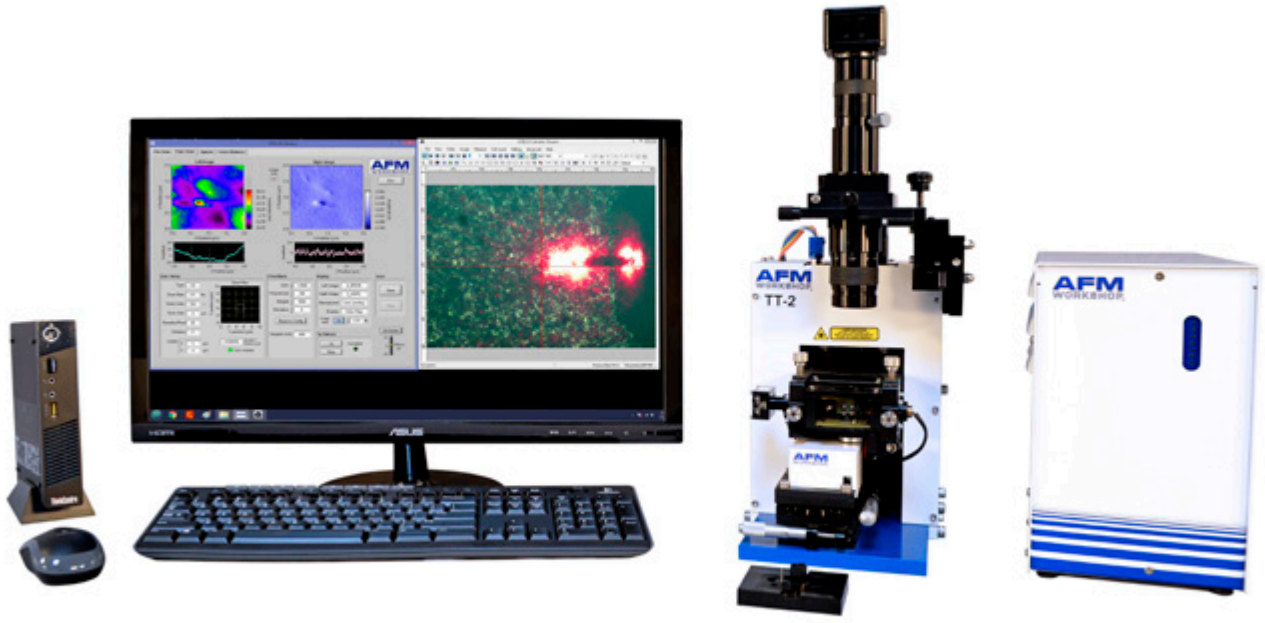
TT-2 AFM

This compact **second generation** tabletop Atomic Force Microscope has all the important features and benefits expected from a light lever AFM.

For:

- **Nanotechnology Engineers/Researchers**
  Wanting to make high resolution scans of nanostructures.
- **Instrument Innovators**
  Using AFM as a platform to create a new instrument.
- **Educators**
  Teaching students about AFM construction, operation, and applications.



Sample Sizes	Up to 1" x 1" x 3/4"
Standard Scanning Modes	Vibrating, Tapping, Non-Vibrating, Contact, Phase, LFM
Scanners	Three scanners: 100 X 100 X 17 µm • 50 X 50 X 17 µm • 15 X 15 X 7 µm
Video Optical Microscope	Zoom to 400X, 2 µm resolution
Stage and Ebox Size	Compact Tabletop Design

STAGE

The **TT-AFM stage** has excellent thermal and mechanical stability required for high resolution AFM scanning. Additionally, its open design facilitates user modification.

Rigid Frame Design
The crossed beam design for the stage support is extremely rigid so the AFM is less susceptible to external vibrations.

Light Lever AFM Force Sensor
Light lever force sensors are used in almost all AFMs and permit many types of experiments.

Integrated Probe Holder/Probe Exchanger
A unique probe holder and clipping mechanism allows quick and easy probe exchange.

Direct Drive Z Stage
A linear motion stage is used to move the probe in a perpendicular motion to the sample. Probe/sample angle alignment is not required, facilitating a much faster probe approach.

