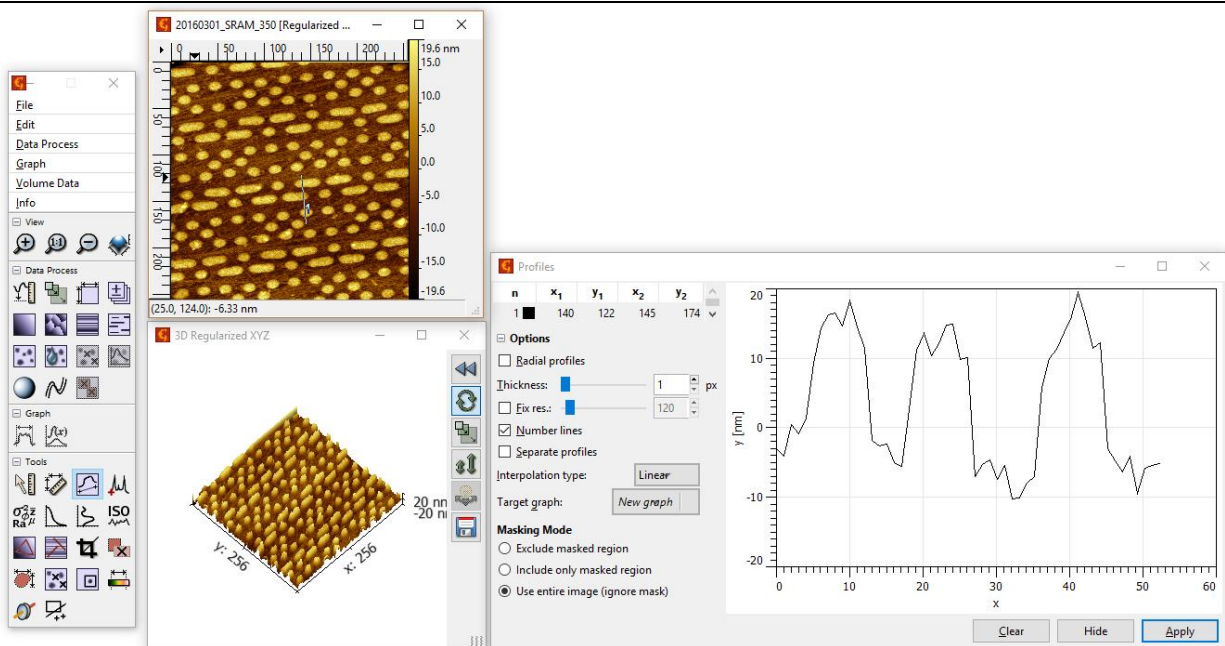
5.0 Post-Processing

5.1 Gwyddion

Gwyddion is free and open-source software for AFM image post-processing. It can be downloaded here: <http://gwyddion.net/download.php> . The nGauge user interface can save images in a Gwyddion-supported format (.gsf) which can then be dragged and dropped into Gwyddion to open them. The Gwyddion user manual gives detailed descriptions of the program's capabilities, but below are some useful functions that are commonly used:

Data Process --> Level --> Polynomial Background	If there is any tilt or curvature in the image, this function will help remove it. You can specify the polynomial degree in the horizontal and vertical directions.
---	---

Data Process --> Correct Data --> Align Rows	If each horizontal line in the image does not quite line up with the ones above and below it, this function will subtract the height differences line-by-line. "Median of differences" works well.
Data Process --> Basic Operations --> Limit Range	A random high or low pixel can throw off the contrast in an image. This function allows you to set a high and low value to remove outliers or extra large features.
Tools --> Crop Data	Crop out unwanted parts of an image.
Tools --> Extract Profile	Drag a line over your image to view the profile.
Tools --> Statistical Quantities	Display values like RMS roughness and Ra. A box can be dragged over your image to select a specific area to measure.
View --> 3D View	Display a 3D view of the image. You can rotate or scale this 3D image, change the colors, and save it.



