



Tip Evaluation Option for NanoScope Atomic Force Microscopes

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Introduction

AFM measurements are limited by the shape of the tip used to probe the sample surface. As the tip wears, the finite size of the AFM tip may not allow the tip to accurately probe narrow or sharp features on a sample, resulting in underestimation of surface roughness and/or rounding/broadening of sharp surface features. For this reason, it is generally desirable to discard a tip when it is no longer sufficiently sharp. This has traditionally been a judgment requiring significant AFM experience.

Veeco now offers the industry's finest tip evaluation system for atomic force microscopy (AFM). Available for NanoScope® controllers for Dimension™, MultiMode®, PicoForce, BioScope™, EnviroScope, and NanoMan systems, the package monitors tip shape to determine whether the tip should be replaced and reports this condition to the user. Timely replacement of worn or bad tips can result in better and more consistent results, better comparison of data collected with different tips and systems, and time savings through greater automation and less user intervention.

How It Works

Based on analysis of a sample or standard, the software presents a worst-case tip sharpness, including displaying an image of the estimated tip itself. Comparing this sharpness to a user-specified criterion, the software tells the user whether the tip is acceptable or should be replaced. The package includes the proprietary tip evaluation software, descriptive documentation, a titanium (Ti) characterization standard, and technical support for software operation. The package performs two functions: Tip Estimation and Tip Qualification.

Tip Estimation

Tip Estimation refers to the approximation of current tip sharpness based on periodic checking of images

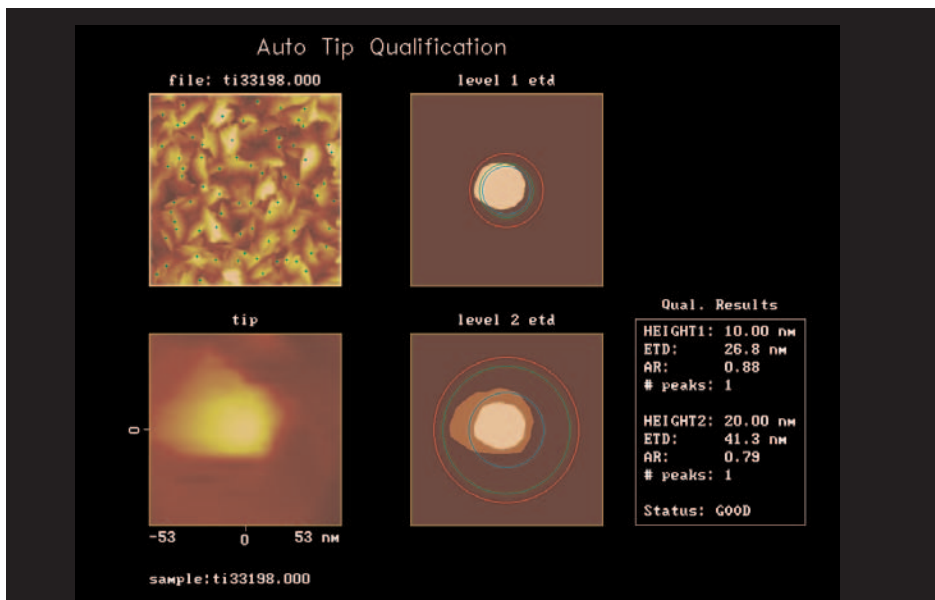


Figure 1. The Tip Estimation software provides two numerical measurements of the tip size and shape at each of two user-selected distances from the tip apex: effective tip diameter (ETD) and aspect ratio (AR). The ETD is the diameter of a circle having the same area as the measured tip cross-section. The ETDs are shown in the frames on the right side of the screen as blue circles. The green circle represents the threshold between GOOD and WORN, and the red circle is the BAD threshold. The AR is calculated as the ratio of the vertical (y) and horizontal (x) size of the tip and is among several factors used to identify suspect tips or data. This evaluation is the first in a series of two for the Ti characterizer (included with the Tip Evaluation package) and shows the tip is within the GOOD range.