Small Footprint
The stage dimensions of 4" X 7" require little space and fit easily on a tabletop.

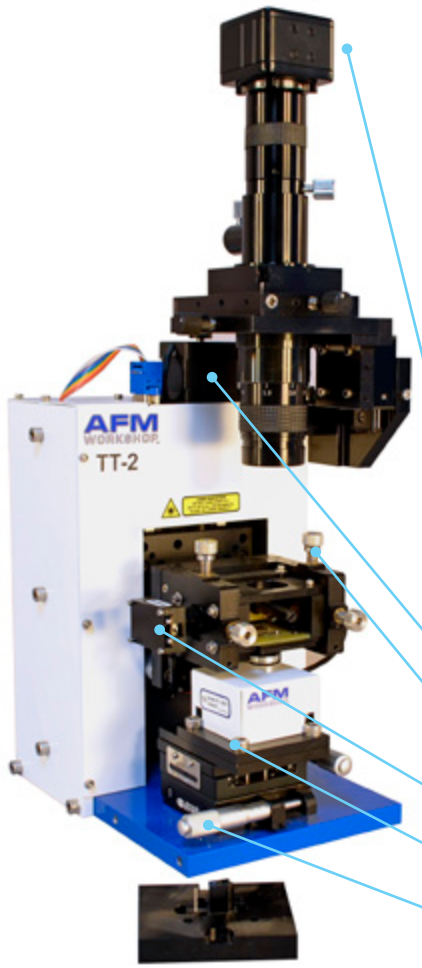
Precision XY Stage with Micrometer
The sample is moved relative to the probe with a precision XY micrometer stage. Thus, the sample can be moved without touch.

Modes Electric Plug
A six pole electrical plug is located at the back of the stage to expand the capabilities of the TT-2 AFM.

XYZ Precision Piezo Scanner
The modified tripod design utilizes temperature compensated strain gauges which ensure accurate measurements from images. Also, with this design it is possible to rapidly zoom into a feature visualized in an image.

Laser/Detector Alignment
Both the light lever laser and the photo detector adjustment mechanism may be directly viewed. This feature simplifies the laser/detector alignment.

Adaptable Sample Holder
At the top of the XYZ scanner is a removable cap that holds the sample. The cap can be modified - or a new cap can be designed – to hold many types of samples.



High resolution video microscope

Direct drive Z motor stage

Light lever force sensor

Mode input/output plug

XYZ linearized piezo scanner

XY sample translation stage

EBOX

Electronics in the **TT-2 AFM** are constructed around industry standard USB data acquisition electronics. The critical functions, such as XY scanning, are optimized with 24 bit digital to analog converter combined with 4 bits of gain.. 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.

28-bit Scanning

With 28-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.

Status Lights

At the front of the Ebox is a light panel that has seven lights. In the unlikely event of a circuit failure, these lights are used for determining the status of Ebox power supplies.

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 a vertical direction with a sample-and-hold circuit.

Variable Gain High Voltage Piezo Drivers

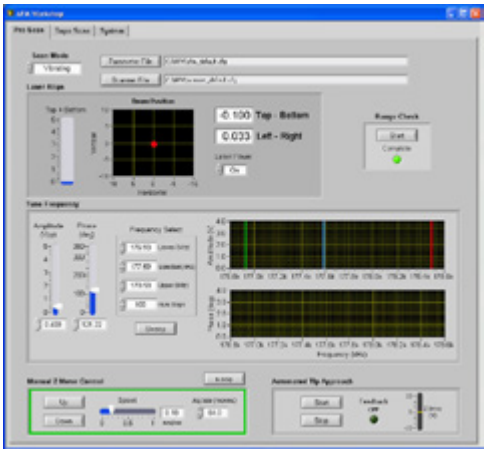
An improved signal to noise ratio as well as extremely small scan ranges are possible with the variable gain high voltage piezo drivers.

