

Artifacts in AFM

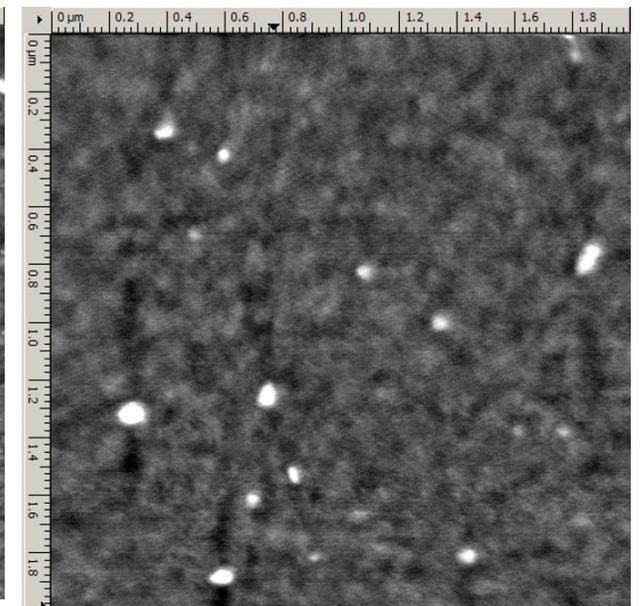
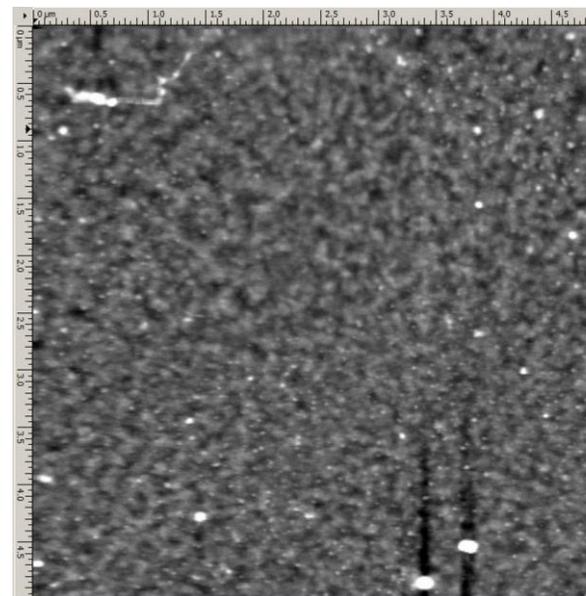
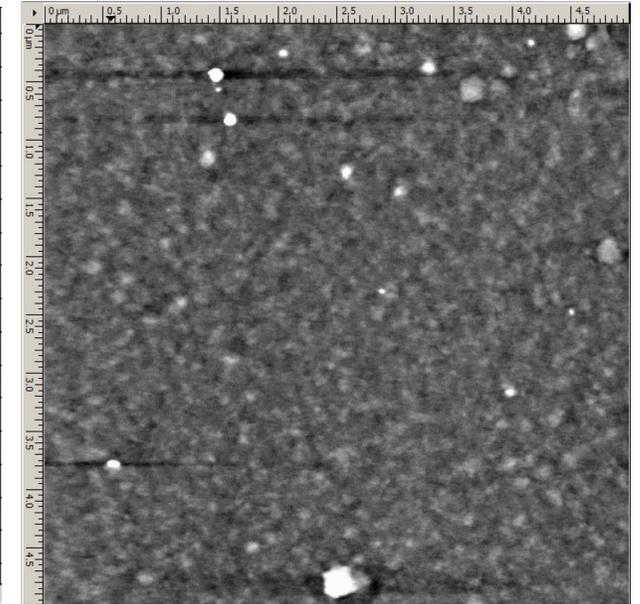
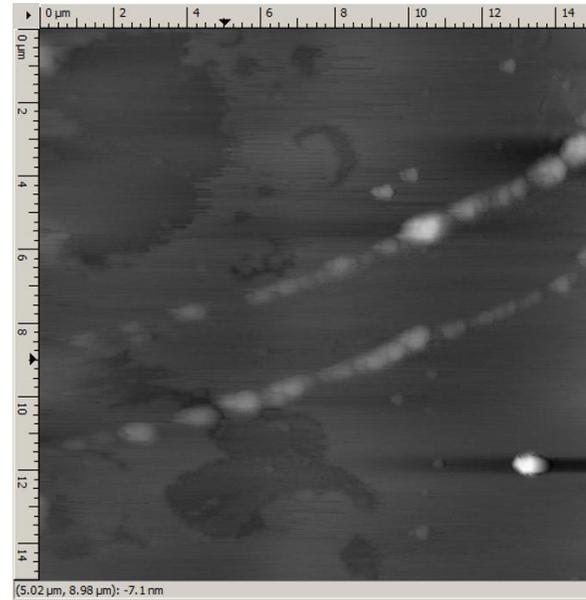
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Line levelling

Line levelling during scanning is used to display image without a bow.

However, with this featured turned ON during the scanning followed by image processing results in streaks in the scan direction originating at sites substantially higher than surroundings.

To eliminate these streaks, turn of the “line levelling” feature during scanning and then process the resulting image in usual manner.



