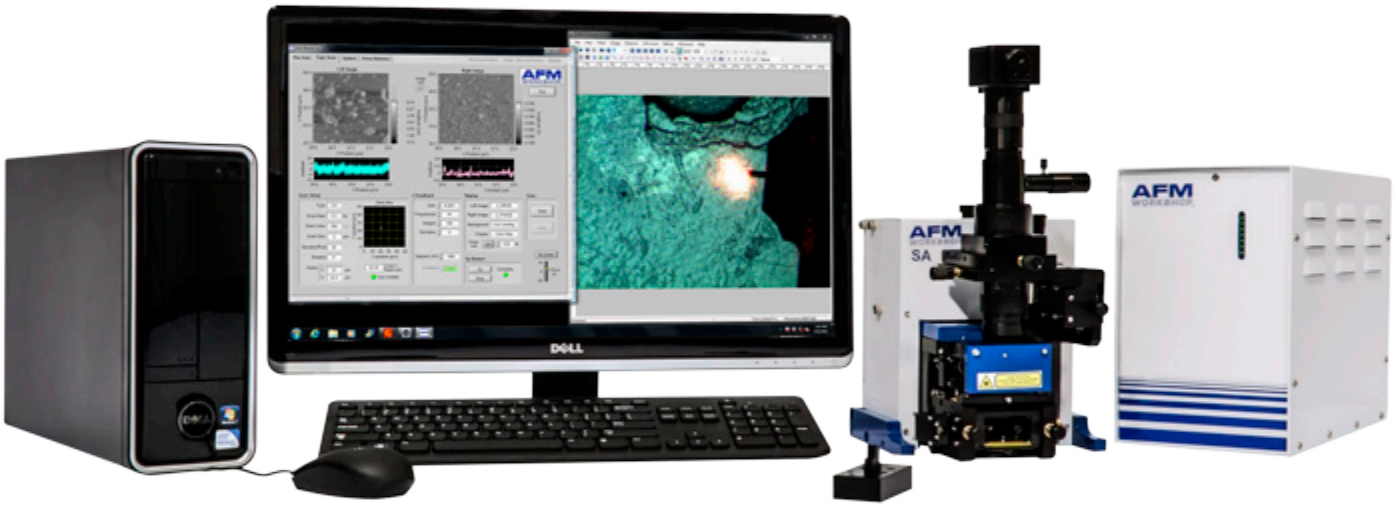
SA-AFM



Use the SA-AFM for scanning life science samples, large samples, routine scanning of technical samples, or for nanotechnology research.

The SA-AFM is a complete system and includes everything required for scanning all sizes and shapes of samples. It is easily integrated with all manufacturer's inverted microscopes.

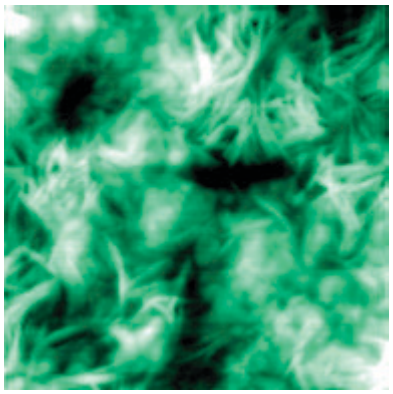
- Flexible, stand alone design
- Scans any sample size
- Adaptable to inverted microscopes
- Linearized xy piezoelectric scanner
- Accommodates widest range of standard AFM probes
- All standard modes, including vibrating, non-vibrating, and phase
- Direct drive motorized probe approach
- Intuitive LabVIEW-based software for image capture

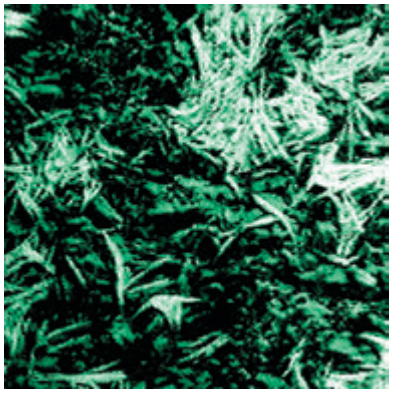
Using the industry standard light lever force sensor, all standard scanning modes are included with the system. Vibrating mode is used for high resolution and soft samples, while non-vibrating mode can be used for routine scanning. Also included with the system are phase and lateral force modes.

