

MULTI PROBE

User's Manual
Version 1.0.19

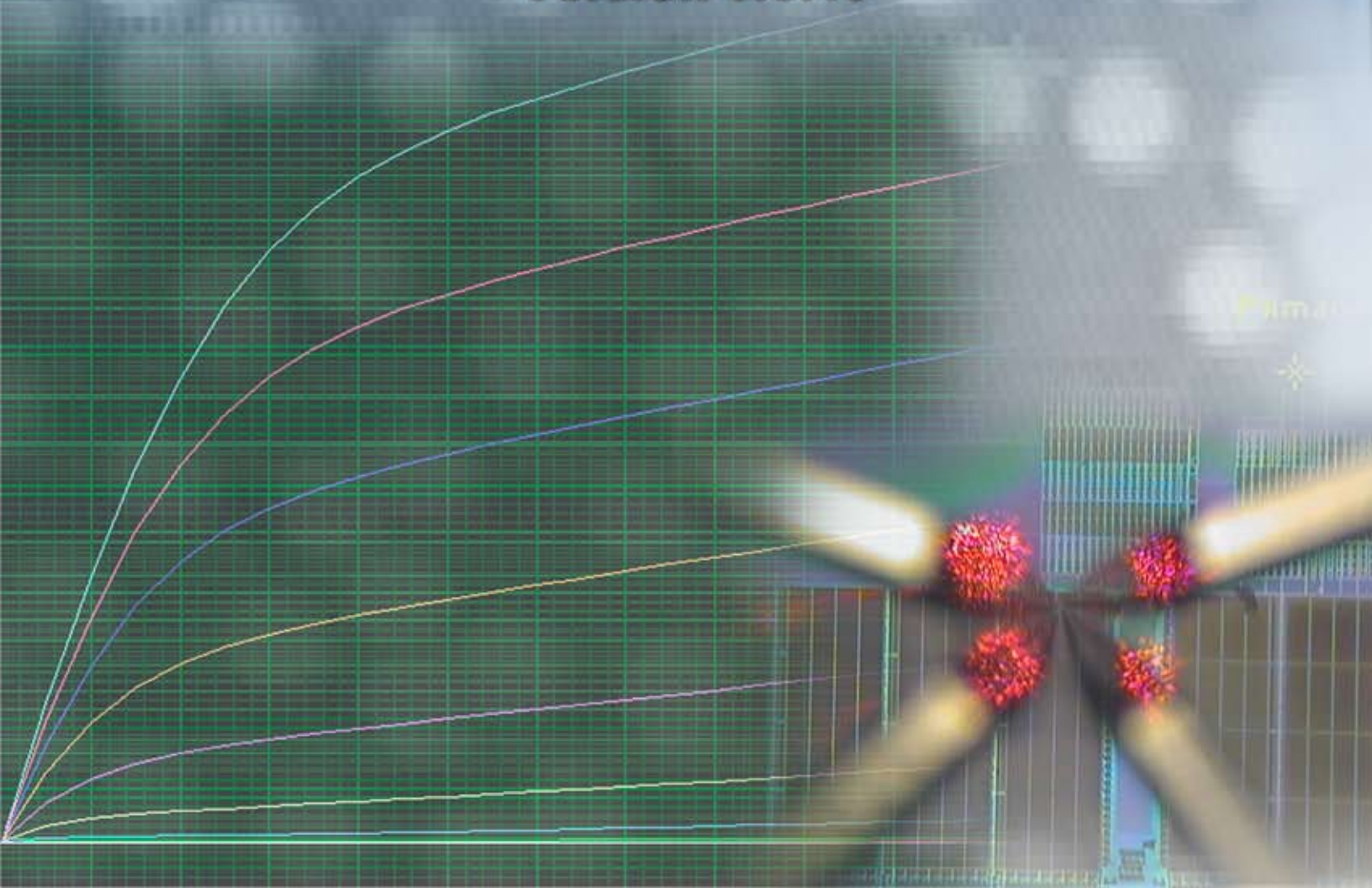


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1. Overview Process

Welcome to the world of sub-90 nanometer transistor characterization. Previously impossible analyses become routine with the Multiprobe Atomic Force Probe™ system. We will guide you through the process of getting up and running as quickly as possible. If you have experience with a standard prober, you'll be probing with the AFP within a couple hours.

The odds are you already know most of what you need to successfully operate the Multiprobe Atomic Force Probe™ (AFP) with Multiscan™ capability. There are few differences between what you've been doing so far with your conventional probe station and what you'll be doing with your AFP system. (By the way, don't let that fancy 'atomic force' nomenclature get you too excited. We've supplemented those coarse positioning knobs on your standard probe station with simple software to control the position of new super-sharp probes.) You'll quickly see the similarities to what you've already been doing once you run through the process for the first time. We'll introduce you to practical aspects of the AFP measurement process so you can begin. The skills you have learned during conventional probing will serve you well while using the AFP. While the AFP makes nano-positioning of the probes easy, the standard issues with skate, keeping tips sharp, making solid ohmic contact, and drift of the station still exist. You will find that learning the AFP will take very little time, but mastering these ever-present probing issues will take experience and practice.

Let us show you the components of the system and explain how they work together. First, learn the names and locations of the components and the general flow of information within the system. Don't try to become an expert in the field of instrumentation (yet!). With this basic knowledge, the detailed process of positioning probes for analyses is easily understood. At the troublesome points in the process, we've included useful diagnostic instructions. If you have any problems along the way, don't hesitate to call us—we're here for you. Good luck and have fun!

2. Important Safety Information



CAUTION: To reduce the risk of electrical shock, do not remove ANY metal covers. There are no user serviceable parts inside. Refer servicing to qualified service personnel ONLY.



The symbols shown above are internationally accepted symbols that warn of potential hazards with electrical products. The lightning flash with arrowhead symbol in an equilateral triangle indicates the presence of uninsulated voltages that may have sufficient magnitude to cause electric shock. The exclamation point within an equilateral triangle is intended to alert the user to the presence of important instructions in the literature accompanying the instrument.



WARNING: Always keep everything plugged into the surge protector provided with the instrument. Always plug the surge protector directly into a three prong receptacle that provides single phase 100-120VAC at least 15 Amps. Also insure that the ground prong of the receptacle is connected to earth ground.



CAUTION: During normal operation, the AFP instrument is energized. Some live circuits are exposed and accidental contact possible. Potential exposures less than 30 volts RMS, 42.2 volts peak, 240 volt-amperes and 20 Joules. (See NFPA 79-14.3, IEC 204, UL 1950 & 1262, IEC 950).



CAUTION: This equipment has been tested and found to comply with the limits of FCC Part 15 and EN55011 Class A. These limits are designed to provide reasonable protection against harmful interference when equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.



CAUTION: No operator-serviceable parts inside unit.

CAUTION: Do not cover chassis ventilation slots or block enclosure openings. Adequate space must be provided for all chassis ventilation holes



WARNING: For continued protection against risk of fire, replace only with the same type and rating of fuse.

WARNING: Disconnect power and unplug unit from wall before installing or removing device or servicing unit.

The U.S. Department of Health, Education and Welfare regulates and classifies all laser products sold in the United States. Multiprobe products comply fully with laser performance standards established by Center for Devices and Radiological Health (CDRH) Regulation 21, parts 1040.10 and 1040.11, Code of Federal Regulations.

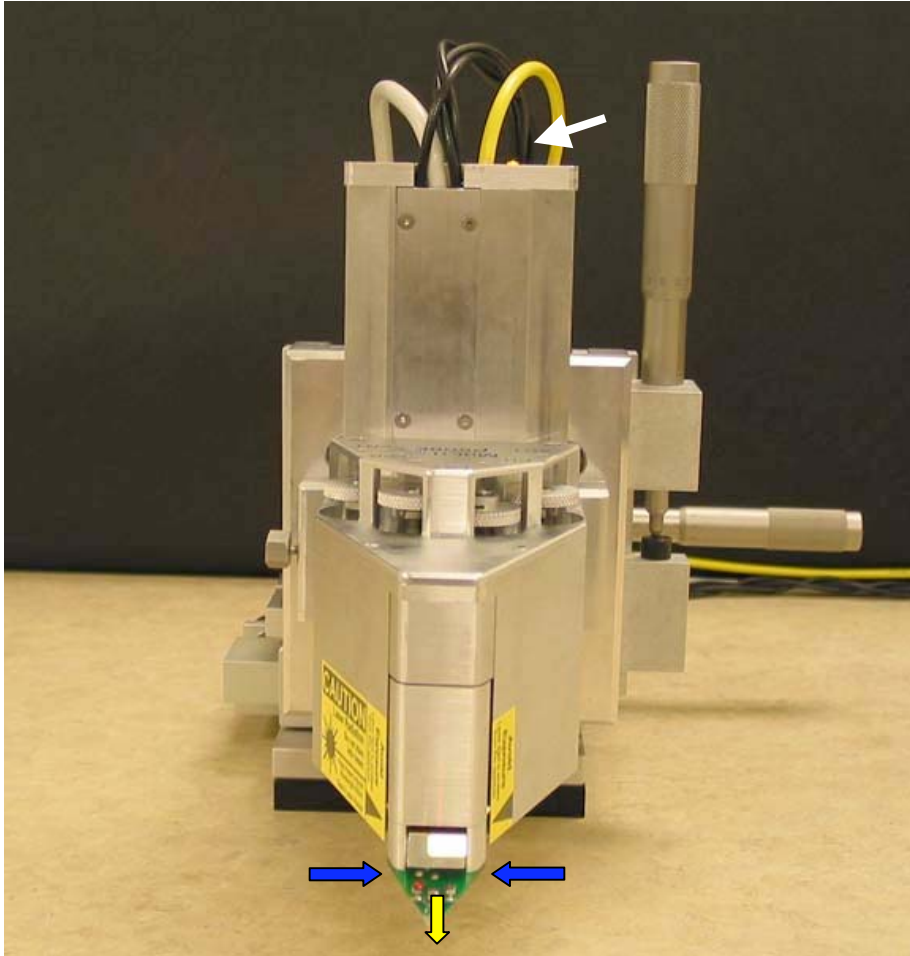
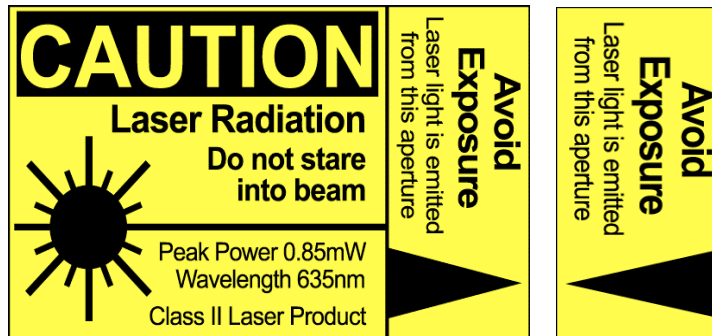


Figure 1: Blue arrows point to the aperture of the laser light. Yellow arrow points in the direction of the laser light. White arrow points to the Laser ON LED.

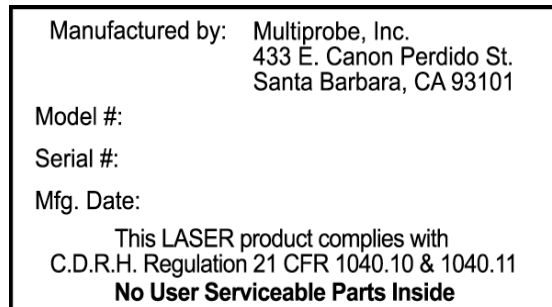
When the Laser On LED on the top of the Head is on, then laser light will be emitted from the aperture with the following output parameters:

<i>Beam Type</i>	<i>Guided AlGaINP Laser Diode</i>
<i>Wavelength</i>	<i>635nm (Typ)</i>
<i>Optical Power</i>	<i><0.85mW</i>
<i>Beam Diameter at aperture</i>	<i>1mm</i>
<i>Beam Convergence</i>	<i>1.88°</i>

The laser light emitted from the AFP may be harmful to the human eye. Always wear eye protection around an exposed laser beam. Direct or diffuse laser radiation can inflict corneal injuries. Never look directly INTO the laser beam. Select protective eyewear that blocks 635nm laser diode radiation. Protective eyewear is available from Multiprobe. **The user will NEVER need to open the AFP Head. Contact Multiprobe if you want to open the head.** Multiprobe recommends a semi-annual service to ensure that the AFP remains complaint with the CDRH regulations. Contact Multiprobe to schedule a calibration of the AFP. Specific labeling is required by Federal Regulations on all laser products. **For your safety and that of others, do not remove any of the labels.** The following safety labels are attached to the AFP Head.



