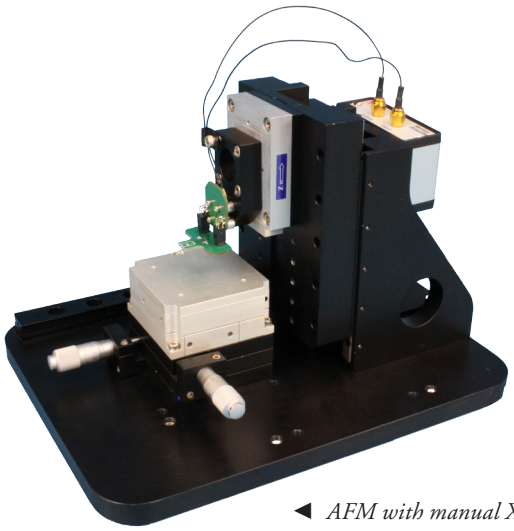
SPM-M Kit

Features

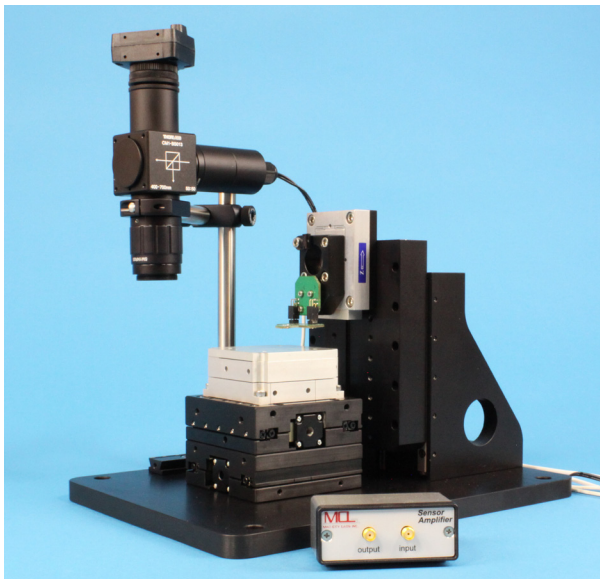
- *Low cost AFM*
- *Atomic Step Resolution*
- *MadPLL® low noise controller*
- *Integrated closed loop piezo nanopositioners*
- *Compatible wth resonant and Akiyama probes*
- *Automated hardware and software control*
- *Custom configurations*

Typical Applications

- *Metrology*
- *AFM*
- *SPM*
- *Combined light microscopy/AFM*



◄ *AFM with manual XY approach and motorized Z approach*



▲ *AFM with motorized XYZ approach, video optical microscope, and coaxial illuminator*

Product Description

Mad City Labs' SPM-M kit is suitable for both research and teaching environments. The assembled SPM is a high performance, closed loop scanning resonant probe microscope.

The SPM-M kit includes:

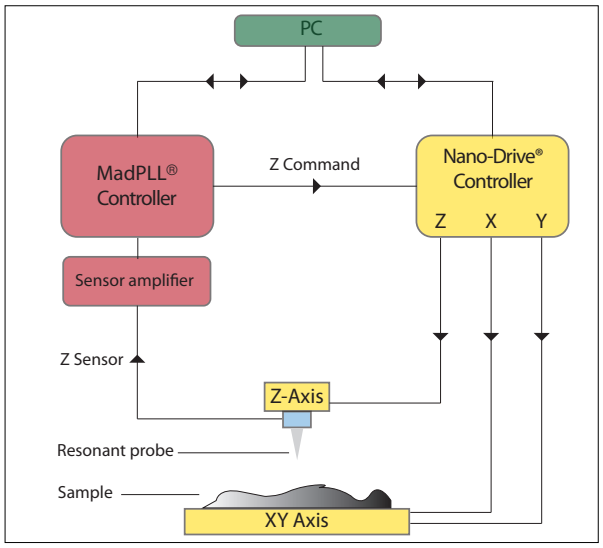
- MadPLL®
- Nano-SPM200 nanopositioning stage (XY)
- Nano-OP30 nanopositioning stage (Z)
- 3 axis closed loop Nano-Drive® controller
- OCL option (Z axis only)
- AFMView™2 software and tutorial
- Probe starter package
- Adapter plate between probe mount board and Nano-OP30
- Application note: "AFM kit with manual positioning"

MadPLL® is an integrated solution that includes the digital phase lock loop (PLL) controller, software, sensor amplifier, probe mounting board, and probe boards. MadPLL® includes five (5) each of the vertical, horizontal, Akiyama and blank probe boards. In addition each unit is shipped with 5 tuning forks. Additional probe boards and tuning forks can be purchased separately. The advantage of the MadPLL® controller is its seamless operation with all Mad City Labs nanopositioning systems.

Mad City Labs nanopositioning systems have low noise PicoQ® sensors and closed loop feedback control yielding high resolution closed loop SPM performance. Our nanopositioners plus a wide range of SPM accessories makes it simple to create inexpensive, customized atomic force microscopes.

Custom SPM

The SPM-M kit may be customized by substituting any of our wide range of nanopositioners and picopositioners and including additional options. The schematic, below, shows the typical AFM instrument layout.



