Cypher SPM User Guide

USER GUIDE 2

Cypher User Guide

Including beta (complete, reviewed) chapters. Including draft (nearly complete, not reviewed) chapters.

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Asylum Research

an Oxford Instruments company

Contents

Introduction

CHAPTER REV. 1702, DATED 10/21/2013, 22:07. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

AR Software Version It is assumed that AR Software version 13 or later is installed on your system. To download the latest software, please register at our support site: http://support.asylumresearch.com.

Getting Help There are many ways to get help with your Asylum Research instrument, and it is always free:

- Join the support site and download software, current manuals, and ask questions in our user forum. http://support.asylumresearch.com. Note that all Asylum scientists are forum members and frequent contributors.
- E-mail us at support@asylumresearch.com.
- Call your local office or distributor.
- Call us at +1-805-696-6466. During US west coast business hours you will get a human being to speak with. After hours you still have a good chance of catching one of our scientists. Within the US you can call our toll free number if you wish (1-888-472-2795).
- If necessary we can initiate a remote session and have one of our scientists operate your AFM over the internet.

Updates to the Manual Bundled with the software updates.

Send Feedback Send e-mail to sba.manuals@oxinst.com (<– clickable link) and mention which version of the user guide you are using and what chapter and section your commenting on.

Part I

System Overview and Powering Up

Who is this part for? After the Cypher SPM has been installed in your lab and you (or someone in your facility) have completed the initial training, this part of the user guide will review the main parts of the instrument and software. Instrument power up is also covered.

Part Contents

1. System Overview

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

1.1. Basic Cypher SPM Hardware

Before starting the tutorial, the user should be familiar with the names and functionality of each of the components of the Cypher. Don't worry if you don't understand everything in this section; the main goal is just to get familiar with the basic purpose of each component of Cypher. Figure 1.1 on page 3 shows a typical set-up for the Cypher SPM. The top-level components are the computer, the ARC2 controller, and the microscope itself.

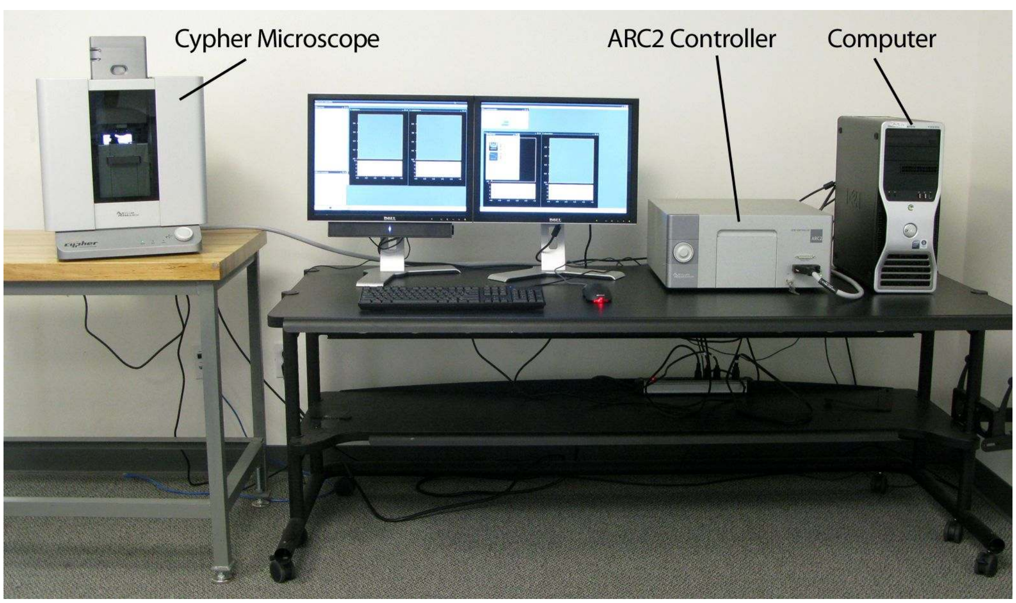


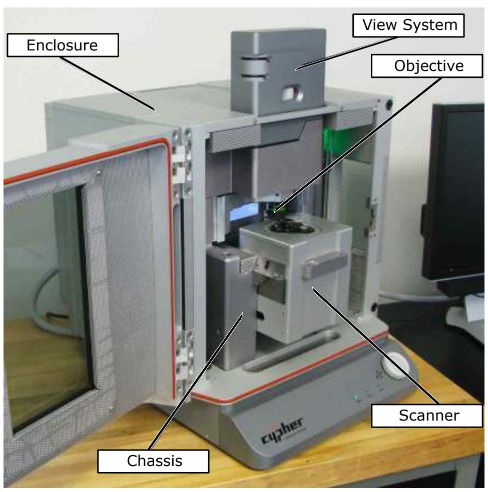
Figure 1.1.: Ideally the Cypher SPM is set up as shown, with the controller and computer on one table and the microscope on its own table. The air temperature controller (ATC) is not shown here. Please see Chapter 19 on page 203 for more information.

Computer The computer is the primary interface for controlling the microscope; its main communication is via a USB1.1 connection to the ARC2 AND via USB 2.0 directly from the computer to the Cypher. See Figure 22.1 on page 264 for recommended USB ports to use.

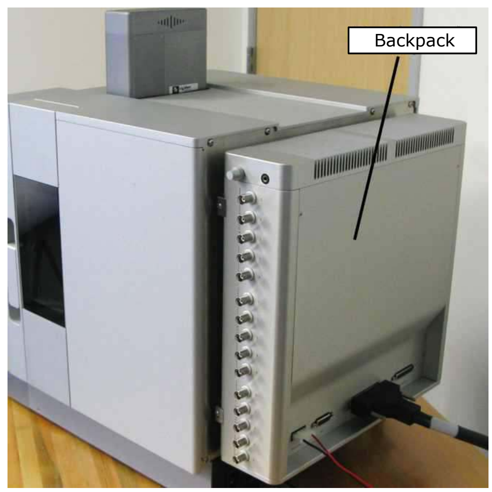
ARC2 The ARC2 (Asylum Research Controller 2) is what is colloquially referred to as "the controller". It houses power supplies and the necessary electronics for controlling the scan motion and acquiring image data from the microscope.

Microscope The microscope itself, where the actual imaging takes place, is the heart of the AFM system. Although the computer, controller, and microscope all comprise the Cypher, the microscope itself will often be referred to as the Cypher.

The microscope is comprised of five basic components (see Figure 1.2 on page 4): enclosure, chassis, camera, scanner, and backpack. The enclosure, chassis, and backpack are common to all versions of the Cypher. In contrast, the scanner and camera are designed to be modular and easily interchanged by the user.



(a) Front View. In this image the enclosure door is open and the scanner is partially pulled out.



(b) Rear View

Figure 1.2.: Cypher parts basic nomenclature

Enclosure The primary function of the enclosure is to isolate the imaging portion of the microscope from acoustic noise such as talking or music. Acoustic noise can cause the mechanical components holding the sample to move, thereby showing up as noise in the microscope images. The secondary role of the enclosure is to provide a local environment for the microscope itself, in which the temperature can be controlled. Keeping the microscope at a constant temperature is important for maintaining long-term control of the relative position between the cantilever and the sample. The air temperature controller (ATC) is a Cypher option that can be used to maintain the temperature inside the enclosure. To learn more about the enclosure and its options, please refer to Part IV on page 181.

Chassis The chassis is the central structural unit supporting the scanner, camera, and head. While the scanner and camera are modular units designed to be interchanged by the user, the **head** is just a sub-assembly of the chassis and is permanently attached to the chassis. The head is responsible for the detection of the cantilever deflection and has integrated motors that allow the user to automatically position the laser spot onto the cantilever. The **objective lens** attached to the head has two important functions: it focuses the laser light onto the cantilever and works with the **camera** to create an optical view of the sample. To learn more about the chassis and its options, please refer to Part IV on page 181.

Camera The camera (also called the "**view module**") is a user changeable module that provides a top down optical view of the cantilever and sample. It is comprised of a tube lens, Koehler illumination with an LED source, and a digital camera. The camera module uses the objective lens in the head to create the optical view. The standard camera module has a bright field reflected light topology and has a 690µm by 920µm field of view with sub-micron resolution. Depending on the application, the view module can be swapped by the user in about 10 minutes, but requires Allen wrenches to complete.

Scanner The primary function of the scanner is to move the sample relative to the cantilever during imaging and other measurements such as force curves. There are various scanner modules which excel at various tasks. The Cypher scanners are "sample scanners", which means that relative to the room that the microscope is sitting in, the cantilever is stationary and the sample moves. The scanner is a modular unit that can be interchanged by the user depending on the application, although at present there is only a single scanner available. Thus far the scanner modules are based on a flexure design that uses piezoelectric stacks to move the sample up to 30µm in XY and 5µm in Z. The secondary function of the scanner is to provide motorized course positioning of the cantilever relative to the sample in the Z-axis. The **cantilever holder** is a component of the scanner that physically holds the cantilever during imaging. There are different cantilever holders for air and liquid operations, and there are also application specific holders for techniques like scanning tunneling microscopy (STM), see Chapter 9 on page 103. Each scanner type has its own family of cantilever holders and other accessories. The available scanner modules are:

- The Standard scanner, described in Part II on page 12.
- The Environmental scanner, described Part III on page 113.

Backpack The backpack is located on the backside of the enclosure and houses a very powerful set of digital and analog electronics that extend the functionality of the ARC2. Like the ARC2, the backpack has ADCs, DACs, BNC connections, and a CrossPoint switch. .

Q Why is there both a backpack and a controller? Isn't the backpack redundant since there is already a controller?

A In a typical AFM design, most of the electronics housed in the Cypher backpack would be located in the controller. The backpack, however, moves these electronics closer to the microscope; Cypher is able to achieve very low noise levels in part because of the proximity between some of its electronics and the actual microscope. Keeping these low noise electronics external to the enclosure balances noise performance with the management of the heat generated by electronics.

Q AFM or SPM? What is the difference?

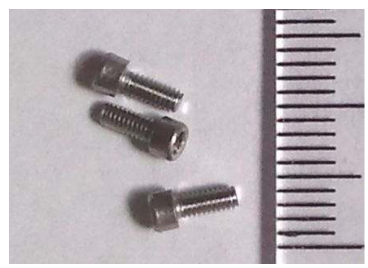
A AFM stands for Atomic Force Microscope. It scans a cantilever over a sample to generate an image. SPM stands for Scanning Probe Microscope. It is the more general, all encompassing term, which also includes techniques that image using non-cantilever probes such as sharp metal needles (Scanning Tunneling Microscopy), optical fibers (NSOM) or tiny hollow glass tubes (SICM). Since Cypher is capable of both AFM and STM, it is classified as an SPM. You may see Cypher referred to in the context of an AFM when its AFM-like functions are being described.

1.2. Parts List

The contents of the accessory kit which accompanies Cypher. Asylum Inventory Number 900.110.1. These parts accompany the AFM irrespective of the type of scanners you purchased.

Itm	Part #	Item Description	Qty	Picture
1	080.122	15mm AFM Specimen Disc. Also available from Ted Pella, part number 16218.	50	
2	290.101	2A Tweezer, SA Tapered Round Blunt, Standard Grade.	1	
3	290.102	7Tweezer, SA Curves Sharp, Standard Grade.	2	
4	290.103	3A Tweezer, Extra Fine Sharp, Standard Grade.	1	
5	290.139	Hex Driver, 1/16” Small Handle.	2	
6	312.003	Renishaw Encoder Readhead Spacer (0.8mm).	1	
7	803. OLY. AC 55 TS	Olympus Cantilevers, Model AC 55 TS.	5	

The scale in the photos is in cm and mm.

Itm	Part #	Item Description	Qty	Picture
8	803. OLY. BL- AC 40 TS	Olympus Biolevers (Mini): Model BL - AC40TS.	10	
9	804. NW. ARROW - UHF AUD	Nanoworld Cantilevers, Model: ARROW UHFAuD	5	
10	900.237	AR calibration Grating - Steel Puck Mounted.	1	
11	1-72 x 3/16" SHCS SS	1-72 x 3/16" screw, spares. Fastens the cantilever holder onto the standard scanner (Step 6 on page 20) and also fits the cantilever holder changing stations.	5	
The scale in the photos is in cm and mm.				

1.3. The Igor Pro Software Environment

The Asylum Research software is primarily written within the programming environment of the commercially available software package Igor Pro, which is developed by WaveMetrics. Igor Pro itself has nothing to do with scanning probe microscopes. Rather it is a stand alone program that has extensive scientific graphing, data analysis, image processing and macro programming capabilities.

Tip	The "Volume I - Getting Started" manual found on the WaveMetrics website (www.wavemetrics.com) takes two to three hours to complete and is an excellent way to learn about the basic graphing and analysis functionality of Igor Pro. Although it is not necessary to complete the Igor Pro portion of the "Getting Started" manual at this time, it is a highly recommended part of all new user training.

When you launched the  software you opened an Igor Pro “Experiment” in which extra software specific to the operation of the AFM has been loaded. An Igor pro experiment is the file that saves the state of Igor Pro.

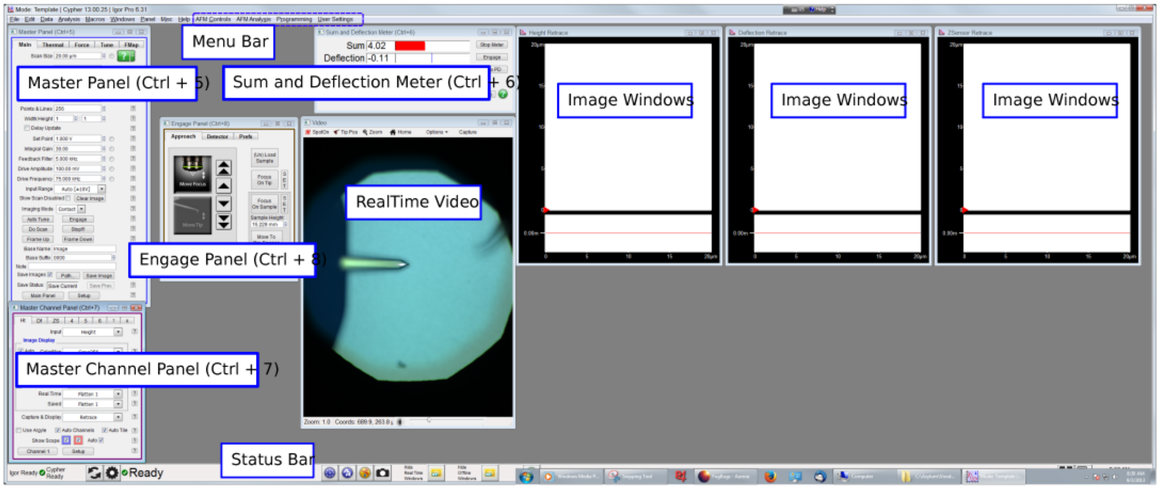


Figure 1.3.: Typical start-up screen for the Asylum Research SPM Software. A few image panels have been cut off in this figure. Usually they are found across the second monitor of your system.

Refer to the screen shot in Figure 1.3 on page 8 as we introduce the various controls and data displays. We’ll go clockwise from the upper left. (Note that if you are viewing this file on a computer, you can zoom in on the screen shot for further scrutiny.)

Master Panel Upper left hand window (Ctrl + 5). It has five tabs with controls and data displays for:

- **Main** AFM imaging, see Chapter 4 on page 17.
- **Thermal** Cantilever thermal spectroscopy.
- **Force** Cantilever force versus distance curves.
- **Tune** Cantilever vibrational tuning, see Section 4.3.2 on page 33.
- **Fmap** Maps of force versus distance curves.

Master Channel Panel (Ctrl + 7) During imaging, multiple data streams, such as height, cantilever amplitude and phase, return from the AFM to the computer. This panel contains information about those data streams and allows for some real time scaling and processing.

Igor Command Window (Ctrl + J) Not shown. The Igor Command window has two parts: the history and the command line. On occasion items executed by clicking software buttons will generate output and print it to the history. It is not a bad idea to keep tabs on what is being printed into the history, especially if you are tracking down software bugs. Advanced users will use the command line to directly execute a variety of tasks. If you followed the Igor tutorial recommended in the Tip on page 7 you will know how to use the command line. The Igor Command Window always has the name of your current experiment, which you can also see at the top of the border of the software window.

Sum and Deflection Meter (Ctrl + 6) This is a real time display of various channels such as cantilever sum and deflection, piezo voltage, amplitude, and phase.

Engage Panel (Ctrl + 8) This panel controls the entire process of the cantilever approach to the sample. Its three tabs control:

Approach Motorized approach of cantilever and microscope objective toward the sample.

Detector Centering of reflected light beam (laser or SLD) onto the optical detector.

Prefs Preferences for the engage process such as approach speed and approach step size.

Real Time Image Display This is an example of an image window, in this case displaying the individual lines of the sample topography as the cantilever moves left to right over the sample. There is usually one such window per active tab in the 'Master Channel Panel' (Lower left hand window). The amplitude and phase data windows are to the right of this clipped screen shot. While this panel is primarily a data display, right clicking with the mouse can activate various commands such as 'Zoom' and 'Translate'. The white area at the bottom of this window shows a real time oscilloscope view of the most recent line of image data.

Scope Graph This oscilloscope view shows a graph of the most current scan line. Both trace and retrace can be selected on the 'Master Channel Panel'.

Q	Oops! I accidentally closed one of the control panel windows. How do I get it back?
A	You can reactivate the panels via *AFM Controls* in the top menu bar.

A few other things of note are:

Menu Bar Along the top of the screen. There are many more controls which can be invoked by items in the menu bar. Menu items to the left are typically standard Igor Pro items, with some Asylum Research functionality. Items to the right of "help" are exclusively SPM related. In particular, the *AFM Controls* menu item is a complete list of all real time controls and the *AFM Analysis* menu item is a complete list of all offline controls.

Status Bar Along the bottom of the screen. Icon controls relate to the status of connected instrument components. The low level software version is also displayed.

We won't dwell on the purpose of all these controls but will proceed with the general process of imaging a sample. This will necessarily cover the most pertinent software controls.

Tip	Note that nearly each individual item in the software control panels has a small question mark button next to it. Click the button to read the relevant parts of the software help file.

2. System Power Up

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Before you start the following tutorials, the system must be properly powered up. This section will walk you through the process.

Before you start:

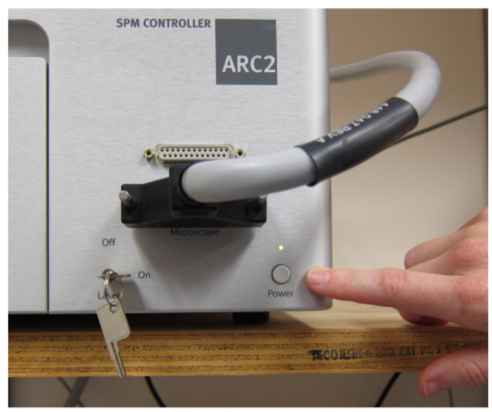
- We assume you understand all aspects of running the Cypher safely: (Chapter 20 on page 229)

1. **Power up:.**

   In no particular order:

   - Boot up the computer.
   - Turn on the Cypher SPM by depressing the power switch on the front of the ARC2 controller.

   If everything is working correctly two different green LEDs will be illuminated. The first LED is located above the power switch on the ARC2 and the second LED (labeled "power") is located at the front of the Cypher enclosure.

2. Double check that the laser key on the ARC2 controller is in the ON position. The red LED labeled "laser" at the front of the Cypher enclosure should be illuminated.
3. Locate the shortcut to the software on the desktop, and double click the icon to start the software.
4. Now take a deep breath and count to ten while the software initializes.

Warning	Make sure your fingers are clear from any pinch points before homing the motors (See Figure 20.1 on page 230). You can abort the homing process at any time by pressing and holding down the 'Esc' key located at the top left corner of the keyboard. If you abort the homing process before it is finished, you will not be able operate the motors.

5.
- Once the software has finished initializing, you will get a prompt asking if you would like to home the engage motors.
- If necessary, slide the scanner all the way into the chassis. Close the microscope enclosure door. For safety reasons the motors cannot home unless the door remains closed during the process.
- Click 'Yes'. You will hear motors moving during the homing process, which will take about 20 seconds.

6. If you are new to the Cypher AFM system, please take the tutorial which is appropriate for your scanner:
   - For the standard scanner see: Chapter 4 on page 17.
   - For the Environmental Scanner see: **??** on page **??**.

Part II

Standard Scanner

Who is this part for? After the Cypher S SPM has been installed in your lab and you (or someone in your facility) have completed the initial training, this part of the user guide will be the principal reference for operating the instrument. Although written with the novice user in mind, experienced SPM users should complete the basic imaging tutorial at least once before attempting to use this instrument.

Part Contents

3. Standard Scanner Overview

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

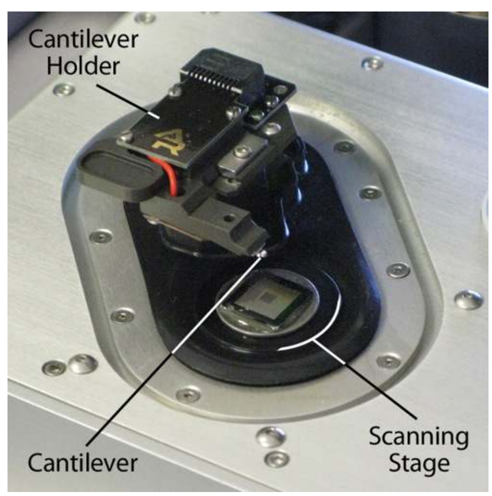
The module dubbed "the scanner" contains the entire mechanics of the AFM except for the optical means for detecting cantilever deflection. This includes:

- Actuators and sensors for closed loop XY scanning of the sample.
- An actuator and sensor for the sample Z motion.
- A cantilever holder and mechanical means for engaging the cantilever with the sample surface.

Since Cypher's scanners are whole AFMs unto themselves, each comes with its own dedicated collection accessories such as cantilever holders and sample stages. In other words, a cantilever holder for one scanner usually does not fit onto a different scanner. Also, an expert user of one model of scanner will not necessarily know anything about operating another model.

This part of the user guide describes in many chapters the use of the Standard Scanner and its many accessories. Once the scanner is exchanged for another, as described in Chapter 16 on page 183, an different part of the user guide will need to be consulted. Typically the first user of a new scanner will need to be trained by Asylum Research personnel.

(a) Standard Scanner.



(b) Names of the basic components.

Figure 3.1.: The Standard Scanner

Figure Figure 3.1 on page 15 shows the standard scanner partially withdrawn from the rest of the AFM. The standard scanner is included with the "Cypher S" AFM, but can also be purchased separately. The

Standard scanner is designed primarily for imaging in ambient conditions, either in air or in a liquid droplet. The optical access to the sample and cantilever is superior to other cypher scanner models.

Many Standard Scanner cantilever holders allow for a variety of imaging modes. See Chapter 5 on page 49 for more information.

The Scanner itself comes in regular and high voltage models. Figure 3.2 on page 16 shows the a magnetic high voltage contact and specialized cantilever holder with high voltage connection to the tip. This arrangement is typically use for PFM techniques. This topic is covered in depth in *Applications Guide, Chapter: PFM Using DART* and *Applications Guide, Chapter: Single Frequency PFM*.

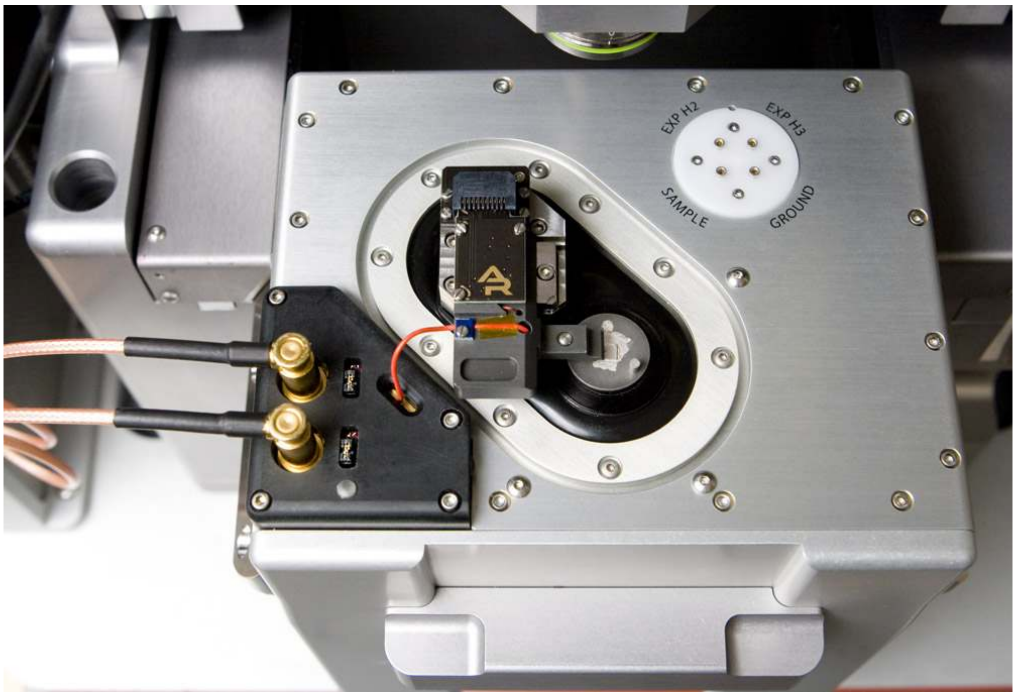


Figure 3.2.: Detailed view of the high voltage option.

4. Tutorial: AC Mode Imaging in Air with the Standard Scanner

CHAPTER REV. 1714, DATED 10/25/2013, 20:36. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This tutorial provides a quick path to learning the basic operation of the Cypher SPM equipped with the Standard Scanner. If you own the Environmental Scanner, please follow the tutorial in Chapter 11 on page 130. The tutorial contains a set of steps that will teach a new user with a basic understanding of AFM operation how to obtain an AC mode topography image in air.

All new users should complete and understand this “AC Mode Imaging in Air” tutorial before attempting any imaging.

The Cypher is a research grade instrument and improper use of the instrument can cause both damage to the instrument and injury to the user. This tutorial will take approximately 3 hours.

Before you start:

- You should understand the aspects of running this system safely: (Chapter 20 on page 229.)
- You should be familiar with the basic names of the hardware components and software controls (Chapter 1 on page 3.)
- You should have powered up the Cypher and launched the software: (Chapter 2 on page 10.)

4.1. Required Materials

This tutorial is designed to be performed, not merely read. You will learn the most if you operate the instrument yourself, with an experienced user watching, providing advice.

It will be necessary to gather a few items prior to beginning the tutorial:

1. Cantilevers: You will need an AC160TS cantilever, which is manufactured by Olympus. The AC160TS, with a spring constant of ~42N/m and a resonance frequency of ~300kHz, is a workhorse for AC mode imaging in air. Every Cypher ships with a package of AC160s, but if these cantilevers are unavailable, any cantilever with a similar spring constant and resonance frequency should work fine.
2. Sample: The tutorial will use the Asylum Research calibration grating that ships with every system (Asylum Part# 290.237).
3. Tweezers: It is preferable to use tweezers with curved tips (for example, Asylum Part# 290.102).
4. Wrench: A 1/16" ball head wrench (for example, Asylum Part# 290.139) is required.
5. SPM: This tutorial is designed for a Cypher equipped with the Standard Scanner and a large spot SLD or Laser Module (See Chapter 18 on page 190).

4.2. Loading the Cantilever and Sample

This section covers sample and cantilever loading as well as the course approach of the cantilever tip toward the sample.

1.

Raise the cantilever holder:

- Rotate the 'Engage Control Knob' on the Cypher *clockwise* and hold it until the cantilever holder is far from the sample or is at its upper limit of travel.

Note Although it is not required, for safety reasons we recommend making motor moves with the door closed. Beware of pinch points (Figure 20.1 on page 230).

2.

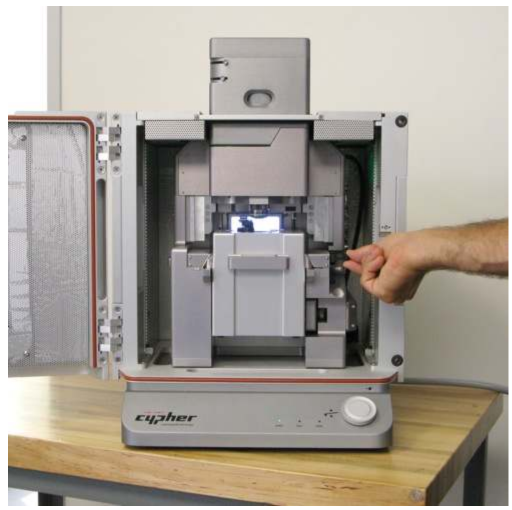
Open enclosure:

- Lift the door latch and open the enclosure door.

3.

Unlock scanner:

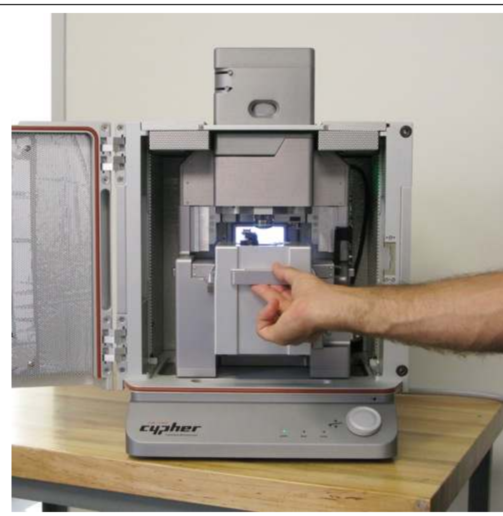
- Lift the lever to the right of the scanner.



4.

Pull the scanner out:

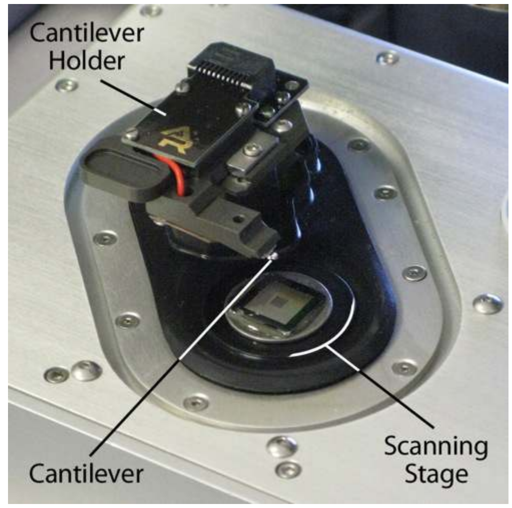
- Pull the scanner forward gently and stop when it is about halfway out. If you continue pulling the scanner, at some point you will feel resistance and should pull no further.



5.

Familiarize yourself with the sample area:

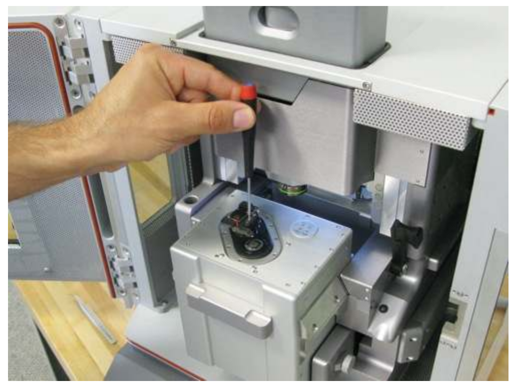
- While it may look solid, the scanner stage moves the sample in the X, Y, and Z directions imperceptibly up to 40μm.

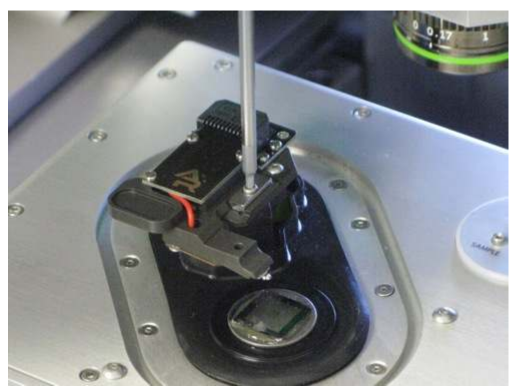


6.

Release the cantilever holder:

- Loosen the screw clamping the cantilever holder. One turn *counterclockwise* should be enough.
- Replace the tool in its storage place (hole in the chassis to the left of the scanner).





7.

Remove the cantilever holder:

- Hold by the tab with the circular recess and pull straight out towards you.

8.

Select AC mode cantilever holder:

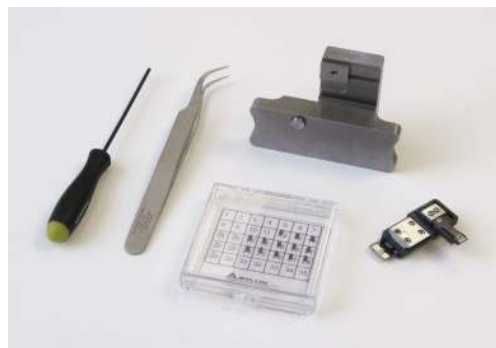
- Identify the cantilever holder. This demo requires the standard “AC Air” holder, Asylum Part# 901.705.

Note To learn more about cantilever holders for the standard scanner, please refer to Chapter 5 on page 49.

9.

Prepare cantilever mounting workspace:

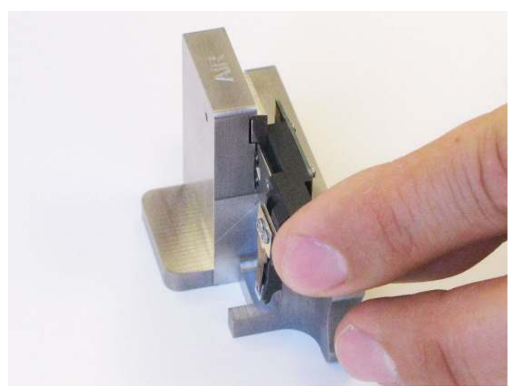
- Set out your changing station, tweezers, and cantilevers on a clean, well lighted surface. Make sure that the changing station is labeled “Air” (there is also a “Droplet” changing station for the droplet holder.)
- A low power binocular dissection stereoscope with light source can be useful for some of the following steps.
- Cleaning the tweezer tips with alcohol improves the handling of the cantilevers.



10.

Mount the cantilever holder in the changing station:

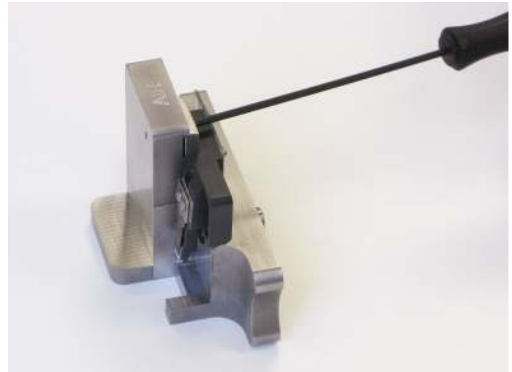
- Carefully insert the cantilever holder as shown. The V-shaped piece of metal on the back of the holder slides into the dovetail joint on the changing station. The cantilever should be pointing down.
- If the cantilever holder does not slide in easily, loosen the screw on the clamping mechanism.



11.

Tighten the clamp:

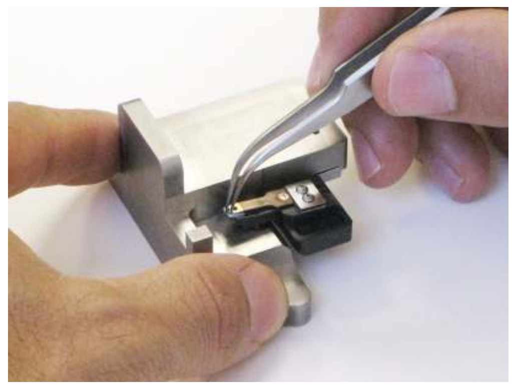
- Once the cantilever holder is fully inserted, use the ball head wrench to gently tighten the clamp.



12.

Remove the old cantilever:

- Position the changing station as shown, on a flat hard surface.
- Take the tweezers in your dominant hand.
- Press down on the station, as shown, with your other hand. This depresses a button on the bottom of the station which drives a pin up under the cantilever retaining clip.
- Remove the cantilever and release pressure on the station.
- Inspect the cantilever area for tiny silicon grit and blow clean with compressed air if necessary.



13.

Select new cantilever:

- Select a new cantilever and pick it up with tweezers.
- Close the box! Ruining $1k of levers by putting your hand on an open box is not unheard of.

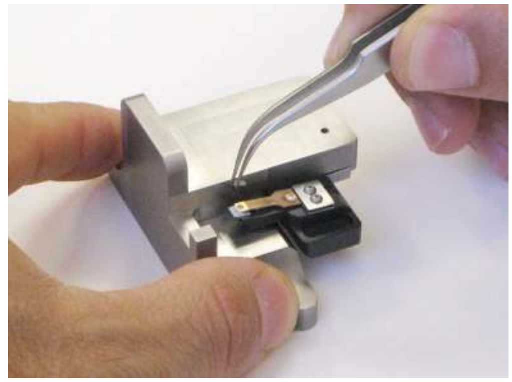
Note If your lab saves some old cantilevers, consider practicing with a “dummy” cantilever.

Tip Some find it useful to first lay the chip down on a non-sticky surface and re-grip it before continuing.

14.

Load new cantilever:

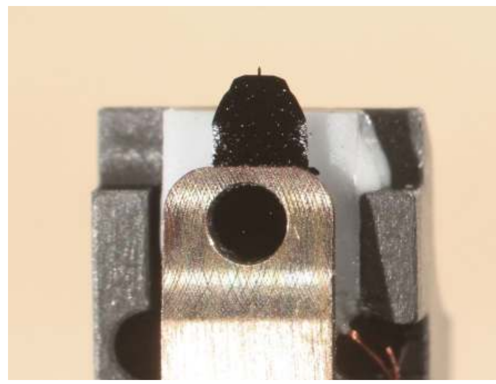
- Place and center the cantilever in the holder (also see photo in next step for alignment).
- A good technique is to release pressure on the changing station while still gripping the cantilever chip with tweezers. This prevents misalignment caused by the cantilever chip sticking to the tweezers.



15.

Check cantilever alignment:

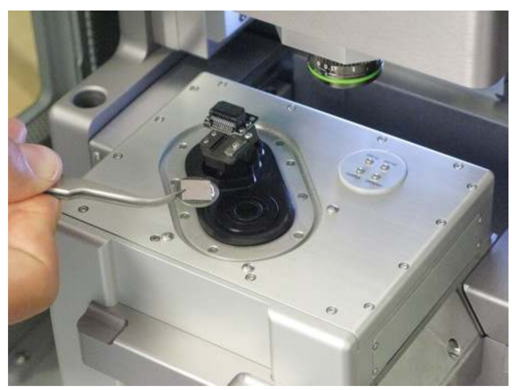
- A properly aligned cantilever seen from above.
- It helps to do this at least once under a binocular stereo microscope.



16.

Prepare scanner and load sample:

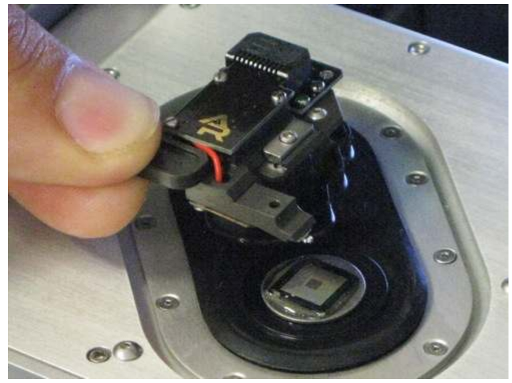
- Leave the cantilever holder in the changing station for now.
- Remove any sample that may be present on the scanner.
- Wipe the scanner stage (defined in Step 5 on page 19) clean with a soft cloth. Any dust or grit will prevent the sample disk from being properly seated.
- Place the Asylum Research calibration grating onto the scanner stage. It will attach magnetically.



17.

Insert cantilever holder into scanner:

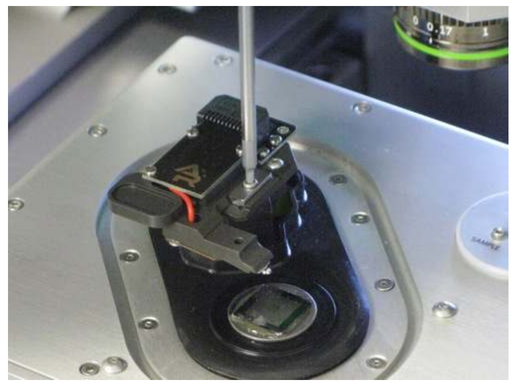
- Remove the cantilever holder from the changing station.
- Insert the cantilever holder into the scanner. Pay attention that the metal dovetail engages properly.
- If it will not go in, loosen the screw by half a turn (see Step 6 on page 20).



18.

Tighten cantilever holder:

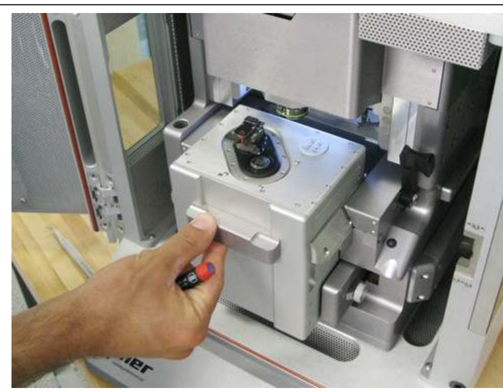
- Use the ball headed wrench to *gently tighten* the screw that clamps the cantilever holder.
- Don't use your whole hand! Be gentle!



19.

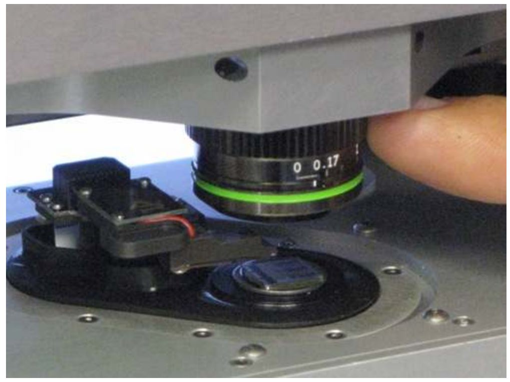
Slide scanner into chassis, lock down:

- Gently slide the scanner back into the chassis.
- Push the lever at the right of the scanner downward to secure the scanner in place.



20. **Check correction collar:**

- Check that the green correction collar on the objective is set to zero (this cantilever holder has no glass window through which the light must focus).



21. **Close enclosure door:**

- *Gently* close the door and latch it.

22. **Motor cantilever toward sample:**

- Place your eyes level with the cantilever and sample, so you can clearly see the gap between cantilever and sample.
- Slowly turn the 'Engage Control Knob' on the AFM enclosure *counterclockwise*. This will lower the cantilever holder and objective toward the sample. The more you turn, the faster it goes.
- Close the gap between tip and sample to about 1 millimeter. There is no harm in playing it safe and stopping a little farther away. It will only cause the automated engage to take a little longer.

Warning: Nothing but your attentiveness will prevent the cantilever holder from crashing into the sample. If you crash the cantilever holder you may cause *SERIOUS* damage to your cantilever holder and scanner.

23. This concludes the manual interaction with Cypher. We next turn our attention to the computer.

4.3. Engaging the Cantilever on the Sample

4.3.1. Bringing the Cantilever Close to the Sample

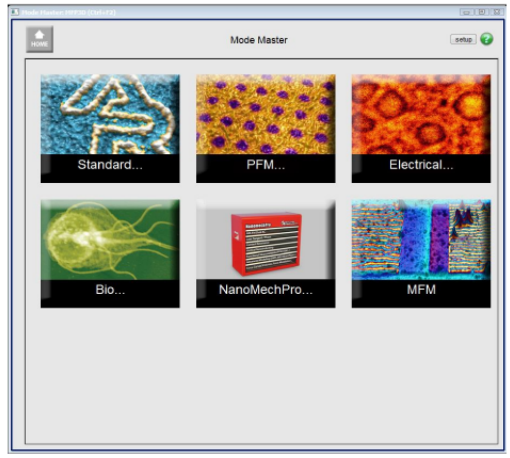
Before you start this section you should have done the following:

- Start up the software (Chapter 2 on page 10).
- Homed the motors (See Step 5 on page 11).
- Positioned the cantilever about 1mm above the sample (Section 4.2 on page 18).

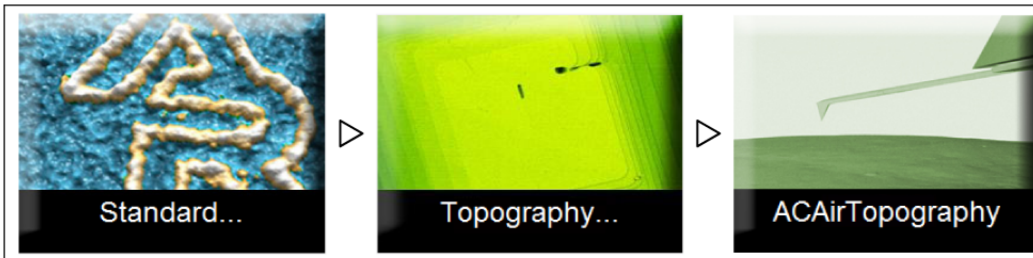
1.

Mode Master:

- The software should now be showing the mode master window.
- If not, click s the Mode Master button at the bottom of the screen: .



2.



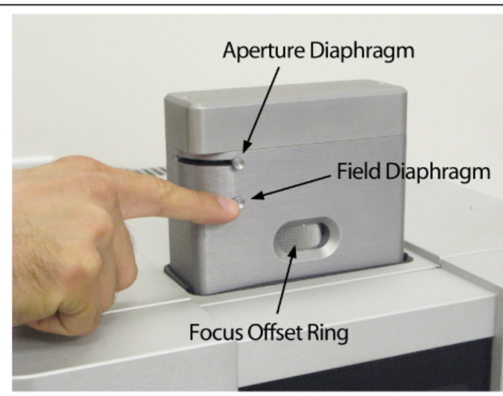
Select Mode Master Mode Example:

- The ModeMaster Panel appears when you first open up the MFP3D software. Select *AR Modes ▷ Topography ▷ ACAirTopography*

3.

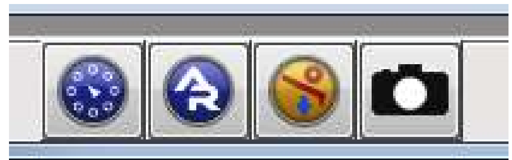
Prepare the view module:

- Turn the **focus offset ring** until the white dot is centered on the alignment mark. There will be a gentle click when this occurs.
- Fully open the **field and aperture diaphragms** by pushing both levers toward the front as shown.



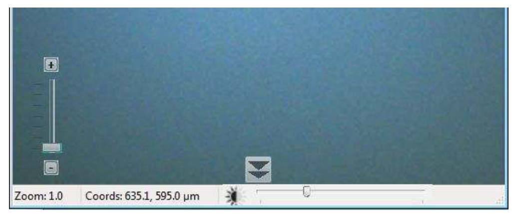
4. **Open video window (If necessary):**

   - In the software, click on the camera icon on the bottom status bar.
   - This will open the video window (or highlight it in case it was already open), which displays an optical view of the cantilever and sample.



5. **Setting video zoom and illumination:**

   - IMPORTANT: Slide the vertical slider at the lower left corner of the video window all the way to the bottom. “Zoom 1.0” will be indicated just below.
   - Turn up the illumination by moving the slider (on the bottom of the video window) to the right a quarter or third of its full range.



6. Familiarize yourself with the Approach tab on the Engage Panel as described next in Step 7 on page 27. *Failure to understand the Approach controls may lead to serious damage to the Cypher.*

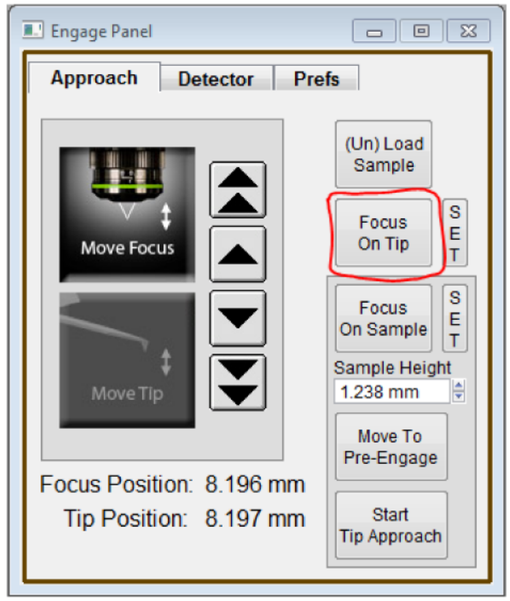
Go to last known Tip Focus:

- On the Engage panel, hit 'Focus on Tip'. This will move the objective lens to the last known position where the cantilever was in focus.

Notes

7.

- Since the 'Focus on Tip' button only moves the objective to the *last known tip focus* and does not actually perform an auto-focus, the cantilever will most likely not be perfectly in focus after the motors are finished moving. (Cantilever chips have varying thicknesses and how the cantilever chip gets positioned in the holder will affect the sample position.)
- Don't be alarmed if the cantilever is not visible at all. It most likely means that when you placed the cantilever chip in the holder, you put it in a place outside the ~1mm field of view of the objective. This will get addressed in the next step.
- If you hit the 'Focus on Tip' button and nothing happens (i.e. the motors do not move), it just means that the objective is already at the tip focus point. Note that after the motors are homed, the objective is moved automatically to the tip focus point.



8.

Locate cantilever in image:

- The goal of this step is just to get the cantilever into the field of view. Use the four arrows at the top left of the video window to look for the edge of the cantilever chip and/or the cantilever. As mentioned in the previous step, most likely the cantilever will not be perfectly in focus.
- If you are oriented such that you are sitting directly in front of the Cypher microscope, hitting the left arrow will move the objective to your left, while hitting the top arrow will move the objective away from you.
- *If you see nothing at all in the field of view, most likely the cantilever chip is located to the left of the field of view.* Hit the *left arrow* to move the objective towards the left and look for the cantilever chip edge.

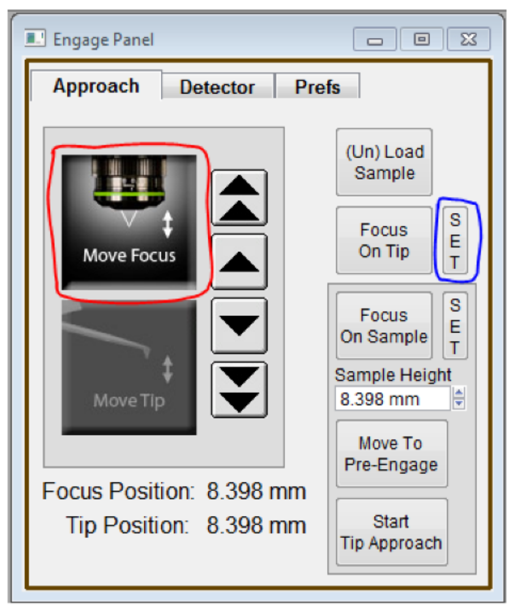
See Figure 4.1 on page 34 for example images.

9.

Set the tip focus position:

- Under the 'Approach' tab on the 'Engage Panel' select the 'Move Focus' (on the left, red) large picture button.
- Use the on screen arrow buttons until cantilever is in focus. Single arrows are slow; double arrows are fast.
- Click 'Set' next to 'Focus on Tip' button (on the right, blue).

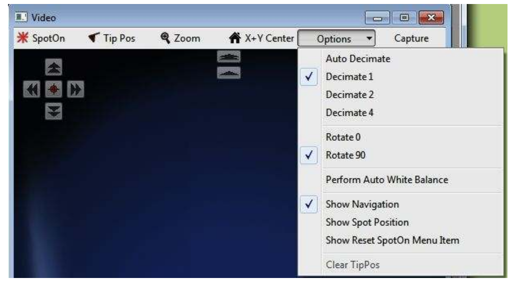
Important The cantilever is at an 11° angle and the whole lever cannot be in focus at once. Bring the end of the cantilever closest to the tip in focus.



10.

Optional image enhancement and zoom, particularly useful for small cantilevers:

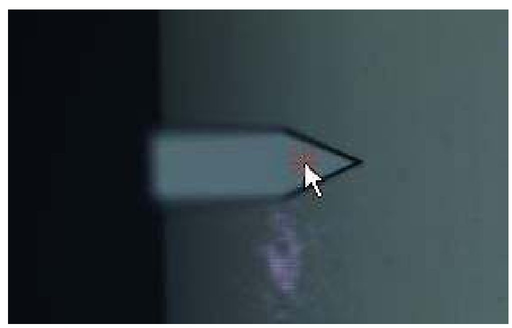
- If you want to see the image with more resolution, select *Decimate 1* from the *Options* pull-down menu. This brings all the pixels down from the video camera but will slow the screen update rate.
- To the left of the *Options* menu is a 'Zoom' button. This button, once clicked, will change the cursor into a magnifying glass. Click on the cantilever to get an enlarged view.
- Both of these items may improve your ability to focus from the previous step. If you do refocus, be sure to click 'Set' next to the 'Focus on Tip' button.



11.

Center laser spot on cantilever:

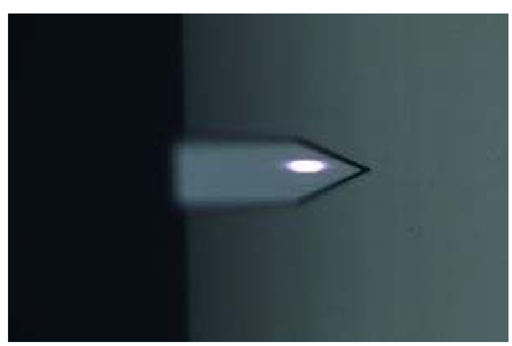
- Click on the 'Spot On' button at the top left of the video window. The mouse pointer will acquire some small red lines.
- Now click on the center of the cantilever (see figure to right).
- Alternately, right-click on the center of the cantilever and then select the 'Spot On' option.



12.

Observe spot on lever:

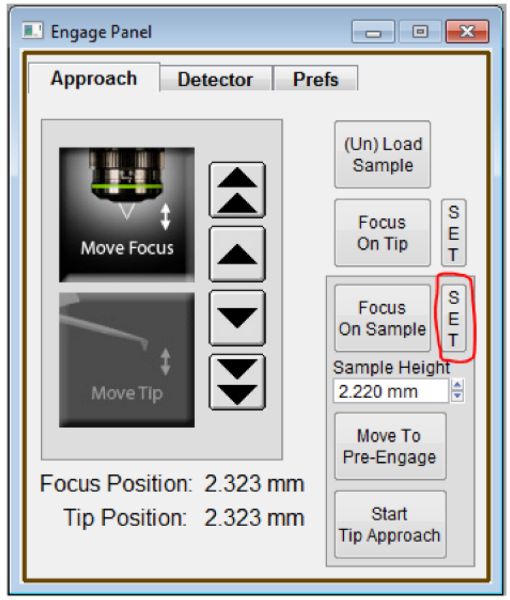
- Motors inside Cypher will now move to bring the laser spot where you clicked.
- The spot position does not need to be perfect here, only roughly centered on the cantilever to produce a decent reflected beam (measured by the Sum signal in the Sum and Deflection Panel).
- If needed, the spot position will be fine tuned in a later step.



13.

Locate sample surface optically:

- Under the 'Approach' tab on the 'Engage Panel' use the downward arrow keys to motor the microscope objective down toward the sample, until it comes in focus (See Image in the next step). Use the up arrows if you overshoot.
- Single arrows are slow, double arrows fast.
- Once in focus, hit the 'Set' button next to the 'Focus on Sample' button. Note that the sample height value updates.

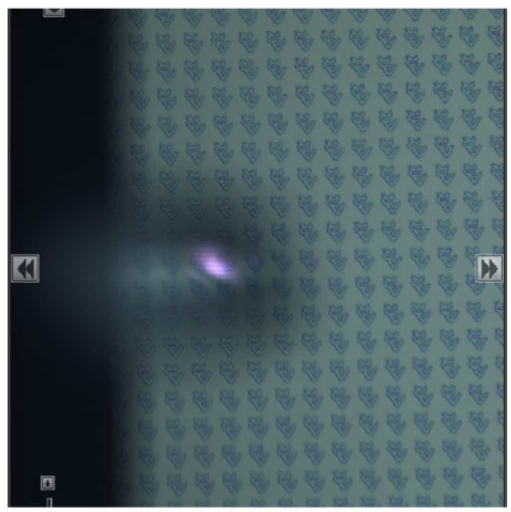


14.

Observe sample surface optically:

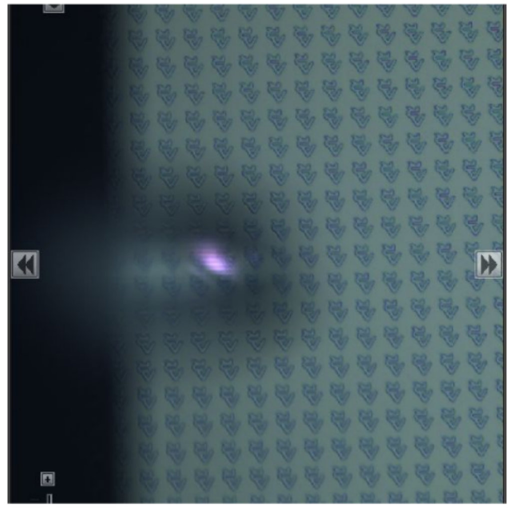
- Features may be hard to see at zoom = 1 and auto decimation turned on. For instance, in the image to the right decimation = 1 and zoom = 2. See Step 10 on page 29 for more information.

Fun Now that you have stored tip and sample position, you can repeatedly click on the buttons 'Focus on Sample' and 'Focus on Tip' and go back and forth between tip and sample.



Question I cannot seem to focus on the surface of my rough sample.

Answer The objective can only motor down a few millimeters before it meets up with the cantilever. If you did not manually move the cantilever close enough you will never get a focused image (such as the one on the right) of the sample. In this case hit the “Focus on Tip” button in the engage panel and repeat Step 22 on page 25.



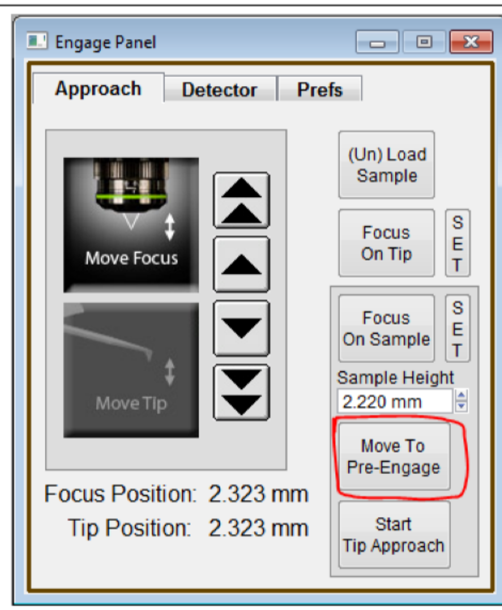
Question I cannot seem to focus on the surface of my smooth sample.

Answer Perfectly reflecting samples may not offer enough features to allow the focus to be determined. In this case move the Field Diaphragm lever (marked with an F) on the view system until you see a dark circle on the screen. As you motor down this circle will become sharper. When the ring is in focus, as in the image to the right, so is the sample.