Warning/Aperture Labels (located on both sides of the head near the aperture)



ID/Certification Label (located on the side of the head)



Protective Housing Label (located on the bottom of the head)

3. General Process Flow Measurement

In this section, we'll give you an idea of the general process flow to the end. If you see any steps in this process that you don't recognize, maybe you should go see your supervisor or drop by a friendly colleague's office for a little background. This guide assumes you already know where to probe a sample and how to use a curve tracer or parameter analyzer to see a family of I-V curves. The general process flow goes like this:

De-process a sample to expose discreet contacts to the substrate and gate electrodes. Your company might call this step 'de-layering,' 'un-layering,' or a similar name describing the removal of material from the top of the device. De-processing a device involves a combination of physical and chemical means to remove material in bulk, or by layer. These processes can be quite dangerous. If proper precautions are not taken and standard (safe) practices are not followed, grinding and polishing equipment can be dangerous. Your skin, digits (fingers), and eyes are at risk. Even more insidious is the danger associated with the chemicals commonly used in the de-processing of devices. Before attempting to de-process a device, please make sure to complete all of the safety training required by state and local authorities, as well as department 'best-practices' training. We don't provide details on how to de-process a device in this manual.

Position the probes on the de-processed sample. You'll mount a sample on the system platform and locate the 'area of interest' or AOI. Once you've contacted the probe(s) to the sample, you'll have to register general features of the device to each probe. Then you'll move the probes closer together before precisely positioning them onto the specific nodes required by the measurement. Of course, you'll have to learn how to replace and align probes. You will also learn expert's 'secrets' of dispositioning (evaluating the condition of) the probe(s) and maximizing their lifetimes.

Measure the I-V properties of a device on the sample. Connect the probes to a curve tracer, apply biases, and measure currents. You will also adjust the position of the biased probe(s) and find diodes, gates and full transistors. Since you already know about the characteristics of curves for these devices, we'll concentrate on how to use these curves to make fine adjustments to the position of a probe (or probes).

That's it. Before reading further, you should be able to describe the general process flow to someone without referring to this sheet. Let's have a look at the parts of the tool.

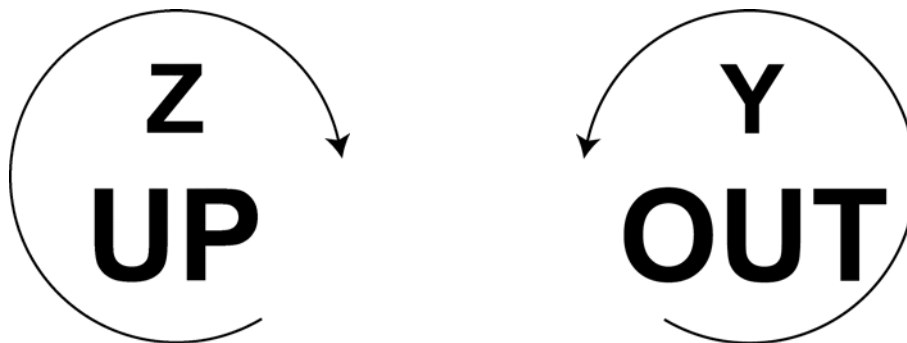
4. Removing probes and bringing the system to a safe state

Although your AFP has already been installed and standard samples have been measured, you're likely to find your AFP in an unknown shape at the start of an analysis. Therefore, it is critical for you to know how to recover the AFP into a safe condition and configure it for an analysis. Your analysis should be straightforward once your system is safely configured and aligned.

Before you adjust or reset any of the system components, you'll need the coarse X-, Y-, and Z-positions of the heads in their safety positions. At the safety position, the ends of the tips are 'up and apart.' Before moving on to the subsequent probe exchange-and-align step you must be confident that you can loosen the dovetail clamp and raise a head without hitting another head or tip, sample or the platen. It may be helpful to see a live image on the station support computer workstation display device. If your optical microscope is not working and you have to work blind, follow these steps in sequence to recover a safe configuration for the AFP.

Software Safe First: Probes to Midrange and Withdrawn.

Tip UP. Systematically rotate the Z-knob of each positioner about ½ turn CW to raise the ends of each tip by at least 250 microns over the surface. You can bypass this step if you are sure the probes will not contact the sample or the platen. Refocus your optical microscope (upwards) on the probes to verify that each of the tips has been raised.



Tip APART. Rotate each positioner's Y- (or, radial) knob ½ turn CCW to move the end of each tip several hundred microns apart from each other (Yum FOV).

Locate a probe using the microscope transport and then bring the probe into the FOV using its X by Y adjusters.

Tip UP. Rotate each positioner's Z-knob four to five full turns CW to raise the ends of each tip by more than 1 mm over the previous coarse Z-position setting. Refocus the optical microscope on the probes. You can **remove** an existing sample by translating the stage to the usual sample-exchange position.

If you intend to place a sample on an empty platen or replace an existing sample, the probes may hit the new sample. Please raise the heads high enough to accommodate the new sample. Add CW turns as required to the Z-positioner to ensure all probes will clear the new sample. Each full turn of the Z-positioner CW raises the head by 500 μ m. Alternatively, the chuck may be lowered to accommodate taller samples.

Tip APART. If you intend to change one or more tips, rotate again each positioner's Y- (i.e. radial) knob another couple of turns CCW to move the end of each tip a couple of millimeters farther apart (figure 1). Even at low zoom, you may not see all of the tips in the field of view. In this safe position, you can reset workstations, software and sample.

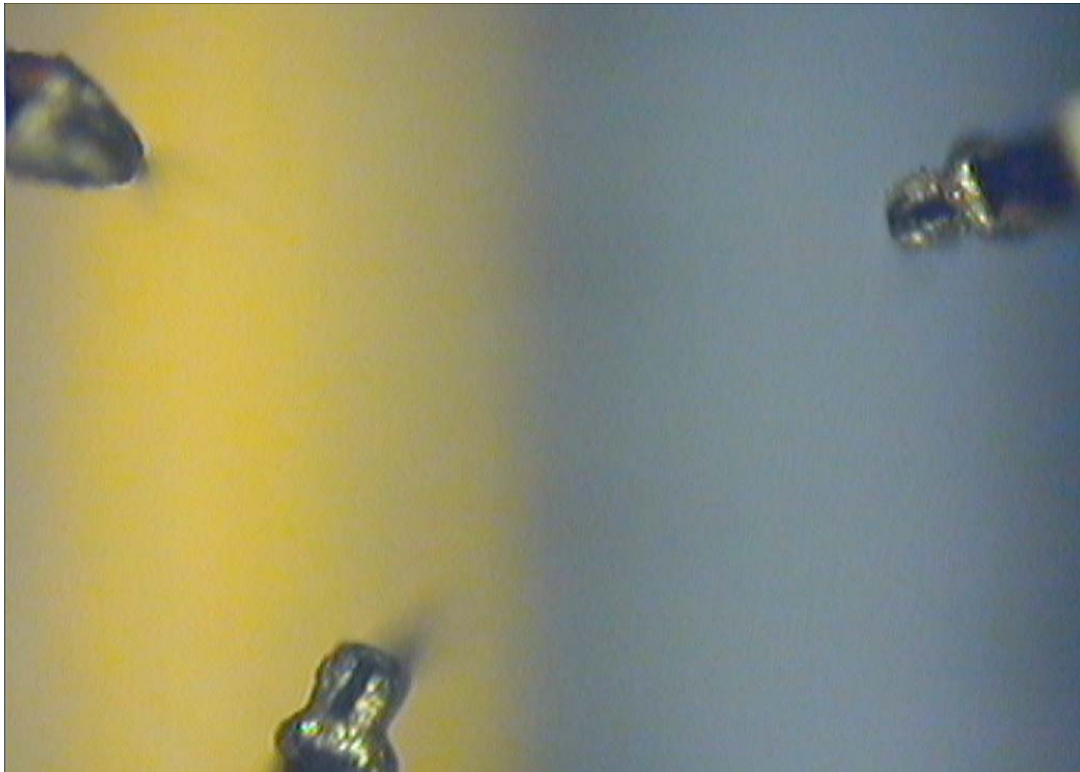


Figure 2: Optical microscope view of 3-probe system at 'System Safe' position (zoom= ~0, light= ~4). The optical microscope is focused about 1mm above the sample surface and the probe shanks are raised into focus. With the probes in the system safe-position, the sample may be removed, tips may be exchanged and the system is safe to power-off.

5. Removing a probe



CAUTION: Always wear eye protection around an exposed laser beam. Direct or diffuse laser radiation can inflict corneal injuries. Never look directly INTO the laser beam. Select protective eyewear that blocks 635nm laser diode radiation. Protective eyewear is available from Multiprobe, Inc.

Removing or installing tips in the AFP system, does not require the laser to be on. Use the Multiscan™ software to turn the laser OFF in the SETUP tab interface and verify that the **Laser On LED** is now OFF. This means that it is safe to access the tip. Alternatively, the beam can be blocked using the VRT knob on the top of the head (see Figure 8a). Turn the VRT knob clockwise, until it hits the end of its range. At this point, laser beam is completely blocked, and the tip can be safely accessed.

Once the AFP system is in a safe configuration, you can exchange one or more probes. To exchange a probe, raise the head up to the **probe-exchange height**, swap the probe, align the laser optics, and return the head to the safety position. If you are not changing a tip, raising the heads further is unnecessary. In this case, a realignment or check of the laser optics may be done from the **system safety height** or the **pre-engage park-position**.

For each head requiring a probe change, you'll follow this entire Exchange-and-Align sub-process before moving on to the next head.

To check or re-align the laser optics without moving any heads make sure all probes are disengaged from the surface.

Simultaneously loosen the dovetail clamp with one hand while raising the head straight up in the dovetail with your other hand. The bottom of the head should be above the top of the platen. Re-tighten the dovetail clamp.



Figure 3: A head is raised to the probe-exchange position before changing probes.

