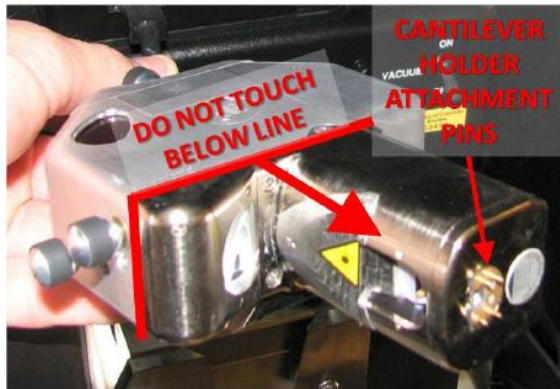


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Safety

This machine uses lasers. Be careful of where you direct the lasers. Do not look into the laser or shine it in anyone's eyes.

Only touch above the stem of the hybrid head when handling



Open the hood of the AFM

Load the tip

- Take the tip holder and place it on the loading block, put posts through the hole. Bring it down so it rests evenly on the base. (You may want to blow any dust/particles off the tip holder prior to loading the tip)



Figure 1 Tip Holder when slot is exposed



Figure 2 Loading block

- Check to see if the tip slot is exposed (see Fig. 1). If not, expose the slot for the tip on the tip holder by holding down the tip holder onto the block with one hand, and pulling the clamp towards center of the block with the other hand. First press down on the end of the clamp to lift it up, then slide it back, away from the slot.
- Using tweezers, gently place the tip in the center of the slot. Be sure that the tip is not tilted and the back of the tip is against the back wall of the slot.
- Use one hand to hold down the tip holder, and use the other to press down on the clamp so it lifts up. Slide the clamp all the way up, and then set it down on the tip.

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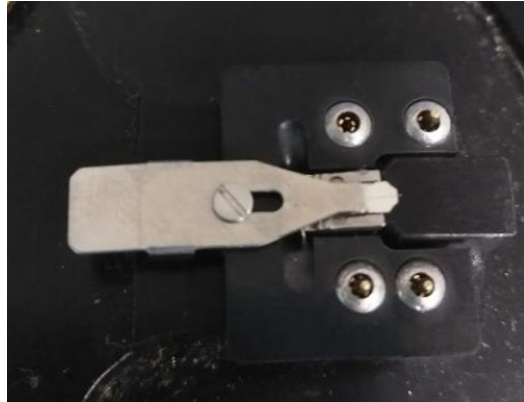


Figure 3 Tip correctly loaded onto tip holder

- Loosen the release screw (Fig. 4) of the hybrid head. Do NOT unplug it. Lift the head off and hold it in front of you.
- Put the tip holder onto the hybrid head (Fig. 5)
 - Be very careful to not drop the head. Be sure you have inserted it correctly, and have not miss the slot. Do NOT let go of it until you've felt it resting on the catcher.
 - Do not touch the stem of the head
- Secure the hybrid head with the release screw on its right side.



Figure 4 Hybrid Head release screw



Figure 5 placing tip holder onto the head

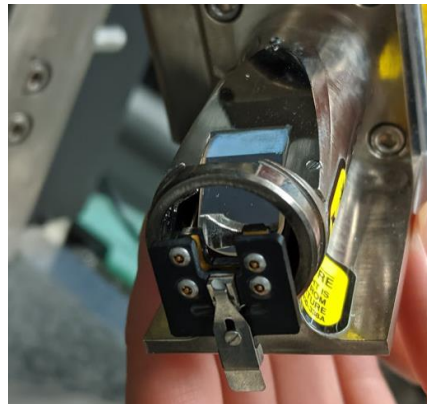


Figure 6 tip holder properly placed onto head

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Turn on the power boxes by flipping the red switch located beneath the computer tower, and behind the keyboard.