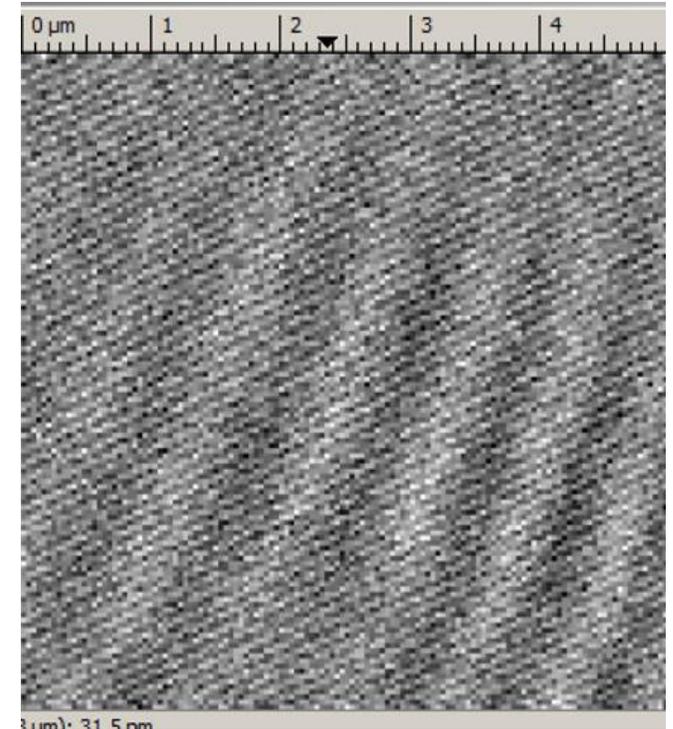
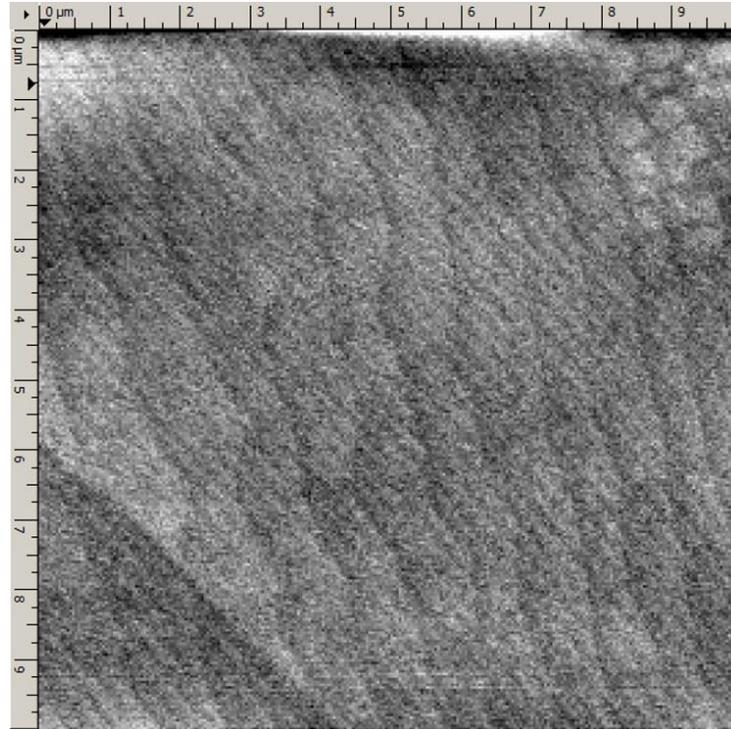
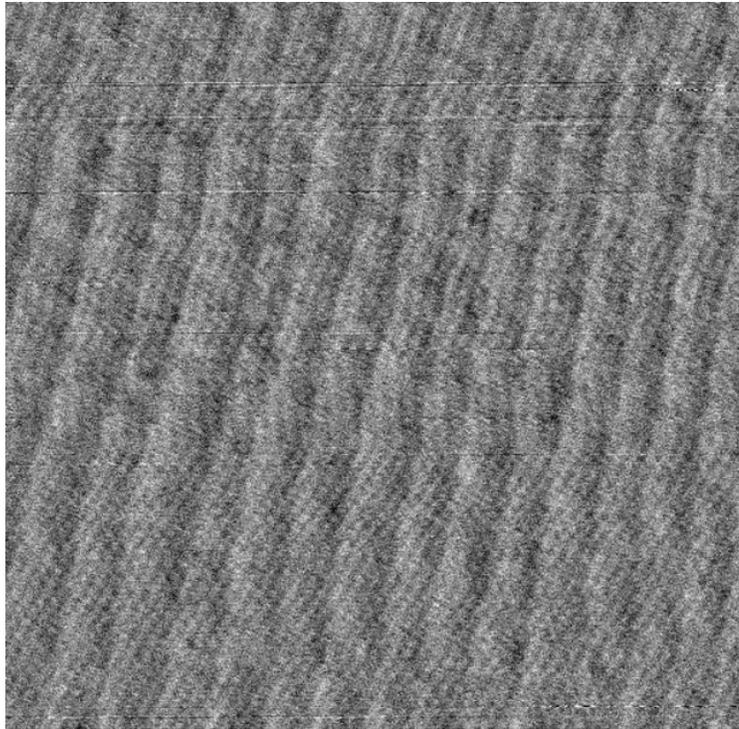
Electronic noise

Artifacts from electronic noise appear as oscillations or repeating patterns.

Often arises due to lack of grounding or broken electronic components in the system.

Can be overcome by changing the scan rate, frequency or GPID parameters, ensuring a proper ground or changing specific electronic components.

Images below exhibit the effect of not having the ground wire attached to the sample stage.

