Planefit Auto

- **Click on Modify-→Planefit Auto**
- Planefit is commonly used to remove tilt or bow from images
- Planefit calculates a single polynomial fit for the entire image and then subtracts the polynomial fit from the image.
- Planefit may be applied by calculating a 1st, 2nd, or 3rd order polynomial fit to the image in the X or Y directions.
- 1st order planefit removes tilt
- 2nd order planefit removes tilt and an "arch-shaped" bow
- 3rd order planefit removes tilt and an "S-shaped" bow
- Extreme variations in the sample topography can alter the planefit, leaving a slight tilt in the image.

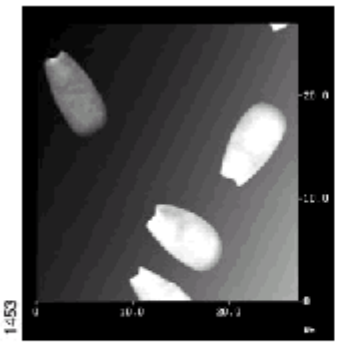
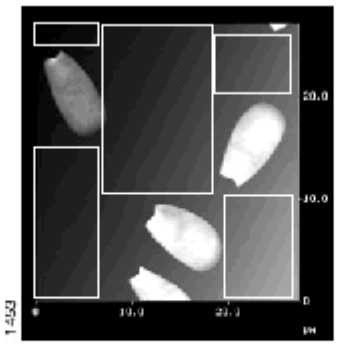


Image before Planefit



Use cursor to select areas to be included in planefit calculation

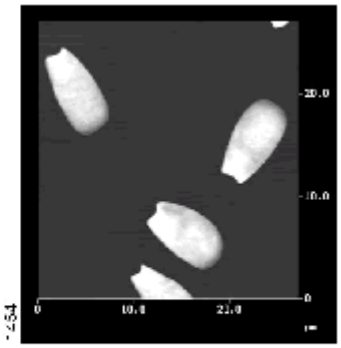


Image after 1st order planefit in X and Y using selected areas

Other commonly Used Filters

- **Planefit Manua**l: Similar to Planefit Auto except that the planefit is calculated from a manually positioned line drawn across the image in X and/or Y.
- **Erase Scan Line**s: Removes scan lines from image due to skips, noise, etc. This routine replaces the selected scan line with the average of the two scan lines adjacent to it. **Click on Modify--→Erase Scan Lines**
- **Zoo**m: Expands a selected portion of the captured image to fill the display screen.
  *Not*e: This does not increase the resolution or fine detail of the captured image.
- **Lowpass**: Removes high frequency data from the image by replacing each data point with a 3x3-weighted average of points surrounding each point. This feature may be useful for removing noise if the gain settings were set too high or if the SPM was in a noisy environment when the image was captured.
- **Medium Filter**: It removes lines, which occurs in the image due to acoustic noise or ground vibrations.

Roughness

- Roughness measurements can be performed over an entire image or a selected portion of the image. Click Analyze→roughness or click on the roughness icon.
- The most commonly used roughness is root mean square roughness.

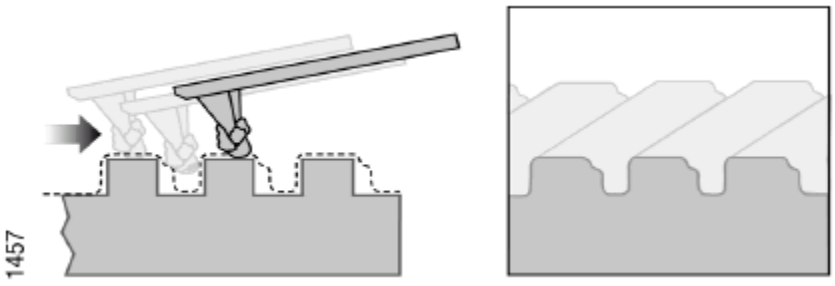
RMS (Rq): The Root Mean Square (RMS) Roughness is the standard deviation of the Z values within a given area.