Align the laser to the tip

- open the software “7.30”
- select “Realtime”



(You can also go to “Realtime” on the tool bar then select “start Realtime”

- select “Use original default parameter values”
- You should be prompted to initialize the stage. If not go to **Tools> Stage>Initialize**. Select “ok” for all the actions
- Open the windows: **Meter, Navigate, and Scan-Single**. (**Scan-dual** should already be opened for you)
 - **Acquire>Meter, Navigate, Scan-Single**
- There should be a laser on the stage. Use the screws on the top of the head to move the laser along the X (back screw) and Y axis (front screw). (view Fig. 7)
 - Adjust the X screw to direct the laser towards the right until it just dims, or disappear. Then move a little back towards the left so you can see the laser.
 - Now adjust the Y screw so the laser moves back and forth. Find where the laser dims and keep the laser there. You are at the base of the tip.
 - Now move the laser left, towards the end of the tip. Keep an eye on the Meter window and find the left most position with the highest Sum Signal (green bar). You should be able to see the shadow of the tip cutting through the laser on the stage.

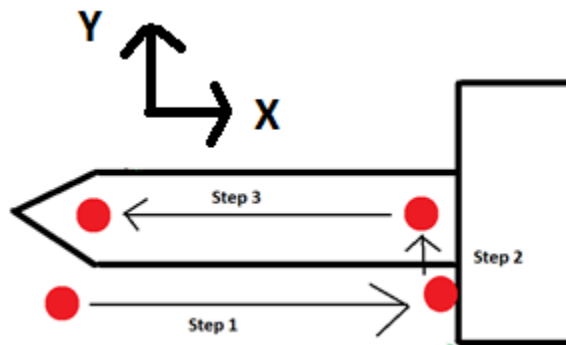


Figure 7 walking the laser to alignment

- Use the screws on the left side of the head to adjust the photodetector so the red dot on the Meter window is centered. The **VertDeflection** should be close to 0V.
 - Note: top screw moves the dot along the y- axis, bottom screw moves the dot across the x-axis

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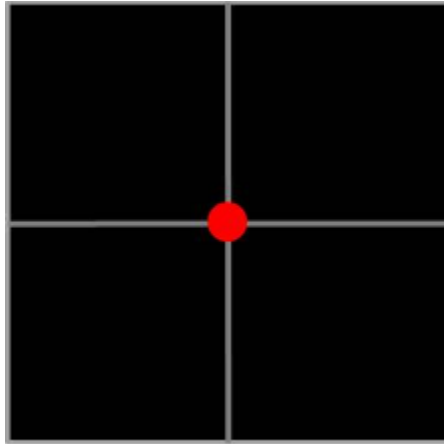


Figure 8 Alignment of Photodetector in the Meter Window

Locate Tip

- In the navigate window, select “Locate Tip” on the bottom right corner
 - Bringing the Z motor down to a reflective surface can help you see the tip more clearly. You can adjust the speed at which the motors moves by selecting **S**, **M**, or **F** (slow, medium, fast).
 - Adjust illumination so you can see the tip in the window. Zoom in on the tip and adjust the focus on tip.