15. **Prepare to land the tip:**

- Click the ‘Move to Pre-Engage’ button. Motors automatically bring the tip to 50μm from the surface.

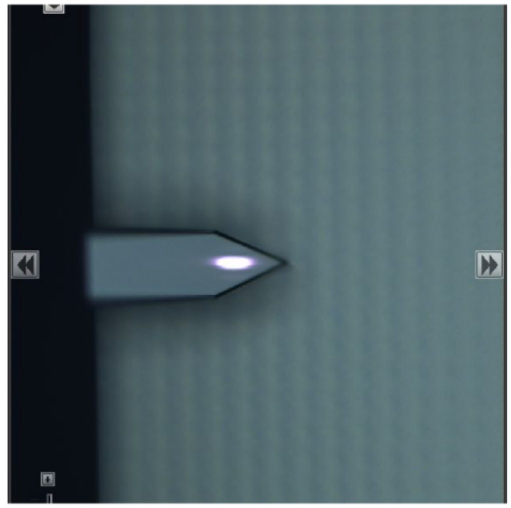
WARNING: If you set a bad sample height and/or tip position you may ram your cantilever into the sample and break it. A firmware safety feature immediately cuts motor power when the optical detector fails to measure reflected light from the broken lever. This prevents the cantilever holder from ramming the sample.



16. **Fine tune spot position:**

- At this point you should adjust the spot position so that it is near the end of the cantilever using the controls in the upper left hand corner of the video panel. Note that a decrease in Sum Signal indicates that light is spilling off the cantilever. The latter is undesirable and should be avoided.

HINT For fine positioning hold down the 'SHIFT' key on your keyboard while clicking the onscreen buttons which move the cantilever under the laser spot (See Step 8 on page 28).



17. **Center the laser on the photo detector:**

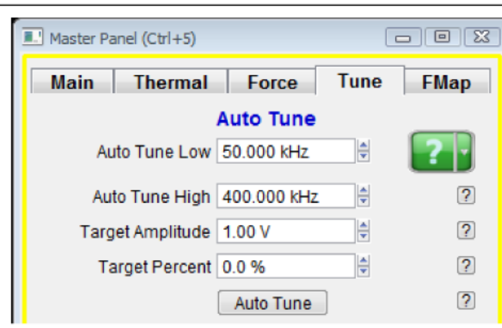
- Hit the red button at the center of the video window motion controls and watch the Deflection Signal go to zero. This action causes small motors to steer the laser beam to the optimum position on Cypher's photo detector.

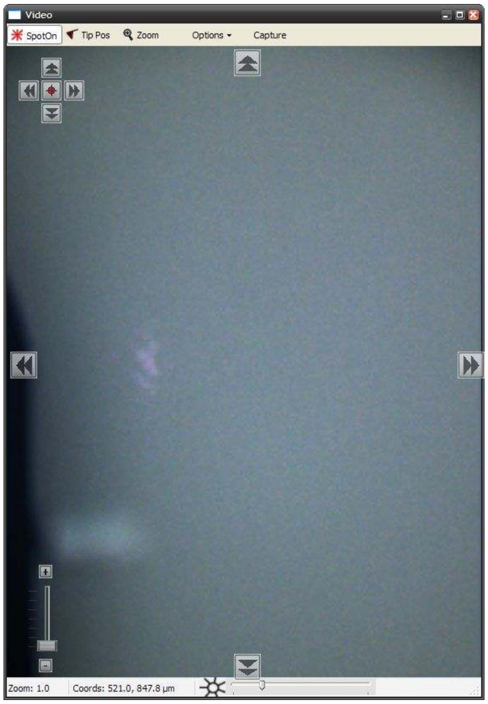
4.3.2. Tuning the Cantilever and Setting Scan Parameters

Since this tutorial focuses on AC imaging, we will proceed to tune the cantilever.

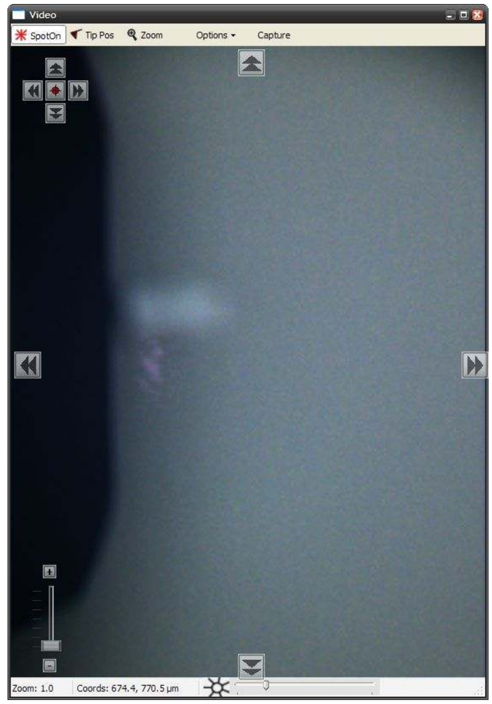
1. **Initiate cantilever tune:**

- Select the tune tab in the master panel.
- Set the four auto tune parameters (Low, High, Amplitude, Percent) as shown to the right.
- Click the 'Auto Tune' button.

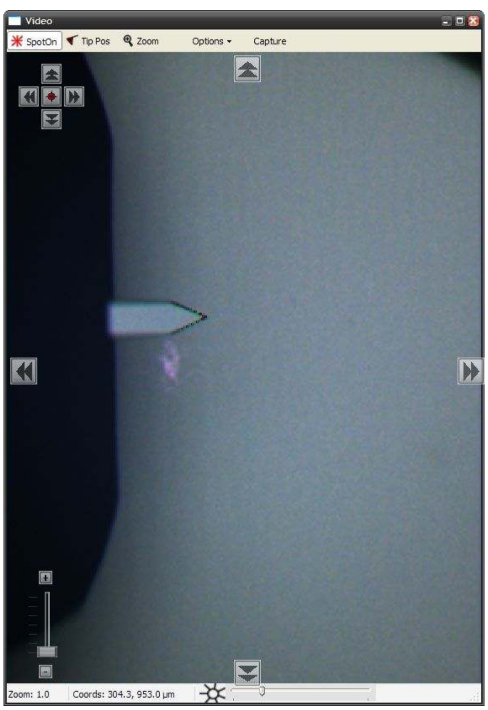




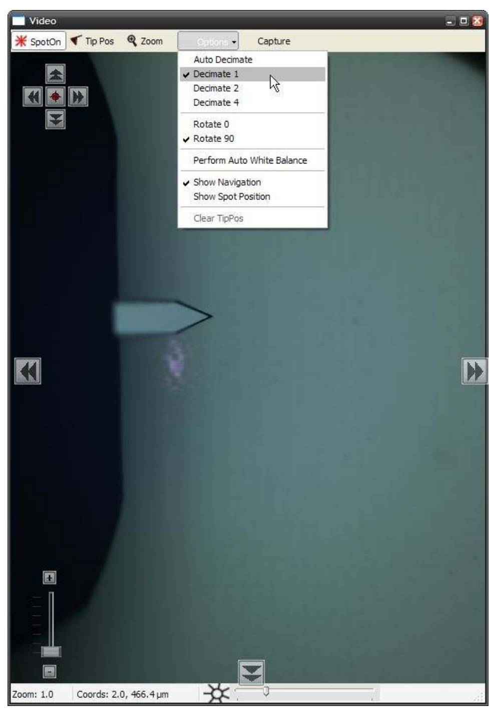
(a) First view of new cantilever.



(b) Cantilever found and roughly centered on screen. Step 8 on page 28.

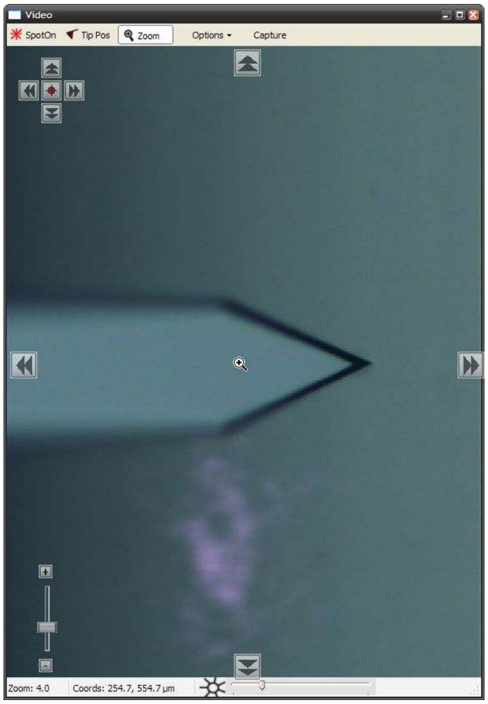


(c) Cantilever in focus. See Step 9 on page 29.

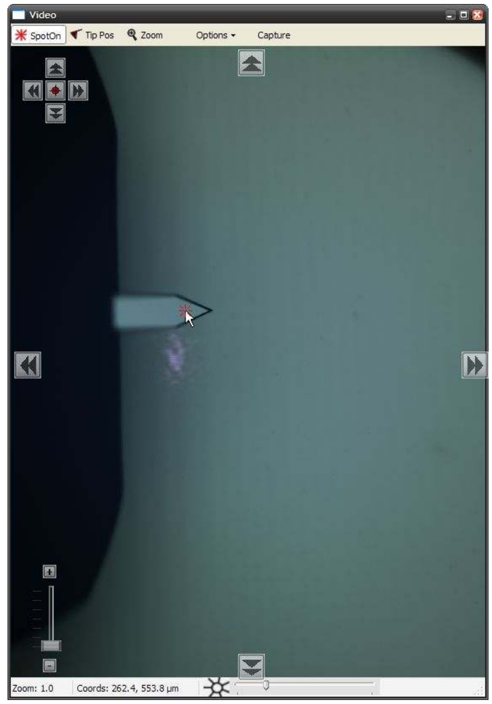


(d) Optimize Resolution. See Step 10 on page 29.

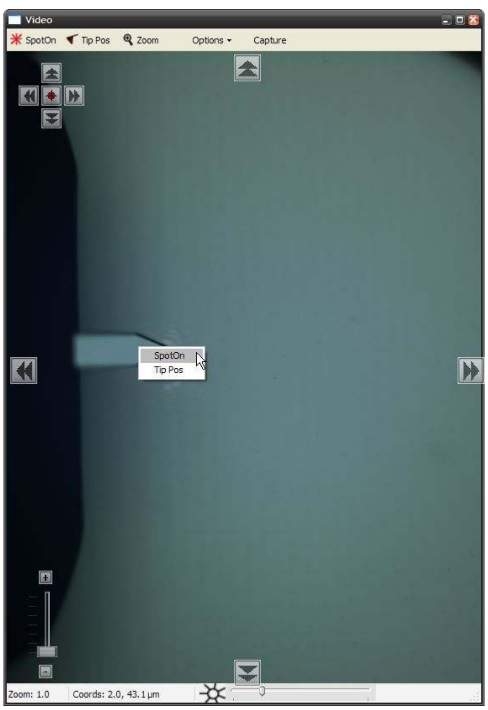
Figure 4.1.: Finding the cantilever and optimizing the video.



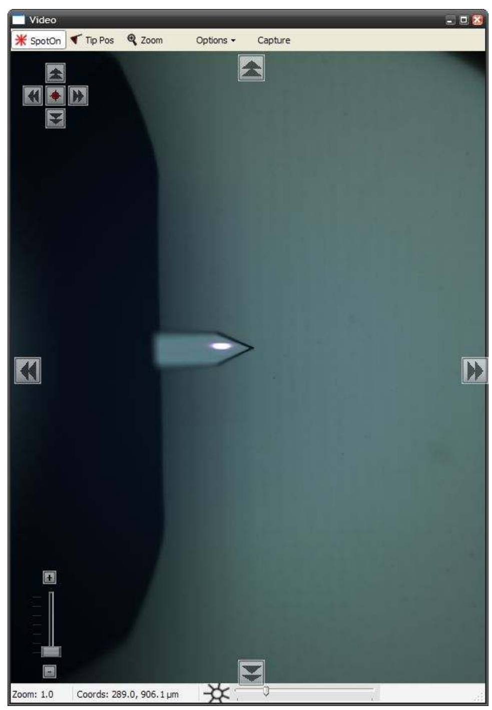
(a) Cantilever Zoom. See Step 10 on page 29.



(b) Laser Spot ON. See Step 11 on page 30.

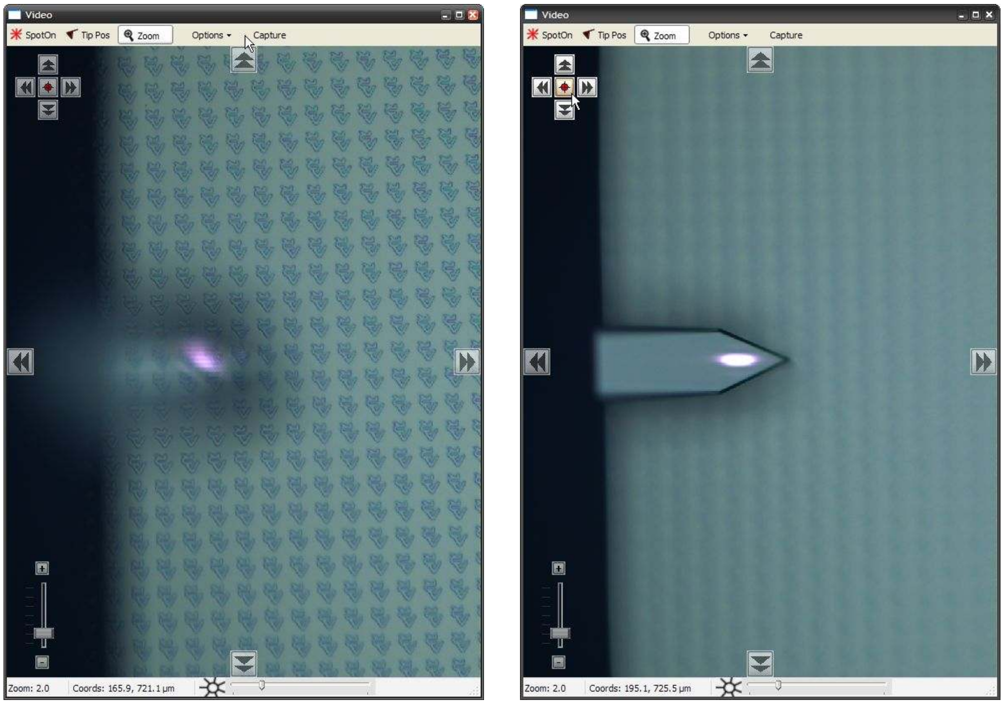


(c) Spot On by right clicking. See Step 11 on page 30.



(d) Laser spot on the lever. See Step 12 on page 30.

Figure 4.2.: Various methods for aligning the laser spot onto the cantilever.



(a) Offset.

(b) The focus offset is centered and the optical image is confocal with the focused laser spot.

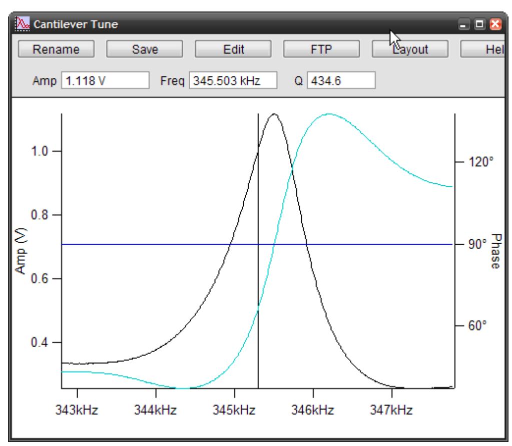
Figure 4.3.: By turning the focus offset knob, it is possible to focus on optical image on the sample while the laser stays focused on the cantilever.

2.

Observe tune result:

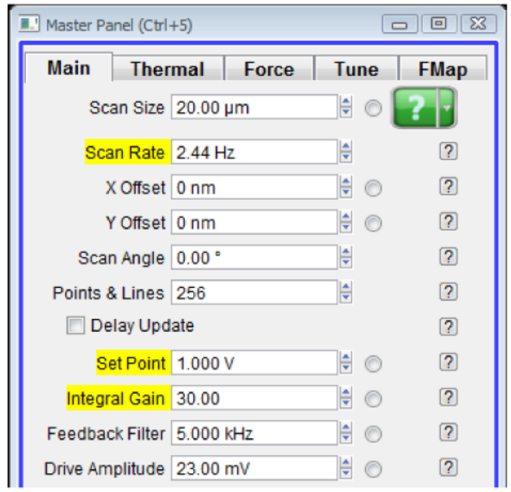
- A graph will pop up with the tune result.
- The resonance curve should peak around 300kHz.
- The relevant results are automatically stored. After inspecting that the amplitude and phase curves look "clean", you can close the graph.

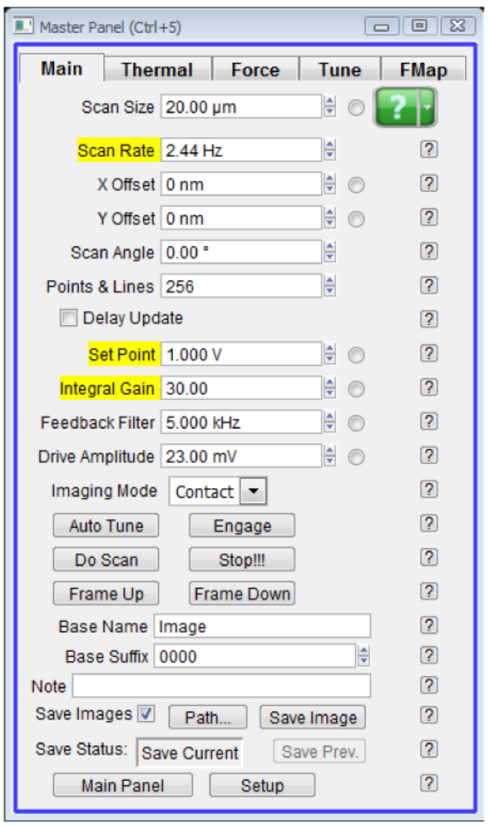
HINT Cleaner tunes can be obtained by blowing the cantilever holder with clean compressed air prior to loading cantilever to get rid of any left over silicon/glass debris.



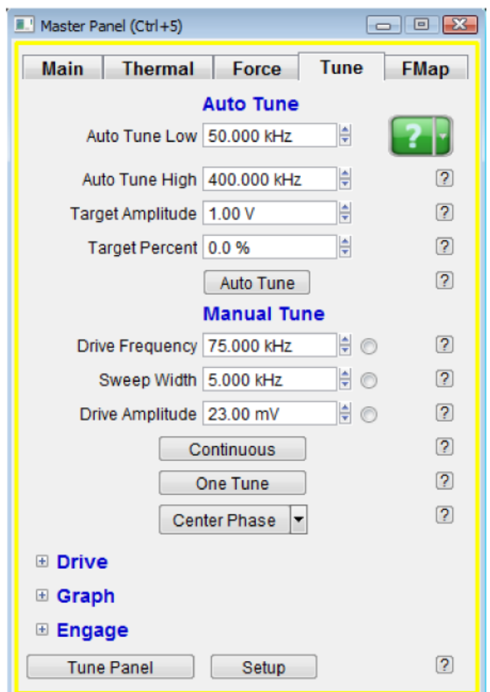
3. **Set scan parameters:**

- Click the 'Main' tab on the 'Master Panel'
.
- Set the set point value to 700mV, the second item highlighted in yellow in Figure 4.4a on page 37.
- Check that all the other values and check boxes of your 'Main' tab panel are the same as 4.4a.





(a) Master Panel, Main Tab.

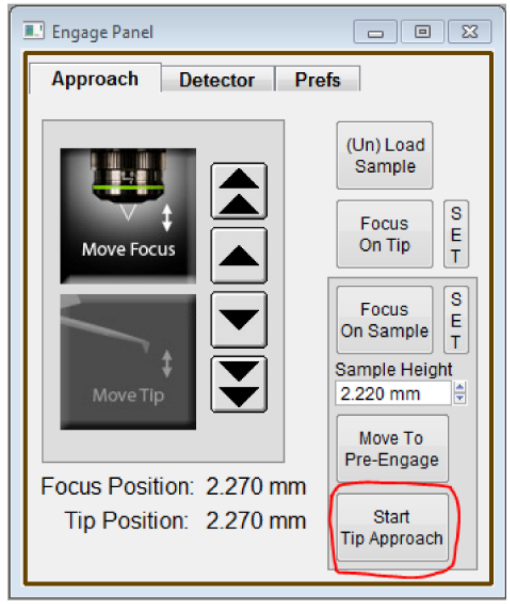


(b) Master Panel, Tune Tab.

Figure 4.4.

4.3.3. Landing the Tip

The preceding sections have left the tip vibrating about 50 microns above the sample surface. It's time to land.



1. **Start final tip approach:**
   - Locate the Engage Panel.
   - Click on the 'Start Tip Approach' button.

2. **Wait for tip to reach sample:**
   - For the next minute or so Cypher will systematically move the tip closer to the sample until the set point is reached.
   - You can cancel the approach at any time by pressing AND HOLDING the 'Esc' key on your computer keyboard.
   - When the process is complete, the computer will beep and the tip will be left about half the Z range (about 3 microns) off the sample surface.

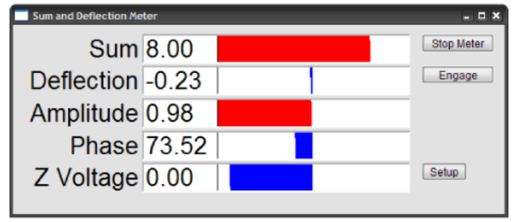
Q What's going on during the tip approach?

A Cypher executes a series of repeated steps. First the scanner fully extends the sample toward the tip while monitoring the cantilever amplitude. If the amplitude reaches the set point, the process stops. If not, the sample is fully retracted again and motors move the cantilever down by one extension length. The process is repeated until the sample is close enough to the vibrating cantilever to reduce its amplitude to the set point. One final time the sample is fully retracted and the cantilever is motored down just enough so that when the sample is brought back up it will trip the tip amplitude set point at half the scanner's vertical extension range.

3\.

Meter check:

- Locate the 'Sum and Deflection Panel'(Ctrl + 6).
- The values should be similar to the figure on the right, typical for a cantilever a few microns off the sample surface.

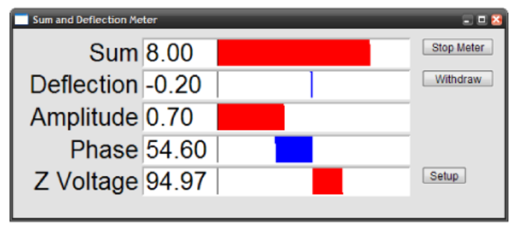


4\.

Engage:

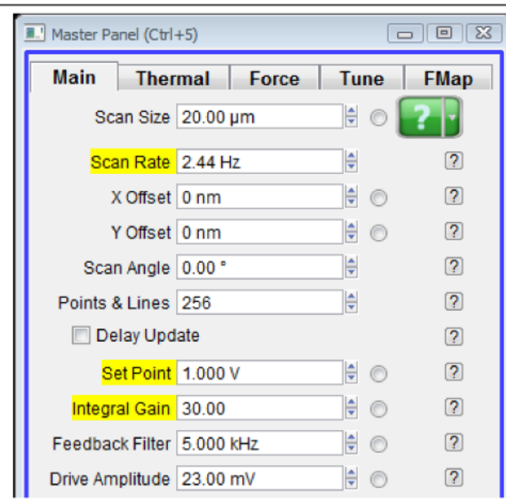
- Hit the engage button on the 'Sum and Deflection' meter panel.
- The scanner will extend the sample into contact with the tip and the 'Sum and Deflection' panel will look like the figure to the right.

Congratulations The tip is on the sample surface.



Question How do I know my tip is firmly engaged on the sample surface?

Answer Type in a slightly lower the set point (such as 650mV). If the Z voltage in the 'Sum and Deflection' meter panel does not change noticeably (*i.e.* more than a Volt) the tip is firmly on the surface.



Question Why does the sample look out of focus when the tip is on the surface? How do I fix this?

Answer The laser and video image both pass through the same microscope objective. While performing AFM, the objective must remain focused on the back of the cantilever to keep the laser focused. Since the sample sits one tip height farther away, it will not be in focus. The fix is extra optics just before the video camera. Adjust the focus ring (at the center in the photo on the right) on the view system until the sample is in focus. Of course the cantilever and laser spot will now appear blurred in the video image.

Note When it comes to focusing on the next cantilever (Step 9 on page 29) you must be sure to set the focus adjustment back to zero, as in Step 3 on page 26. Cypher includes a sensor to see that this has occurred and the software will warn you to zero the focus offset when necessary.

4.4. Imaging

This section will get you scanning and tracking the surface.

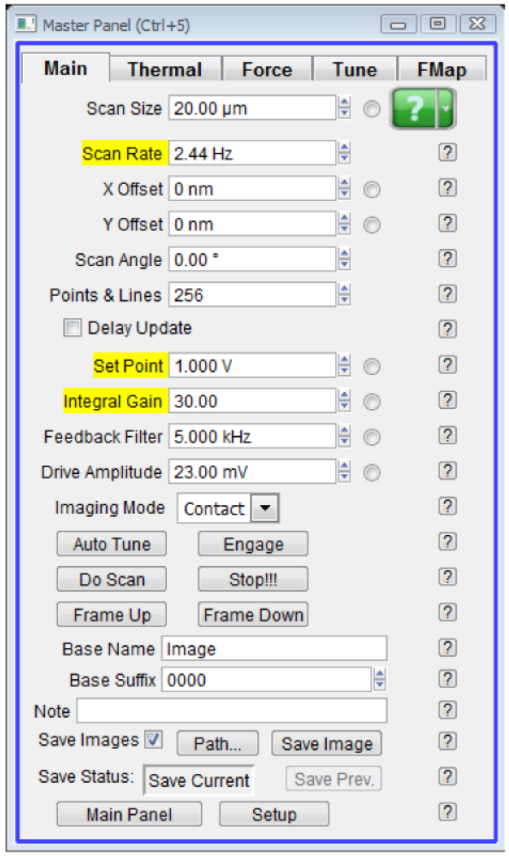
4.4.1. Set-Up and Initial Parameter Selection

Based on the previous section, it is assumed that:

- The cantilever tip is on the surface, or was just disengaged from the surface.
- The laser is aligned on the cantilever and the photo detector difference (deflection) signal has been zeroed.

1. **Set up Master Panel:**

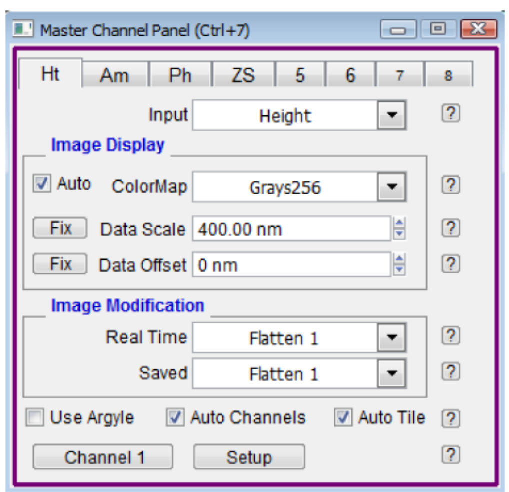
   - In the 'Main' tab of the 'Master Panel', confirm that 'AC Mode' is selected from the 'Imaging Mode' pull down menu.
   - Integral gain (I): 24 to 30.
   - Scan rate: 2.44 Hz.
   - Scan angle, resolution (scan points & lines) and image size is up to you. The figure to the right gives typical values.



2. **Image channel selection:**

   - Go to the 'Master Channel' panel
   - Select the leftmost tab and confirm the default setting of 'Height' under the *Input* pull-down menu.
   - For the next two tabs do the same for 'Amplitude' and 'Phase'.
   - For the fourth tab, do the same for 'Zsensor'.

   Note While not necessary, it's a good habit to activate the Z sensor channel when imaging, especially when sample features are larger than a few hundred nanometers; the LVDT sensors are more linear than the piezo actuators, and thus it's a more precise Z measurement.



3. Images are saved to disk automatically at the end of every image if you leave the 'Save Images' check box selected, near the lower left hand corner of the Master Panel in Step 1 on page 40.

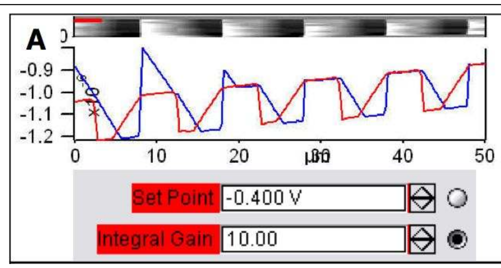
4.4.2. Start Imaging and Parameter Tuning

1.

- Click the 'Do Scan' button on the 'Main' tab of the 'Master Panel', and imaging will begin after a moment. Scan initiation first moves the tip to the starting point of the image, then lowers the tip onto the surface, and then begins an endless series of image scans. The red cursor to the left of each image window indicates the scan line/ location of the tip.

Tip	To enhance contrast on the image display, click and drag a box around the area of interest. Then right click and select fix scale.

2.



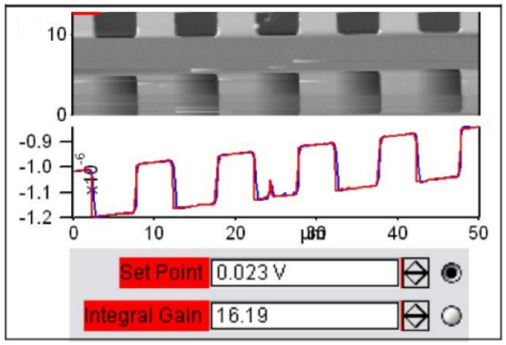
Determining Image Quality:

- Start the learning process on a sample with a known topography, like the Asylum Research Calibration Grating being used in this tutorial.
- Look at the 'Scope Trace' below the image. This graph represents the most recent line of the image. Blue indicates the tip moving left to right (a.k.a **trace**) and Red indicates tip returning from right to left (a.k.a **retrace**).

On most samples with relatively slowly changing features, trace and retrace should look the same. In other words, the landscape should look the same if you are flying the exact same route one way or the reverse. The image above shows the two as being quite different; this is an indication that imaging parameters need to be adjusted.

Nomenclature	In the previous image the tip is not following the surface. As the blue trace shows (left to right), the tip seems to climb up out of the pits of the calibration grating quite nicely (the left edge of each pit is quite sharp) but then it descends back into the next pit along a relatively gentle slope. During this descent the tip actually "flies through the air" while it is completely un-deflected, a bit like a hang glider running off a cliff. The lateral motion of the tip simply marches on as dictated by the XY scan pattern. The feedback control algorithm is simply not aggressive enough to bring the tip back down to the bottom of the pit. Such behavior is commonly called **parachuting** or **poor tracking**.

Hamster	The next steps will go into the details of strategies for tuning parameters in the main panel. Use the arrow clickers (to right of variable fields) to adjust parameters, rather than typing the values in. Alternatively, you can fine-tune the parameters using the 'Hamster' wheel on the front of the controller. Any parameter with a radio button next to it can be changed during a scan when it is activated (looks like black/ green dot in circle) with the 'Hamster'. The Hamster gives "digital control with analog feel". On the MFP-3D AFM controller the toggle switch to the left of the 'Hamster' allows you to toggle between radio buttons in the panel. On the ARC2 SPM controller the outer 'Hamster' ring performs this function. This tactile experience lets you concentrate on the image while tuning parameters.



3.

Adjusting Set-Point, i-gain, and scan speed:

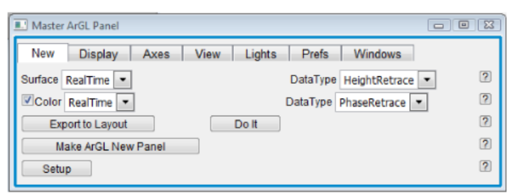
- The goal is to get trace and retrace to fall on top of each other (as shown above).
- Increase the 'Integral Gain' or *i-gain* parameter (second highlighted item in Step 1 on page 40) and see what happens. The match between trace and retrace should improve. The feedback becomes more aggressive and the slope with which the tip "parachutes" down into the pits should become steeper.
- Keep increasing the 'Integral Gain' until suddenly the trace and retrace start to oscillate wildly, a phenomenon called ringing. The feedback loop is now unstable and the i-gain needs to be lowered a bit.
- If increasing the i-gain does not seem to help, try to increase the 'Drive Amplitude' a bit. This will cause the cantilever to oscillate with greater amplitude.
- Lowering the Set Point can also improve tracking.
- Decreasing the 'Scan Rate' control will also improve tip tracking.

Note The overall goal is usually to make a good compromise between imaging speed and tip tracking.

4.

View Data in Real Time 3D:

- Open the 'Master ArGL Panel' by selecting from the menu bar *AFM Analysis ▷ 3D Surface Plots.*
- From the 'Surface' pull-down select 'Real time'
- From the 'Data Type' pull-down to the right of it, select the desired channel in that image (usually *Height* or *Zsenor*).
- Click the 'Do It' button.
- You can click and drag on the 3D data to change the view.



Moving the Sample Between Scans:

- Sometimes, it is desirable to move to another point of interest after some scans have been taken. For features within 12.5 microns, use the *X Offset* and *Y Offset* fields. Note that a negative is to the left or below the initial area.
- For features that are further away, use the arrows toward the edges of the Video Panel. The single arrows are slow, and the double arrows are fast. It is also possible to click and hold the double arrows for faster, continuous movement. See Figure 4.5 on page 46 for an example of sample movement.

Note These buttons move the sample rather than the cantilever, and so the laser and objective stay in alignment. Be sure to avoid accidentally moving the tip, and remember that the smaller arrow buttons in the upper left hand corner of the Video Panel are set to the cantilever rather than to the sample.

Q When I make changes to scanning parameters, when do those changes take effect in the scanned image?

A Most parameters in the main tab of the main panel (See 1) will update as soon as you make a change. Note that changing points, lines, or scan rate, will tak effect next frame.

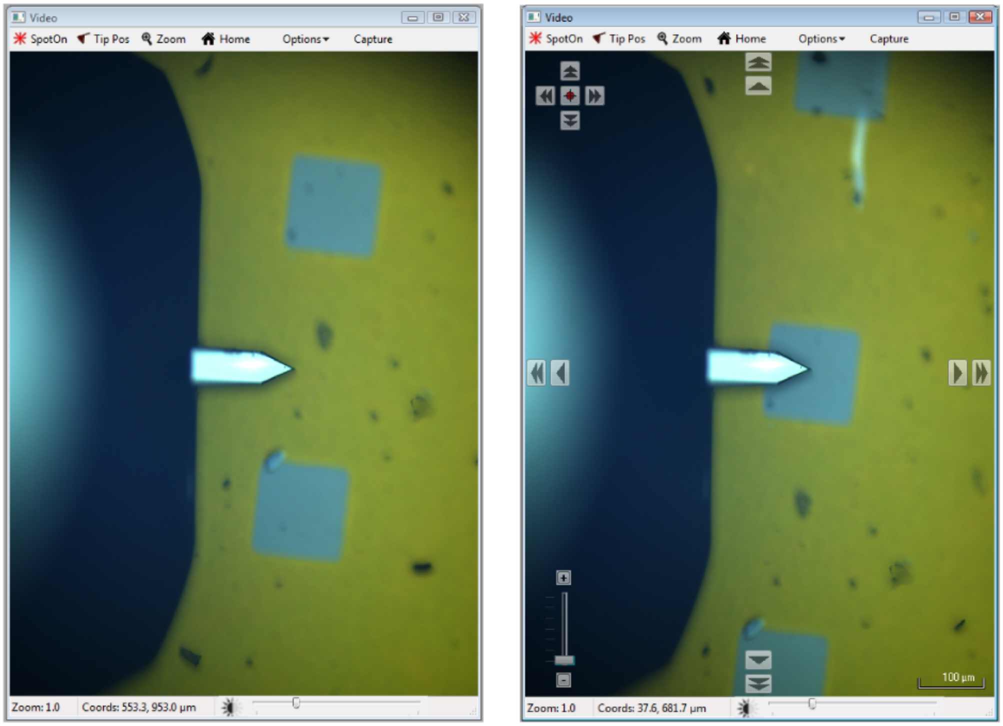
If you check the 'Delay Update' box just above the 'Setpoint' parameter, then any changes you make to parameters above that box will only update next frame. Until the image is complete, the changed variables are highlighted in blue.

You can always force a new image by clicking 'Frame Up' or 'Frame Down'. A nice way to see the effect of changing imaging parameters can be as follows:

- Check the 'Delay Update' box as described above.
- Click 'Frame Up' and collect a dozen scan lines. Observe the image quality
- Make some changes to the scan parameters (number of points, rate, gains, setpoint).
- Click 'Frame Up' again.
- Observe as the exact same scan region is "painted over" with new data taken with your new parameter choices.

4.4.3. Image Refinement

To learn more about using the Asylum Research SPM software to refine your imaging parameters, please refer to *Applications Guide, Chapter: AC Mode Imaging in Air* and also *MFP-3D User Guide, Chapter: Tutorial: AC Mode Imaging in Air*. Also consider watching this introductory video: AC Mode Imaging in Air (requires an internet connection).



(a) Before the Move. **(b)** After the Move

Figure 4.5.: Moving a Sample After a Scan

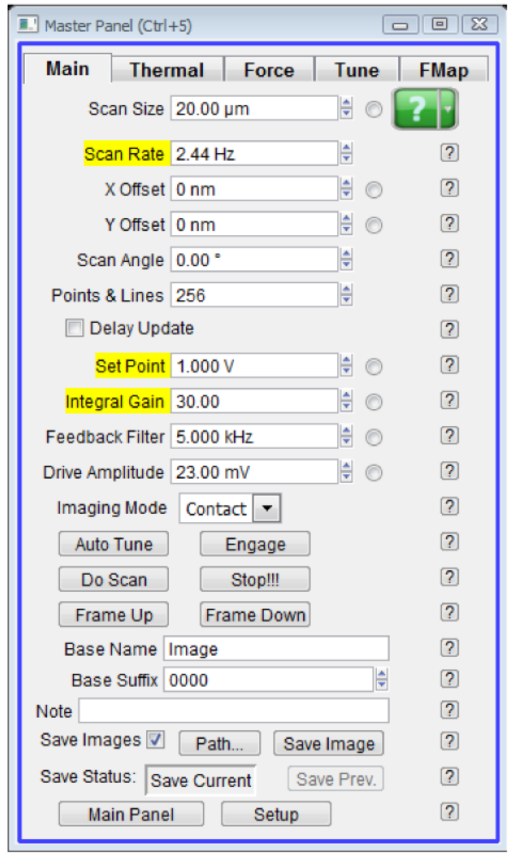
4.5. Stopping Imaging

1.

General Procedure for Stopping Imaging

- Once a scan has begun, the 'Do Scan' button on the Master Panel will change to 'Last Scan'.
- Clicking on 'Last Scan' will cause scanning to cease once the current scan has completed.

Note 'Last Scan' will change to 'Undo Last' if clicked. Clicking Undo Last will cause the software to keep imaging with current parameters.



2.

Emergency Stopping Procedures

- Clicking the 'Stop!!!' button on the Master Panel will halt the scanning mid-image; this is a fairly abrupt way of halting scanning, and should only be used if there is a problem. For instance, it would be appropriate to use this button if the cantilever were gouging holes in the sample.
- Measures such as closing the software, turning off the controller, or unplugging the microscope will stop scanning, but are not recommended except in extreme circumstances because of the complications and the risk of tip, sample, or hardware damage.

4.6. Shutting the System Down

The following procedure should be used if the Cypher will not be used for some time, for instance, at the end of the workday.

1. Once you are done imaging, save your data to a desired directory. Close Igor and shut down the computer.

2. The tip will disengage automatically when imaging stops, but for added safety, motor the tip away from the sample. You may want to remove the sample at this point.
3. Turn off the laser key on the controller.
4. Power off the controller.

5. Cantilever Holder Guide

CHAPTER REV. 1710, DATED 10/23/2013, 21:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

Depending on your specific imaging application the appropriate cantilever holder must be used. This chapter serves as a guide to the available Standard Scanner options and to help you identify the types of cantilever holders you may already own.

All the available cantilever holders have many things in common:

- All have a circuit board which allows the system to identify the type of cantilever holder and to activate the appropriate software control panels.
- Nearly all have a piezoelectric actuator and allow AC mode and contact mode imaging.
- Nearly all have the ability to apply DC and AC voltage to the cantilever.

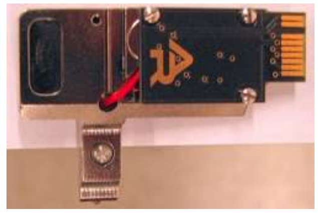
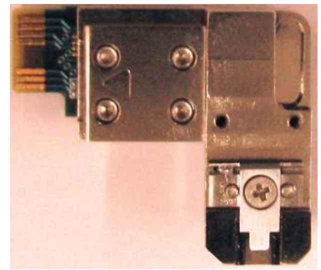
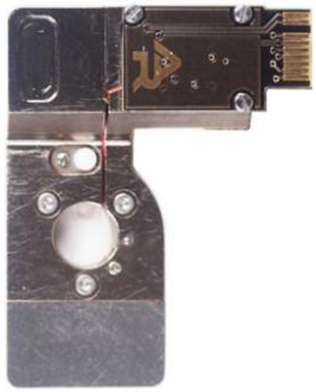
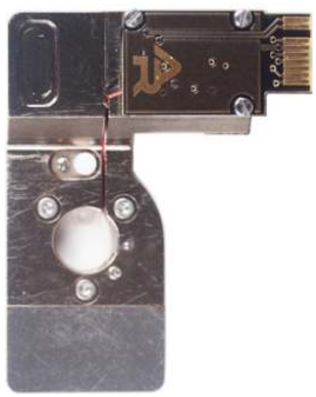
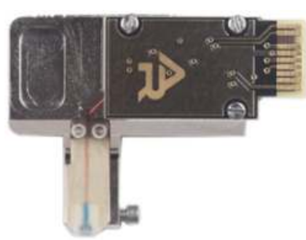
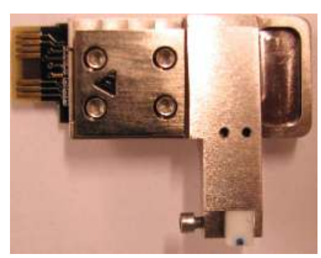
Many more contain specific electronics allowing for current measurement, application of high voltage to the tip,, and more.

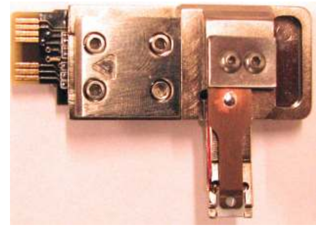
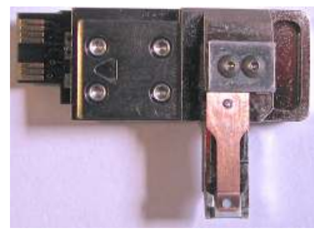
Be Careful	Cantilever holders are the most delicate components of the AFM. Treat it like you might treat your great grandfather's pocket watch. Never drop it. Remember that even the most basic cantilever holder costs thousands of dollars to replace.

5.1. Identifying Cantilever Holders

5.1.1. Visual Guide of Cantilever Holders

Please use this table to identify your cantilever holders and find the relevant sections which describe them.

Part #	Holder Description	Front Photo	Back Photo
901.705	**Air** For most contact and AC mode Imaging. It's use is described well in this tutorial: Section 4.2 on page 18. Fits in the Air Changing Station. For use in air only.		
901.730	**Droplet*** For fluid imaging in a droplet. See Chapter 6 on page 53. Fits in the Droplet Changing Station. For use in air or liquid.		
901.740	**iDrive*** For Electromagnetically Driven imaging, in air and droplets. See Chapter 7 on page 75. Fits in the Droplet Changing Station. For use in air or liquid.		
901.727	**STM** Scanning Tunneling Microscopy. See Chapter 9 on page 103. Fits in the Air Changing Station. For use in air or liquid.		

Part #	Holder Description	Front Photo	Back Photo
901.73x	**ORCA** Conductive AFM with a single current range. See Chapter 8 on page 92. Fits in the Air Changing Station. For use in air only.		
901.708	**Dual Gain ORCA** Conductive AFM with a two simultaneous current ranges. See Chapter 8 on page 92. Fits in the Air Changing Station. For use in air or liquid.		

5.1.2. Electronic Identification of Cantilever Holders

1. Attach the cantilever holder to the Cypher Scanner. (See Step 17 on page 23).
2. From the main menu bar in the software select *Programming ▷ Cantilever Holder and Sample Panel*.
3. At the bottom left of this panel click the 'Check Holder' button and the type of cantilever holder will be highlighted.

5.2. Cantilever Holder Changing Stations

Part #	Item Description	Picture
901.715	Air Cantilever Holder Changing Station. Used with Cypher cantilever holders that look like the Standard Air Cantilever Holder.	

Part #	Item Description	Picture
901.716	Air Cantilever Holder Changing Station. Used with Cypher cantilever holders that look like the Standard Droplet Cantilever Holder.	

6. Fluid Imaging in a Droplet

CHAPTER REV. 1710, DATED 10/23/2013, 21:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This chapter explains the use of the droplet cantilever holder designed for use with the Cypher Scanner. In this design, the sample is such that the scanning area is submerged in small volume of water (typically around 100uL) which encapsulates both the scanning area and the cantilever. The water environment is maintained by the meniscus bridge formed between the sample substrate and the underside of the glass window of the droplet holder.

Liquids other than water are not recommended. Volatile solvents may fill the Cypher enclosure with damaging or harmful vapors. The membrane is made of silicone and was not designed for a high level of chemical resistance.

The cantilever holder can be used for contact mode and AC mode imaging in fluid. It has a built-in piezoelectric actuator for driving cantilevers at resonance. Please refer to Chapter 7 on page 75 for specifics on iDrive imaging only.

6.1. Nomenclature

Please refer to Figure 6.1 on page 54.

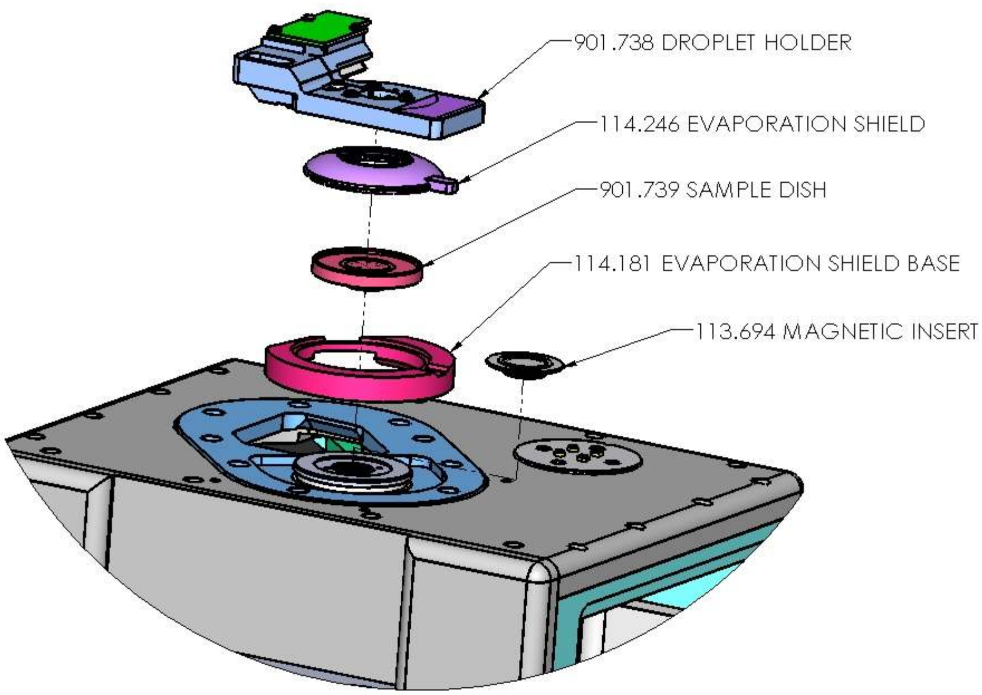
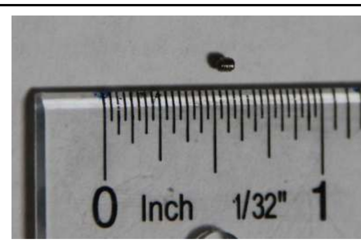
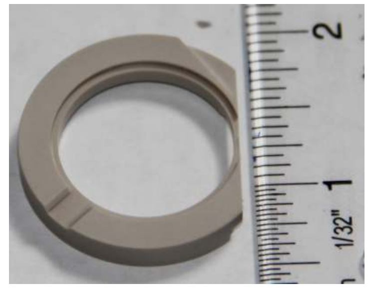
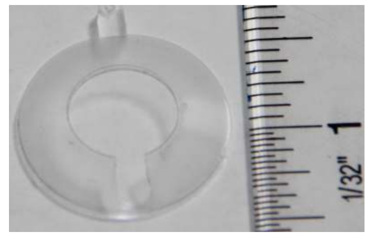
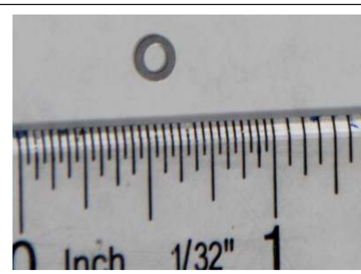


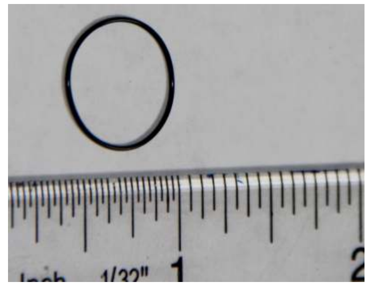
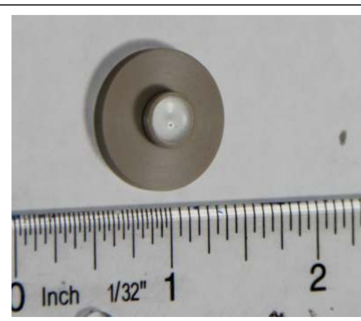
Figure 6.1.: Droplet Cantilever Holder nomenclature.

6.2. Parts List

Asylum Inventory Number 901.738.1

Itm	Part #	Item Description	Qty	Picture
1	004. SETS <#80 x 0.063> CUP	0-80 x 1/16” set screw, cup point.	6	

Itm	Part #	Item Description	Qty	Picture
2	114.181	Ring, Gasket Base	1	
3	114.246	Shield, Low Profile Evaporation.	3	
4	222.070	Socket Head Cap Screw, 0-80 X 7/64”	12	
5	222.072	Screw, M2 X 4, Stainless.	5	
6	222.094	Washer, 0.157” x 0.096” x 0.010” 17-7 stainless steel.	5	

Itm	Part #	Item Description	Qty	Picture
7	230.035	O-ring, 0.551” x 0.022”, 60 Durometer FKM.	2	
8	290.111	0.050”: Wiha Allen Driver 263 1,3 – 0.05” X 40.	1	
9	290.136	Short arm hex key, 0.028”.	1	
10	290.144	T5 2.5MM Torx Driver.	1	
11	901.738	Cypher Droplet Holder Assembly, V2.	1	
12	901.739	Small Diameter Droplet Holder Cup Assembly.	1	

6.3. Preparing for Imaging

Before you start:

- We assume you understand the aspects of running this system safely: (Chapter 20 on page 229.)

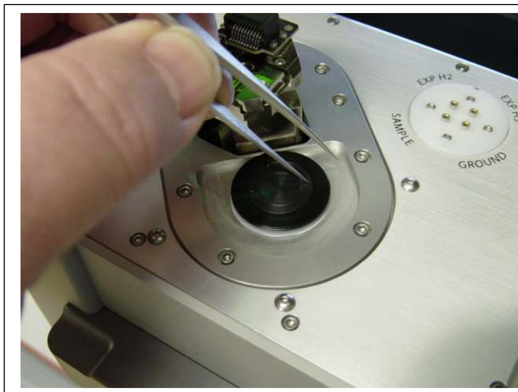
- You are familiar with the basic names of the hardware components and software controls (Chapter 1 on page 3.)
- You have powered up the Cypher and launched the software: (Chapter 2 on page 10.)
- You are comfortable with AC Mode Imaging in Air, as instructed by the tutorial: (Chapter 4 on page 17).

6.3.1. Mounting the Sample Dish

The sample dish was originally integral to the evaporation control in an earlier droplet holder design where an evaporation shield attached to the droplet holder. This scheme was difficult to use so the evaporation control components were redesigned as is now described. The sample dish is now only used to catch fluid overflow.

Fluid scanning experiments can be carried out with or without the use of the sample dish since in either case the fluid should be confined between the glass of the droplet holder and the sample. The dish is not intended to be used as a reservoir for liquids. To install the sample dish remove the magnetic insert in the scanner cap and thread the dish into the scanner.

1.



Remove the magnetic insert

- Use a tool like the point of a pair of tweezers to fit into one of the holes in the insert.
- Push the insert counter clockwise to loosen the threads.
- Remove the insert and store in a safe place.

2.

Install the Sample Dish

- Thread the dish into the scanner cap and gently tighten.

6.3.2. Mounting the Cantilever

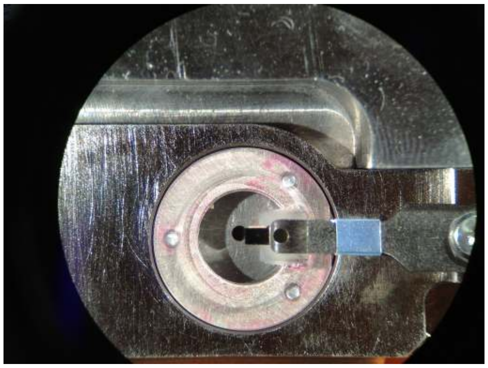
This cantilever holder requires the 901.716 droplet changing station (See Figure 6.2a on page 58).

Warning	Using the wrong changing station will not work and may damage your cantilever holder.

Once you have located the changing station, the procedure is the same as you are probably familiar with from AC mode imaging in Air. If you are not familiar with this you should seriously consider following the tutorial in Chapter 4 on page 17 at least once. Herein the specifics of mounting cantilevers is described in Step 9 on page 21 through Step 14 on page 22.

When finished your aligned cantilever should look like Figure 6.2b on page 58.

(a) Droplet Cantilever Holder Changing Station XXX.XXX. Notice the markings.



(b) Properly centered cantilever in the Droplet Cantilever Holder.

Figure 6.2.

6.3.3. Using the Evaporation Shield

Since the volume of liquid is small, evaporation will limit the experiment time to about 30 minutes. It is possible to extend the experiment without disengaging the tip by adding liquid into the gap between the sample and the droplet holder from the side by using a pipette.

The droplet holder is supplied with a set of parts which will allow you to build a semi enclosed chamber to help reduce the rate of evaporation. With the evaporation control in place, the typical time of the experiment can be extended about three times compared to scanning without them. Basically, the evaporation shield surrounds the scanning area while contacting the underside of the droplet holder window.

The current design of the evaporation base is sized to work with or without the sample dish using a sheet of mica or a glass cover slip mounted to a steel puck. Thicker bases can be provided if your typical specimen thickness prevents the shield from contacting the holder.

1.

Install the evaporation shield base

- Place the base into the recess around the sample stage

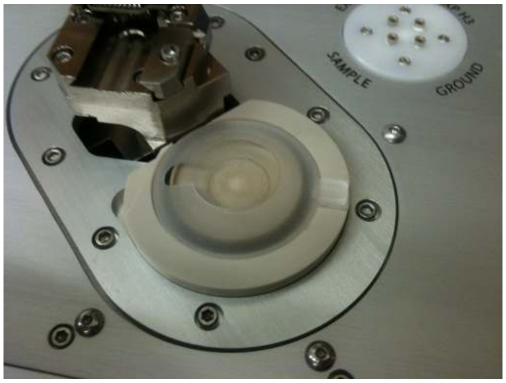
Note: The top of the base has a lip where the evaporation shield fits.

2.

Install the evaporation shield

- Place your sample onto the scanner.
- Place the evaporation shield on the base.
- Add a drop (approx. 100uL) of liquid to submerge the sample

Note: The tab on the shield makes a nice handle to allow you to manipulate it into position. Use tweezers to fit the bottom edge of the shield into the groove on the base.



6.3.4. Sample Mounting

Typically a sample is mounted directly to a steel AFM puck as you would for air imaging. The sample should be large enough to allow a drop of liquid to be placed on it. If the specimen is a material which requires a substrate, a piece of mica or a 15mm glass cover slip should be epoxied to the steel puck.

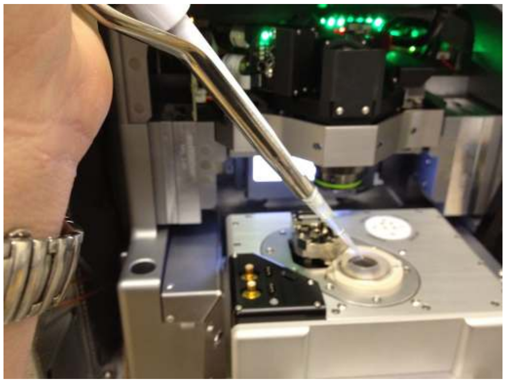
6.3.5. Installing the Cantilever Holder

1. Install the appropriate cantilever for your experiment.

2.

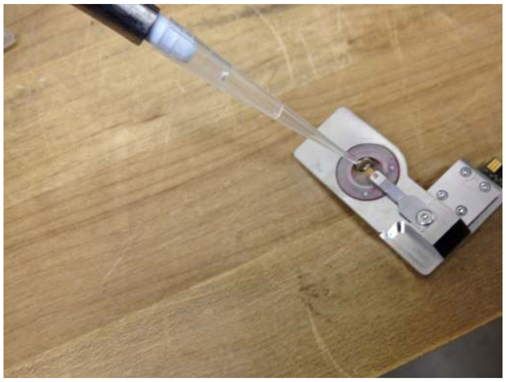
Immerse the sample:

- Add a drop of liquid (approx. 100uL) onto the sample surface.
- A laboratory pipette is recommended to deliver the liquid.



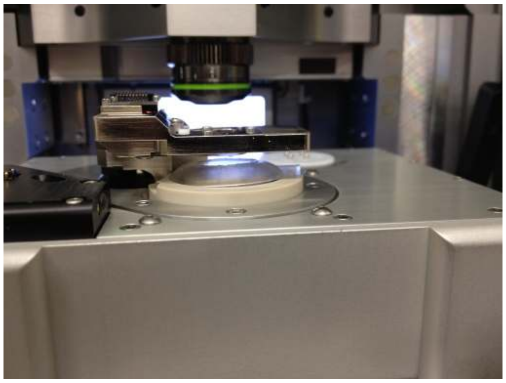
3. **Wet the cantilever:**

- Add a small drop of liquid to the window of the droplet holder to submerge the cantilever.
- This prevents bubbles and unwanted bending of very soft levers.



4. **Mount the cantilever holder:**

- Fit the droplet holder into the dovetail socket on the scanner as you would for the air cantilever holder (see Step 17 on page 23)
- If necessary, use the coarse approach wheel on the front of the enclosure to raise the cantilever holder pillar high enough to clear the evaporation shield if it's installed.