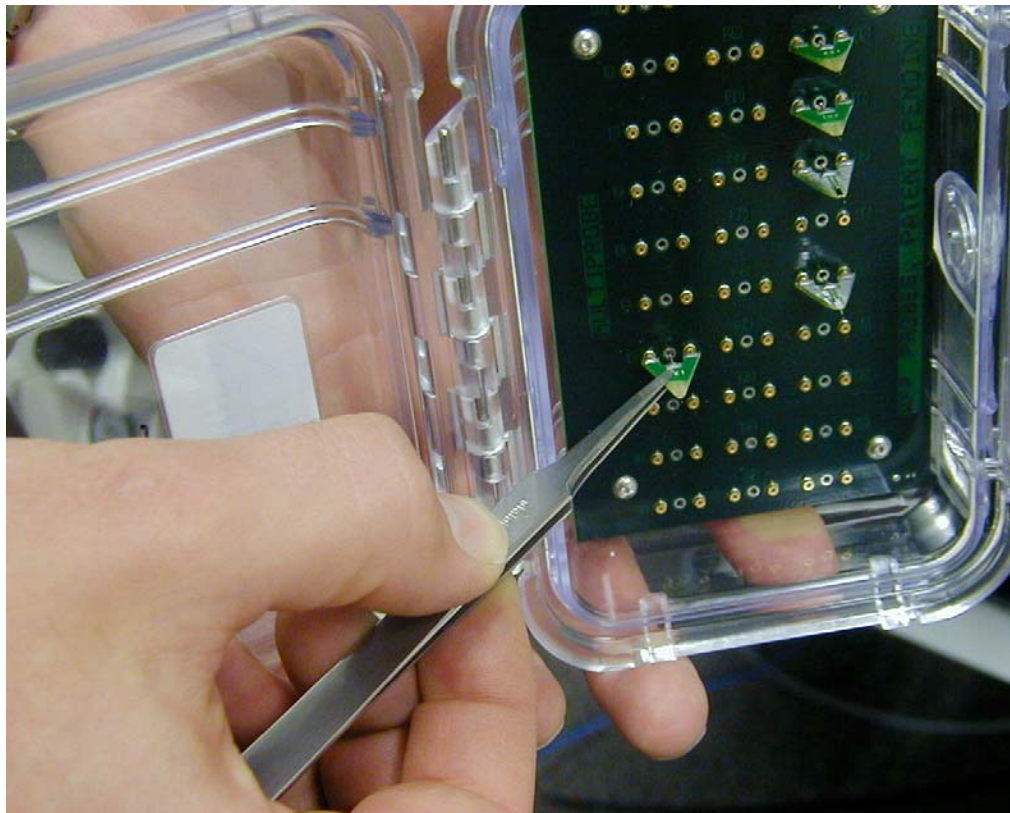


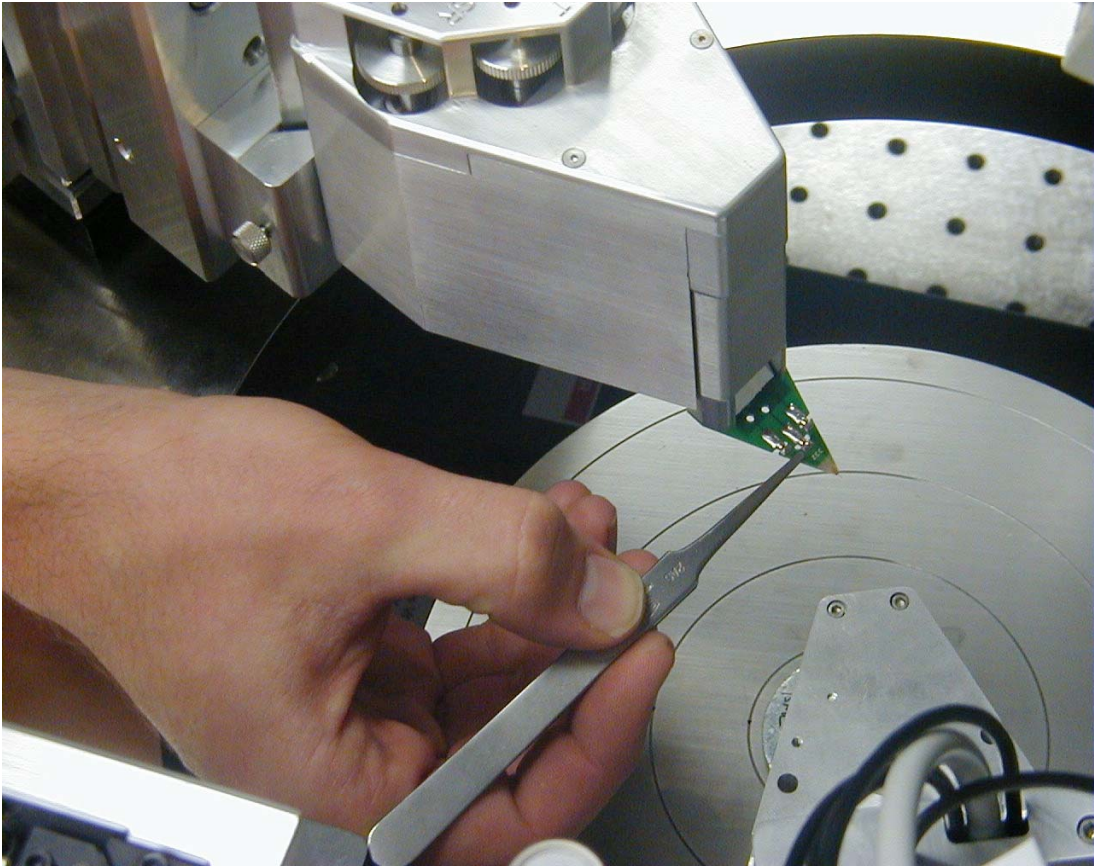
Figure 4: A new probe is ready for installation. Before removing a probe from the probe box, orient the box at the same angle as the receiving head for easy replacement.

5.a. Carefully put the tip in the application module with tweezers

Using tweezers, grab the near center of the probe mount along one of the angled sides (figure 4). Unplug the probe mount from the application Module Board, pulling gently along the long-axis of the probe mount. **Excess torque to board can damage piezo stage so pull gently.** Place the probe in a probe box and make a notation about the condition of the probe in your probe log book.

5.b. Start the Multiscan™ software

On the Multiscan computer, click on the start menu, then program files, then Multiprobe, the Multiprobe Multiscan. This will start the Multiscan software. If you have not already done so, the software will remind you to turn on the control box.



*Figure 5: While exchanging the probe, securely grip the probe mount in the center.
Gently remove the probe by sliding it away from the head.*

6. Installing a new probe

When holding the AFP Head, hold only the dovetail, shell or top cover. The Application Module and front face are attached to the sensitive piezo stage and should not be touched.

Hold the probe box so that a new probe has the same orientation as the destination Application Module Board. Use the tweezers to extract a probe mount from the probe box and subsequently insert all of the probe mount leads into the Application Module Board receptacles. Gently seat the probe mount leads in the receptacles.

6.a. Be careful not to push too hard, the piezo stage is very delicate

The probe receptacle is attached to sensitive piezo stage. Being mindful of the probe you just replaced and the rest of the probes in the system, and being gentle with the piezo stage at all times, take one finger on each side of the newly replaced probe tip board, and gently press the probe tip board further into the receptacles to ensure that it is completely seated.



Figure 6: Manually verify tip board is secure.

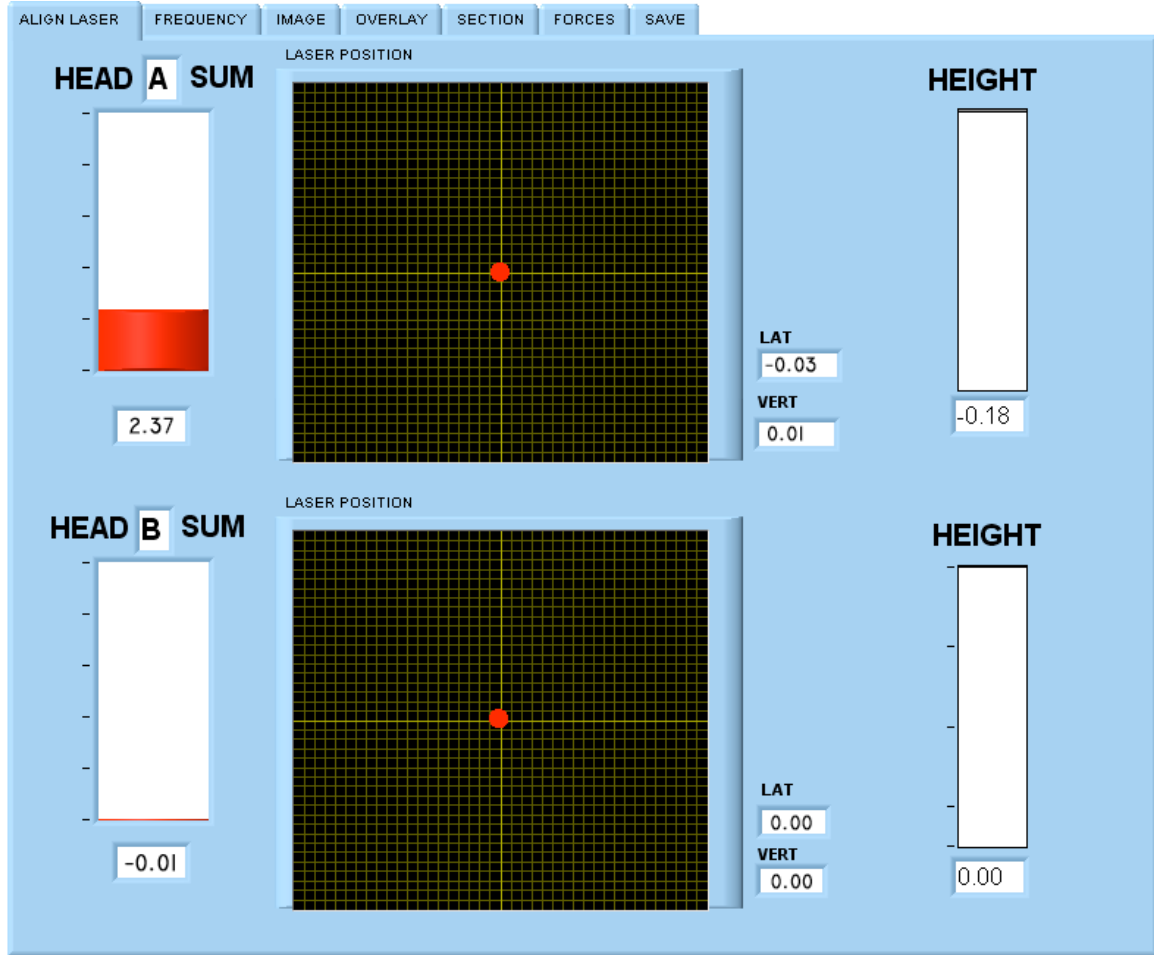


Figure 7: Multiscan™ ALIGN LASER tab interface comparing laser alignment maps of an aligned optical lever (Head A) and a completely misaligned optical lever (Head B). Such misalignment is typical with a newly exchanged probe, and is corrected with a full laser alignment-procedure.

7. Aligning the laser



CAUTION: Always wear eye protection around an exposed laser beam. Direct or diffuse laser radiation can inflict corneal injuries. Never look directly INTO the laser beam. Select protective eyewear that blocks 635nm laser diode radiation. Protective eyewear is available from Multiprobe, Inc.

In the Multiscan™ interface, verify the lasers are ON in the SETUP tab interface. Verify probes to Midrange is set to ‘Mid-Range’. Then select the ‘Align Laser’ tab. Two laser alignment-maps are displayed simultaneously. In Figure 6, Head A is shown having a well aligned laser, with sum greater than two volts and nominally

zero volt lateral (LAT) and vertical (VERT) deflections. Head B is typical for a tip that was just replaced. Laser alignment maps for other system heads (C, D, etc.) can be displayed by changing the head letter (x) in a pull-down menu in the 'HEAD (x) SUM' portion of the interface.

Adjust the two knobs on the right side of the top of the head (marked LSR, LAT and VRT) to move the laser so the spot can be seen on the probe mount (figure 7). The knob labeled 'LSR VRT' moves the laser along the long-axis of the probe, away from the head if turned CCW, and towards the head if turned CW. LSR LAT moves the laser perpendicular to LSR VRT. The laser moves left if LSR LAT is turned CCW and right if turned CW. The functions of the PD knobs are discussed in a following section.

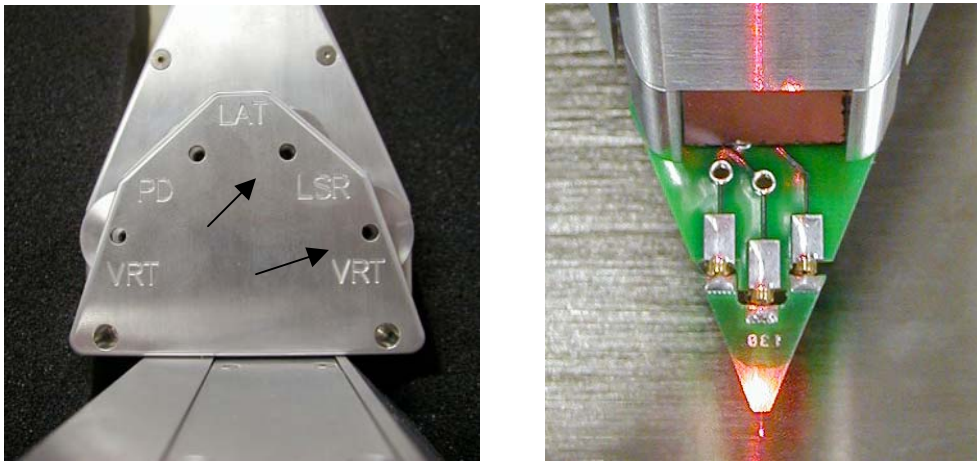


Figure 8a,b: Laser optic alignment knobs and the appearance of the laser spot when it is positioned on the probe mount after probe exchange.

7.a. Adjust the laser until you see the ‘flash’ at the end of the lever

Adjust LSR LAT (front) to position the laser spot so that the laser will run down the probe shaft when the LSR VRT knob is turned CCW. You should adjust the LSR VRT knob until you see the retro-reflector at the end of the probe brighten with scattered light. Maximize the brightness by adjusting LSR LAT (figure 8). In the align laser panel, you should see a ‘flash’ at the end of the cantilever and a SUM greater than zero in the sum bar on the software. Lateral and vertical deflections show random values. If you do not see a SUM greater than zero, continue to make small adjustments to the LSR VRT and LAT knobs until you see the ‘flash’ and the SUM becomes greater than zero. Lateral and vertical deflections will show random values.

7.b. Adjust both laser knobs to maximize the sum

Adjust the LSR LAT and LSR VRT to maximize the sum. If the maximum attainable sum is less than one volt, you can troubleshoot the problem by checking the location and quality of the reflected spot. Details on troubleshooting a reflector are available in the maintenance guide.