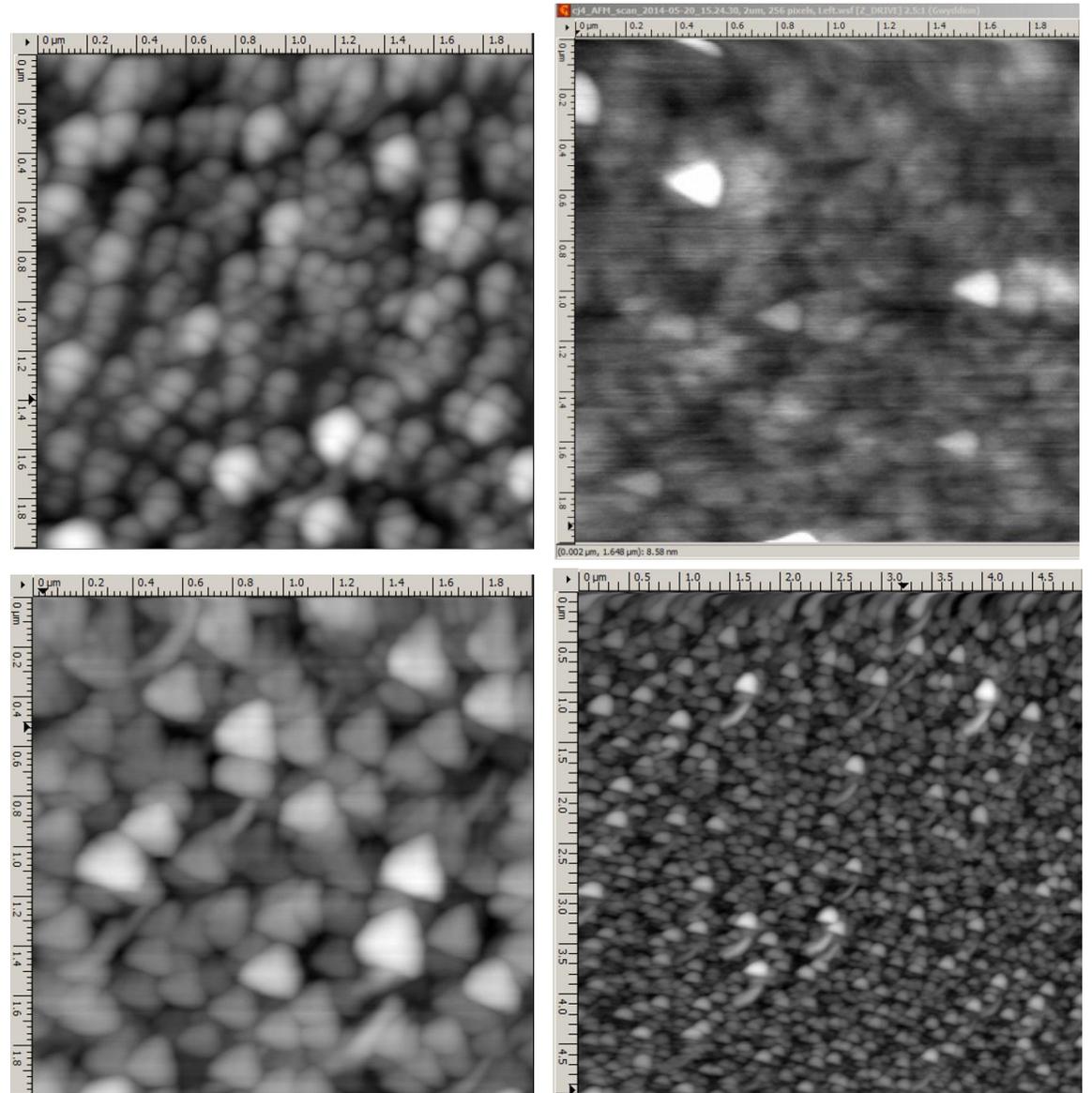
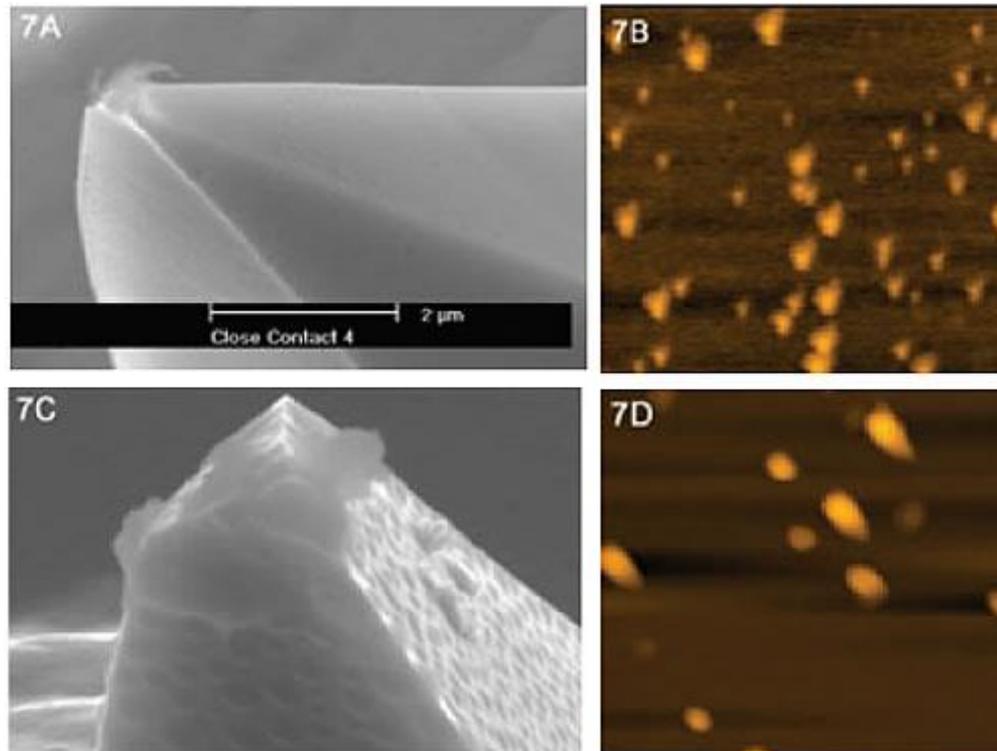


Broken or Chipped tip

If the surface being scanned has features much smaller than the dimensions of the tip, multiple images are usually seen.

A chipped tip often manifests itself in the form of triangular patterns.

Chipping of tip can occur due to fast tip approach.

