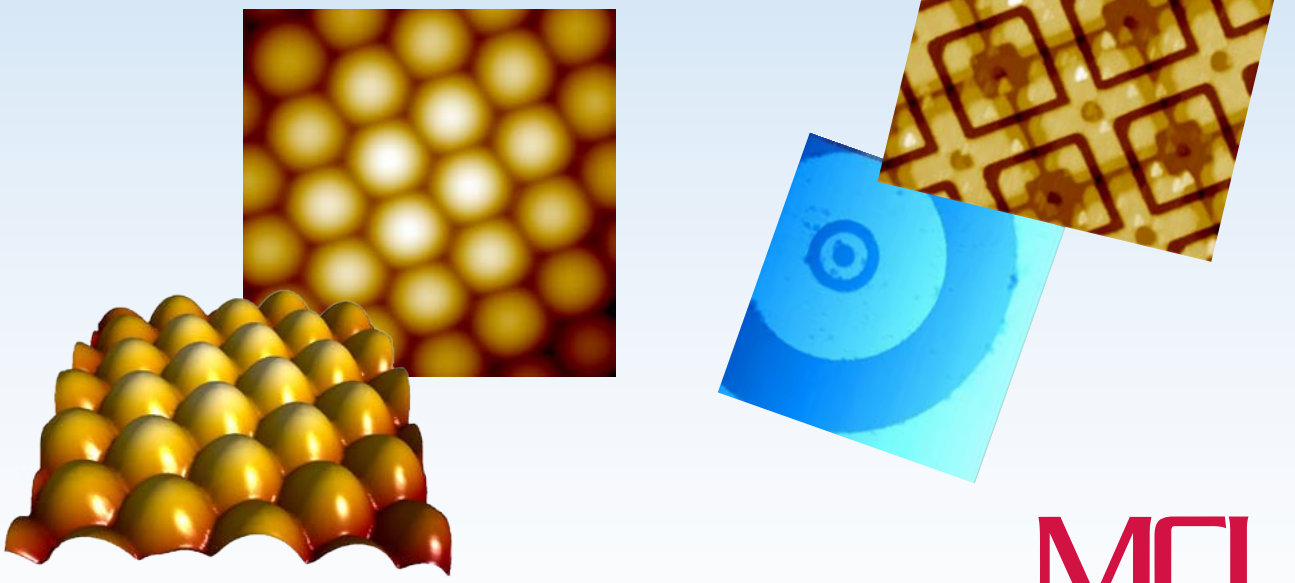
MadPLL®

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. In addition MadPLL® is fully compatible with Mad City Labs' high resolution nanopositioning systems which makes it easy for users to build a scanning probe microscope with a flexibility that cannot be achieved with other commercial systems. The seamless integration of hardware combined with the built-in automated control of MadPLL® means that you can concentrate on getting results.

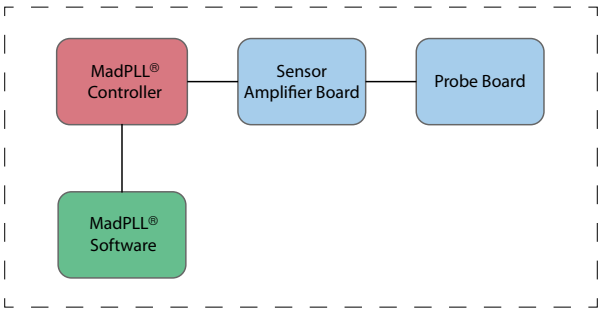
MadPLL® is ideal for research and teaching laboratories offering high performance, versatility, simplicity and excellent value.

Features of MadPLL®

- Low cost
- Software, PLL controller, sensor amplifier, and probe boards included
- Easy and flexible configuration
- Fully self contained - no external signals required
- Automated software control
- Auto PCC control
- Auto Q Calculation, auto resonant frequency detection
- Integrated Z axis PI control loop
- Fully compatible with Mad City Labs positioning products

What is MadPLL®?