7.c. Place the spot on the laser align screen in the center using both detector knobs

After maximizing the sum, adjust the photodiode (PD) position to center the spot on the laser alignment map. The left-front knob of the top of the head (PD LAT) moves the spot left and right (laterally). When the photodiode is adjusted to the proper range, PD LAT will move the spot along a line sloped slightly upward and to the left. Adjusting the left-back knob of the head (PD VRT) moves the spot almost perfectly up and down (vertically). An optimum alignment of laser optics will result in an ‘ALIGN LASER’ screen similar to that shown for Head A in figure 6.

7.d. Turning the ‘Lat’ knob should yield a slight motion from lower right to upper left.

Turn the PD LAT knob and verify that the laser spot moves from lower right to upper left. If, the spot motion on the detector screen is opposite, please see the maintenance manual for troubleshooting of the reflector.

7.e. Align laser for constant sum

Readjust the LSR LAT and VRT knobs to a location where changes in the knob position affect the SUM as little as possible. While you are adjusting LSR LAT and VRT the spot will move around on the detector screen, this is okay. You are making fine adjustments of the laser spot location on the reflector.

7.f. Realign the detector

Re-center the spot on the detector screen by re-adjusting the PD LAT and VRT knobs.

7.g. Check Z-vert coupling

While clear of the sample, change the feedback mode to SERVO MANZ. With the MANUAL Z value set to zero, note the value of VERT (also called deflection). Enter a MANUAL Z value of 30 and note the new value of VERT. The value of VERT should have increased by a value between 0V and 0.1V.

Return the value of MANUAL Z to zero and return the feedback mode to CONTACT.

7.h. Optical Interference

Optical interference is a consistent striping superimposed on the image. Optical interference appears to be “wavy” topography. Optical interference is the result of poor laser alignment. There is no test we can do at this point to determine the quality of our optical interference, however, if this irregular problem occurs when you begin to image, readjust the laser spot location on the reflector, such that optical interference is minimized.

8. Approaching the tips and sample

8.a. Without the optics in place, bring the tips close to one another and close to the sample

Rotate the raised head's Y- (or, radial-) axis knob two full turns CCW to back the tip off at least one additional millimeter from the lowered probes. This precaution minimizes the risk of hitting other probes when you lower the head

Loosen the dovetail clamp and lower the head to the height where the probe is about 3mm above the other probes. Re-tighten the clamp to secure the head in the dovetail.

Make sure the dovetail clamps are tight.

Inspect the radial position of the repositioned probe and determine if it can be lowered further. If there is a possibility it will hit one of the probes, rotate the radial-axis knob CCW until the probe is clear for lowering to the height of the lower probes.

Rotate the Z-axis knob CCW until the newly replaced probe is level with the other probes (at least 1-3 mm above the highest surface, sample or empty sample platen).

The closer you get them now, the easier the next step will be. However, crashing the tips or sample together would be very bad.

You must complete the entire Exchange and Align process for each head requiring a probe change before proceeding.

8.b. Lower the optics

Bring careful not to crash the optics into the heads, lower the optics into position and verify focus on the tips. Do not descend below the tip focus and crash into the tips.

8.c. Bring all tips in so they are viewable on the same screen at the lowest zoom (0), but still far apart.

8.d. Verify the software settings

Once the probes are in a safe position, but still more than 50um from the surface, you can check the workstations and software settings to clear any dangerous settings.



Figure 9a,b: Image a) At zoom= ~50, light- ~8, the optical microscope is re-focused up from the surface. Image b) is about 20microns 'over' the sample. The tips are about 1mm above the surface.

The probes should all be at the same height, safely above the surface of the sample, either in the Parked or Pre-Engage position.

In the Multiscan™ interface, verify these 'SETUP' Tab settings:

Number of heads: set to the number of heads on your system. In this example, the system has 2 heads.

Lines per image: 100

X and Y scan sizes: 15µm

Scan angle: 0 degrees

Probes to MID-RANGE

If the alignment step was done with the probes set to 'HOME' or DISABLED they will crash when set to MID-RANGE

8.e. Set all offsets to zero

A time saving step when all probes are roughly the same height is to bring all probes to within a 1-2 mm of each other. If this is done by eye before using the optical microscope, most probes will be within the FOV.

While focused on the tips, and with all tips far apart from one another, set the X OFFSET and Y OFFSET values to zero. Clicking the CLEAR OFFSETS button will do this.

Deselect the PROBES TO MID-RANGE, which will start the probes scanning. Verify that all probes scan in the same direction. If the probes do not scan together, the angle can be adjusted by changing the parameter PLATEN ANGLE.

Verify that the probes are at mid-range (not scanning) and that all offsets are zero.

At this point you should have a sample mounted on the chuck. Make sure the probes are safely above the sample and all are at approximately the same height. Be sure to verify the optical microscope and station support computer workstation are functional. While focused on the tips, and with all tips far apart from one another, set the X OFFSET and Y OFFSET values to zero. Clicking the CLEAR OFFSETS button will do this.

8.f. Verify that all probes are scanning together

Platen angle settings require the measurement of the angle of each head on your AFM platen. Using a protractor, measure the angle that each head relative to the normal of the front face of the plate (the zero degree reference). Angles are measured counter-clockwise from the front face as shown in figure 10.

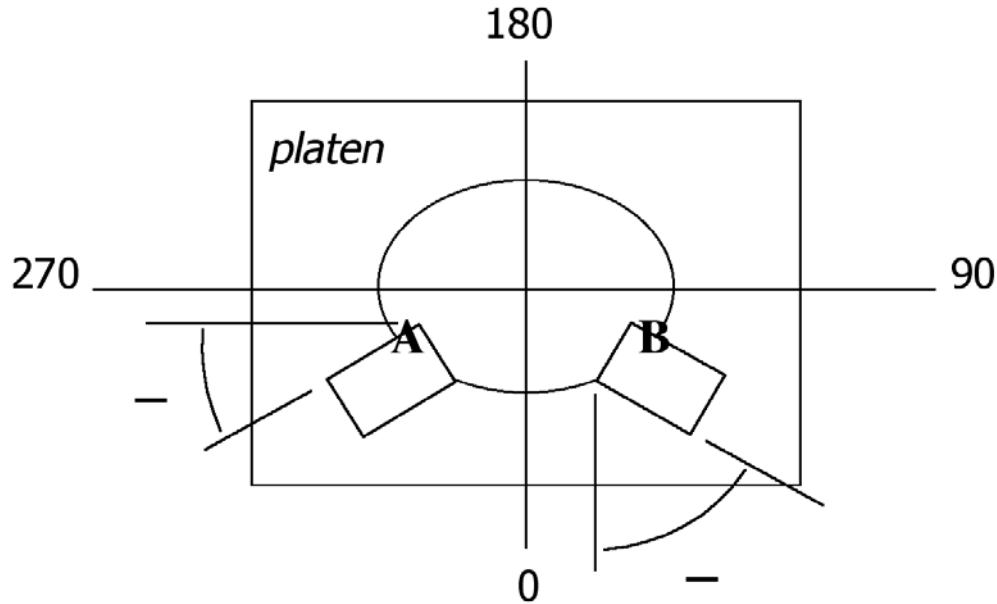


Figure 10: Schematic top-view of an AFP platen with an example orientation of a two head system. Platen angles are determined relative to the front face of the platen and the angles are recorded in the SETUP tab of the Multiscan™ software interface.

For example, with a two head system having this particular arrangement of heads, Head A is measured at a degree relative to the 270 degree-line. Thus, the platen angle of A is $270+A$. Head B makes an angle relative to the 0-degree line so the platen angle of Head B is simply B.

Enter your values into the Platen Angle variable fields of the Multiscan™ setup tab. Remember that the Head ID (A, B, etc.) is determined by the connection of the head to the control box. Regardless of the position on the platen, Head A is defined by a connection to the left-most interface board of the controller, as you view the controller from the back (where the cables exit).

Click the PROBES-TO-MIDRANGE button to release the probes from their midrange position and start them scanning. Verify that all of the heads are scanning in the same direction.

If the heads are not scanning exactly together, adjust the platen angle of the unsynchronized head until all heads scan together visually.

Click the PROBE-TO-MIDRANGE button again to stop the probes from scanning and send them to their mid-range position.

8.g. Make sure all offsets are set to zero and the probes are at mid-range

Verify that all offsets are zero and that the PROBES TO MID-RANGE button is true. If either of these cases is not satisfied, a serious probe crash could result later in the process.

Set the optical microscope to zoom= ~0, light= ~4. If the sample is not directly under the probes, move it into position now. Locate one or more probes and focus with the optical microscope focus-knob. If the other probes are not in the FOV, translate the optical microscope objective to locate each of the other probes and bring these probes into focus by adjusting the appropriate Z-positioner. All probes should be at the same height. It is not necessary that all probes will be in the same FOV at the end of this step.

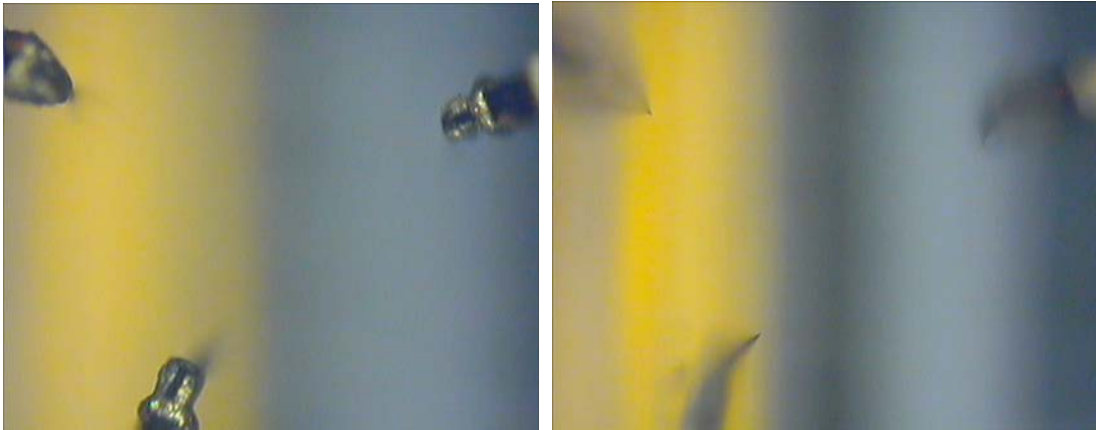


Figure 11a,b: Image a) All three probes are in the optical microscope field of view (zoom= ~0, light= ~4), sitting 1mm above the surface. Focusing downward, Image b) shows the relative focus of the tips.

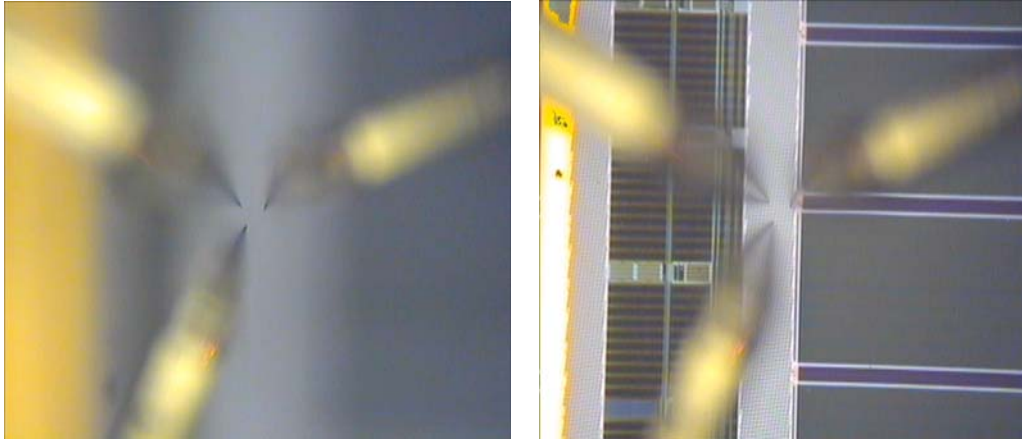


Figure 12a,b: All three probes are within 250 μ m of each other. Image a) shows the focus on the tips. Image b) is focused on the sample surface.

To be safe, adjust the height of the probe upward if it is not in focus. Remember that the Z-positioner moves up when its knob is rotated CW. Select one of the probes as the reference (not to be moved) position and incrementally translate each of the other probes into the same FOV as the reference probe. You must avoid hitting the other probes. Iterate the repositioning of the probes and the shifting of the optical microscope FOV to keep the 'moving' probe always in the optical microscope FOV. Adjust both X- (radial) and Y- (lateral) positioners to move all the probes into a single optical microscope FOV (figure 12).



