



Standard Guide to Scanner and Tip Related Artifacts in Scanning Tunneling Microscopy and Atomic Force Microscopy¹

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1. Scope

1.1 All microscopes are subject to artifacts. The purpose of this document is to provide a description of commonly observed artifacts in scanning tunneling microscopy (STM) and atomic force microscopy (AFM) relating to probe motion and geometric considerations of the tip and surface interaction, provide literature references of examples and, where possible, to offer an interpretation as to the source of the artifact. Because the scanned probe microscopy field is a burgeoning one, this document is not meant to be comprehensive but rather to serve as a guide to practicing microscopists as to possible pitfalls one may expect. The ability to recognize artifacts should assist in reliable evaluation of instrument operation and in reporting of data.

1.2 A limited set of terms will be defined here. A full description of terminology relating to the description, operation, and calibration of STM and AFM instruments is beyond the scope of this document.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards*:²

E1813 Practice for Measuring and Reporting Probe Tip Shape in Scanning Probe Microscopy

3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *artifact*—any feature of an image generated by an AFM or STM that deviates from the true surface. Artifacts can

have origins in sample preparation, instrument hardware/software, operation, post processing of data, etc.

3.1.2 *image*—surface topography represented by plotting the z value for feature height as a function of x and y position. Typically the z height value is derived from the necessary z voltage applied to the scanner to allow the feedback value to remain constant during the generation of the image. The “image” is therefore a contour plot of a constant value of the surface property under study (for example, tunneling current in STM or lever deflection in AFM).

3.1.3 *tip*—the physical probe used in either STM or AFM. For STM the tip is made from a conductive metal wire (for example, tungsten or Pt/Ir) while for AFM the tip can be conductive (for example, doped silicon) or non-conductive (for example, silicon nitride). The important performance parameters for tips are the aspect ratio, the radius of curvature, the opening angle, the overall geometrical shape, and the material of which they are made.

3.1.4 *cantilever or lever*—the flexible beam onto which the AFM tip is placed at one end with the other end anchored rigidly to the microscope. The important performance parameters for cantilevers are the force constant (expressed in N/m) and resonance frequency (expressed in kHz typically). These values will depend on the geometry and material properties of the lever.

3.1.5 *scanner*—the device used to position the sample and tip relative to one another. Generally either the tip or sample is scanned in either STM or AFM. The scanners are typically made from piezoelectric ceramics. Tripod scanners use three independent piezo elements to provide motion in x , y , and z . Tube scanners are single element piezo materials that provide coupled x,y,z motion. The important performance parameters for scanners are the distance of movement per applied volt (expressed as nm/V) and the lateral and vertical scan ranges (expressed in microns).

3.1.6 *scan angle*—the angle of rotation of the x scan axis relative to the x -axis of the sample

3.1.7 *tip characterizer*—a special sample used to determine the geometry of the tip. The tip in question is used to image the characterizer. The image then becomes an input to an algorithm for determining the tip geometry.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.