- Microprocessor for scan generation through 24-bit DAC's
- 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

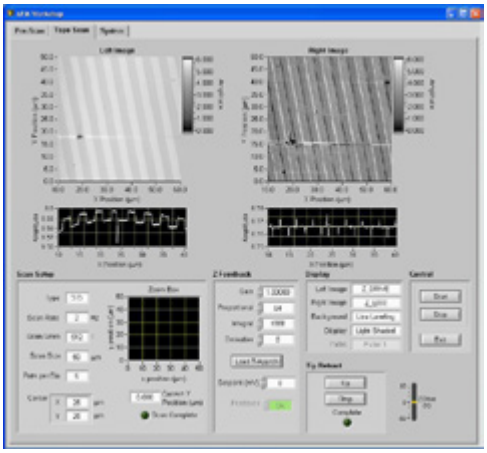
Software for acquiring images is designed with the industry-standard LabVIEW™ programming visual interface instrument design environment. There are many functions, including setting scanning parameters, probe approach, frequency tuning, and displaying images in real time. LabVIEW™ facilitates rapid development for those users seeking to enhance the software with additional special features. LabVIEW™ also enables the **TT-2 AFM** to be readily combined with any other instrument using LabVIEW™ VI.

Pre-Scan Window



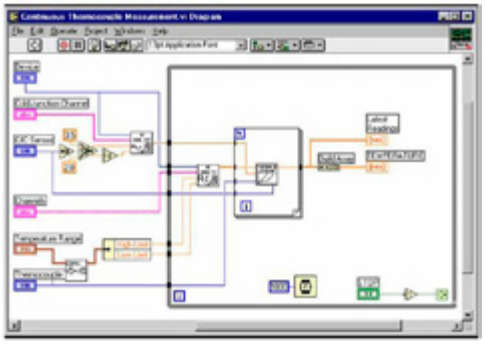
A pre-scan window includes all of the functions required before a scan is started. The functions are presented in a logical sequence on the screen.

Scan Window



Once all 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.

LabVIEW™ Window



Industry-standard programming environment. Readily customized and modified for specialized applications. Instrumentation already using LabVIEW™ can be added to the TT-2 AFM to create new capabilities.

IMAGE ANALYSIS SOFTWARE

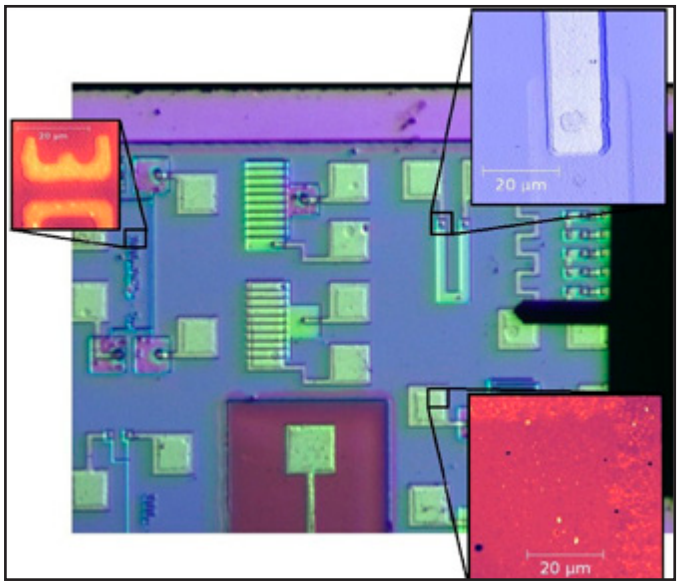
Included with the **TT-2 AFM** is Gwyddion open source SPM image analysis software. This complete image analysis package has all the software functions necessary to process, analyze, and display SPM images.

- Visualization: false color representation with different types of mapping
- Shaded, logarithmic, gradient- and edge-detected, local contrast representation, and 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, and resampling
- Leveling: plane leveling, profiles leveling, three-point leveling, facet leveling, polynomial background removal, and leveling along user-defined lines
- Value reading, distance, and angle measurement
- Profiles: profile extraction, measuring distances in profile graph, and profile export
- Filtering: mean, median, conservative denoise, Kuwahara, minimum, maximum, and 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, and 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, and watershed marking
- Grain statistics: overall and distributions of size, height, area, volume, boundary length, and bounding dimensions
- Integral transforms: 2D FFT, 2D continuous wavelet transform (CWT), 2D discrete wavelet transform (DWT), and wavelet anisotropy detection
- Fractal dimension analysis
- Data correction: spot remove, outlier marking, scar marking, and 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, and shrinking
- Simple graph function fitting, and critical dimension determination
- Force-distance curve fitting
- Axes scale calibration
- Merging and immersion of images
- Tip modeling, blind estimation, dilation, and erosion