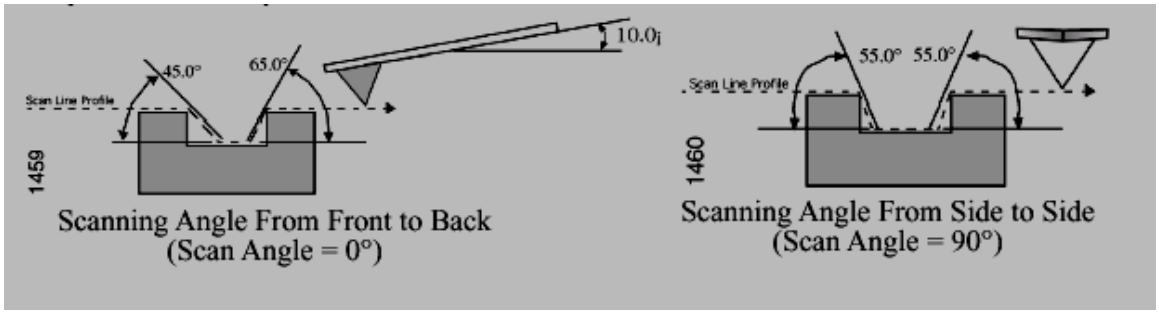
$$RMS = \sqrt{\frac{\sum_{i=1}^{N} (Z_i - Z_{ave})^2}{N}}$$

Z_{ave} is the average Z value within the given area, Z_i is the current Z value, and N is the number of points within a given area.

Tip Shape Issues

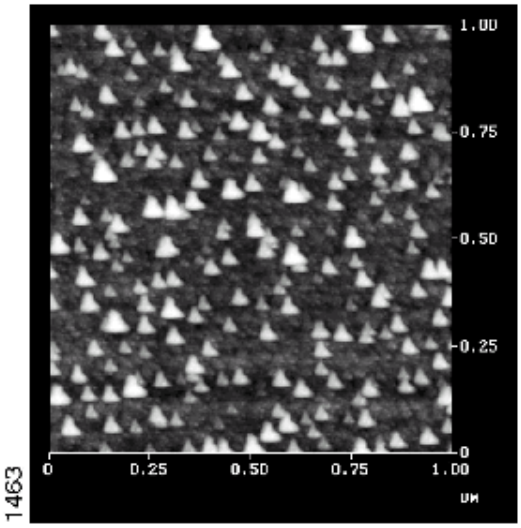
- The SPM image is a result of the interaction of the tip shape with the surface topography.
- There are two primary features of the tip, which affect the SPM image: the radius of curvature and the tip sidewall angles.
- The smaller the radius of curvature, the smaller the feature that can be resolved. A sharper tip will be able to laterally resolve smaller features than a dull tip with a larger radius of curvature.
- The accumulation of debris on the end of the tip can also dull the tip and result in image distortion, as shown below.