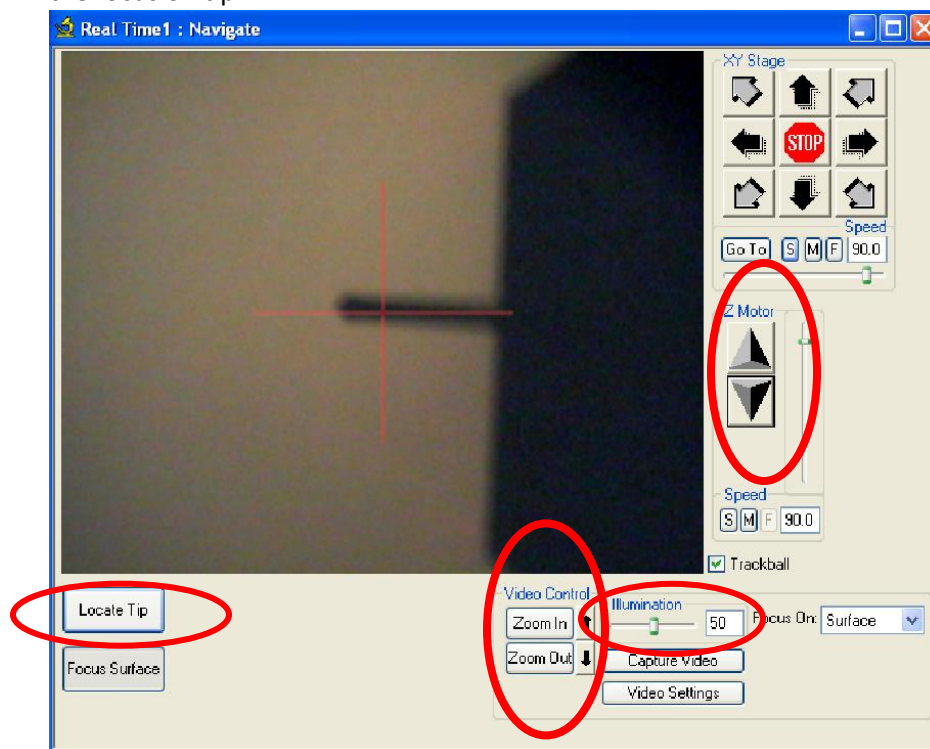


Figure 9 Navigate Window

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- Align cross hairs to the points of the tip by turning the adjustment screws on the camera, left of the head. Adjust focus as you zoom, and realign cross hairs if necessary. (see Fig. 10)

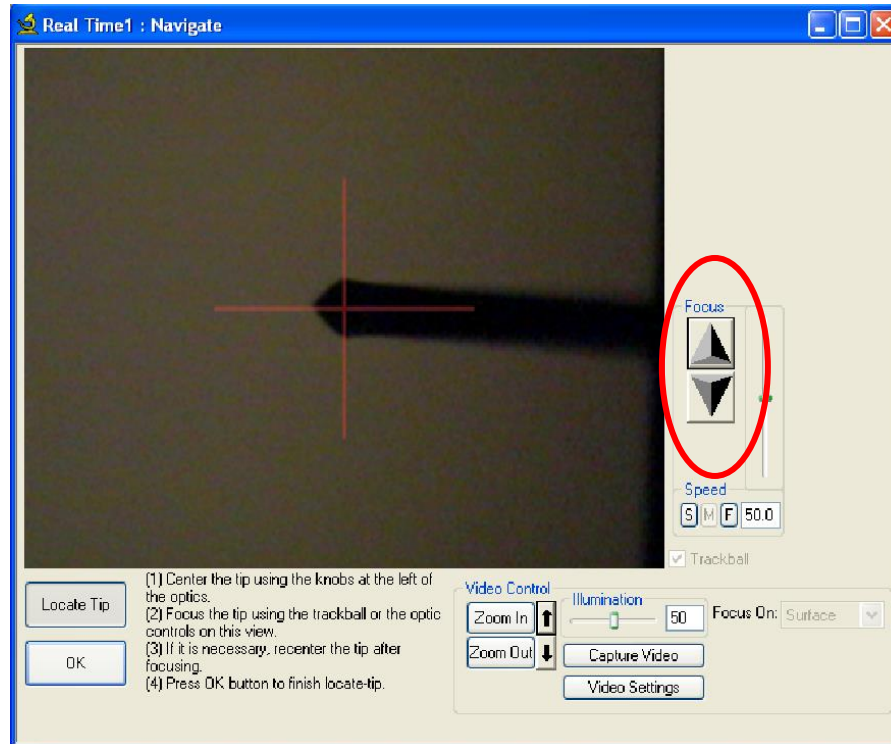


Figure 10 Navigate Window: Locate Tip, cross hairs properly aligned

- When done, click “OK”