generated by scanning with that tip. A model of the tip is constructed by analyzing a collection of different features from the image data. The software first identifies a set of local peaks in the image data (green crosses in Figures 1, 2). At the top of each of these peaks, the software determines the rate at which surrounding data slopes down in all directions. The degree of the slope determines the minimum tip sharpness; i.e., no data in the image can have a slope steeper than the slope of the tip with which it was scanned. As this basic process is repeated for each local peak, any feature sharper than corresponding features from all previously analyzed peaks will cause the tip model to update to a new, sharper estimate. Figure 1 and 2 show estimated tip sharpness at two scanning times for the Ti characterizer.

Note that unless the scanned sample contains extremely sharp features, the calculated tip sharpness estimate may not be the actual shape of the tip – but it does provide the sharpest tip shape that the features on the scanned sample allow. The user has the choice of using their own sample for the sharpness estimate or the Ti characterizer, which contains extremely sharp features.

Tip Qualification

The Tip Qualification software generates a tip status by comparing the estimated tip diameter and aspect ratio (see Figures 1 and 2) with user-selected threshold and limit values. The

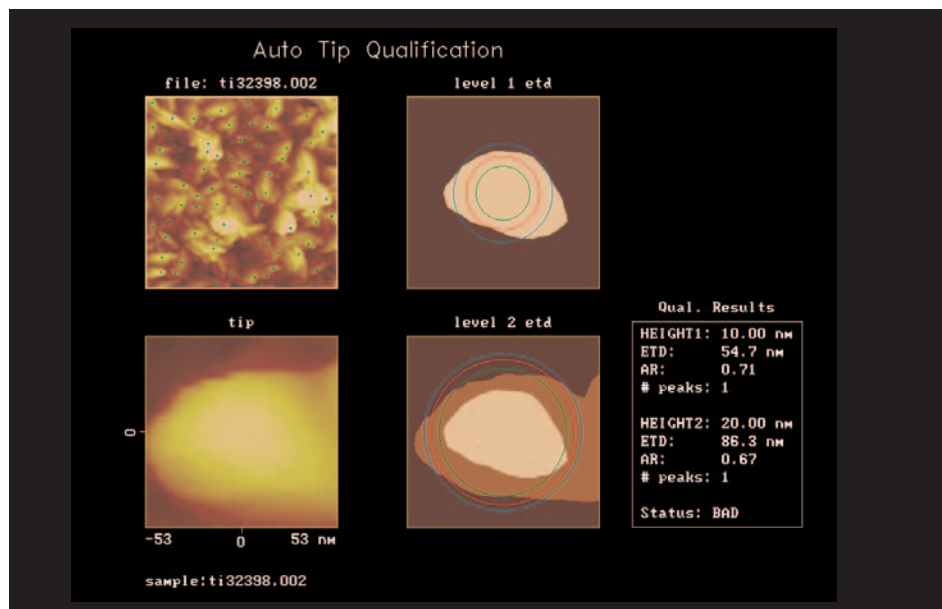


Figure 2. This evaluation is the second in a series of two for the Ti characterizer and shows the tip is BAD and requires replacement.

software will usually return one of the following tip statuses:

- GOOD indicates that the tip is still sufficiently sharp and that the image data should be acceptable.
- WORN indicates that the tip is becoming dull and should be changed, but previous image data taken with this tip should still be acceptable
- If a BAD status is returned, the tip should be changed and the current image data discarded.

In cases where imaging errors are suspected, Tip Qualification may return one of two other statuses: SUSPECT or NO TIP flags that tell the user to investigate further.

Summary

The tip is one of the prime components of any AFM. Undetected tip wear or damage can degrade images and measurements and lead to faulty interpretation of data. This Tip Evaluation tool helps users quickly identify tip problems by comparing user-selected thresholds with calculated tip characteristics obtained directly from scanning. This new capability can result in better and more consistent results, better comparison of data collected with different tips and systems, and time savings through greater automation and less operator oversight.