Once you are satisfied with the post-processed image, you can save it as JPG, PNG, etc using the **Save As** option. You will be prompted with export options in which you can customize the resolution, scale bars, font sizes, colors, and other options.

6.0 Troubleshooting

Issue

Solution

Hardware not detected by computer

Unplug and then plug in the USB and/or power. Restart the software if necessary. In your computer's Device Manager, check to see if there is a COM port called Bossa Program Port or AT91. If there is no COM port by these names, but the hardware shows up as a USB device, right click on the USB device, click Update Driver Software, then Browse My Computer For Driver Software, and navigate to "C:\Program Files (x86)\ICSPI\nGauge\firmware\ISP\sam-ba_3.1.1\driver\atm6124_cdc.cat". After installing this driver, try unplugging and plugging in the USB cable,

	and restarting the software again.
Stage will not move	<p>Restart the software and make sure that the hardware connects properly by watching for the “AFM Ready” notification on the splash screen. The sample platform can only be lowered so far before a limit switch prevents further travel. Once the limit switch is triggered, you will not be able to retract any more, but you should be able to approach. However, if there is no functional AFM chip affixed to the stage, the platform cannot approach. Override controls exist in the Menu button on the top right of the screen. After clicking the Menu button, the Motor Controls can be used to approach without a functional AFM chip.</p> <p>If the stage still will not move, contact info@icspicorp.com for help.</p>
Auto approach will not run	<p>An AFM chip must be affixed and running at resonance in order to start the Auto Approach. If an AFM is already affixed, go to the Frequency Sweep tab and click Sweep. A smooth curve with an obvious peak should be shown. If the maximum value of the peak is less than 2V, click on Advanced and increase the Amplitude, then sweep again. If the top of the curve is cut off, decrease the amplitude and sweep again. If the frequency sweep plot data is flat and noisy, tighten the thumb nut on the AFM chip. If the problem persists, the AFM chip may be damaged.</p>
Frequency sweep flat	<p>A frequency sweep should return a smooth curve with an obvious peak. If instead the data is flat and noisy, try tightening the thumb nut on the AFM chip to make a better electrical connection, and sweep again. If the data is still flat and noisy, the AFM chip may be damaged. Click on the Menu on the top right of the screen and scroll down and click Read All. If any of the values under Resistances is greater than 1000, the AFM chip is damaged and must be replaced.</p>
Peak value of frequency sweep is lower than 1 or getting cut off above 3.3 Drift in Z when imaging	<p>Click on show advanced options and adjust Cantilever Drive Amplitude (%). Increase the value if peak value is lower than 1; decrease if greater than 3.3. Generally, a drive amplitude of 20-35% is appropriate.</p> <p>If there are large line-to-line variations in height, the sample may not be secure. For instance, if imaging a lightweight sample (e.g. piece of paper), air drafts may cause significant drifts - fasten the sample down with a heavy object.</p> <p>If the approach completes early and the image does not contain topography information, it is possible that the surface is charged. One way to verify this is to perform another frequency sweep. If a complete curve is obtained, with the peak at a new frequency, the sample may need to be discharged before imaging.</p>
Noisy image	<p>If the image results are excessively noisy, this may be caused by vibrations or air drafts. Try moving the stage to a different location, placing the stage on some soft foam or bubble wrap, or place a box over the stage to eliminate drafts.</p>
Data "plateaus"	<p>The Z actuator is split into Coarse Z and Fine Z controls. The Fine Z has a smaller range, and it's the control that is used to track sample topology while scanning. If a sample has tall features that extend beyond the range of the Fine Z control, the image will get clipped. To increase or decrease the Fine Z scan range, click on the Menu, then under PGAs, adjust the Fine Z. For maximum imaging resolution, the smallest Fine Z range should be</p>

used. It is also possible that the sample topology is not centered around the middle of the Fine Z range, which could result in image clipping. The Approach tab displays a graph with the Fine Z position. If it appears that most of the image data is at the lower or higher end of the Fine Z range, you can click **Show Advanced Controls** and increase or decrease the Coarse Z to center the data. In some cases, you may even need to **Disengage** and then re-**Approach**.