Figure 13: At pre-engage park the probes are approximately 20 microns above the surface. At zoom= ~0, light= ~4 setting, each probe and fuzzy outlines of the larger sample features can be seen in the FOV of the optical microscope.

Translate the probes into the middle of the FOV. The probes can be safely positioned to within about 250 μ m of each other. Adjust the X- (radial-) and Y- (lateral) positioners incrementally to avoid probe collisions. The height of the tips is should be about 1mm above the sample surface.

Translate the sample in X- and Y-directions to find the brightest area.

Adjust the optical microscope downward, bringing into focus the small black region at the end of one of the probes. This is the actual tip. Adjust the height of the other probes with the Z-Positioner to bring the tips of each probe into focus (figure 12).

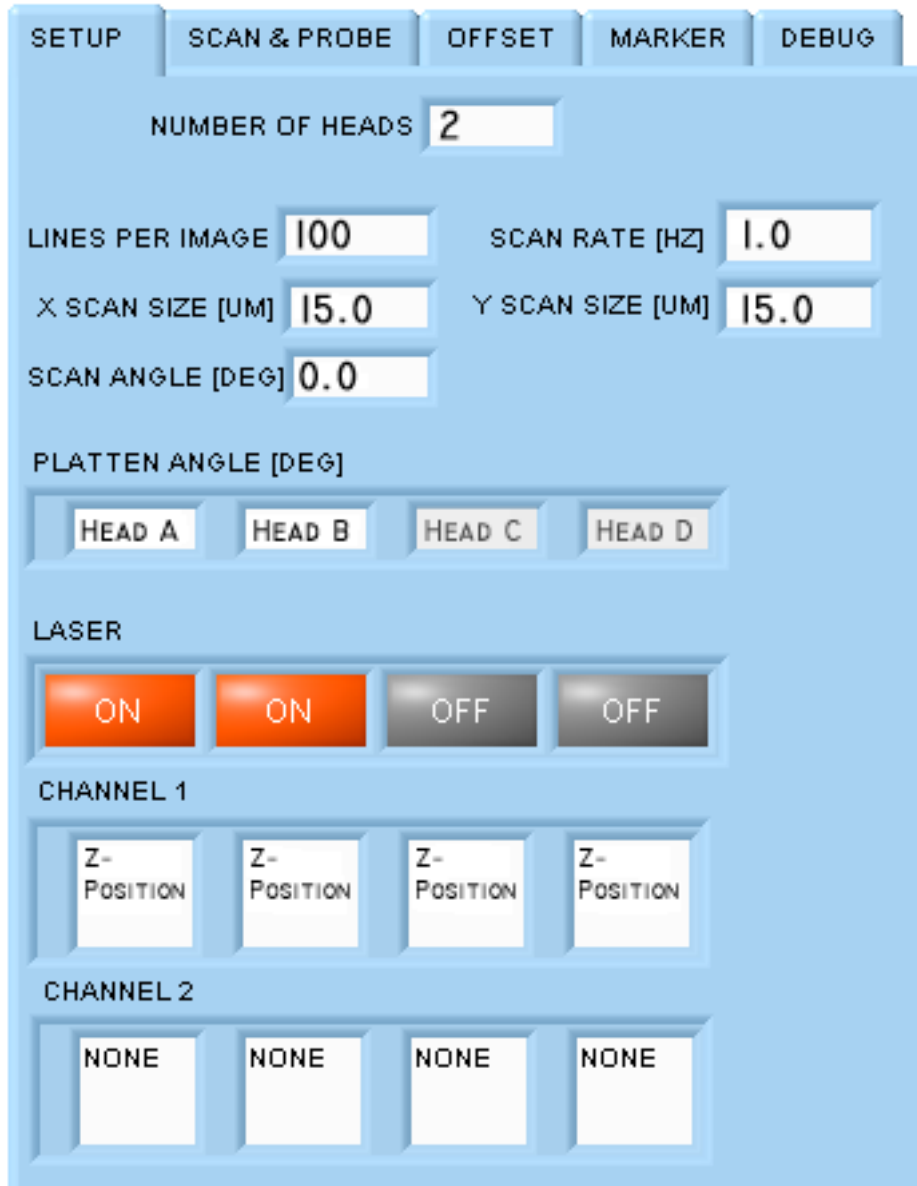


Figure 14: Example of a completed Multiscan™ interface SETUP tab upon completion of the pre-scan system check. This is suitable for a two head AFP configuration.

If the Multiscan™ interface shows more variables than your system has heads, you should enter select ‘Disable Head’ button.

Verify that the laser for each of the heads is ON.

Verify that the Channel 1 selection for each of the heads is set to Z-position.

When finished, the Multiscan™ interface SETUP Tab settings should look like those in figure 14.

8.h. Approach the tips and sample

Carefully bring the tips to within about 3 mm of one another under high zoom (AZoom = 50).

Focus below the tips (clockwise) by 100 mm with the optics. Using the Z sample stage, bring the sample into focus. Be careful not to overshoot the focus, as this could crash all of your probes into the sample.

Focus below the tips by 25 mm with the optics. Verify you are still in high zoom. Using the Z sample stage, bring the sample into focus. Be extra careful of a crash at this close proximity between the tips and sample.



Figure 15: Example of a completed Multiscan™ interface SETUP tab at the end of the pre-scan system check. This is suitable for a two head AFP configuration.

8.i. Bring the tips very close, to within about 3 mm, under high zoom (AZoom>50)

Carefully bring all probes very close together using the coarse positioners. Typically within about 3 mm is achievable, while still maintaining a low risk of crashing the probes.

8.j. Focus 20-25 m below the tips

Focus 50 m below the tips. Using the fine adjustment knob on the optics, focus down 50 m. Using the Z lift on the chuck, bring the sample up into focus. Be very careful not to overshoot the focus, as this will crash all of the probes into the sample.

Refocus on the tips, and then focus 25 m below the tips.

8.k. Carefully and slowly move the Z sample stage up to the tips by turning the adjuster clockwise, under the same magnification

Again, using the Z lift on the chuck, carefully bring the sample up into focus. Be very careful not to overshoot the focus.

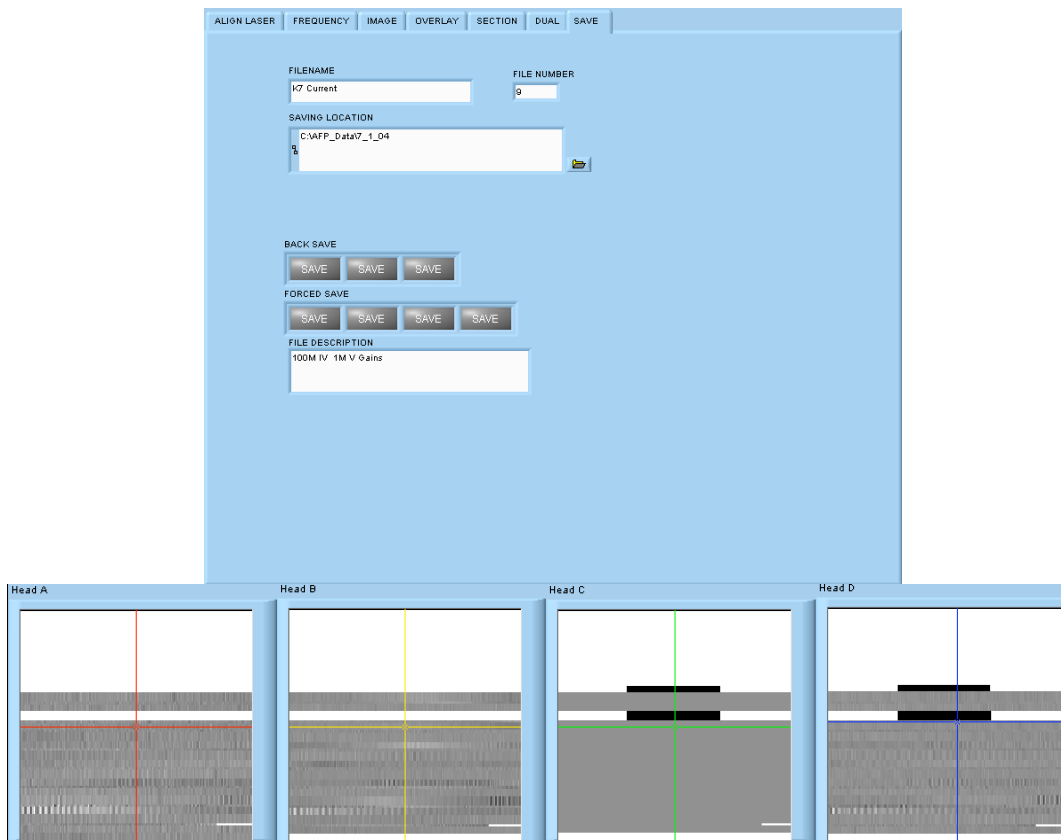


Figure 16: Multiscan™ SAVE Tab interface configures the ‘SAVE’ path and provides a field to include descriptive notes for the ‘capture’ of scanned images.

8.l. Configure Save Tab

In the Multiscan interface, select the ‘SAVE’ tab. You can now modify filenames, file save paths and descriptive file notes according to the requirements of your analysis. You should consider changing filenames between analyses to avoid confusion in the image archives.

9. Configuring Force Feedback

In the Multiscan™ interface, verify the 'OFFSET' tab settings for X- and Y-Offsets are zeros (figure 15). The offsets can be set to zero manually by entering zeros in the variable fields for each of the heads. Likewise, the offsets can all be cleared (set to zero) simultaneously by clicking the 'CLEAR OFFSETS' button.

During this step, it is easy to accidentally hit one of the 'OFFSET TO CURSOR' buttons or the 'OFFSET TOGETHER' button. , If the values in the X- or Y-OFFSET variable fields change from zero, you can re-set the offsets to zero as described above. These two functions will be discussed in a later section.

In the Multiscan™ interface, select the 'SCAN & PROBE' tab and verify the settings are as follows:

Engage: all heads set to 'OFF.'

Probes to Midrange: MID-RANGE. If set to 'SCANNING' click button once to return probes to MID-RANGE.

PROBE ALL: OFF

DARK PROBE: OFF

Feedback Mode: the switch field is set to 'CONTACT' for each of the connected heads on your system. In this example, the system has 2 heads, connected to the controller as heads 'A' and 'B'. If the number of heads on your system is less than the maximum number, those feedback mode switch fields will default to 'MNZ', a function setting not explained in this manual.

DEFLECTION SETPOINT: for each head, set the value to 0.05 Volts above its 'DC' vertical deflection (VERT) value. VERT is shown in the Multiscan™ interface 'ALIGN LASER' tab (figure 5, page 11). You must check the VERT value for each head before setting the deflection setpoint. If the DC value of any of the heads is more than $\pm 0.1V$, re-align in the photodiode position to bring VERT closer to zero. Be careful not to crash the probes during re-alignment.

9.a. The surface engaged in force feedback

Select the Multiscan™ interface 'SCAN & PROBE' and 'ALIGN LASER' Tabs and verify the 'DEFLECTION SETPOINT' variable setting for each head is 0.05 Volts HIGHER than the VERT value displayed for the corresponding head.

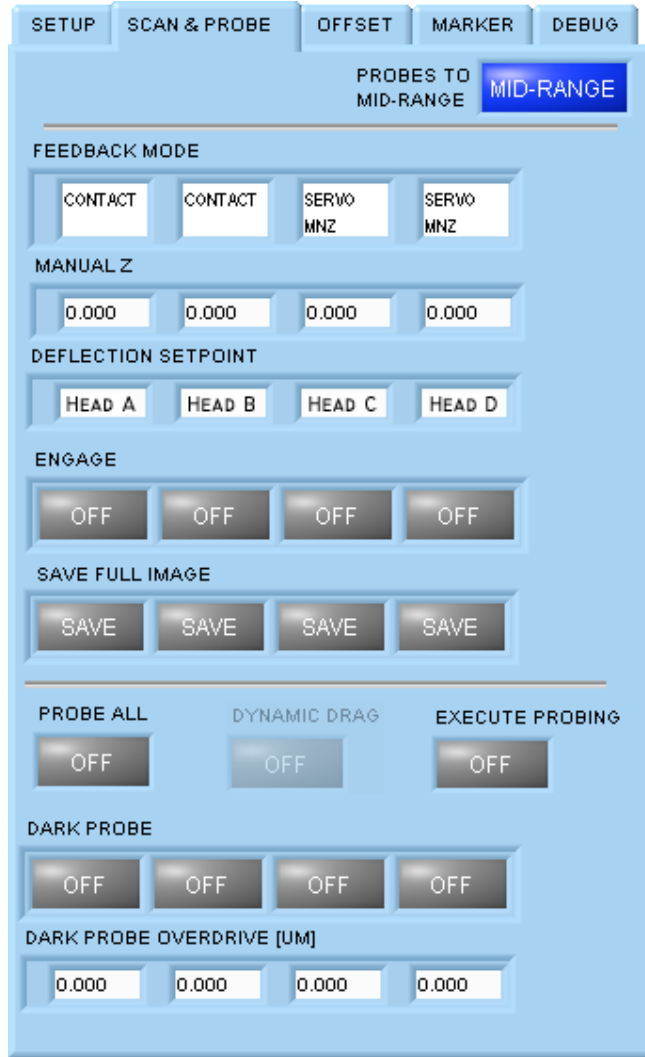


Figure 17: Example of a completed Multiscan™ interface ‘SCAN & PROBE’ tab, as it should appear at the end of the pre-scan system check. This is shown for a two head AFP system.

