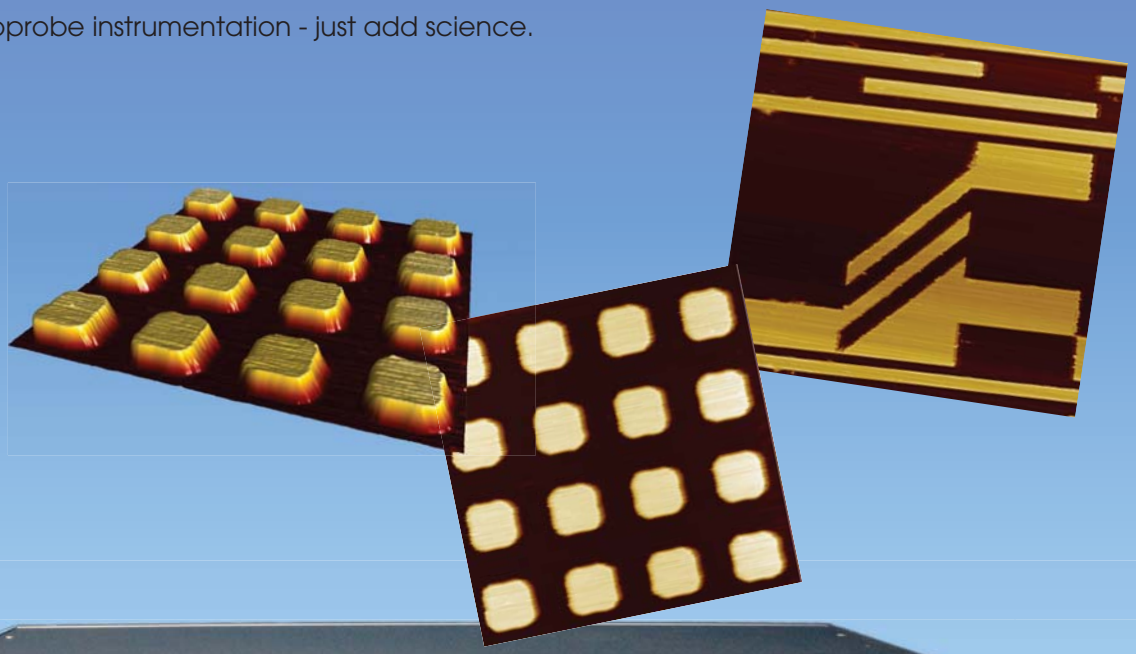
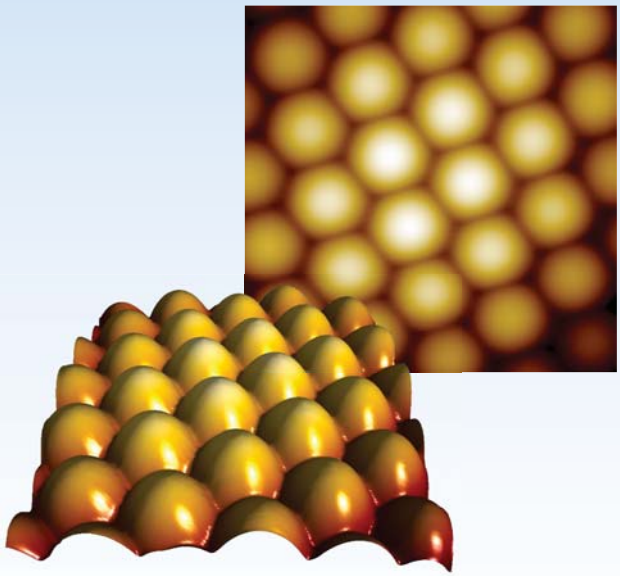
MadPLL®

Instant AFM and nanoprobe instrumentation - just add science.





MCL®

MAD CITY LABS INC.

www.madcitylabs.com

Introduction

MadPLL® is a powerful instrument package that allows the user to create an inexpensive, high resolution resonant scan probe microscope using Mad City Labs nanopositioning systems. In short, MadPLL® can be used to create an "instant" closed loop AFM or NSOM at a fraction of the cost of other commercial systems.

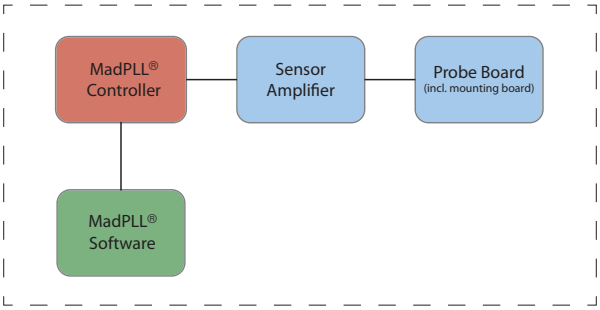
MadPLL® has been specifically designed for resonant probes such as tuning forks and Akiyama probes. MadPLL® is fully compatible with Mad City Labs' high resolution nanopositioning systems giving users seamless integration of hardware and software with flexibility and performance not available in commercial scanning probe microscopes.