Schematic of a typical AFM instrument

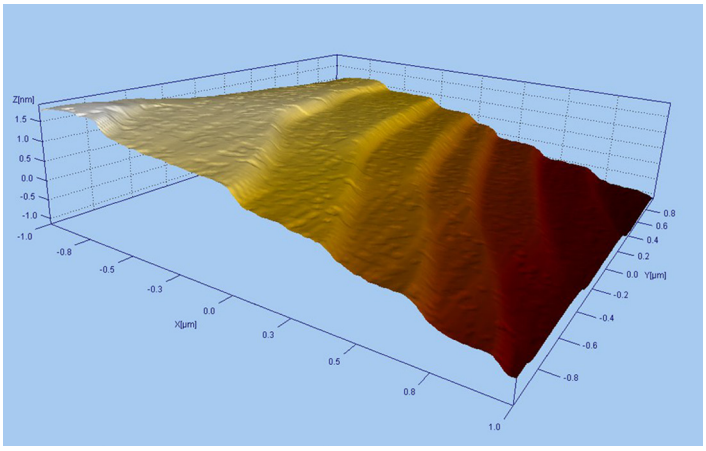
Our resonant probe SPM instruments are ideal for both materials research and biophysical research and are fully compatible with our RM21® microscopes.
On the following pages are examples of SPM-M kit customizations. These examples have been used for a wide variety of applications from material science to life sciences.

SPM Accessories

- Tuning Forks
- Motorized XY or Z-axis approach
- Manual XY or Z-axis approach
- SPM baseplate
- Coaxial Illuminator
- Video optical microscope
- Isolation enclosure
- SPM tip etch kit
- Probe starter package

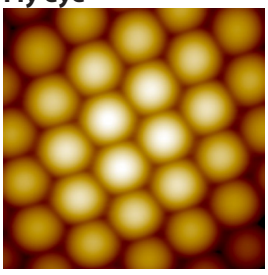
Images

Atomic steps on Si(111)



2 µm x 2 µm
Self oscillation mode, constant probe signal
Z force feedback: frequency
312 pm atomic steps on Si(111). Data taken using MadPLL® with Nano-HS3 XYZ nanopositioning system with an etched tungsten tip on a quartz tuning fork.

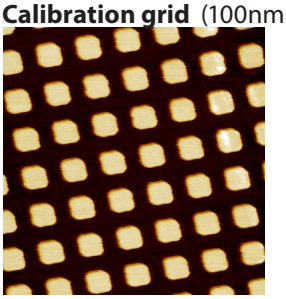
Fly eye



100 µm x 100 µm
Bidirectional scan
PLL mode, constant probe signal
Z force feedback: frequency

Data taken using MadPLL® with Nano-OP30 nanopositioning system (Z-axis), Nano-OP100 nanopositioning system (XY axes)

Calibration grid (100nm tall, 10 µm pitch)



70 µm x 70 µm, Unidirectional scan
PLL mode, constant probe signal
Z force feedback: frequency

Data taken using MadPLL® with Nano-OP30 nanopositioning system (Z-axis), Nano-OP100 nanopositioning system (XY axes)

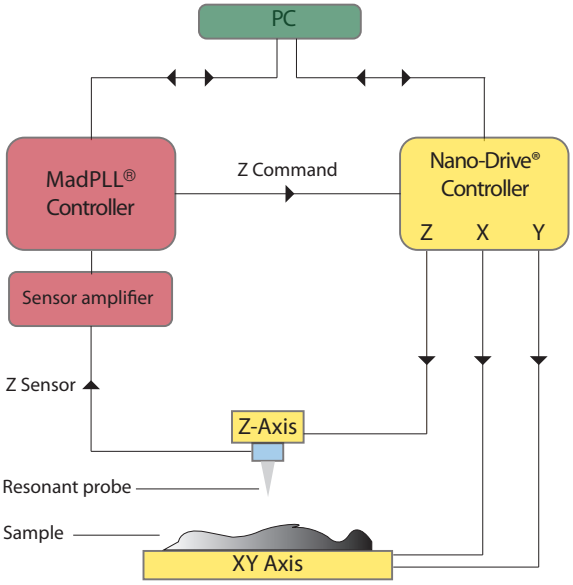
* The following items are described in the application note "AFM Kit with manual positioning" and are listed in the bill of materials (BOM) but not included with the SPM-M kit.

- Manual micropositioners for XY, Z axes.
- SPM Baseplate
- L-Bracket
- Fasteners or clamps

SPM-M kit Customization

The SPM-M kit may be customized to your application by substituting different nanopositioning systems and adding in automated micropositioning. A range of accessories, including probes and isolation enclosures, are described in a separate brochure. The schematic, shown at left, is a typical AFM instrument layout.

The motion control components can be divided into two categories: probe positioning and sample positioning. In all applications, it is necessary to have at least a single axis of nanopositioning and an automated approach for the probe. Examples of stand-alone probe positioning and combination probe and sample positioning configurations are shown below.
All configurations shown are compatible with the MadPLL® phase lock loop controller and included AFMView™2 software.