Auto Tune

- Click the tuning fork icon



- The auto tune window will pop up. Review parameters and select “Auto Tune”

Auto Tune	
Start frequency	2.00000 kHz
End frequency	500.000 kHz
Target amplitude	500 mV
Peak offset	5.00 %
Minimum Q	0.00

- These parameters may be adjusted for your sample or tip.
- When done tuning, check for the drive amplitude. If your drive amplitude is high (>80mV), you may have a poorly loaded tip, or the tip is damaged. If your drive amplitude is high, you may choose to proceed or reload the tip.
- Select “Zero Phase” under the graphs then “Exit”

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Load the sample

- Place a sample disc on your sample, then place the sample on the magnetic chuck.
- Place the sample onto the stage. The magnetic chuck will prevent your sample from moving.
- Place desired scan area under the laser

Engage the Tip

- If your sample has a reflective surface, select **surface** on **Focus on:** drop down menu in the Navigate window. If not, select **Tip Reflection** on **Focus on:** drop down menu in the Navigate window.
- Using the **Z motor** on the right of the **Navigate** window, or the track ball, bring the tip down to your sample. Be careful to not crash the tip onto your sample. You should be able to see the surface of your sample and the laser.
 - When you are within 1mm of the sample, only approach closer with the Z-motor in slow speed to prevent crashing the tip
- Keep lowering the tip until either the tip or your surface comes in to focus, depending on your choice of focus.
- Set your scan parameters for engagement on the **Scan-Single** window. You may change these parameters during the scan.
 - Scan Size: 500nm
 - Scan Rate: 1Hz
 - Integral Gain: 0.5
 - Proportional Gain: 0.8

*note that the **Sample/Lines** and **Lines** parameter is to determine how many pixels per line and how many lines in your scan respectively. This parameter is up to the user's desired resolution.
- Close the hood
- Click **Engage**

Adjusting Scan Parameters during the Scan:

- Adjusting **set point**: The Amplitude set point should be set so the minimum amount of force is applied when scanning your sample. In tapping mode, the lower you make it, the smaller the force between your sample and tip. The smoother your surface, the lower you can make it. (The sample reference should need no lower than 200mV)

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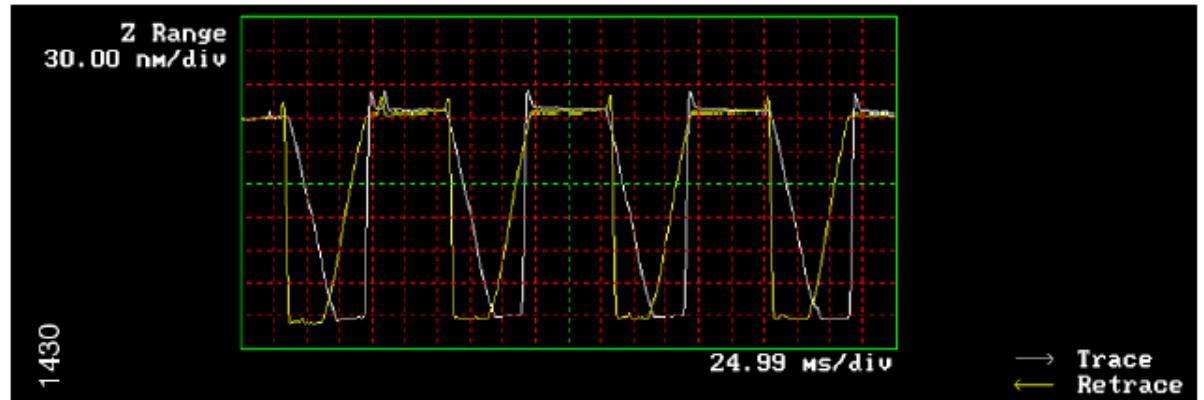


Figure 11 example of set point set being too high

- Adjust **Integral Gain** until you get a good match on the Trace/Retrace line. You increase feedback as you increase integral gain. You want the highest Integral Gain possible without any noises in your lines. Noise is usually seen when the Integral Gain is between 1 and 2. You can set the Proportional Gain to be 1.3x the Integral gain.