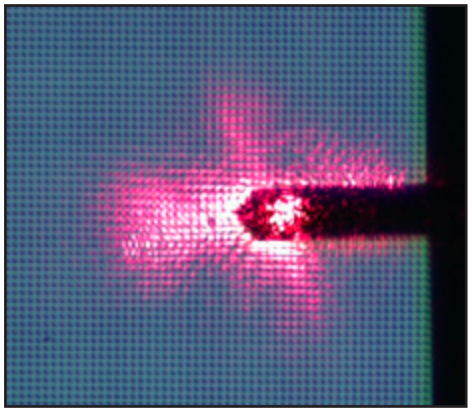
VIDEO MICROSCOPE

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.

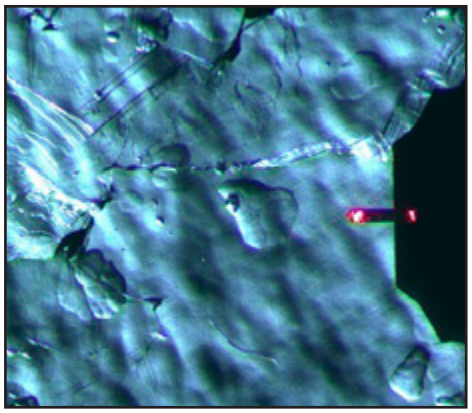
The **TT-2 AFM** includes a high performance video optical microscope along with a 5 megapixel camera, light source, microscope stand, and Windows software for displaying images.



Here the video optical microscope allows viewing features on a test structure. The AFM cantilever is on the right. Three images show results of areas selected for AFM scanning.



Laser alignment is greatly facilitated with the video optical microscope. This vibrating cantilever is 250 µm long. The red spot is from the laser reflecting off the cantilever.

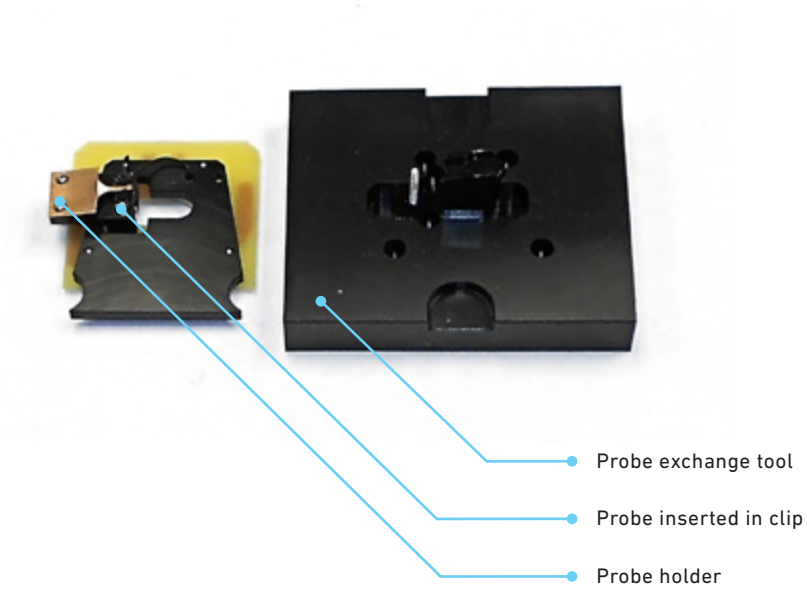


The video optical microscope zooms in to show an HOPG sample surface and the AFM cantilever.