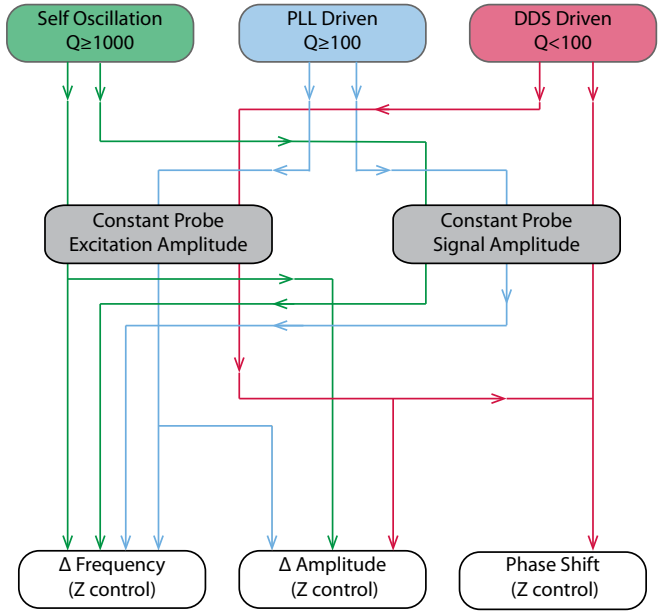
MadPLL® is an integrated solution that includes the digital phase lock loop (PLL) controller, software, sensor amplifier board and resonant probe mounting board. Simply add your Akiyama probe or tuning fork to the probe board to create a powerful force sensor for scanning probe measurements.



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

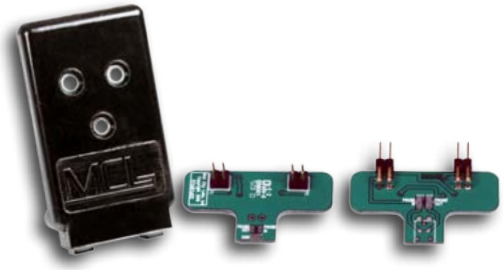
The PLL controller contains a digitally controlled proportional integral (PI) loop designed to work seamlessly with Mad City Labs' nanopositioning systems. The addition of closed loop nanopositioners adds to the high performance of MadPLL®. Additional options are available for multi-axis closed loop 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 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 and probe board assemblies are compact and can be fitted to existing instrumentation. The probe board simply plugs into the sensor amplifier board. The sensor amplifier board can be mounted to a precision positioner such as a closed loop 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.



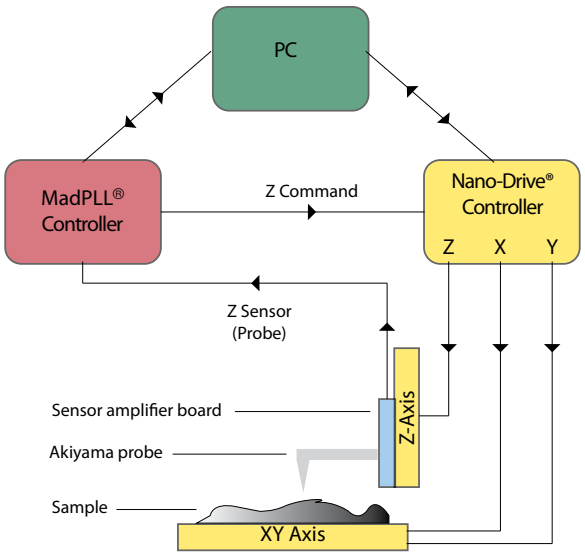
MadPLL® includes a sensor amplifier board and probe boards. The probe boards are designed for use with tuning forks, Akiyama probes and Accutune probes.

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® can be used to create a customized, high resolution atomic force microscope (AFM) at a fraction of the cost of commercial systems. MadPLL® has been designed to directly interface with Mad City Labs' low noise single and multi-axis nanopositioning systems, making it possible to create a fully closed loop AFM. The AFM described is suitable for both research and teaching environments and can be further customized for vacuum operation. A typical AFM instrument based on MadPLL® is shown schematically below.