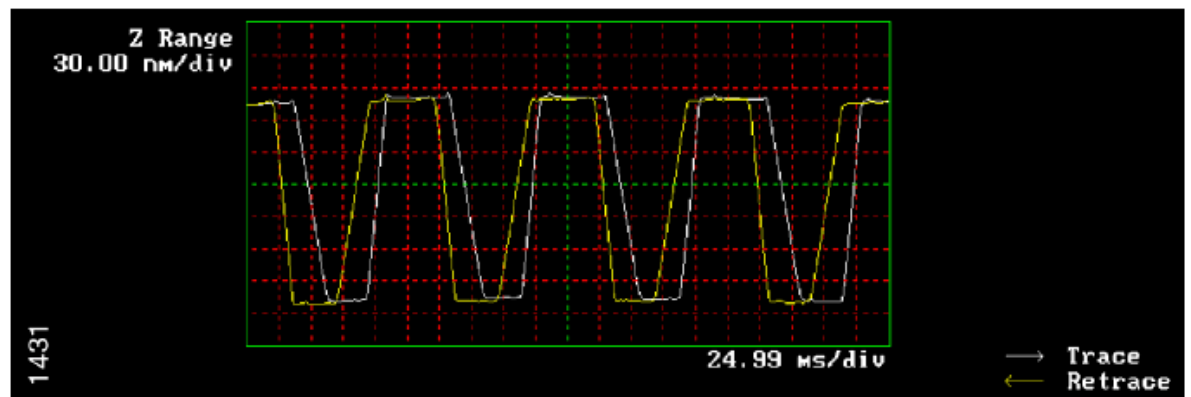


Figure 12 Example of Integral Gain being too low

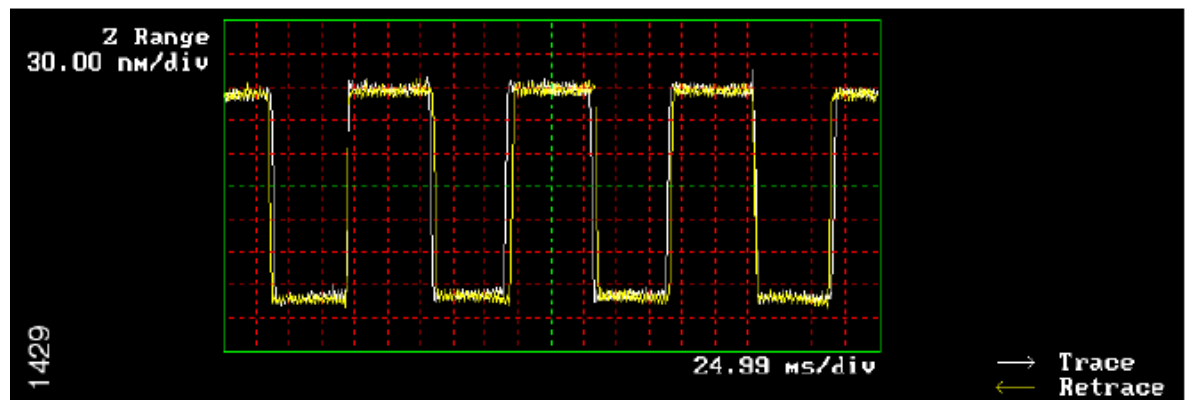


Figure 13 Example of Integral Gain being too High

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- **Scan Rate/ Scan Size:** Generally, smoother surfaces can be scanned faster. Keep note that when you increase the **scan size** parameter without adjusting the **scan rate** parameter, you are increasing the scan rate as well.