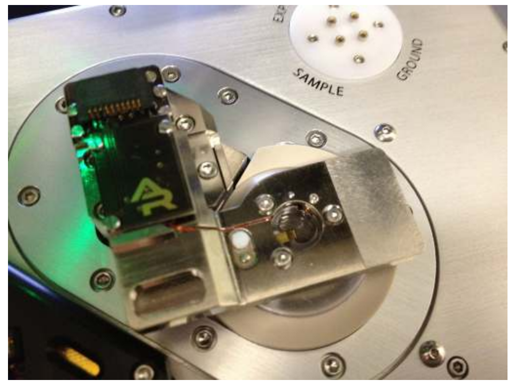


5. Secure the droplet holder to the engage pillar by tightening the dovetail clamp. Remember to only hold the driver tool with your fingertips and gently tighten the screw.

6.3.6. Engaging

6.3.6.1. Pre-engage adjustments

1. **Coarse Engage:**
   - Pull the scanner forward.
   - Using the control wheel on the instrument base, slowly lower the holder toward the sample.
   - Look down through the glass window and watch for the moment it contacts the liquid. You will notice the drop on the window will disappear and the view through the glass becomes slightly darkened.
   - Stop lowering the holder when this happens.

2. Push the scanner into the chassis and close the scanner clamp on the chassis.

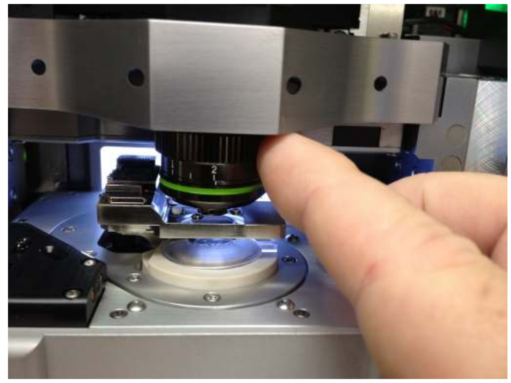
Warning	The droplet holder is designed to work only in fluids. Do not try to engage the tip in air. The software automatically compensates for the refractive index of water. Focusing on the tip and sample in air will cause the actual distances to be incorrect and the cantilever will crash into the sample. This feature can be disabled but for general usage, please only focus the optics through water.

6.3.6.2. Focus on the cantilever

1. **Adjust objective focus ring:**

   - Move the focus offset ring on the objective to the 2mm position. This is necessary in order to compensate for the change in focal depth of the objective focusing through the glass window and liquid.

   Note: Moving the focus offset ring to 2mm is important to correctly focus the instrument's optics. The system requires correctly knowing the tip and sample focus in order to avoid the tip crashing into the sample and for proper deflection detection.

2. Focus on the cantilever as you would normally do for air imaging, outlined in more detail in 4.3. We assume you are familiar with that tutorial and will only cover the main points briefly.
3. Set the cantilever focus position.
4. Use Spot On to move the cantilever under the AFM light spot.
5. Zero the deflection voltage.

Note: On occasion, an air bubble may get trapped between the glass window and the cantilever. If this has happened, raise the droplet holder out of the liquid and lower it back into coarse position over the sample. If the bubble is still there you may need to remove the droplet holder, suck off any liquid on the window and reapply a fresh drop to the cantilever area.

6.3.6.3. Focus on the sample

1. Lower the objective until features on the sample surface come into focus.
2. Set the sample focus position.
3. Click on the 'Move to Pre-Engage' button.
4. Make any adjustments to the AFM spot or the deflection voltage before engaging the tip.

Using the Field Diaphragm to focus on transparent samples

In cases where there is nothing to focus on because the specimen is featureless and the substrate is transparent, you can focus on the edge of field diaphragm which typically comes into focus about 30µm above the actual sample surface.

Being familiar with this method takes a little practice but once you know what visual ques to look for, it becomes relatively easy.

1.

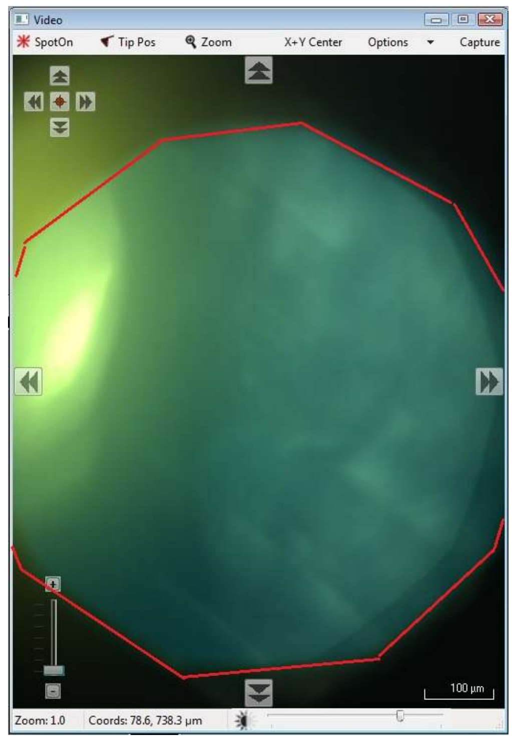
Adjust the aperture diaphragm:

- Adjust the Aperture Diaphragm lever (labeled A) on the View Module to reduce the illumination by about 90%.
- In the software, increase the illumination brightness to compensate for the reduction of light. This will help increase the image contrast and in many cases this is enough to see fine surface details.

2.

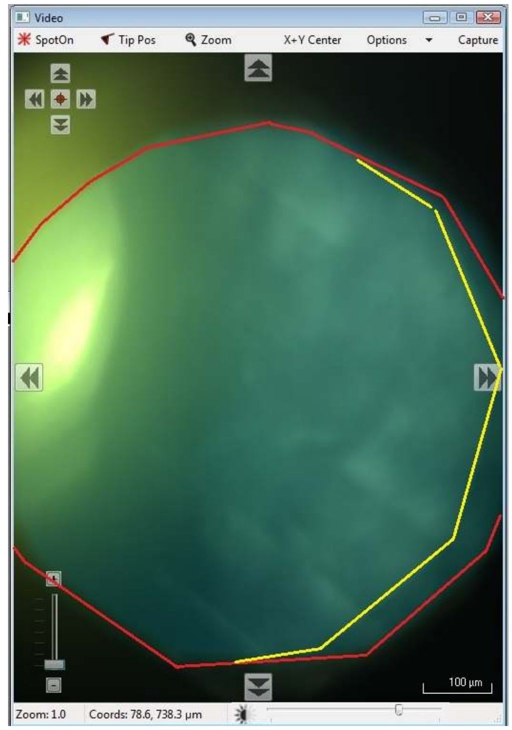
Adjust the aperture diaphragm:

- Adjust the Field Diaphragm lever (labeled F) on the view module until the edge of the aperture comes into view in the video image.



3\. **Lower the objective:**

- Lower the objective while watching for the surface to come into focus.
- As you lower the objective, you will first see the edge of the field diaphragm come into focus.
- Once the field diaphragm is in focus, slowly continue to lower the objective. Look for subtle structures like the edge of a layer of mica or a small bits of debris. This is most likely the sample surface.

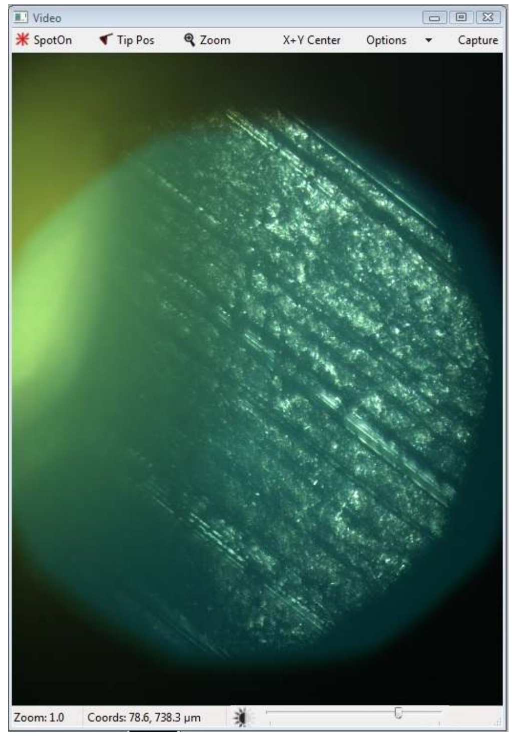


4\. One way to confirm this is to note the focus position distance located just below the arrow buttons. Raise the objective back up to focus on the field diaphragm and note how much the focus distance has changed. Typically, the sample focus distance is about 30µm below the focus distance of the field diaphragm.

Note You may see that the edge of the field diaphragm is shifted off center. This is due to a small amount of misalignment of the illumination path in the view module. In many cases this can help you distinguish when the edge of the field diaphragm is in focus.

5. **Going too far:**

   - If you cannot confirm you are focused on the surface, slowly continue to lower the objective until you see lots of coarse looking features. These features are typically scratches on the steel puck you have mounted beneath the substrate. If you see this type of structure, you have focused below the sample surface and need to raise the objective.
   - Slowly raise the objective until you either see:
     - 1st - a feature on the sample surface or
     - 2nd - the edge of the field diaphragm or
     - 3rd - the cantilever.



6. If you have raised the objective focus all the way up to the level of the cantilever then lower the objective back down to focus on the field diaphragm and set the sample focus there. You will be approximately 30µm higher than the actual sample. The result of this is a slightly longer time for the system to engage the tip.
7. Once the tip and sample (Field Diaphragm) focus have been set, click on the 'Move to Pre-Engage' button and make any small adjustments to the AFM spot position or deflection voltage prior to engaging the tip.

6.4. Imaging with the Droplet Holder

6.4.1. AC Mode Tuning Specifics

The technique of AC mode imaging in fluid relies on the motion of the piezoelectric actuator in the droplet holder to be sent to the cantilever through the fluid. This indirect or "acoustic" drive of the cantilever is greatly affected by the volume of fluid, the stiffness of the cantilever, and the frequency of the drive signal.

In most cases it is not possible to simply auto tune the cantilever at it's resonance. Manually tuning the drive signal is the preferred method. In order to know where to tune you typically find the amplitude peak by first measuring the thermal resonance of the lever. Once the thermal resonance is found, you can overlay the thermal spectrum on the tune plot. As you drive the piezo in the droplet holder will see several peaks in the amplitude plot as the drive frequency is swept. The peak you choose is typically the highest peak inside or near the thermal peak.

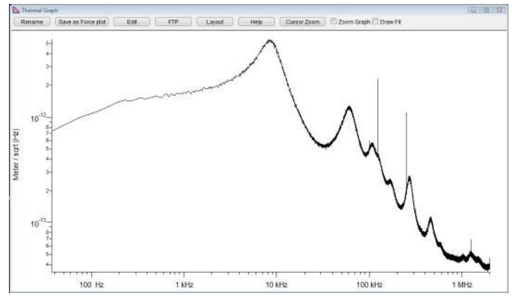
Once an amplitude peak is selected and the engage routine initiated it is not uncommon for the system to false engage as the driving forces on the cantilever change. It is therefore common to re-tune the system as the tip gets closer to the surface. A typical tuning session goes something like this:

1.

Capture a thermal plot

- Collect the thermal signature of the cantilever.
- For more information on capturing thermal spectra please read *Applications Guide, Chapter: Thermals*.

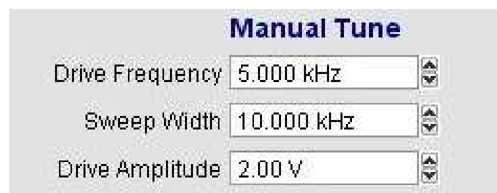
In this example the cantilever used is an Olympus TR400PSA having a nominal air resonance of about 40KHz and a spring constant of .1nN/nM.
In water, the thermal resonance is about 7KHz.



2.

Manually tune the cantilever

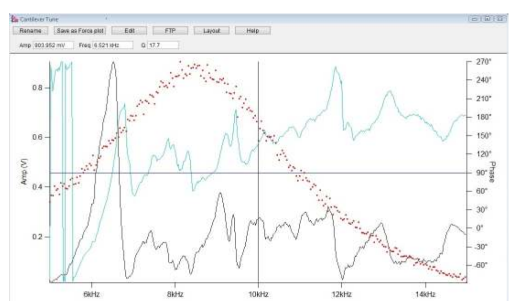
- In the manual tune parameters set the drive frequency to the approximate frequency of the cantilever's thermal resonance.
- Set the sweep width to 10KHz.
- Set the drive amplitude to 1-2v.
- Click on the continuous tune button and sweep the drive frequency.



3.

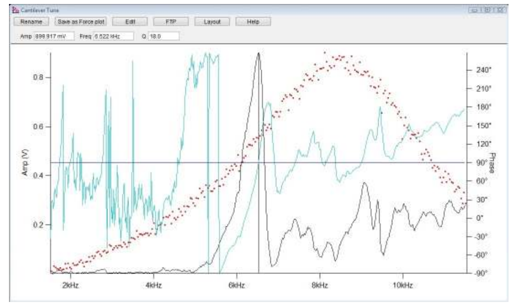
Select an amplitude peak

- Click on the append thermal check box to overlay the thermal data onto the amplitude plot
- Look for a peak inside the thermal signature. Generally the peak with the highest amplitude is the one to try. The peak should have a smooth rise in amplitude and have stable output as the frequency is swept.
- The peak near 6Khz is good although the lower amplitude peak at 9KHz would also work.



4. **Set the drive frequency and calibrate the phase signal**

    - Move the mouse cursor to the apex of the amplitude peak, right click and select ’Set Drive Frequency’
    - The software will center the pot on the peak.
    - Click on the ’Center Phase’ button in the tune panel to adjust the phase signal to the center of it’s range.

5. Click on the ’Stop’ button in the tune panel when the system is tuned.

6.4.2. Imaging Specifics

6.4.2.1. Engaging in fluid in AC mode

As the tip is being lowered to the surface during the engage routine, the Cypher is doing a series of triggered force curves looking for the free amplitude to equal the setpoint voltage. Once the free amplitude is seen as equal to the setpoint voltage, the system stops the approach and is considered to have found the surface. This works pretty well but in fluid there are several things that can trigger a false engagement.

- The Feedback Filter - The default frequency response of the feedback filter is 5KHz. Since the resonance of the cantilever in this example is around 6.5KHz, the instrument is allowed to see frequencies too close to the oscillating frequency of the lever. This will cause the software to detect the alternating movement of the cantilever as the amplitude is changing and trigger a false engagement. Lowering the feedback filter value to around 2KHz will avoid this. Using stiffer cantilevers with a higher natural resonance will not need this adjustment.
- Hydrodynamic drag - The abrupt drop in the cantilever holder pillar during a motor step can cause a jump in the deflection signal. This is caused by the drag of the liquid bending a low spring constant cantilever. Lowering the Feedback Filter to around 2KHz will help reduce this effect. Stiffer cantilevers will not show this problem.
- The amplitude changes due to the peak shifting frequency - As the probe is lowered to the surface, the amount of liquid between the glass in the droplet holder and the sample surface can change the coupling of the drive signal into the cantilever. This may excite the cantilever at a different frequency so a previously tuned cantilever may not be in tune anymore. If the instrument triggers an engagement, you may want to go back to the tune panel and do a single tune to see the amplitude response and re-tune if necessary.

Check for a real tip engage by clicking on the ’Engage’ button in the Sum and Deflection meter panel. Reduce the setpoint voltage in the master controls panel and watch the behavior of the Z control voltage. If by lowering the setpoint voltage you see the Z voltage move all the way to 150volts then the system has false engaged and you should check the tuning of the lever and adjust as necessary. If you see the Z control voltage move to a value and stop then you most likely have correctly engaged. Begin scanning.

Tip

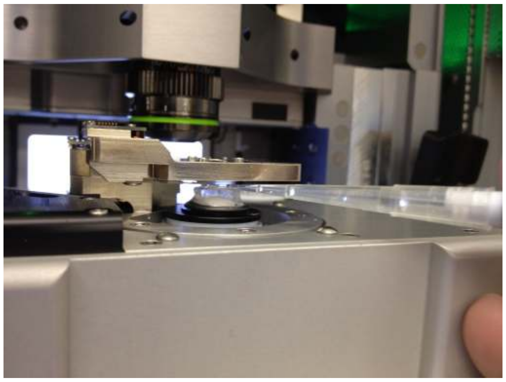
One useful thing is to monitor the deflection signal. Normally the deflection signal is not shown since the feedback signal is the Amplitude. Monitoring the deflection signal is helpful because in some cases the deflection will jump up as though the tip is has engaged in contact mode when the amplitude is falling. If this happens it indicates that the amplitude signal may be the result of deflections from the droplet holder components themselves resonating or the cantilever bending in a way that produces angular motion of the optical spot and not the result of the cantilever flexing at the tip end. If you see the deflection signal changing as though it's engaging in contact mode then most likely you should re-tune the system and try driving the lever at a different frequency (choose a different peak). This behavior is the result of using low spring constant cantilevers. Stiffer levers typically do not do this.
To display the deflection signal, click on the 'Setup' button in the Sum and Deflection meter panel. Change the deflection from Auto to Show.

Tip

Do a force curve and monitor the amplitude signal. The amplitude signal should show an abrupt drop to 0 volts just before tip contact is made. Doing a force curve is equivalent to seeing the conditions of the last engage cycle during the tip approach.

1.

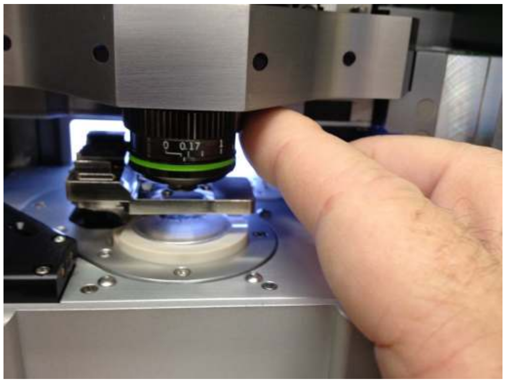
Adding additional fluid during scanning
During the experiment, you may find that the tip develops a tendency to float off the surface. This may be due to evaporation causing a loss of fluid volume which directly affects the AC drive oscillating the cantilever. If you suspect this has happening, use a pipette to add additional fluid to the tip/sample area and re-tune the system.



2.

After scanning

- After you are finished scanning move the focus offset ring on the objective back to 0mm.



6.5. Removal and Storage

6.5.1. Removing the Dish

Please seeSection 6.3.1 on page 57for details.

1. Unscrew the sample dish from the scanner.
2. Thread the standard scanner magnetic insert into the scanner sample stage.
3. Use the point of a pair of tweezers to tighten the insert.

6.5.2. Storage

Always clean the cantilever holder before storage. If it is particularly dirty, disassemble it before cleaning. Please see Section 7.2 on page 80 for the details. When clean and dry, store the cantilever holder and the other parts and tools in its designated kit box.

6.6. Cleaning and Repair

In daily use, the droplet holder can be cleaned by rinsing the exposed surfaces of the glass window and cantilever clips with clean de-ionized water. Following the rinse, the holder can be dried using low-pressure compressed air or by blotting with a soft tissue.

For thorough cleaning, the droplet holder must be disassembled. Only the parts exposed to the sample liquid should be cleaned. The cantilever holder body and associated electronics should be kept dry.

The cantilever holder clip, window assembly and evaporation control components can be cleaned by soaking in ethanol. Sonication of the parts can also be performed. Rinse the parts in clean de-ionized water. Dry the parts with either low-pressure compressed air or a soft tissue before reassembling the holder.

6.6.1. Disassembly

The following steps will guide you through removing various components for cleaning as well as reassembling the holder afterward.

Before you disassemble the droplet holder, take the time to familiarize yourself with the way it is assembled.

The key components are:

- The cantilever clip and the associated mounting hardware
- The droplet holder window assembly and associated mounting hardware

As you disassemble the holder, take note that the screws for attaching the window assembly are a specific length. Reassembling the window with the longer screws can result in damage to the glass by either cracking or causing it to become detached from the metal mounting ring.

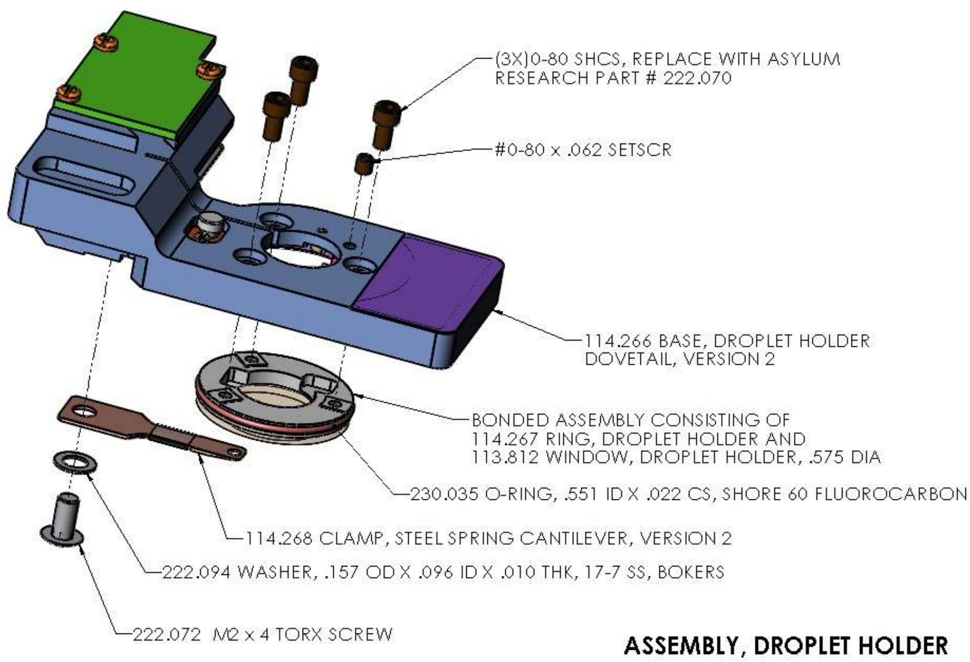


Figure 6.3.: Droplet Cantilever Holder Assembly Overview

- Use only 0-80 x 7/64" Socket Head Cap Screws to attach the window assembly.
- Use only 0-80 x 1/16" Cup Point Socket Set Screws for the piezo preload screw.

Due to wear and tear of use, the droplet holder accessory kit comes with replacement screws. Please contact Asylum Research for additional hardware if proper replacements cannot be obtained locally.

1.

Required tools and fasteners:

- 0.050" hex driver or Allen wrench for the 0-80 x 7/64" socket head screws to attach the window assembly.
- T5 x 40Torx driver for removing the cantilever clip
- 0.028" hex driver or Allen wrench for the 0-80 x 1/16" Cup Point Socket Set Screws for the piezo preload screw.

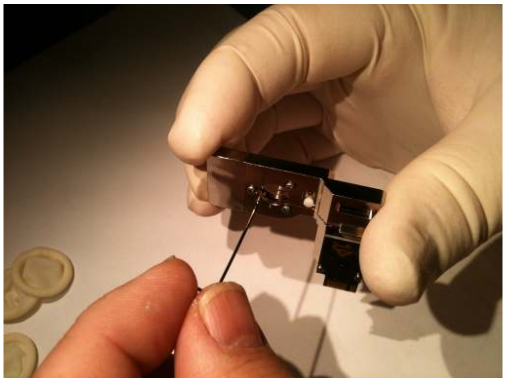
Warning Using other fasteners than those specified will damage your equipment.

2.

Loosen the piezo preload screw

Tools 0.028” hex driver or Allen wrench

- Loosen the piezo preload setscrew ¼ turn.

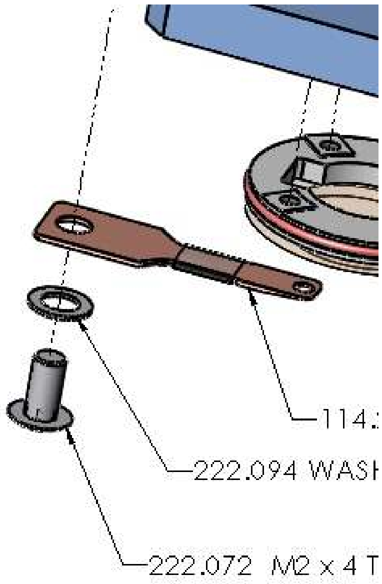


3.

Remove the spring clip

Tools T5 x 40 Torx driver

- Remove the screw securing the spring clip to the droplet holder body.
- Remove the clip from the droplet holder body.
- Set the parts aside for cleaning.



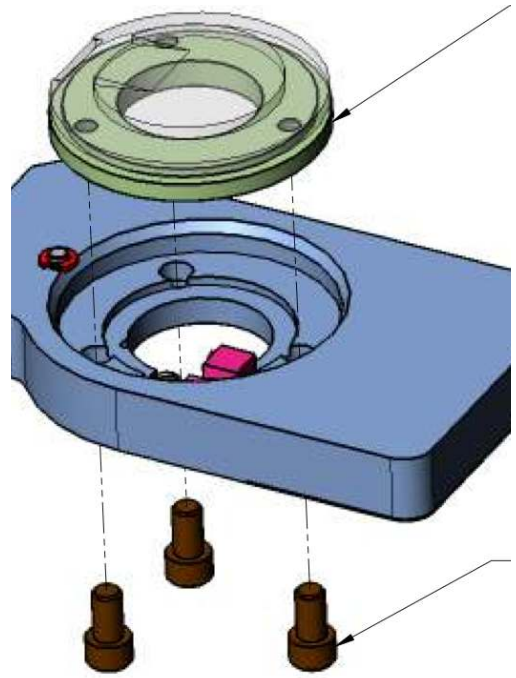
4.

Remove the window assembly

Tools 0.050" hex driver or Allen wrench

- Remove the three screws holding the glass insert into the holder body.
- Remove the window assembly.
- Use a Q-Tip[1] to gently push the window out of the Droplet holder body

Caution: Push gently on the top side of the window. Be careful not to push on the piezo actuator (Pink block in illustration)



6.6.2. Cleaning

The cantilever holder clip, window assembly and O-ring can be cleaned by soaking in ethanol. Sonication may result in weakening the glue bond of the adhesive used to attach the window to its mounting plate so limited amounts of sonication (less than 15 minutes) of the parts is recommended. Rinse the parts in clean de-ionized water. Dry the parts with either low-pressure compressed air or a soft tissue before reassembling the holder.

The rest of the holder parts can be cleaned with a cotton swab and ethanol. Avoid areas with electrical wiring or circuit boards. If you are unsure about having gotten the wrong bits wet, dry the parts (perhaps under the warmth of a desk lamp) for a while. Dry the parts with low pressure compressed air in any case.

6.6.3. Reassembly

1. Fit the o-ring into the groove in the window mounting plate. Spare o-rings are supplied in the accessory kit for the droplet holder and more can be obtained from Asylum Research if necessary.
2. Place the window in the holder aligned so that the ramp in the glass points toward the hole for mounting the cantilever spring clip. The O-ring around the edge of the window mounting ring will prevent the window from fitting directly into the holder body.
3. Use a finger to gently push the window into the holder body. As you push on the window, be aware that the o-ring will need to compress in the recess of the holder body. In order for this to happen, it may be necessary to use a small tool like the point of a pair of tweezers to help guide the O-ring to fit.

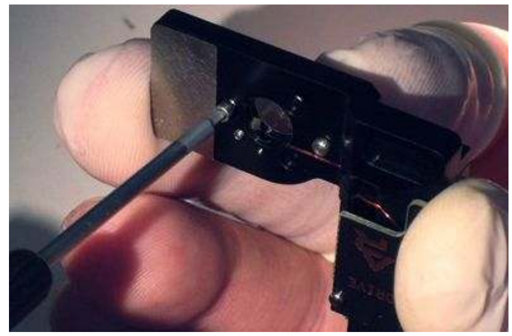
Note: There is a small recessed area in the metal ring where the piezo actuator fits. Be careful not to hit the piezo or twist the window into position.

1. **Secure the window assembly**

Tools 0.050” hex driver or Allen wrench.

- Using a finger to hold the window in place, thread the three 0-80x7/64” socket head screws the window to the holder using. Once all three screws are started, gently tighten them with uniform pressure.

Note Do not over tighten the screws. A small amount of torque is all that’s required.



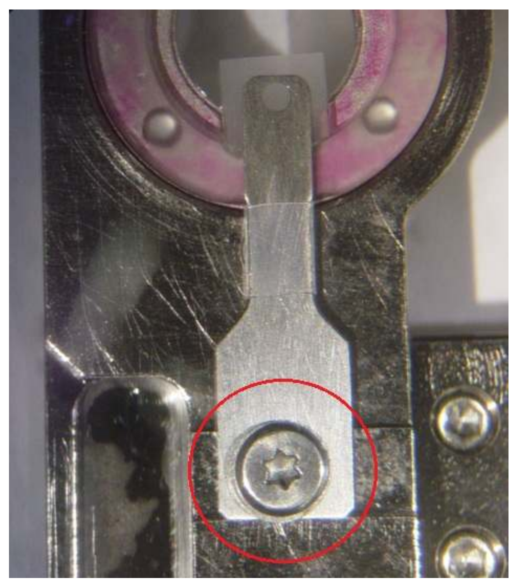
2. **Install the cantilever clip**

Tools 0.050” hex driver or Allen wrench.

- Lay the cantilever holder body circuit board side down.
- Place the clip on the holder body with the taper on the clip facing away from the window.

Note The end of the clip is tapered to provide clearance between the underside of the clip and the sample surface. Be sure the flat side is against the glass and the taper is away from the glass.

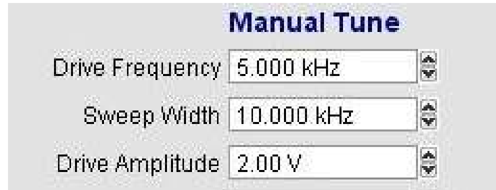
- Secure the clip to the holder with the Torx screw and washer. The clip may want to rotate as you tighten the screw. Use a pair of tweezers to hold the clip in the center of the ramp while you tighten the screw.



6.6.4. Adjusting Piezo Preload

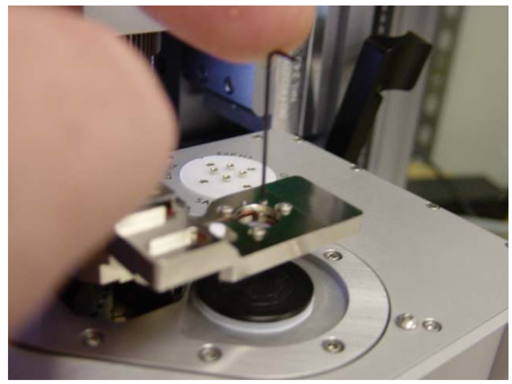
When first disassembling the droplet holder for cleaning, the preload screw was loosened. Doing this allows you to readjust the compression on the piezo element properly after it is reassembled. This is recommended since the amount of compression is very small and the piezo position may change when you remove and reinstall the glass window.

1. Install the Droplet holder into the scanner.
2. Lock the clamp on the scanner to secure the droplet holder.
3. **Activate the tune sweep**
   - In the AR SPM Software, select the *tune tab* of the *master panel*.
   - Under *Manual Tune*, set the parameters as shown to the right.
   - Hit the 'Continuous' (tune) button.



4. **Adjust the piezo compression**

   Tools 0.028" hex driver or Allen wrench
   - Listen for a small chirping sound coming from the droplet holder.
   - Gently tighten the preload setscrew until the chirping sound becomes abruptly louder. This is the point where the set screw has compressed the piezo into the back of the window assembly. Once this happens the preload is set.



6.6.4.1. Finishing up

1. Back to the software, under *Manual Tune* hit the Stop Tune button.
2. Done. Remove the cantilever holder and store it or put in a cantilever and start imaging.

7. iDrive Imaging

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This section explains the use of the iDrive version of the Cypher Droplet Cantilever Holder. In addition to the standard Droplet Cantilever Holder's functionality, the iDrive version has the ability to drive a small AC current through special iDrive compatible cantilevers. It also contains a small magnet, the field from which causes a torque on the current flowing through an iDrive cantilever causing it mechanically oscillate. This allows for an AC mode imaging experience in liquid superior to that achieved with standard acoustically driven AC Mode imaging.

Before you start:

- We assume you understand the aspects of running this system safely: (Chapter 20 on page 229.)
- You are familiar with the basic names of the hardware components and software controls (Chapter 1 on page 3.)
- You have powered up the Cypher and launched the software: (Chapter 2 on page 10.)
- You are comfortable with AC Mode Imaging in Air, as instructed by the tutorial: (Chapter 4 on page 17.)

- You have mastered fluid imaging in a droplet: (Chapter 6 on page 53.)

Review: The iDrive cantilever is based on the Droplet Holder covered in Chapter 7 on page 75. Please read this chapter for general use of the cantilever holder and the basics of using it for contact mode and AC imaging in liquid drops.

7.1. Nomenclature

See figure Figure 7.1 on page 76

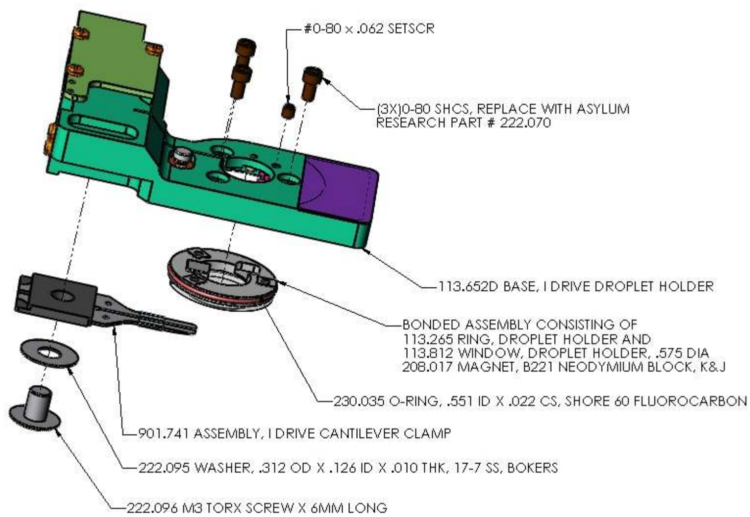


Figure 7.1.: iDrive Droplet Holder

7.1.1. Specific iDrive Droplet Holder Differences

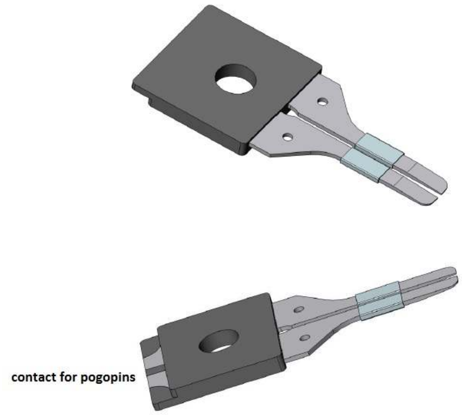
7.1.1.1. The cantilever clip assembly

The spring clip that holds the cantilever in the droplet holder is an assembly of two thin clips molded into a plastic block which together are the same basic shape as the single clip found on the standard droplet holder. In addition to clamping the cantilever, the split clip design is used as pair of electrical contacts to send the AC drive signal through an iDrive style cantilever. Inspecting the design of the iDrive holder will show that there are two gold spring clips (Pogo pins) that contact the back of the clips. These pins carry the AC drive signal from the droplet holder's circuit board.

Figure: Here are top and bottom views of the split clip assembly.

Notice:

- the exposed area of the clips which are the contacts for the pogo pins.
- the step along the molded section is used for keying the clip into the droplet holder body.
- the bands of Teflon act as a hydrophobic barrier.
- like the standard droplet holder clip, the bottom of the clips are tapered to provide sample clearance.

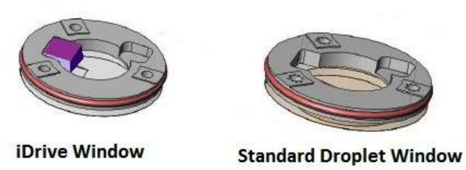


7.1.1.2. The window assembly

The window assembly used in the iDrive droplet holder differs only in that there is a magnet bonded to the top side of the glass window just above the cantilever.

Figure Here is a view of both window assemblies for comparison.

Note Due to limited space in the design of the droplet holders, the windows are not intended to be interchangeable. However, the standard window will fit into the body of the iDrive holder but the window from the iDrive holder will not fit in the standard droplet holder body.



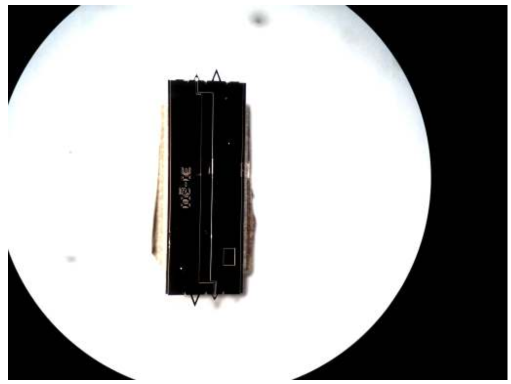
7.1.1.3. Installing an iDrive cantilever

Installing an iDrive style cantilever is basically the same process as a standard cantilever. The difference is that you need to pay close attention to the placement of the cantilever chip so that the split in the contact area on the chip is between the split in the cantilever clip. This will create a circuit so that AC current flows up through one clip, through the cantilever and returns through the other clip.

Figure Here is a view of the surface of an iDrive style cantilever.

Note

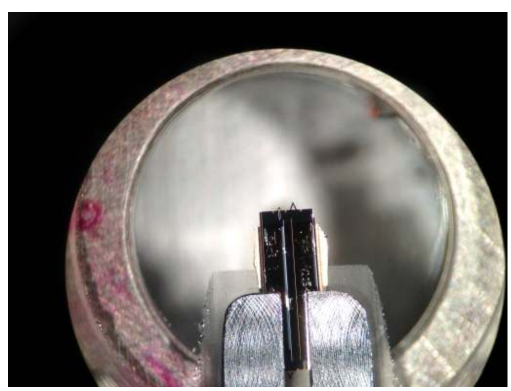
- The entire surface of the cantilever is coated with a layer of gold.
- The insulating lines are etched in surface to create to contact pads.
- Each of the outer pads are connected to one leg of the smaller cantilever.
- The center area is isolated and is not associated with the cantilever's function.
- The typical resistance between the electrodes is 10 Ohms with both of the small cantilevers intact.
- It is okay to scan with both levers intact. Breaking off the unused small lever will simply raise the resistance of the conducting path but generally doesn't improve performance.



1. **Install an iDrive cantilever into the droplet holder**

   - Align the chip under the electrodes so that only one cantilever clip contacts one of the contact pads.
   - Use an Ohm meter to check the resistance between the cantilever holder spring clips.

   Note The center narrower electrode is isolated so it's okay to allow one of the clips to touch it.



7.1.2. Preparing for Imaging

Since this cantilever holder is nearly identical mechanically to the Droplet Cantilever Holder, please refer to Chapter 7 on page 75 for details on

- mounting the sample and the sample dish,
- using the evaporation shield,
- installing the cantilever holder in the scanner,
- contact mode or acoustic AC mode imaging specifics,
- removal and storage.

Only keep reading on here for the specifics of iDrive imaging and cleaning and assembly instructions.

Tip	For contact mode or acoustic AC mode imaging, there is no need need to use special iDrive cantilevers. You can still use any standard cantilever for this type of imaging, just as you would with the standard Droplet Holder. Only use special iDrive cantilevers if you actually intend to use this method of exciting the cantilever.

7.1.3. iDrive AC Mode Tuning Specifics

1. With an iDrive cantilever installed, align the laser onto to the lever and take a thermal measurement.
2. Perform the same steps to manually tune the drive signal around the frequency range of the thermal peak as you would do for acoustic AC mode imaging.

Feature: Activating the tune for iDrive cantilevers

The software automatically scans the cantilever holder socket and identifies the type of holder you are using. In the Tune tab, the check box labeled iDrive will automatically be checked if an iDrive droplet holder is detected. If the iDrive check box is checked, the drive frequency is routed to the cantilever clip instead of the piezo electric actuator.

- Uncheck the iDrive check box to deselect the iDrive signal and send the drive frequency back to the piezo for acoustic AC imaging.

Figure iDrive Tune

Here is an example of a magnetically driven iDrive cantilever

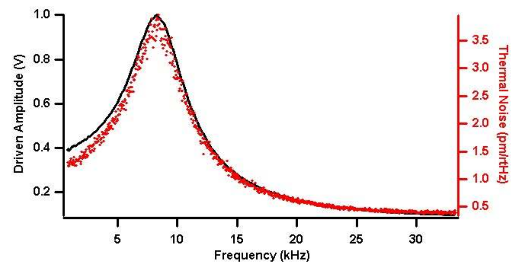
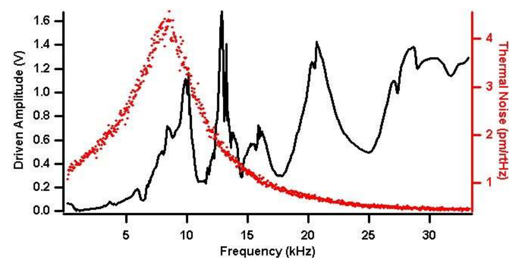


Figure Acoustic AC tune

Here is the same iDrive cantilever acoustically tuned using the piezo actuator.



7.1.4. Imaging Specifics

Once the cantilever is tunes and you initiate the engage routine, you may notice the free amplitude slowly decreases as the tip gets closer. This is due to the interacting of the steel sample puck interfering with the magnetic field lines emitted by magnet in the iDrive holder. As you see this begin to happen you may wish to increase the drive amplitude in the main controls tab. Generally a few "UP" clicks while the tip is approaching is all that's needed.

As a point of reference, a free amplitude of around 500mv may require 2-5v of drive. This is not a problem but simply a point to note as you learn to operate the system with these types of probes.

Another thing to note is that the volume of liquid has lilt affect over the amplitude response. Since the cantilever is driven magnetically and not by pressure waves transmitted through the fluid.

After an imaging session is completed, clean the cantilever holder before storage. If it is particularly dirty, disassemble it before cleaning. Please see 7.2 for the details. When clean and dry, store the cantilever holder and the other parts and tools in its designated kit box.

7.2. Cleaning and Repair

In daily use, the iDrive cantilever holder can be cleaned by rinsing the exposed surfaces of the glass window and cantilever clips with clean de-ionized water. Following the rinse, the holder can be dried using low-pressure compressed air or by blotting with a soft tissue.

For stringent cleaning, the iDrive cantilever holder must be disassembled. Only the parts exposed to the sample liquid should be cleaned. The cantilever holder body and associated electronics should be kept dry.

The cantilever holder clip, window assembly, Mounting hardware and evaporation control parts can be cleaned by soaking in ethanol. Sonication of the parts can also be performed. Rinse the parts in clean de-ionized water. Dry the parts with either low-pressure compressed air or a soft tissue before reassembling the holder.

7.2.1. Disassembly

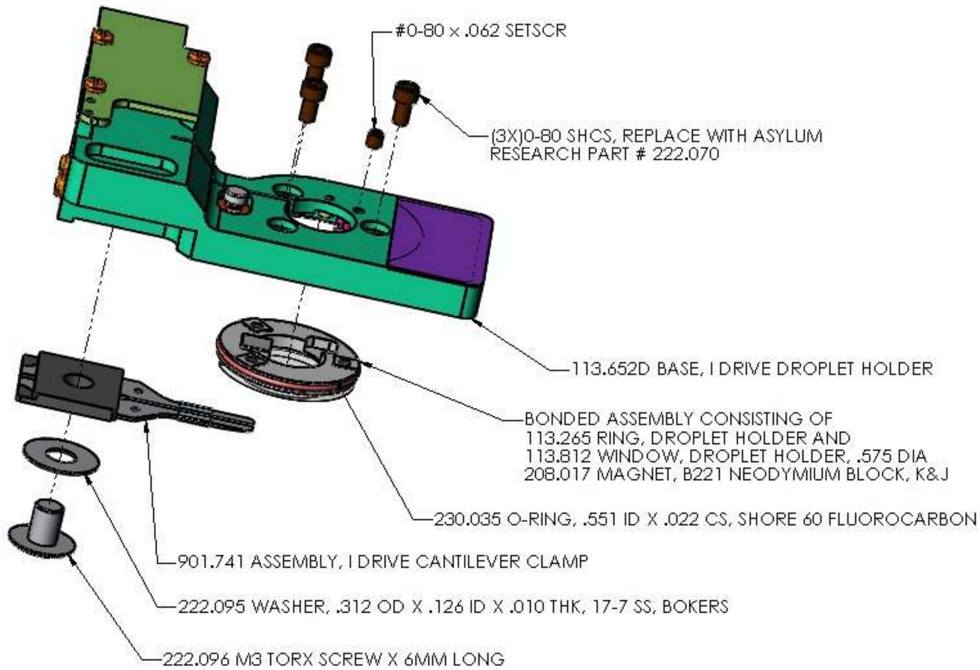


Figure 7.2.: Droplet Cantilever Holder Assembly exploded view

With the exception of the cantilever spring clip and the addition of a magnet to the window assembly, the iDrive Droplet holder is mechanically identical to the standard Droplet Holder. Please refer to the cleaning and repair section for the standard Droplet Holder.Section 6.6 on page 69

To summarize the steps to disassembling and cleaning the holder:

1. Remove the cantilever clip.
2. Loosen the preload set screw above the piezo actuator.
3. Remove the three screws retaining the window.
4. Gently push the window out of the holder body.
5. Clean the parts.

7.2.2. Reassembly

To summarize the steps in reassembling the iDrive holder

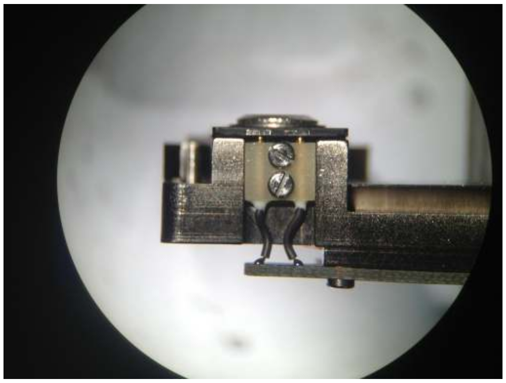
1. Install the window assembly.
2. Install the cantilever clip assembly.
3. Set the preload on the piezo for acoustic AC imaging.

Attention You may ask why the acoustic AC mode piezo is necessary when the iDrive system is available as an AC drive for the cantilever. Practically speaking, it's useful to switch back and forth between acoustically driving the cantilever and using iDrive. Even if you don't see the need, the next person using the cantilever holder might, so it's a good idea to perform the final piezo pre-load steps.

Tip Pogo pins

The pogo pins are spring loaded and carry the signal to the cantilever clip. Be careful not to bend them as you reinstall the cantilever clip assembly.

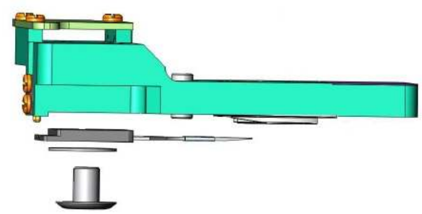
- Start by placing the cantilever clip in place
- Loosely thread the retaining screw. Don't forget the washer.
- Use tweezers to help keep the clip from rotating until the step on the back of the assembly mates with the step that is machined into the holder body.



Tip Aligning the cantilever clip on the body

The cantilever holder body and the clip assembly have a step that engage to help align the clip straight.

- The step in the plastic of the clip assembly can be crushed if you tighten the retaining screw with the clip improperly aligned.
- If the step becomes damaged residual plastic may be pushed over the pogo pin area and prevent the clip from touching the pins.
- Take time to familiarize yourself with the parts.
- Take your time when reassembling the holder



7.3. Older Models

There has been one significant redesign to both the standard and iDrive droplet holder. The design addressed:

- the complexity of disassembling and reassembling the holders after cleaning,
- Improvements in sealing the window from fluid leaks,
- ease of use of the evaporation shield.

If you have one of these versions of the droplet holders, please refer to this section for cleaning and maintenance.

Note These revision holders are no longer made. There is an ongoing campaign to replace all of these holders free of charge. If you have already received a replacement droplet holder and you you experience a failure of this design, we cannot support it. If you have not yet received a replacement droplet holder, and are experiencing a failure please contact Asylum Research.

7.3.1. Cleaning and Repair

In daily use, the iDrive cantilever holder can be cleaned by rinsing the exposed surfaces of the glass window and cantilever clips with clean de-ionized water. Following the rinse, the holder can be dried using low-pressure compressed air or by blotting with a soft tissue.

For stringent cleaning, the iDrive cantilever holder must be disassembled. Only the parts exposed to the sample liquid should be cleaned. The cantilever holder body and associated electronics should be kept dry.

The cantilever holder clips, insulator plates, window assembly and evaporation skirt can be cleaned by soaking in ethanol. Sonication of the parts can also be performed. Rinse the parts in clean de-ionized water. Dry the parts with either low-pressure compressed air or a soft tissue before reassembling the holder. please see 7.3.1.1

7.3.1.1. Disassembly

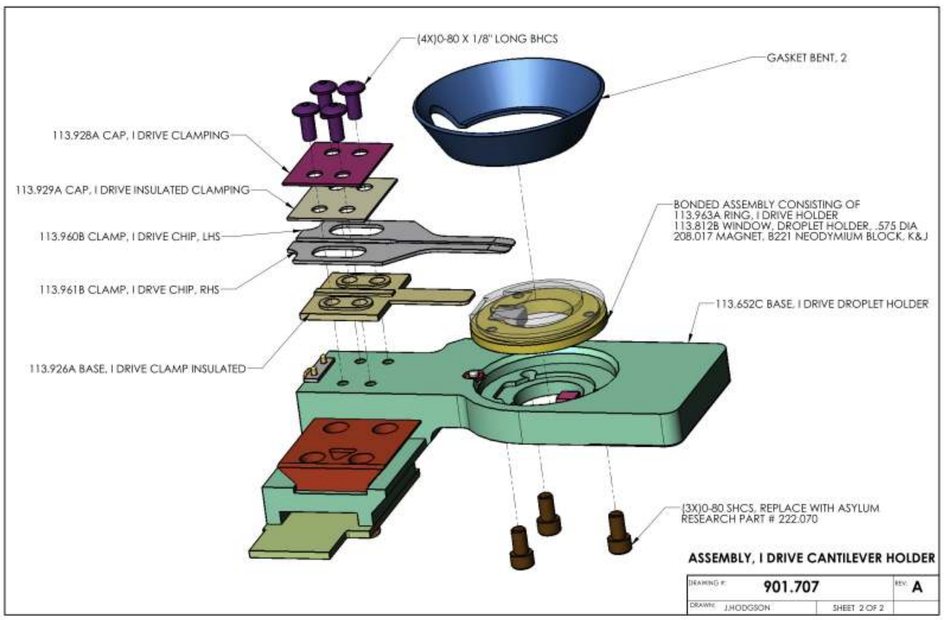


Figure 7.3.: Droplet Cantilever Holder Assembly Overview

The following steps will guide you through removing various components for cleaning as well as re-assembling the holder afterward.

Before you disassemble the droplet holder, take the time to familiarize yourself with the way it is assembled.

The key components are:

- The cantilever clip and the associated mounting (insulating) plates
- The droplet holder window assembly
- The piezo actuator for performing AC mode.

As you disassemble the holder, take note that the screws for attaching the window assembly are shorter than the screws holding the cantilever clips. Reassembling the window with the longer screws can result in damage to the glass by either cracking or causing it to become detached from the metal mounting ring.

- Use only 0-80 x 7/64” Socket Head Cap Screws to attach the window assembly.
- Use only 0-80 x 1/8” Button Head Cap Screws to attach the cantilever holder clips.
- Use only 0-80 x 1/16” Cup Point Socket Set Screws for the piezo preload screw.

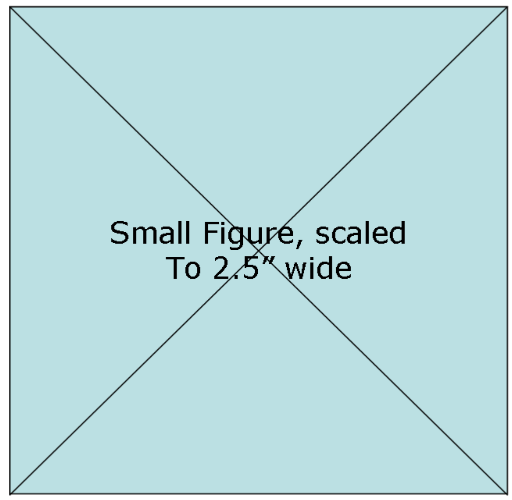
Due to wear and tear of use, the droplet holder accessory kit comes with replacement screws. Please contact Asylum Research or your local Asylum distributor for additional hardware if proper replacements cannot be obtained locally.

1.

Required tools and fasteners:

- 0.050” hex driver or Allen wrench for the 0-80 x 7/64” socket head screws to attach the window assembly.
- 0.035” hex driver or Allen wrench for the 0-80 x 1/8” button head screws to attach the cantilever holder clip.
- 0.028” hex driver or Allen wrench for the 0-80 x 1/16” Cup Point Socket Set Screws for the piezo preload screw.

Warning Using other fasteners than those specified will damage your equipment.

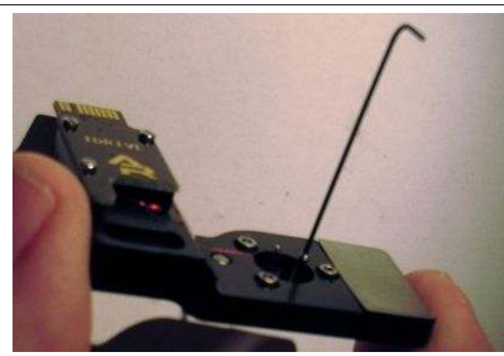


2.

Loosen the piezo pre-load screw

Tools 0.028” hex driver or Allen wrench

- Loosen the piezo preload setscrew ¼ turn.

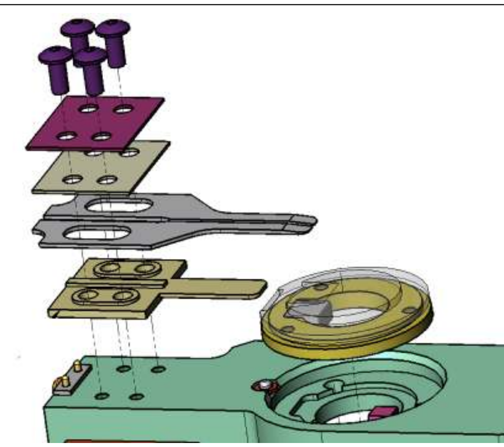


3.

Remove the spring clip

Tools 0.035” hex driver or Allen wrench

- Remove the screws securing the spring clips to the droplet holder body.
- Remove the clip and the spacer plates from the droplet holder body.
- Set the parts aside for cleaning.

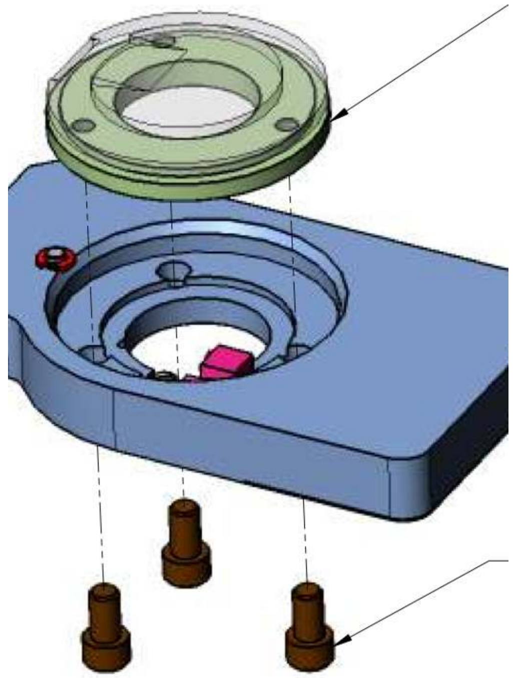


4.

Remove the window assembly

Tools 0.050” hex driver or Allen wrench

- Remove the three screws holding the glass insert into the holder body.
- Remove the window assembly.
- Separate the silicone evaporation skirt if installed.



7.3.1.2. Cleaning

The cantilever holder clips, spacer plates, window assembly and evaporation skirt can be cleaned by soaking in ethanol. Sonication of the parts can also be performed. Rinse the parts in clean de-ionized water. Dry the parts with either low-pressure compressed air or a soft tissue before reassembling the holder.

The rest of the holder parts can be cleaned with a cotton swab and ethanol. Avoid areas with electrical wiring or circuit boards. If you are unsure about having gotten the wrong bits wet, dry the parts (perhaps under the warmth of a desk lamp) for a while. Dry the parts with low pressure compressed air in any case.

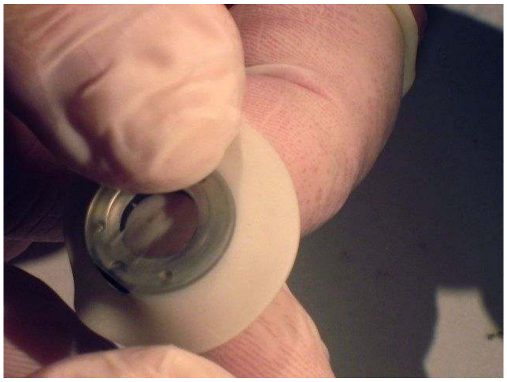
7.3.1.3. Reassembly

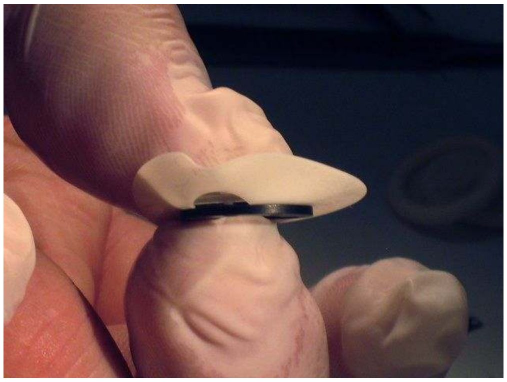
1.

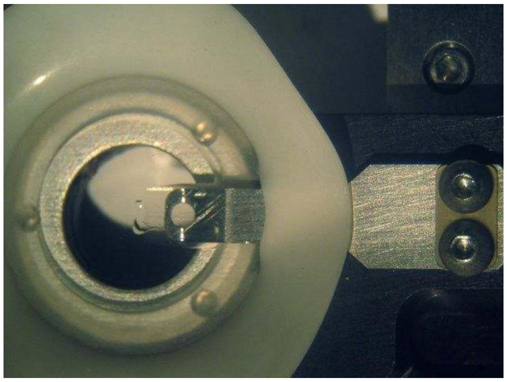
Optional: Install the evaporation skirt

- Stretch the evaporation skirt around the edge of the window. The edge of the window has a small groove where the skirt fits.
- Align the cutout in the skirt with the cantilever pocket. The cutout is made to allow a hole for the cantilever clip to fit through the skirt.

Note The evaporation skirt is an optional part and is not required for normal use. If you decide not to use this part, please disregard the steps where reference to the skirt is mentioned.







2.

Position the window assembly

Tools 0.050” hex driver or Allen wrench.

- Place the window in the holder and use a finger to gently press the window into position.