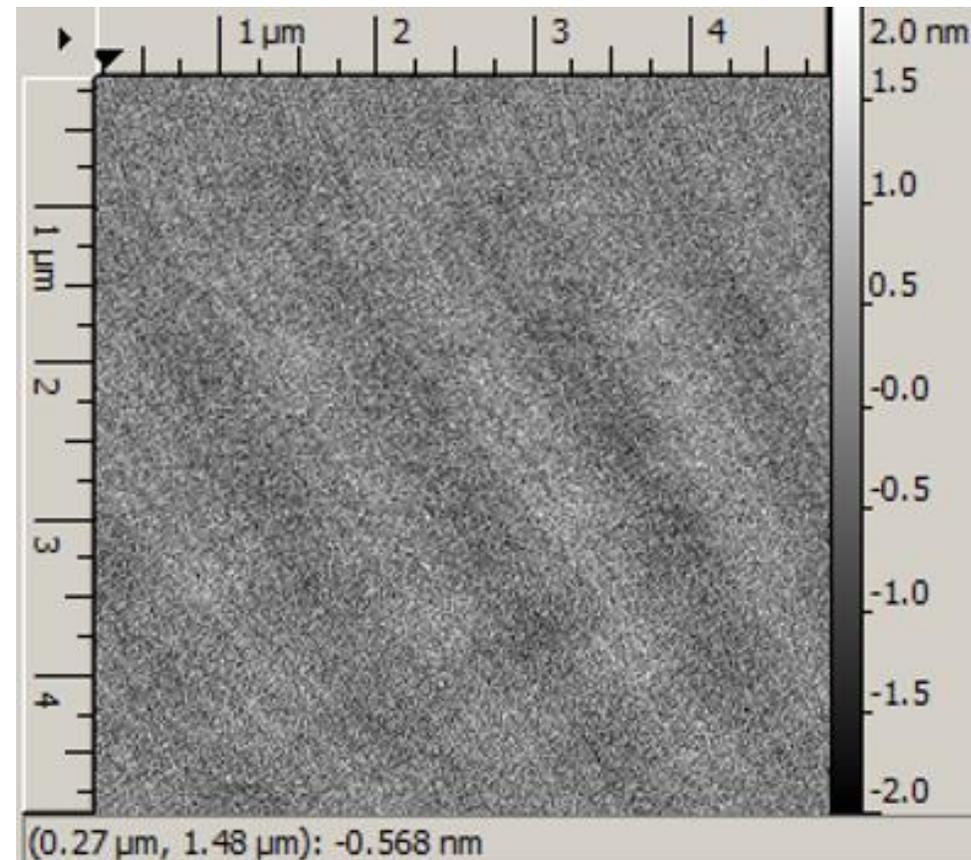
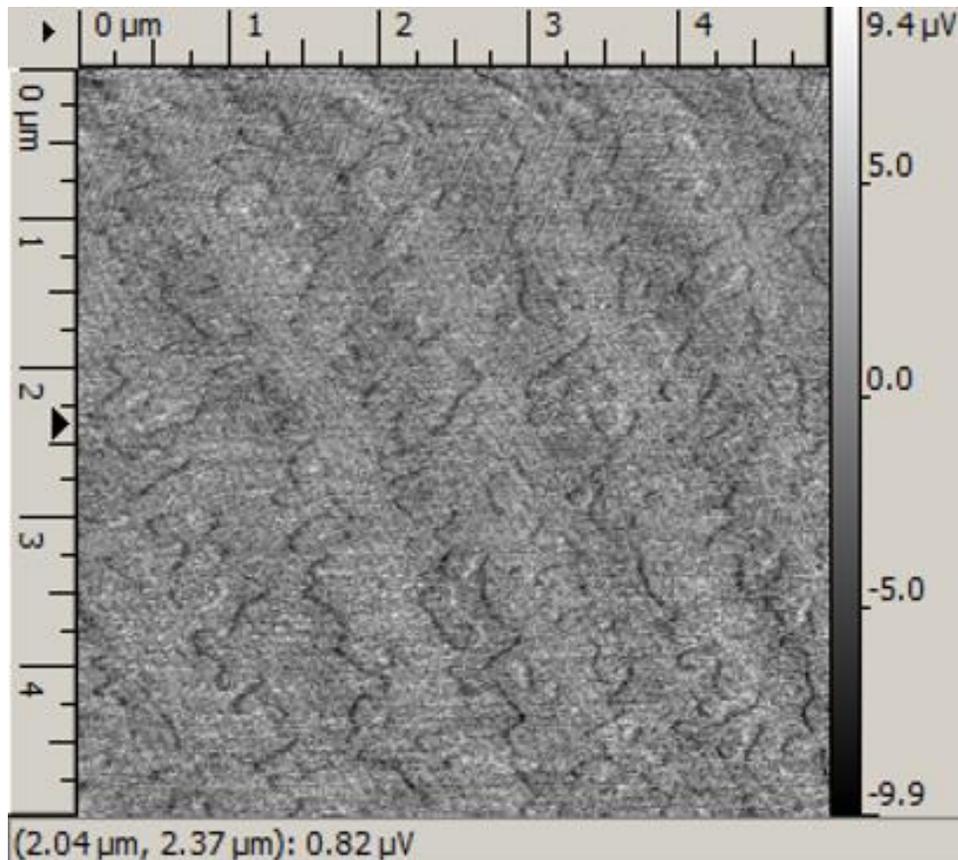


Interference

Occurs due to interference of laser beam reflected off of the cantilever or the sample surface in the immediate vicinity.