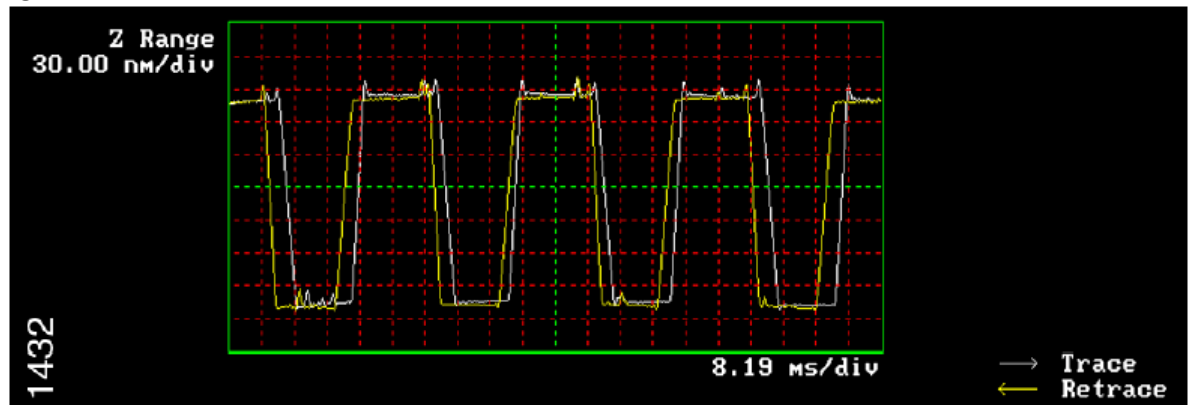


Figure 14 Example of scan rate being too high

- **Z limit:** you may adjust the Z-limit to be lower in the **Other** scan parameters. This should only be done if you have a smooth surface.
- **Additional ways to read how well you are scanning:** Trace and Retrace on the height graph should align, if not perfectly, then very closely. Amplitude error graph should have symmetrical, narrow, peaks and not have noisy oscillations. An example of good readings is shown below.