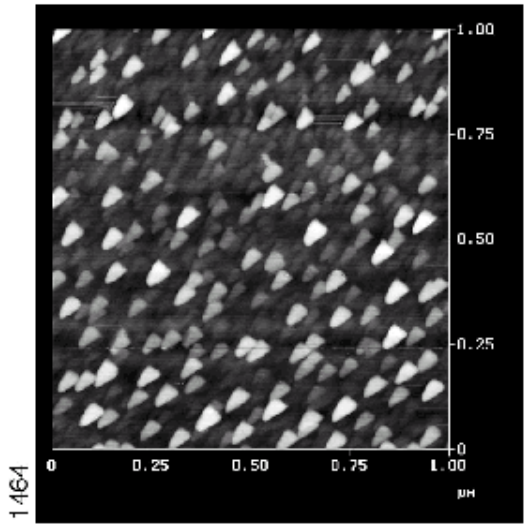




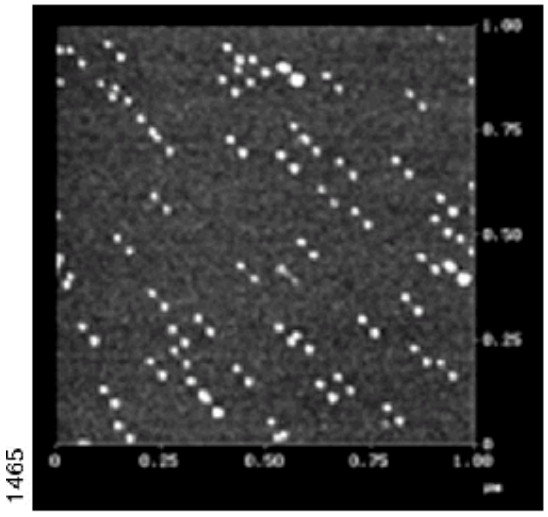
Typical Image Artifacts

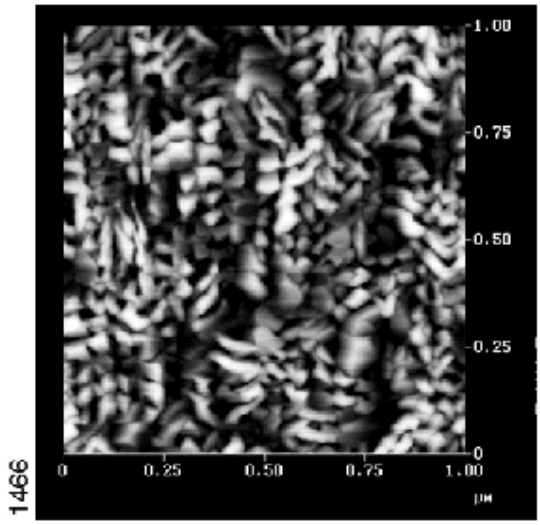
- **Image with dull or dirty tip**



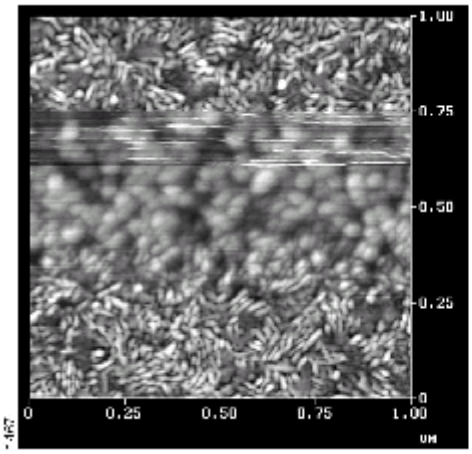


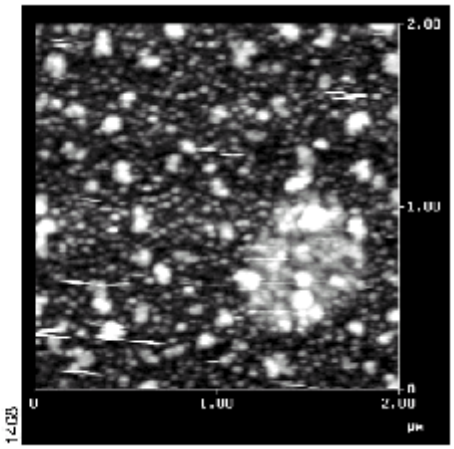
- **Double or Multiple Tip Effects**



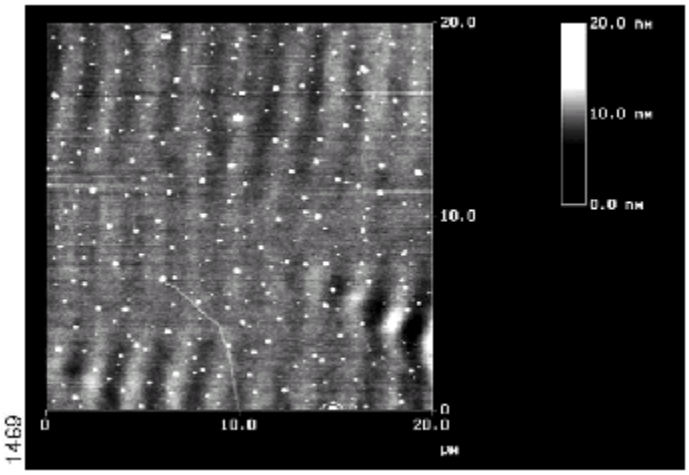


- **Contamination from the Surface:** Loose debris on the sample surface can cause loss of image resolution and can produce streaking in the image. The image on the left is an example of the loss of resolution due to the build up of contamination on the tip when scanning from bottom-to-top. It can be seen how the small-elongated features become represented as larger, rounded features until the debris