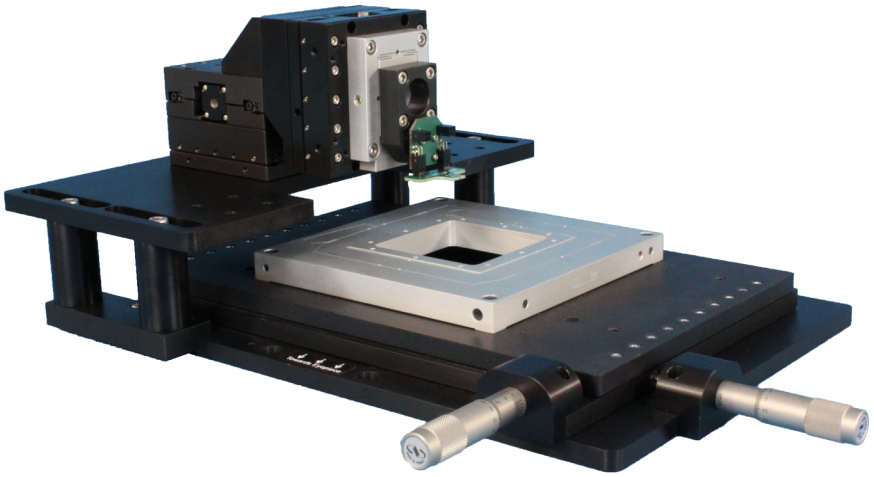
Schematic of a typical AFM instrument

Examples

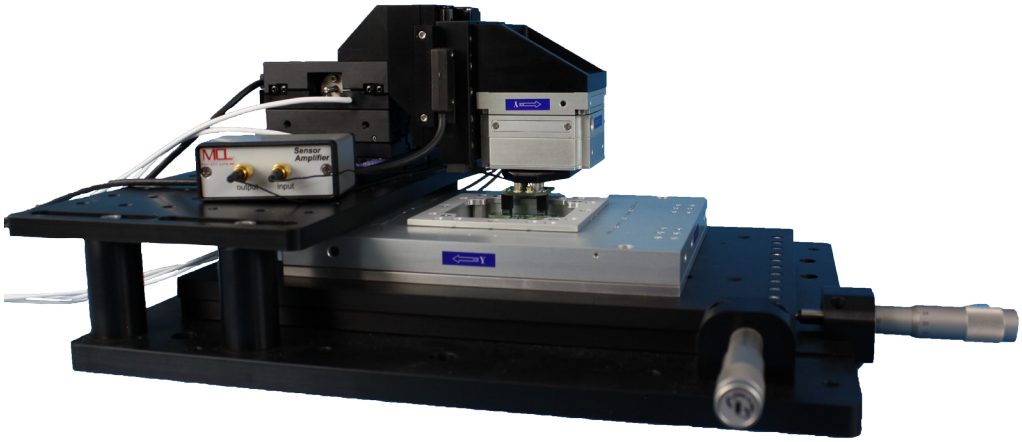
▲ *A three axis high resolution tip scanner. A single axis motorized approach is provided by the SPM-MZ. The high resolution tip scanner is the Nano-HS3M with 10 × 10 × 5 μm of motion. This example is designed for users who require picometer precision.*

◄ *A simple probe positioning configuration. This probe positioner uses an MMP1 automated positioner for the z-axis approach and a Nano-OP30 nanoposiitoning system for the high resolution probe positioning and feedback. The adapter for the probe mounting board is included with the MadPLL® controller.*

▲ *Three axis probe positioner with three axis micropositioning of the probe head. Ideal for use on optical tables when mounted on an optional platform (as shown). The probe nanopositioner is a compact custom nanopositioner with 100 × 100 × 20 μm of travel. The probe head micropositioning is the MMP3H micropositioning system.*



Combined probe positioner and sample positioner for an AFM for use on an inverted optical microscope. The probe positioner comprises a 3 axis motorized positioner with a high resolution Nano-OP30 to hold the probe mounting board.
The sample is positioned using the Nano-View® 100-2/M system. This sample positioner comprises a high resolution 100 × 100 μm nanopositioning stage paired with a high stability manual microscope stage.



Combined probe positioner and sample positioner for an AFM or NSOM for use on an inverted optical microscope. The probe positioner comprises a 3 axis motorized positioning with a custom three axis nanopositioner with 100 × 100 × 20 μm travel range. The probe positioner is designed for automation and high precision. The sample is positioned using the Nano-View® 100-3/M system. This sample positioner comprises a high stability 100 × 100 × 100 μm nanopositioning stage paired with a manual microscope stage.