PROBE HOLDER/ EXCHANGE

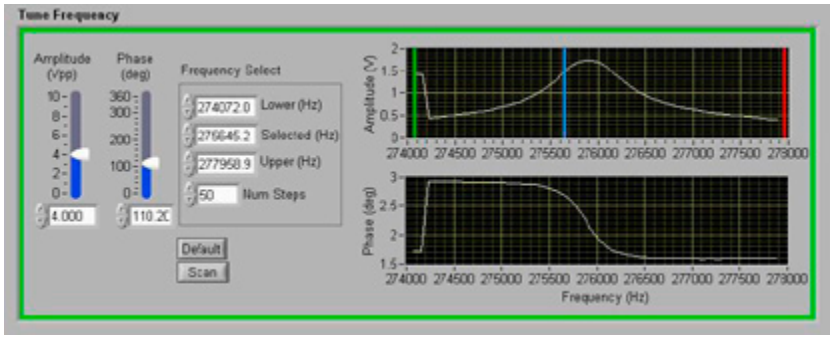
The **TT-2 AFM** utilizes a unique probe holder/exchange mechanism. Probes are held in place with a spring device that mates with a probe exchange tool.

This combination makes changing probes fast and easy on the TT-2 AFM.

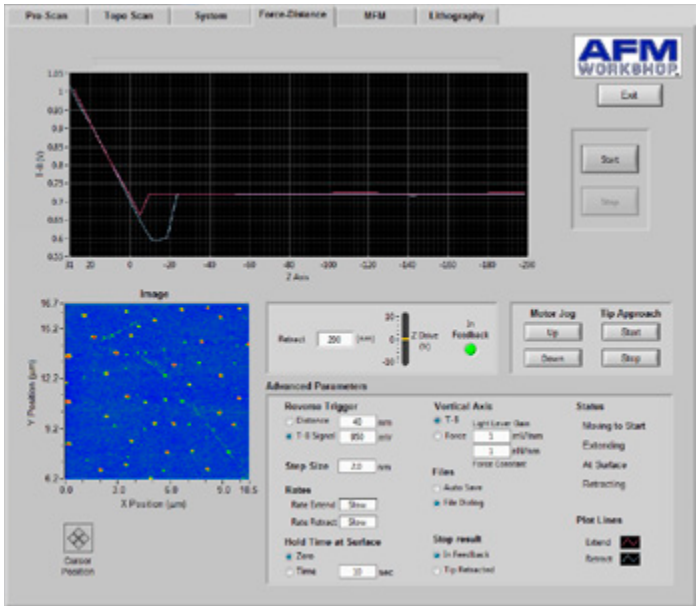


SCANNING MODES

Standard with every **TT-2 AFM** are non-vibrating (contact) and vibrating (tapping) 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 **TT-2 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.

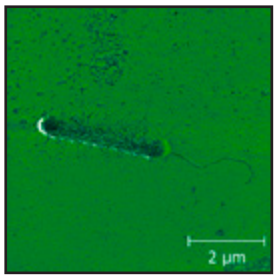


TT-2 AFM IMAGES

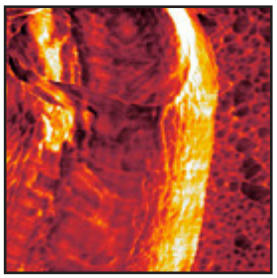
With a vertical noise floor of 0.1 µm and a horizontal resolution of 0.08 nm, most types of samples may be imaged with the **TT-2 AFM**. These include hard as well as soft samples.

OPEN DESIGN

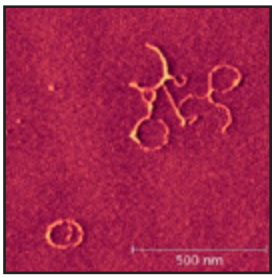
An open design is at the core of all products offered by the AFM Workshop. New types of experiments are more readily designed and implemented through the use of LabVIEW™ software. All the mechanical drawings for the **TT-2 AFM** are available in the documentation package option. Finally, the company's website offers a Users Forum to directly share specialized designs developed for the **TT-2 AFM**. For specialized applications, other types of scanners, such as flexure and tubes, can be easily added to the microscope stage.