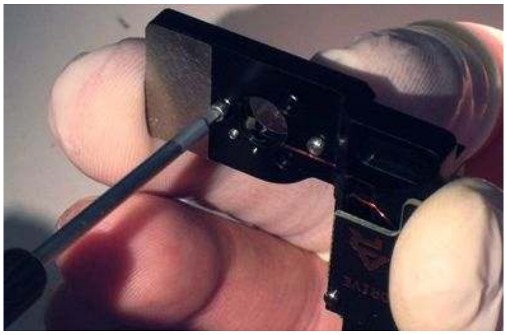
3.

Secure the window assembly

Tools 0.050" hex driver or Allen wrench.

- Secure the window to the holder using three 0-80 x 7/64" Socket Head Cap Screws.

Note Do not over tighten the screws. A small amount of torque is all that's required.



4.

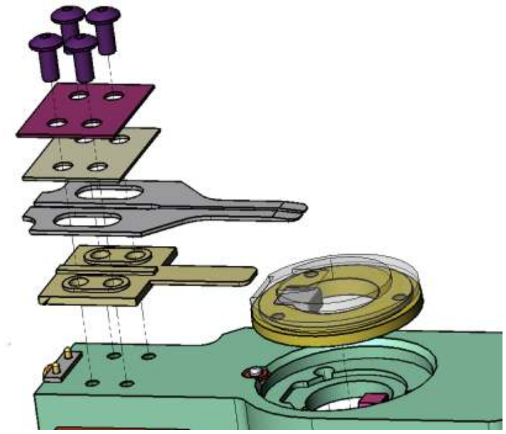
Install the cantilever clip

Tools 0.035" hex driver or Allen wrench.

- Lay the cantilever holder body circuit board side down.
- Using tweezers, place the bottom spacer, clip, and top spacers. Pay attention to the raised features on the bottom spacer. They must face up to mate with the clips.
- The top-most spacer is metal (purple in the drawing) the one below that is plastic. Don't reverse the order. The clips must be sandwiched between plastic or the iDrive current will be shorted before it reaches the cantilever.

Note The tips of the clips are tapered. Be sure the flat side is against the glass.

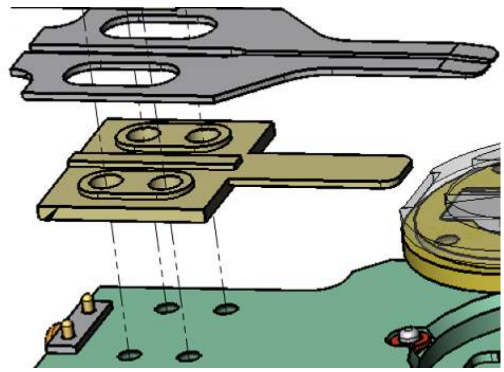
- If using the evaporation shield, maneuver the clips through the hole in the shield.
- Thread in the 0-80x1/8" button head screws by only a few turns.



5.

Settle the parts together.

- Adjust the clips so that they seat over the raised portions of the lower insulator. As you shift the position of the clips they will locate around the raised areas on the lower insulator. When this happens the clips will feel looser in the stack up of the assembly.
- Continue to gently tighten the screws and readjusting the clip position until the gap between the parts is gone. Do not tighten the screws yet.

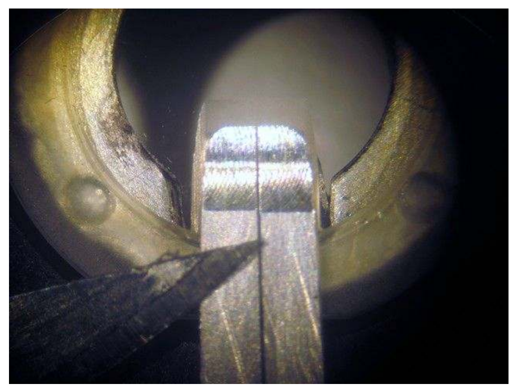


6.

Adjust clips, tighten screws

Optional Tools Stereoscope, scalpel or razor blade.

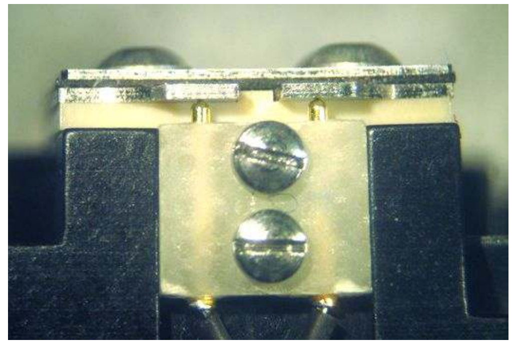
- Inspect the two clips at the end where the cantilever is held. The two clips should not touch. Adjust the clips if necessary. The point of a sharp razor or scalpel works well for this step. A stereoscope helps to see the details.
- Gently tighten the screws. Do not over tighten the screws. A small amount of torque is all that is required. Use only your fingertips on the hex driver tool.



7. **Optional final inspection**

Optional Tools Ohm meter.

- Where the clips are widest, measure the resistance between the two clips. It should be infinite (open circuit). If it is finite, then the clips are touching and you should loosen the four button head screws and repeat the previous step.
- The photo on the right shows a view from behind where you should see a stack-up (from top to bottom) of screw heads, metal plate, plastic plate, clips, thicker plastic plate, and then the aluminum cantilever holder. Note the two gold coated spring loaded pogo pins that must make contact with the clips for the iDrive system to function properly.



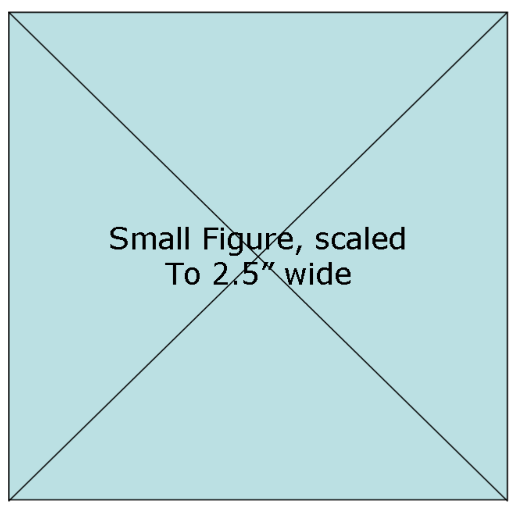
7.3.1.4. Adjusting Piezo Preload

When first disassembling the droplet holder for cleaning, the preload screw was loosened. Doing this allows you to readjust the compression on the piezo element properly after it is reassembled. This is recommended since the amount of compression is very small and the piezo position may change when you remove and reinstall the glass window.

1. **Install the cantilever holder**

Tools 0.050” hex driver or Allen wrench

- Take the assembled cantilever holder, without cantilever installed, to the Cypher SPM.
- Insert the cantilever holder into the scanner.
- Finger tighten the screw which clamps it down.
- No need to do any motoring up or down. Move to the next step.



2.

Activate the tune sweep

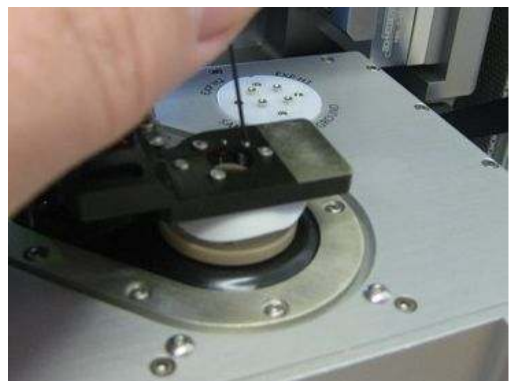
- In the AR SPM Software, select the *tune tab* of the *master panel*.
- Under *Manual Tune*, set the parameters as shown to the right. Note the phase offset is not important and sweep time of 1s is fine too.
- Uncheck the *iDrive* control, or the piezo will not receive any drive signal.
- Hit the 'Continuous' (tune) button.

3.

Adjust the piezo compression

Tools 0.028" hex driver or Allen wrench

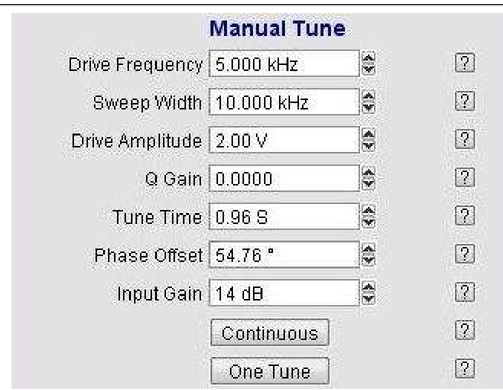
- Listen for a small chirping sound coming from the droplet holder.
- Gently tighten the preload setscrew until the chirping sound becomes abruptly louder. This is the point where the set screw has compressed the piezo into the back of the window assembly. Once this happens the preload is set.



4.

Finishing up

- Back to the software, under *Manual Tune* hit the 'One Tune' button to stop the chirping.
- Done. Remove the cantilever holder and store it or put in a cantilever and start imaging.



You may ask why the acoustic AC mode piezo is necessary when the iDrive system is available as an AC drive for the cantilever. Practically speaking it's quite useful to switch back and forth between acoustically driving the cantilever and using iDrive. Even if you don't see the need, the next person using the cantilever holder might, so it's a good idea to perform the final piezo pre-load steps above.

8. Conductive AFM (ORCA)

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This chapter explains the use of the ORCA cantilever holder. In practical terms, the ORCA cantilever holder is simply a standard air cantilever holder with the addition of a current to voltage converting amplifier.

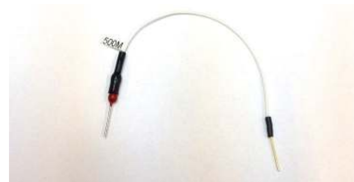
Basic AC and Contact mode imaging can be performed with the ORCA holder. One major difference in its construction however is the use of the electrical connection to the cantilever spring clip. The cantilever clip is used as a connection to the input of the current amplifier rather than a connection to a bias voltage source. Because of this difference, the ORCA holder will not work for measurement techniques where the tip needs to be biased.

Note	EFM (Electric Force Microscopy), Surface Potential - SKPM (Kelvin Probe Microscopy), PFM(Piezoelectric Force Microscopy) imaging techniques require the use of the standard air cantilever holder.

8.1. Parts list

The following items are included in the ORCA cantilever holder kit. These accessories are included in both the single and dual gain versions of the holder.

Itm	Part #	Item Description	Qty	Picture
1	901.730 901.708	ORCA Holder 2nA/V Dual Gain ORCA 1uA/1nA/V For other available versions see 8.2.	1	
2	ASTELEC-01	10 pack of conductive levers. Used for the measurements described in this section.	1	
3	823.009	HOPG sample. Used as a conductive AFM test sample. See Section 8.3.2 on page 98.	1	
4	448.079	Sample bias wire assembly. Connects sample to voltage source on top of the scanner. See Step 1 on page 98.	6	
5	208.05	Samarium Cobalt Magnet, 0.07” D X 0.104” L. Used to connect the bias wire to the sample. See Section 8.3.2 on page 98.	6	
6	290.160	Leitsilber Conductive Paint, 0.5 Oz. Used to conductively glue the sample to an AFM disc. See Section 8.3.2 on page 98.	1	

Itm	Part #	Item Description	Qty	Picture
7	448.082	Cypher ORCA 500M Resistor Assembly. A 500M Ohm Test Resistor. See Section 8.5 on page 99.	1	
8	448.081	Cypher ORCA 1M Resistor Assembly. A 1M Ohm Test Resistor (Dual Gain ORCA Only). See Section 8.5 on page 99.	1	

8.2. The ORCA Amplifier

There are a variety of ORCA cantilever holders each based on either a single or dual amplification design. The design type and amplification gain are labeled on the top of the holder. Like all the Cypher cantilever holders, a built-in circuit in the holder allows the software to automatically sense the type of holder and configure the system accordingly.

The amplification range of the ORCA amplifier is expressed by it's sensitivity. Basically the ability to produce a voltage output from a certain current flow into the tip. In terms of the full range of the ORCA amplifier, the output is +/-10v so multiplying the sensitivity by +/-10 will tell you the full range.

The ORCA amplifier incorporates the use of a trans-impedance amplifier which converts the input current from the tip to an output voltage. The input potential of the amp is referenced to ground so the tip is essentially held at 0v potential. During the measurement, the sample can be biased between +/-10v using a voltage source provided by the Cypher electronics.

Each ORCA cantilever holder has a fixed gain(s) to provide the highest current measurement range while considering the lowest noise. The following ORCA holders are currently available. Custom holders can be configured on request.

Part number	Sensitivity	Current Range	Typical noise 1-1KHz
901.730	2nA/V	+/-20nA	1.5pA
901.737	0.2nA/V	+/-2nA	750fA
901.708	1nA/V	+/-10nA	3pA
	1uA/V	+/-10uA	75pA

8.2.1. Single Gain

Here is a conceptual block diagram of the single gain ORCA amplifier. The sample is biased from a voltage source within the Cypher electronics. The feedback resistor R1 sets the amplifier's sensitivity. The output signal representing tip/sample current flow can be monitored by enabling the 'Current' channel in the master channel control panel. See Figure 8.1 on page 95.

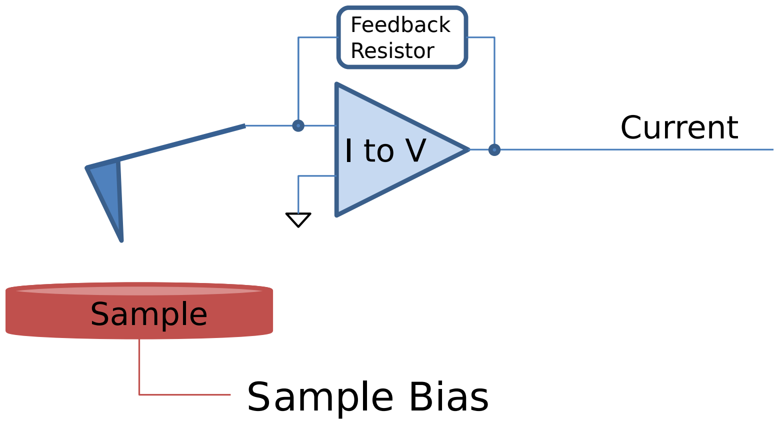


Figure 8.1.: Single Gain ORCA

8.2.2. Dual Gain

A conceptual diagram of the dual gain ORCA amplifier shows the initial current to voltage converter stage feeding the input of a second gain stage to create an additional output signal. In the case of this design the more sensitive signal comes from the second stage and is monitored as 'Current' from the master channel panel like the single gain ORCA holder.

The output of the current to voltage amplifier's first stage has a lower gain (more total current range) signal is monitored as 'Current 2' from the master channel panel.

Having a dual gain design is useful in that it expands the dynamic range of your measurement capability but at a sacrifice of some increased noise at small current levels. In many cases the sample you may wish to measure may have widely different regions of conductivity where the current may be too large for the range of the more sensitive stage but suitable for the lower gain stage where more current can me measured. In this case it is common to see the 'Current' signal (high gain stage) saturate while the 'Current 2' signal show a measurable current flow. See Figure 8.2 on page 95.

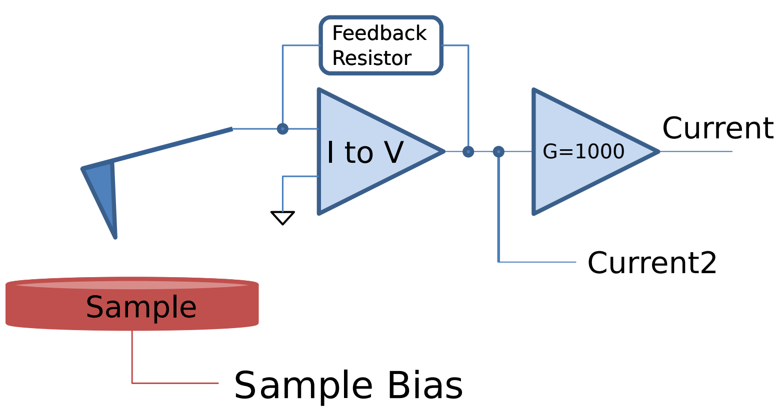


Figure 8.2.: Dual Gain ORCA

8.3. Preparing for Imaging

8.3.1. Zeroing the ORCA Current and Sample Bias signals

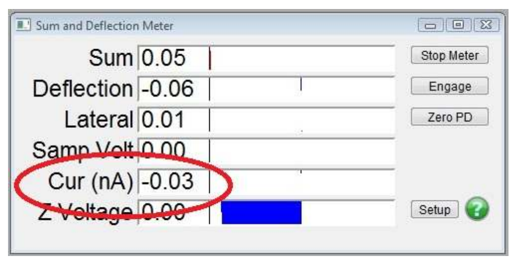
The signal path through the Cypher can pass through many stages of signal conditioning. Each particular circuit in the signal path can introduce a voltage offset which when added together can skew the zero point of your measurement. The following adjustments should be made to your system prior to imaging.

8.3.1.1. Zeroing the ORCA current signal

1. Start the Cypher software if not already running.
2. Select contact mode as an imaging mode.
3. **Install the ORCA holder into the scanner's tip engage pillar.**

   - The software will automatically add the ORCA current and Sample Voltage to the items shown in the SUM and Deflection meter window.
   - Push the scanner into the chassis and close the enclosure door. The ORCA current amplifier is sensitive to RF and other emitted signals such as florescent lighting.
   - Note the current being registered in the Cur display. In this example, the offset current is around -30pA.

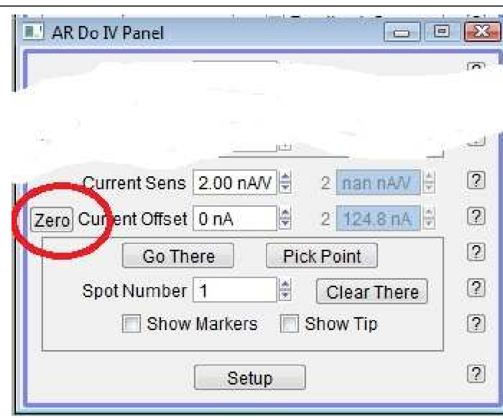
   Note If the Sum and Deflection meter window does not update, Try adding Current as one of the data channels in the Master Channel panel and then reselect Contact mode as the imaging mode the system.

4. **Open the Do IV control panel**

   - Go AFM Controls to locate the DoIV panel.
   - Locate the Current Offset parameter at the bottom of the window.

   Note If you are using a Dual Gain ORCA holder holder, the Current 2 offset and Sens. will be active.

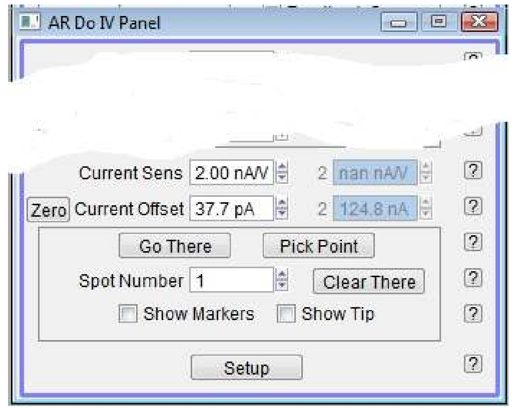
   

5. **Press the 'Zero' button to zero the current**

- The Software will add the appropriate offset from the Current data to make the Current 0A.
- Verify that the current is zeroed.

Note This is only a software offset. The actual electrical offset in the instrument is still present.

Note If the zero button is not present in your version of the software, zero the offset current by typing the amount of current shown in the Cur value in the SUM and Deflection meter panel.

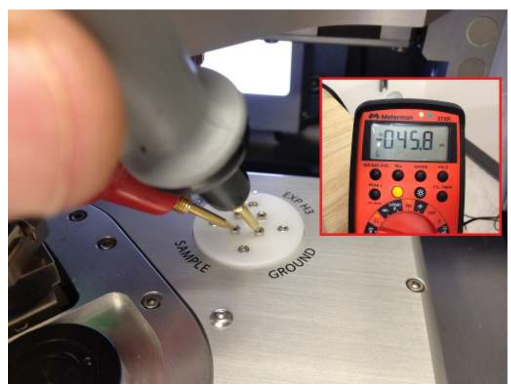


8.3.1.2. Zeroing the Sample Bias

1. **Measure the Sample Bias voltage on the scanner's terminal block.**

- Check the 'Use' check box next to the Sample Voltage parameter in the DoIV control panel.

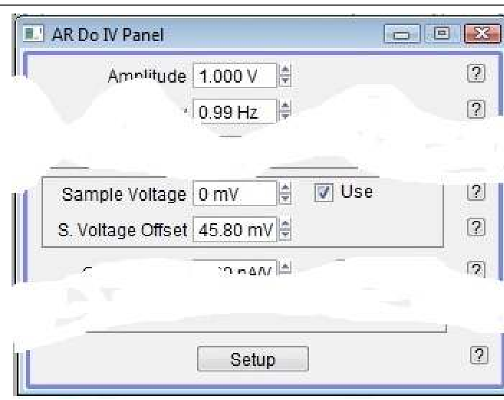
Note In this example, the measured offset Bias voltage is -46mV



2. **Enter the amount of offset voltage needed in the S. Voltage Offset control parameter.**

- Use the opposite sign of the voltage measured on you voltmeter to negate the actual voltage.

Note Make sure that the Sample voltage parameter is set to 0 volts when making this adjustment.



3. Change the Sample voltage parameter and verify that the corresponding voltage appears on the Sample pin on the scanner's terminal block.

8.3.2. Preparing the Sample

Sample preparation varies but basically the goal is to provide an electrical path between the sample bias and the surface of your sample. In addition to the electrical connection, care should be taken to mount the sample mechanically to a sample puck as you would with any sample.

The ORCA kit comes with a practice sample of graphite (HOPG) mounted to a steel puck. A small magnet is attached to the sample puck to provide an easy way for the bias lead to attach.

The magnetic connection method is convenient but is not necessary. A bias lead of your own design can be mounted directly to the sample puck and used as long as the end of the lead is able to fit into the sample voltage socket on the scanner's terminal block. Also, be certain to use wire that is flexible enough to not impede normal scanning.

The following steps describe how this sample was prepared.

1. Use a small amount of 5 minute epoxy to attach the HOPG to the sample puck.
2. Place a magnet onto the puck.
3. Cover the sides of the sample and the entire magnet with silver paint.

Attention	The silver paint is not an adhesive. It will not provide good attachment of the sample to the sample puck. Use the paint only to make an electrical connection from the sample to the bias voltage lead.

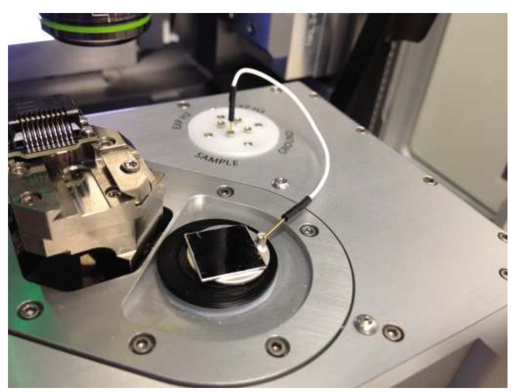
8.3.2.1. Install the sample on the scanner and connect the bias lead

1.

Place the sample on the scanner stage and connect the bias lead

- Position the sample so that the magnet is on the right hand side of the scanner to prevent interference with the cantilever holder.
- Plug on end of a bias voltage lead into the sample socket on the terminal block.
- Place the other end of the lead on the magnet. The lead is magnetic and will stick to the magnet when it's close enough.

Note The scanner cap is hard anodized and will insulate the the sample puck so bias voltages up to +/-10v can be directly connected without additional insulation.

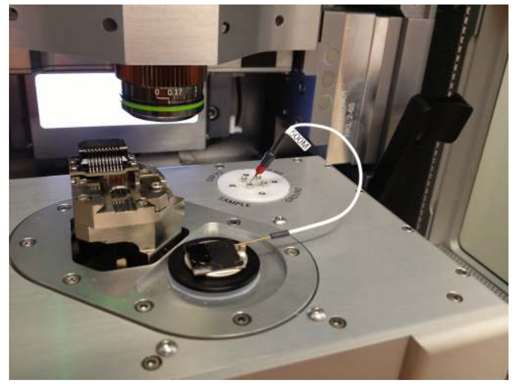


2.

Adding resistance in the bias voltage path

- In cases where your sample is highly conductive, you may want to add a known resistance to keep the OR CA amplifier from saturating. An example of this is the HOPG sample provided in the kit.
- Substitute the Bias lead with a bias lead including a resistor.

Note The ORCA holder kit includes a 500Meg. Ohm test resistor. If you are planning on scanning the HOPG sample to practice using the ORCA holder, use the test resistor instead of the bias lead.



8.3.3. Mounting the Cantilever

Mounting a cantilever is the same procedure as is used in all other AFM applications with the exception of lever type. Conducting AFM (ORCA) requires a conductive path between the tip and the cantilever spring clip. The ORCA kit includes a sample pack of 10 Electrilevers. Additional levers can be purchased from Asylum Research.

If you are not familiar with basic AFM operating practices, please review The basic operating tutorials section at the beginning of this guide.

8.4. Imaging with the ORCA

Please refer to *Applications Guide, Chapter: Conductive AFM*.

8.5. Testing the ORCA Amplifier

The ORCA cantilever holder kit includes an appropriately sized resistor to test the measurement range of the ORCA amplifier. Testing the ORCA is fairly straight forward. Basically the test resistor in installed between the sample bias and the cantilever clip. An I/V ramp is plotted and the correct current flow through the resistor should be observed.

1.

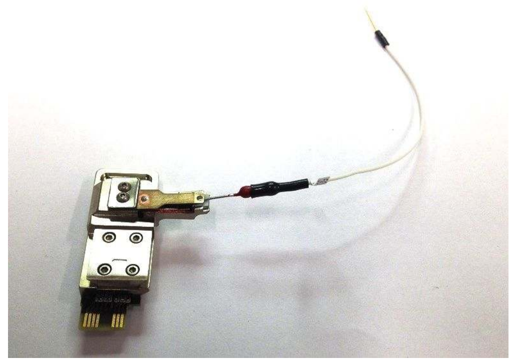
Install the test resistor under the clip on the ORCA holder

- Hold the ORCA holder upside down in you hand and use a fingernail to press on the button on the top side of the holder to open the cantilever clip.
- Slide the resistor lead under the clip.
- Release the button to clamp onto the resistor lead.

Note Using the changing stand also works but you may find that getting the resistor installed and removing the holder from the stand is a bit tricky. Using your fingers as described works well.

Note The cantilever holder body is conductive. Position the lead under the clip so that is does not touch the holder body. Basically, take care not to insert the resistor lead too far under the clip or have it off center.

Note It is not harmful if the resistor shorts to ground. The current from the sample bias through the resistor will not be measured by the holder.



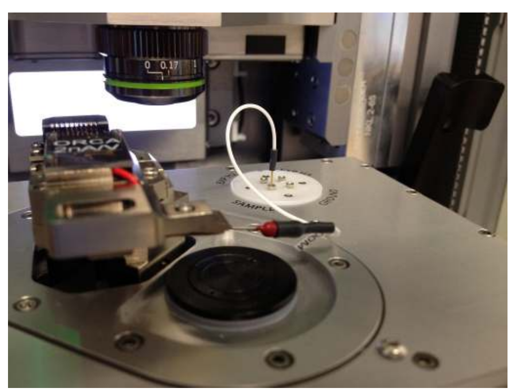
2.

Install the cantilever holder and connect the test resistor to sample bias

- Insert the ORCA holder into the scanner's engage pillar.
- Plug the lead from the test resistor into the sample bias socket on the scanner's terminal block.
- Slide the scanner into the chassis and close the enclosure door.

Note You may wish to double check the lead under the cantilever clip to ensure it is not shorted to the holder body.

Note The enclosure acts like a Faraday shield which will help reduce outside electrical noise.

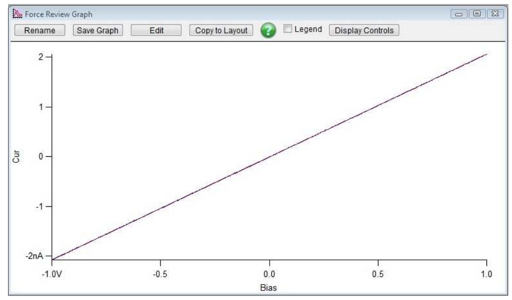


3.

Do an I/V plot and confirm the correct current flow

- Go to AFM Controls-> Do IV panel and open the I/V voltage controls.
- Press the Do I/V button to perform an I/V curve.
- Confirm the current flow is the correct amount based on the test resistor value.
- Confirm the I/V plot is linear with 0 current flow coinciding with 0 volts of bias voltage.
- If the current is not flowing through 0 then recheck the current and voltage offsets are set correctly.

Note The 500M Ohm resistor should allow 2nA of current to flow for 1V of bias voltage.



8.5.0.1. Testing the first gain stage of a Dual Gain ORCA Amplifier

Testing the final output of a Dual Gain ORCA amplifier is done in the same manner as testing the the single gain ORCA amplifier. Because the two gain stages are in series, the first gain stage is automatically checked by default.

You can verify that both the Current and Current 2 data channels are active in the software by monitoring both signals when doing an IV plot. When using the 500M Ohm test resistor, you will notice the limits of resolution and noise in the Current 2 signal as compared to the Current signal. See Figure 8.3 on page 101.

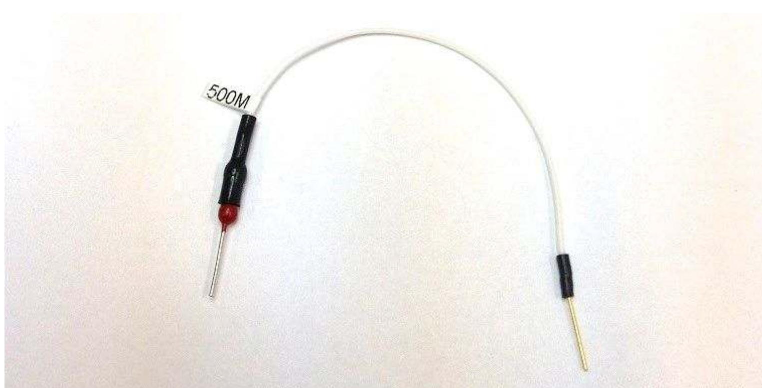


Figure 8.3.: 2nA current flow through a Dual Gain ORCA

The Dual Gain ORCA accessory kit includes a second 1M Ohm test resistor which is more suitable for the current ranges of the primary gain stage.

1.

Test the first gain stage of the Dual Gain ORCA Amplifier

- Install the 1M Ohm test resistor.
- Do an IV plot.
- Monitor both the Current and Current 2 data channels.
- Verify that the 1Meg Ohm resistor produces 1uA for 1 volt of sample bias.

Note Note the behavior of the Current signal as it saturates from too much current flow through the circuit. This test is not harmful to the ORCA amplifier. It is mainly a way of demonstrating the behavior of the circuit when the final gain stage is saturated.

9. Scanning Tunneling Microscopy (STM)

CHAPTER REV. 1659, DATED 10/07/2013, 22:54.   USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

9.1. Introduction and Preparation

This is a fairly basic set of instructions on STM imaging with Cypher. At some point we hope to do a more proper STM tutorial chapter which focus on imaging graphite with atomic resolution.

This chapter assumes you are familiar with AFM techniques on Cypher. You should completed the tutorial in Chapter 4 on page 17 at least once.

9.2. Required Equipment

- Cypher Standard Scanner
- Handheld Digital Voltmeter
- Cypher STM tip holder (See Figure 9.1 on page 104)
- STM tips
- Jumper wire for applying bias to conducting sample
- Some tiny magnets and some tweezers and a few tools.

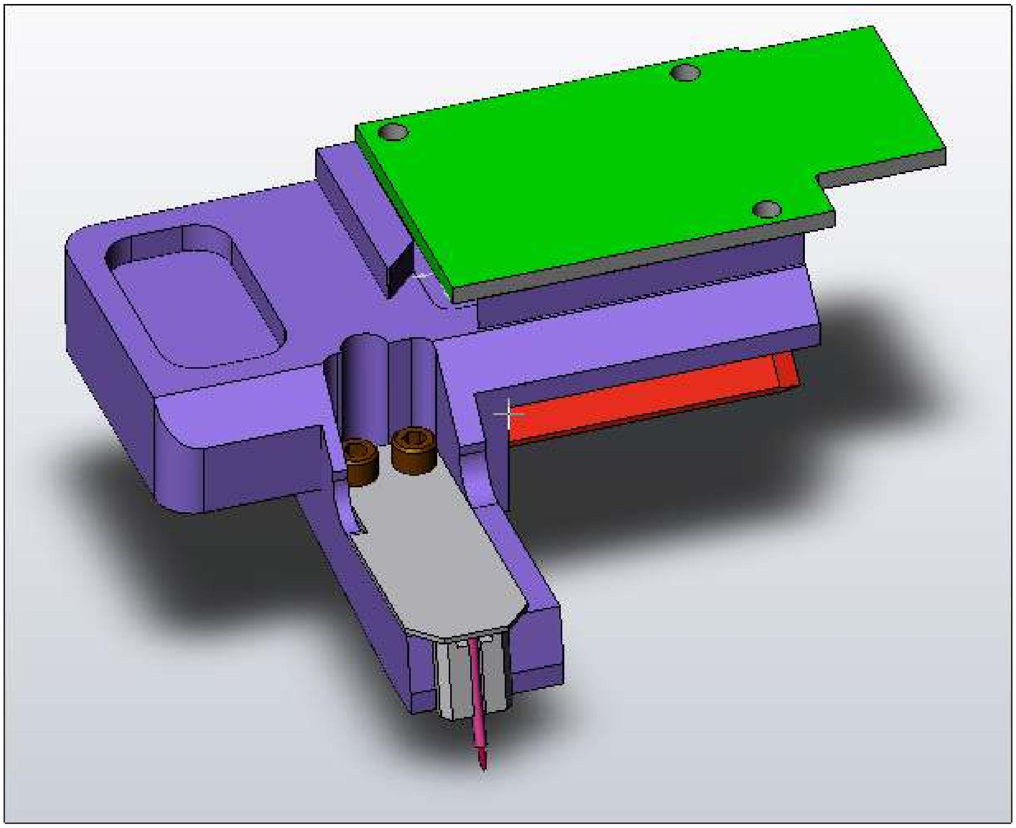


Figure 9.1.: Cypher STM tip holder. Note the probe tip sticking from the small tube.

9.3. Preparing an STM sample

1. Place your sample on a steel AFM disc. It's assumed the sample is conducting and has a relatively flat bottom.
2. Put some small dots of silver paint around the perimeter of the sample. And let the paint dry in a warm place, like under a desk lamp.
3. Place the sample on the Scanner.
4. Place a small magnet next to the sample. The STM kit includes 5.
5. Plug the bias wire into the 'sample' socket on the scanner's terminal block.
6. Stick the other end of the wire to the magnet next to the sample. You can also attach the wire directly to the sample puck.

Note The surface onto which you place the magnetic AFM disc is black anodized aluminum. The anodization acts as an insulator which means the sample is only electrically connected to the attached bias wire. If you ever see any metal through the black surface (a possibility due to excessive wear, nicks, or abuse) then the sample bias may not work properly. In that case a thin insluating layer, such as a very thin sheet of mica, can be placed under the sample disc.

Additional magnets and bias leads can be purchased separately if this mounting method is desired.

Alternately, simply bonding a small length of wire directly to the sample puck with solder or silver epoxy works well. In many cases fixing the sample and bias voltage connections are sample specific. The sample socket on the terminal block is sized to accept the diameter of a standard 1/4watt resistor lead or similar diameter wire for making your own bias leads.

9.4. Load the tip

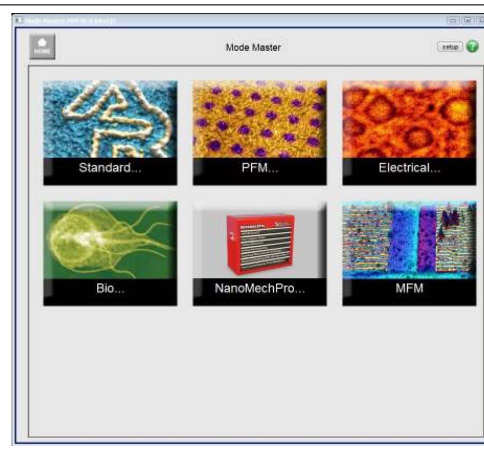
1. Locate your box of STM probe tips or see Section 9.10 on page 111 about making your own.
2. With tweezers insert the STM probe into the holder. Note that the probes are straight and not curved. This is intentional. The tube in the STM holder is bent with a slight curve. This bend will cause the straight probe wire to fit tightly and reduce potential of drift due to the effects of stress in the wire. Push the probe wire into the tube until the end of the wire begins to extend out of the top of the tube. Don't touch the tip at any time.
3. Install the sample on the scanner.
4. Attach bias voltage lead from sample to 'Sample' socket on scanner's terminal block.
5. Insert the tip holder into the scanner and secure it with the 0.050" hex driver tool.

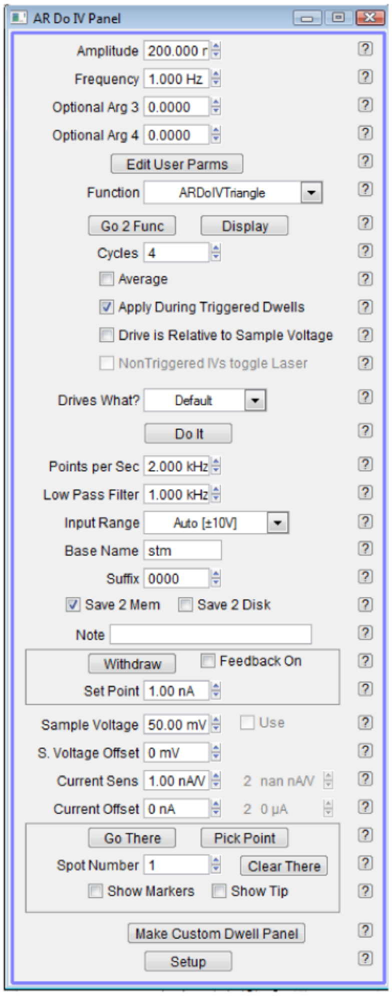
9.5. Zero Various Offsets

NOTE The specific values in the screen shots in the following steps are often just examples of what you might encounter. Read the instructions carefully and record your own values where necessary. The parameters used in this procedure are for the Graphite test sample provided.

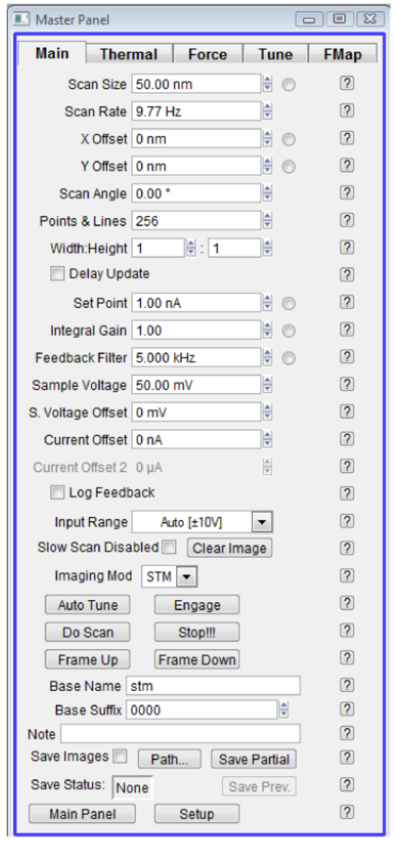
1. **Mode Master:**

- The software should now be showing the mode master window.
- If not, click s the Mode Master button at the bottom of the screen: .



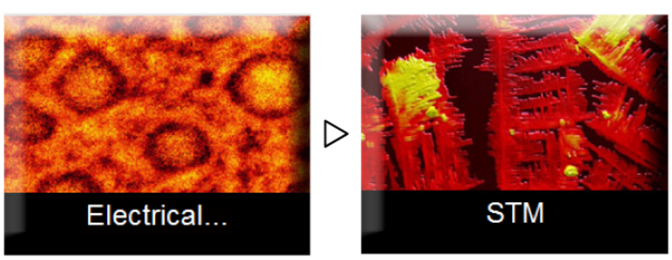


(a) DO IV Panel with highlights for STM



(b) Master Panel Main Tab set up for STM imaging

Figure 9.2.: Some relevant control panels you will encounter during STM operation.

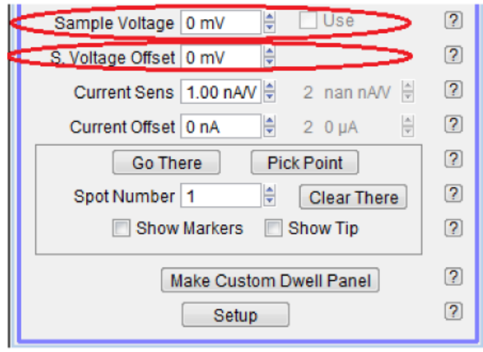
2. 

Select Mode:

- Select *Electrical* ▷ *STM*
- The screen will now re-arrange and present all the controls necessary for this type of AFM imaging.

3. **Set surface voltages**

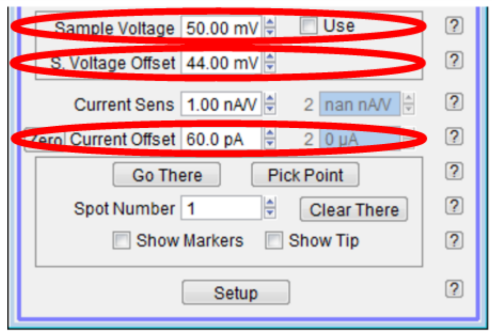
   - On the *Do IV Panel* Set the Surface Voltage and the Bias offset to 0V.



4. Use a hand held digital voltmeter to measure the voltage between the Sample and Ground pins on the scanner's terminal block.

5. **Enter Bias Offset**

   - Enter the measured voltage in the Sample Bias Offset field, but the opposite sign to zero the offset voltage.
   - Enter 100mV for the 'Surface Voltage' and hit enter.

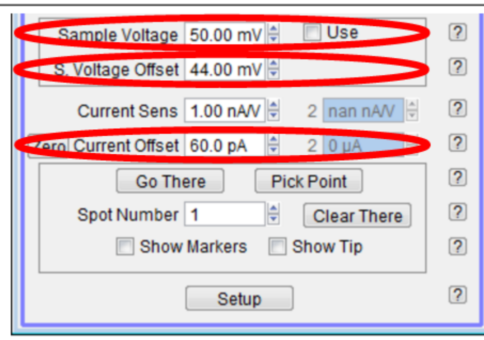


6. Use your digital voltmeter to measure the voltage between the Sample and Ground pins on the scanner terminal block again and verify that it also reads 100mV. Try this a few more times for some additional 'Surface Voltage' values to make sure the offset bias is doing its job.

7. When done, set the 'Surface Voltage' back to 0V.

8. **Enter Current Offset**

   - Go back to the ARDoIV panel.
   - Click on the zero button to the left of current offset. The current should now read zero in the sum and deflection meter.



9.6. Set up to engage

Note The optics in the view module were intended for an AFM cantilever. Due to the tip position pointing down below the probe wire and focus distance of an STM probe from the objective being relatively long, it is necessary to bypass the normal AFM alignment process and simply bring the tip down manually close to the surface and then click the *Engage* button.

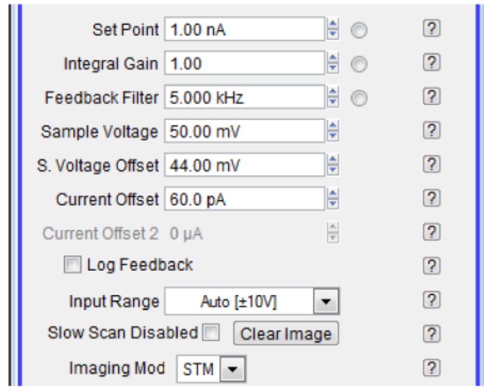
1. Use the wheel on the enclosure to move the tip to the sample. Get the tip to the desired engage distance of about 0.5 to 1 mm above the sample. Use the tip and the reflection of the tip in the sample surface as a guide to bring the probe close.

9.7. Set scan parameters

1. Go back to the *Master Panel*, Main Tab (See Figure 9.2b on page 106). You can enter your scan size and rate as in the figure and modify it once you are scanning.

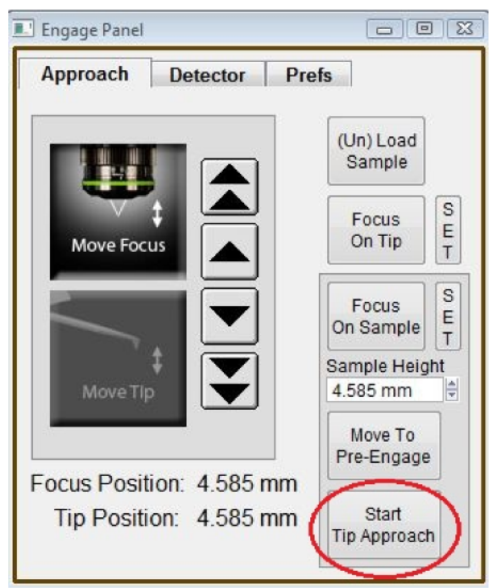
2. **Enter Feedback Parameters**

   - Set the *Surface Voltage* to the desired bias voltage for the sample. For Highly Oriented Pyrolytic Graphite (HOPG) use ~50mv.
   - Set the Setpoint voltage to the desired tunneling current. Use ~1nA for HOPG.
   - Set the *Feedback Filter* to 10KHz.
   - Set the Integral gain to ~0.5 or 1.0. The STM feedback uses much less gain than typical AFM due to the use of log feedback.



3. **Start Tip Approach**

   - In the 'Engage Panel' click on the 'Start Tip Approach' button. Because the sample surface was not optically located, as we do with a typical AFM approach, this process may take a little longer than you are used to from AFM. In that case Cypher will first rapidly motor down to about 50 µm above the surface (measured from the optical image focus position) and then start its slower final engage process (for more information see the Q&A box on page 38). In the case of STM the slower engage process starts from where ever you motored the tip to manually.



4. Once on the surface you can perform scans as you are used to with AFM.

9.8. STM IV Curves

The process of doing an STM IV curve uses a triggered force curve where the system will:

1. Trigger off of the Current channel

2. Dwell at the surface using the Z position sensor to hold the tip at a constant Z height above the surface

3. Ramp the bias voltage using the ramp functions in the Do IV panel.

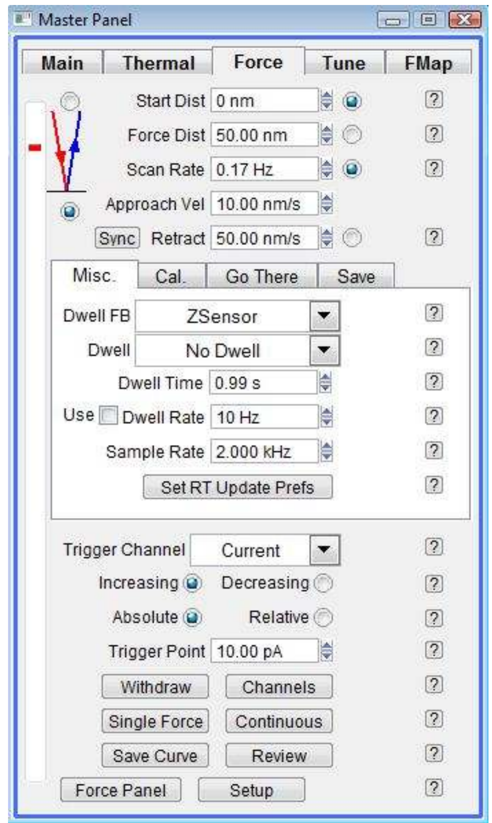
9.9. Set IV Parameters

1. The *Feedback Filter* must be reduced to 1kHz in the *Master Panel*. Typically for scanning, the feedback filter is between 5kHz and 10kHz but for IV measurements when triggering on currents as low as 10pA (in a quiet lab) high frequency signals must be filtered.

2.

Trigger Channel Current

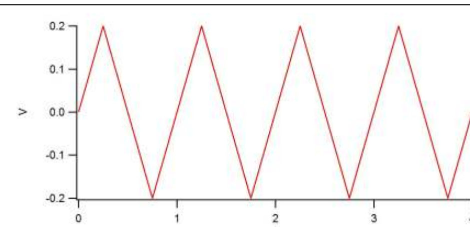
- Click on the *Force* tab and set the desired trigger point. The trigger point is the setpoint current where the system establishes the tip height during IV measurements. The lowest trigger current possible is ~10pA, any current lower than this will be close to the noise limit and cause the system to false engage.
- To reduce the approach velocity the *Force Distance* is set to 50nm and *Scan Rate* ~0.2Hz . This is necessary to avoid the tip moving beyond the height when the feedback loop clamps the Z-position. A sudden change in tip speed can cause the tip to overshoot.



3.

AR Do IV Panel

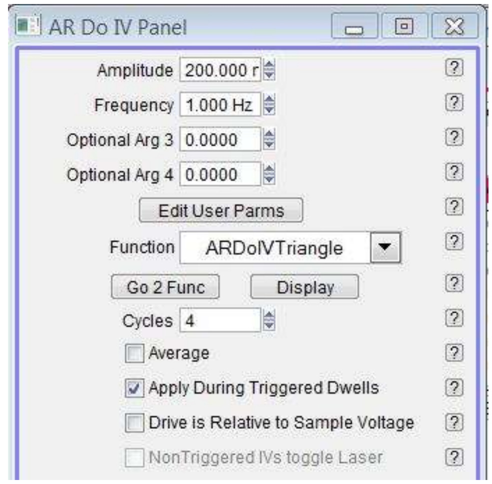
- Click on the *Display* button in the *AR Do IV* Panel to display the bias ramping waveform



4.

Drive Graph

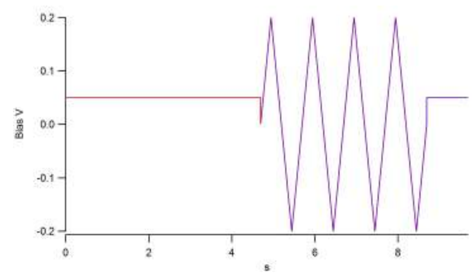
- Adjust the *Amplitude*, *Freq*, *Optional Arg 3* (Phase Offset), Optional Arg 4 (Voltage Offset) parameters to make the desired ramping waveform.



5.

Drive Graph

- This is the result of the Ramp during IV measurements. Notice that the voltage before and after the ramp is not 0v, the voltage used for the triggered current (in this case 50mV) is kept before and after the ramp.

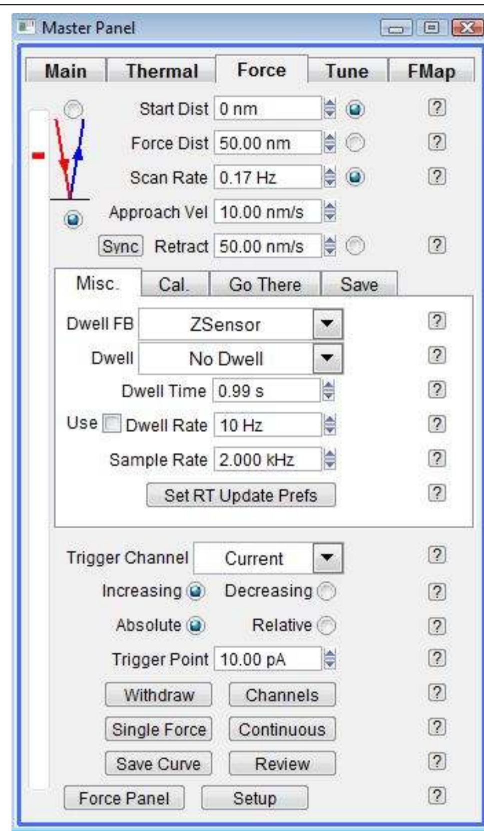


6.

Finding the Surface There are two ways to bring the tip close to the surface for IV curves

a) Click *Engage* in the master panel and when the tip is on the surface hold the shift button and left click mouse button on the vertical bar for the z-range piezo. This will set the force range to be close to the surface. Make sure the Integral gain is low enough such that the tip does not oscillate.

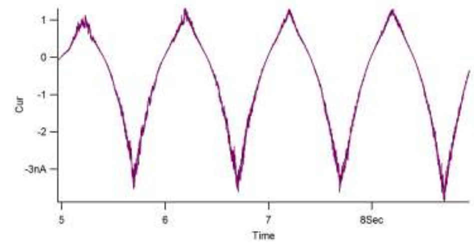
b) The other method is to change the *Force Distance* to 300nm, and click *Single Force* (50nm Force Distance will take too long). Make sure to switch the Force Distance back to 50nm when making measurements.



7.

Single Force

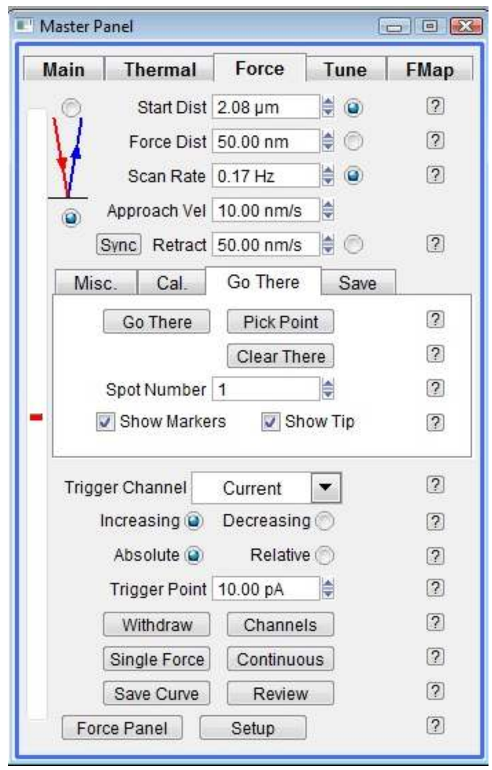
- Clicking *Single Force* button will perform individual IV measurements.
- This will perform a triggered force curve and dwell on the surface using the Z sensor while running the ramp waveform from the *Do IV Panel*.



8.

Point and Shoot Tip positioning

- Engage and image the sample surface
- Hit *Stop* or *Withdraw* to pull the tip away from the surface
- Click Show Markers and Show Tip
- Select Sights on the image to do a *Force Curve* and hit the *Pick Point* and That's It for each location
- Hit *Single Force* at each point and *Go There* to move for each numerical location



NOTE	A 10pA trigger current works only if the system is acoustically isolated well. If the trigger point is reached before the tip is on the surface, increase the trigger current greater than 10pA. Try 20pA or 50pA.

NOTE	If the magnitude of the current increases with time during the cycles this is probably due to thermal drift. If the temperature of the sample is still equilibrating, there could be expansion of the sample which will increase the tunneling current.

9.10. STM probes

The Cypher STM kit came supplied with 20 mechanically formed (i.e. carefully clipped with super sharp wire cutters) probes. Additional probes can be purchased from Asylum Research. If you wish to make your own probes the material and dimensions for making the supplied probes are:

Material: 80%/20% Platinum Iridium. Wire should be drawn straight. Wire cut from a roll has a small radius and may not hold tightly into the tube on the STM holder. The tube is bent with a large radius. This is intentional to help reduce drift due to the stress of bending the probe wire upon insertion into the holder.

Wire size: 0.01" diameter (0.25mm) , cut approximately .3" long. Longer probes are usable but may introduce image distortion from drift due to the length. Contact Asylum Research about further tools and technique required to make the proper cuts.

9.11. Troubleshooting

9.11.1. Testing the STM holder

A 500M Ω resistor is supplied in the STM accessories kit. The resistor is soldered to a short length of wire terminated by some Pt Ir probe wire.

To test the holder,

1. insert the platinum wire into the tip tube and
2. plug the resistor into the Sample socket in the terminal block.
3. Set the surface bias to 1V and
4. note the measured current. It should be 2nA (1/500e6 Ω).
5. Use the test panel, Email Support@AsylumResearch.com for details on loading this software.
6. Use the noise tab to measure the current noise of your holder.
7. The typical noise should be ~8mV (~8pA) Adev from 1hz-1kHz with little perceivable periodic noise in the spectrum.

9.11.2. The Current2 Signal

The initial current to voltage conversion takes place in the first stage of a two channel op amp. The first gain stage labeled Current2 in the data channels has an output sensitivity of 20nA/V. In most cases this signal is not suitable for feedback but can be monitored as well as the final 1nA/V final stage if desired. The reason for this signal is derived from the design of the STM amplifier that is the same basic circuit as the ORCA - CAFM cantilever holder.

Environmental Scanner

Who is this part for? After the Cypher ES Environmental AFM has been installed in your lab and you (or someone in your facility) have completed the initial training, this part of the user guide will be the principal reference for operating the instrument. Although written with the novice user in mind, experienced SPM users should complete the basic imaging tutorial at least once before attempting to use this instrument.

Part Contents

10. Environmental Scanner Overview

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

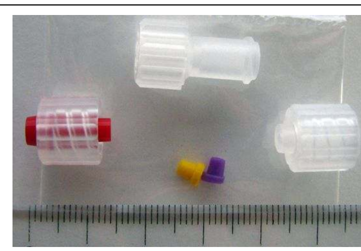
Chapter Contents

The Environmental Scanner is included with the Cypher model ES AFM. Please review the parts lists below and the basic imaging tutorial in Chapter 11 on page 130.

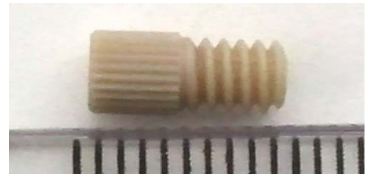
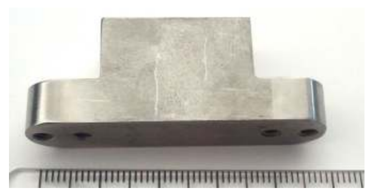
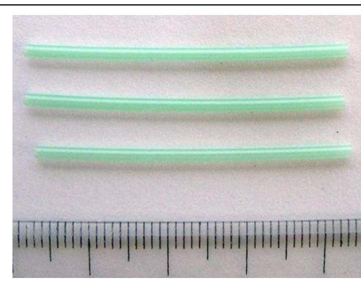
10.1. Parts list

The following table describes all the tools and other items included with your Environmental Scanner. Please refer to the part number when seeking support or ordering replacements.

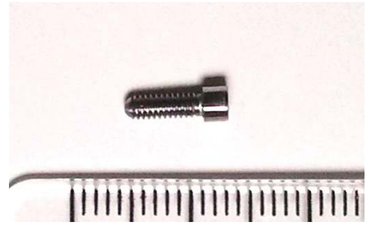
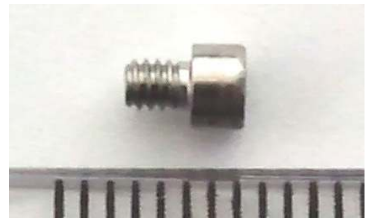
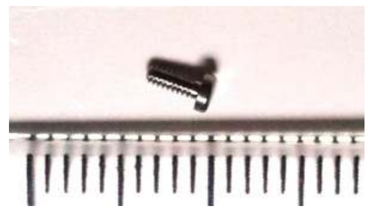
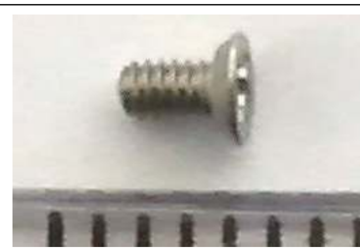
Itm	Part #	Item Description	Qty	Picture
1*	290.147	Scalpel Handle. Used to attach liquid perfusion tubing to the cantilever holder.	1	
2*	290.148	No. 15 scalpel blade. Used to attach liquid perfusion tubing to the cantilever holder.	10	
3	290.130	1/16" Hex Driver. Used to remove the cantilever holder (see Step 6 on page 132) and chamber bodies (see Step 2 on page 166).	1	
The scale in the photos is in cm and mm.				