Control software, written in LabVIEW, is simple and intuitive to use. Differing windows walk users through the process: a pre-scan window helps align the AFM probe, a scanning window aids in acquiring images, a force position window measures force distance curves, and finally, a system window assists in altering system parameters.

SA-AFM MEASUREMENTS

In addition to measuring surface structure, the SA-AFM is ideal for modes measurements. For example these images are of a polymer sample. The top image is the topography image and the bottom image is the phase image, measuring the relative hardness of the polymer sample.



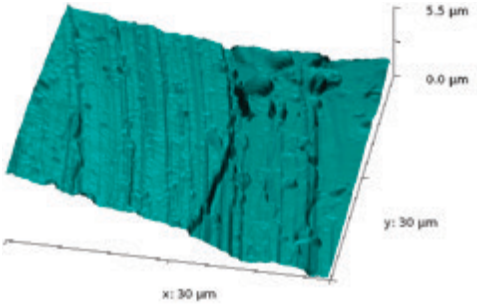


Surface Texture

Surface texture on polished and machined surfaces is readily measured with the SA-AFM.

With the SA's flexible stage design, fixtures for holding almost any sample shape can be created.

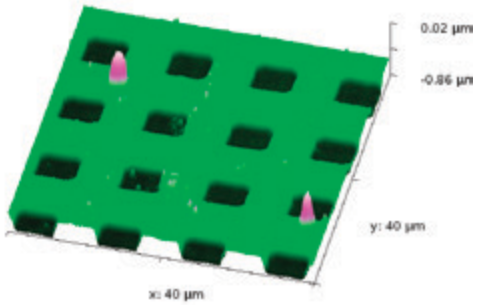
Once measured, the AFM images can be analyzed and standard surface texture parameters such as Ra are readily calculated.



Polished Surface - 30x30x5 microns

Dimensional

Atomic force microscopes are capable of accurately measuring the dimensions of semiconductor and other micro-fabricated devices. Because the SA-AFM accommodates commercially available AFM probes, specialized probes for metrology measurements can be used.

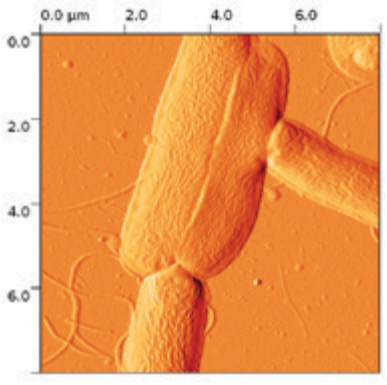


Calibration reference - 40x40x1 micron

Visualization

One of the most powerful capabilities of the SA-AFM is the capability to visualize surface structure. Although not easily quantified, the surface texture of this cell structure is readily visualized.

Features that may be readily visualized with the SA-AFM range in size from a few nm to a few microns.



Cells - 8x8 microns. Image measured by Dr. Peter Eaton on the TT-AFM

SA-AFM STAGE

High Resolution Z Stage
The direct drive's Z stage controls motion down to 330 nm, assuring optimal tip approach. Software controls for the Z stage rapidly move the light lever up and down and regulate the automated probe approach.

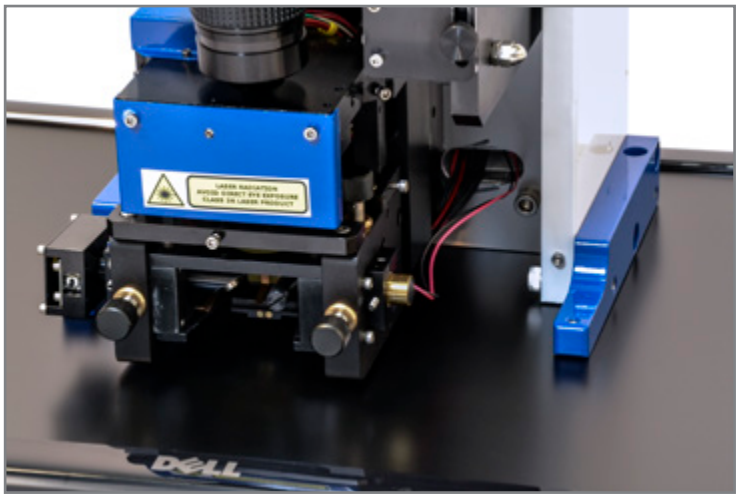
Light Lever Force Sensor
An industry standard light lever force sensor is utilized in the SA-AFM. The probe holder accommodates the widest range of commercially available AFM probes. The light lever force sensor can make measurements in standard modes, including vibrating, non-vibrating, lateral force, and phase mode.