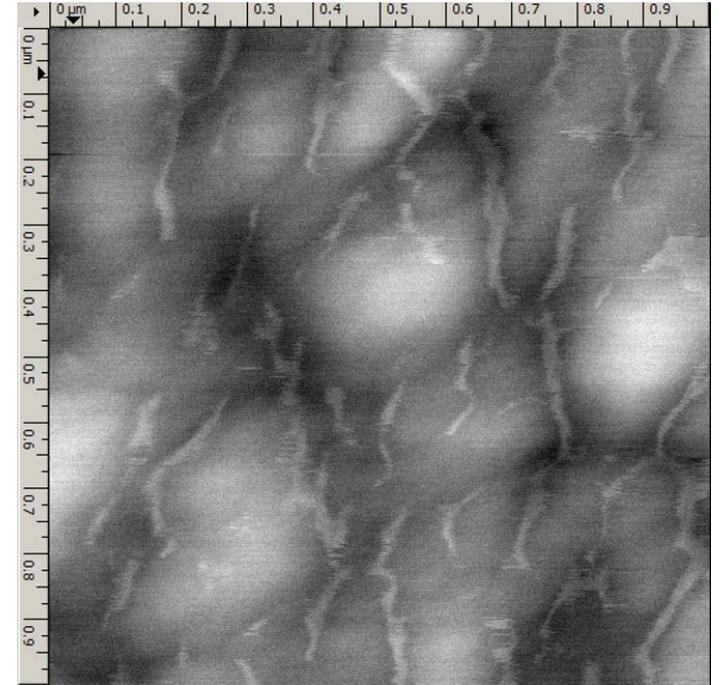
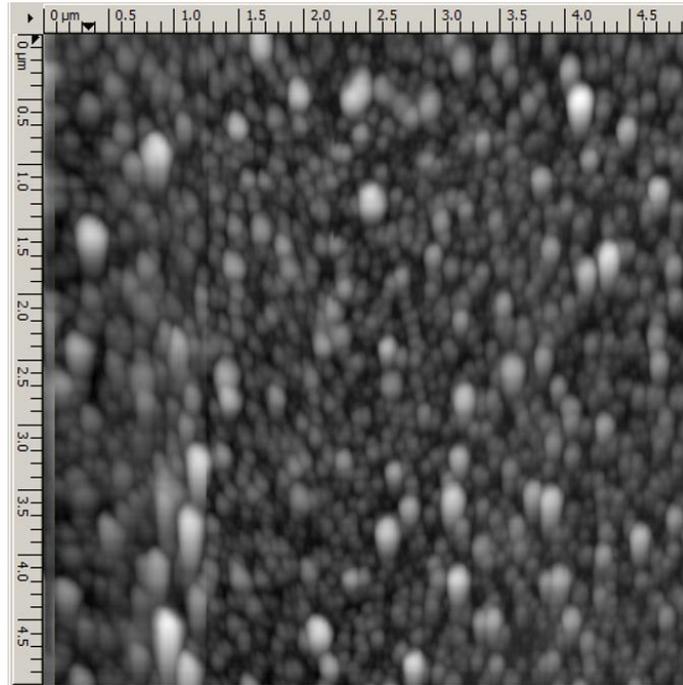
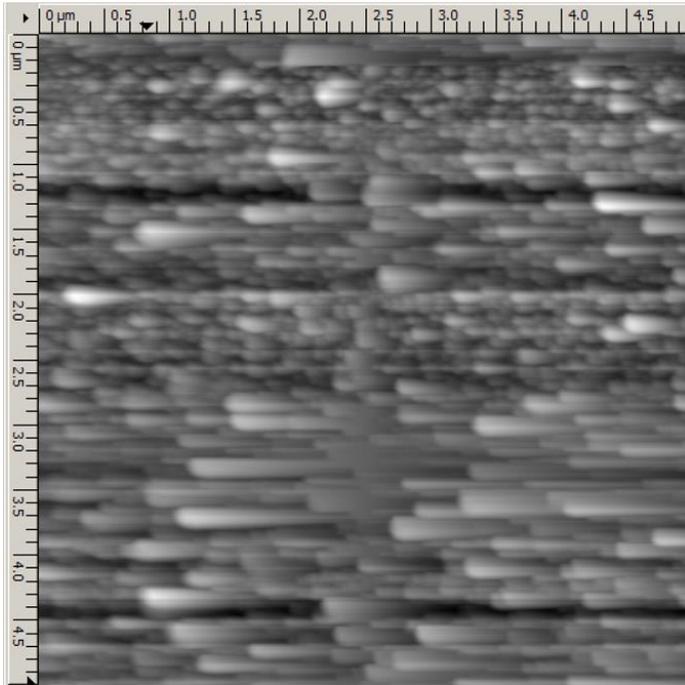
Results in low frequency undulations on the image. The period of these oscillations is typically equal to the wavelength of the laser light.

To get rid of this artifact, move the tip to a different location on the surface.



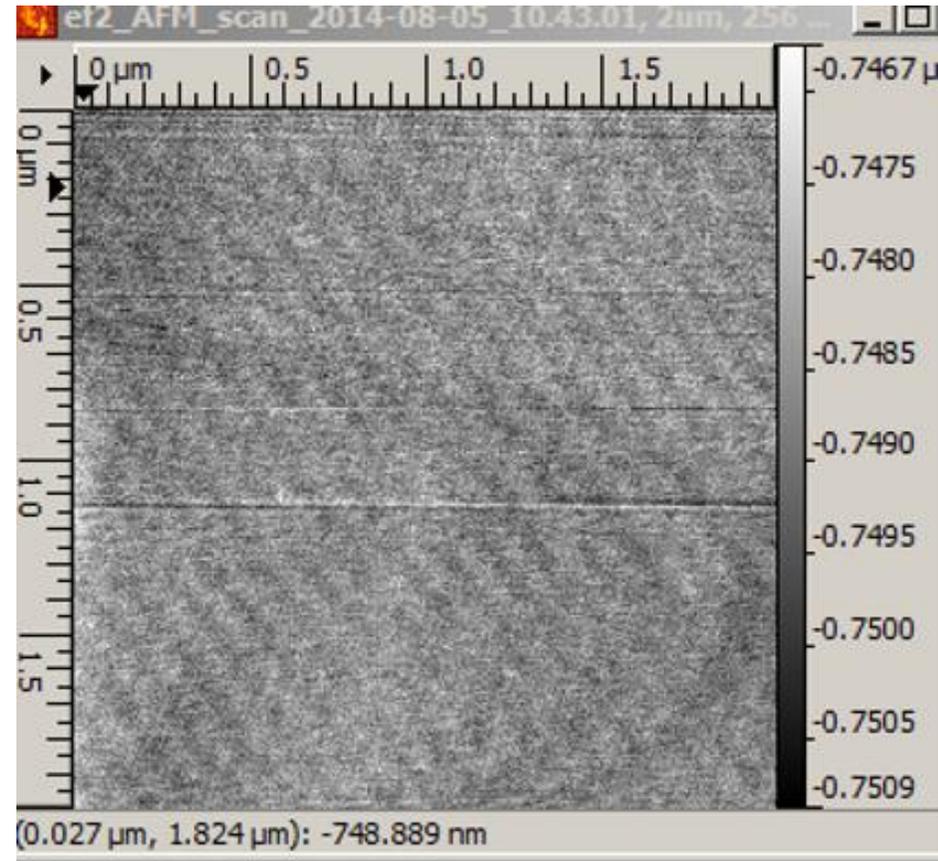
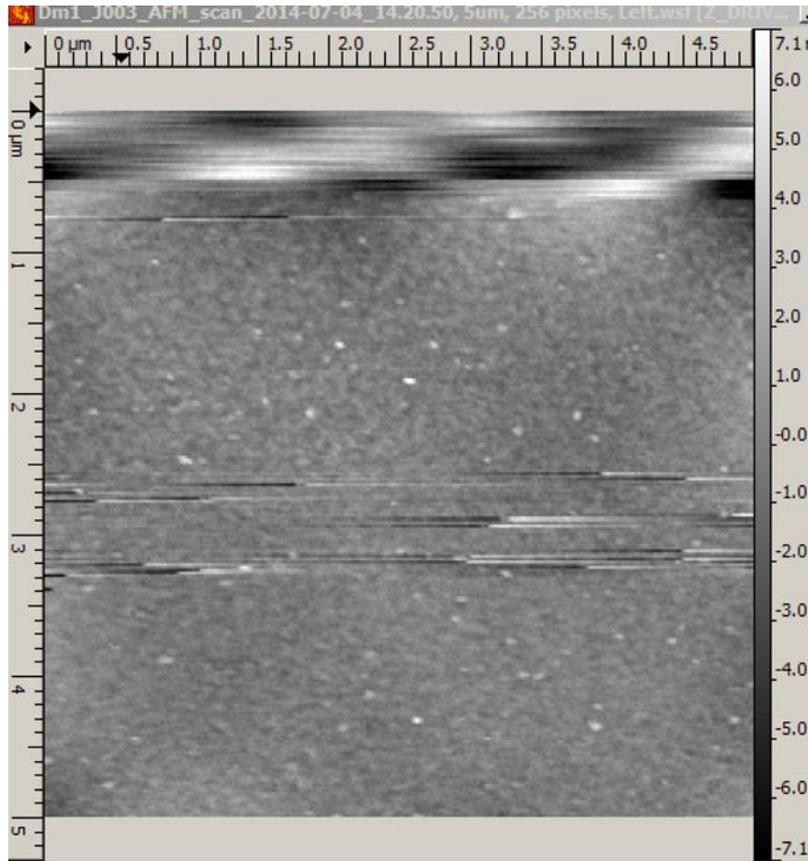
Surface contamination