In the Multiscan™ interface ‘SCAN & PROBE’ tab, switch ‘ENGAGE’ to ‘ON’ for each of the heads connected to the Multiscan™ Controller Electronics Box.

In the Multiscan™ interface ‘ALIGN LASER’ tab, note the ending position of the grey HEIGHT bar for each of the heads you set to ‘ENGAGE ON’ in the previous step. The target position for an engaged probe is 20µm ± 5µm. If the HEIGHT bar is out of range, select the appropriate corrective procedure:

9.b. Reposition sample chuck in Z, if needed

—If the grey height bar above shows the Z-piezo of EVERY head to be fully extended ($>30\mu\text{m}$), the chuck needs to be repositioned:

Disengage the heads by switching ENGAGE to OFF (SCAN & PROBE).

Never make physical adjustments when engaged. ALWAYS switch ENGAGE to OFF before moving any knob: positioner knobs, laser knobs, detector knobs or sample stage. Also note that the station itself should not be touched at all when the tips are engaged.

Rotate the Z-axis of the sample chuck, and then carefully bring the chuck up. Monitor the vertical deflection (VERT) of the Head being lowered. If you see the laser spot position move up on the alignment map and the VERT value move positively, you have hit the surface and the probe is likely ruined and needs to be replaced.

In the Multiscan™ interface 'SCAN & PROBE' tab, re-engage only the probe of the just-lowered head. Switch the ENGAGE setting for that head to 'ON'.



Figure 18: Optical microscope view of multiple tips parked above the relatively bright periphery area (zoom= ~50, light= ~8). The pre-engage park-position is approximately $15\mu\text{m}$ above the surface and the probes are $250\mu\text{m}$ apart.

9.c. Repositioning one head, if necessary

—If the grey HEIGHT bar shows the z-piezo of any one of the heads to be extended greater than 30 μ m but not fully extended, that head needs to be repositioned:

In the Multiscan™ interface SCAN & PROBE tab, switch every head ENGAGE to 'OFF'.

Rotate the Z-positioner of the out-of-range head CW enough to bring the engage height into range. Recall that the index on the positioner knob corresponds to 10 μ m/division.

In the Multiscan™ interface SCAN & PROBE tab, re-engage only the probe of that head just lowered. Switch the ENGAGE setting for that head to ON.

Observe the ending position of the grey HEIGHT bar and evaluate as described above.

Once the above is engaged within the proper range, disengage the head.

Focus the optical microscope (zoom= ~50, light= ~8) on the end of the tip of the re-positioned head.

Lower the other heads with the Z-positioner (CW) to bring the tip of each head into focus.

In the Multiscan™ interface SCAN & PROBE tab, switch every head to engage and re-evaluate the position of the HEIGHT bar of each head as described above.

—If the grey HEIGHT bar shows the z-piezo of any one of the heads to be extended to less than 10 μ m, that head needs to be raised:

In the Multiscan™ interface SCAN & PROBE tab, switch every head ENGAGE to OFF.

Rotate the Z-positioner of the CCW to bring the engage height into range. The index on the positioner knob corresponds to 10 μ m/division.

In the Multiscan™ interface SCAN & PROBE tab, re-engage only the probe of that head just raised. Switch the ENGAGE setting for that head to 'ON'.

In the Multiscan™ interface SCAN & PROBE tab, switch every head to engage and evaluate the position of the HEIGHT bar of each head as described above) Bring the tips into Pre-Scan Proximity (<10 μ m apart).

Verify that no probes is Engaged (ENGAGE switched to OFF).

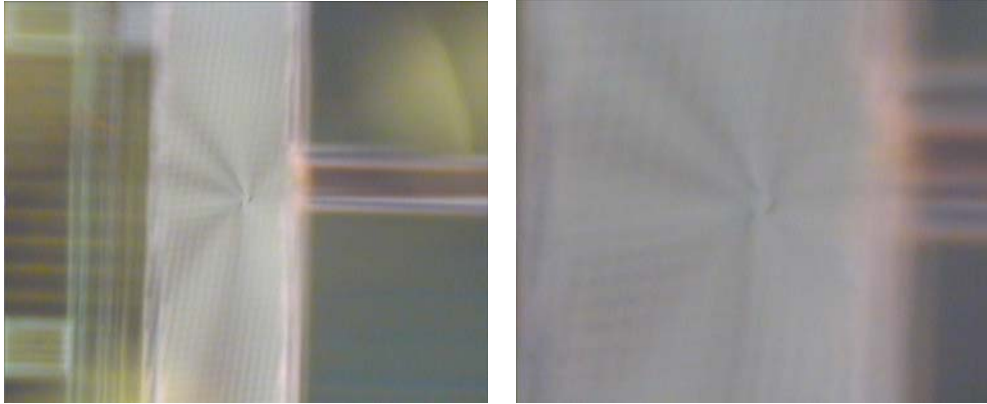


Figure 19: At 15 μ m height above the surface, it is safe to bring probes into close proximity. Zoom= ~0, light= ~4 (Image a) is inadequate for the final positioning. Zoom= ~50, light= ~8 (Image b) allows the probes to be final-positioned to within less than 10 μ m apart.

Translate the probe tips into close proximity by rotating the X- (radial) and Y- (lateral) positioners of each head CW as needed (figure 19), if needed. The distance between the probe tips should be no more than 5 μ m. The width of the cantilever is approximately 100 μ m.

Translate the sample to center a unique feature between the probes.

Check the Setup of the Scanner and Force Feedback sub-systems.



Figure 20: Optical microscope view of the probes in position to image the corner of the array. The corner is a unique feature appearing in each of the scanner images that serves as an alignment mark for registering the relative head positions.

9.d. Verify force feedback settings

In the SCAN & PROBE tab of the Multiscan™ interface, verify that the FEEDBACK MODE for all heads is set to CONTACT.

Verify that the DEFLECTION SETPOINT parameter settings are set at 0.1 to 0.05 volts above the VERT display in the ALIGN LASERS tab. Re-adjust the deflection setpoints as needed.

In the SETUP tab of the Multiscan™ interface, set SCAN SIZE to 10-15µm and SCAN RATE to 1.0 Hz.

Switch the ENGAGE buttons for each head to 'ON'. Verify that all heads engage on the surface.

10. Scanning the AFP

Switch the PROBES TO MID-RANGE button to SCANNING and scan the sample. Scan from top (ctrl+t) or scan from bottom (ctrl+b) as required to shorten the time required to get a full scan for each head.

10.a. Too little force

If the deflection set point is too low, there will be very little force applied to the sample by the tip and the tip will have a tendency to lift off the surface. Increase the deflection setpoint by 0.01 V (clicking F1 for Head A, F3 for Head B, ... will also achieve this)

10.b. Too much force

If the deflection set point is too high, there will be too much force applied to the surface of the tip and the tip will have a tendency to drag and stick to the surface. Decrease the deflection set point by 0.01 V (clicking F2 for Head A, F4 for Head B, ... will also achieve this).

10.c. Align Image Overlay

Register heads on a common (big) sample feature. Place the cursor of each head onto a feature common to all images. In the Multiscan™ top menu bar, 'Image Overlay' pull-down the menu to 'Record Relative Position of Heads.' In the Multiscan™ interface OVERLAY tab, the images are shifted and multiple images are 'montaged' (figure 22) In the region of overlap, you should find a recognizable and uniquely shaped or sized feature. A corner feature in the periphery (a generally bright area where the tips are easily seen optically), near the edge of an array is ideal.

Verify platen angle settings. With the OVERLAY tab on top, verify that the overlay images are rotationally aligned. Check the relative orientation of edge features from in the overlay image by bringing each head-image to the top and comparing common features within images. If necessary, adjust the platen angle:

In the SETUP tab, change the platen angle variable of one of the misaligned images to rotate the images into alignment. Raising the angle will rotate the displayed image CCW by the incremented amount.

After adjusting the platen angles to correct the rotational misalignment, fully re-scan the sample. Set PROBES TO MID-RANGE to SCANNING and display a set of newly acquired full images. Frame-up (ctrl+b) or frame-down (ctrl-t).

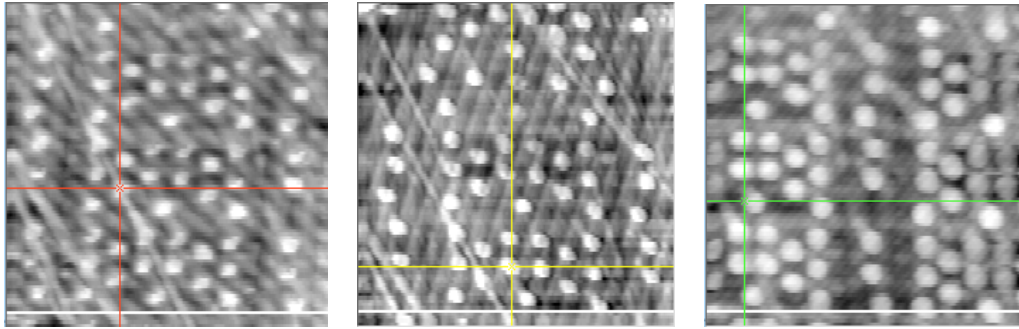


Figure 21: Each head depicts a common sample feature.

Repeat the previous and current as necessary to obtain a good angular relationship between each of the overlay images and stop the scan (PROBES TO MIDRANGE switched back to MID-RANGE)

Re-register the heads on a common feature.

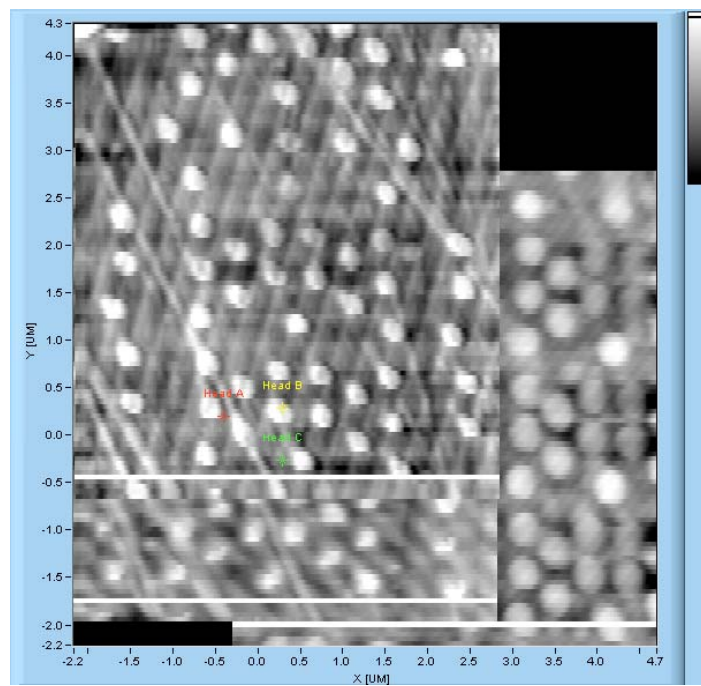


Figure 22: After registering the heads to a feature common to each image, an overlay image is created for easy placement of the probes.

Remember the platen coordinate-system when adjusting the angle of an overlay with misoriented constituent images. In the platen coordinate-system, the PLATEN ANGLE increases in a CCW manner. Multiscan™ calculates the scanner rotation and also adjusts the associated display image when the platen angle is changed.

10.d. Move the probes closer together

Bring the head-cursors in the OVERLAY image within 2µm of each other. In the OFFSET tab of the Multiscan™ interface, switch the 'OFFSET TO CURSOR' buttons to ON. For a moment the 'OFFSET TO CURSOR' button will show ON (blue). Once the offset is complete, the X- and Y-OFFSETS will update and the button will return to gray and show OFF.