PID Controller Tuning

The PI controller measures the tip oscillation amplitude and subtracts this value from the setpoint to give an error term. The error term is multiplied by the Proportional (P) coefficient and the Integral (I) coefficient to generate a response in the Fine Z. If the P and I coefficients are too low, the controller response will be slow and the tip will not track the sample topology very well. If the P and I coefficients are too high, the controller may oscillate and the image will look like noise. One method of tuning the P and I values is to set them both to zero and increase the P until it begins to oscillate, then decrease P by a bit. Then begin to increase the I until it begins to oscillate and decrease I by a bit. For more detail, refer to https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method

7.0 Advanced Controls

The main controls that are visible in each screen should be sufficient for normal imaging conditions. However, each tab in the navigation contains advanced controls that can extend the functionality or control of the scan. In addition, there is a side menu available by clicking the button on the top right of the screen that will enable access to all of the controls available.

7.1 Frequency Sweep - Advanced Controls

In the frequency sweep tab, click on **Show Advanced Controls**. These additional controls are for running a manual frequency sweep and controlling the driving frequency and tip oscillation amplitude. When the advanced controls are displayed, the drive frequency can also be set by clicking the sweep graph at the desired frequency.

Start Frequency	The frequency at which you would like to start a manual frequency sweep
Stop Frequency	The frequency at which you would like to stop a manual frequency sweep
Step Size	The step size, in hertz, that the manual frequency sweep will increment. Step Size determines the number of data points in the results.
Manual Sweep	Manual Sweep will perform a frequency sweep from Start Frequency to Stop Frequency, incrementing the frequency by Step Size. The results will be displayed in the main Frequency Sweep plot.
Clear	Clears all the results from the main Frequency Sweep plot.
Amplitude (%)	Controls the amplitude of the driving signal applied to the Z actuator. This can be thought of as the tip oscillation amplitude. Increasing this value will increase the tip oscillation amplitude.

7.2 Approach - Advanced Controls

In the approach tab, click on **Show Advanced Controls**. These additional controls are for the controller, and the coarse Z positioning.

Proportional	The proportional gain coefficient of the PI controller. See section 4.3 Imaging for details on tuning the controller.
Integral	The integral gain coefficient of the PI controller. See section 4.3 Imaging for details on tuning the controller.
Setpoint	The tip oscillation amplitude that the controller will try to maintain. Increasing this value can be thought of as applying less force between the tip and sample. Decreasing this value can be thought of as applying more force between the tip and sample.
Enable/Disable	Manually turns the controller on or off.
Z Coarse	Controls the coarse Z tip position. Increasing this value retracts the tip away from the sample, decreasing this value approaches the tip towards the sample. This controls the AFMc chip's integrated Z scanner and should not be confused with the stage controls that raise or lower the sample platform.

7.3 Scan - Advanced Controls

In the scan tab, click on **Show Advanced Controls**.

Scan Mode	Switch between the normal "Area" mode which scans a square 2D area, and "Line" mode which scans a long 1D line. The "Line" mode results will still be displayed as a 2D image, even though only a single line is being scanned repeatedly.
Leveling Direction	To correct for the 15 degree tilt of the AFM chip relative to the sample, a hardware leveling feature is applied. Leveling Direction switches between adding or subtracting the 15 degree tilt and is device-specific. Different types of AFM chip may require different Leveling Directions.
Leveling	If the raw data of an image still contains significant tilt in the Y direction, This value can be increased or decreased to compensate.
Z Coarse	The Z actuator is split into two controls: Coarse Z and Fine Z. Fine Z has a smaller range and is the channel that the PI controller uses to follow the sample topology during a scan. Coarse Z has a large range and is simply used to coarsely position the Z actuator so that that the entire sample topography is in the range of the Fine Z.
Proportional	The proportional coefficient of the PI controller. Increasing this value increases the response time of the controller, but increasing it too much can cause instability in the Z actuator.
Integral	The integral coefficient of the PI controller. Increasing this value increases the response time of the controller, but increasing it too much can cause instability in the Z actuator.
Setpoint	The tip oscillation amplitude that the controller will try to maintain. A lower setpoint is analogous to applying a larger force between the tip and sample.
Enable/Disable	Turns on or off the PI controller that maintains a constant tip oscillation amplitude equal to the setpoint by controlling the Z actuator (Fine Z).