Related products

- SPM-M kit
- MadPLL®
- SPM Accessories

SPM Accessories

Available Accessories

- *Tuning Forks (with and without tips)*
- *SPM Baseplate*
- *Double Insulated Enclosure*
- *Video Optical Microscope*
- *Coaxial Illuminator*
- *SPM Etch Kit*
- *Probe Starter Package*
- *SPM-MZ*
- *MMP Series*
- *SPM XY Manual Micropositioner*

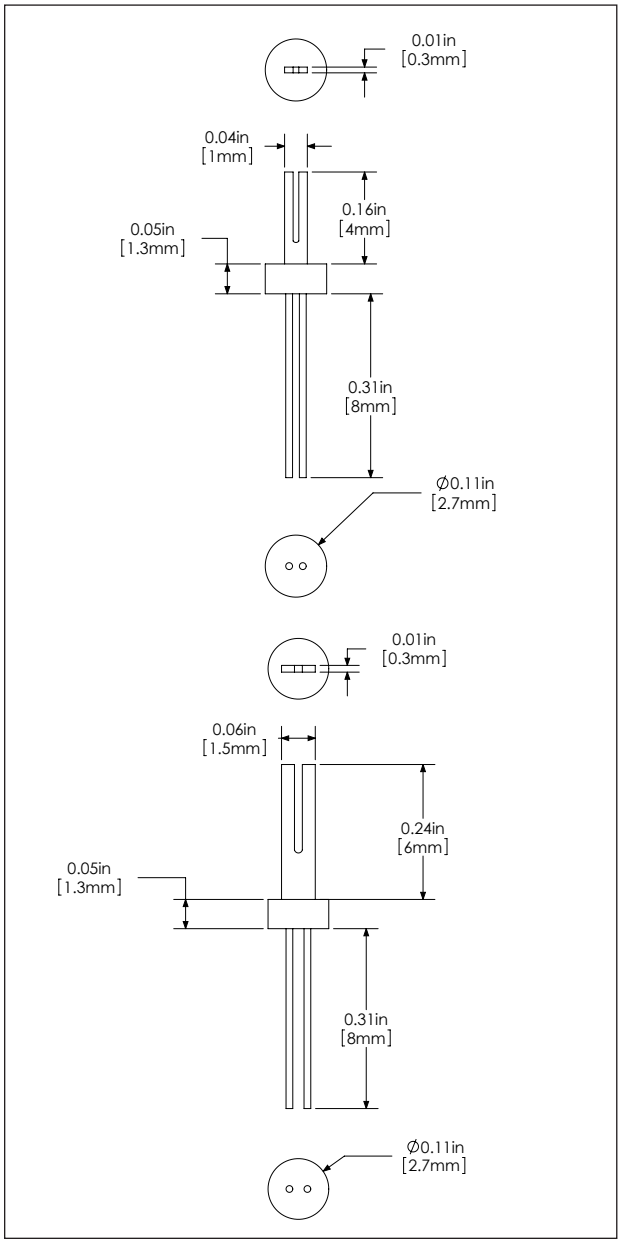
Mad City Labs offers an extensive range of accessories to complement our SPM-M kit and MadPLL® digital controller. These accessories combined with our nanopositioning systems allow users to build customized, high resolution atomic force and scanning probe microscopes.

Tuning Forks

Mad City Labs offers quartz crystal tuning forks for scanning probe microscopy applications such as atomic force microscopy (AFM) and near field scanning optical microscopy (NSOM). Each tuning fork has two electrical leads for connection to a driving oscillator such as the Mad City Labs MadPLL® phase lock loop controller. Our tuning forks are available in two sizes, and are shipped to you conveniently ready to use - "out of the can" - with the typical cylindrical housing removed. Bare tuning forks available in boxes of 20. Tuning forks with tungsten tips available in boxes of 8.

Technical Specifications

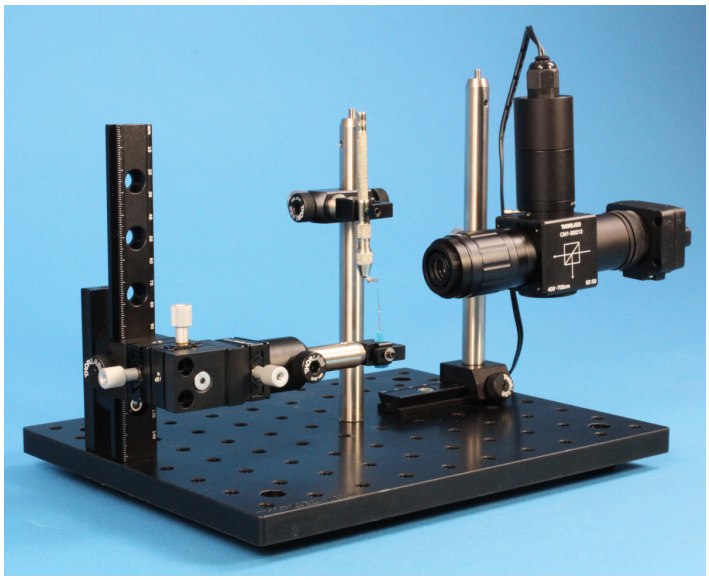
Center Frequency	32.768 kHz
Oscillation Mode	Fundamental
Series Resistance (max.)	30 kΩ
Tolerance (@25°C)	±18 ppm
Operating Temperature Range	-10°C to +60°C
Frequency Stability over Temperature	-0.038 ppm/°C
Drive level	10 µW
Shunt Capacitance (max.)	1.7 pF
Motional Capacitance	2.5 fF
Load Capacitance	12.5 pF
Aging (max.)	± 3 ppm/year



Tuning fork dimensions. Medium (top), large (bottom)

SPM Etch Kit

The Mad City Labs SPM etch kit is designed to allow users to create a sharp tungsten tip suiable for scanning probe microscopy. The instrumentation allows the user to attach a tungsten wire to a quartz tuning fork and electrochemically etch the wire. The attachment of the wire is done with the assistance of a three axis manual micropositioner and video optical microscope.
The etching process uses the lamella method where the wire passes thorugh a thin lamella and into a bath of potassium hydroxide (KOH) or sodium hydroxide (NaOH). A bias voltage is applied to the electrodes in the film and bath which causes the tungsten wire to be etched by the film. When the wire is completely etched, the bottom portion of the wire falls, the etching process is complete, and remaining portion of wire attached to the tuning fork is left with a very sharp tip.