6 x 6 µm, e.coli w/flagellum

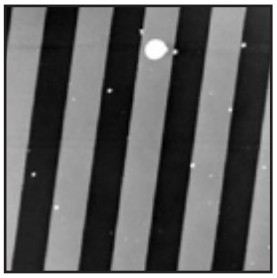


3 x 3 µm, bacteria

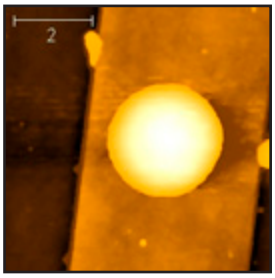


1 x 1 µm, DNA

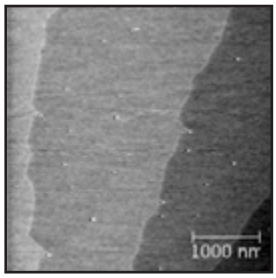
MEMS multiple level gear



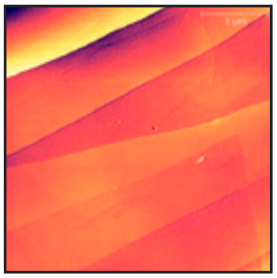
40 x 40 µm, silicon test pattern



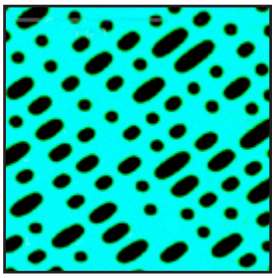
7 x 7 µm, defect



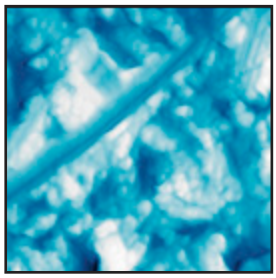
atomic terraces on Si sample, each terrace is 0.3 nm high



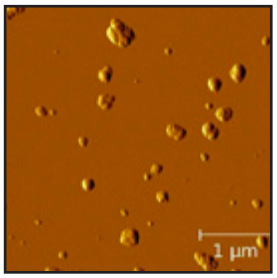
4 x 4 µm, HOPG



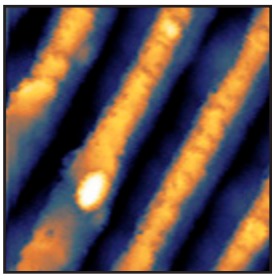
6 µm x 6 µm, DVD



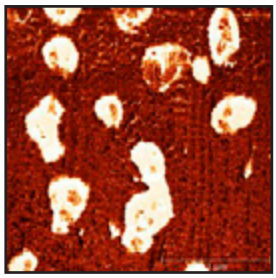
10 x 10 µm, scratch in metal



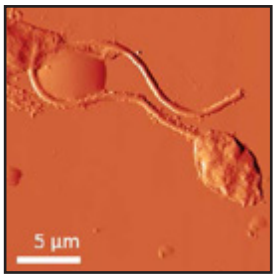
4 x 4 µm, 17 nm nanoparticles



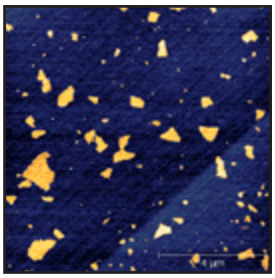
1 x 1 µm, 278 nm test pattern



5 x 5 µm, polymer phase image



25 x 25 µm, parasites



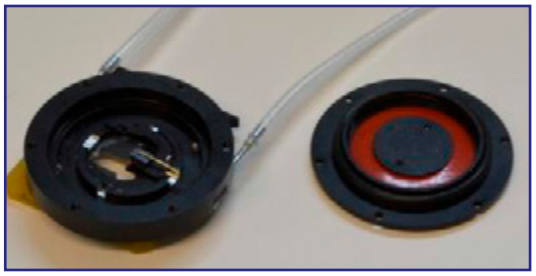
300 x 300 nm, phase PMMA

TT-2 AFM OPTIONS

Although the **TT-2 AFM** comes with everything you need to make AFM images, several additional options are available.