7.4 Menu Button - Advanced Controls

In the top right corner of the screen, click on the button with three horizontal lines, the "menu" button.

Motor Controls	Controls the sample platform. Motor Speed adjusts how quickly the platform moves. Approach makes the platform move up, Retract makes the platform go down, clicking either Approach or Retract takes a single step, while clicking and holding Approach or Retract moves the platform continuously.
PID Controller	Proportional is the proportional gain coefficient of the PI controller. Integral is the integral gain coefficient of the PI controller. Setpoint is the tip oscillation amplitude that the controller will try to maintain. Enable/Disable turns the controller on or off.
DACs	Digital to Analog Converters (DACs) output analog voltages. These voltages drive the X, Y, and Z actuators. The DAC controls allow you to set the voltage level that is being applied to any of the actuators, including the lateral actuators (X1, X2, Y1, Y2), the Coarse Z and Fine Z, and the Leveling control (which is integrated into the Z actuator). There is a conductive path to the AFM tip and the Tip control allows you to set the tip voltage. All DACs range from 0-3.3V
PGAs	Programmable Gain Amplifiers (PGAs) are able to scale the voltages output by the DACs. The PGAs are used to adjust the XY scan size, the range of the Coarse and Fine Z, the amplitude of the AC driving signal on the Z actuator, and the amount of leveling that is added to each scan. PGA values can range from 0-140%.
ADCs	Analog to Digital Converters (ADCs) read analog voltages. Clicking Read All will display the current voltage level of the current sensing circuits for X, Y, and Z, as well as the voltage levels of the amplitude and phase measurement circuits. The ADCs range from 0-3.3V.
Resistances	Measured resistances of the MEMS actuators. Click Resistance button to refresh measurements.
DDS	DDS (direct digital synthesis) section controls the drive signal frequency. To set a new frequency, change both start and end frequencies to the desired frequency.
Safety Configurations	Encapsulates various safety features. Safety thresholds and features may be modified or disabled in this section. Approach Low Limit specifies the low signal threshold that constitutes a safe situation for auto-approach. If the measured signal at the beginning of auto-approach is lower than the specified value, the approach will be aborted. It is recommended to leave the setting at its default value of 0.7 V. Check Resistances refers to the safety routine that is executed prior to every Sweep , Approach , and Scan command. If enabled, the software will measure resistances and check for any anomalies. Limit Switch refers to the end-stop mechanism to prevent motor from driving the stage too low. In the unlikely circumstance that the switch is damaged and you cannot retract properly, you can uncheck the limit switch feature to

	override the mechanism.
Updates	If internet connection is available, this section shows if the software and firmware used are up to date. If updates are available, please go to www.icspicorp.com/resources to find the newest versions of software and firmware. Click on Check Updates button to query the server again for availability of updates.
Miscellaneous	<p>Force Curve: opens a window where you can run a routine to generate the force curve. A force curve ramps the Fine Z from 2V to 0V, then back up to 2V and measures the cantilever oscillation amplitude and phase. The resulting graph shows the tip-sample interaction force with respect to tip-sample distance.</p> <p>Reset AFM: resets the microcontroller. Please close and reopen the software to connect to the microcontroller again.</p> <p>Restore Defaults: reset all of the settings to the default values.</p> <p>Release Port: release the usb connection.</p> <p>Enter Bootloader: erase the firmware program to allow for firmware updates. To reprogram firmware, please execute bash script %installation_directory%/firmware/ISP/flash-usb-win. Caution: do not click this button unless you need to reprogram firmware and that you are confident with the process as this will erase current firmware. Contact info@icspicorp.com for any questions regarding firmware updates.</p>