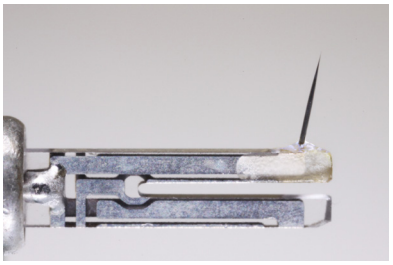
Included in the etch kit

- Coaxial illuminator
- Video optical microscope (1x, 50mm)
- Tip etching station controller
- LabVIEW based software
- Baseplate
- Three axis manipulator, fixturing rails and posts
- Wire holder
- Five large tuning forks

Not included

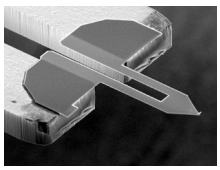
- Potassium hydroxide
- Sodium hydroxide
- Glassware
- Tungsten
- Screen for video optical microscope

Tip Etching Station controller



Tuning Fork with etched tungsten tip

Akiyama Probes



Akiyama-Probe is based on a quartz tuning fork combined with a micro-machined cantilever. The great advantage of this novel probe is that one can benefit from both the tuning fork's extremely stable oscillation and the silicon cantilever's reasonable spring constant with one probe.
Available from www.akiyamaprobe.com

Probe Starter Package

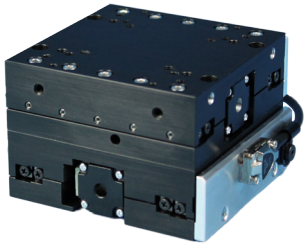
Starter package for SPM probes. Recommended for new users of resonant probe AFMs. Includes calibration sample and easy-to-use probes. The package includes (1) box of Akiyama Probes, (1) 100nm height calibration grating, (2) tuning forks with silicon shards attached, (1) 15mL bottle of First Contact cleaning solution.

SPM Accessories

SPM-MZ

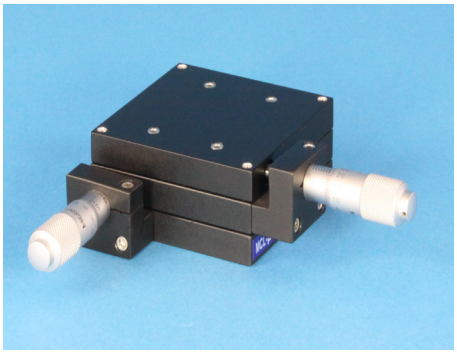
The SPM-MZ is a precision aligned, highly stable single axis micropositioner designed as a high stability, Z-axis approach for scanning probe microscopes. The SPM-MZ employs our proprietary intelligent motor control for low drift performance and incorporates a built-in right angle bracket to ensure high stability. The total travel range of the SPM-MZ is 25mm with a minimum step size of 95nm. An optional high resolution linear encoder may be ordered to continuously monitor positions down to 20nm. The USB digital interface provides direct PC control of the micropositioner as well as access to the linear encoder.
The SPM-MZ is compatible with standard optomechanical components, including tables, and Mad City Labs Nano-OP30 nanopositioners. Combining the SPM-MZ with the Nano-OP30 offers the user an integrated Z-axis approach with both long range travel and closed loop sub-nanometer precision making it ideal high resolution probe microscopy.

MMP Series



The MMP Series are a precision, stepper motor driven, micropositioning system for high precision positioning suitable for SPM/AFM applications. Long range linear positioning is provided in one, two or three axis configurations with high resolution and excellent repeatability. Employing our proprietary intelligent control scheme results in exceptional stability with high native precision. Optional high resolution (50nm) linear encoders provide real-time feedback of the actual stage position. The included Micro-Drive™ controller connects to a PC via a standard USB port and can be controlled via the supplied LabVIEW based software. Complex motion profiles can be programmed and sophisticated control parameters such as automatic acceleration and deceleration is employed to achieve high stability and native accuracy. Optional wireless gamepad control is also available.

SPM XY Manual Positioner



An XY manual micropositioning stage with 12.5mm/0.5" travel per axis. Constructed from aluminum. The stage is designed with integrated preloading making it suitable for nanopositioning. The XY manual micropositioner is suitable for positioning samples in areas of interest. The micrometers have 10 micrometer graduations. Compatible with the Nano-SPM200 and other nanopositioning stages with 2.25" x 2.25" hole pattern. Compatible with the SPM baseplate.

Coaxial Illuminator

Coaxial illuminator designed for use with the video optical microscope to view the probe approach to the surface. The illuminator assembly includes the LED with a pre-calibrated collimating lens housed in a 1" diameter lens tube, terminated with an iris. The brightness of the illuminator is controlled via a dial on the controller. The easy to use LED light source fits directly to the port of the video optical microscope.