Features of MadPLL®

- Low cost
- Software, sensor amplifier, and probe boards included
- 2 additional ADC connections for instrument versatility
- Low noise, atomic step resolution
- Automated software control
- Auto PCC control
- High resolution Auto Q Calculation & resonant frequency detection
- Integrated Z axis PI control loop
- Fully compatible with Mad City Labs positioning products

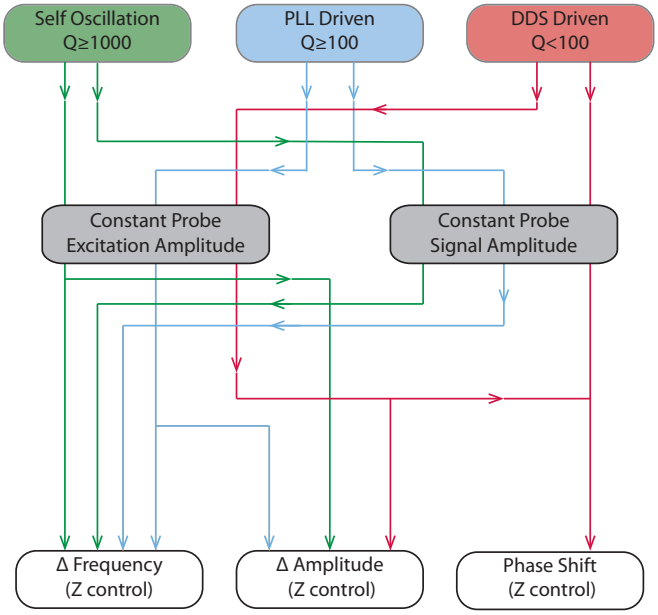
What is MadPLL®?

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.



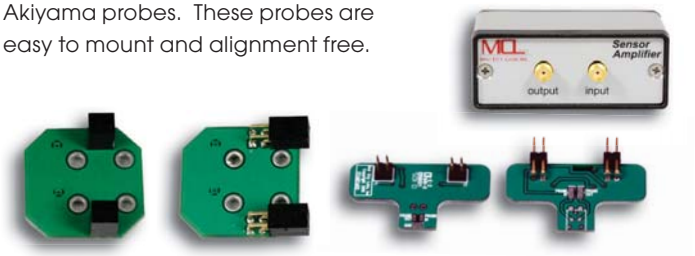
The MadPLL® package includes the MadPLL® digital PLL controller, sensor amplifier, probe board and MadPLL® software. Ease of integration with resonant probes and Mad City Labs' low noise, closed loop nanopositioning systems give users the ability to create high performance, low cost NSOM and AFM instruments.

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 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.

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.



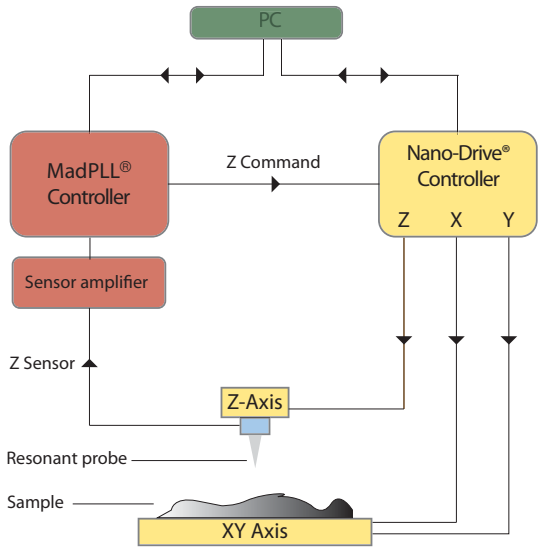
MadPLL® includes a sensor amplifier, probe boards, and intermediate probe mount. The probe boards are designed for use with tuning forks, Akiyama probes and Accutune probes.

MadPLL® Software

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™ software. AFMView™ software is part of our complete SPM development system.

Application
Instant AFM - Just add science!

MadPLL® is the foundation of a customized, high resolution atomic force microscope (AFM) at a fraction of the cost of commercial systems. MadPLL® seamless integration with Mad City Labs' low noise single and multi-axis nanopositioning systems makes it possible to create a fully closed loop AFM. The AFM described can be further customized for vacuum operation. A typical AFM instrument based on MadPLL® is shown schematically below.



The configuration described above is a highly flexible 3 axis closed loop AFM. The **SPM-M kit** is a pre-configured package for a 3 axis closed loop AFM that is quick to assemble and easy to upgrade with our wide range of accessories.