Contamination of the surface by fingerprint, oil film, etc. can cause artifacts such as smearing of the features or streaks in regions with sharp features as the tip may drag/pull material while scanning. Such artifacts can be eliminated by cleaning the sample.



Vibrations

Acoustic and floor vibrations can induce several kinds of artifacts in the form of long streaks across the whole scan, smearing of sharp edges, decrease in contrast, etc.

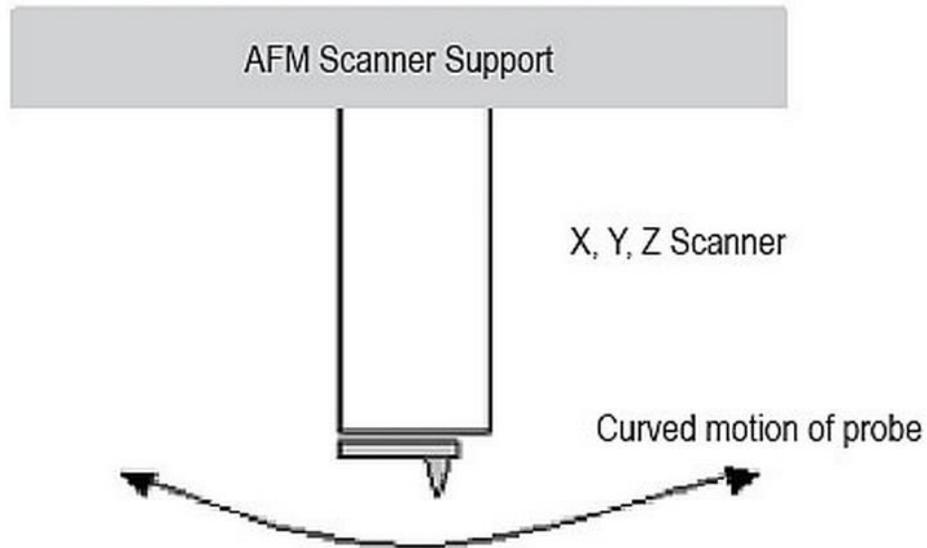


Background Bow/Tilt

The piezoelectric scanners move probe over a curved trajectory. The curved motion results in a “bow” like pattern in the AFM image.