Technical Specifications

Power supply: 12V/3.0A
Color temperature: 3000-9000K (min-max)
Axial intensity: 30lm
Cable length: 6'

Video Optical Microscope 2x, 100mm

Video optical microscope designed for viewing the probe approach to the sample surface. Manual XYZ positioning included. Recommended for use with the coaxial illuminator.

Technical specifications

2x magnification
100mm focal length
USB 2.0 output. Screen not included.

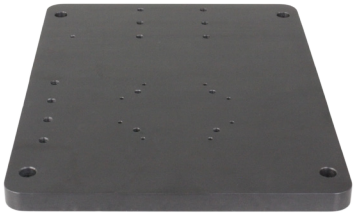
Double Insulated Enclosure

A double insulated enclosure for use with the SPM-M kit or any of our SPM products. This enclosure fits on most vibration isolation tables, offers a hinged front viewing window, and rear cable exit.

Dimensions

Exterior: 17" x 20" x 20"
Interior: 12" x 16" x 11.5"

SPM baseplate



Black anodized aluminum plate compatible with Mad City Labs manual and motorized micropositioning XY stages for SPM as well as the SPM-MZ. Baseplate includes additional 1/4-20 tapped holes on 1 inch spacing for accessories.

Dimensions

10.75" x 8" x 0.5"

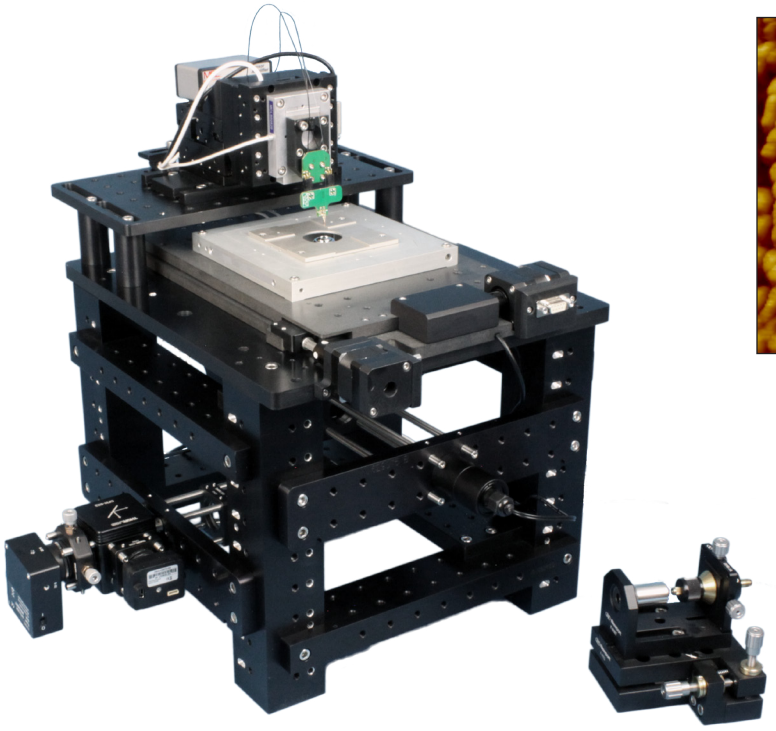
MCL-NSOM

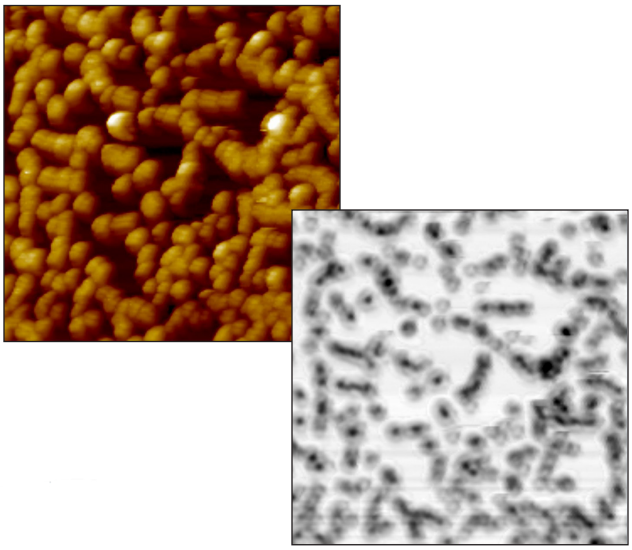
Features

- *Complete inverted optical microscope*
- *Six axes of motorized control*
- *Closed loop nanopositioning in XYZ*
- *Independent automation for fiber alignment to optical axis*
- *Alignment camera and detection APD included*
- *Software included*

Other Applications

- *Aperture-less NSOM*
- *Resonant probe AFM*
- *Near field spectroscopy*
- *Fluorescence & epifluorescence microscopy*





▲ *50 µm x 50 µm images of 500nm diameter polystyrene beads on a glass coverslip.*
Images taken using Mad City Labs AFM (left) and NSOM (below). NSOM: Transmission mode using 640nm light with 100x, 1.25 N.A. objective lens and avalanche photodiode.