You can also use the AUTO OFFSET feature to move the probes closer together. Note that AUTO OFFSET only works after RECORD RELATIVE HEAD POSITION has been used, and that AUTO OFFSET only works when the X and Y offsets are set to zero. This is due to AUTO OFFSET centering the heads about their actual, physical center position.

Set the X- and Y-scan sizes to 3 to 4µm for 0.13µm technology to make your features large enough to probe.

Re-start the scan and display a new full image.

Re-register the heads and sample.

Each time you execute an OFFSET TO CURSOR command, the actual relative head positions are changed absolutely. Because the unique capabilities within the Multiscan™ interface OVERLAY tab are necessary for probing of sub-100 nanometer devices, it is best to re-scan and re-record the relative head positions after any probe is offset.

10.e. Withdraw the tips (deselecting 'Engage') and move to the area of interest

Stop the scanner (switch PROBES TO MID-RANGE to MID-RANGE).

Once you have configured and aligned the various AFP sub-systems, it is simple to place probes and execute an analysis. However, thermal-drift induces offset errors that are the primary problem at this stage of the process. Periodically check and correct the registration of your heads and sample.

Disengage all probes from the surface (Multiscan™ interface SCAN & PROBE tab, switch ENGAGE to OFF)

11. Probe Device

Verify the scan size. The size you will use depends on the feature size and layout of your sample's technology.

Re-focus optical microscope on the surface of the sample. Select a lower zoom setting to see the color fringes in the oxide and to more easily locate the area of interest more easily.

Translate your sample to the area of interest (from the fiducial area used to register the probes and sample).

In the SCAN & PROBE tab interface, compare the DEFLECTION SETPOINT against the VERT values of each head in the ALIGN LASER interface. Adjust the values to keep the force feedback calibration in specification.

Switch ENGAGE for each of the system's connected heads to ON (SCAN & PROBE tab)

Resume scanning by switching SCANNING from MID-RANGE to SCANNING (SCAN & PROBE tab).

Collect a full scan of the area of interest.

In the OVERLAY tab, quickly evaluate the registration of heads by sequentially bringing each head's image to the top. As you cycle through the overlay images, the overlay will show the features in the overlapped area to shift by only a few 10s of nanometers from image to image. If the size of the shift is larger than the size of a shell, re-register the heads.

In the OVERLAY tab, move each cursor to the proper contact of the top-image of the overlay. Use the probe cartoon to be sure you have not crossed any of the probes. (Do not OFFSET any of the probes to the cursor, as this will crash the probes.) You are now using the cursors for probing, as bringing the probes close to one another and the overlay alignment has already been achieved.

In the 'SCAN & PROBE' tab, verify that the status of PROBES TO MIDRANGE is SCANNING. If the status shows MID-RANGE, switch to SCANNING.

In the 'SCAN & PROBE' tab, switch PROBE ALL to ON In the 'SCAN & PROBE' tab, switch 'EXECUTE PROBING' to ON. The probes will automatically offset their positions on the sample to where you placed the cursors in each head's image. F12 is assigned to the 'EXECUTE PROBING' function. For a complete list of hotkeys, please refer to Appendix C.

Now your AFP probes are positioned and the analysis is ready for execution.

Placing the probes may require iteration to verify the position of all of the probes. Also, plan your remaining steps and proceed quickly. As soon as you stop scanning you are in a race against drift effects, such as thermal drift. However, at any time you can rescan the area of interest, reregister overlay and update your images to any drift that has occurred.

Using your curve tracer, parameter analyzer or the Multiscan™ GPIB interface, check that the parameters are still appropriate for the immediate analysis. Note the placement of probes on their respective nodes and re-confirm that the assignment of the Head (A, B, etc.) to the node (gate, etc.) is correct.

Evaluate the I-V curve response and characterize the node connections (e.g., open, high-resistance, good, etc.) accordingly. Re-position the probes as necessary, according to the procedure described in section 4.E.2, to optimize the results.

If your measurement is satisfactory, you may re-position the probes on other devices within the intersection of the image overlay.

If your probing proceeds fruitlessly, re-check the registration:

Re-image the area of interest by switching PROBE ALL to OFF. The SCANNING switch should automatically be set to SCANNING.

In the Overlay image (OVERLAY Tab of the Multiscan™ interface), move each of the ‘head cursors’ onto one of the features of the top image. Place all of the cursors on the same feature, near the middle of the intersection (overlap) of the overlay images.

Bring each of the heads’ image to the top of the overlay. As each ‘head’ is brought to the top, re-center that head’s cursor on the feature. You will see a small shift in the position of the features although the cursors should be within a few 10’s of nanometers from each other.

If you are not satisfied with the alignment and are ABSOLUTELY SURE that the cursors are on the same feature, re-register the heads and samples.

Eventually, thermal drift will alter the registration of the tips and reference images to the point that you must re-register the tips and sample.

12. Probing Techniques

12.a. Effective nanoprobng takes practice and skill (just like manual microprobing but at a much smaller scale)

Effective nano-probing takes practice and skill. The same factors exist as in micro-probing, but at a much smaller scale. Skate, making good contact and keeping tips sharp are all still probing issues, just with much finer force, finer positional control and sharper tips.

12.b. Check the contact of each tip on a source or drain node of a bulk transistor with the back contact (bulk) grounded and the gate floating

Effective probing is a sequential process. Establish one contact before moving forward to the next. For a bulk measurement it is possible to verify each connection before placing the next. First, verify that each tip is making good contact. With the backside (bulk) contact connected to ground, verify that each probe can establish a reverse diode contact to the backside through a source or drain via. Make sure that the gate of the transistor is floating during this process.

12.c. Always probe from the image from the head that is probing

Because the probe tip that gathered the image is the same tip that will be probing, always be sure to probe with the cursor on the same image. Especially in overlay there can be a tendency to probe from a different head's image. This adds in additional alignment errors, and can unnecessarily complicate getting contact.

12.d. Search for the contact, starting with the center of the target via

Use a sensible search pattern when looking for good contact. You can aid your search by moving "across" the via when creating your search pattern. Often times a probe will have a certain, specific location that will make the best contact. Try to remember this location, so you can locate the best contact more quickly.

12.e. If the search doesn't work, try adjusting the force

In addition to the probing location, the probing force is another factor that contributes to quality, solid contact. Increasing the probing force can often times create a solid and lasting ohmic contact. Similarly, the DARK PROBE feature can generate much larger forces than the force-controlled CONTACT probing can. DARK PROBE should be used with caution when translating large distances (and should not be used when scanning), but it can be a very valuable tool for making good contact.

12.f. If contact cannot be made

If contact cannot be made, you will need to verify that everything is still working. Checking that the probes have not drifted off of the surface, rescanning to see if the sample or tips have drifted, pulling other probes back in case the probes are shorting together, checking wiring to your curve tracer and conditioning the tip (see below) are all common solutions to problems that can cause no contact. Repeat this process for all of the tips, so you are confident that each of your tips can make good contact to a via.

12.g. Place the source tip, as described above, to get a source-bulk diode

Place the source, as demonstrated above, onto the source of interest. (add picture of source-bulk reverse diode, P7). The curve tracer should be in reverse or AC mode, the bulk needs to be grounded and the gate needs to be floating. Moving the tip away from a good contact should cause the diode to disappear. Source-bulk diodes and drain-bulk diodes should appear the same. If the diode is resistive or flaky, see Conditioning a tip, below.

12.h. Then, place the drain, to get a source-drain diode

Place the drain to get a source-drain reverse diode (add picture, P8). The curve tracer should still be in reverse or AC mode, bulk grounded and gate floating. Moving the source or drain away should cause this curve to disappear. The source-drain diode will have less resistance than the source-bulk diode (it will also have a diode turn-on, on the positive sweep). This is the Breakdown voltage Source Drain (BVDSS). If contact is lost, go back to placing the source, above.

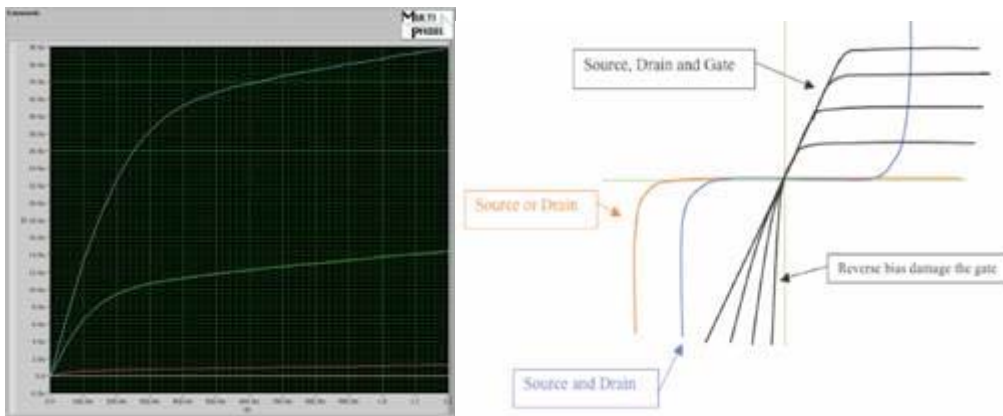


Figure 23a,b: Image a) Typical transistor curve. Image b) Schematic of IV curves for source, source-drain and source-drain-gate contacts.

12.i. Next, place the stepping gate tip (regular polarity) to get the transistor curve

Adjust the location and force of each probe for best contact. The curve tracer should be in forward mode to avoid damaging the gate. If contact is lost, go back to placing the drain, above.

13. Conditioning a tip

If a single tip won't make good contact, as checked with a reverse diode to bulk (ground) either the tip or the sample are liable to have a resistive or capacitive problem. There are several experiments to try to improve the contact-ibility of a probe and sample:

- Tip or sample cleaning or preparation
- Scanning with a voltage on the tip
- Increasing voltage on while on a connection to the backside. (Do not perform this test while on a valuable device)
- Verify all wiring
- Verify sample preparation
- Replace the suspect probe

Note that all of these tests change the performance of a probe. Therefore, if a probe is not behaving as you desire, one or more of these actions may help you out. Similarly, if you have a probe that is performing very well, any and all of these actions should be avoided.

14. Typical probing problems

Can't tell which probes are conduction well and which aren't:

Check each probe is making good contact by checking the reverse diode from the source or drain to the grounded bulk or backside.

Equipment not set up properly:

Verify equipment setup independent from probing challenges. Check all cabling as well. A discrete device can show you if you setup is working.

One probe is not working:

- Move the probe in a search pattern to establish contact
- Increase the force (set point)
- Reengage in contact mode
- Switch to DARK PROBE.
- Rescan the sample to acquire an updated image
- Verify you are probing from the same image that gathered the data
- Make sure the bulk is grounded

Contact is flakey:

- Move the tips around to reestablish contact. Go through the sequential placing of probes, source first, then drain, then gate.
- Increase applied force (small forces are usually okay for the gate: contact mode. Larger forces are sometimes needed for the source and drain)
- Switch the source and drain. If the curves look different there is likely a problem with the driven tip. Try to condition the problem tip. See Section 13.

Each individual probe contact looks good, but multiple probes don't get transistor curves:

- Too much drift has occurred: Rescan the area to locate all contacts
- Overlay is off by one or more cells: Repeat the overlay procedure.
- One probe is pushing another probe off of it's contact: Verify this behavior with the sequential placing of probes. Then arrange the probes so they don't push each other, or replace the large, pushing probe.
- I don't fully understand the device layout: Make sure you know, for certain, the layout and expected performance of your devices.
- Semiconductor parameter analyzer is not programmed properly: Verify the analyzer with a discrete part.

At the end of your probing experiment:

Turn off PROBE ALL

Return probes to MID-RANGE

Disengage all probes by switching ENGAGE to OFF

Move probes apart and up.

APART. Rotate the X- (radial-) positioner of each head $\frac{1}{4}$ turn CW to move the probes to the corners of the Optical microscope (zoom= ~25, light= ~6) FOV.

UP. Rotate the Z-positioner of each head about 2 turns CW to raise the heads to one millimeter above the sample surface. It is safe to remove or replace your sample at this point. If you intend to replace the sample, be sure to raise each head high enough to clear the new sample.

Turn off the optical microscope illuminator (light=0).

Appendix A: Shutting down the AFP

The AFP system should be put in a 'safe' configuration at the end of a measurement session. Before the AFP system is re-configured in any way, the probes and software should be made safe and the system powered down.

Verify that PROBE ALL is OFF (SCAN & PROBE TAB),

Verify that the probes are at MID RANGE (SCAN & PROBE TAB)

Verify that the probes are not engaged on the surface of the sample (SCAN TAB). If the ENGAGE buttons show ON, click each button to OFF. The probes will disengage and the Z-positioner will fully retract. After disengagement, the probes will be within 30 microns of the surface.