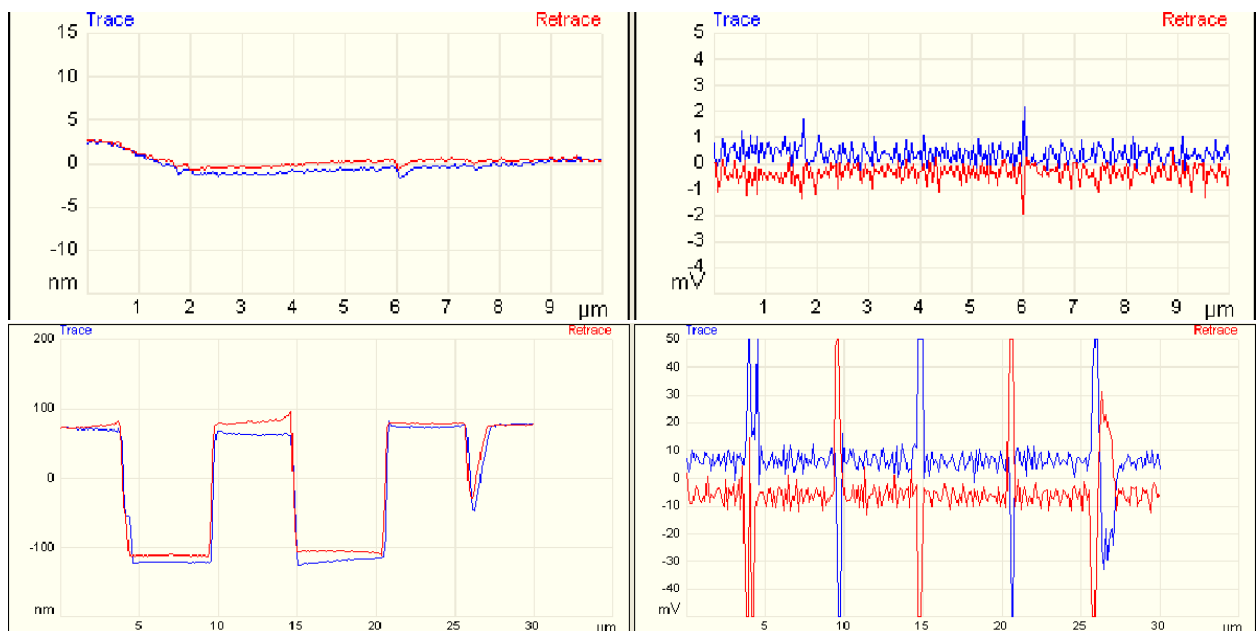


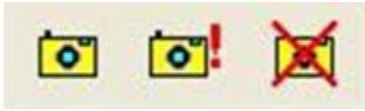
Figure 15 Good readings. Right image is height data, left image is amplitude error. The top image is from GaN and the bottom is from the silicon reference sample

Image Capturing

- Set the default directory for your images by going to **Realtime > Capture Filename**

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- **Capture** icon turns on Capture. **Capture Now** takes the current image. **Abort Capture** stops capturing



- to view your captured images: **View > Browse**, then select your directory

Withdraw

- Select **withdraw** when you are finished scanning
- Raise the head/ z-motor all the way up
- Remove sample from stage
- Remove tip holder from head
- Remove tip from the tip holder, and replace tip holder to its container. Do not leave it on the loading block

Image modification and analysis:

*To use any of these tools, open the image file. The tool bar will change to give you all the options.

- **Erase:** replaces a scan line with the average of the two adjacent lines. (before and after images below)
 - Select an output file name.
 - The default tool is a dashed line. Highlight the line you want to erase by clicking on it, then select **Execute**. If you have a larger area you want to highlight, right click and select **Area**. Now you can highlight a larger area