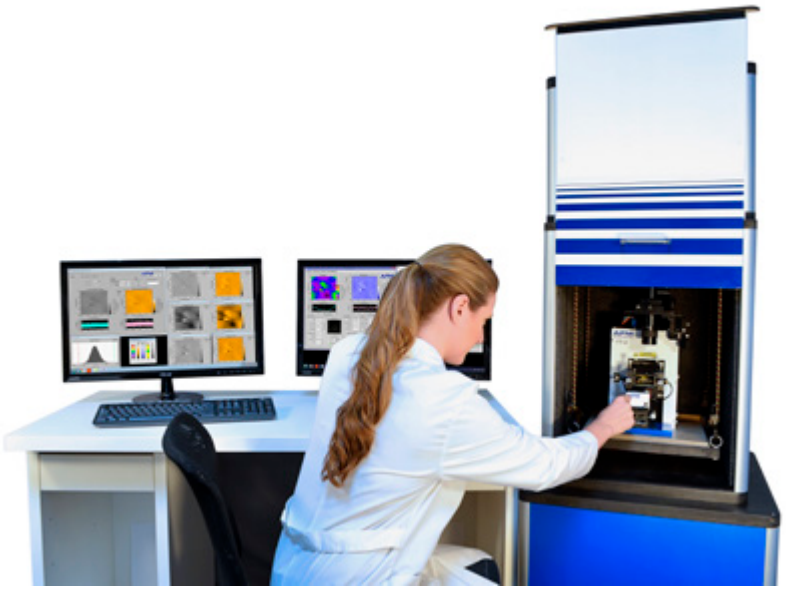
AFMWorkshop regularly develops new options.

Contact AFMWorkshop for information on options for the **TT-2 AFM**.



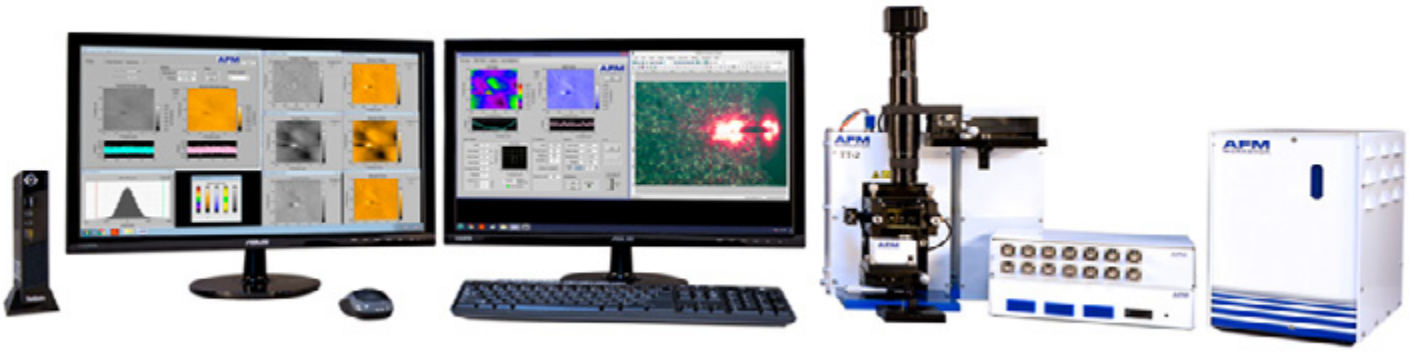
Environmental cell

15 µm scanner



- **Dunk and Scan Probe Holder**
  Open liquid cell for scanning samples submerged in liquid
- **Environmental Cell**
  Permits scanning in inert environments or liquid
- **Scanner Options**
  100 X 100 X 17 µm, 50 X 50 X 17 µm, 15 X 15 X 7 µm
- **Acoustic Enclosures**
  Reduces unwanted acoustic and structural vibrations
- **Conductive AFM**
  Measures the 2D conductivity of sample surfaces
- **Magnetic Force Microscopy**
  Measures surface magnetic field by incorporating a magnetic probe into the AFM
- **Lithography**
  Enables the probe to alter the physical or chemical properties of a sample source
- **Image Logger**
  Display six images changes with forward and reverse displays, six data channels, and spectrum analyzer
- **Focus Assist**
  Facilitates rapid tip approach as well as more accurate focus control
- **User Data I/O option**
  Adds 32-bit or 18-bit ADC and DAC to the control system
- **7 Step Software**
  Software for novice and casual AFM users
- **Scanning Tunneling Microscopy (STM)**
  Current to voltage converter and probe holder to make STM images
- **Electric Force Microscopy (EFM)**
  Two pass imaging allows capture of electric field images

TT-2 AFM ADVANCED CONFIGURATION



The **TT-2 AFM Advanced Configuration** gives all of the advanced features required for demanding projects.