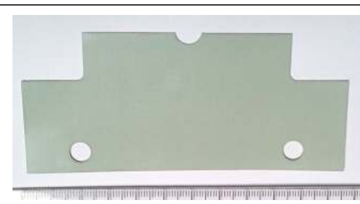
Itm	Part #	Item Description	Qty	Picture
4	290.106	#00 Phillips Screwdriver. Used to replace the cantilever. See Step 12 on page 134.	1	
5	290.163	5/64” (2mm) Hex Driver. Used to remove the cell body from the scanner. See Step 1 on page 166.	1	
6*	080.165	1cc HSW Norm-Ject Syringe. Typically used to perfuse fluid.	4	
7*	080.010	5cc syringe, HSW. Typically used for fluid or gas perfusion.	4	
8	231.006	PFA Tubing, 1/16” OD, 0.040” ID. 5 ft package. Special large bore tubing for gas perfusion. . IDEX part number 1503.	2	
9*	231.028	FEP Tubing, 1/32” OD, .016” ID. 5 ft package. Used for fluid perfusion. . IDEX part number 1692. Note, all 4 sections are in one container.	4	
10	231.008	Luer Right fitting 1/16”. Used for connecting tubing to syringes. . IDEX number P-837.	4	

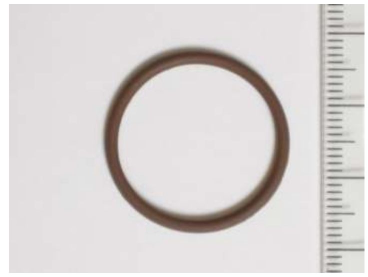
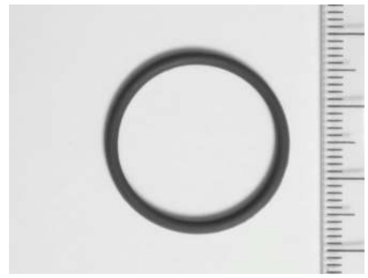
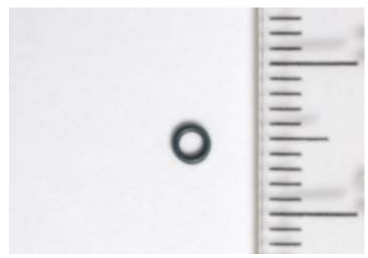
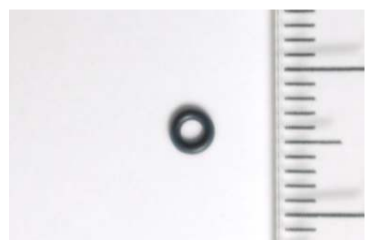
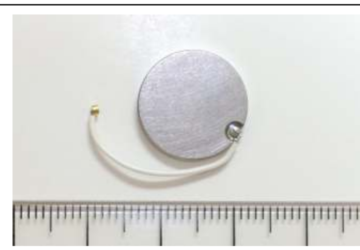
The scale in the photos is in cm and mm.

Itm	Part #	Item Description	Qty	Picture
11	232.015	Fittings, 1/16”. Used to connect 1/16” tubing to the cell chamber wall. See Step 4 on page 167. IDEX part number M660. Use with tool 290.164.	4	
12	114.800	Extender Tool Fitting Wrench. Use to tighten Fittings 230.015. See Step 1 on page 175. IDEX part number N-290. DO NOT use on the cell body fittings: Step 4 on page 167.	1	
13	232.016	1/16” Ferrules. Each ferrule requires a metal and a plastic part. Used with 1/16” fittings. IDEX part number M660.	6	
14	114.721	Fitting Compression Fixture. Required to attach fitting ferrules to 1/16” tubing.	1	
15	290.165	Platypus Tweezers. EMS part 78317 style 2AZ. Useful for removing standard sample pucks from the sample chamber. See Step 19 on page 137.	1	
16*	231.019	1/16” to 1/32” tubing reducer sleeve. Used to connect 1/32” OD fluid perfusion tubing to standard syringes. IDEX part F-247X	4	
17	1-72 x 0.25 SHCS SS	1-72 x 1/4” long screw. Spare screws used to lock down the cantilever holder. See Step 2 on page 159.	10	

The scale in the photos is in cm and mm.

Itm	Part #	Item Description	Qty	Picture
18	114.576	Stage locking screw with integrated ball end . Spare screws used to lock down the sample stage. Step 8 on page 170. Be careful, these are very expensive screws.	2	
19	2-56 x 0.125 SHCS SS	2-56 x 1/8” long screws. Spare screws used to lock down the cell chamber body. See Step 2 on page 166.	12	
20	00-90 x 1/8” Pan Head SS	00-90 x 1/8” screw. Spare screws used to fasten the sample stage membrane to the cell body. See Step 4 on page 160.	12	
21	230.040	FKM O-ring, 1.5mm x 0.5mm, 75A Durometer. Used to seal the 1/16” gas ports on the side of the cell body. Custom size, only available from Asylum Research. Equivalent FFKM part is 230.051. See Step 3 on page 168.	10	
22	230.039	FKM O-ring, 1.5mm x 0.7mm, 75A Durometer. Used to seal the cantilever clip. Custom size, only available from Asylum Research. Equivalent FFKM part is 230.050.	8	
23	114.738	Modified (shortened) Flat Head Phillips M2 screw, Stainless steel. Spare screws to hold down the cantilever clip.	3	 photo needs update!
The scale in the photos is in cm and mm.				

Itm	Part #	Item Description	Qty	Picture
24	222.077	1/16” dowel pin. Used to restore slightly compressed fitting parts.	2	
25	290.168	1.8mm slotted screwdriver. Used to fasten the sample stage membrane to the cell body.	1	
26	232.017	1/8” NPT X 6mm tubing connector. Used to connect 6mm tubing to gas flow rotameter.	1	
27	232.018	1/8” X 1/4” union. Used to connect 1/4” tubing to gas flow rotameter.	1	
28	xxx.xxx	1/8” OD X 1/16” ID vinyl tubing. Used to connect to the gas flow rotameter.	6 ft	
29	114.801	Thermal pad, spare. Adheres to the back of the environmental scanner. Use as a replacement in case the original is damaged.	1	
30	114.820	Cantilever holder cleaning cup. Used to rinse and clean the cantilever holders while not causing damage to the circuit board.	1	
The scale in the photos is in cm and mm.				

Itm	Part #	Item Description	Qty	Picture
31	230.044	O-ring, 0.75"ID X 1"OD Viton, Durometer 75A. Equivalent FFKM part is 230.038. Standard AS568-020 size, can also be purchased from other vendors. Sits around cantilever holder perimeter.	2?	
32	230.038	O-ring, 0.75"ID X 1"OD Kalrez 6375, Durometer 75A. Equivalent FKM part is 230.044. Standard AS568-020 size, can also be purchased from other vendors. Sits around cantilever holder perimeter.	1	
33	230.050	O-ring, 0.022" C/S X 0.063” ID x 0.107” OD, FFKM, 75A Durometer. Custom size, only available from Asylum Research. Equivalent FKM part is 230.040. Used to seal the chamber side ports. For use,	2	
34	230.051	O-ring, 0.032" C/S X 0.062” ID x 0.126” OD, FFKM, 75A Durometer. Custom size, only available from Asylum Research. Equivalent FKM part is 230.039. Used to seal the cantilever holder clip. For use,	1	
35	448.140	Electrical Sample Puck Assembly. Used to electrically bias or ground a sample. Includes Puck Bias Lead wire (448.139) and Modified 000-120 screw (114.853).	2	
The scale in the photos is in cm and mm.				

* These items are only likely to be used for fluid perfusion experiments which require a perfusion capable cantilever holder and a fluid compatible sample stage .

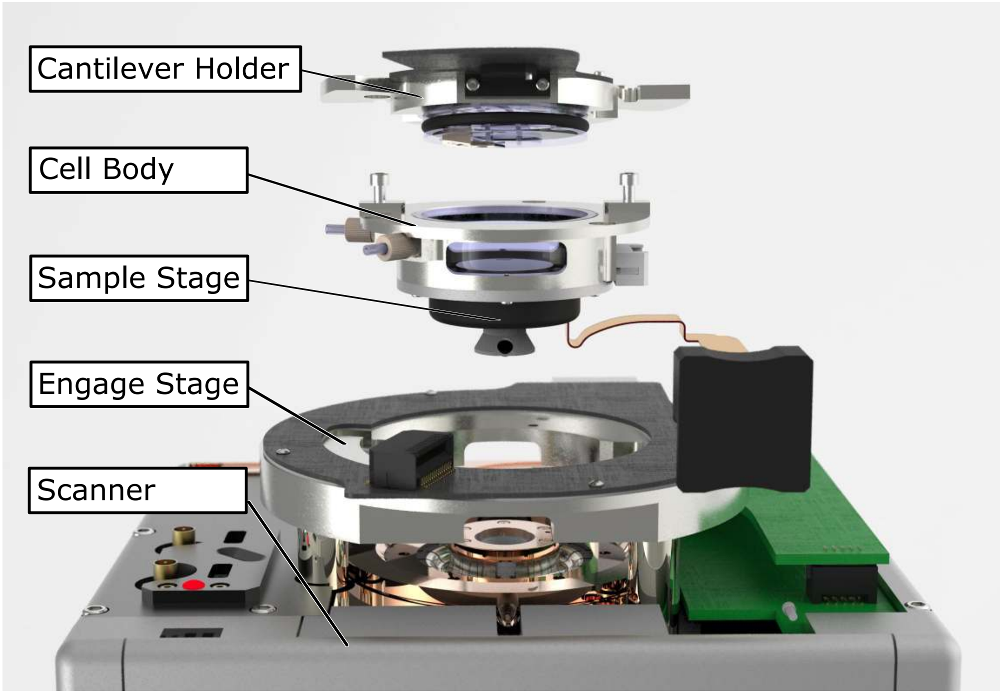


Figure 10.1.: Cypher Environmental Scanner Basic Parts

10.2. Terminology

Referring to figure Figure 10.1 on page 121:

Cantilever Holders: Chapter 12 on page 141

Cell Bodies: Section 13.1 on page 148

Sample Stages: Section 13.2 on page 155

Scanner Swapping: Chapter 16 on page 183

10.3. Cypher ES Quick Reminder List

In this section, we provide a list of pitfalls to avoid during use of the Cypher ES. The target audience of this section is fairly specific: it is written for those users who are experienced Cypher S users but have had only a basic training on the Cypher ES. This list then allows the regular Cypher S user a quick way to remind themselves of important warnings before using the Cypher ES. Note that this reminder list assumes the user has already received basic training on the ES. New users can safely skim this section and then return to it after they have had a better understanding of ES operation.

10.3.1. Reminders for imaging

1.

Remember to fully raise the engage stage before loading the cantilever holder.

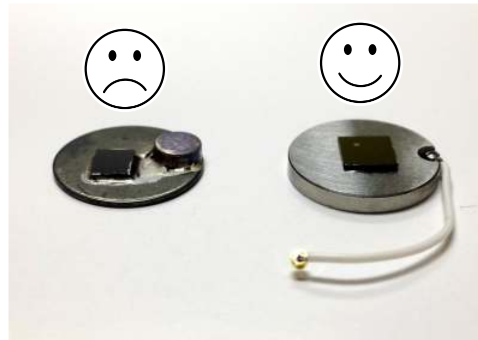
- Compared to the S, on the ES scanner it is more difficult to see if there is enough clearance for safely loading the cantilever holder.
- The stage needs to be high enough so that when you mount the cantilever holder it does not come in contact with the sample.
- Rotate the 'Engage Control Knob' on the Cypher *clockwise* and hold until the engage stage is at its upper limit of travel. Or, Hit the '(Un)/Load Sample Button' prior to mounting the cantilever holder. The upper position is safe for all samples other than those that are too thick to be run in the ES.

Warning: Pay attention! Failure to check for clearance may cause serious damage to your cantilever holder and/or sample stage.

2.

Never load "non-flat" samples into the ES scanner.

- Unlike the S scanner, the ES scanner cannot accept "non-flat" samples.
- *A "non-flat" sample is any sample in which the region to be scanned is not the tallest feature on the sample puck.* For example, the sample shown shown on the left has a magnet glued to the puck that is taller than the sample.
- Given the low profile of the ES cantilever holders, it would not be possible to engage on the sample shown shown on the left since the magnet would hit the cantilever holder before the cantilever engaged on the sample.
- For electrical measurements, use the low-profile electrical sample puck (as shown on the right) provided in the accessory kit.

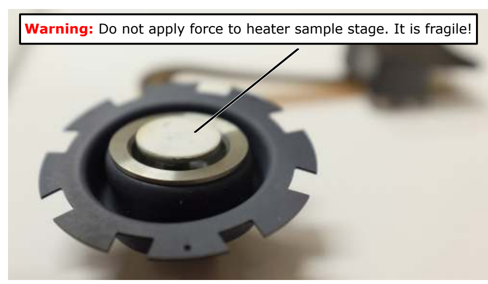


Warning: Pay attention! Attempting to starting a tip approach on a "non-flat" sample may cause serious damage to your cantilever holder and/or sample stage.

3.

Never touch the Heater sample stage with your tweezers.

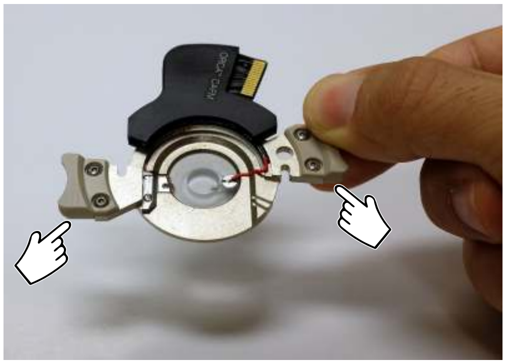
- The Heater sample stage is extremely fragile. In order to achieve high temperatures while still maintaining low drift performance, the Heater Sample Stage is constructed with fragile ceramics.
- When loading/unloading the samples, take care to never push directly on the sample stage with your tweezers.
- When adjusting the lateral position of the sample, use minimal force. Pushing on the sample with too much force may crack the heater.

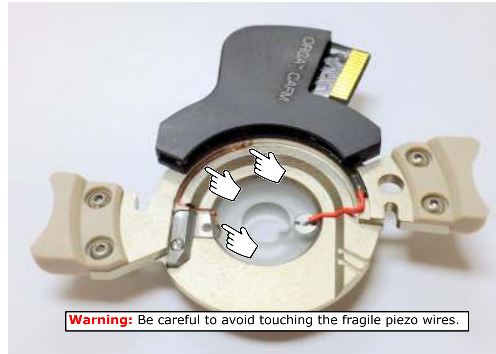


Note Although it is not required, lowering the cantilever holder stage fully (with the cantilever holder removed!), will make it easier to exchange samples without touching the heater stage.

Warning: Pay attention! If you are careless when loading/unloading the Heater sample stage you will break it.

4.





Hold the cantilever holder only by its handles.

- Hold the cantilever holder only by its two plastic handles (upper image).
- In particular, avoid contacting the wires running to the tapping piezo (lower image).
- Be careful not to scrape the piezo wires when tightening the right side cantilever holder locking screw.

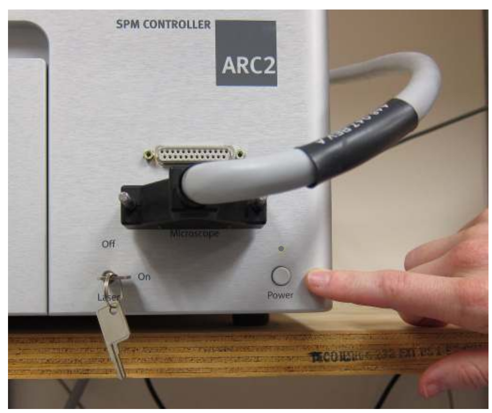
Warning: Pay attention! The piezo wiring is very fragile. Be careful not to touch it.

5.

Always power off the microscope *before* exchanging scanners.

- Before exchanging scanners, remember to first motor the objective to its upper limit of travel.
- Then *power off the controller* before disconnecting the scanner.
- Exchange scanners and then power the controller back on after the new scanner has been reconnected.

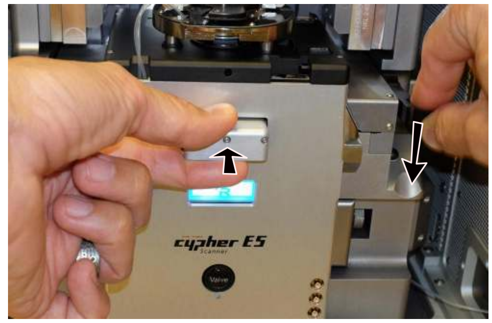
Warning: Pay attention! On older Cyphers, exchanging the scanner while the system is powered up can damage the backpack electronics.



6.

Make sure the scanner is fully seated against the chassis before locking in place.

- Unlike the S scanner, which has a hard stop on the back of the scanner, the ES scanner has a spring loaded stop that needs to be fully engaged.
- When inserting the ES scanner into the chassis, push the scanner until you feel the spring on the back of the scanner engage. Fully depress the spring until you feel the hard stop.
- After fully engaging the spring loaded stop at the back of the scanner, lock the scanner in place.



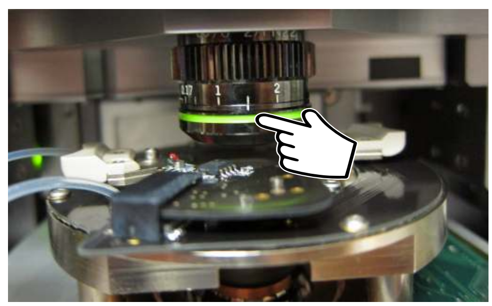
Note Proper seating of the scanner is most important when using the cooling capabilities of the Cooler-Heater sample stage. During normal operation it is not particularly important.

7.

Take care to properly set the correction collar on the objective.

- The ES scanner uses different correction collar settings than the S scanner.
- The ES scanner uses 1.5 for gas operation and 2.0 for liquid operation.

Note Incorrectly setting the correction collar will degrade the optical image quality. In addition it will cause slight errors in the XY calibration of the scanner.



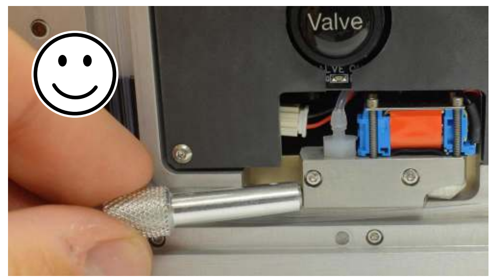
10.3.2. Reminders for cell exchange and handling

1.

The fitting wrench should never be used to attach gas lines to the cell body.

- The fitting wrench (114.800) supplied in the accessory kit should **NEVER** be used with the cell bodies (see top right image).
- The fitting wrench should only be used with the fitting fixture (114.721), which is also supplied in the accessory kit, or the manifold on the front of the scanner. See the bottom right image.

Warning: Pay attention! Using the fitting wrench on the cell body will crack the cell body glass.



2.

Be careful not to poke the sample stage diaphragms.

- Be careful never to poke the sample stage diaphragms with tweezers or screwdrivers as this may cause a hole in the diaphragm.
- Some versions of the sample stages have permanently attached diaphragms. These stages cannot be repaired if their diaphragms are damaged.

Warning: Pay attention! Don’t poke a hole in your sample diaphragm by being careless.

3.

Be careful when reattaching the cantilever clip to not crack the glass.

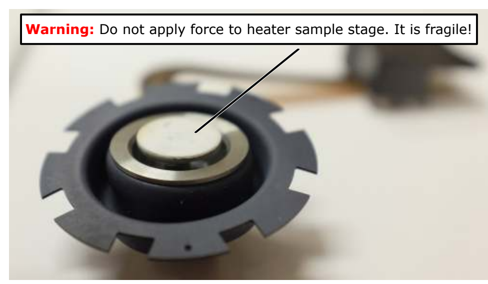
- Anytime the cantilever clip has been completely removed - for cleaning - care must be taken when reattaching the clip.
- Do not tighten the screw until you are sure that the clip is aligned correctly and has dropped into the pocket in the glass body.

Warning: Pay attention! Failure to align the cantilever clip with the pocket before tightening the clip will break the cantilever holder glass.

4.

Use extra care when loading the Heater sample stage.

- The heater sample stage is extremely fragile. Only use minimal force when seating the sample stage dovetail against the scanner.
- If you use your finger to push the stage down into the scanner, you should only need enough pressure to extend the diaphragm. Any more pressure will break the heater. If it is taking more pressure to push the dovetail into the scanner, simply push the dovetail over (with a wrench from the bottom of the sample stage) until it drops into the scanner.
- It is a good idea to wear gloves when doing this so that you minimize finger grease getting cooked onto the heater stage.

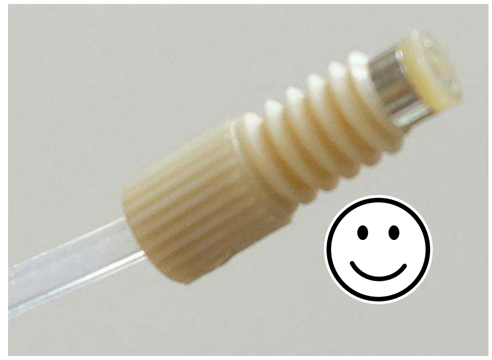


Warning: Pay attention! If you apply too much force to the heater stage you will break it.

5.

Remember to cut off extra tubing before connecting gas lines to the cell body.

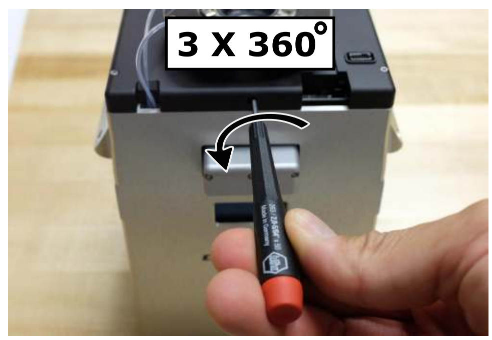
- If you are using a Cypher ES that shipped before 2014 it is likely that you need to cut off the extra length of tubing that extends past the end of the ferrule on the gas lines.
- Cut the tubing so that is flush with the ferrule. You only need to do this for the end of the line that connects to the cell body.
- Failure to cut off the tubing will not break anything, but it will make it much more difficult to get a good seal between the gas line and the cell body.



6.

When unlocking the sample stage from the scanner you only need 3 turns.

- To unlock the sample stage from the scanner, turn the locking screw counter-clockwise three turns.
- Turning the locking screw more than three turns may cause the screw to come all the way out.
- If the screw comes all the way out, you may need to lean the scanner forward until the screw slides out to a place where you can put it back on the wrench.



7.

Don't apply more than 200mbar pressure to the cell.

- When checking for leaks in the cell, it is useful to apply pressure to the chamber by using a syringe.
- Don't pressurize the chamber over 200mbar as higher pressures may damage the diaphragm.

Image Needed

10.4. Chemical Compatibility

The ES scanner is equipped with FKM (Viton equivalent) O-rings in the factory. For cases where viton is chemically attacked, please switch to the included FFKM (Kalrez equivalent) O-ring. These rings can be found in a small box, shown in 10.2. When you no longer require these O-rings, please store them back in the case. FFKM Costs between 10 and 100 times more than FKM, so do not misplace them.

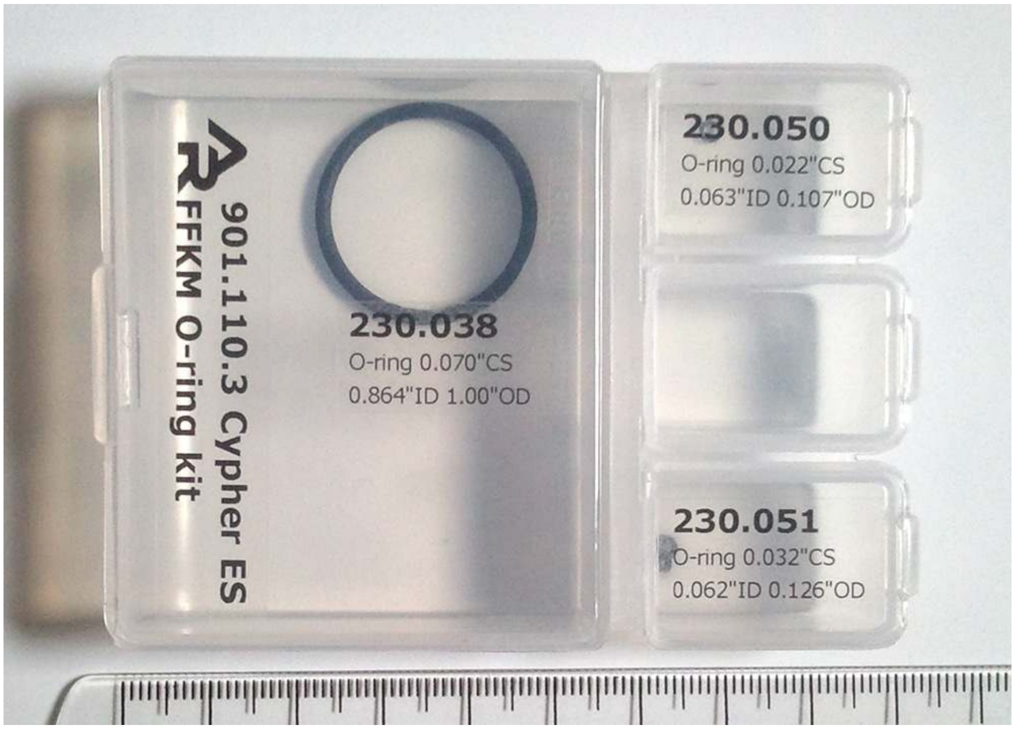


Figure 10.2.: The FFKM O-ring Kit.

11. Tutorial: AC Mode Imaging in Air with the Environmental Scanner

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This tutorial provides a quick path to learning the basic operation of the Cypher ES Environmental AFM. If you own the standard scanner, please follow the tutorial in Chapter 4 on page 17. The tutorial contains a set of steps that will teach a new user with a basic understanding of AFM operation how to obtain an AC mode topography image in air.

All new users should complete and understand this "AC Mode Imaging in Air" tutorial before attempting any imaging.

The Cypher is a research grade instrument and improper use of the instrument can cause damage to the instrument and/or injury to the user. This tutorial will take approximately 3 hours.

Before you start:

- We assume you understand the aspects of running this system safely: (Chapter 20 on page 229.)
- You are familiar with the basic names of the hardware components and software controls (Chapter 1 on page 3.)
- You have powered up the Cypher and launched the software: (Chapter 2 on page 10.)

11.1. Required Materials

This tutorial is designed to be performed, not merely read. If possible, take the tutorial under the supervision of an experienced user (tell them to mostly sit back though, or you will not learn as much as you would by yourself).

It will be necessary to gather a few items prior to beginning the tutorial:

1. Cantilevers: You will need an AC160TS cantilever, which is manufactured by Olympus. The AC160TS has a spring constant of ~42N/m and a resonance frequency of ~300kHz and is a workhorse for AC mode imaging in air. Every Cypher ships with a package of AC160s, but if these cantilevers are unavailable, any cantilever with a similar spring constant and resonance frequency should work fine.

2. Sample: The tutorial will use the Asylum Research calibration grating that ships with every system (Asylum Part# 290.237).
3. Tweezers, preferably with curved tip (for example, Asylum Part# 290.102).
4. Tweezers, "platypus style" (Asylum Part# 290.165).
5. A 1/16" ball head wrench (for example, Asylum Part# 290.139).
6. A Cypher equipped with the Environmental Scanner and a large spot SLD or Laser Module (See Chapter 18 on page 190).

11.2. Loading the Cantilever and Sample

This section covers sample and cantilever loading as well as the coarse approach of the cantilever tip toward the sample.

1.

Raise the cantilever holder:

- Rotate the 'Engage Control Knob' on the Cypher *clockwise* and hold until the cantilever holder is far from the sample or is at its upper limit of travel.

Note Although it is not required, for safety reasons we recommend making motor moves with the door closed. Beware of pinch points (Figure 20.1 on page 230).

Warning: Pay attention! If you turn the knob the wrong way (counterclockwise), you will *lower* the cantilever holder instead of raising it. When you lower the cantilever holder, you can crash the cantilever holder into the sample and cause serious damage to the scanner.

2.

Open enclosure:

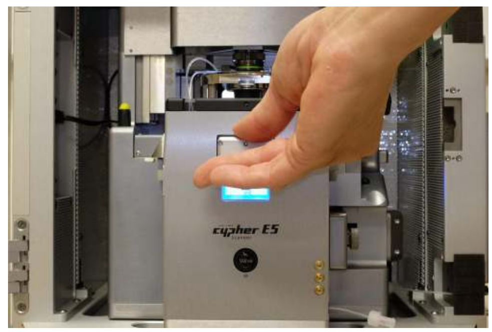
- Lift the door latch and open the enclosure door.

3. **Unlock scanner:**

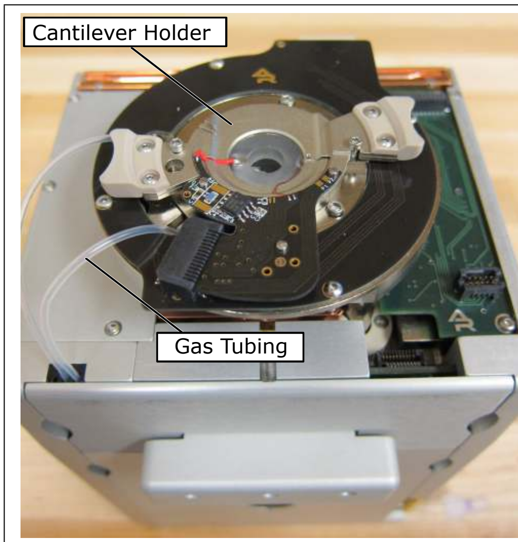
- Lift the lever to the right of the scanner.

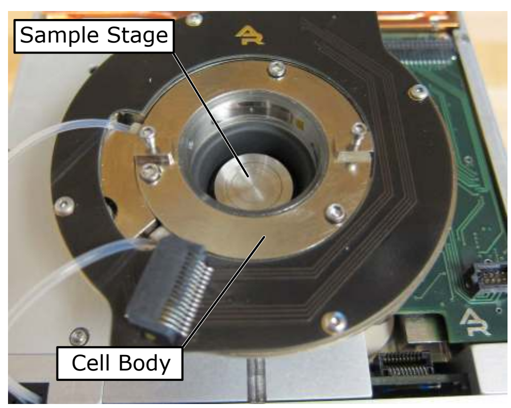
4. **Pull the scanner forward:**

- Pull the scanner forward gently and stop when it is about halfway out. As you pull the scanner out, at some point you will feel resistance and should pull no farther.



5.





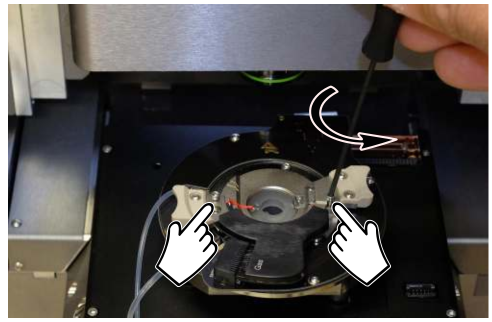
Familiarize yourself with the sample area:

- While it may look solid, the scanner sample stage moves the sample in X, Y, and Z imperceptibly up to 40μm.

6.

Release the cantilever holder:

- Locate the tool with yellow tip in the chassis to the left of the scanner.
- Use tool to loosen the two screws clamping the cantilever holder. One turn *counterclockwise* should be enough (do not completely unthread screws.
- Replace the tool.



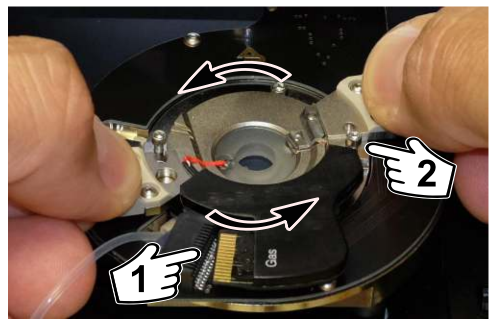
7.

Rotate the cantilever holder:

- Place your fingers on the two side cantilever holder handles.
- Rotate *counterclockwise* a few degrees.

1 the cantilever holder circuit board come out of its mating connector. Stop when the board has cleared the connector.

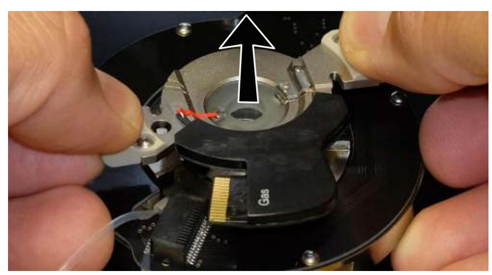
2 Notice the screws come away from the cutouts in the cantilever holder.



8.

Remove the cantilever holder:

- Once the board has cleared the connector, *carefully* wiggle the cantilever holder up and out.
- The resistance you feel as you remove the cantilever holder comes is the cantilever holder O-ring sliding out from the cell body. Once the O-ring clears the cell body, be ready for the resistance to drop suddenly. *Keep a firm grip on both handles* to keep from flinging the cantilever holder across the room!



9.

Set aside the cantilever holder:

- Set the cantilever holder on its handles with the cantilever facing up so that you do not crush the cantilever.

10.

Locate your cantilever holder:

- Identify the appropriate cantilever holder. This tutorial requires the standard Gas cantilever holder, Asylum Part# 901.758.
-

Note To learn more about cantilever holders for the Environmental Scanner, please refer to Chapter 12 on page 141.

11.

Prepare cantilever mounting workspace:

- You will need the following items:

a) Tweezer, curved (Asylum Part #290.102)

b) 300 Philips Screwdriver (Asylum Part #290.106)

c) Box of AC160TS cantilevers

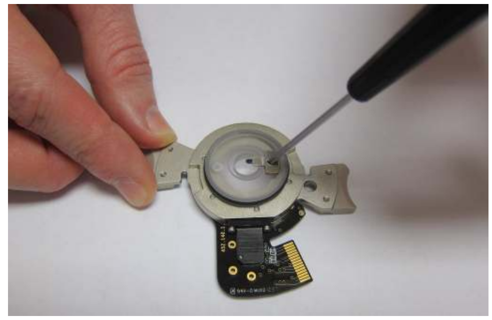
d) Gas cantilever holder

- A low power binocular dissection stereoscope with light source can be useful for some of the following steps.
- Cleaning the tweezer tips with alcohol improves the handling of the cantilevers.

12.

Loosen the cantilever clip:

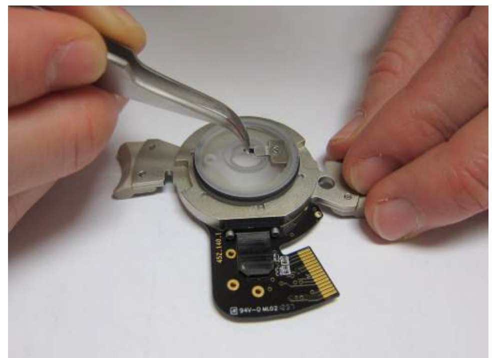
- Unscrew the clamping screws by one half turn.
- Do not unthread the screw completely. If you accidentally do, please refer to the cantilever holder chapter.



13.

Remove the old cantilever:

- If a cantilever has already been loaded, use tweezers to remove it from the cantilever holder.



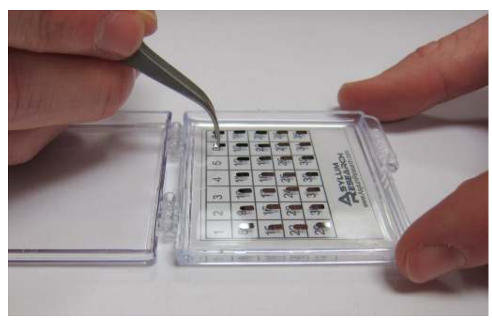
14.

Select new cantilever:

- Use tweezers to pick up new cantilever.
- Close the box! Ruining $1k of levers by putting your hand on an open box is not unheard of.

Note If your lab saves some old cantilevers, consider practicing with a "dummy" cantilever.

Tip Some find it useful to first lay the chip down on a non-sticky surface and re-grip it before continuing.

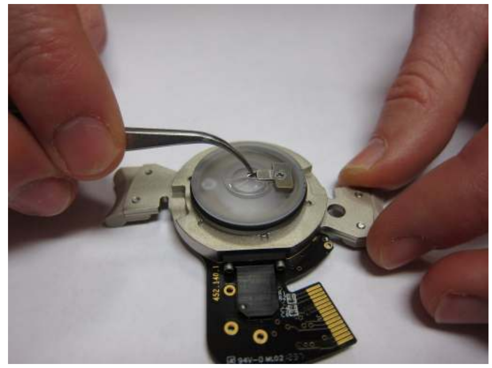


15.

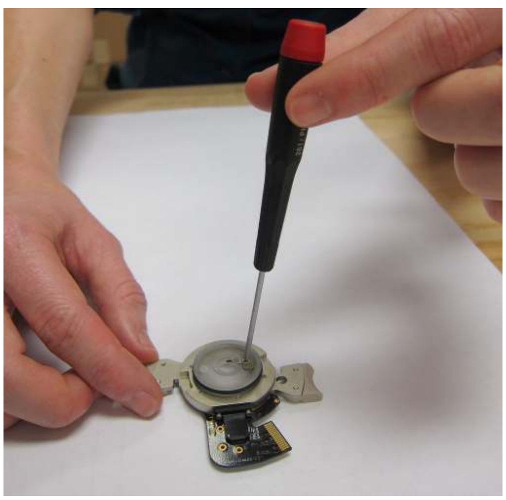
Load new cantilever:

- Use tweezers to slide the new cantilever under the clip. You can "push" or "pull" the cantilever into place as you find comfortable.
- Position the cantilever so that the tip is approximately centered in the cantilever holder window.

Note You may nudge the cantilever chip from the side to align it, but do NOT nudge the end of the chip, as you risk damaging the cantilever. It helps to do this at least once under a binocular stereo microscope.



16.



Secure the new cantilever:

- Using *fingertip pressure only*, lightly tighten the screw securing the cantilever to the cantilever holder.
- The clip should be just tight enough to secure the cantilever chip when it is pushed from the side.

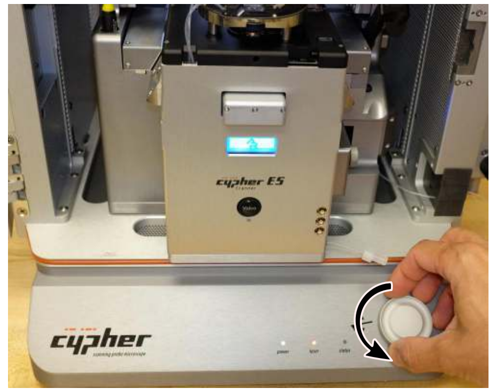
17.

Prepare scanner to remove old sample:

- Leave the cantilever holder on your workspace for now.

Note To load or unload a sample, you will need to lower the coarse engage stage so that you can access the sample stage.

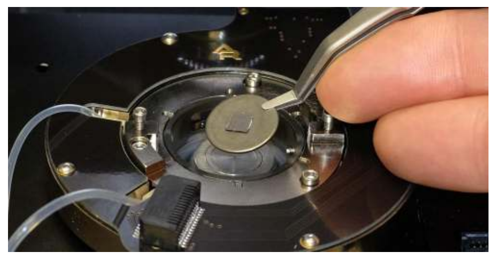
- Rotate the Engage Control Knob *counterclockwise* until it reaches its lower limit of travel.



18.

Remove old sample:

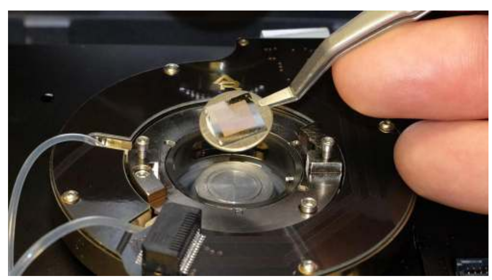
- Use “Platypus” tweezers (Asylum Part # 114.721) to remove the old sample from the sample stage.
- Wipe the sample stage clean with a cloth or use compressed air. Any dust or grit will prevent the sample disc from seating properly.



19.

Replace with new sample:

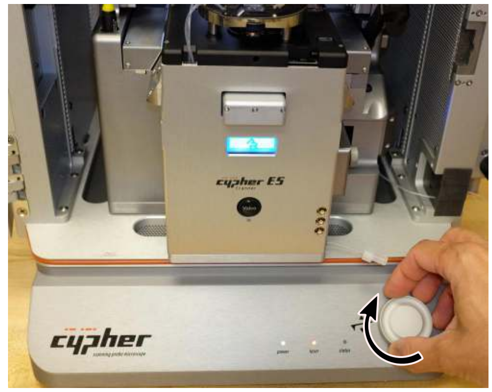
- Use “Platypus” tweezers (Asylum Part # 290.165) to place new sample on sample stage. For this tutorial, use the Asylum Research calibration grating sample, part # 900.237. It will attach magnetically.



20. **Prepare scanner to load cantilever holder:**

- RAISE THE COARSE ENGAGE STAGE by turning the Engage Control Knob *clockwise*.Raise the stage until it reaches its upper limit of travel.

Warning: Before loading the cantilever holder, raise the coarse engage stage. If you do not raise the coarse engage stage, you will crash the cantilever into the sample and ruin your cantilever, sample, and possibly even the cantilever holder!

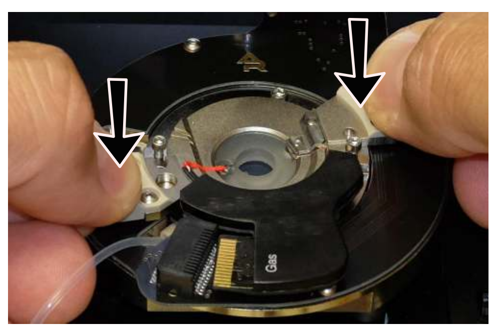


21. **Place cantilever holder:**

- Check to make sure that the coarse engage stage is raised to its highest position.
- Position the cantilever holder in the cell body as shown in the image to the right. The cantilever holder should sit level and be rotationally aligned so that the cantilever holder board is almost touching its mating connector.

22. **Press the cantilever holder down:**

- Before starting this process it is important that the cantilever holder is sitting level with respect to the top of the cell body.
- With fingers on both handles of the cantilever holder, use firm pressure to wiggle the cantilever down into the cell body. The O-ring will offer some resistance. When the cantilever holder is firmly seated, you will feel a hard stop as metal parts make contact.



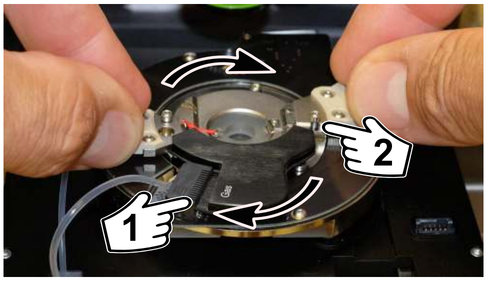
23.

Rotate:

- Rotate the cantilever holder *clockwise* until you feel a hard stop.

1 The cantilever holder contacts slip into the mating connector.

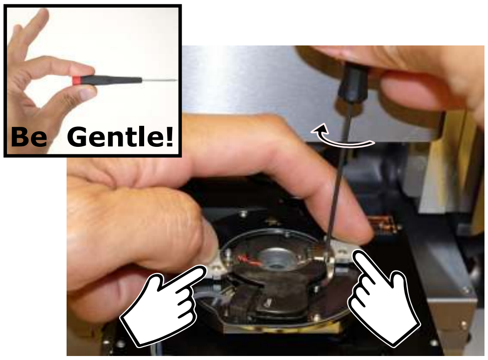
2 Notice the screws cause the hard stop as they slip into the matching metal cutouts.



24.

Tighten the screws:

- Place pressure on the cantilever holder handles as shown. Make sure it's firmly seated.
- Finger tighten one of the screws **and stop as soon as you feel any resistance**.
- Do the same to the other screw.
- Release the pressure on the handles and tighten both screws a tiny bit more.
- At all times, only hold the screwdriver with your fingertips.



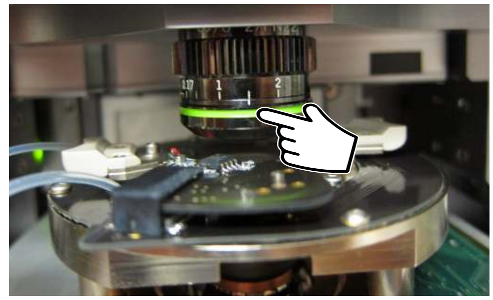
25.

Slide scanner into chassis:

- Slide the scanner back into the chassis. Use firm pressure until you feel a hard stop. Before you feel a hard stop you will feel a spring-like resistance. You are making thermal contact between the scanner and the chassis. This is necessary for best performance.
- Maintain pressure on scanner and press the lever at the right downward to lock the scanner into place.

26. **Check correction collar:**

- Check that the green correction collar on the objective is set properly. For the Gas cantilever holder, set the correction collar to 1.5.

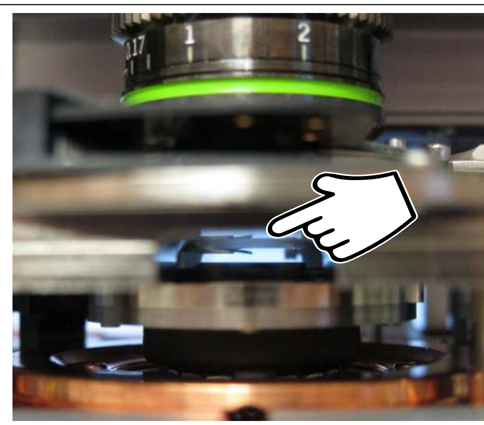


27. **Close enclosure door:**

- *Gently* close the door and latch it.

28. **Motor cantilever toward sample:**

- Place your eyes level with the cantilever and sample, so you can clearly see the gap between cantilever and sample.
- Slowly turn the 'Engage Control Knob' on the AFM enclosure *counterclockwise*. This will lower the cantilever holder and objective toward the sample. The more you turn, the faster the stage moves.
- Close the gap between tip and sample to about 1 millimeter.



Warning: Nothing but your attentiveness will prevent the cantilever holder from crashing into the sample. If you crash the cantilever holder you may cause *SERIOUS* damage to your cantilever holder and scanner.

29. This concludes the manual interaction with Cypher. We next turn our attention to the computer. Please jump to Section 4.3 on page 26.

12. Cantilever Holder Guide

CHAPTER REV. 1707, DATED 10/23/2013, 13:57. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

Depending on your specific imaging application the appropriate cantilever holder must be used. This chapter serves as a guide to the available options and to help you identify the types of cantilever holders you may already own.

All the available cantilever holders have many things in common:

- All have a circuit board which allows the system to identify the type of cantilever holder and to activate the appropriate software control panels.
- All have a piezoelectric actuator and allow AC mode and contact mode imaging.
- Nearly all have the ability to apply a voltage to the cantilever.

Many more contain specific electronics allowing for current measurement, application of high voltage to the tip, and more.

Be Careful	Cantilever holders are the most delicate components of the AFM. Treat it like you might treat your great grandfather's pocket watch. Never drop it. Remember that even the most basic cantilever holder costs thousands of dollars to replace.

12.1. Identifying Cantilever Holders

12.1.1. Visual Guide of Cantilever Holders

Please use this table to identify your cantilever holders and find the relevant sections which describe them.

Part #	Holder Description	Top Photo	Bottom Photo
901.758	**Gas** For most contact and AC mode Imaging.		
901.770	**Liquid** For fluid imaging in a droplet.	Photo Needed	Photo Needed
901.745	**Perfusion** For fluid imaging in a droplet with flow.		
901.767	**ORCA** Conductive AFM with a single current range, 2nA/V.		
901.771	**High Voltage** Typically used for High Voltage PFM Imaging.		

12.1.2. Electronic Identification of Cantilever Holders

1. Attach the cantilever holder to the Cypher Scanner.
2. From the main menu bar in the software select *Programming ▷ Cantilever Holder and Sample Panel*.
3. At the bottom left of this panel click the ‘Check Holder’ button and the type of cantilever holder will be highlighted.

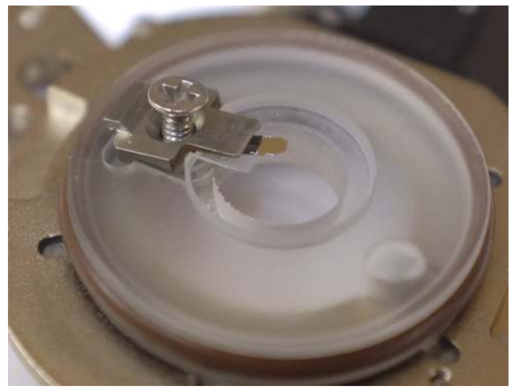
12.2. Disassembly

Only the cantilever clip can be removed from the cantilever holder. All other parts should not be removed or serviced by the user.

12.2.1. Removing the Clip

1. **Remove the screw:**

   - Using a small phillips screwdriver, simply unscrew the screw completely.



2. **The clip:**

   - The clip should come off as shown.
   - Spare screws and O-rings can be found in the parts kit (see Section 10.1 on page 115).

12.2.2. Attaching the clip

1. **Cantilever holder:**

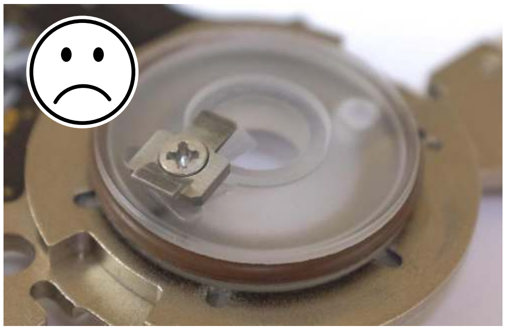
   - The Cantilever holder should be sitting ready without a clip, as shown.

2.

Prepare the clip:

- Put the screw, clip, and O-ring together as shown.
- Screw only a few turns into the threaded hole in the glass of the cantilever holder.
- DO NOT TIGHTEN YET!

3.



Check clip rotation:

- Rotate the clil so it does not overhang any of the glass cutout's edges.
- Press down on the clip so it settles down into the cutout area of the glass.

4.

Tighten the screw:

- Using a small phillips screwdriver, tighten the screw until you feel some resistance. This will be the O-ring compressing.
- If the clip still has a tendency to turn around during tightening of the screw, consider holding the clip pressed down (right photo) so it seats properly in the cutout feature.

12.3. Cleaning

Only the glass parts of the cantilever holder should come into contact with fluid during cleaning. To prevent fluid from touching the circuit components, please use the cleaning cup as shown below.

1.

Locate parts:

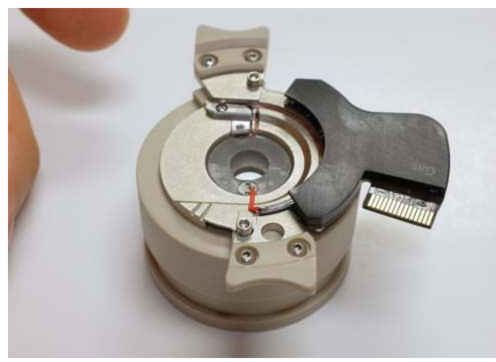
- Locate the Cleaning Cup (114.820).
- Select the cantilever holder you want to clean.
- Optionally, remove the screw and clip (see Section 12.2.1 on page 143).

2.

Attach holder to cup:

- Make sure the screws are loose enough.
- Fit and rotate the holder onto the the cup, same procedure as fitting the holder to the AFM (see Step 22 on page 138).
- Tighten the screws lightly.

Note: A perfusion cantilever holder should have plugged fluid ports before proceeding to the next step.



3.

Add cleaning fluid:

- Pour a small amount of solvent or water into the cup. We recommend ethyl or isopropyl alcohol or deionized water.

Note Acetone and Methylene Chloride and other aggressive solvents should not be used since they can attack epoxy which is exposed when the cantilever holder clip is removed.

4. **Clean:**

   - Use a soft swab to clean the surface of the cantilever holder.
   - Rinse and repeat as desired.

5. Blow dry with compressed filtered air.
6. Remove the holder from the cup.
7. Blow dry around the large O-ring, some solvent may have become trapped in the outer perimeter O-ring groove.

12.4. Storage

After cleaning, store the cantilever holder in the membrane box in which it originally shipped.

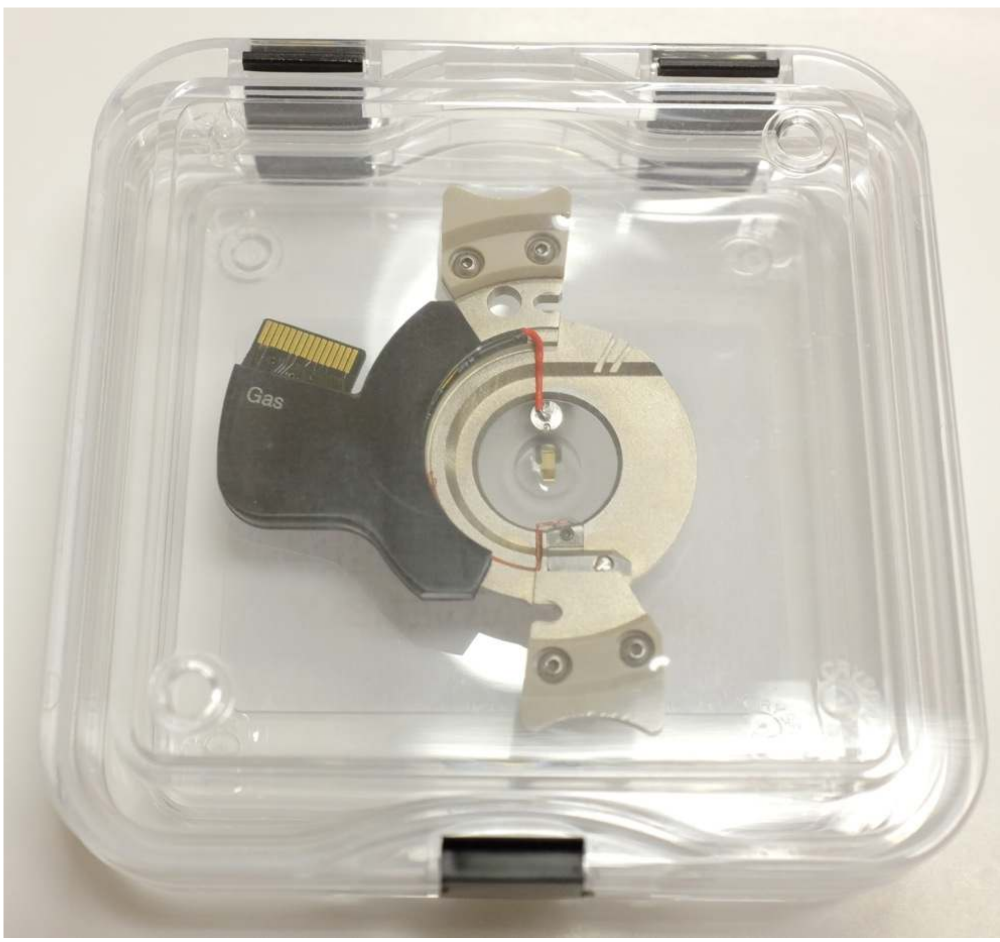


Figure 12.1.: A cantilever holder properly stored in its box.

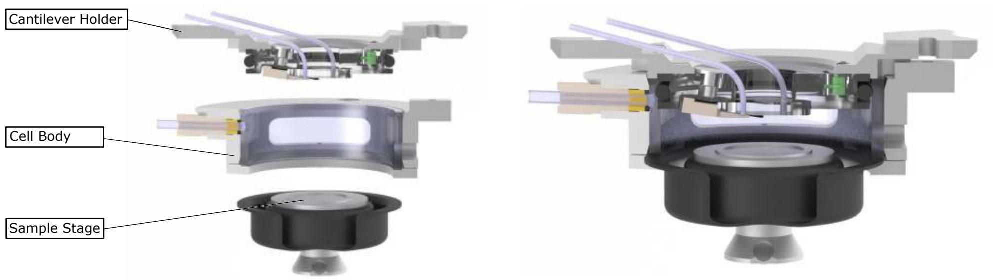
13. Cell Body and Sample Stage Guide

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

The sealed environment around the sample and cantilever is formed by three components:

- The cantilever holder forms the lid.
- The cell body forms the sides.
- The sample stage forms the bottom.



(a) A Perfusion Cantilever Holder, Fluid Cell Body, and Ambient Sample Stage, disassembled.

(b) A fully sealed assembly.

Figure 13.1.: Ambient Stage

The various cell bodies are described in Section 13.1 on page 148, the cantilever holders in Chapter 12 on page 141, and the samples stages in Section 13.2 on page 155.

The connection between cell body and sample stage is always the same mechanism and is described in Section 13.3 on page 158.

The process of attaching the gas lines to the side of the cell body is described in Section 13.4.4 on page 168.

13.1. Cell Body Guide

13.1.1. Identifying Cell Bodies

Please use this table to identify your cantilever holders and find the relevant sections which describe them.

Part #	Holder Description	Front Photo	Back Photo
901.746	**Gas** This cell is meant to be used primarily for gas environments as it has electrical feedthroughs. However, it can also be used in a droplet environment.		

Part #	Holder Description	Front Photo	Back Photo
901.760	**Fluid** This cell is the same ast the Gas cell, but it does not have electrical feedthroughs.		

13.1.2. Gas Cell

The Gas cell has three magnetic contacts which can be used to route electrical signals to the sample.

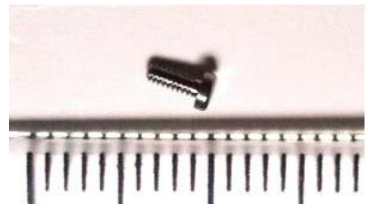
(a) Electrical Connector

(b) Magnetic Contacts

Figure 13.2.: Gas Cell Body

13.1.2.1. Parts list

Itm	Part #	Item Description	Qty	Picture
1		Gas Cell Body.	1	
The scale in the photos is in cm and mm.				

Itm	Part #	Item Description	Qty	Picture
2	114.884	Boot Clamp Ring, 8 Bolt Pattern. Connects to the bottom of the cell to form the seal between the cell body and the sample stage membrane. See Step 3 on page 161.	1	
3	00-90 x 1/8” Pan Head SS	00-90 x 1/8” screw. Spare screws used to fasten the sample stage membrane to the cell body. See Step 4 on page 160.	8	
4	1-72 x 0.25 SHCS SS	1-72 x 1/4” long screw. Used to lock down the cantilever holder.	2	
5	448.137	Gas Cell Cable. Cable to connect to magnet contacts. See Section 13.1.2.3 on page 151.	1	
The scale in the photos is in cm and mm.				