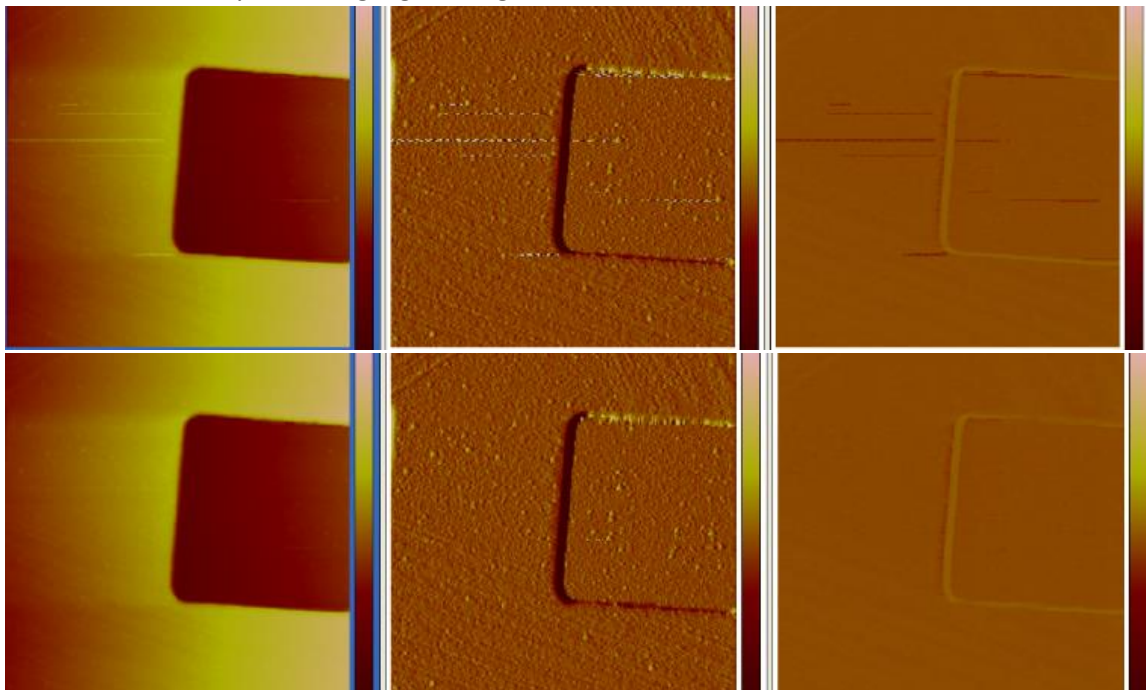


Figure 16 before and after erasing scan lines from an image

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- **Flatten:** Can help with clarifying height images by removing bowing in X and Y axis. (before and after images below)
 - Select output file name. Select the degree in which you would like to flatten. Click **Execute**

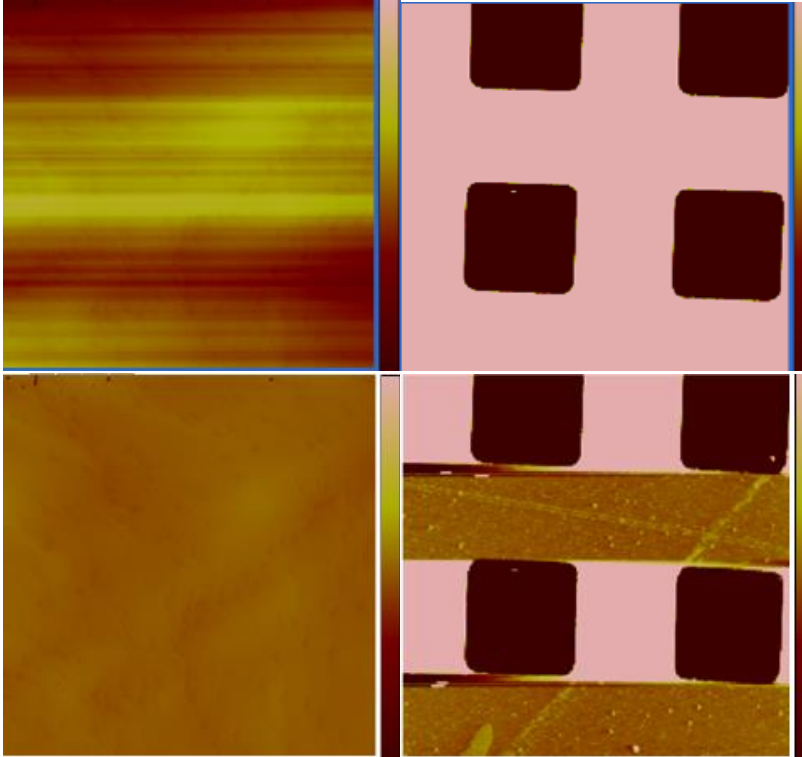


Figure 17 Using the **Flatten** function to modify images. Right column is Gallium Nitride surface, left column is Silicon surface

- **Low Pass:** filters out noises on your images
- **High Pass:** highlights where there are rapid changes in height.
- **Plane Fit:** subtracts from your image the curvature in the X or Y axis, and fits the image to the same plane.
 - Select plane (X, Y, or XY). Select what order fit you would like. Select output file name. click **Execute**.
- **Roughness:** calculates surface area of the image, the number of peaks, peak height, and zero-crossings.
 - Highlight the area you want to analyze.
 - Turn on **peak** and **zero crossing** if you would like them to be calculated.
 - Peak threshold is the minimum height you would consider a peak.
 - Select **Execute**
 - R_{\max} = max height
 - R_a = mean roughness
 - R_q = RMS

*for more instructions on how to analyze your sample, please refer to chapter 12 – 13 of the manual.

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When done

- Exit out of the program. DO NOT save any changes.
- Turn off Power boxes underneath the monitors. Do not shut down the computers.
- Close the hood of the AFM