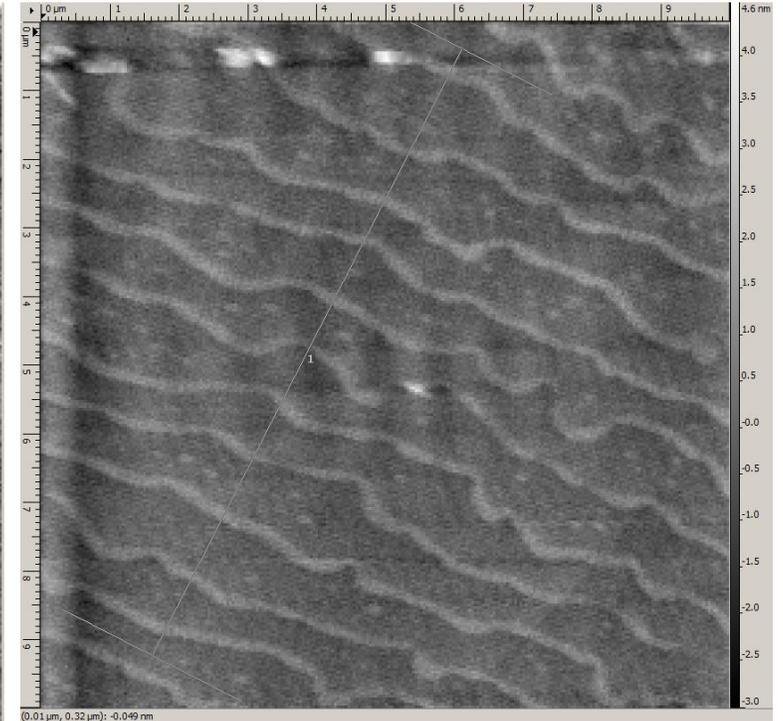
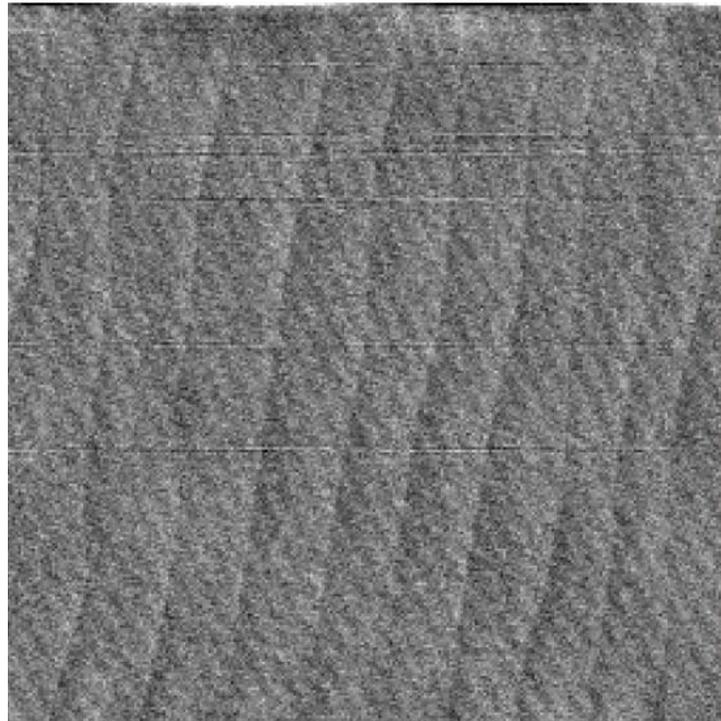
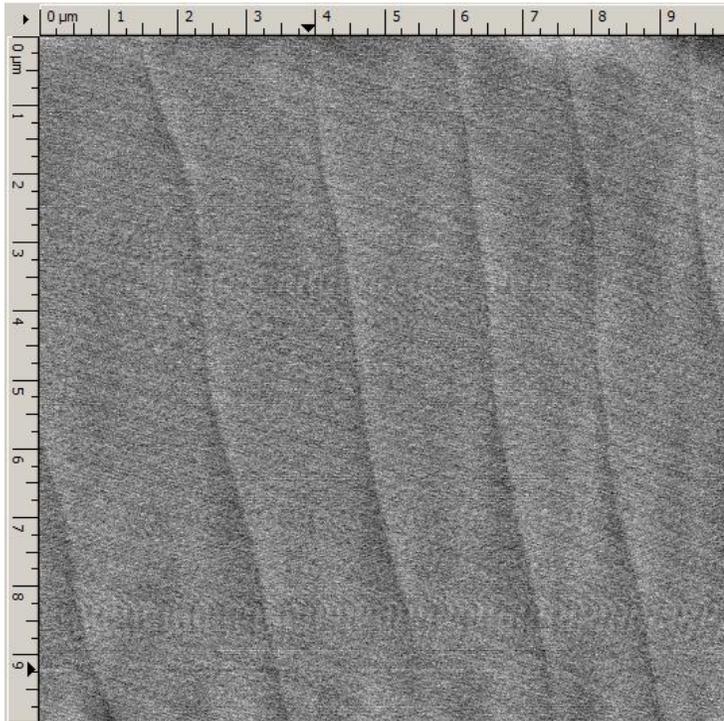
If the probe is not perpendicular to the surface a large planar background is observed, also known as “Tilt” is observed.

These artifacts can be eliminated by subtracting the background from the image. This is called as “levelling” or “flattening” the image.