13.1.2.2. Specifications

Exposed Materials:

Cell wall: Borosilicate Glass.

Contacts: Nicked or Gold Plated.

Other: Epoxy.

Cleaning: The whole cell body can be immersed or sonicated in ethyl or isopropyl alcohol or water. Do not use acetone or methylene chloride or other aggressive solvents as it will attack the epoxy between the glass and metal parts.

Liquid use: Safe for use with most liquids being used in a droplet, but we recommend the fluid cell body for use with liquids.

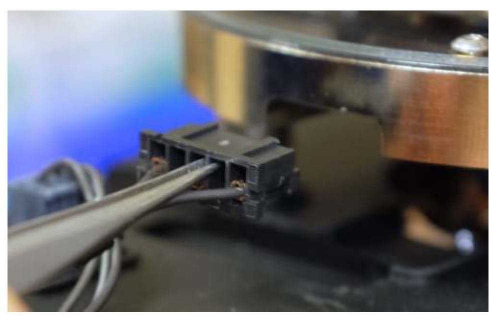
13.1.2.3. Gas Cell Cable Installation

1. Raise the engage stage fully (see Step 1 on page 131).
2. Unlock the scanner and pull it all the way forward. This will give enough access to plug in the cable. You may find it more comfortably to take the scanner out of the AFM completely. To do so, turn off the system power and follow instructions here: Section 16.1 on page 183.

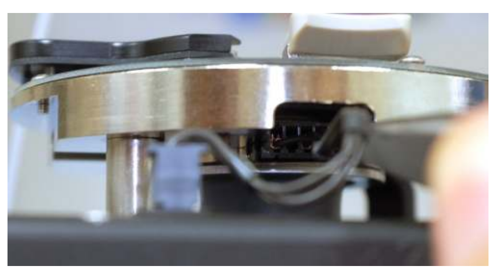
3. **Locate Cable:**
   - Locate the Gas Cell Cable (448.137).

4. **Orient the cable:**
   - The cable will plug in with the holes facing toward the top of the scanner.

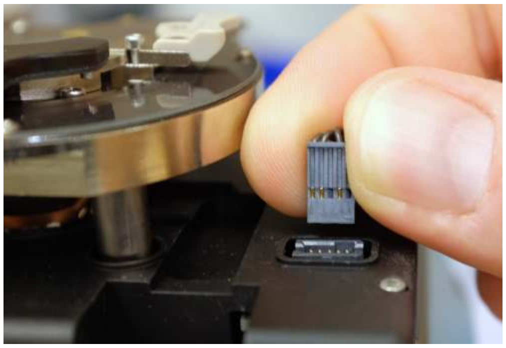
5. **Grip the cable with tweezers:**
   - Using sharp straight tipped tweezers, grip the connector as shown.

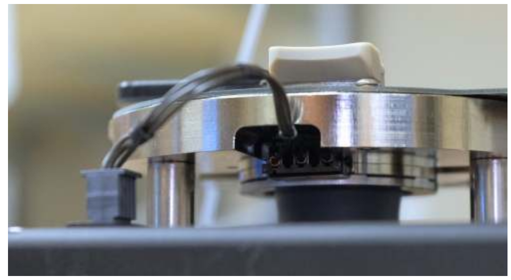


6. **insert the connector:**
   - Carefully insert the connector as shown.



7.





Insert the smaller connector:

- Insert the smaller connector as shown on the left.
- The final cable position is shown on the right.

13.1.2.4. Applying Sample Bias or Ground

1.

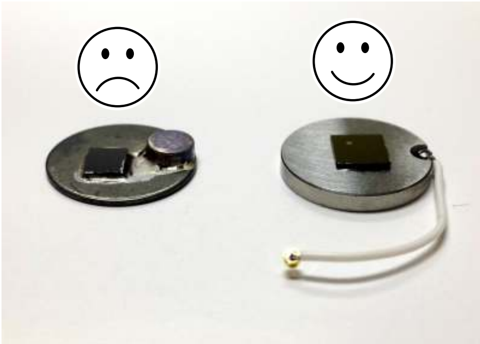
Sample mounting:

- Mount your sample onto the Electrical Sample Puck Assembly (448.140) using silver paint or some other conductive adhesive.

2.

WARNING: Never load “non-flat” samples into the ES scanner.

- Unlike the S scanner, the ES scanner cannot accept “non-flat” samples.
- *A “non-flat” sample is any sample in which the region to be scanned is not the tallest feature on the sample puck.* For example, the sample shown shown on the left has a magnet glued to the puck that is taller than the sample.
- Given the low profile of the ES cantilever holders, it would not be possible to engage on the sample shown shown on the left since the magnet would hit the cantilever holder before the cantilever engaged on the sample.
- For electrical measurements, use the low-profile electrical sample puck (as shown on the right) provided in the accessory kit.



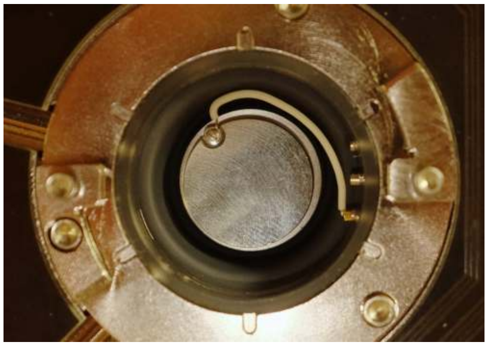
Warning: Pay attention! Attempting to starting a tip approach on a “non-flat” sample may cause serious damage to your cantilever holder and/or sample stage.

3.

Sample BIAS Connection:

- Insert the sample puck as shown.
- Use blunt tipped tweezers to connect the wire as shown: to the FRONT connection. This applies a sample bias.

Note Lower the cell body to get more sample access: see Step 17 on page 136.

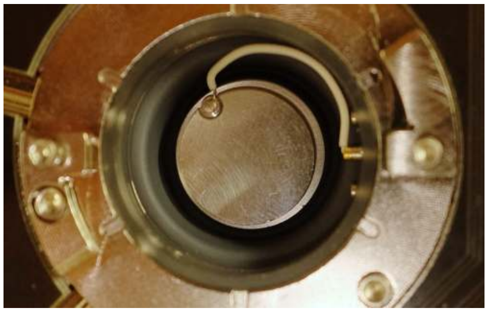


4.

Sample GROUND Connection:

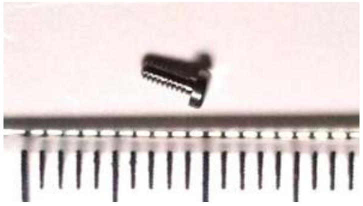
- Insert the sample puck as shown.
- Use blunt tipped tweezers to connect the wire as shown., to the MIDDLE connection. This applies a sample bias.

Note Lower the cell body to get more sample access: see Step 17 on page 136.



13.1.3. Fluid Cell Body

13.1.3.1. Parts list

Itm	Part #	Item Description	Qty	Picture
1		Fluid Cell Body.	1	
2	114.884	Boot Clamp Ring, 8 Bolt Pattern. Connects to the bottom of the cell to form the seal between the cell body and the sample stage membrane. See Step 3 on page 161.	1	
3	00-90 x 1/8” Pan Head SS	00-90 x 1/8” screw. Spare screws used to fasten the sample stage membrane to the cell body. See Step 4 on page 160.	8	
4	1-72 x 0.25 SHCS SS	1-72 x 1/4” long screw. Used to lock down the cantilever holder.	2	
The scale in the photos is in cm and mm.				

13.1.3.2. Specifications

Exposed Materials:

Cell wall: Borosilicate Glass.

Cleaning: The whole cell body can be immersed or sonicated in ethyl or isopropyl alcohol or water. Do not use acetone or methylene chloride or other aggressive solvents as it will attack the epoxy between the glass and metal parts.

Liquid use: Safe for use with any liquid compatible with borosilicate glass.

13.2. Sample Stage Guide

13.2.1. Identifying Sample Stages

Please use this table to identify your cantilever holders and find the relevant sections which describe them.

Part #	Holder Description	Front Photo	Back Photo
901.761	**Ambient** For imaging at ambient temperatures. Safe for gas and fluid operation.		
901.747	**Heater** For imaging at ambient temperatures up to 250C. Safe for gas operation only.		
901.748	**Cooler Heater** For imaging at 0C to 120C. Safe for gas and fluid operation.		

13.2.2. Ambient Sample Stage

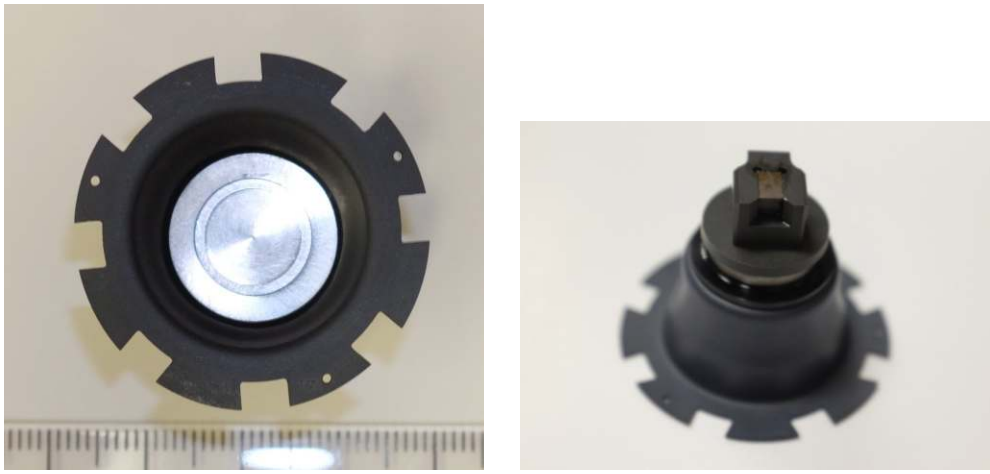
The ambient sample stage is the first choice for imaging at room temperature

13.2.2.1. Parts list

There are no associated parts. The stage comes by itself and has part number 901.761.

13.2.2.2. Specifications

Exposed Materials:



(a) Top Surface **(b)** Bottom View

Figure 13.3.: Ambient Stage

Membrane: FFKM.

Stage surface: Stainless Steel

Sample Hold down: Embedded magnets.

Electrical: Stage surface is not grounded (floating) and sufficiently isolated to be safe for use with high voltage applications. .

Cleaning: The whole stage can be immersed or sonicated in ethyl or isopropyl alcohol or water.

Liquid use: Safe for use with samples in liquid droplets.

13.2.3. Heater Sample Stage

The ambient sample stage is the first choice for imaging at room temperature

13.2.3.1. Parts list

There are no associated parts. The stage comes by itself and has part number 901.747.

13.2.3.2. Specifications

Exposed Materials:

Membrane: FFKM.

Figure 13.4.: Heater Stage

Stage surface: Ceramic.

Other surfaces: Stainless steel, Epoxy.

Sample Hold down: Embedded magnets.

Electrical: Stage surface is not grounded (floating) and sufficiently isolated to be safe for use with high voltage applications. .

Cleaning: Only wipe the sample stage with a swab dampened with alcohol.

Temperature range: Ambient to 250C°C as measured by a sensor embedded several 0.5mm below the surface on which the sample sits.

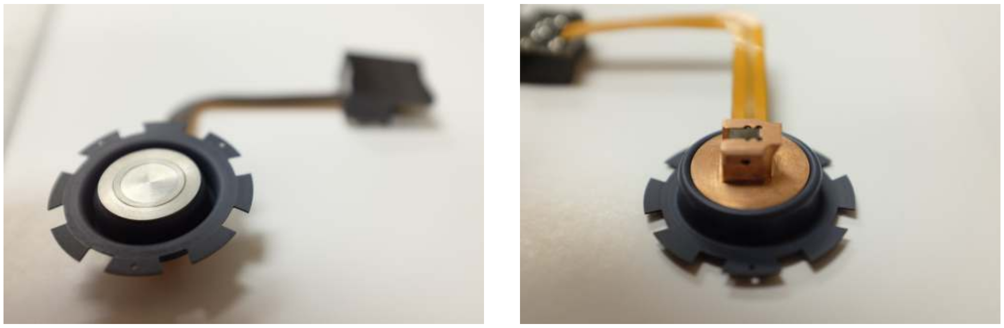
Liquid use: Not for use with any kind of fluid. Only use in air or with inert gas purge.

13.2.4. Cooler Heater Sample Stage

The ambient sample stage is the first choice for imaging at room temperature

13.2.4.1. Parts list

There are no associated parts. The stage comes by itself and has part number 901.748.



(a) Top Surface **(b)** Bottom View

Figure 13.5.: Cooler Heater Stage

13.2.4.2. Specifications

Exposed Materials:

Membrane: FFKM.

Stage surface: Stainless Steel

Sample Hold down: Embedded magnets.

Electrical: Stage surface is not grounded (floating) and sufficiently isolated to be safe for use with high voltage applications. .

Cleaning: When mounted to a CES cell body, it can be filled with nearly any solvent compatible with FFKM and Stainless steel and quartz. When disassembled, wipe with a solvent soaked swab or cloth, but keep liquids away from the back of the device and the circuit board connector.

Temperature range: -10ºC to 120ºC as measured by a sensor embedded several mm below the surface on which the sample sits.

Liquid use: Safe for use with samples in liquid droplets.

13.3. Tutorial: Disassembling the Sample Stage from the Cell Body

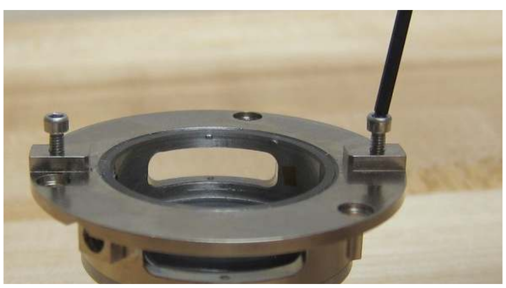
This tutorial will go through the steps of removing one sample from a cell body and replacing it with another. This tutorial starts with the combination of a gas cell body attached to an ambient stage, and replaces that ambient stage with a heater stage.

Your cell body and sample stage may differ, but the way the two attach is universal.

Figure 13.6.: Ambient stage / fluid cell body combination on the left. Heater stage / gas cell body combination on the right.

13.3.1. Separate Sample Stage and Chamber

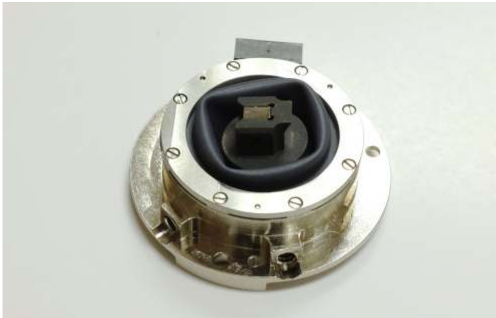
1. Locate the 1.7mm slotted screwdriver and a pair of curved tweezers.

2.  

   Remove screws:

   - Remove the two cantilever locking screws as shown and lay them aside.

3.



Extend the membrane:

- Place the assembly as shown.
- Pull on the sample stage bottom and extend the membrane as shown.

4.

Loosen all the screws:

- Using a 1.7mm flat tipped screwdriver, loosen all the screws.

NOTE: Be careful not to slip and possibly puncture the membrane with the screwdriver.

5.

Remove the ring:

- Remove the retaining ring and set it and the screws aside.

6.

Remove the sample stage:

- Lift off the sample stage.

7.

Finished:

- Your parts should now be as shown to the right.
- Store the sample stage as discussed in Section 13.5 on page 171.

13.3.2. Attach Cell Body and Sample Stage

1.

Prepare parts:

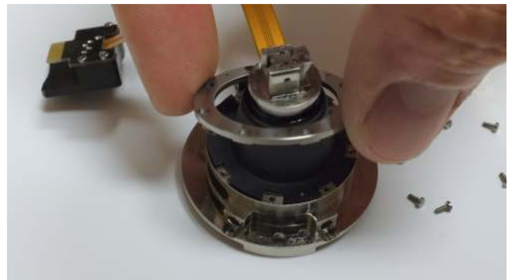
- Sample stage on the left.
- Cell body in the middle
- Membrane clamping ring and screws to the right. More screws (00-90 X 1/8”) can be found in the Environmental Scanner accessory kit (see Section 10.1 on page 115).

2.

Place the stage:

- Note the three small holes in the “petals” on the diaphragm perimeter.
- Align those with the three pins on the bottom of the cell. The parts can only go together one way.
- Assist the diaphragm so the pins go through the holes.

3.



Place the ring:

- As shown in the photos, place the ring.
- The ring has three small holes that line up with the pins.
- Seat the ring flush against the diaphragm.

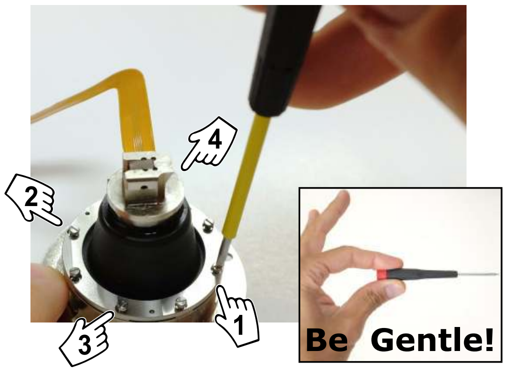
NOTE: The ring has a smooth side and a side with raised metal features. When the ring is properly placed, the smooth side is showing and the raised features face the diaphragm.

4.

Place the screws:

- As shown, place all the screws in the holes.
- Double check that the ring is not upside down!

5.



Tighten the screws:

- Using a 1.7mm flat tipped screwdriver, tighten all the screws.
- First tighten them in the pattern shown for the first four. When all 8 screws are snug, go around once more and tighten firmly while holding the tool only with fingertips to prevent over-tightening.

NOTE: Be careful not to slip and possibly puncture the membrane with the screwdriver.

6.

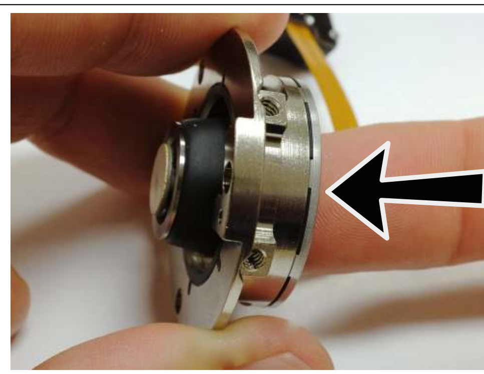
Finished:

- Your parts should now be as shown to the right.

7.

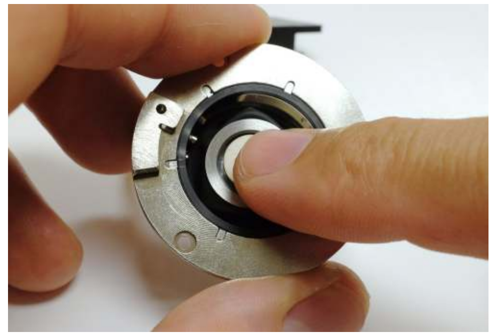
Preforming the diaphragm:

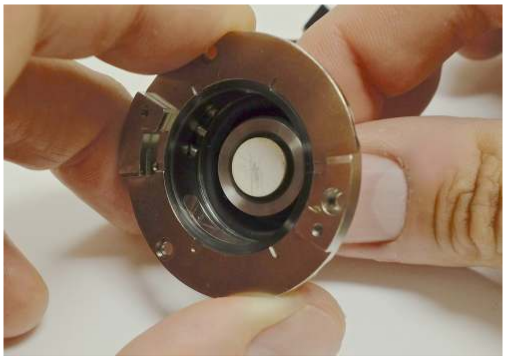
- Gently press the sample stage as shown so the diaphragm pops through to the other side.



8. **Press back:**

- Press the stage back a little until you can grab it from the back side.



9. 

Finish preforming:

- Pulling from the back of the sample stage, move the stage back and forth until the membrane is formed as shown on the right.

At this point the stage is ready to be mounted on the scanner (see Section 13.4.4 on page 168) or store it in its storage container (see **??** on page **??**).

13.4. Tutorial: Exchanging the Sample Stage and Cell Body

This tutorial provides a quick path to learning the basics of changing cell bodies (see Chapter 13 on page 147 for various options) and sample stages (see Section 13.2 on page 155 for various options).

The Cypher is a research grade instrument and improper use of the instrument can cause damage to the instrument and/or injury to the user. This tutorial will take approximately 3 hours .

Before you start:

- We assume you understand the aspects of running this system safely: (Chapter 20 on page 229.)
- You are familiar with the basic names of the hardware components and software controls (Chapter 1 on page 3.)

This tutorial makes the rather arbitrary choice of starting with an environmental scanner equipped with an ambient stage / fluid cell body and replacing that with a heater stage / gas cell body combination (See Figure 13.7 on page 165). Depending on what you have available, please make the necessary substitutions.

Figure 13.7.: Ambient stage / fluid cell body combination on the left. Heater stage / Gas cell body combination on the right.

13.4.1. Required Materials

This tutorial is designed to be performed, not merely read. If possible, take the tutorial under the supervision of an experienced user (tell them to mostly sit back though, or you will not learn as much as you would by yourself).

1.

Prepare your materials: It will be necessary to gather a few items prior to beginning the tutorial:

a) Tweezers, preferably with curved tip (for example, Asylum Part #290.102)

b) 1/16" Hex Driver (Asylum Part #290.130)

c) 5/64" (2mm) Hex Driver

d) Sample stage already attached to a cell body.

13.4.2. Prepare the scanner

1.

Remove the cantilever holder:

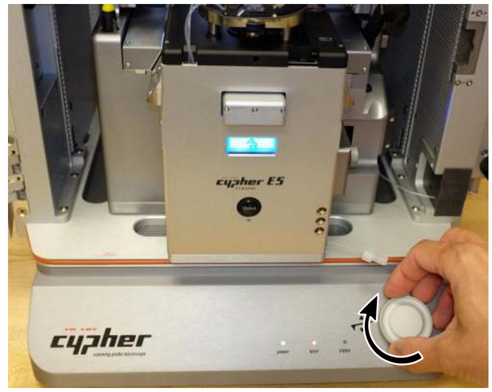
- Remove the cantilever holder and place it, cantilever tip facing UP, to the side. See Step 6 on page 132 and the following few steps.

2.

Prepare scanner for Removal.

- RAISE THE COARSE ENGAGE STAGE by turning the Engage Control Knob *clockwise*.Raise the stage until it reaches its upper limit of travel.

This will prepare the engage mechanism for a later step of installing a heated temperature stage.



3.

Remove the scanner:

- Turn off the ARC2 controller power and remove the scanner from the Cypher Chassis (see Section 16.1 on page 183 for further details) and place it on a well lighted clean work surface.

13.4.3. Remove the Sample Stage and Chamber

1.

Loosen the sample stage clamping screw:

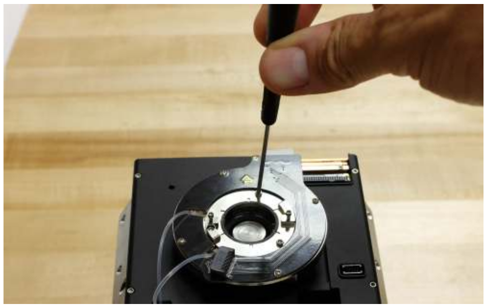
- Insert the 5/64” Hex Driver into the screw hole at the front of the scanner.
- Turn the Hex Driver *counterclockwise* at most **THREE** full rotations to loosen sufficiently.

Note Turning the locking screw (114.576) more than three turns may cause the screw to come all the way out.

Note If the screw comes all the way out, you may need to lean the scanner forward until the screw slide out to a place where you can put it back on the wrench.

2. **Loosen the cell body screws:**

   - Use the 5/64" Hex Driver to loosen the screws at the top of the cell body.
   - Discard the screws.
   - Extra screws are available in your kit. Replace old screws with Item 20, 2-56 x 1/8" long screws (Asylum Part #SHCS SS).

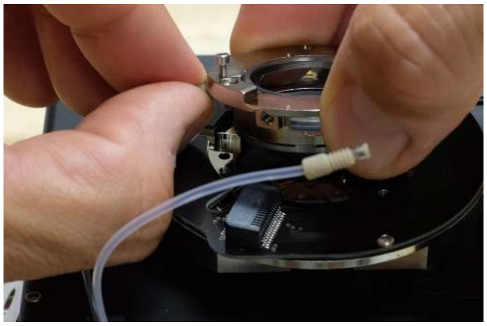


3. **Pull the cell body partway out:**

   - Grasping the cell blocks, pull up on the cell body until the diaphragm is fully extended.

4. **Loosen fittings of gas in/out lines:** In this step, you will remove the gas in/out lines. Notice that the gas lines are sealed by a small O-ring which may or may not come out when you pull out the gas lines.

   - Grasp the cell body with your dominant hand.
   - With the opposite hand, use ONLY YOUR BARE FINGERS to loosen the fitting by turning it *counterclockwise* to loosen it.
   - Detach both gas lines.



5. Check the gas lines to see if small O=rings are stuck to the end. Usually the rings will stay inside the cell, but in case they are stuck to the gas lines, please unstick them and place aside.

6. **Lift out the sample stage:**

- Lift the sample stage out of the cell body.
- If you encounter resistance, you may need to further loosen the sample stage clamping screw (see Step 1 on page 166).

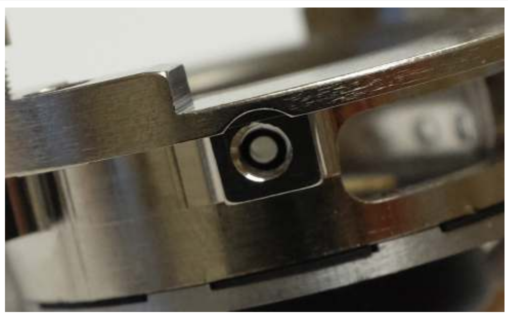
7. Store the sample stage / cell body combination it its proper storage container. See **??** on page **??**.

13.4.4. Mount the New Stage/Cell Combination

1. **Check the membrane shape:**

- Make sure the rubber membrane on the sample stage is properly formed as shown in the photo.
- If necessary, see Step 7 on page 163 on how do form the membrane.

2. 



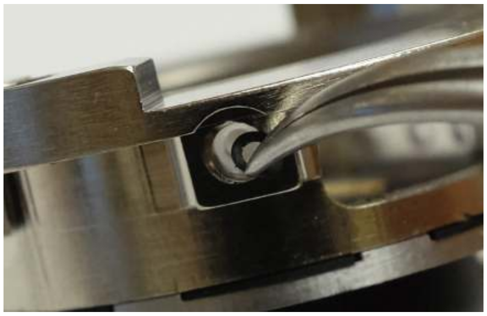
Check for O-rings:

- The cell body on the left has the O-ring missing.
- The cell body on the right has a properly seated O-ring.

3.

Place O-rings if necessary:

- If no O-ring (230.040) is present, place it in the bottom of the port, up against the glass.
- If the O-ring is not properly centered, remove it (preferably with a sharp wooden stick) and replace it.
- If you are gentle with the cell, the O-rings should stay in place during the following steps.



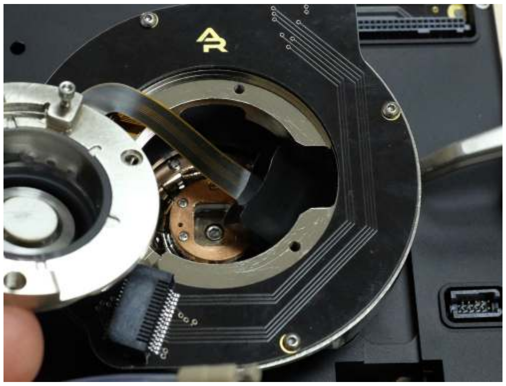
4.

Prepare to route the cable:

Note This step requires that the engage stage was fully raised before the scanner was unplugged.

- Hold the stage/cell as shown and tuck the cable connector under the engage ring using the "platypus" tweezers.

5.



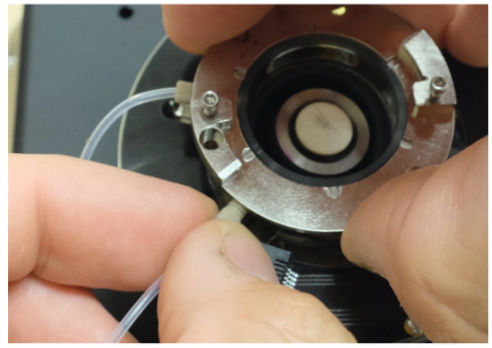
Guide the heater cable under the ring:

- As shown, guide the connector under the ring.
- Leave it sitting loose on the top of the scanner.

6.

Attach Gas Lines:

- Using only your fingers to tighten the screws, attach the gas lines to the cell body as shown.
- Tighten until snug, don’t overdo it.



7.

Seat the sample stage:

- Lower the dovetail connection at the bottom of the stage into the receiving hole on top of the scanner.
- Press lightly onto the top of the sample stage until the sample stage sinks down into the hole.
- Check that the cell body is seated on the scanner engage ring.

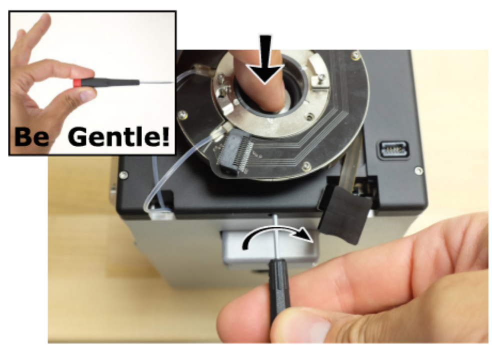
Note A properly seated sample stage is centered in the cell body and

BE GENTLE!

8.

Tighten sample stage:

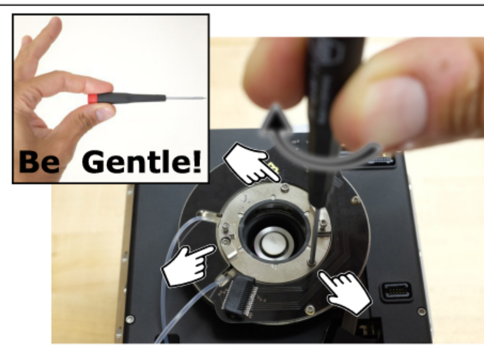
- Press down on the sample stage to keep it flush against the scanner.
- Tighten the screw using the 5/64” driver. This will take about three turns before you feel resistance.
- Tighten snug, only using your fingertips to handle the tool.



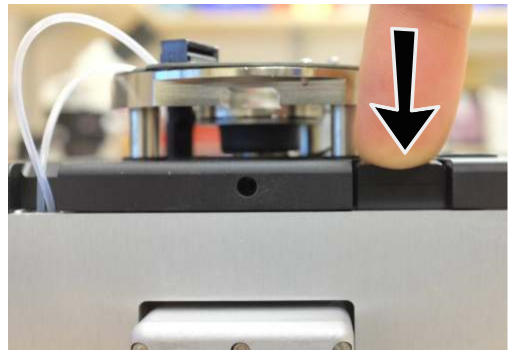
9.

Secure the cell body:

- Locate three 2-56 X 1/8” screws and the 1/16” hex driver tool.
- Fasten the screws as shown, using only your fingertips to hold the tool. This will prevent over tightening.



10.



Connect the heater cable:

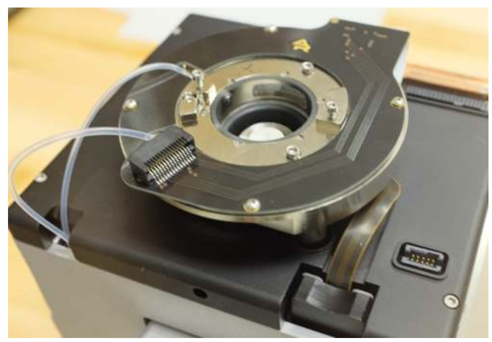
- As shown, insert the heater cable connector.
- Push it flush.

11.

Final checks:

- Your scanner should now look like the photo to the right.

CHECK The sample stage top surface sits quite deep as shown, below the glass sidewalls of the cell body. View the stage through the windows on the sides of the cell and make sure you cannot see it. If the sample stage was not seated properly, you will crush it when you go to insert the cantilever holder.



13.4.5. Replace the Scanner

1. Refer to 16.3.
2. When pressing the scanner against the back of the chassis, you should sense a hard stop of metal touching against metal. This requires a little extra pressure to compress some springs behind the copper plate at the back of the scanner. Not pressing the scanner all the way into the chassis may hamper thermal performance when using cooling or heating stages.

13.5. Storage

13.5.1. Storing disassembled sample stages

Once a sample stage has been removed from a cell body (See 13.3.1), it should be stored in the membrane container in which it shipped. See Figure 13.8 on page 172.

(a) Heater Stage **(b)** Gas Cell Body **(c)** Passive Stage

Figure 13.8.: Various stages and cell bodies stored in their containers.

13.5.2. Storing disassembled cell bodies

Once a sample stage has been removed from a cell body (See 13.3.1), the cell body should be stored in the membrane container in which it shipped. See Figure 13.8 on page 172.

For cell bodies were recommend storing the membrane clamping ring attached tot the cell body with its eight screws and placing any other associated accessories such as cables with the cell in the box.

14. Gas Handling and Leak Testing

CHAPTER REV. 1702, DATED 10/21/2013, 22:07. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

14.1. Gas Handling Overview

Figure 14.1 on page 174 shows the front of the scanner with the cover removed (see 14.2.1 to accomplish this). The two gas lines attached to the sample cell body are routed via tubing guides to the bottom left of the scanner. One of the lines branches off to a pressure sensor and then passes through a computer controlled valve. Depending on the application, this valve may be open or closed, and it may be manually or computer controlled.

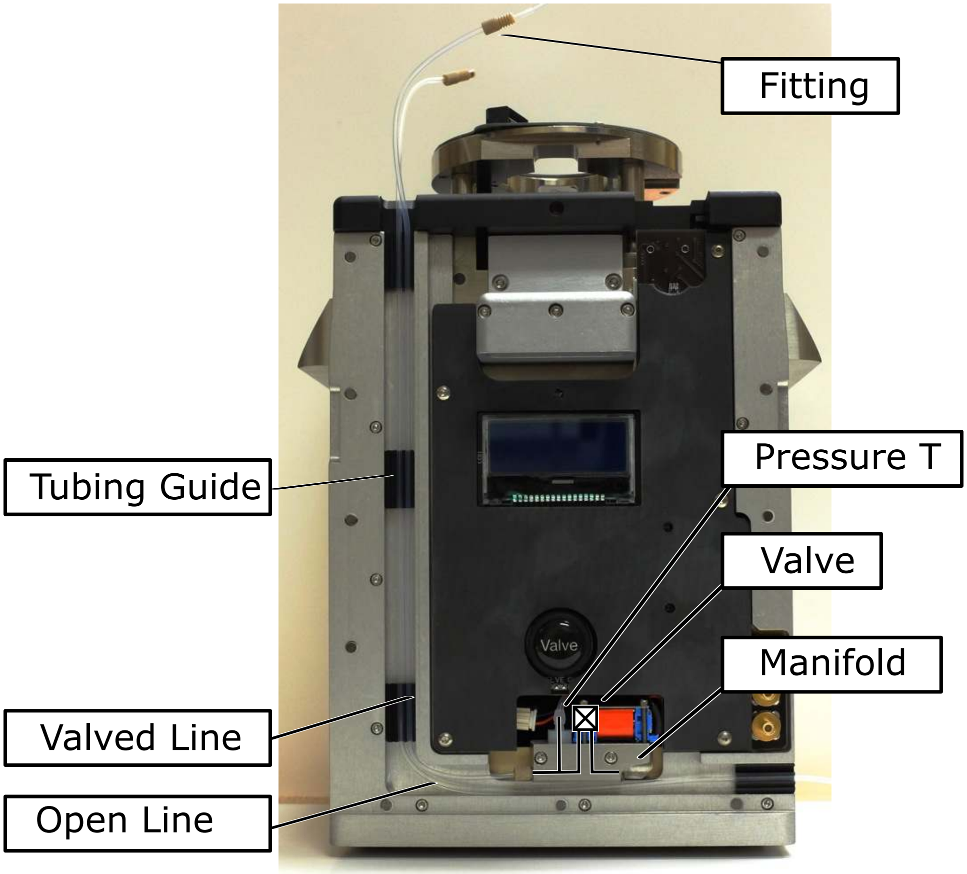
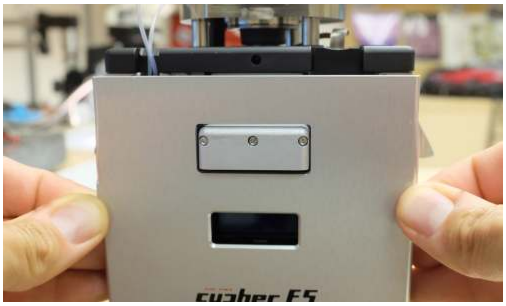


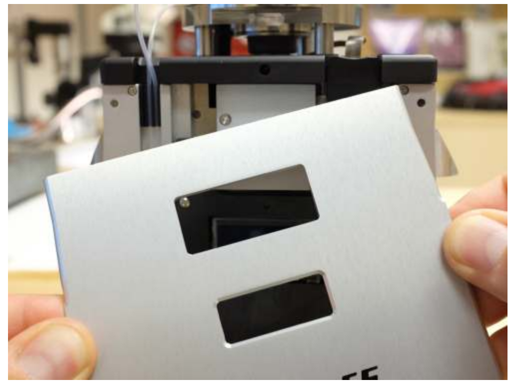
Figure 14.1.: Gas Handling Overview

14.2. Manifold Connections

14.2.1. Scanner Faceplate Removal

1.





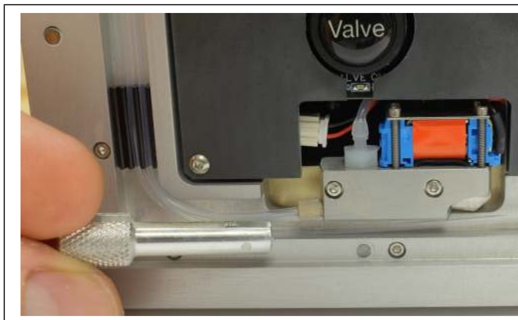
Remove the scanner cover:

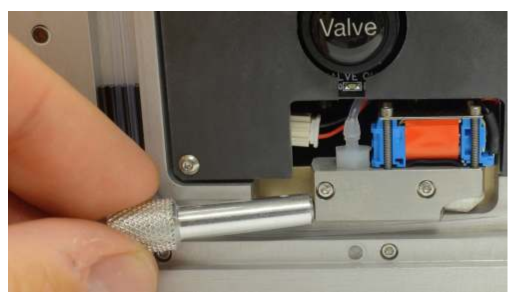
- Grip the cover as shown.
- Pull forward. The cover is attached magnetically.

14.2.2. Manifold Cell-side connection

Process for removing the tubing connected on the cell-side of the valve manifold.

1.





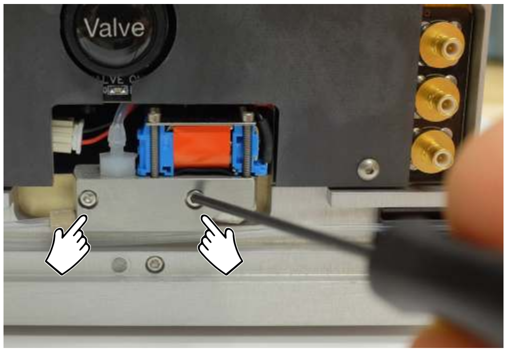
Remove the fitting using the tool:

- Place the tool on the fitting. The slot in the tool slides over the tubing.
- Unscrew until the fitting comes loose. An O-ring should stay attached to the tubing. If not, you may need to retrieve it from the port with tweezers.
- If it feels there is not enough room to complete this step, please follow to the next step:

2.

Remove the manifold (optional):

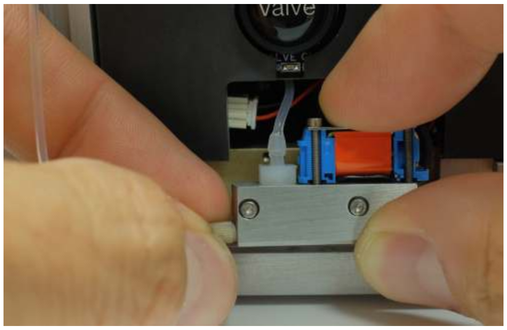
- ONLY IF there was not enough room to complete the last step, remove the two screws shown in the photo.



3.

Remove fittings while holding manifold:

- Pull the manifold forward a little. Pay attention not to apply tension to the tubing or the wires.
- Remove the fitting using fingers or the tool shown in previous steps.
- When the tubing has been replaced, reverse attach the manifold again with its screws.

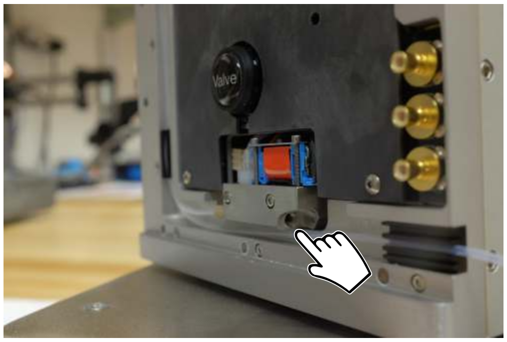


14.2.3. Manifold Lab-side connection

1.

Locate the manifold port:

- The lab-side port of the valve manifold is shown in the photo.



2.

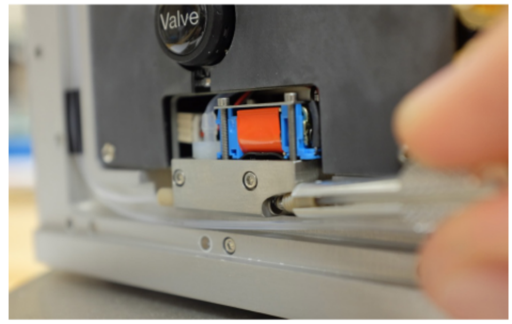
Prepare tubing:

- Attach the tubing with fitting to the fitting tool as shown.
- Note that the tubing should have a small bit extending beyond the ferrule. This space holds the O-ring (230.040)

3.

Tighten fitting:

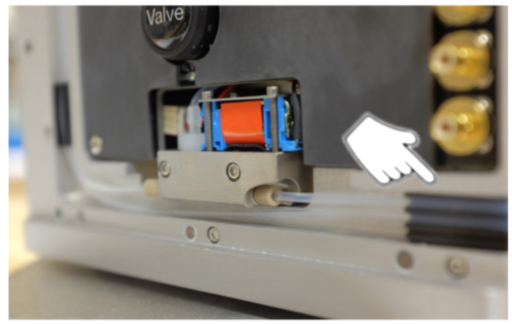
- Tighten the fitting as shown.
- Do not over tighten. Holding the tool with fingertips only should prevent any damage to the fitting.



4.

Guide the tubing:

- Press the tubing into the guides. Note that the tubing is not perfectly round and it may fit better if it is twisted a bit.



15. Conductive AFM

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

15.1. parts list

To be completed at a future date.

15.2. Required items:

- An ORCA conductive AFM cantilever holder, such as 901.767 shown in Section 12.1.1 on page 141.
- The gas cell body (901.746) shown in Section 13.1 on page 148.
- The gas cell cable (448.137) shown in Section 13.1.2 on page 149.
- The Electrical Sample Puck Assembly (448.140) , included in the Environmental Scanner Accessory kit.
- An electrically conducting cantilever, such as the Asylum Electrilever.

15.3. Tutorial: Conductive AFM

1. This technique will work only with the Gas Cell Body, but with any sample stage. Please follow the tutorials on:
   - Sample stage and cell body assembly: Section 13.3 on page 158.
   - Mounting the sample stage onto the Environmental Scanner: Section 13.4 on page 164.
2. Install the gas cell cable. See on page 151.

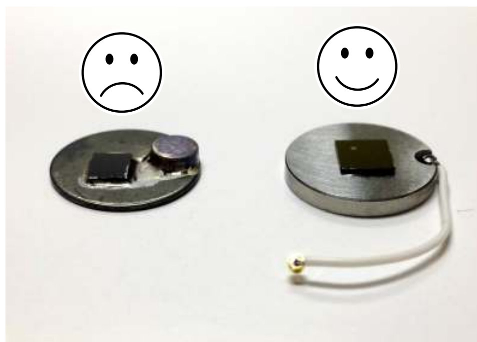
3. Prepare the cantilever holder and AFM. Follow the AC Mode Tutorial from Step 1 on page 131 THROUGH Step 17 on page 136 to prepare your AFM system and cantilever holder.

4. **Sample mounting:**

- Mount your sample onto the Electrical Sample Puck Assembly (448.140) using silver paint or some other conductive adhesive.

5. **WARNING: Never load "non-flat" samples into the ES scanner.**

- Unlike the S scanner, the ES scanner cannot accept "non-flat" samples.
- *A "non-flat" sample is any sample in which the region to be scanned is not the tallest feature on the sample puck.* For example, the sample shown shown on the left has a magnet glued to the puck that is taller than the sample.
- Given the low profile of the ES cantilever holders, it would not be possible to engage on the sample shown shown on the left since the magnet would hit the cantilever holder before the cantilever engaged on the sample.
- For electrical measurements, use the low-profile electrical sample puck (as shown on the right) provided in the accessory kit.

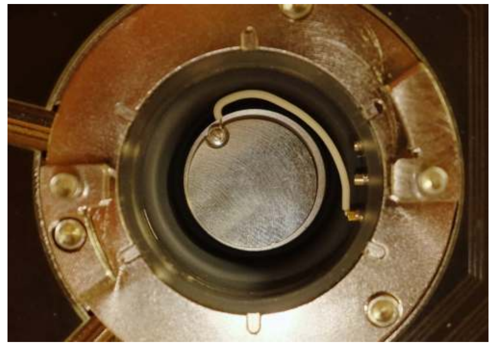


Warning: Pay attention! Attempting to starting a tip approach on a "non-flat" sample may cause serious damage to your cantilever holder and/or sample stage.

6. **Insert sample into the AFM:**

   - Remove the cantilever holder.
   - Insert the sample puck as shown.
   - Use blunt tipped tweezers to connect the wire as shown., to the front connection. This applies a sample bias.

   Note Lower the cell body to get more sample access: see Step 17 on page 136.

7. Continue the AC mode tutorial from Step 20 on page 137.
8. Once imaging, refer to *Applications Guide, Chapter: Conductive AFM*.

15.4. Testing the ORCA Amplifier

To be completed at a future date.

Part IV

Chassis and Enclosure

Who is this part for? This part covers general topics relating to the "frame" of the instrument, such as scanner exchange, laser module exchange, and air temperature control.

Part Contents

16. Tutorial: Scanner Exchange

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

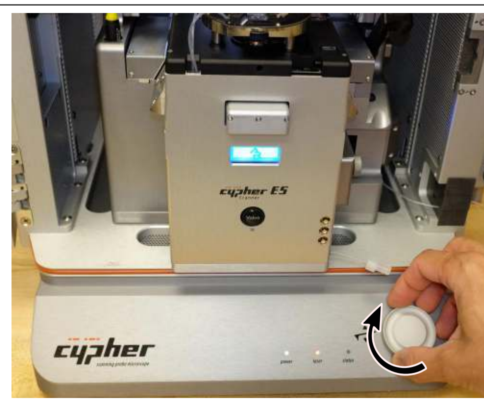
The Cypher AFM can be purchased with various scanner modules. This tutorial describes how to safely swap from one scanner to another.

16.1. Removing the scanner

The photos show the removal of the Environmental Scanner. The steps are the same for any other model.

1. **Raise the coarse engage stage:** It’s likely you’ll need to change a cell body after scanner removal, so it’s best to raise the stage now to make those later actions possible.

- Rotate the Engage Control Knob on the Cypher **clockwise** and hold it until the cantilever is at its highest position.



2. **Open the enclosure:**

- Lift the door latch and open the enclosure door.

3. **Power OFF the ARC2:**

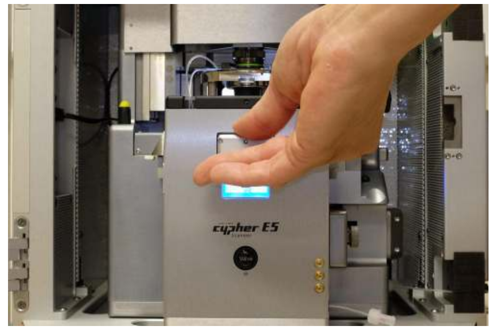
- Turn the ARC2 off before proceeding.
- Press the button as shown and verify the green light is OFF.

NOTE: The light behind the display on the scanner front will not turn off because it's powered by a different power supply. It is OK to unplug the scanner with this power supply active.

4. **Unlock scanner:**

- Lift the lever to the right of the scanner.

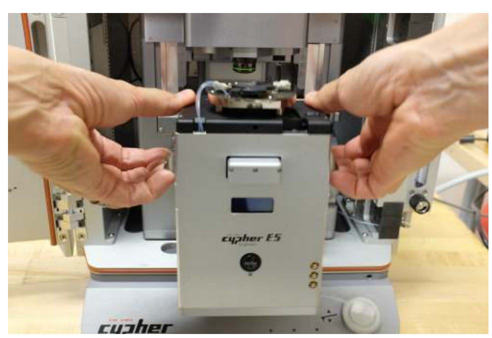
5. **Begin to pull the scanner out:**
   - Pull the scanner out about halfway.



6. Now go and clear out a place to set the scanner down once you remove it. We recommend you first place the scanner right in front of the AFM system, and then grip the scanner again to move it elsewhere. If the scanner is dropped it might become irreparably damaged.

7. **Detach the scanner from the chassis:**
   - Check that the light behind the scanner is off. This confirms the controller was turned off.
   - The light behind the display on the front of the scanner will remain on. This is OK. It is powered by an alternate power supply.
   - Turn the knob on the right side of the scanner *counterclockwise* to unscrew.
   - The knob will disengage and retract back towards the chassis. If the knob does not disengage readily, make sure the scanner body is pulled out sufficiently from the chassis.

8. **Remove scanner:**
   - Use two hands to grasp both sides of the scanner and remove. Place your fingers under the two dovetail rails as shown in the photo.
   - Use care because the scanner is HEAVY.
   - Preferably place the scanner right in front of the AFM and then pick it up again to move it to its storage location.

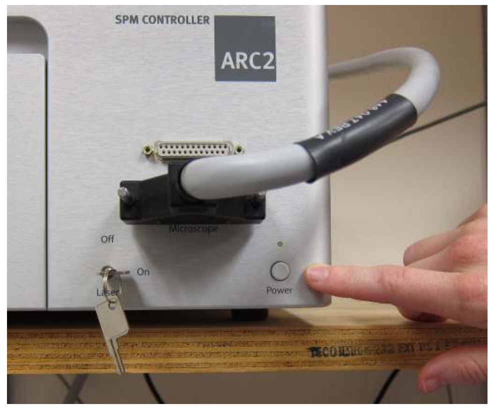


16.2. Scanner Storage

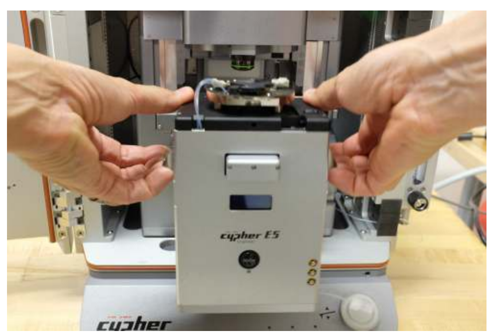
The scanner should be stored under basic laboratory conditions, preferably in a locked cabinet or drawer where it will not collect dust, be accidentally knocked over, or be “borrowed”. At the very minimum, place it on a shelf and cover it with a soft cloth.

16.3. Replacing the Scanner

1. **Verify that the ARC2 is off:**
   - Double check that the ARC2 power light is indeed off. If not, turn off the controller.



2. Clear a space in front of the AFM.
3. Set the scanner down in front of the AFM.
4. Swing the scanner connector to the side so it does not block the scanner’s insertion.
5. Make sure the locking lever on the chassis is in the RAISED position.
6. **Set the scanner on the rails:**
   - Use two hands to grasp both sides of the scanner and remove. Place your fingers under the two dovetail rails as shown in the photo.
   - Use care because the scanner is HEAVY.
   - Lift the scanner as shown and set it on the rails.
   - Push it in far enough so it sits stably on the rails.

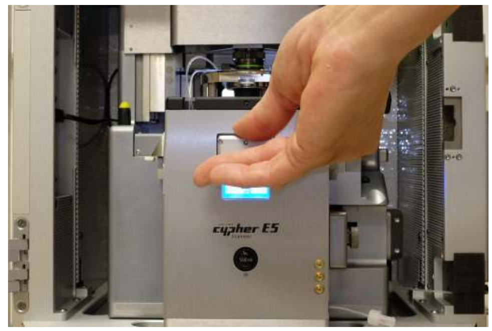


7. **Secure the scanner connector:**

- Press the connector into its mating socket.
- Turn the knob on the right side of the scanner *clockwise* until firmly tight.

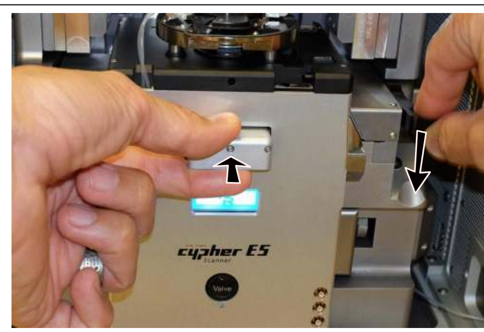
8. **Push the scanner in:**

- Push the scanner all the way into the chassis until it connects with the chassis.



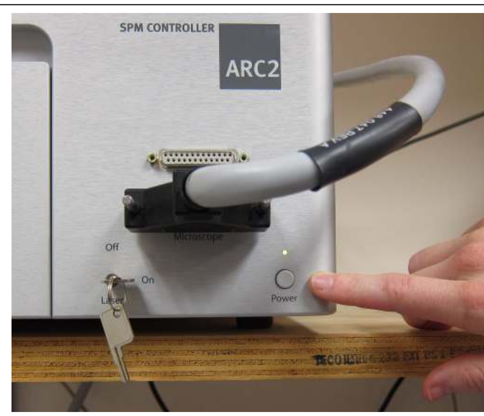
9. **Lock the scanner:**

- Continue to apply pressure against the scanner.
- Lower the lever to the right of the scanner to lock it into place.



10. **Turn the AC2 back on:**

- Press the button as shown. The light must remain green.



11. Sometime during the following steps you may be asked to re-home the motors. Please do so when the software requests it.

12. When the process completes and click the  button and the popup list of attached hardware should include the scanner.

17. Optical System

CHAPTER REV. 1711, DATED 10/23/2013, 22:16. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

17.1. Overview

The Cypher AFM has an excellent optical system. A high quality microscope objective sits at the heart of this system. It affords an excellent optical view of the sample but also guides laser beams for the cantilever detection system.

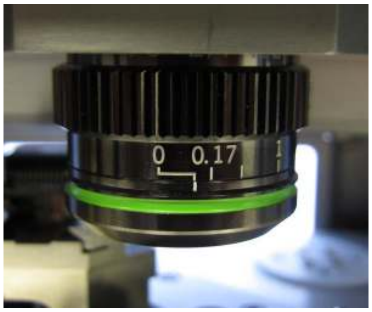
A camera and white light source are embedded in the "view system" which protrudes from the top of the cypher enclosure.

17.2. Microscope Objective

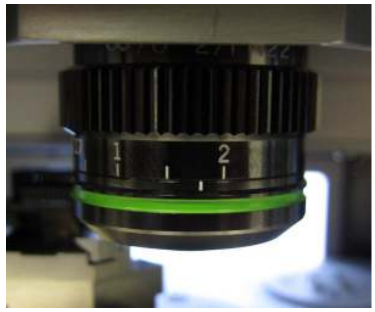
The objective is not user replaceable. The magnification is fixed. Only digital zooming is possible within the software.

Depending on the imaging conditions (air, fluid) a correction collar on the objective must be adjusted. The tutorials in this user guide will always indicate the correct setting. An overview of these various settings is given in the table below.

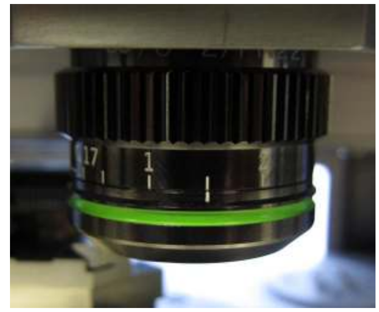
Collar setting	Cypher S Cantilever Holders	Cypher ES Cantilever Holders
0	Any "Air Only" cantilever holder.	Never
1.5	Any "Droplet" cantilever used WITHOUT liquid.	Any cantilever holder used with Gas.
2	Any "Droplet" cantilever holder used WITH water.	Any cantilever holder used with water.



(a) Zero



(b) 2



(c) 1.5

Figure 17.1.: Some examples of correction collar settings.

17.3. View system

The view system protrudes from the top of the AFM enclosure. It contains a software controlled white light source and camera. It also has three user controls. Two levers for adjusting image brightness and contrast, and a focus ring.

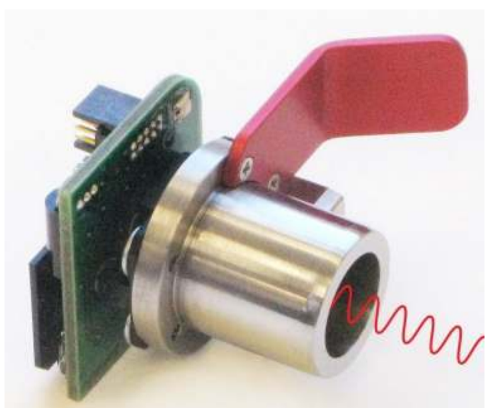
The focus ring is typically set at its detent position, in which case the optical view in the camera is focused in the same plane as the laser spot used to detect cantilever motion, which usually brings the back of the cantilever into focus. In most cases a focused view of the sample, and not the back of the cantilever is desirable. During imaging, use the focus ring on the view system to bring the sample into focus.

During the engage process, the ring should be returned to the neutral (detented) position. A sensor will inform the software if this is not the case and you will be warned before engaging to adjust the view system focus if necessary.

18. Light Tubes (Laser Sources)

CHAPTER REV. 1672, DATED 10/16/2013, 23:04. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents



The following instructions describe exchanging light tube assembly in the Cypher AFM. The light tube can be exchanged without disassembly through the front of the instrument with a little familiarity of the process. For the reason of clarity the instructions describe exchanging the light tube by disassembling the enclosure followed by the process done through the front of the instrument.

18.1. Types of Light Tubes and How to Identify Them

The Cypher can be equipped with interchangeable light sources. Some of the nomenclature:

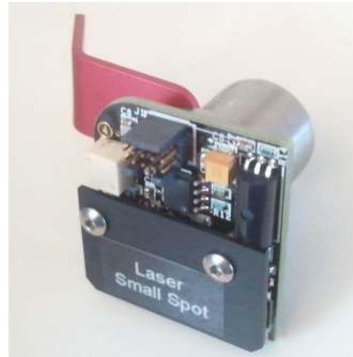
Laser Diodes: Best all around choice for AFM imaging. Lower noise for imaging techniques, but with some interference effects which can lead to background oscillations when performing force curve measurements.