detaches from the tip near the top of the scan. The image on the right is an example of skips and streaking caused by loose debris on the sample surface.

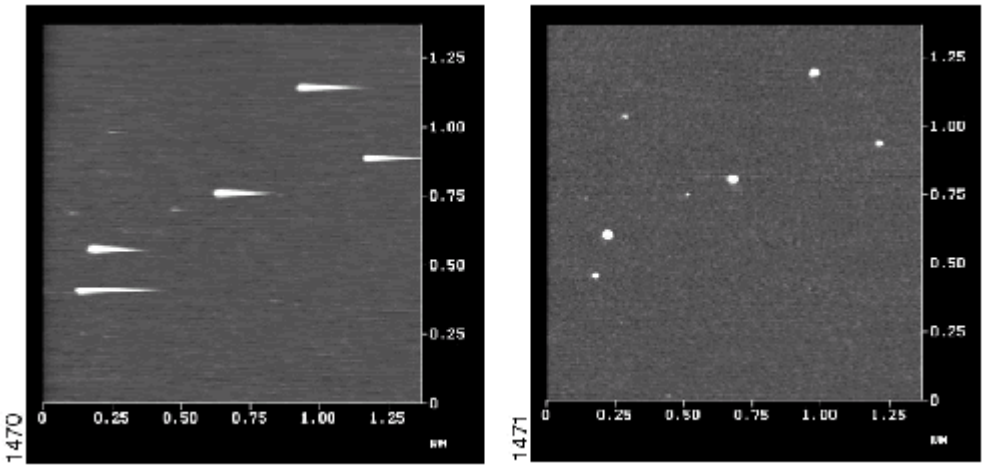




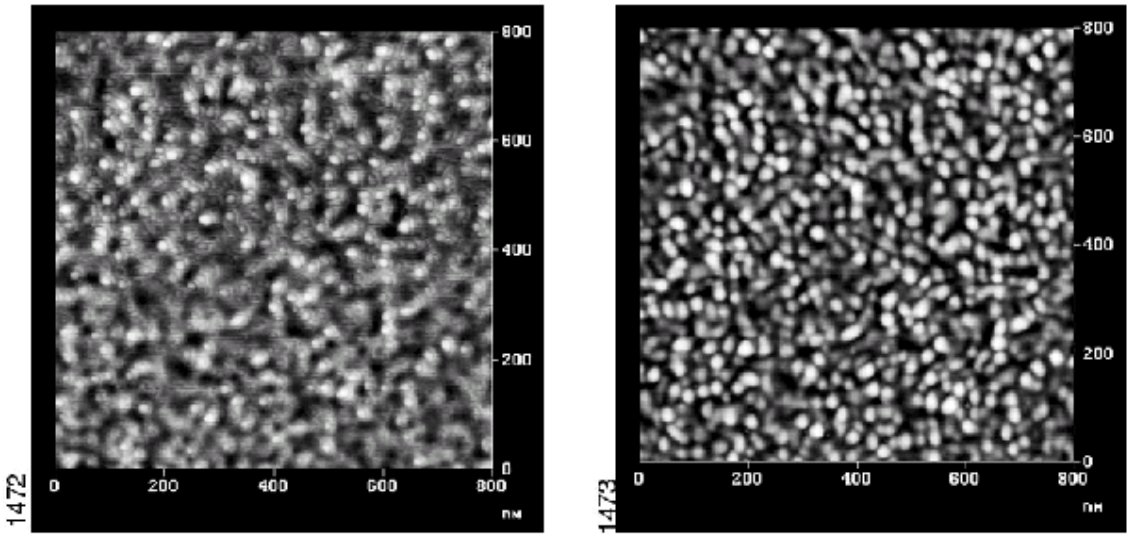
- **Optical Interference:** Interference between the incident and reflected light from the sample surface can produce a sinusoidal pattern on the image with a period typically ranging between 1.5-2.5µm. This artifact is most often seen in contact mode on highly reflective surfaces; however, it occasionally appears in Tapping Mode. This artifact can usually be reduced or eliminated by adjusting the laser alignment so that more light reflects off the back of the cantilever and less light reflects off the sample surface.