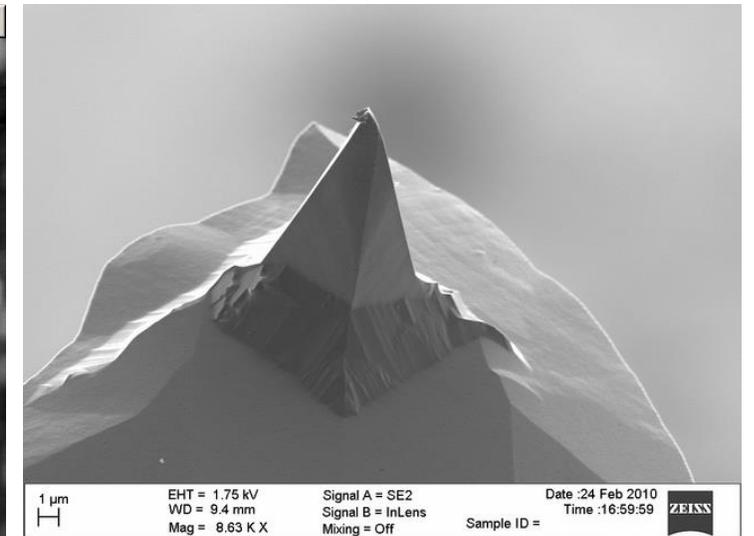
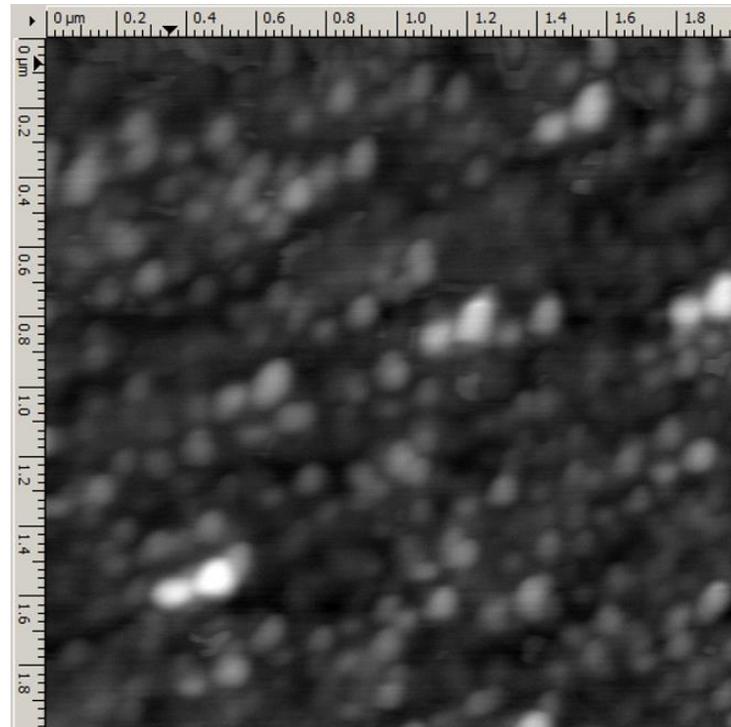
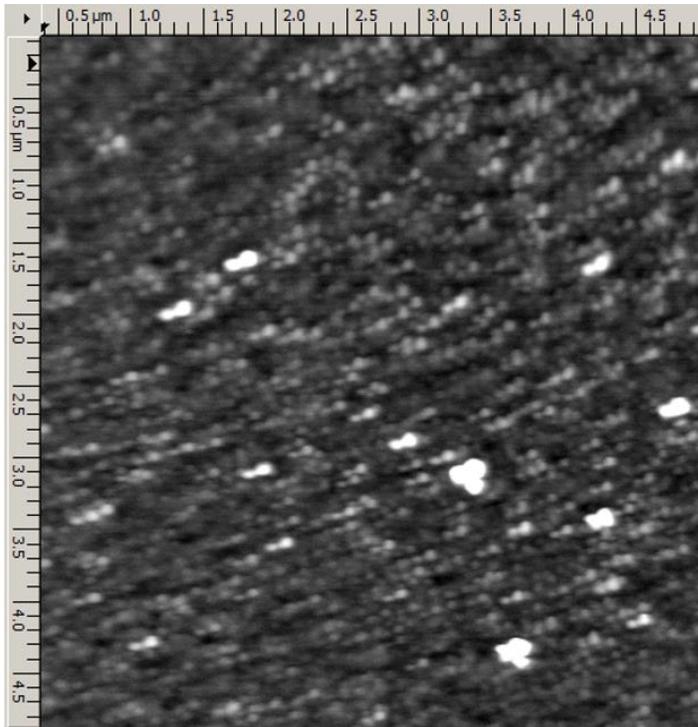
Hysteresis

Unlike other artifacts, hysteresis enhances the image especially at edges by increasing apparent distance across the edge. However, such artifacts usually lead to erroneous measurements. This can be fixed through PID parameters.



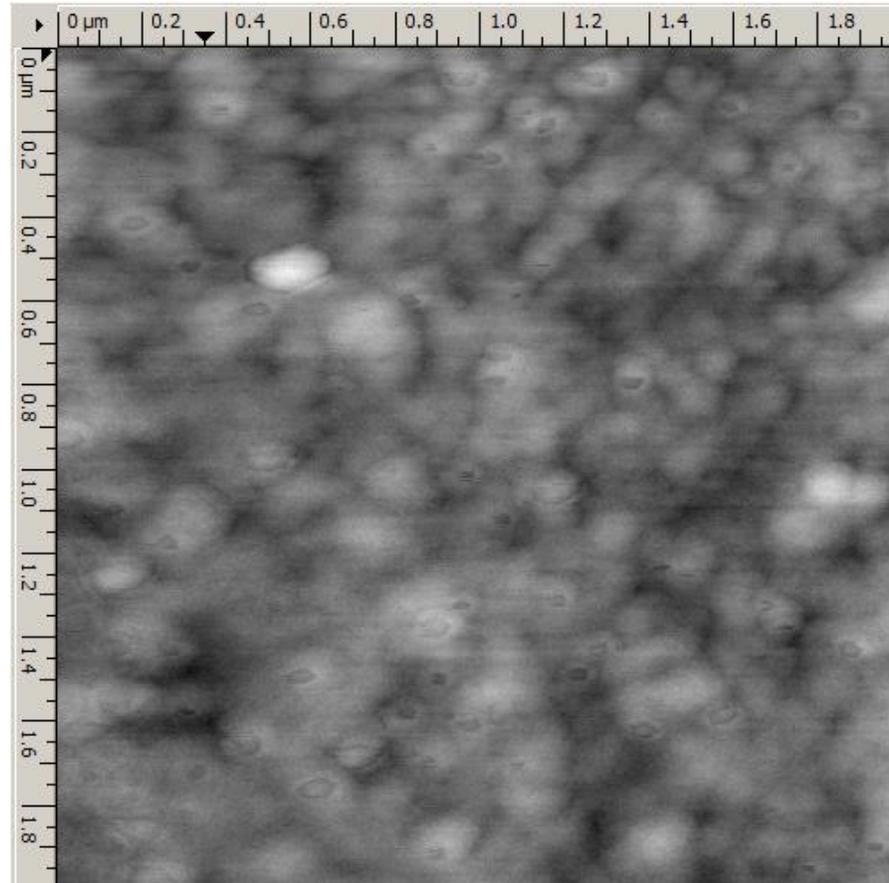
Contaminated tip

A contaminated tip usually results in multiple repetition of surface features. Sometimes it could also lead to emergence of triangle-shaped particles (as are observed with a chipped tip) in the image.



High frequency ringing

Ring-like features are observed in the image if while scanning the cantilever is vibrating at a frequency higher than its resonance value. Lowering the frequency of vibration solves this problem.



Calibration and linearity

Ceramic piezos are non-linear devices, i.e. over long range they respond non-linearly to applied voltage. For example, if the scanner is calibrated at 100nm, it will not read a correct value at 2-3 nm range. For a correct measurement, the calibration needs to be done close to the dimensions of the features that are to be scanned.

Scanner Drift

This causes distortion in image due to variation thermal response of the piezos. The image appears to be curved in the beginning (common) as well as during the scan.

Lack of proper re-centering

Shows up in the form of partly textured and partly blank image