Super Luminescent Diodes: Also known as SLDs. Best all around choice for force curve measurements. Slightly higher noise than the laser diode sources, but remarkably lower oscillating background for force curve work.

Small Spot: 3µm by 9µm spot size. Mandatory for cantilevers smaller than the large spot, to prevent light from spilling over the sides.

Standard Spot: 10µm by 30µm spot size. Preferable for larger (traditional) cantilevers since a spot that fully fills the cantilever leads to lower imaging noise..

Part #	Item Description	Picture
901.601	SLD assembly, standard spot size.	
901.602	SLD assembly, small spot size.	
901.603	Laser Diode assembly, standard spot size.	

Part #	Item Description	Picture
901.604	Laser Diode assembly, small spot size.	

18.2. Tutorial: Light Tube Exchange

As noted at the beginning of this procedure, it is possible to exchange the Light tube without removing the top of the enclosure. It is highly recommended that you first familiarize yourself with the system by removing the top cover once so that you are certain of the location of the components involved.

1. Remove your sample from the scanner.

2. **Lower the cantilever holder:**

   - Rotate the 'Engage Control Knob' on Cypher *counter-clockwise* to lower the tip to a close distance ~1mm) above the top of the scanner. This will allow easy access to the top of the head assembly where the light tube is located.

   Note Although it is not required, for safety reasons we recommend making motor moves with the door closed. Beware of pinch points (Figure 20.1 on page 230).

3. Turn the ARC2 controller power off. This will shut off most of the Cypher's power. It is not necessary to disconnect the motor power supply when exchanging the light tube assembly.

4. **Remove optics cover:**

- Grip the cover at its lower edge and gently pull forward. It is attached magnetically and will detach of smoothly.

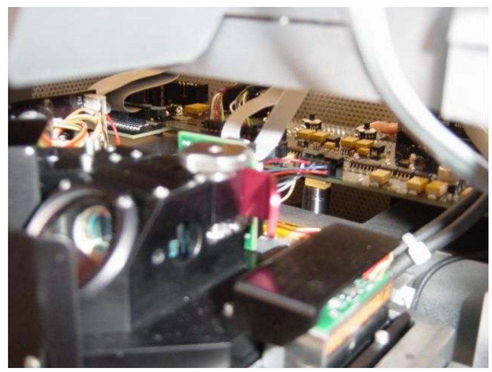
Note This will expose the head assembly and allow access to the light tube from the front.

5. Locate the light tube container for the one you are removing now. You will need to store it properly as soon as it is removed from the SPM.

6. Locate the light tube (hopefully in its container) which you will be installing.

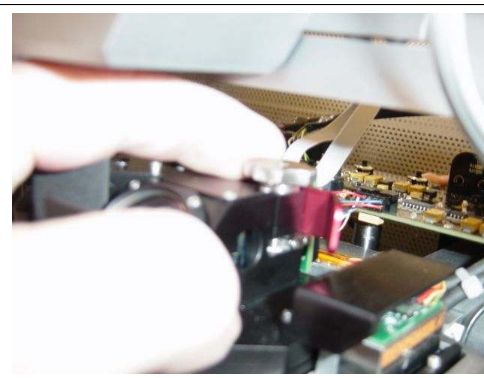
7. **Locate the light tube:**

- Look in the area where you just removed the optics cover.
- The light tube is easily identified by its red handle.
- Above that note the metallic silver cross shaped clamping knob.



8. **Loosen the clamp:**

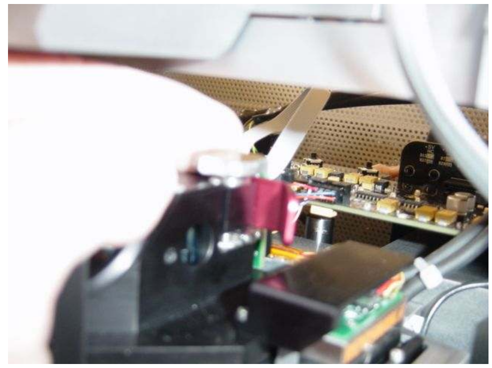
- Turn the clamping knob about ½ turn *counter-clockwise* or until it feels loose.



Redo photo.

9. **Pull the light tube out:**

- Touch a metal part of the SPM instrument to ground yourself.
- Grip the light tube's red handle.
- Gently push straight back. The light tube should slide out very smoothly. If not, further loosen the knob.
- Once the tube clears its cradle, move it to the right and pull it forward and out.



Redo photo.

10. Unplug the power cable.

11. **Store the light tube immediately:**

- Place the light tube in its pink anti static bag (IMPORTANT!)
- Place the bag and light tube inside its plastic enclosure.
- Store in a safe place. The light tube is fragile and can be damaged or knocked out of focus if it is dropped.

12. Connect the new Light Tube to the power cable.
13. Install the light tube (reversing the removal process) into the head making sure that the tube is fully seated. The tab on the left side of the tube will key the rotation of the tube in the head.
14. Tighten the clamping knob to secure the Light Tube.
15. Replace the optics cover (See Step 4 on page 192)
16. Turn theARC2 power back on.
17. Power the system back up and align the laser spot on the cantilever. If you are unsure of this process, follow these steps

    a) Power up the system as described in Chapter 2 on page 10.

    b) Follow the "AC Mode in Air tutorial" (Chapter 4 on page 17) up to Step 12 on page 30.

    c) If the 'Spot On' process does not perfectly center the laser, then please see Section 18.3 on page 194.

18.3. 'Spot On' calibration

A small amount of misalignment in the light spot position is normal after the light tube is exchanged. Great care is taken at the factory to ensure that the "spot on" calibration is correct but due to subtle position shifts in the relationship of the optical components, the light may settle in a new location. Once the light tube is installed and any corrections are made to the calibration, the spot accuracy of the "Spot On" routine is very repeatable. If the "Spot On" software routine appears to misalign the light on the back of the cantilever, it may be for the following reasons:

- The light tube you installed may be clamped in a different position from when it was tested at the factory. With the light tube powered on, loosen and jiggle the light tube to allow it to re-seat in the head. Re-tighten the clamp. If the light moves back to the same (unwanted) location repeatedly then consider recalibration.
- If the light tube was purchased at a later time from when the system was delivered or it was exchanged due to a repair then the "spot on" parameters were calibrated on a different Cypher and small system to system differences make the spot on calibration parameters in the light tube incorrect for your system.

18.3.1. Readjusting the 'Spot On' calibration.

The spot on software routine relies on two parameters stored in the Light Tube calibration information block (info block). These parameters are set at the factory but may need to be changed if the light tube is exchanged.

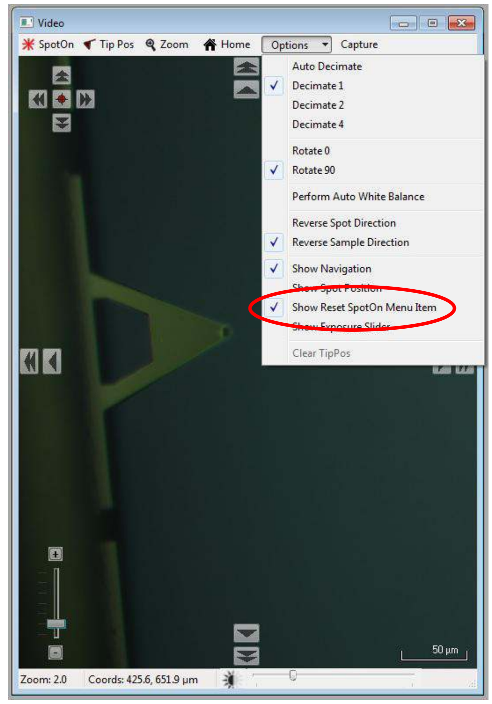
If you find that the Spot On position is still off after re-seating the light tube and allowing it to warm up:

1. Allow the light tube to come to operating temperature. Subtle changes in the relative position of the optical emitter and focusing lenses inside the light tube can occur during warm up after installation. Allow an hour for the light tube to come to thermal equilibrium with the system. You may find that the error in the "Spot On" positioning will reduce. If the Cypher is left powered off for an extended amount of time, i.e. overnight or for a day, you may find that the Spot On position may be off. Allow ample time for the system to reach thermal equilibrium before deciding to make adjustments

2.

Prepare to reset:

- Click on "show reset spot on menu item" in the options pull down selection.



3.

Reset the spot position:

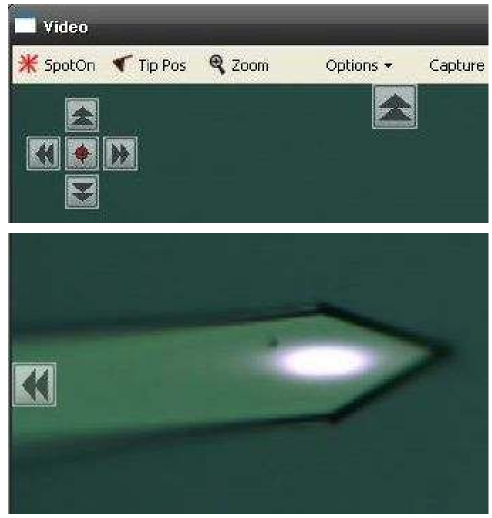
- Zoom in at least once.
- Point the mouse cursor to the center of the laser spot. Right click and click on "reset spot on position".
- The new XY spot centers will be stored in the light tube's infoblock.

Note The photo shows a laser spot which did not quite center onto the cantilever holder, hence the need for the recalibration.

4.

Test 'Spot On':

- Use the arrow markers at the top of the video window to steer the spot off the cantilever.
- Click the Spot On button at the top left of the video window.
- Click in the center of the cantilever and confirm that 'Spot On' is properly calibrated.



From now on this light module should be properly calibrated for use (and re-use) in your Cypher SPM, since each light tube has a small memory element which stores the calibration values.

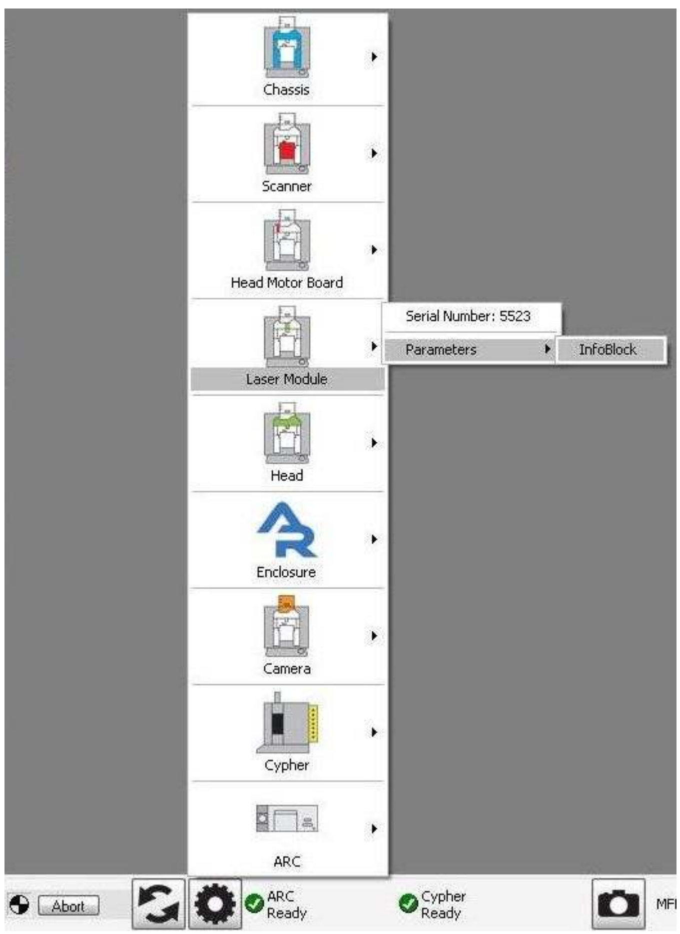


Figure 18.1.: To open the Light Tube (Laser Module) infoblock, click on the "gear" icon at the bottom of the screen, then mouse up to the Laser Module and over to the infoblock. Then release the mouse button.

18.4. Troubleshooting

18.4.1. Accidentally Disconnected Light Tube Cable

Oops! You accidentally pulled too hard on the light tube cable, and it became unplugged from the circuit board inside the AFM. This is fairly harmless, but it will require some work to plug it back in:

- Remove the AFM enclosure top cover
- Plug in the cable
- Replace the AFM top cover.

Please follow the detailed instructions below to get the job done.

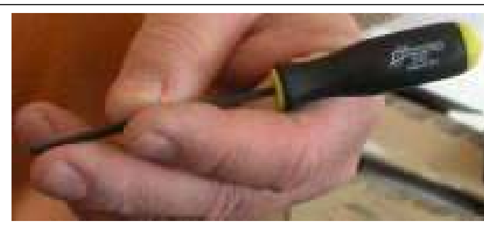
18.4.1.1. Removing the Enclosure Top cover

Warning	The enclosure top is the only thing keeping your Cypher SPM from sliding around inside its enclosure. Be especially careful while removing and replacing the cover and in general any time the cover is missing. The SPM is heavy, but it can slide around. If it does slide around, the electrical connections to the SPM can be dislodged or even damaged.

1. Power down your Cypher by turning off the power to the ARC2 controller.

2. **Locate tools:**

- Locate the 3/32 Hex Driver (part#290.134)



3. **Open enclosure:**

- Lift the door latch and open the enclosure door.

4.

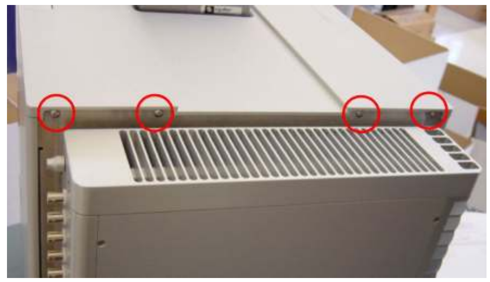
Remove Bracket:

- Take out two screws on the bracket in front of the view system.
- After removing both screws pull this piece out and set aside.

5.

Remove backside screws:

- Remove all 4 screws from back edge of the enclosure top plate. They are visible above the backpack.
  SCREW INFO: 8-32 x ¼ BHCS SS

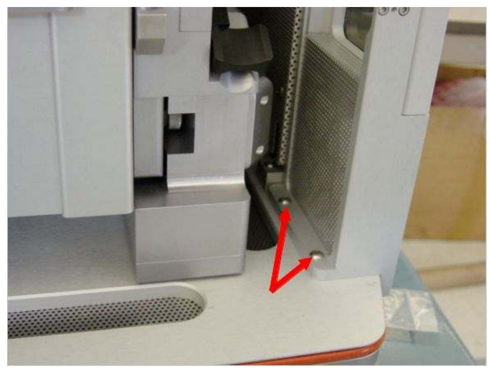


6.

Unscrew right door bottom:

- Unscrew 2 screws in the right door on the bottom and set aside.
  SCREW INFO: 8-32 x ½ BHCS SS

Note: There may only be 1 screw.

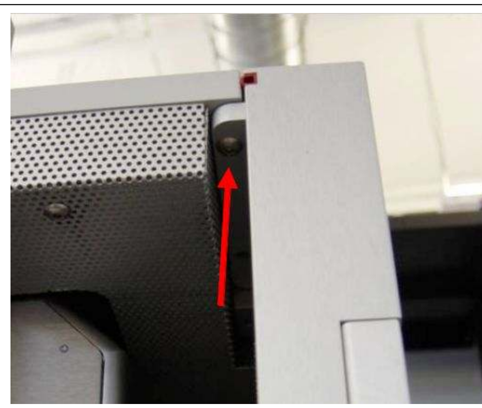


7.

Unscrew right door top:

- Unscrew right door top inside screws and set aside.
  SCREW INFO: 8-32 x ½ BHCS SS.

Note There may only be 1 screw.

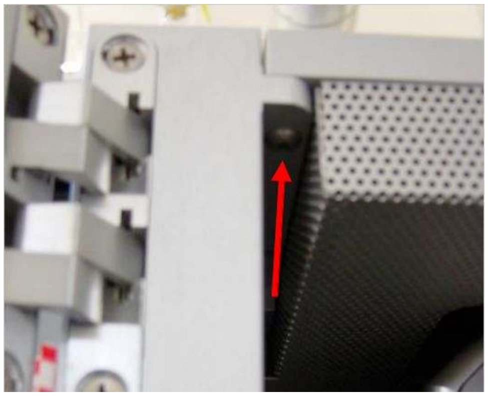


8.

Unscrew right door top:

- Unscrew left door top inside screws and set aside.
  SCREW INFO: 8-32 x ½ BHCS SS.

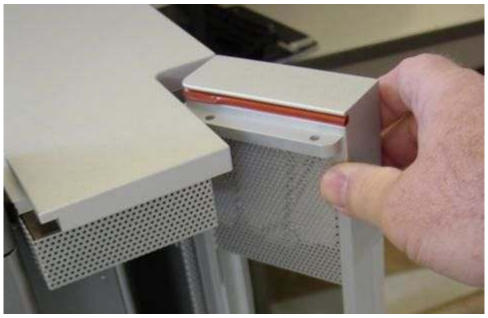
Note There may only be 1 screw.



9.

Open right enclosure door:

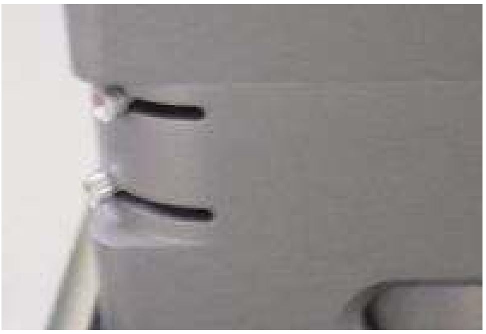
- Fully open the right enclosure door.



10.

Adjust view system sliders:

- Adjust the view system slider controls to their half-way positions. This puts them safely out of way of the top cover.

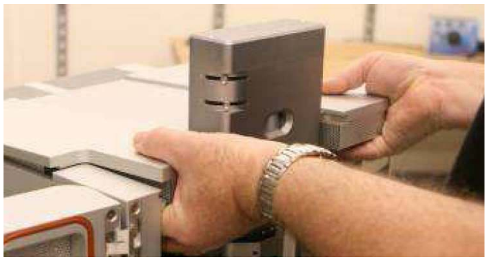


11.

Remove enclosure top:

- Lift upward while wiggling to remove the enclosure top. Set aside.

Note Don't pull forward. The SPM instrument is not secured inside the enclosure and if it moves you may disconnect circuit board connections.

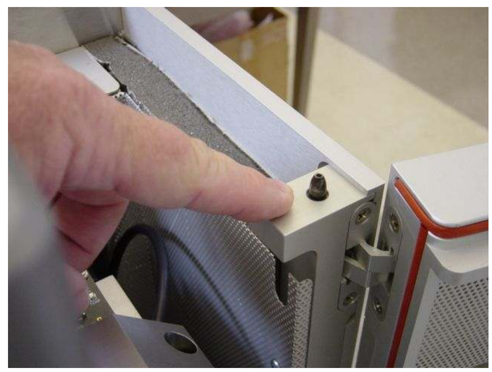


18.4.1.2. Plugging the Light Tube Cable Back in

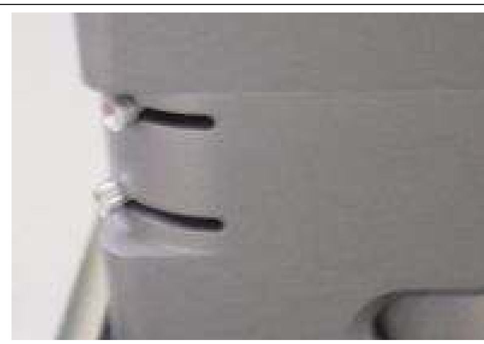
18.4.1.3. Installing the Enclosure Cover

Warning The enclosure top is the only thing keeping your Cypher SPM from sliding around inside its enclosure. Be especially careful while removing and replacing the cover and in general any time the cover is missing. The SPM is heavy, but it can slide around. If it does slide around, the electrical connections to the SPM can be dislodged or even damaged.

1. Make sure the right door is still open.
2. **Note alignment pins:**
   - Note the pins which help the top cover align and finds its proper place.
   - When the top cover is removed, the weight of the doors can bend the enclosure's vertical support outward. When the cover is pressed in place, these pins will pull everything back into alignment.



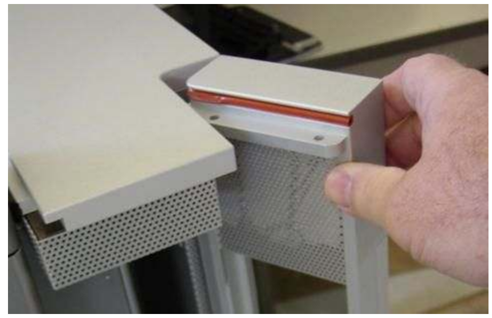
3. **Adjust view system sliders:**
   - Adjust the view system slider controls to their half-way positions. This puts them safely out of way of the top cover.



4. First Lower the **rear** of the top cover down to fit it into the enclosure.
5. Then Lower the front of the top cover down and fit it onto the two alignment pins.
6. Adjust the position of the cover until it fits on the enclosure without any force applied.

7. **Close right enclosure door:**

- Close the right enclosure door.
- While pressing it firmly closed to compress the rubber seal, install the two screws at bottom of the door. These screws were removed in Step 6 on page 199.



8. Install the upper screw on the right hand door (removed in Step 7 on page 199).
9. Install the upper screw on the left hand door (removed in Step 8 on page 199).
10. Install the four rear screws (removed in Step 5 on page 199) into the top cover.
11. **Replace View System bracket:**

- Replace the bracket in front of the view system.
- Tighten the screws.

19. Air Temperature Controller (ATC)

CHAPTER REV. 1658, DATED 10/07/2013, 20:47. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

19.1. Overview

This chapter covers the installation and operation of the Cypher ATC (Air Temperature Controller).

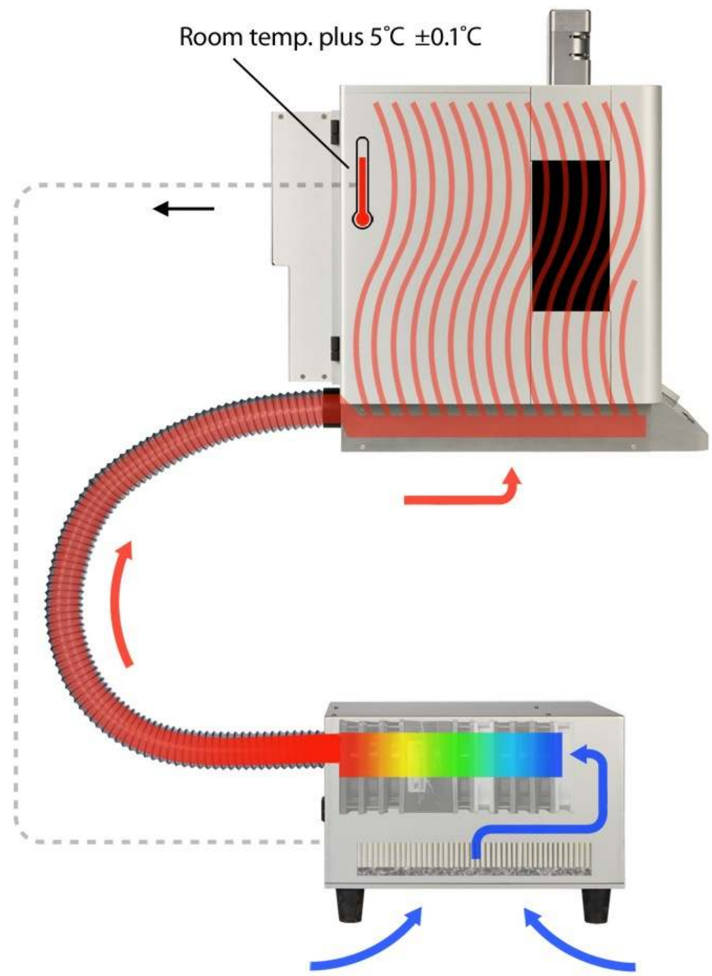


Figure 19.1.: Basic Diagram of ATC airflow. Cool lab air enters via a HEPA filter at the bottom of the Cypher ATC and then passes through fans and heater coils and travels via corrugated hose to the Cypher enclosure. Temperature signals travel from the Cypher back to the ATC (dotted line). Air exits the Cypher from the bottom rear.

If the temperature of your laboratory varies by more than a few tenths of a degree over time (almost all labs do), your SPM images may be suffering from distortion due to differential thermal expansion and contraction of the entire instrument. The Cypher ATC can improve the situation by gently forcing filtered temperature controlled air through the AFM enclosure.

The Cypher ATC is a box containing a heater/fan sub-assembly and an electronics board for controlling the amount of heat generated and the volume of air flowing into the Cypher SPM enclosure. The interior temperature of the Cypher enclosure is regulated by a software driven feedback loop that controls the ATC system's heater to maintain the temperature of a thermal sensor located on the back of the Cypher SPM chassis.

The temperature in typical labs will vary by a few degrees during the course of the day, often oscillating due to the turning on and off of air conditioning. The ATC will counter these temperature swings by adding more of less heat to counteract these temperature swings. Since the ATC can only add heat, the temperature setpoint must be set above the maximum temperature swing of the laboratory, typically 2-5

C above the average room temperature.

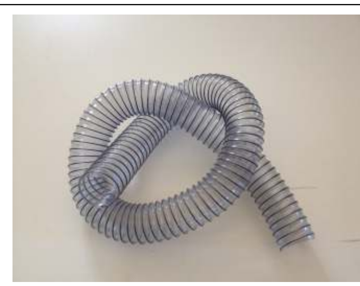
The ATC is not designed as an environmental controller to drive the working temperature of the sample.

19.1.1. Good Practices

To get the most out of your Air Temperature Controller, please follow these guidelines (even if you don't own an ATC, they will improve your imaging stability):

- A laboratory with decent temperature control will always lead to improved imaging stability. Typically a windowless room with air conditioning operating at all times is preferred.
- Do not place your Cypher AFM in strong air currents, such as from an air conditioning vent. If you have no choice, fashion some sort of air deflector panel.
- It can take between 6 and 12 hours for all the metal and components of the cypher AFM to thermally stabilize. Therefore the best approach is to always leave the Cypher AFM turned on and the ATC regulating the instrument temperature. If you wish you can turn off the laser at night to extend its lifetime, but note that there may still be a period of thermal drift even from turning on the laser.
- Keep the enclosure door closed as much as possible. Only open it briefly when exchanging samples or cantilevers.
- Keep critical items, such as spare cantilever holders, somewhere inside the Cypher enclosure. This will ensure all parts are at the same temperature. Some people also leave the cantilever holder changing station (see Step 9 on page 21) inside the enclosure to prevent the cantilever holder from cooling down during tip exchange. Needless to say, work quickly when replacing tips.

19.2. Parts List

Itm	Part #	Item Description	Qty	Picture
1	901.901.1	ATC Unit.	1	
2	330.002	Air Hose.	1	

Itm	Part #	Item Description	Qty	Picture
3	113.407	Hose Fitting.	1	
4	279.066	Hose Clamp.	1	
5	409.002	AC power Cable.	1	
6	449.025	ATC Control Cable.	1	
7	448.088	Auxiliary Temperature Sensor.	1	
8	290.118	5/64” Hex wrench.	1	

19.3. Hardware Setup

19.3.1. Power requirements

The ATC has a fixed power input for use with either 100/120VAC or 220/240VAC. In all cases the power should be single phase power where the mains supply has a load and neutral line in addition to an earth ground.

During normal ATC operation the voltage on the load line is “chopped” with a circuit to supply pulses of current to the heater coils in order to vary the amount of heat generated. The return path of the current from the heater flows to the neutral line which is essentially at 0V relative to earth ground. The chopping circuit is only on the load line and cannot operate correctly with 2 phase power.

The ATC has built-in sensors on both the load and neutral lines to monitor their condition. If the sensor on the neutral line detect a voltage higher than 10VAC, the system will detect a fault state and the software will display an error message indicating that 2 phase power is present.

Please consult your facilities personnel to establish weather or not you have the proper supply voltage in you lab.

19.3.2. Connect the ATC air hose

The hose feeding the ATC air connects to a fitting on the lower half of the enclosure. If the ATC was purchased with the Cypher, the fitting will be attached. If the ATC was a separate purchase after the Cypher, the fitting will need to be attached using the following instructions.

1. Shut the ARC2 controller power off.

2. **Disconnect Cypher cables:** Disconnect:
   - The Motor Power
   - The Main controller cable
   - The USB cable
   - The Fire wire cable

   Note For ease of installation only. If you have unobstructed access to the back of the Cypher then you may choose to leave the cables connected.

3. Position the Cypher so you have access to the back of the enclosure.

4. **Remove cover:** The air inlets and outlets need to be uncovered.
   - Locate the 5/64” hex wrench.
   - Remove the six screws holding the cover onto the enclosure
   - Remove the cover and save with the other Cypher accessories

5. **Install the air inlet fitting:**

- Insert the fitting into the hole in the enclosure. The end with the short flange goes in the hole.
- Secure the fitting onto the enclosure using four of the screws you removed with the cover.

6. **Install the air hose:**

- Adjust the hose clamp so it fits loosely over the hose.
- Slide the hose clamp onto the hose.
- Push the air hose over the fitting on the enclosure.
- Tighten the hose clamp to secure the hose to the enclosure.

7. **Connect the air hose to the ATC:**

- Place the ATC on the floor below the table under the Cypher.
- Move the Cypher back to its normal location.
- Route the air hose over the edge of the table and down to the ATC.
- Push the hose into the exhaust hole on the back of the ATC. Start by guiding the end of the spiral wire inside the hose into the hole. Gently push the hose and allow the wire to go into the hole on the ATC until about 1 to 1 1/2 turns of the wire is inside the ATC.

Note You may need to install the ATC next to the Cypher if your instrument position does not allow you to have the ATC on the floor. Be aware that the ATC has two small fans which can possibly induce vibration into the system.

19.3.3. Connect the ATC

1.

Connect the ATC control cable:

- Connect the cable to the connection labeled ATC on the backpack.
- Route the cable over the table and down to the ATC unit.
- Connect the ATC Control cable to the ATC.

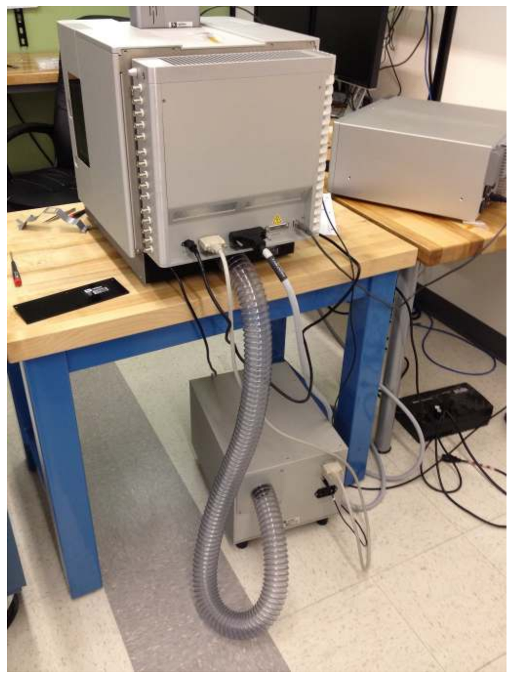
2. Connect the AC power cord to the ATC and plug it into wall power.

3.

Reconnect the Cypher cables: Reconnect:

- The Motor Power
- The Main controller cable
- The USB cable
- The Fire wire cable

The final result is shown in the photo to the right.



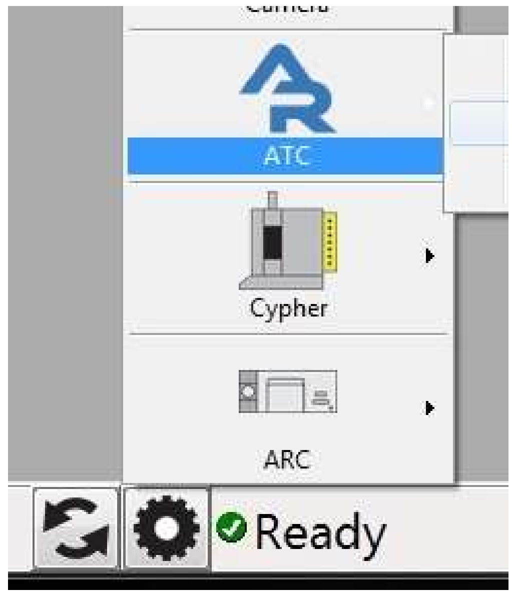
4.

Plug in remote temperature sensor:

- As shown to the right, connect the auxiliary temperature sensor.
- Locate the sensing end in a place where it is sampling the room temperature. Choose a location away from warm instrument enclosures or plumes of warm instrument exhaust air.

19.3.4. Power-up and Software Initialization

1. Turn the ATC power on.
2. Turn the ARC2 controller on.
3. Re-Start the AR SPM software and home the Cypher motors.
4. **Check connectivity:**
   - In the status bar of the software, click on the “gear” icon and confirm that the ATC is indeed in the list of attached instruments. If not, please check all the cable connections and click on the “recycle arrows” and then the “gear” again.



19.4. Operation

With the ATC connected and software running, from the main menu bar select *AFM controls* ▷ *ATC* to open the ATC control panel. The control panel is broken into sections containing controls grouped together based on function. Like all the other control panels in the software, a detailed explanation for each menu item can be seen by clicking on the “?” button to the right of the item of interest.

The ATC control panel (Figure 19.2 on page 211) allows you to control every aspect of ATC operation. allow the user to adjust the conditions for both heating and air flow. There are two basic mode settings:

Manual Temperature control feedback operates based on values typed into the ATC panel. When the AR SPM software is exited or restarted, temperature control quits. This mode is typically used for the first few days when optimal parameters are being determined. Once these parameters are saved into ATC firmware, auto mode will likely become the typical ATC setting.

Auto The ATC operates autonomously based on values stored in its firmware. It will continue operating as long as the ARC2 controller is turned on, regardless of what the software is doing. This will likely be the typical mode of ATC operation.

Please read on for more details.

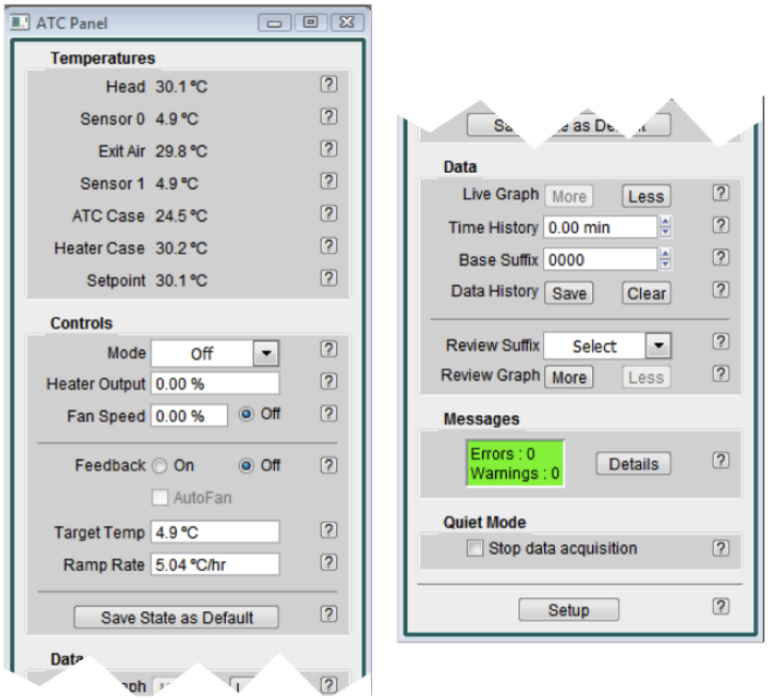
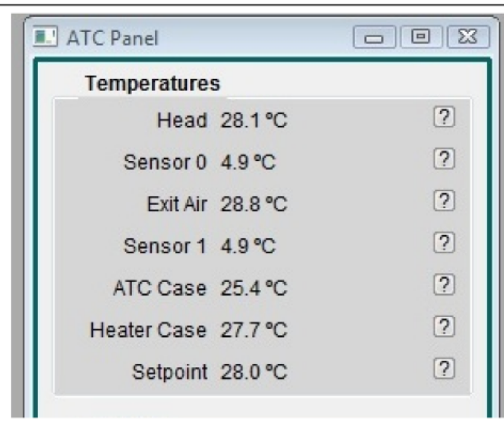


Figure 19.2.: Typical View of the ATC control panel.

19.4.1. Manual Control

1. **Note the room temperature:**
   - From the ATC control panel, note the 'sensor 0' temperature. This is the room temperature based the external sensor connected in Step 4 on page 209.

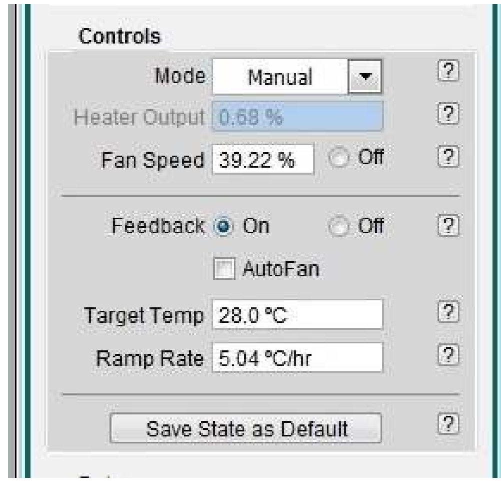


2.

Choosing the temperature setpoint:

- Make sure the feedback is set to off.
- Make sure the mode is set to manual.
- Set the 'Target Temp' to ~3 degrees C above the room temperature recorded in the previous step.
- Check that the ramp rate is 5C/sec and change if necessary.

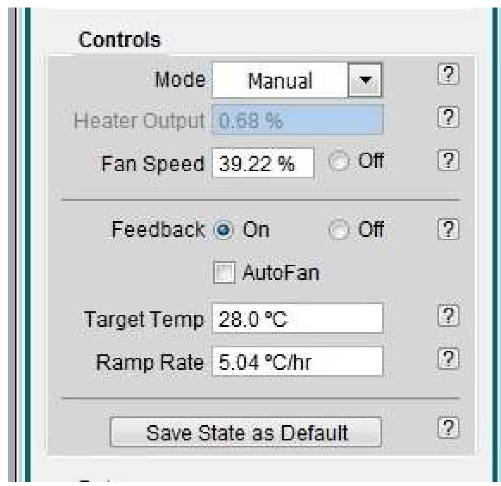
Note Target Temp is the temperature setpoint for the ATC temperature feedback control.



3.

Set fan speed:

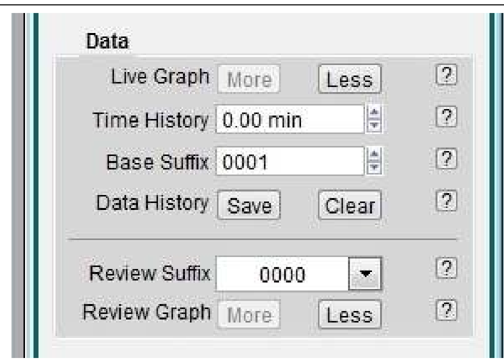
- Start with a fan speed of 100%.
- If you find imaging artifacts related to the fan, consider lowering the speed.



4.

Display datalogging: It's important to be aware of how well the temperature feedback is operating so you should get used to monitoring the temperature data history:

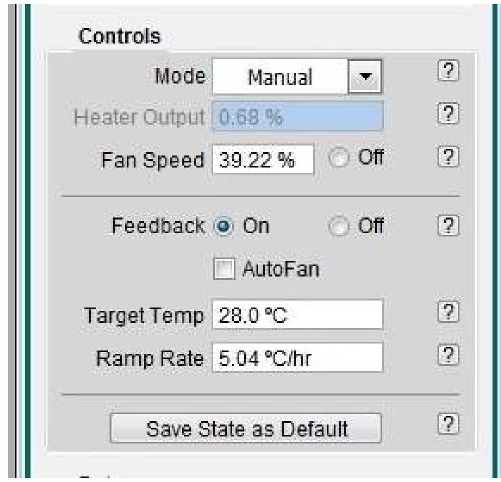
- Live graph - Click on the 'More' button once to display the graph. Click on the 'More' button multiple times to add sensors to the data plotted.
- For more information on datalogging, please see Section 19.7 on page 217.



Note Even if you don't display the data, it is logged nonetheless for later inspection.

5. **Turn the feedback on:**

- Click the feedback control to ON.
- Over the next hours observe the heater power variation and the head temperature converging on the temperature setpoint.
- A properly operating system will apply between 5% and 15% heater power to keep the head temperature within 0.1C of the setpoint.



19.4.2. Further Description of ATC Controls

Heater Output This controls the amount of power provided to the heating coils. The power can be adjusted to 50% power. Typically the amount of power required to maintain temperature stability is under 5%. Although not recommended, you can use this control to briefly send a burst of hot air into the enclosure to accelerate initial warm up time.

Fan Speed Has a range of 0% to 100% and is variable from 39-100%. In cases where you are scanning near atomically flat surfaces, you may see periodic noise from the fans. Reducing the fan speed will eliminate this but be aware that you need to circulate air through the Cypher in order to maintain thermal stability. In most cases, reducing the speed to 39% for a few hours will not be a problem as long as the lab temperature is sufficiently below the Target Temperature. Noise levels from the fans at 39% show negligible to no effect on the Cypher's performance.

Feedback On/Off. Enables the feedback loop which controls the heater power to maintain a constant head sensor temperature.

Target Temp. The final temperature to be maintained by the feedback loop.

Ramp Rate Rate at which the ATC adjusts the current Setpoint Temperature to achieve the Target Temp.

Note The Setpoint Temperature is located the Temperatures display area. This is a transition temperature based on the ramp rate parameter changing the feedback loop's current operating point to the Target Temp

19.4.3. Explanation of Temperature Sensors

There are three temperature sensors located inside the ATC that are primarily used to monitor the operating temperature of the unit while it's being used.

ATC Case This sensor is attached to the inside wall of the ATC box. It is used to monitor the incoming air from the room which is essentially the room temperature.

Heater Case This is a sensor mounted directly on the portion of the heater/ fan assembly containing the heating coils. Typically used for diagnostic purposes in case of overheating.

Exit Air This sensor is mounted directly in the path of the outgoing air just inside the hole where the air hose is connected to the ATC. Used for diagnostic purposes.

Head Temperature This sensor is located on the back of the Cypher Chassis about 1 inch above the rear air vent in the enclosure floor. This sensor is used by the ATC as the primary feedback source. Its location allows the sensor to be shielded from abrupt thermal changes when the door is opened.

Sensor 0 Input connection on the outside of the ATC unit. For auxiliary use.

Sensor 1 Second input connection on the outside of the ATC unit. For auxiliary use.

The ATC is shipped with 1 remote temperature sensor. This sensor can be used as the feedback sensor or to simply monitor some specific place in your setup, or, as suggested above, to monitor room temperature.

The ATC Case sensor is a reasonable second choice indicator of the lab temperature if you have are using the auxiliary sensor (see Step 4 on page 209) for another purpose.

19.4.4. Automatic Operation

After a few days of data logging you will have characterized the temperature swings in your laboratory and will have chosen an ATC temperature setpoint which is a few degrees above the maximum daily room temperature.

Tip	Your goal is to run the Cypher AFM as cool as possible since this minimizes thermal shock to the instrument when the door is opened. Ideally you choose this setpoint so that the ATC is producing heat at about the 5% level when the room temperature is maximum.

Now is a good time to store the values of the ATC panel in the firmware of the ATC unit itself with the following single step:

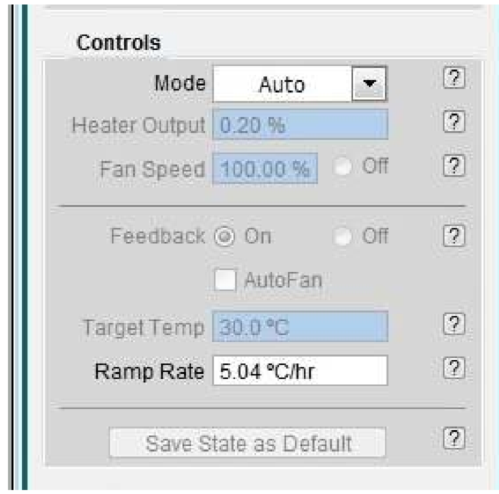
1. Under the 'controls' section of the *ATC Panel*, click on the 'Save State as Default' button.

Setting the ATC to automatic mode is also easy:

1.

Setting the mode to Auto:

- From the ‘Mode’ pulldown in the ATC Panel, select ‘Auto’.
- You will notice that some values will become “grayed out” since they are now controlled by values stored in the ATC firmware.



During operation, the ATC feedback will be maintained as long as the power to the ARC2 controller and ATC unit are left on. Exiting the software will not interrupt the ATC operation.

19.5. Enclosure Door Function

When the enclosure door is open, the ATC cannot realistically attempt to control the temperature inside the Cypher enclosure. Therefore the ATC senses the opening of the door and temporarily freezes the feedback process but keeps the fans running and also keeps the air heater power at the same level when the door opened.

Once the door is closed again (we urge you do this quickly, see Section 19.1.1 on page 205) the air keeps blowing for about a minute and then the feedback automatically resumes. You will see the LEDs on the front of the ATC change colors while this is happening. More on the LEDs in the next section.

19.6. ATC Front Panel LEDs

The LEDs on the front of the ATC unit provide a basic visual cue regrading the condition of the system.

Summary	If all three lights are green, the ATC is functioning properly and attempting to control the temperature inside the Cypher enclosure. For any other combination of colors, please read further.

ATC temperature control OFF: The ATC power is on, the Cypher enclosure door is closed and the ATC Feedback is OFF.

- This is a normal condition until the feedback is activated in the software.

Normal Operation, ATC ON, and controlling temperature. The ATC is on, The door is closed and the ATC Feedback is ON.

- Normal condition where the system should be.

Note If the ATC was just activated, the lights do not indicate if stable feedback has been reached.

Feedback ON, but door open: The ATC is on, the door is OPEN and the ATC feedback loop is in Standby mode.

- This is a typical condition when the Cypher door is opened during use.
- When the door is opened, the feedback loop is paused and the software holds the fan and heater power steady. Feedback resumes a few minutes after the door is closed again.

Note Be aware that the longer you keep the door open the more unstable the interior will become due to heat loss. It is good practice to open the enclosure door only long enough to remove the cantilever holder or exchange samples in the instrument.

Note Close the door when exchanging the tip in the cantilever holder or when you are prepping a sample.

Door just closed, but feedback still on hold: The ATC power is on, the door is CLOSED and the ATC Feedback is in Standby mode.

- The is a typical condition when the Cypher door is opened and closed.
- The Feedback loop will stay in standby mode for an additional 30 seconds and then reactivate automatically, turning all three lights to green again.

19.7. Data Logging

The data logging area allows you to monitor the temperature sensors as well as the fan speed and heater power over time. You already encountered it in 4 and we'll follow up here with some more detail.

Please refer to the data section of the ATC panel (see Figure 19.2 on page 211).

Live graph Click on the 'More' button once to display the graph. Click on the 'More' button multiple times to add sensors to the data plotted.

Data History Click on the 'Save' button to capture the history of the data.

- The data history is saved with the experiment. To review the data click on the pull down arrow attached to the 'review suffix' menu item. Select the particular data set you wish to review and hit the 'more' button to load the data into a graph.

Clear Erases the data in the graph and restarts the data acquisition. Be sure to use the 'Save' button first or those data will be lost.

Note Remember to click on the '?' button to the right of any menu item for a description of its function.

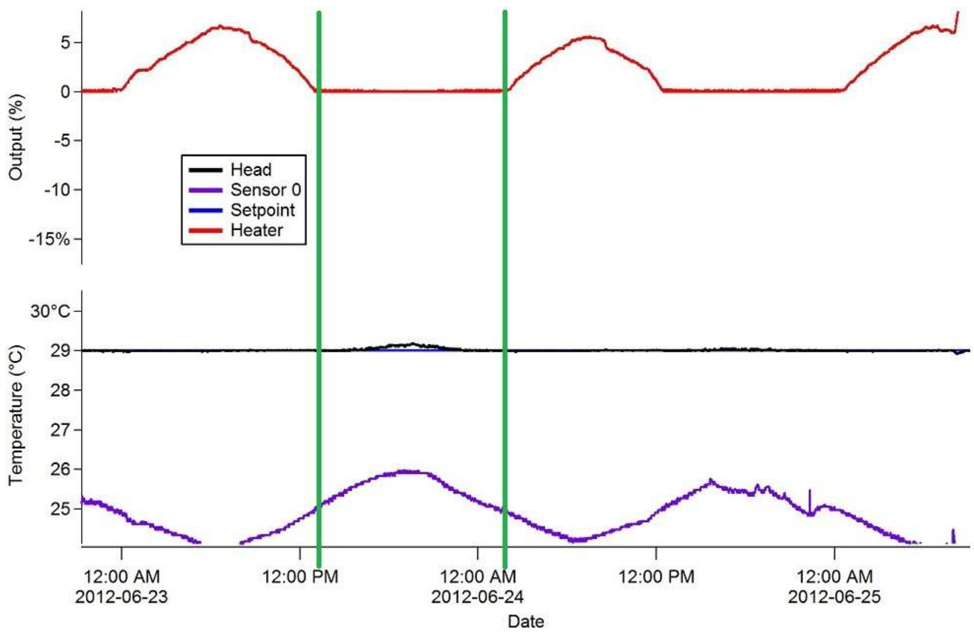


Figure 19.3.: Sample Data Log

Some example logged data are shown in Figure 19.3 on page 218. These particular data log shows an ATC unit under feedback set for 29 degrees C. The fan was set to 100%

Notice:

- The data between the green lines. The feedback loop has shut the heater power off. The Cypher was already warmed up so all that needed to happen was for the fan to cool the head sensor down. At this point the ambient temperature is rising high enough so that the fans can not cool the enclosure temperature down to maintain 29 degrees. This is indicated by the head temperature increasing above the Target Temperature

Note This is an example where the Target Temperature should be raised a degree to allow the ATC to regulate the enclosure air temperature better. Ideally the target temperature is set so that the ATC never applies 0% power. That means when your lab is at its maximum daily temperature swing, that the heater is still able to control temperature.

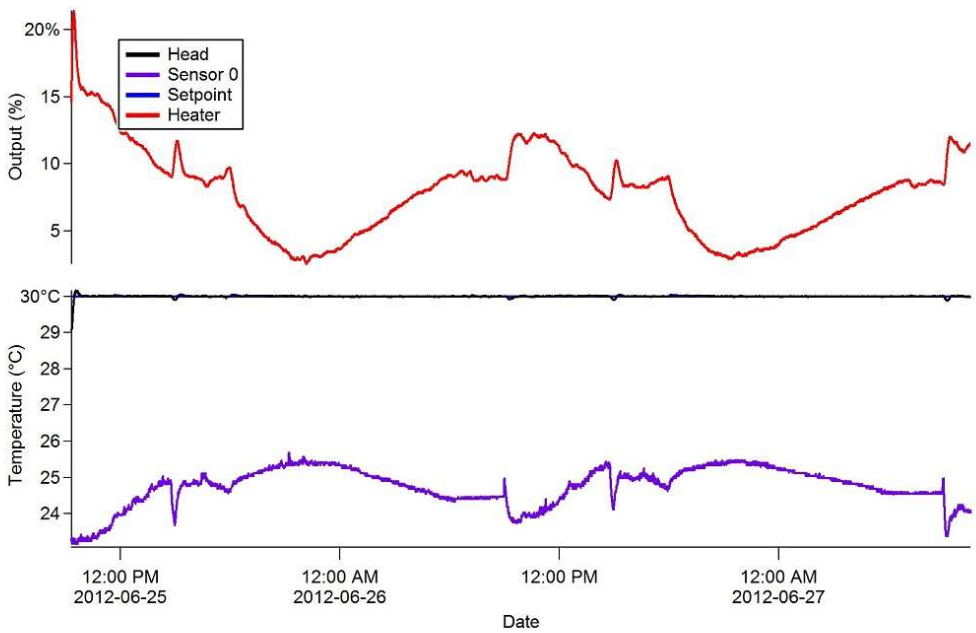


Figure 19.4.: Sample Data Log

This is an example of the ATC running with the Target Temperature set to 30 degrees C.

Notice:

- The head temperature is now equal to the target temperature.
- The heater power is between 2 and 15%. The ATC fan is still at 100% so air flow is constant.

Note This is an example where the Target temperature is set high enough above the room temperature to allow the head temperature to remain constant.

19.8. Using the Remote Temperature Sensor

19.8.1. Inserting the Sensor Inside the Cypher Enclosure

Step 4 on page 209 already suggested using the remote sensor for measuring room temperature, but there are other uses.

The Remote Temperature Sensor can be used to monitor the temperature of a particular location inside the Cypher enclosure and can even be used as a feedback source for the ATC.

1. Turn off the power to the ARC2 controller and the ATC box.

2. **Connecting the Sensor** Plug the remote temperature sensor into either Sensor input connector on the back of the ATC unit.

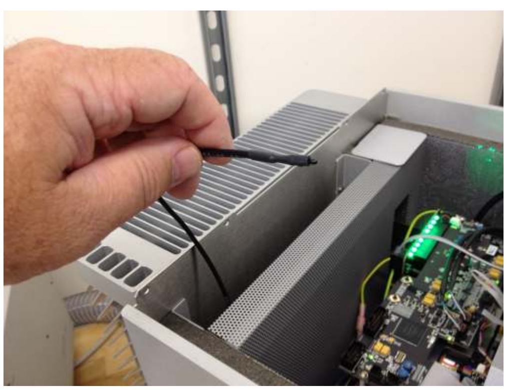
   - The temperature will displayed on the corresponding sensor channel in the ATC control window.
   - Hold the sensor between your fingers and watch the temperature rise as a test.
   - Log the sensor data in the data logger as an additional channel.

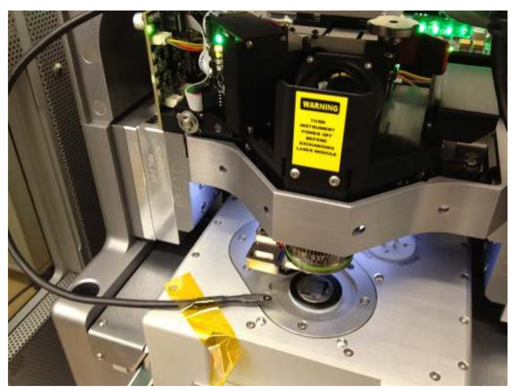
   Note Additional sensors can be purchased from Asylum Research.

3. Remove the top of your Cypher enclosure by following these instructions: Section 21.4.2 on page 242.

4. **Insert Sensor inside the Cypher enclosure:**

   - Insert the sensor into the exhaust port on the back of the enclosure.
   - Pull the sensor cable up through the space in the back of the enclosure.
   - Locate and secure the sensor in the position you wish to monitor.



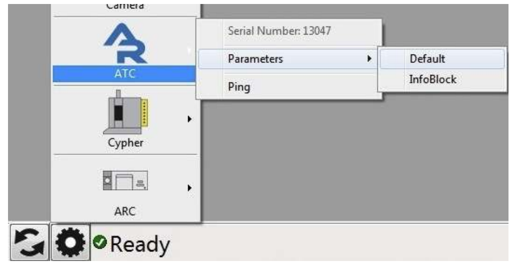


5. Replace the top of the enclosure. See Section 18.4.1.3 on page 201.
6. Turn the ARC2 and ATC power back on.
7. You can now monitor the sensor from the ATC control panel or its data logging function.

19.8.2. Using the remote sensor for temperature feedback control

1. **Open the ATC default parameter window:**

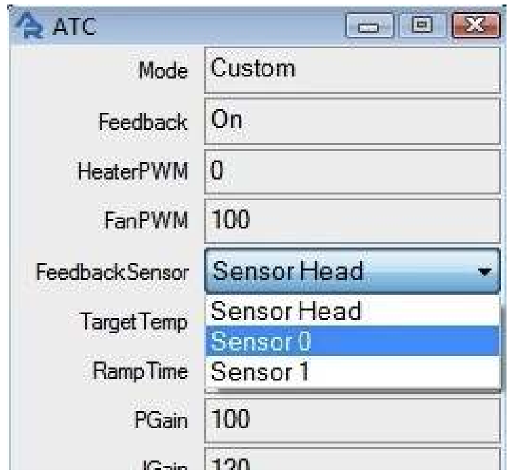
- Click on the device list (Gear Icon).
- Select *ATC* ▷ *Parameters* ▷ *Default*.



2. **Select the feedback sensor:**

- Change the feedback sensor to the sensor input channel you are using.
- Set the change by clicking on the 'Write' button.

NOTE: This will change the feedback sensor temporarily. The software will default to the Head Sensor when you exit the software.



19.8.3. Permanently assigning feedback control to the remote sensor

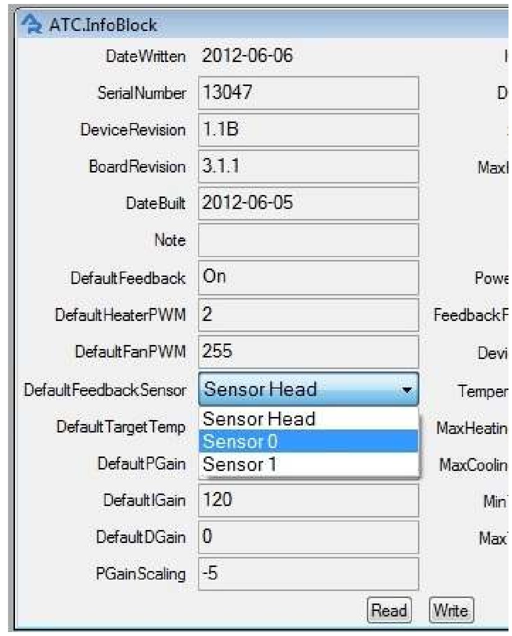
NOTE: This change is not advised in a multi-user facility or for long term use. If you feel strongly that the location of the standard head feedback sensor should be different, it can be relocated. The sensor is on a 12" cable and can be moved or a replacement sensor can be purchased and substituted leaving the original one in place. Please contact Asylum Research for additional information.

1. **Open the ATC default parameter window:**

- Click on the device list (Gear Icon).
- Select *ATC* ▷ *Parameters* ▷ *InfoBlock*.

2. **Permanently select the remote feedback sensor:**

- Change the feedback sensor to the appropriate input channel.
- Click on Write to save the change.
- Rescan the smart start bus by clicking on the blue spiral button or close and open the software.



19.9. Error messages

19.9.1. ATC Messages

The **messages** area on the ATC control panel (see Figure 19.2 on page 211) shows the current operating state of the ATC. The window is typically green indicating normal operation with no errors. If an error occurs, the message box will turn red. Clicking on the 'Details' button will pop up a window with a description of the error.