Video Microscope
The high resolution video microscope has a zoom tube which allows a field of view between 2 X 2 mm and .3 X .3 mm. The video microscope is essential for aligning the light lever laser, locating features for scanning, and facilitating tip approach.

XY Piezo Scanner
For XY scanning, linearized piezo electric ceramics utilize real time feedback control to assure accurate measurements. The multiple modified tripod design (MMTD) of the xy scanner provides scans with minimal background bow.

Probe holder
A modular probe holder is used in the light lever force sensor and held in place with a spring clip. Probes can be replaced in less than two minutes with the probe exchange tool. Additionally, the probe holder's spring clip can be used to supply voltages to the AFM probe for techniques such as conductive AFM.

- High resolution 3MP CCD Color Camera Video Microscope
- High Performance Linear Z Translator
- XYZ Video Microscope Positioning
- Linearized X-Y Scanner
- Light Lever Force Sensor
- Small Footprint High Stability Stage Structure



Large objects that will not fit in a traditional stage may be imaged with the SA-AFM. In this example, the monitor of a commercial AFM is being imaged.

EBOX

Electronics in the SA-AFM are constructed around industry standard USB data acquisition electronics. The critical functions, such as xy scanning, are optimized with a 24-bit digital to analog converter. With the analog z feedback loop, the highest fidelity scanning is possible. Vibrating mode scanning is possible with both phase and amplitude feedback using the high sensitivity phase detection electronics.

- **24-bit Scan DAC**
  Scanning waveforms for generating precision motion in the X-Y axis with the piezo scanners are created with 24 bit DACS driven by a 32 bit micro controller. With 24 bit scanning, the highest resolution AFM images may be measured. Feedback control using the xy strain gauges assures accurate tracking of the probe over the surface.

- **Phase and Amplitude Detector Circuit**
  Phase and amplitude in the Ebox are measured with highly stable phase and amplitude chips. The system can be configured to feed back on either phase or amplitude when scanning in vibrating mode.

- **Signal Accessible**
  At the rear of the eBox is a 50 pin ribbon cable that gives access to all of the primary electronic signals without having to open the eBox.

- **Precision analog feedback**
  Feedback from the light lever force sensor to the Z piezoceramic is made using a precision analog feedback circuit. The position of the probe may be fixed in the vertical direction with a sample-and-hold circuit.

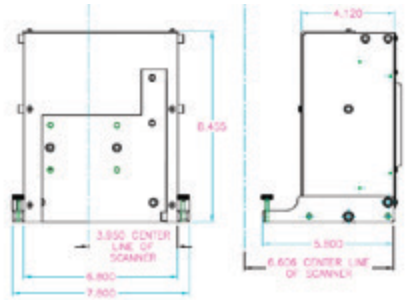
- **Variable Gain High Voltage Piezo Drivers**
  An improved signal to noise ratio as well as extremely small scan ranges are possible with the variable gain high voltage piezo drivers.

- Microprocessor for scan generation through 24 bit DACs
- Low noise, variable gain high voltage amplifiers with PID feedback for XY scanning
- Dimensions: Width 6" | Height 10" | Depth 14"
- High fidelity, low noise z feedback circuits for accurate probe tracking
- Phase and amplitude detection circuits for vibrating mode AFM
- Industry standard National Instruments USB data acquisition board
- Internally accessible header for signal input/output
- Eight channels of ADC for monitoring and displaying data with LabVIEW software

SOFTWARE

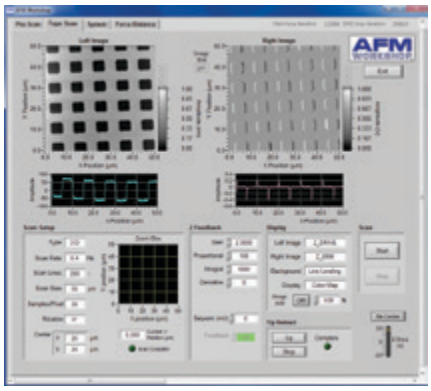
Software for acquiring images is designed with the industry standard LabVIEW programming visual interface instrument design environment. Functions such as setting scanning parameters, probe approach, frequency tuning and real time image display are all standard, and included with the product. If special enhancements are needed, LabVIEW's programming environment facilitates rapid software development. LabVIEW standards ensure that the SA-AFM can be combined with any other instrument using LabVIEW VI.