Included with the packaged is:

- TT-2 AFM
- 50 µm and 15 µm Scanner
- Motorized Focus
- Advanced Force Distance
- Image Logger
- Acoustic Cabinet, Bungee Option, and Base Cabinet
- Documentation Package with all schematics, mechanical drawings, and software protocols
- Break Out Box

The TT-2 AFM Advanced Configuration package offers a substantial discount versus purchasing them separately. Most importantly, purchasing the package ensures you are ready for demanding projects as soon as the AFM is delivered to your lab.

Scanner Specifications

	100 X 100 X 17	50 X 50 X 17	15 X 15 X 7
Engineering Specifications			
» XY Resolution	0.010 nm	0.005 nm	0.003 nm
» XY Linearity	,<0.1%	<0.1%	<0.1%
» Z Resolution	0.003 nm	0.003 nm	0.0015 nm
» Z Linearity	<0.1%	<0.1%	<0.1%
Performance Specifications			
» XY Range	100 µm	50 µm	15 µm
» XY Linearity	<1%	<1%	<1%
» XY Resolution			
• Closed Loop	<6 nm	<3 nm	<1 nm
• Open Loop	<1 nm	<1 nm	<0.3 nm
» Z Range	17 µm	17 µm	7 µm
» Z Linearity			
• Open Loop	<5%	<5%	<5%
• Closed Loop	<1%	<1%	N.A.
» Z Sensor Noise	1 nm	1 nm	N.A.
» Z Feedback Noise	<0.15 nm	<0.15 nm	<0.08 nm
Actuator Type	Piezo	Piezo	Piezo
Design	Modified Tripod	Modified Tripod	Modified Tripod
XY Sensor Type	Strain Gauge	Strain Guage	Strain Gauge
Z Sensor Type	Strain Gauge	Strain Gauge	N.A.

Electronic Control Specifications			
» XY Scan	2 X 28 bits	24-bit Scan DAC, 4-bit gain	192 Khz
» XY Linearization Control	2 X 24 bits	24-bit ADC	192 Khz
» Z Axis Control	Analog	4 amplifier – GPID	1 microvolt noise
» Input Signal Bandwith	5 Mhz		
» Z axis Signal Capture	20 bits	16-bit ADC, 4-bit gain	50 Khz
» Phase Signal Capture	2 X 16 bits	ADC	50 Khz
» L-R Signal Capture	2 X 16 bits	ADC	50 Khz
» Amplitude Signal Capture	2 X 16 bits	ADC	50 Khz
» Z error Signal Caputre	2 X 16 bits	ADC	50 Khz
» Main Controller MPU	80 Mz/105 DMipts, 32 Bits (5-stage pipeline, Harvard architecture)		
» Excitation/Modulation	Analog PLL	0-800 Khz	
» Communication	USB 2.0		
» Signal capture specified includes the image logger option- Without Image Logger 1 X 16 bits			

Optional Electronics Specifications			
» User Input Signal (1)	32 X 18 bits	ADC	625 Khz
» User Output (1)	32 X 18 bits	DAC	625 Khz
» User Monitor (1)	48 Lines	Digital IO	Mhz
» Optional Controller MPU (2)	80 Mz/105 DMipts, 32 Bits (5-stage pipeline, Harvard architecture)		

(1) Optional User I/O upgrade

(2) Used for MFM, PhotoCorrect, EFM

SPECIFICATIONS *CONTINUED...*

Software

» Environment	LabVIEW™
» Operating System	Windows
» 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°
» 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 Pallet
» Calibration	System Window
» Probe Center	Yes

Video Microscope

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

Computer

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

* *Z Noise performance depends greatly on the environment the TT-AFM is used in. 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 AFMWorkshop's control specifications are subject to change.*