19.9.2. Critical Error messages

Any time a critical error is generated, the ATC will go into a state where all heating capability is disabled. A critical error requires that a service technician reset the system. In the event of a critical error, please contact Asylum Research for assistance. A report log is generated by the system computer which can be sent to us to help diagnose the reason for the error. Please go to: my documents\asylumresearch\devices\ATC. In the ATC folder you will see a file called ERRORDUMP.PXP. If there is more than one error dump file, please send us the newest one along with a brief description of any events that may be helpful in troubleshooting the problem.

19.9.2.1. Error: Overheating

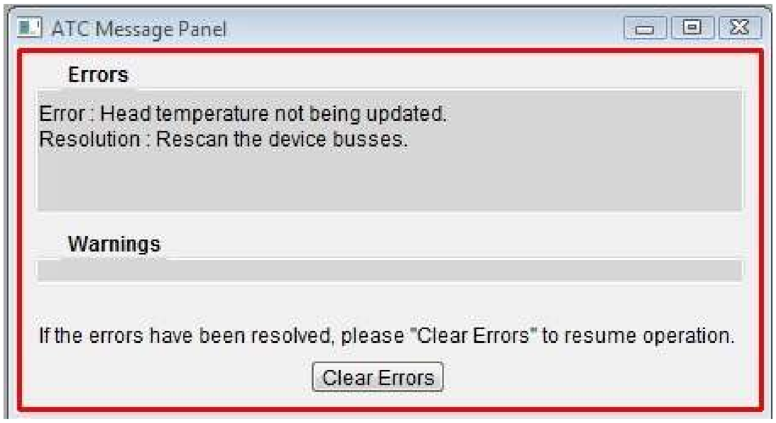
This error is the result of the ATC overheating internally which has caused one of the two thermal switches to trip. A high pitched audible alarm will also sound. The possible reasons for this error to happen can be:

- The Heater power is set too high for too long in the manual mode. This will cause the heater case to overheat and trip its safety switch. To avoid this, do not drive the heater power at max power for more than a minute or keep the heater case temperature below 50C
- The exit air is too hot causing the thermal switch in the exit air to trip. It is possible to run the heater at max power with the fan set to 100% for a longer period of time. This will keep the heater case cool but will generate too much hot air and will over heat the heater hose. The exit air switch trips at about 70C.
- The door on the enclosure is not latched completely. If the door is left ajar, it may be closed enough to keep the door detection switch closed. This essentially allows the air to escape and forces the ATC to ramp up the heat to try to compensate for the heat loss.
- The ATC air hose has fallen off or is disconnected. Same situation as above. The interior of the Cypher enclosure is cooling down while the ATC continues to heat up trying to compensate.

19.9.3. Noncritical Error messages

Noncritical error messages indicate a problem with the setup and can be cleared after the fault is corrected. After the error is cleared, the message box will turn green and full function of the ATC is restored.

19.9.3.1. Error: Head Temperature Not Updating

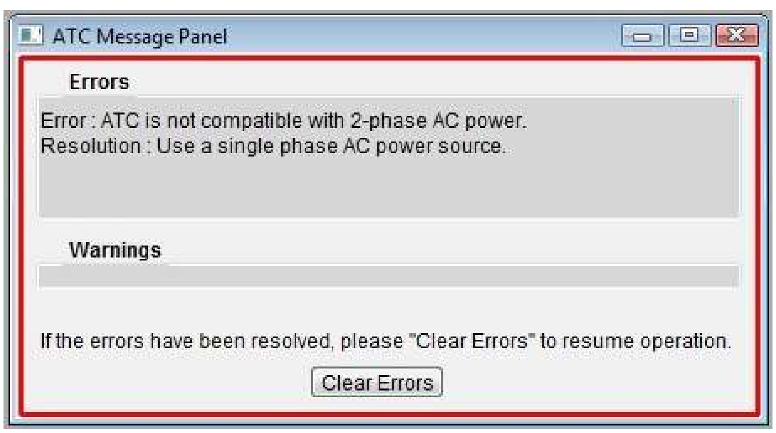


This error is caused by the Feedback Sensor (Head Sensor) not being read. The possible causes can be:

- The ATC power was shut off for more than a minute while the software was running.
- A change was made to the ATC's infoblock programming.
- The software was started with the ATC off and then the ATC power was turned on.

Note Click on the blue spiral button to the left of the device list. This will rescan the smart start bus. Alternately, you can power cycle the ARC2 controller to force a smart start rescan. Finally you can exit and reenter the software.

19.9.3.2. Error: Reverse AC Power Polarity



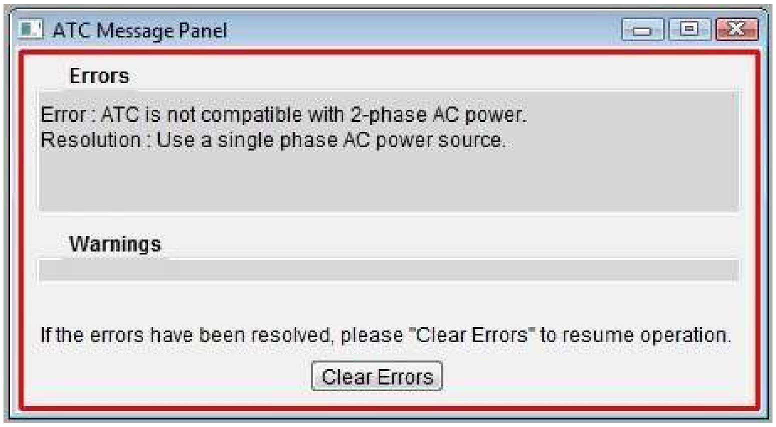
This error is caused by faulty wiring in the wall receptacle.

Usually only happens on new installations or if you've relocated the instrument to a new location.

Reverse plug on non-polarized receptacles.

Note Contact your facilities personnel to confirm correct wiring exists. Once repaired you can clear the error.

19.9.3.3. Error: 2 Phase Power



The ATC requires single phase power. This error is typically caused by the wrong type of wall power or:

- The earth ground connection may be faulty
- There is current flowing in the neutral power line which may indicate a disconnected neutral line and the return path is though the earth ground connection.

Note Contact your facilities personnel to confirm correct wiring exists. Once repaired you can clear the error.

19.10. Alarms

The ATC has two thermal switches that will trip an audible alarm when their respective temperature is reached. The alarm is an indication that an unsafe temperature has been reached inside the ATC. This condition will generate a critical error to display in the status box and cause the ATC to go into a disabled state until the error is cleared by a factory service technician.

In the event that the alarm sounds and the ATC does not shut the heater power off, an additional thermal switch on the main AC power will activate turning the unit completely off. This switch will reset after the ATC has cooled down but will reactivate if the unit continues to overheat.

Part V

Safety, Specifications, Set-up, and Shipping

Who is this part for? Every new user should read the safety section at least one. If you need to move your AFM or ship it to Asylum Research for any reason, please consult this manual. Beyond that, this portion of the manual will probably not see much day to day use.

Part Contents

20. Safety Precautions

CHAPTER REV. 1659, DATED 10/07/2013, 22:54.   USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

During normal use, the Cypher SPM poses no harm to the operator. Nevertheless, there are potential dangers in and around the instrument. Please read this section carefully to understand where the potential dangers lie before attempting to use the Cypher.

20.1. Motor Safety

The Cypher SPM contains six motors which direct the laser beam and move the objective lens and cantilever holder into position. All the motors are highly geared and can generate powerful torques that could seriously pinch a finger. The most important moving parts to be aware of, from a safety perspective, are the cantilever holder and the objective lens, along with its carriage. Always keep your hands clear of the Cypher when performing any software or manually controlled motor moves.

20.1.1. Avoiding unsafe situations

- Familiarize yourself with potential pinch points. Figure 20.1 on page 230 indicates the areas of concern: directly under the objective lens and cantilever holder, at the edges of the scanner module, and both above and below the two cross-roller bearing stages.
- It is advisable to always leave the optics cover in place. Removing it will expose additional areas where one could get pinched.

- Operate motors only with the enclosure door closed.

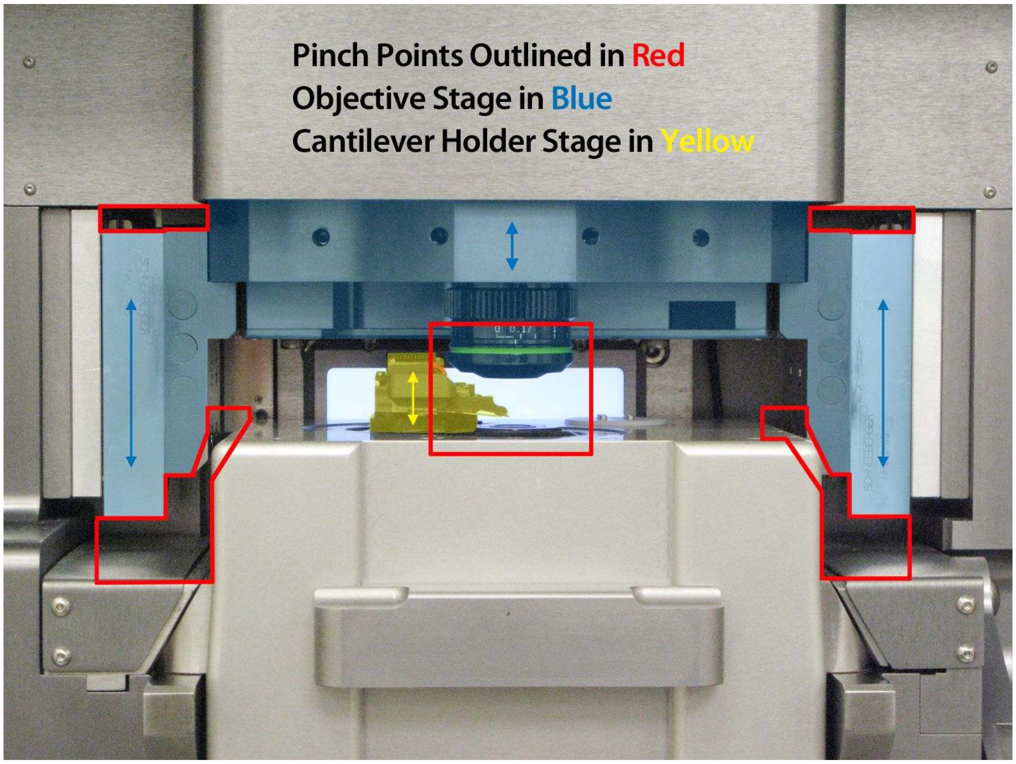


Figure 20.1.: Areas to avoid in particular when motors are driving the objective lens or cantilever holder. Tinted parts can move as shown by the arrows.

20.1.2. How to stop the motors

In case of an emergency, the motors can be stopped in one of the following ways:

- The motor control knob at the lower front of the Cypher can be used at any time to override computer commanded **objective lens** or **cantilever holder** motor moves. Turning the knob will immediately stop any current motor moves and will transfer control of both the cantilever holder and objective motion to the knob. Note that turning the knob always moves BOTH the cantilever holder and the objective lens simultaneously. *This means that if you were to have your finger pinched between the cantilever holder and the objective lens, the best way to release your finger would be to use the software to motor the objective lens upwards while leaving the cantilever holder stationary.*
- Press and HOLD DOWN the 'Esc' on the PC keyboard. This will always stop any automated motor moves.
- Turn off the ARC2 controller. This is not advised since it will not allow you to use the knob or software to control the motors and manually move them to a safer position.
- Unplug the power brick, which is connected to the Cypher. This power brick supply feeds the motors. As was the case with turning off the controller, cutting power will stop the motors but will not give you any quick method for moving the motors to a safe position.

- If the power is cut and you must move the objective, you can reach inside the enclosure and feel for a wheel at the lower left hand side near the rear of the Cypher chassis. This wheel turns the motor manually. Ten turns are required for every millimeter of objective motion. Turn clockwise to move the objective DOWN and counter-clockwise to move the objective UP.

20.2. Light Source Safety

Caution	Use of controls or adjustments or performance procedures other than those specified herein may result in harzardous invisible laser energy exposure.

20.2.1. Non-visible Laser Diode or Super Luminescent Diode Light

The Cypher SPM contains a laser diode (LD) or super luminescent diode (SLD) light source. Superluminescent diodes are like lasers, but have a shorter coherence length. As of the writing of this manual all Cypher light sources have an output of several mW around 850 nm, which is non-visible. From a safety perspective LDs and SLDs can be regarded as identical and the terms will be used interchangeably.

The Cypher laser is sufficiently well shielded that the Cypher SPM qualifies as IEC Class 1 laser product that complies with 21 CFR 1040.10 and 1040.11, except for deviations pursuant to Laser Notice No. 50, dated 24 June 2007. Complies with IEC/EN 60825-1, Ed.2:2007. In layman's terms this means the Cypher SPM is in the same class as a home DVD player, and in a safer class than a laser pointer. When used as prescribed there is no danger of exposure. Nonetheless, it is still good to have an understanding of the laser in the instrument and the safety features.

Figure 20.2.: A class 1 laser product (IEC 60825-1:2007 and EN60825-1:2007) is safe under all conditions of normal use.

20.2.2. The Laser Optical Path

Understanding the laser optical path is the best way to reduce the possibility of harmful exposure to non-visible light, which may cause eye damage. Figure 20.3 on page 232 shows a simplified picture of the laser optical path. The light originates inside the removable laser module, then reflects via a mirror (called the "hot mirror" because it reflects infrared light while transmitting visible light) into the objective. The only place a person can be exposed to the light during normal operation is where the light exits the objective. As you will see in the next section, there are numerous interlocks to make the possibility of exposure very low. Still, here are a few things you should avoid:

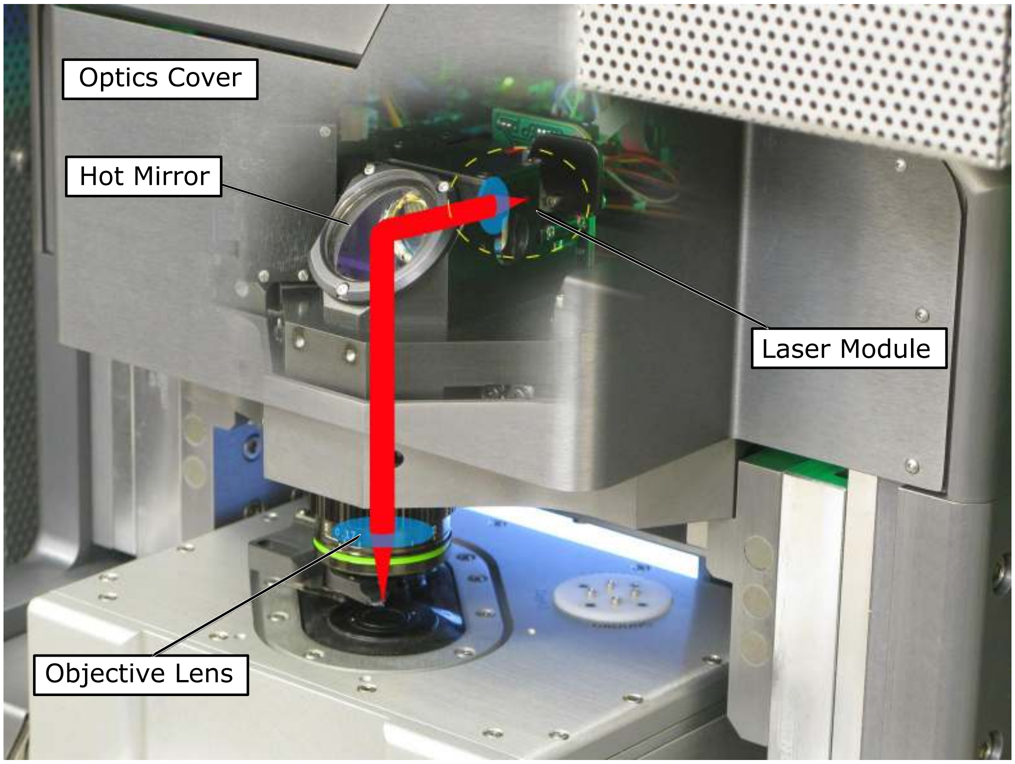


Figure 20.3.: Simplified laser path. Removing the optics cover exposes the hot mirror and laser module. The non-visible laser light originates in the laser module and comes out as a collimated beam. The collimated beam is reflected off of the hot mirror and into the objective lens, which focuses it onto the cantilever. During normal operation the only place a person can be exposed to the light is where the light exits the objective.

- While unlikely, it is possible to place a small mirror below the objective and reflect the light in the direction of the user. Even then the beam spreads rapidly and is not powerful enough to classify the instrument differently. Nevertheless, you should be aware of the fact that non-visible light is coming out of the objective.
- While it is not recommended, it is possible to unscrew the objective lens by overcoming the loc tite glue used to keep the lens in place. At this point a flat mirror placed under the beam exit can reflect approximately 1 mW of collimated IR light into your eye. Never remove the objective lens or you may void your warranty.
- Never change or remove the laser module without first turning off the laser power key on the ARC2 controller. Never look directly into a plugged in laser module (Figure 20.4 on page 233).

20.2.2.1. Laser Safety Interlocks

The laser on the Cypher AFM is turned on an off by a control voltage which originates inside the ARC2 controller. On its way to the laser the voltage passes through various safety switches. This electrical path is explained in Figure 20.5 on page 234 and in the following text.

Figure 20.4.: Light source module removed from the Cypher AFM. During the removal process it is possible to tamper with safety overrides in such a way that collimated light shines out of the module. As a safety precaution, never look directly into the module while its power cable is attached (power cable not shown in this image).

Light Source Remote Jack In case your laboratory safety specifications require extra measures such as a door or foot interlocks to operate laser equipment, you can attach such a switch to a connector on the back of the ARC2 controller. If this switch is open, the laser power will be interrupted. Since such requirements are rare, the ARC2 controller ships with a shorted connector, keeping this switch permanently closed. Removing the connector will shut the laser off. Call Asylum Research for an additional connector to which you can attach your own customized interlock system.

Laser Power Key Switch The laser is generally turned on and off by means of the key on the front of the ARC2 controller. The key is captive when the laser is on, but can be removed in the 'off' position.

Scanner Laser Interlock When the scanner module is removed there is significantly more space under the objective lens to insert objects which might reflect the laser light in the direction of the user. To prevent this, the laser power circuit is broken as soon as the scanner cable is disconnected, a necessary step for scanner removal.

Collimated Source Magnetic Interlock The collimated laser source (or laser module) includes magnetically activated switches which cut the laser power unless the module is inside its cradle. This prevents the module from emitting collimated light when it is outside the confines of the instrument. The presence of strong magnetic fields can override the interlock operation. For additional safety always turn the laser key on the front of the ARC2 controller to the off position and/or turn off the controller power. Also note that a red LED on the front of the laser module indicates whether collimated light is being emitted. Never look into the module if this LED is on. An additional precaution is to simply never look into the module's collimating lens.

Optical System Cover While it is safe to operate the system with the cover removed, keep it in place at all times to avoid the temptation of touching the inner workings around the laser optical path.

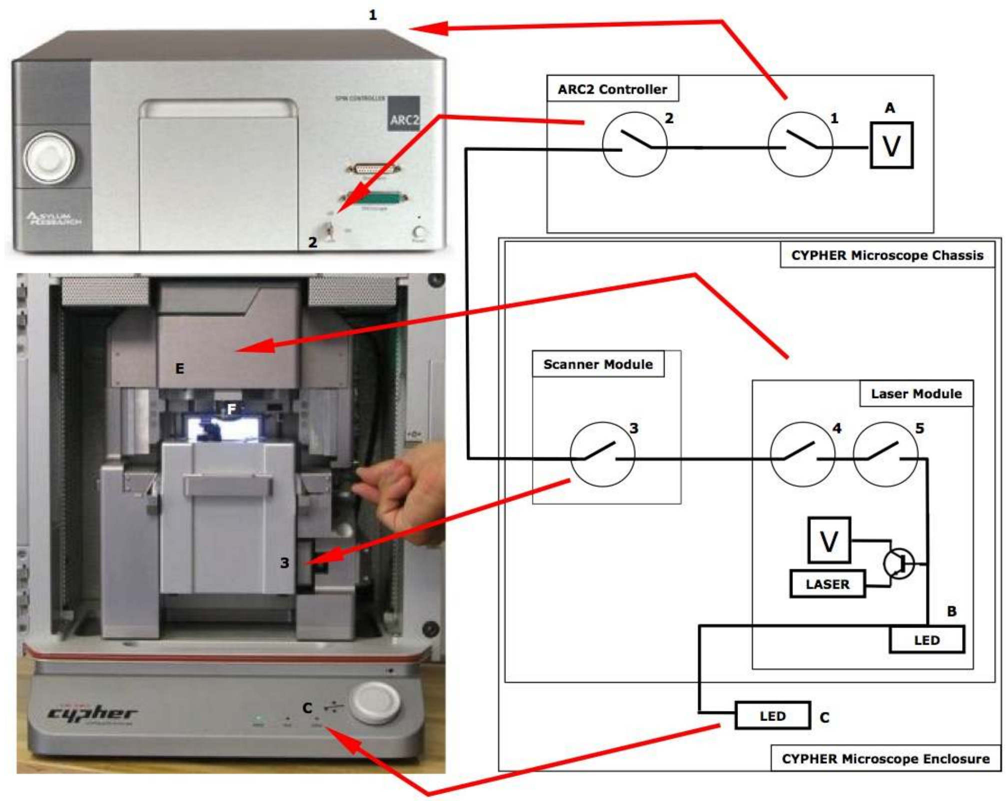


Figure 20.5.: Cypher and ARC2 laser safety interlock system. (A) Laser Voltage Source. (1) Back panel remote interlock connector, or Light Source Remote Jack. (2) Front panel laser power key switch. (3) Scanner interlock. (4,5) Laser module dual magnetic switch interlock. (B) Laser Module LED. (C) Cypher enclosure laser LED. (E) Optical system cover. (F) Objective Lens. Not shown is an additional software controlled laser power switch.

20.3. Power Supply Safety and Thermal Management

20.3.1. High Voltage

The voltages inside the Cypher SPM are as dangerous as those present in a standard wall socket; therefore, you should respect all of the components under the instrument covers as you would a wall socket. Never touch anything or insert anything conductive under the instrument covers. Also, the piezoelectric actuators in the scanner have a large capacitance and can hold charge for many minutes after the scanner is disconnected from any power supply. *For this reason never touch the scanner connector, unless it has been unplugged for at least 10 minutes.*

Warning	The Cypher SPM and ARC2 controller contain internal voltages up to 165VDC, 0.5A. Use caution when handling system pieces to avoid electrical injury. These voltages may be lethal.

20.3.2. Fuses

Adhere to the fuse ratings appropriate to the main supply voltage listed on the back side of the ARC2 controller. Not following the recommended ratings may cause the instrument to overheat or sustain damage.

20.3.3. Overheating

Keep the backside of the ARC2 clear. Cool air is drawn into the heat sinks on the back of the ARC2 controller and two fans exhaust warm air from the same place. Obstructing any part of the ARC2 back will cause power supplies and electronics to overheat.

Keep the top of the Cypher SPM backpack clear of items. The backpack is passively cooled and requires all the heat fins on the side and top be in open air. Don't place paper or notebooks on top of the backpack.

20.4. Instrument Weight

The Cypher instrument is made of many heavy metal parts. Be prepared to have two people on hand whenever lifting of the empty enclosure is required. If you are thinking of lifting or moving the instrument (even a few inches) you MUST first contact Asylum Research or your instrument will be damaged and you will experience downtime and incur costs.

Note Even the scanner module is quite heavy. Be prepared to support its weight as you pull it from the support rails.

21. Shipping or Moving

CHAPTER REV. 1659, DATED 10/07/2013, 22:54. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

This chapter contains instructions on how to take a fully operational Cypher AFM, partially disassemble it, and move it to another location.

21.1. "Moving," what does it mean?

Move a few inches Grip the AFM by its base and slide it around on your workbench by a few inches. DO NOT LIFT.

Warning	If you have to lift the AFM in order to move it, you must take it apart. READ THIS CHAPTER, or you may be looking at costly repairs and weeks of downtime. Also contact Asylum Research to discuss this operation before you embark on it.

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

Move to another desk or nearby room Any action that requires lifting of the AFM requires significant care and some disassembly. Please follow the relevant sections of this chapter which will outline shutting down the AFM, removing it from its enclosure, and packaging it. Even if you are moving to another room, we recommend placing the components in their shipping cartons to prevent damage from jostling by carts and dollies or accidental dropping.

Moving to another building This we consider nearly equivalent to shipping it halfway across the world. See the next step.

Shipping to a remote location Follow this chapter in its entirety.

Warning	ONLY use the original cartons and foam for shipping this delicate equipment. If you do not have the cartons described in this chapter, please contact Asylum Research and request empty cartons with foam.

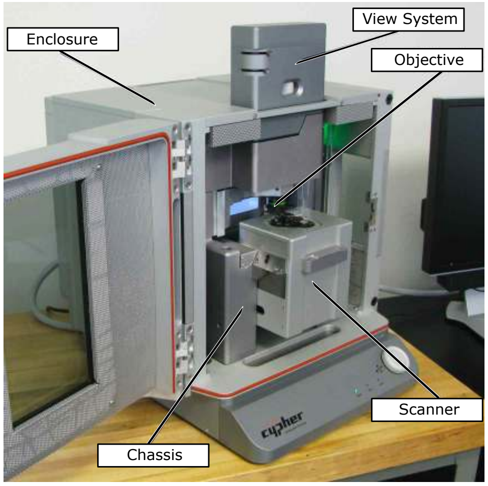
21.1.1. Shipping a Cypher component

When shipping or moving all of the Cypher AFM, follow this chapter start to end. When only shipping one component (say scanner, or camera view system) then jump straight to the section which focuses on that component. Each section will contain a “minimum preparation” list which indicates what needs to be done prior to that section. For instance, shipping the scanner is relatively easy, since its removal does not depend on many other parts. Something like the view system, however, will require significant disassembly of the whole AFM.

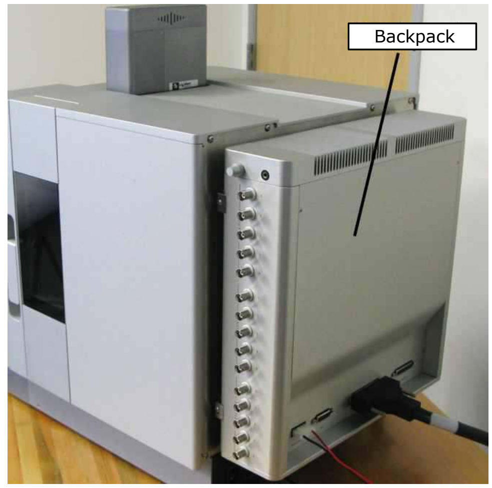
21.1.2. A note on unpacking

If you have just received your new AFM, do not unpack it yourself. It must be installed by a certified technician. Your warranty may be voided if you unpack a new instrument yourself.

If you have packed your AFM or some part thereof for repair and have to unpack it upon return, please use this guide as a reminder.



(a) Front View. Note that Camera is also referred to as View System in this chapter.



(b) Rear View

Figure 21.1.: Cypher parts basic nomenclature

21.2. Nomenclature

21.3. Proper System Shut Down

1. Motor up the cantilever holder.
2. Remove any samples from the scanner.
3. Remove all loose items from the AFM enclosure.
4. Shut down the IGOR software and the computer.
5. Power off the AFM controller.
6. Unplug all cables leading to the AFM enclosure and place them aside, keeping them together.

Warning	Never lift the AFM enclosure with the instrument inside. Don't try to move the AFM from the lab to, say, the loading dock prior to packaging. Disassemble the AFM within its normal laboratory setting.

21.4. Shipping a Complete Cypher AFM System

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

21.4.1. Scanner: Removal and Packaging

Materials	991.001: Carton: 10”x10”x10” 990.035: Foam: (Scanner)
Tools	Asylum Par# 290.111: 0.050” Hex Driver.
Final Wt	14 lbs / 6 kg

Minimum Preparation System Shut Down: (Section 21.3 on page 238)

1. Remove the Scanner from the Enclosure.

a)

- Lift the lever located to the right of the scanner.
- Gently pull scanner out ¾ way and stop. It cannot fall out as it is attached to a cable.

b)

Unscrew the scanner connector cable on the right side of scanner, and loosen the knob to release it.

c) Once the scanner cable is released, slide the scanner all the way out. Anticipate the significant weight of the scanner as you slide it off the rails.- HANDLE CAREFULLY. Set the scanner aside. It has rubber feet and can be set on any level surface.

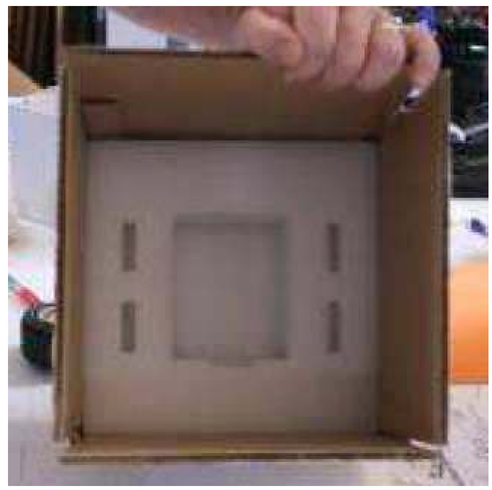
2. Remove any cantilever holders from scanner stage and set them aside.

a) Use the .050 WIHA Allen Wrench to unscrew the screw on the silver plate-ONLY ¼ turn!!!

b) Once unscrewed a ¼ turn - gently pull the cantilever holder out and set it aside (The cantilever holders ship in the accessory Kit Box along with their accessories (See on page 260). Only the scanner goes in the scanner box.)

3. If customer shipment – Clean scanner for fingerprints – careful on top!

4. Place the scanner in an anti-static bag.

5.	Tape the bag shut. Kapton tape is preferred.	
6.	Place the scanner carefully on the bottom foam.	
7.	Be careful putting on the top foam; make sure it is the right side and lines up with scanner already in box.	

8. Close & Tape Shut the box.

Warning	SCANNER BOX SHOULD REMAIN UPRIGHT AT ALL TIMES IF POSSIBLE WHEN SHIPPING ON CRATE OR PALLET.

21.4.2. Enclosure: Remove Top

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

Tools	290.134: 3/32" Hex Driver

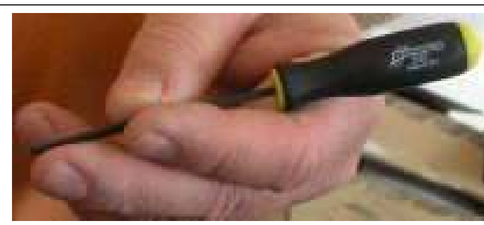
Minimum Preparation System Shut Down: (Section 21.3 on page 238)

1. Remove the Airflow Shield – the metal piece right above scanner- by pulling it off (it is magnetic).

2. Remove the Optics Cover – the big metal piece in front of chassis and view module – by pulling it off (it is magnetic).

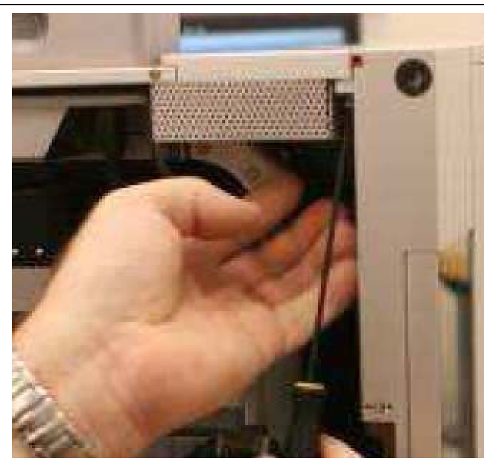
3. Take the top enclosure cover off.

   a) Locate the 3/32 Hex Driver (part#290.134).



   b) Open the enclosure door with the latch found on the right side.

   c)
   - Undo the bracket in front of the view module; take the 2 screws out and set them aside.
   - After removing both screws, pull this piece out and set it aside.

d)	Remove all 4 screws from back edge of the enclosure top plate. They are visible above the backpack. (SCREW INFO: 8-32 x ¼ BHCS SS)	
e)	Unscrew 2 screws in the right door on the bottom and set aside (note: there may only be 1 screw) - (SCREW INFO: 8-32 x ½ BHCS SS).	
f)	Unscrew the right door top inside screws and set them aside (note: There may only be 1 screw on each side). (SCREW INFO: 8-32 x ½ BHCS SS.)	

g) Unscrew the left door top inside screws and set them aside (note: There may only be 1 screw on each side). (SCREW INFO: 8-32 x ½ BHCS SS.

h) Open the door on the right all the way.

i) Remove the top enclosure cover by wiggling it – BE CAREFUL: SIDES ARE SHARP! – then set it aside.

4. Leave the enclosure as it is; we will return to it later in Section 21.4.5 on page 248.

21.4.3. Backpack: Removal and Packaging

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

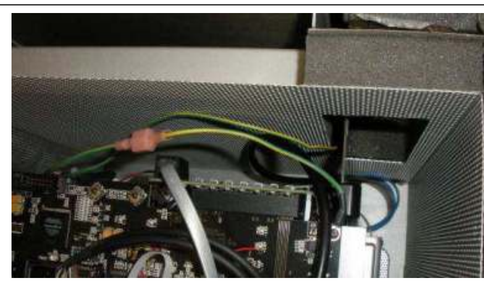
Materials	991.018: Cardboard Carton 18”x18”x6” – 990.038: Foam (Backpack)
Tools	290.134: 3/32” Hex Driver
Final Wt	15 lbs / 7 kg

Minimum Preparation System Shut Down: (Section 21.3 on page 238)
Enclosure Top Removal: (Section 21.4.2 on page 242)

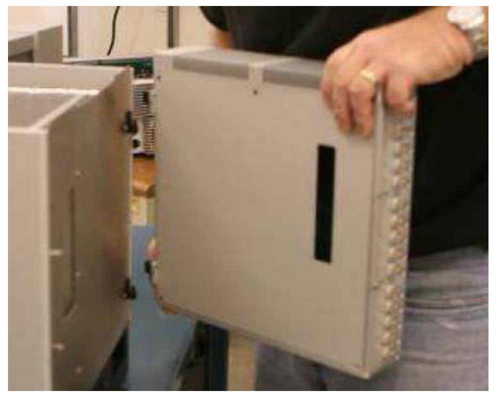
1. Loosen the 2 side screws (only loosen from Enclosure – do not remove completely) using the 3/32 Hex Driver.

2. Remove the piece of foam from inside the chassis nearest the backpack screws you just loosened.

3. Disconnect the ground cable (yellow & green cable) by pulling apart the pink connectors.



4. Next, put your hand inside the chassis and release the pass through the board from the chassis by popping it out away from the chassis.

5.	Once released, slowly pull the backpack toward yourself, carefully guiding both the disconnected pass through the board and the ground cable through the hole so as to separate it completely from the chassis.	
6.	Carefully take the Backpack off the hinges on the right by pulling up.	

Warning DO NOT SET BACKPACK ON ITS TALL SIDE. IF IT FALLS OVER IT CAN CAUSE SEVERE DAMAGE TO ITSELF!

7. Remove the pass through the board from the backpack by pulling it out toward yourself. Set this board aside (It ships in the View Module optics box, See Section 21.4.6 on page 251).
8. Put the foam back (removed in 2).
9. Tape the ground cable to the backpack itself. (Kapton tape is preferred.)
10. Place the backpack in an anti-static bag and tape shut.
11. Put it in the backpack box and tape shut.

21.4.4. Chassis: Removal

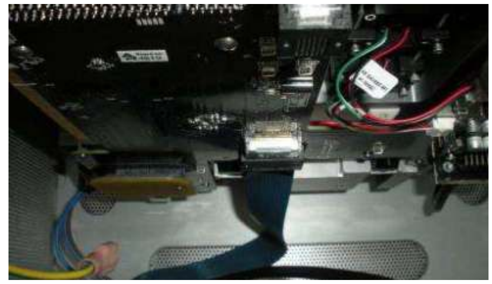
STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

Minimum Preparation System Shut Down: (Section 21.3 on page 238)
Scanner Removal: (Section 21.4.1 on page 239)
Enclosure Top Removal: (Section 21.4.2 on page 242)
Backpack Removal [partial]: (Section 21.4.3 on page 244 through step 4)

1. Undo the HDMI cable from the back of the chassis (The stiff blue ribbon cable).

a) Slide the AFM chassis about 1-2 inches forward.

b) Put your hand down between the chassis and the enclosure back wall and grip the blue ribbon cable at the center of the picture.



c) Release the cable from the chassis by pinching its sides and pulling down.

2. Undo the Heater Cable (Brown & Blue Cable on the side)

a) Slide the chassis to the left about 1-2 inches.

b) Place your hand down the right side of chassis and grip the white connector.

c) To release this cable from the chassis there is a catch on the latch of this cable – squeeze the bottom side of it and wiggle loose to release.

3. Remove the chassis from the enclosure using the handles on either side of the chassis-CAREFUL IT IS HEAVY! Use all your fingers to lift it (not like the picture!).

4. Set it aside on a safe, hard surface. We will return to the chassis/head in Section 21.4.7 on page 254.

21.4.5. Enclosure: Packaging

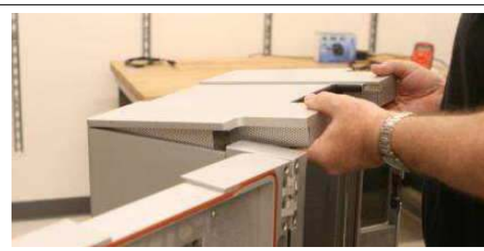
STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

Materials	991.015: Cardboard Carton 21” X 20” X 21” 991.015: Foam (Cypher Enclosure) Kapton Tape (1/2” or 3/4”)
Tools	290.134: 3/32” Hex Driver
Final Wt	90 lbs / 41 kg

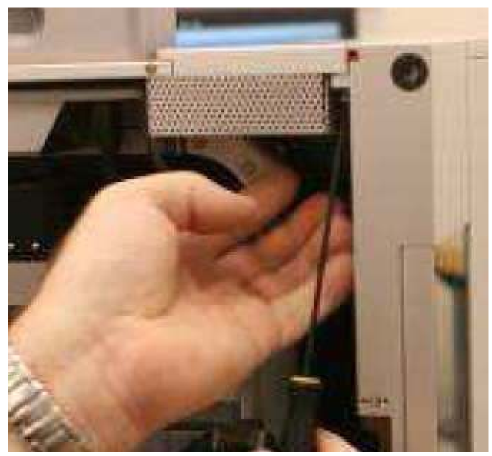
Minimum Preparation System Shut Down: (Section 21.3 on page 238)
Scanner Removal: (Section 21.4.1 on page 239)
Enclosure Top Removal: (Section 21.4.2 on page 242)
Backpack Removal: (Section 21.4.3 on page 244)
Chassis Removal: (Section 21.4.4 on page 246)

1. Secure all 3 cables inside the enclosure by taping them down to the center floor with Kapton Tape.

2. The right door of the enclosure should still be open. With the door open, put the roof of the enclosure back on by setting it back ½ down first and then using the dowels and the 2 holes in the top front to guide you.



3. When the roof is on completely, shut the door on the right side carefully.

4.	Screw in the 2 screws on right side door using the 3/32 Hex Driver (part#290.134). Note: There may only be 1 screw in which case do the front screw closest to you. (SCREW INFO: 8-32 x ½ BHCS SS) (TOOL INFO: 3/32”)	
5.	Replace the right door top inside screws and set them aside (note: There may only be 1 screw on each side). (SCREW INFO: 8-32 x ½ BHCS SS.)	
6.	Replace the left door top inside screws and set them aside (note: There may only be 1 screw on each side). (SCREW INFO: 8-32 x ½ BHCS SS.)	
7.	Replace all 4 screws from the back edge of the enclosure top plate. They are visible above the backpack. (SCREW INFO: 8-32 x ¼ BHCS SS)	

8. Replace the bridge in the front top of the enclosure. Slide it in so the screw holes and foam line up.

9. Screw in 2 screws to secure the bridge.
10. Close the enclosure door and latch the side lock.
11. If customer system – clean all Glass and fingerprints off
12. Tape the side lock down with Kapton tape.

13. Prepare the box and foam. Note the cutout in the foam which aligns with the rear of the enclosure.

14. Carefully –with 2 people – lift the enclosure and place in the bottom of the box, but on top of the foam. CAUTION: VERY HEAVY – ABOUT 90 LBS!

15. Place 1-2 plastic bags over the enclosure once it is already in the box to protect the finish from damage.

16. Slide on top the foam (in 2 pieces) – one on each side.

17. Place the power cord for the airbase in the foam cut-out.
18. Place the 3/32 Hex Driver in the foam cut-out.
19. Close the box and tape it shut.

Warning	SCANNER BOX SHOULD REMAIN UPRIGHT AT ALL TIMES IF POSSIBLE WHEN SHIPPING IN A CRATE OR ON A PALLET.

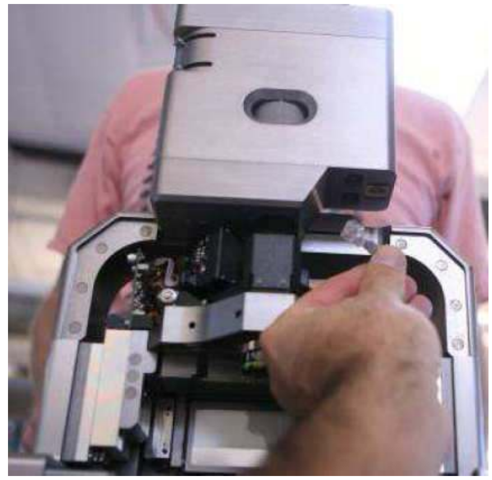
21.4.6. View Module: Removal and Packaging

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

Materials	991.005: Cardboard Carton 20”x14”x8” 990.037: Foam (Cypher Optics & Accessory) Lens Tissue Kapton Tape (1/2” or 3/4”)
Tools	290.105: 3/16” Ball End Allen Wrench L-Key
Final Wt	11 lbs / 5 kg

Minimum Preparation System Shut Down: (Section 21.3 on page 238)
Scanner Removal: (Section 21.4.1 on page 239)
Enclosure Top Removal: (Section 21.4.2 on page 242)
Backpack Removal [partial]: (Section 21.4.3 on page 244 trough step 4)
Chassis Removal: (Section 21.4.4 on page 246)

1. Remove the phone cable from the bottom side of the view module (note: you need to pinch one side).



2. Remove the FireWire cable from the bottom side of the view module (black cable-like USB).

3. Unscrew and remove 2 screws from the top bridge of the view module using the 3/16" Ball End Allen Wrench L-Key. (part#290.105)-BE CAREFUL TO HOLD VIEW MODULE TIGHTLY WITH YOUR OTHER HAND BECAUSE IT WILL FALL FORWARD OTHERWISE!!!

4. Set down the view module, then set aside the 2 screws and the L-key tool.

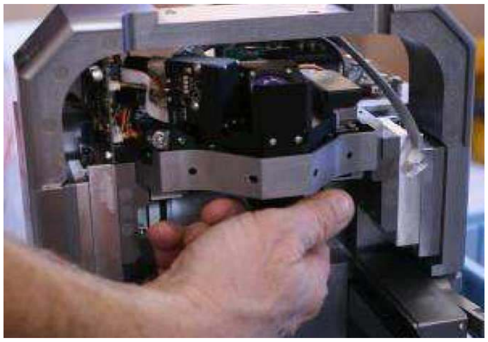
5. Use Kapton tape to secure lens tissue over the view module lens.

6. Put it in a plastic bag and tape shut.

7. Put it in the view module foam, which has asquare spot in the far corner.

8. Tape the 2 screws and the L-key tool to the view module bag for safekeeping.

9.
   - First, locate the clear plastic objective container with the black cap. Remove the black cap and have it sitting ready.
   - Remove the objective from the chassis by unscrewing it. Be careful as it is both very fragile and very expensive.
   - Immediately screw the objective to the black cap, followed by the clear plastic cover.
   - Always store the objective in this container. If you do not have one, please contact Asylum Research for a spare.



10.

a) Place the objective in the round hole in the view module foam and push it all the way in; the lid should be flush with the top of the foam.

b) Put the chassis/optics cover in the view module foam (a part that was taken off the front of the chassis before).

c) Put the airflow shield in the view module foam (a part that was taken off the front of the chassis before).

11. Place the motor power supply with the power cord inside the view module foam, parallel to the view module itself.

12. Put on the top foam; make sure the square hole lines up with the corner where the view module piece sticks up.

13. Bag Pass through Board in Anti-Static Bag (part taken from Backpack & Chassis) and put in top hole of foam

14. Coil the black FireWire cable in the top. Pass it through the board.

15. Close the box and tape it shut.

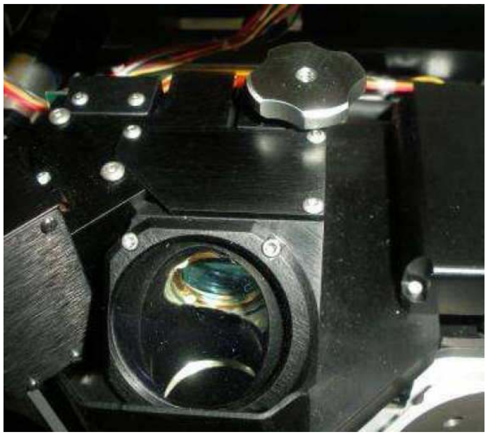
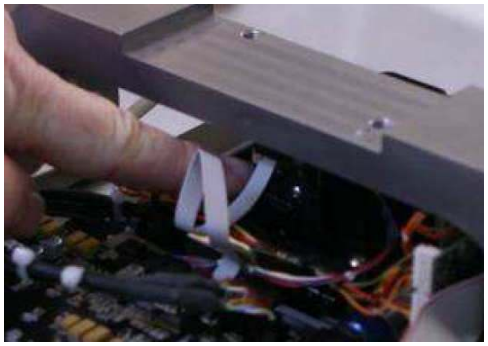
21.4.7. Chassis: Packaging

STOP!! Call or otherwise contact Asylum Research and talk to us before moving anything. Chances are that with a few phone calls and the help of this chapter you can do the job yourself. Not calling us will likely result in instrument damage, costly repairs and downtime, and the voiding of your warranty.

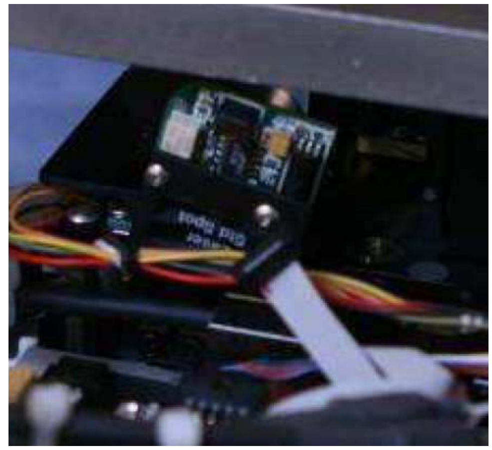
Materials	991.016: Cardboard Carton 16”x14”x17” 990.034: Foam (Chassis Foam) 113.495: Chassis Packing Guard a.k.a “the Mullet” 10-32 x ¼ or ½ BHCS SS Bolts (2EA) depending on which guard you have 10-32 x1 ½ or1 ¾ BHCS SS Bolts (2EA) depending on which guard you have) 10-32 Kepnuts (2 EA) Lens Tissue Kapton Tape (1/2” or 3/4”)
Tools	290.119: 1/8” Hex Wrench L-key Pair of pliers or adjustable wrench.
Final Wt	51 lbs / 23 kg

Minimum Preparation System Shut Down: (Section 21.3 on page 238)
Scanner Removal: (Section 21.4.1 on page 239)
Enclosure Top Removal: (Section 21.4.2 on page 242)
Backpack Removal [partial]: (Section 21.4.3 on page 244 trough step 4)
Chassis Removal: (Section 21.4.4 on page 246)

1. Remove the light cube from the head.

a)	Undo the clamping (4 petal knob); screw ONLY ¼ turn.	
b)	Disconnect the light cube mating cable (thin gray ribbon cable) from the light cube; pinch and wiggle loose until it is detached.	

c) Slide the light cube out carefully.

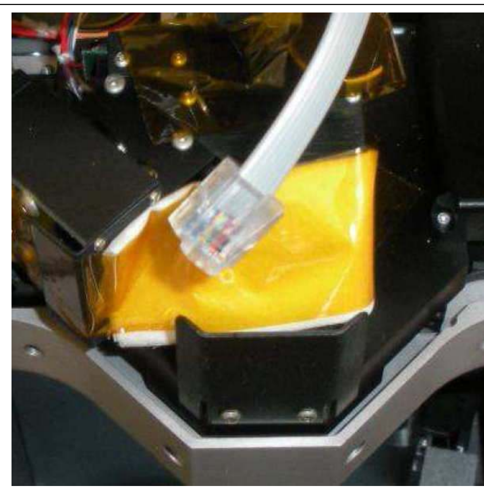


d) Turn the clamping screw to close – only ¼ turn back – DO NOT OVER TIGHTEN! (See Figure in Step 1a on page 255)

2. Tape down the clamping screw.

3. Tape both the phone cable & the laser module cable to the top bridge of the chassis in the center.

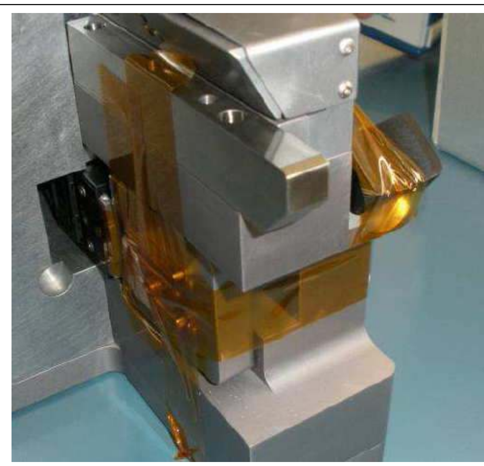
4. Put lens tissue and Kapton tape over the hot mirror and wrap tape around to cover the side port hole.



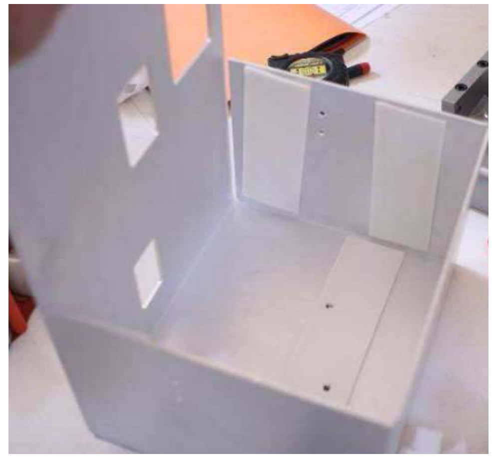
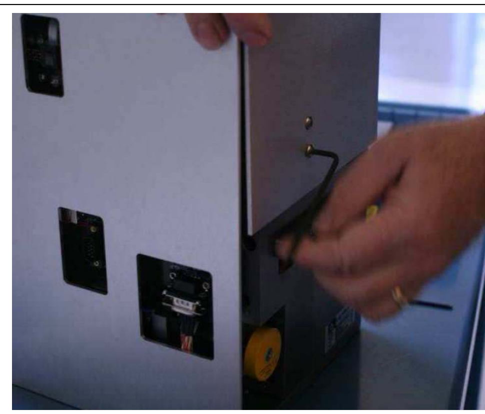
5. Kapton tape the ground cable (green & yellow cable on back side of chassis) straight down behind the board (Do not tape to the side, as it must be back to be safe from the shipping guard/mullet).

6. Use lens tissue and Kapton tape to fill and cover the objective hole in the underside of the head.

7.
a) Tape down the scanner release lever
b) Tape down the scanner connector cable so it does not move in shipment.



8. Once everything is secure, put on the shipping guard/mullet (NOTE: there are variations of this design in the field.).

a)	If this is shipping for the first time, put 5 pieces of foam tape inside the pullet (2 on each side and one in the middle) to pad it and make it slide easier – avoid putting tape over the screw holes!	
b)	Slide on the guard carefully.	
c)	1-2 screws need to go in either side using a 1/8” Hex Wrench L-key (part#290.119). (SCREW INFO: 10-32 x ¼ or ½ BHCS SS depending on which guard you have)	

d)	2 screws need to go in the bottom back using 1/8” Hex Wrench L-key (part#290.119). Include a nut on each screw. The nut sits between the mullet and the chassis. Tighten to the point where it is flush with the mullet metal. Don’t bend the metal visibly.	
e)	Now turn the nut back toward the screw head and tighten it with pliers (Pliers not provided with system) – one on each side. (SCREW INFO: 10-32 x1 ½ or1 ¾ BHCS SS depending on which guard you have & 2 10-32 Kepnuts.)	
9.	Once guard is on, lift the chassis with the side handles and place it into the bottom foam/box carefully. NOTE: HEAVY, ABOUT 51 LBS.	

10. Place a plastic bag around the chassis once it is in the foam.

11. Place the top foam atop the chassis.

12. Place the 1/8” Hex Wrench L-key in the foam cut-out or tape it to the top foam.

13. Close the box and tape it shut.

Warning	SCANNER BOX SHOULD REMAIN UPRIGHT AT ALL TIMES IF POSSIBLE WHEN SHIPPING ON CRATE OR PALLET.

21.4.8. Accessories: Packaging

Materials	991.014: Cardboard Carton 12”x12”x10 990.040: Foam (Cypher Optics & Accessory)
Final Wt	5 lbs / 2 kg

1. Put the laser cube in anti-static bag! (VERY IMPORTANT!)

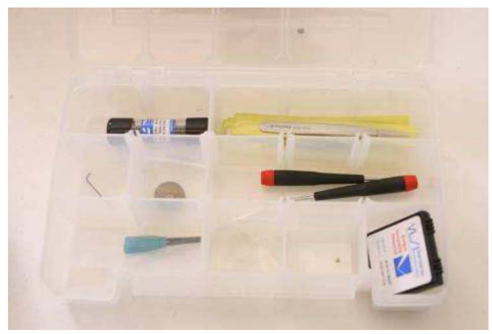
2. Put the laser cube, after it is bagged, in the plastic case (Part#279.055). Open and close the case with Yellow Plastic Clips C.

3. Put the light cube case inside any slot of the accessory foam.

4. Bag the cantilever changing station.

5. Put it in the square slot in the foam – be careful of the lever.

6. Bag all the cantilever holders and accessories and place them in the Cypher Accessory Kit.



7. Close the Cypher Accessory Kit and place it in a foam slot in the accessory foam/box.

8. If this is anew system, put the Olympus Sample Pack in a slot in the foam/box.

9. Put any additional accessories for this specific order in the foam/box. If they aresmall items, place them in the Cypher Accessory Kit Plastic Case for safekeeping.

21.5. Ancillary Equipment

21.5.1. ARC2 Controller

Set of instructions on how to pack the ARC2. Section has yet to be written.

21.5.2. Computer and monitors

Pack computers and monitors in the original Dell Computer boxes.

21.6. Weights and Dimensions

21.6.1. Standard Cypher System Weights (packed in Carton)

Chassis/Head 51 lbs / 23 kg

Scanner 14 lbs / 6 kg

Enclosure 90 lbs / 41 kg

View Module 11 lbs / 5 kg

Backpack 15 lbs / 7 kg

Cypher ARC2 62 lbs 28 kg

Computer 45 lbs / 20 kg

Monitors 22 lbs each x Qty 2 = 44 lbs / 20 kg

Accessories Box: 5 lbs / 2 kg

Crate/Pallet 46 lbs / 21kg

STANDARD CYPHER TOTAL: 383 lbs / 174 kg

21.6.1.1. OPTIONS THAT AFFECT WEIGHT

TS-150: 48 lbs / 22 kg

30" Monitor: 31 lbs / 14 kg

CYPHER-ATC: 25 lbs / 11 kg

21.6.2. Crate Dimensions

48"x40"x42"

22. Troubleshooting and Maintenance

CHAPTER REV. 1658, DATED 10/07/2013, 20:47. USER GUIDE REV. 1714, DATED 10/25/2013, 20:36.

Chapter Contents

22.1. Using a USB drive causes Cypher to lose communication

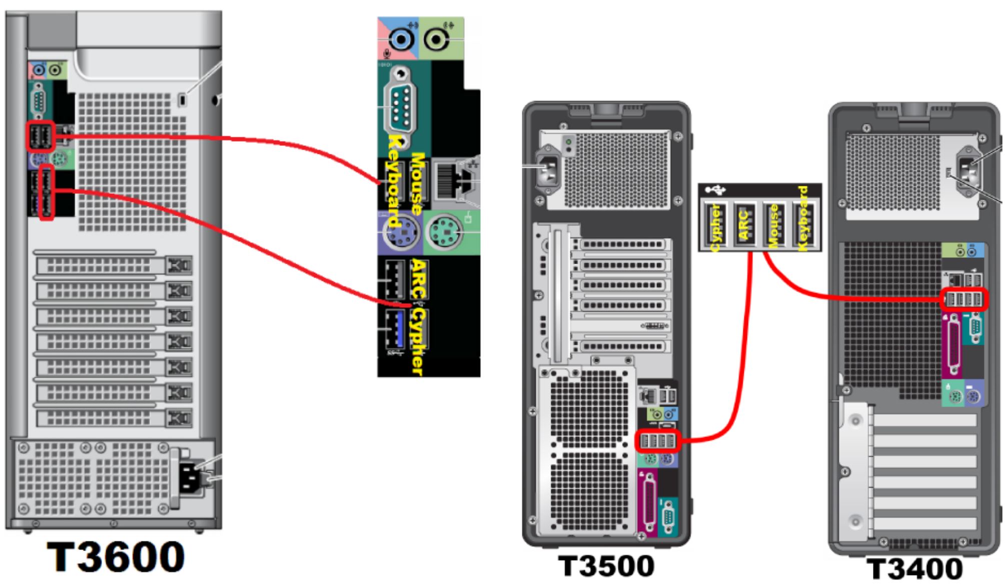
22.1.1. Problem Summary

A USB memory stick or portable USB drive is plugged into the front panel of the computer, causing all sorts of communication errors to show up in the Igor log window. A customer may report only the communication errors, not remembering they were using a portable USB device at the time.

22.1.2. Workaround

This applies only to Dell T3400 and T3500 computers.

- Plug Cypher, ARC, mouse and keyboard into the bottom USB ports.
- USB 2.0 devices like USB drives and printers and LCD monitor hubs may now safely be plugged into the remaining non-circled ports, including the two USB ports on the front of the computer. See Figure 22.1 on page 264.



(a) USB connections for T3600 computers

(b) USB connections for T3400 and T3500 computers

Figure 22.1.: If you have a Dell T3600, T3500, or T3400 workstation, please see the following graphics for the best way to set up the USB connections. Connecting in this manner will insure that the Cypher and the ARC will not compete with other USB devices for bandwidth.

Part VI

Bibliography, Glossary, and Index

Part Contents

Bibliography

Cited Scientific References

Cited Asylum Research Documents

Applications Guide, Chapter: AC Mode Imaging in Air.

Applications Guide, Chapter: Conductive AFM.

Applications Guide, Chapter: PFM Using DART.

Applications Guide, Chapter: Single Frequency PFM.

Applications Guide, Chapter: Thermals.

MFP-3D User Guide, Chapter: Tutorial: AC Mode Imaging in Air.

Index

About the index:

- Page numbers are preceded by the user guide part. The two are separated by a dash.
- **Bold** printed page numbers are references to the definition of terms.
- Other page numbers indicate the use of a term.

V