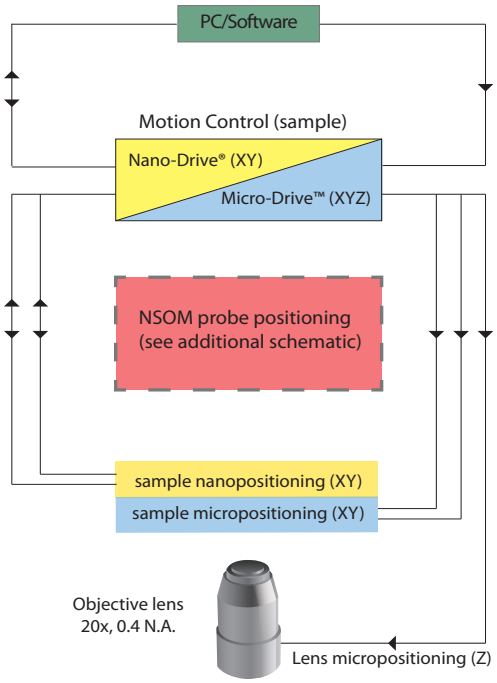
Product Description

The MCL-NSOM is a fully operational near field scanning optical microscope. It has been built on Mad City Labs versatile RM21® microscope which allows users to convert between NSOM, SPM, and fluorescence optical microscopy techniques.
The MCL-NSOM builds on our successful resonant probe SPM and incorporates common elements such as the MadPLL® phase lock loop controller. The NSOM also exploits our expertise in precision motion control by including six axes of motorized positioning, for the sample and NSOM probe, and three axes of closed loop nanopositioning to provide exceptional position resolution and accuracy.

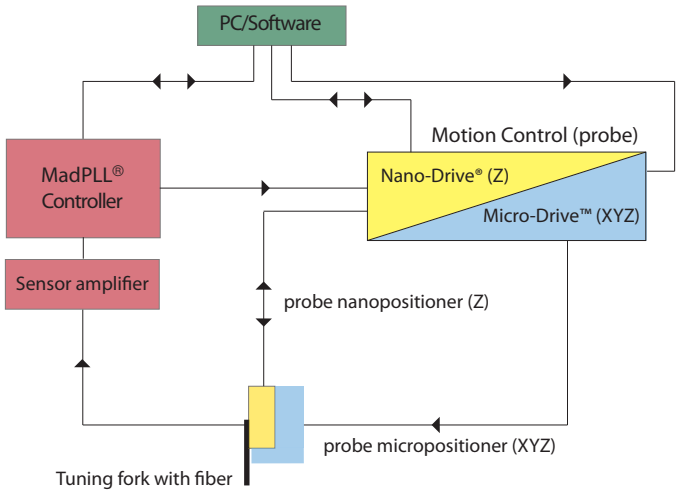
The MCL-NSOM also includes a 635nm laser excitation source, fiber launch, objective lens (20x, 0.4 N.A.), CMOS alignment camera and avalanche photodiode detector. The microscope configurable design allows researchers to tailor the instrument for many different optical microscopy techniques including near field spectroscopy.
The MCL-NSOM is operated in aperture mode with shear force feedback. The standard 5 NSOM modes are supported: illumination, collection, illumination and collection, reflection and reflection collection.

Technical Specifications

Motion Control	
Sample micropositioning (XY)	25 mm
Lens micropositioning (Z)	50 mm
Fiber micropositioning (XYZ)	25 mm
Micropositioning step size	95 nm
Micropositioning controller	Micro-Drive™
Nanopositioning range of motion (XYZ)	200 µm × 200 µm × 30 µm
Resolution	0.4 nm (XY), 0.06 nm (Z)
Step size	0.2 nm (XY), 0.03 nm (Z)
Nanopositioning controller	Nano-Drive®
Communication	USB 2.0
DAC/ADC	20 bit
NSOM	
NSOM operation	Aperture
Feedback	Shear Force
Phase lock loop controller	MadPLL®
Software	AFMView™2
Software compatibility	C#
Objective lens	20x, 0.4 N.A. (Infinity corrected)
Excitation and detection	635nm, 4.5mW laser diode with fiber launch
	0.3MP fiber alignment CMOS camera
	Avalanche photodiode (200nm-1000nm, 1mm active area)
Supplied accessories	Coaxial illuminator (LED)
	Tuning fork with attached single mode fiber for NSOM
	Tuning forks with etched tungsten tips (3)
	Tuning forks (10)
	Fiber launch
	Instrument enclosure
Power supply	90 - 260 VAC (50/60Hz)
Operating system	Windows Vista/7/8/10



Instrument overview of MCL-NSOM hardware



Schematic of the probe positioning element

MadPLL®

Features

- *Low Cost*
- *Software, sensor amplifier, probe boards included*
- *Two additional ADC connections*
- *Low noise, atomic step performance*
- *Automated software control*
- *Auto PCC control*
- *High resolution Auto Q calculation*
- *High resolution resonant frequency detection*
- *Integrated Z axis PI control loop*
- *Fully compatible with Mad City Labs nanopositioning systems*

▲ *MadPLL® digital phase lock loop controller*
Sensor amplifier with probe boards shown at right. ►

Product Description

MadPLL® is an integrated solution that includes the digital phase lock loop (PLL) controller, software, sensor amplifier, probe board mount, and resonant probe mounting board. Simply add your Akiyama probe or tuning fork to the probe board to create a powerful force sensor for scanning probe measurements with no optics required. The PLL controller contains a digitally controlled proportional integral (PI) loop designed to work seamlessly with Mad City Labs' nanopositioning systems. The addition of closed loop nanopositioners adds to the high performance of MadPLL®. Additional options are available for multi-axis closed loop nanopositioning control.