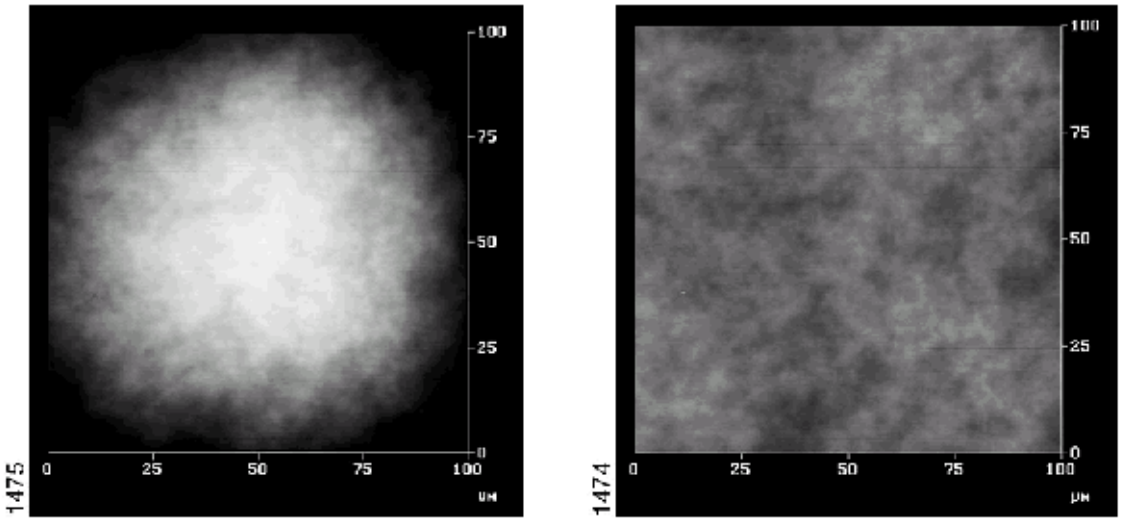
- **Tip not Tracking Properly:** When the feedback parameters are not adjusted properly, the tip will not trace down the backside of the features in Tapping Mode. An example of this can be seen in the image on the left, which as scanned from left-to-right (trace) producing “tails” on the colloidal gold spheres. The image on the right is the same area imaged with a lower set point voltage, increased gains, and slower scan rate.



- **Rings during High Frequency Operation:** In Tapping Mode, when operating on the high frequency side of the resonance peak, rings may appear around raised features which may make them appear as if they are “surrounded by water.” An example of this can be seen in the image of the Ti grains on the left. Decreasing the Drive Frequency during imaging can eliminate this artifact, as shown in the image on the right (when reducing the Drive Frequency, the Set point voltage may need to be reduced as well).



- **2nd Order Bow:** The arch shaped bow in the scanner becomes visible at large scan sizes (left). The bow in this image can be removed by performing a 2nd order Planefit in X and Y (right). (Data Scale = 30 nm).



- **3rd Order Bow:** At large scan sizes, the bow in the scanner may take on an S-shaped appearance (left). This may be removed by performing a 3rd order plane fit in X and Y (right). (Data Scale = 324 nm)/