Pre-scan Window



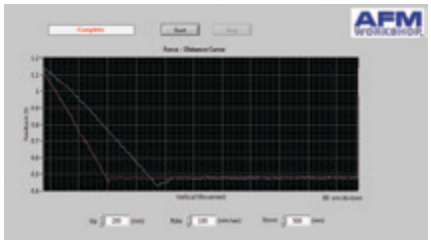
A pre-scan window presents users with a logical sequence to all functions required before initiating a scan.

Scan Window



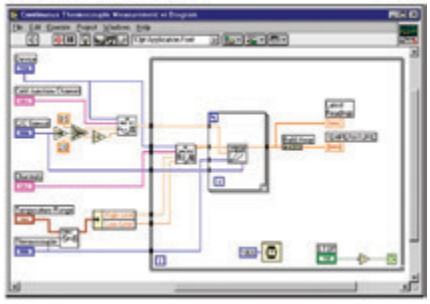
Once the steps in the pre-scan window are completed, the scan window is used for measuring images. Scan parameter, Z feedback parameters, and image view functions may be changed with dialogs on this screen.

Force/Distance Curves



There is a tab for measuring F/D curves in the AFMWorshop software. Data is exported to a .csv file for analysis in standard programs such as Microsoft Excel™.

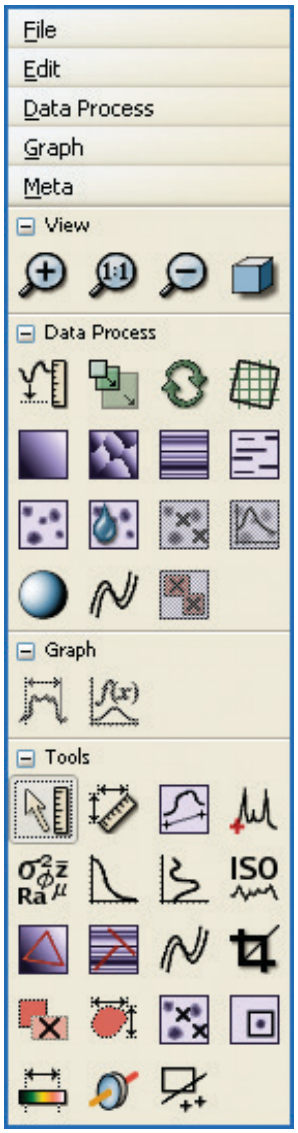
LabVIEW



LabVIEW is an industry standard programming environment for controlling instrumentation. All the software for the SA-AFM is written with LabVIEW and can be readily customized for specialized applications. Any instrumentation already using LabVIEW can be added to the SA-AFM to create new capabilities.

IMAGE ANALYSIS SOFTWARE

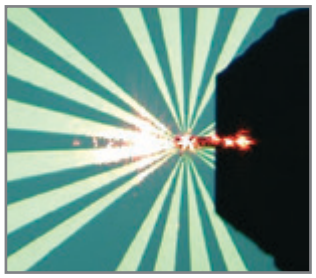
Included with the SA-AFM is the Gwyddion open source SPM image analysis software. This complete image analysis package has all of the software functions necessary to process, analyze and display SPM images.



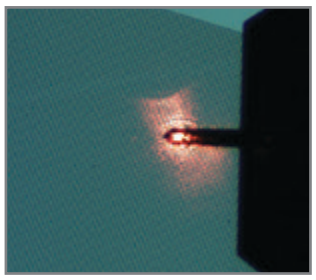
- Visualization: false color representation with different types of mapping
- Shaded, logarithmic, gradient- and edge-detected, local contrast representation, Canny lines
- OpenGL 3D data display: false color or material representation
- Easily editable color maps and OpenGL materials
- Basic operations: rotation, flipping, inversion, data arithmetic, crop, re-sampling
- Leveling: plane leveling, profiles leveling, three-point leveling, facet leveling, polynomial background removal, leveling along user-defined lines
- Value reading, distance and angle measurement
- Profiles: profile extraction, measuring distances in profile graph, profile export
- Filtering: mean, median, conservative denoise, Kuwahara, minimum, maximum, checker pattern removal
- General convolution filter with user-defined kernel
- Statistical functions: Ra, RMS, projected and surface area, inclination, histograms, 1D and 2D correlation functions, PSDF, 1D and 2D angular distributions, Minkowski functionals, facet orientation analysis
- Statistical quantities calculated from area under arbitrary mask
- Row/column statistical quantities plots
- ISO roughness parameter evaluation
- Grains: threshold marking and un-marking, watershed marking
- Grain statistics: overall and distributions of size, height, area, volume, boundary length, bounding dimensions
- Integral transforms: 2D FFT, 2D continuous wavelet transform (CWT), 2D discrete wavelet transform (DWT), wavelet anisotropy detection
- Fractal dimension analysis
- Data correction: spot remove, outlier marking, scar marking, several line correction methods (median, modus)
- Removal of data under arbitrary mask using Laplace or fractal interpolation
- Automatic *xy* plane rotation correction
- Arbitrary polynomial deformation on *xy* plane
- 1D and 2D FFT filtering
- Fast scan axis drift correction
- Mask editing: adding, removing or intersecting with rectangles and ellipses, inversion, extraction, expansion, shrinking
- Simple graph function fitting, critical dimension determination
- Force-distance curve fitting
- Axes scale calibration
- Merging and immersion of images
- Tip modeling, blind estimation, dilation and erosion