The PLL controller has three operational modes: self oscillation, PLL driven, and lock-in/DDS driven. The probe can be controlled in constant excitation or constant signal mode. Measured outputs from the controller include changes in frequency, amplitude or phase shift.

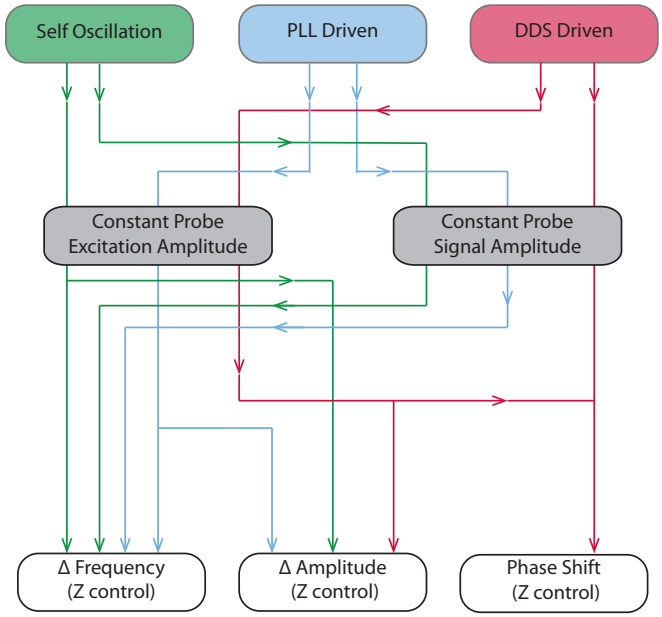
The sensor amplifier is the interface between the MadPLL® controller and the probe. The sensor amplifier contains a preamplifier, an excitation signal attenuator, and a parasistic capacitance compensation (PCC) circuit. The probe board mount and probe board assemblies are compact and can be fitted to existing instrumentation. The probe board simply plugs into the probe board mount. The mount can be fixed to a precision nanopositioning system. The probe board has been designed for use with tuning forks and Akiyama probes. These probes are easy to mount and alignment free.

MadPLL® software simplifies the control of your scanning probe microscope. All of the functions of MadPLL® are fully automated but accessible via individual software control. Among the software features are automated setup, configuration control, auto-Q calculation and automatic parasitic capacitance compensation (PCC) control. These included features are designed to simplify setup and accelerate the data acquisition process. MadPLL® software integrates seamlessly with Mad City Labs' AFMView™2 software. AFMView™2 software is part of our complete SPM product suite.

Technical Specifications

Lock-In Amplifier	
Phase Shifter	0° - 360°
Demodulation Bandwidth	3 kHz
Phase Lock Loop	
Auto Range Selection	YES
Measurement Range	± 500 Hz
Measurement Resolution (rms)	50 mHz
Preamplifier	
Input Gain (Attenuator)	0x - 1x (16 bit internal DAC)
Parasitic Capacitance Compensation (PCC)	YES (16 bit internal DAC)
Automatic PCC	YES
Probe Oscillation Loop	
Operating Modes	self oscillation
	PLL driven
	lock-in/DDS driven
Amplitude Control Modes	constant excitation
	constant signal
Probe DDS resolution	92 mHz
Amplitude Setpoint	16 bit internal DAC
Amplitude Control	YES, adjustable PI loop filter
Input Voltage Range	± 10 V (peak)
Input Voltage Gain	2x - 40x
Frequency Range	10 kHz - 100 kHz
Output Voltage Range	± 10 V (peak)
PI Loop Filter (Z-Axis)	
Integration Time Constant	digitally controlled
Digitally Set Parameters	YES
Error Signal Inversion Capability	YES
Sensor Signals	frequency
	phase
	excitation amplitude
	signal amplitude
Command Signal	16 bit internal DAC
Automatic Loop Filter Setup	YES, after initialization.
Loop Output	0 - 14 V

General		
Spectrum Analysis		amplitude
		phase
Feedback Monitor BNC		frequency
		phase
		excitation amplitude
		signal amplitude
ADC input (2 x BNC)		0 - 10V input range, 16 bit
Probe Signal Monitor (BNC)		sinewave amplitude probe (diagnostic)
Power Supply		90 - 260 VAC (50/60 Hz)
Controller Dimensions		16.75" x 14" x 1.75" (1U) (42.55cm x 35.56cm x 4.45 cm)
PC Connection		USB 2.0
Operating System	32 bit	Windows Vista/7/8/10
	64 bit	Windows Vista/7/8/10



The digital MadPLL® controller has three operational modes: self oscillation, PLL driven, and DDS driven. The probe can be controlled in constant excitation amplitude or constant signal amplitude. Changes in frequency, amplitude, or phase are measured for Z control.