Available Accessories

- Tuning forks
- Double insulated enclosure
- Vacuum compatible nanopositioners
- XYZ positioning (manual or automated)
- Coaxial Illuminator
- Video optical microscope
- Baseplate
- Tungsten tip etching station

Recommended additional items

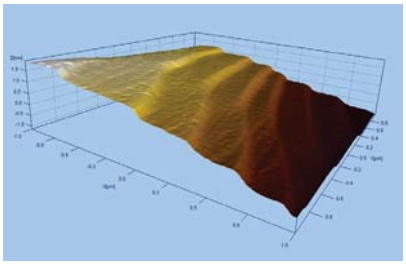
- Vibration isolation table

AFM configurations typically achieve Z resolutions of 0.5nm (rms) and a scanning frequency of 1Hz. Atomic step resolution and higher scan speeds can be achieved using a wide selection of Mad City Labs nanopositioning systems designed for metrology and high resolution microscopy applications. All Mad City Labs nanopositioning systems have low noise PicoQ® sensors and closed loop feedback control.

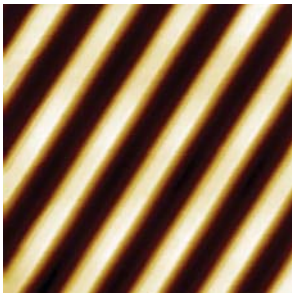
* All Mad City Labs' nanopositioning systems include the Nano-Drive® controller which is fully LabVIEW/C++/MATLAB compatible.

Seeing is Believing!

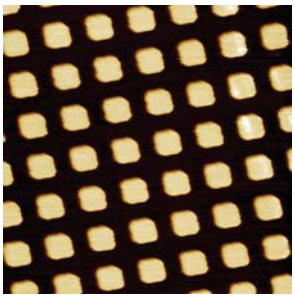
The images below were acquired using MadPLL® with Mad City Labs closed loop nanopositioning systems.



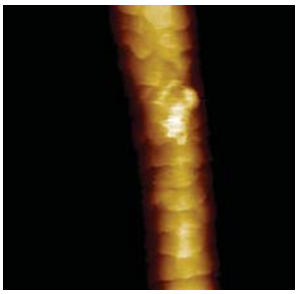
Silicon Atomic Steps
2 µm x 2 µm
Self oscillation mode, constant probe signal
Z force feedback: frequency
Data taken using MadPLL® with Nano-HS3 XYZ nanopositioning system with an etched tungsten tip on a quartz tuning fork.



Calibration grid
(100nm tall lines, 2µm apart)
10 µm x 10 µm
Unidirectional scan
Self oscillation mode, constant probe signal
Z force feedback: frequency
Data taken using MadPLL® with Nano-HS3 3-axis nanopositioning system.

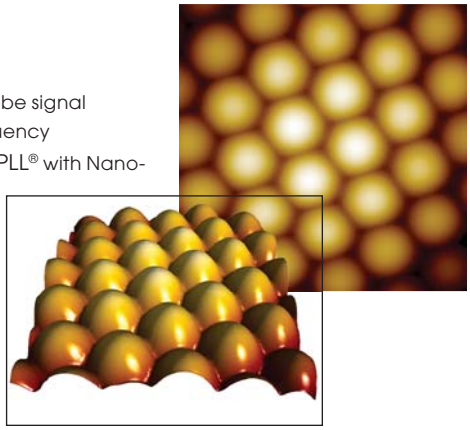


Calibration grid
(100nm tall, 10 µm pitch)
70 µm x 70 µm
Unidirectional scan
PLL mode, constant probe signal
Z force feedback: frequency
Data taken using MadPLL® with Nano-OP30 nanopositioning system (Z-axis), Nano-OP100 nanopositioning system (XY axes)



Human Hair
100 µm x 100 µm
Bidirectional scan
Self oscillation 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)

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)

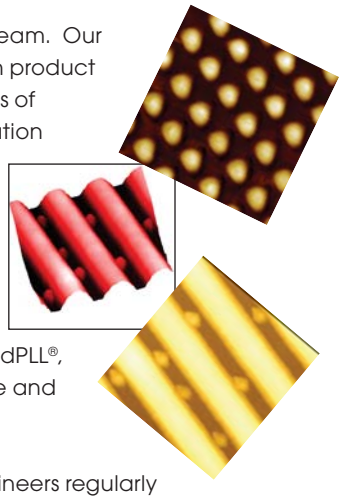


Technical Specifications

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
Operating System	32 bit	Windows 2000/XP Pro/Vista/7/8
	64 bit	Windows XP Pro/Vista/7/8
LabVIEW Software OS	32 bit	Windows 2000/XP Pro/Vista/7/8
	64 bit	Windows XP Pro/Vista/7/8

OK, I'm sold. What's next?



Call or email our technical sales team. Our sales team is heavily involved with product development and has many years of experience providing instrumentation solutions. Our knowledgebase is your resource.

Each sales engineer will discuss your requirements and then recommend the best solution for your application - MadPLL®, nanopositioning systems, software and probes.

Need a custom system? Our engineers regularly produce custom solutions and innovative designs for our academic and industrial customers. Get the solution you need by calling Mad City Labs.

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