VIDEO MICROSCOPE

A video optical microscope in an AFM serves three functions: aligning the laser onto the cantilever in the light lever of the AFM, locating surface features for scanning, and facilitating probe approach. The SA-AFM includes a high performance video optical microscope along with a 3 mega pixel CCD camera, light source, microscope stand, and Windows software for displaying images.



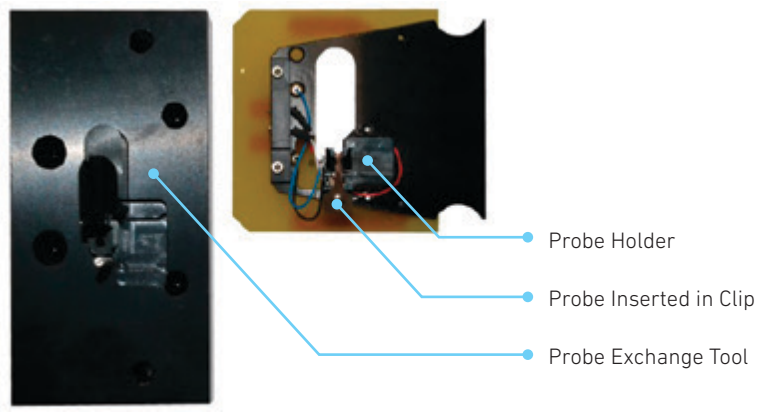
The video microscope is used to locate surface features for scanning. The vibrating mode probe cantilever shown here is 125 microns long. The sample is a reference for conductive mode AFM which has several electrodes that come together in the center.



Laser alignment is greatly facilitated with the video optical microscope. With a resolution of 1.5 it is possible to directly visualize the position of a laser spot on the cantilever. The video optical microscope is also used to increase the rate of probe approach. It is possible to estimate the distance between a sample and probe by focusing first on the sample and then on the probe.

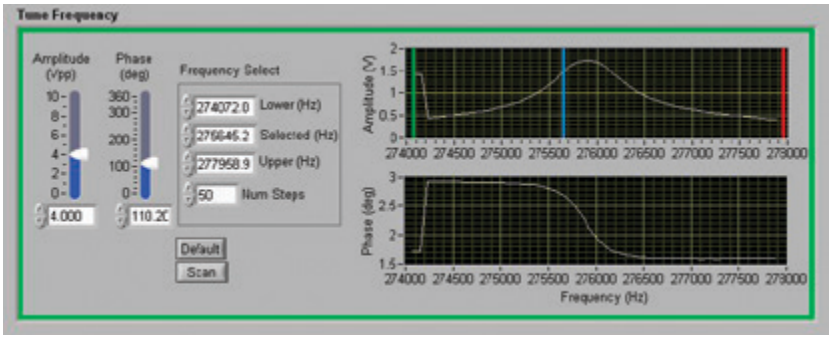
PROBE HOLDER/ EXCHANGE

The SA-AFM utilizes a unique probe holder/exchange mechanism. Probes are held in place with a spring device that mates with a probe exchange tool. This combination makes changing probes fast and easy on the SA-AFM.



MODES

Standard with every SA-AFM are non-vibrating (NV) mode and vibrating (V) modes for creating topography scans. Additional modes included with the product are lateral force imaging and phase mode imaging. Any scanning mode that can be implemented with a light lever AFM is possible with the SA-AFM.



With the window above the resonance frequency of a cantilever is readily measured. Additionally, the phase characteristics of the probe-sample interaction may be captured.