Visually inspect the probes in the platen-sample area and verify that all probes are more than one millimeter above the surface. If they appear to be less than 1 millimeter above the surface, the probes need to be re-positioned to a safe height for shutdown. Likewise, if you disengaged the probes earlier, the probes will require repositioning according to the following procedure.

If the visual inspection of the probes reveals the probes to be less than one millimeter above the surface, assume the probes are in the pre-engage 'park' position. The probes may be less than 30 μ m above the surface and within five μ m of each other.

On the station support computer workstation, bring the optical microscope image to the top.

Verify the probes are APART. Set the optical microscope to the lowest zoom and determine the radial proximity of the probes. If the ends of the probes are within 100 microns of each other (the width of a cantilever is approximately 100 μ m), rotate each of the X- (radial-) positioners at least one full turn CCW. The ends of the probes should be greater than 1mm apart from each other. All probes should be clearly in the FOV of the optical microscope at zoom= ~0, light= ~4. UP. Rotate the Z-positioner of each head 2 turns CW to raise the heads to one millimeter above the sample surface.

Re-focus the optical microscope upwards (left-side knob CCW) to bring one of the probe's cantilever into focus (light=0).

Adjust the heights of the other probes by first rotating the Z-positioner CW (safely upward). If the focus gets worse, rotate the same Z-positioner CCW (reverse the direction) to bring the probe's cantilever in focus. Repeat for each of the out-of-focus probes.

Turn off the optical microscope illuminator.

In the Multiscan™ interface OFFSETS Tab, clear all offsets.

In the Multiscan™ interface SETUP Tab, set the scan size to 15 μ m.

In the Multiscan™ interface SCAN & PROBE Tab, verify that the feedback mode for each of the heads is switched to CONTACT.

Multiprobe recommends leaving the lasers ON as a best practice for your laboratory regarding the usage of the AFP system. Lasers should be turned off before shut-down of the Multiscan™ application. In general, the lasers should always be kept on.

In the Multiscan™ interface SETUP Tab, turn all lasers OFF.

Exit Multiscan™ by clicking the EXIT button in the upper-right corner of the interface, under the Multiscan™ Logo. The shutdown process may require up to 15 seconds to complete. Please allow time for the application to update several settings-files before shutting down the Multiscan™ workstation.

Shut down the operating system on the Multiscan™ workstation.

Exit the Multiscan™ GPIB Communication application by clicking the EXIT button in the upper-right corner of the interface, under the Multiscan™ Logo, if applicable.

Shut down the operating system on the station support computer workstation.

Switch off the optical microscope Illuminator

Switch off the Multiscan™ Control Electronics box

At the power-strip:

Power-Off the parameter analyzer or curve tracer.

Power-Off the optical microscope illuminator

Power-Off the Multiscan™ workstation.

Power-Off the station support computer workstation

Power-Off the Multiscan™ Control Electronics box

The AFP system is now completely safe to disconnect and/or reconnect cables, power cords, etc.

The AFP workstations and Multiscan™ Controller Electronics contain High Voltage electrical components that may remain charged even after powering-off at the power strip. These components may still be able to deliver a lethal shock after you have completed this shutdown procedure.

Here we provide an overview of the AFP setup and measurement process. Depending on the condition of your AFP, you may not need to complete every step. Use this summary as a pre-flight checklist at startup or as a convenient desktop reference.

Heads to Probe Safety-Position (1-3 mm 'up and apart')

Reset workstations, etc.

Load/Remove Sample

- 1) Head to Probe-Exchange Position.
- 2) Remove Probe.
- 3) Replace Probe.
- 4) Align Laser Optics.
- 5) Head(s) Down to System Safety Height.
- 6) Probes to Parked Position.

Appendix B: Process Flow

- 1) Scanner Setup.
- 2) Clear Offsets.
- 3) Configure Force Feedback Systems.
- 4) Initialize Software Controlled Systems.
- 5) Configure SAVE Tab.

- 6) Find the Surface.
- 7) Bring the tips into Pre-Scan Proximity (<10 μ m apart).
- 8) Align Image Overlay (Make a Sample Probing-Map)
- 9) Image Device Region.
- 10) Place Probes on Nodes.
- 11) Execute Analysis

- 12) Probes to Safe Position.
- 13) Software to Safe Settings.
- 14) Power Down Components.

Appendix C: Summary of Hot Keys

F1- Head A setpoint or MNZ down

F2- Head A setpoint or MNZ up

F3- Head B setpoint or MNZ down

F4- Head B setpoint or MNZ up

F5- Head C setpoint or MNZ down

F6- Head C setpoint or MNZ up

F7- Head D setpoint or MNZ down

F8- Head D setpoint or MNZ up

F12- Execute Probing

Control + S- Save AFP files (every head)

Control + Shift + S- Back Save

Control + M- Probes to Mid-Range

Control + A- Advanced Features

Control + T- Scan from Top

Control + B- Scan from Bottom

Control + P- Probe All

Control + E- Execute Probing

Control + L- Align Laser

Control + F- File Viewer

Control + I- Large Image

Control + D- Dual Image

Control + O- Overlay Image

Appendix D: Summary of Facilities Specification

Please refer to the facilities specification for exactly where to place your AFP system and the requirements for the building/room/facilities for the AFP.

Appendix E. GPIB Communication Software

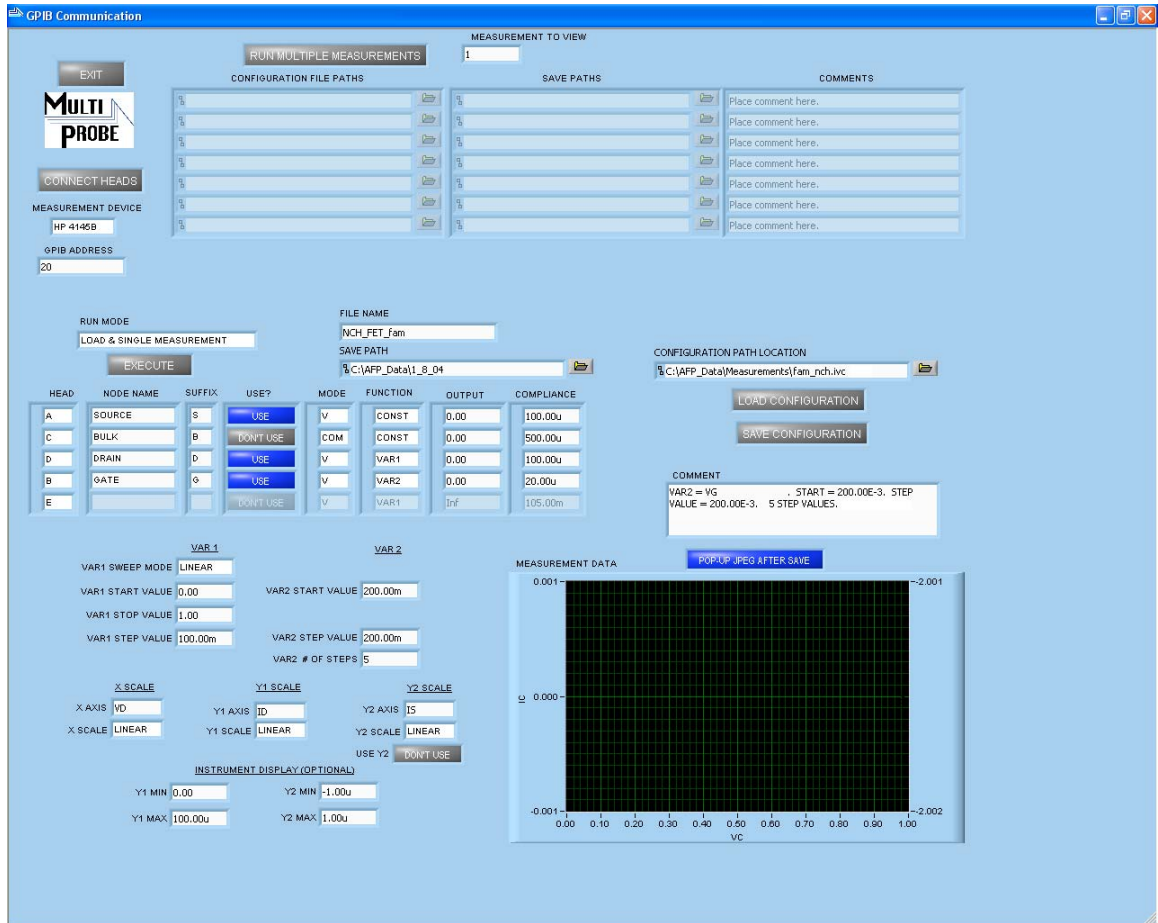


Figure 24: Multiscan™ GPIB Communication interface configured for a four probe ‘family of curves’ analysis on an ‘N-FET’ device.

Power up the HP 4145B (semiconductor parameter analyzer) and check that the USB-GPIB cable is connected between the station support computer workstation and the HP 4145B communication port.

Double click on the Multiscan™ GPIB desktop icon to open the Multiscan™ GPIB interface software on the station support computer workstation. Once inside the Multiscan™ GPIB interface, adjust parameter fields and switches:

Load a parameter configuration file for your current measurement for eventual uploading to the HP 4145B at the time of analysis.

In the GPIB communication software interface shown in figure 24, the example configuration file for an N-Channel device measurement is c:\AFP_Data\Measurements\fam_Nch.ivc. Each ‘.ivc’ file contains all of the parameters to program the HP 4145B for any particular analysis. Loading a ‘.ivc’ file into the Multiscan™ GPIB communication program sets the parameter fields in the interface.

If you choose to modify the parameters for your analysis, we recommend saving a new configuration file with a unique name.

Verify that the HP 4145B is set for remote control.

Upload the configuration file by clicking on the ‘EXECUTE’ button. This step is particularly useful if you have to ‘hunt’ for nodes in the early stages of the measurement—especially if you set the HP 4145B to a ‘local’ continuous sweep-mode.

Before the HP 4145B can be programmed or controlled by the Multiscan™ GPIB interface software, the HP 4145B must be taken out of local mode and put into a remote mode. Consult your HP 4145B manual for more information.

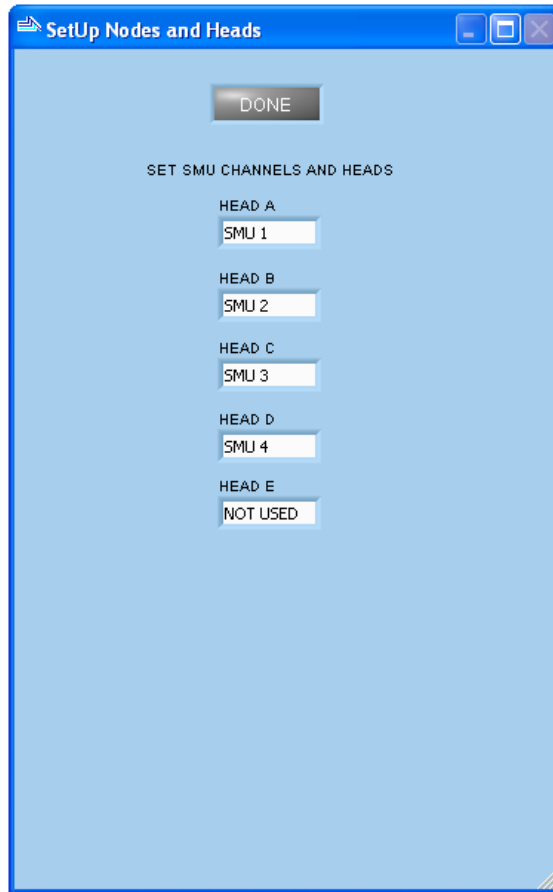


Figure 25: GPIB communication ‘CONNECT HEADS’ pop-up interface used to configure the connection between AFP heads and HP 4145B. This is a four head AFP system configuration.

Set the switches that connect 'HEAD' to 'NODE' (e.g., Head A to gate, etc.). With the device layout in hand AND the orientation of your sample already known (or visible in the optical microscope), you can pre-configure the Multiscan™ GPIB interface Node connection switches. Knowing the relative orientations of the heads, you can decide which probe (e.g., Head 'A', Head 'B', etc.) will be placed on which node (e.g., Gate, etc.) of the device to be analyzed.

You are now ready to automatically UPLOAD experiments to your HP 4145B when the AFP probes are properly positioned on the surface.

Appendix F: Measuring noise

See Maintenance Manual.

Appendix G: Debugging and troubleshooting

See Maintenance Manual.

Appendix H: Glossary of software features

Notes