SPECIFICATIONS

40 Micron xyz Scanner

Type	Modified Tripod
xy Linearity	< 1%
xy Range	> 40 µ
xy Resolution	< 3 nm closed loop < 0.3 nm open loop
xy Actuator type	Piezo
xy Sensor type	Strain Gauge Th
z Range	> 7 µ
z Linearity	< 5 %
z feedback noise	< 0.15 nm*
z Actuator Type	Piezo
z Sensor type	None

Light Lever AFM Force Sensor

Probe Types	Industry Standard
Probe Insertion	Manual Probe Exchange Tool
Probe Holding Mechanism	Clip Vibrating Mode Piezo Electrical Connector to Probe
Laser/Detector Adjustment Range	+/- 1.5 mm
Adjustment Resolution	1 micron
Minimum Probe to Objective	25 mm
Laser Type	670 nm Diode, < 3 mW
Laser Focus	<25 microns
Detector	
Type	4 Quadrant
Band Width	> 500 kHz
Signals Transmitted	TL, BL, TR, BR
Gain	Low, High Settings
Probe sample angle	10 degrees

Digital Data Input Output

Connection	USB
Scanning DAC	
Number	2
Bits	24
Frequency	7 kHz
Control DAC	
Number	2
Bits	14
Frequency	2 kHz
ADC	
Number	8
Bits	14
Frequency	48 kHz

Z Motion

Type	Direct Drive
Range	25 mm
Drive Type	Stepper Motor
Min. Step Size	330 nm
Slew Rate	8 mm/minute
Limit Switch	Top, Bottom
Control	Software – Rate, Step Size

Analog Electronics

Vibrating Mode	
Freq Range	2 kHz – 800 kHz
Output Voltage	10 Vpp
Demod. Freq	TBD
Z Feedback	
Type	PID
Bandwidth	> 3 kHz
Sample Hold	Yes
Voltage	0-150 V
xy Scan	
Voltage	0 – 150 V
Bandwidth	> 200 Hz
Pan & Zoom	22 Bits
Tip Approach Cutoff	< 20 µ sec.

Software

Environment	LabVIEW
Operating System	Windows 7
Image Acquisition	Real Time Display (2 of 8 channels)
Control Parameters	
PID	Yes
Setpoint	Yes
Range	Yes
Scan Rate	Yes
Image Rotate	0 and 90 degrees
Laser Align	Yes
Vibrating Freq. Display	Yes
Force Distance	Yes
Tip Approach	Yes
Oscilloscope	Yes
Image Store Format	Industry Standard
Image Pixels	16 x 16 to 1024 x 1024
H.V. Gain Control	xy and z
Real Time Display	Line Level, Light Shaded, Grey Color Palette
Calibration	System Window
Probe Center	Yes

SPECIFICATIONS *Continued*

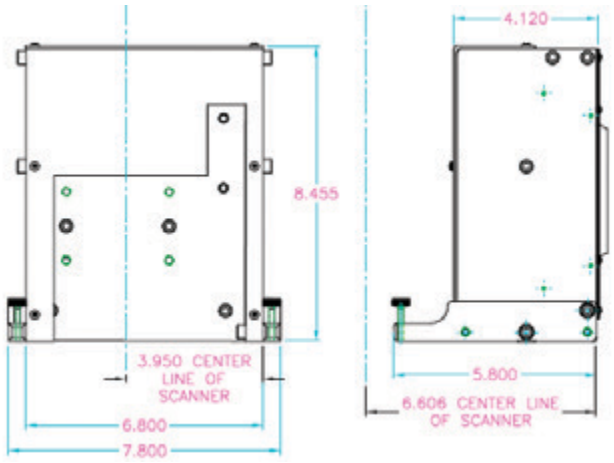
Video Microscope

	Minimum Zoom	Maximum Zoom
Field of view	2 x 2 mm	300 x 300 u
Resolution	20 µ	1.5 µ
Working Distance	114 mm	114 mm
Magnification	45X	400X

Computer

- Industry Standard Computer & Monitor (laptop available upon request)
- Windows 7
- AFMWorkshop LabVIEW .exe installed

Stage



Back and side view of the SA-AFM stage without the AFM/video microscope. The feet at the bottom may be removed if the stage is rigidly mounted to a surface.

** Z Noise performance depends greatly on the environment in which the SA-AFM is used. Best Z noise performance is obtained in a vibration free environment.*

*** Every effort is made to present accurate specifications; however, due to circumstances out of the AFM Workshop's control, specifications are subject to change.*