Example Bill of Materials

- MadPLL®
- 3 axis closed loop nanopositioning system*
  (e.g. Nano-HS3 Series, Nano-OP30 (Z) +Nano-SPM200 (XY))
- Akiyama probe
- PC (32 bit or 64 bit Windows XP/Vista/7 compatible)

This configuration is a highly flexible multi-axis closed loop AFM. Mad City Labs also offers the **SPM-M kit** which allows the user to assemble a high performance, closed loop scanning probe instrument at low cost.

Recommended additional items

- Vibration isolation table
- Coarse z-axis approach (manual or automated)

Additional Options (available from Mad City Labs)

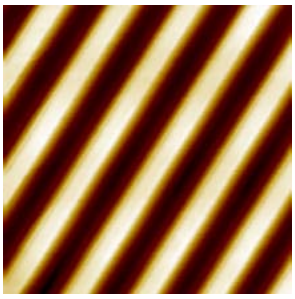
- Tuning forks
- AFMView™ software
- Vacuum compatible nanopositioners
- LED Illuminator
- Tungsten tip etching kit

AFM configurations typically achieve Z resolutions of 0.5nm (rms) and a scanning frequency of 1Hz. Higher resolutions and scan speeds can be achieved using different nanopositioner combinations. All Mad City Labs nanopositioning systems have low noise PicoQ® sensors and closed loop feedback control.

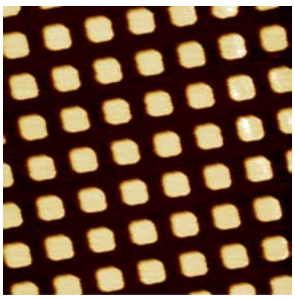
* All Mad City Labs' nanopositioning systems include the Nano-Drive® controller which is fully LabVIEW/C++/MATLAB compatible.

Seeing is Believing!

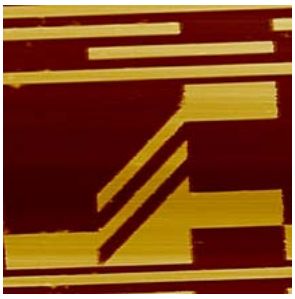
The images below were acquired using MadPLL® with Mad City Labs closed loop nanopositioning systems.



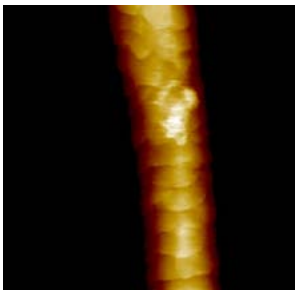
Calibration grid
(100nm tall lines, 2µm apart)
10 µm x 10 µm
Unidirectional scan
Self oscillation mode, constant probe signal
Z force feedback: frequency
Data taken using MadPLL® with Nano-HS3 3-axis nanopositioning system.



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)

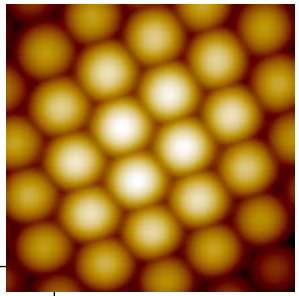


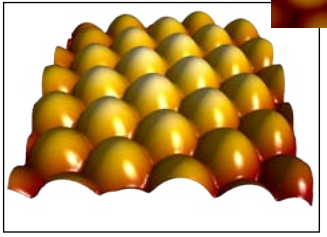
Etched structures
80 µm x 80 µm
Bidirectional scan
Self oscillation mode, constant probe signal
Z force feedback: frequency
Data taken using MadPLL® with Nano-OP30 nanopositioning system (Z-axis), Nano-OP100 nanopositioning system (XY axes)



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)



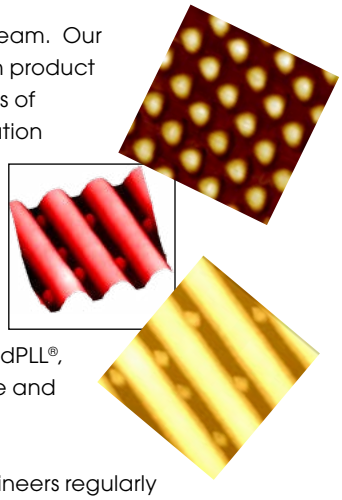


Technical Specifications

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

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.

MAD CITY LABS INC.

+1 608 298-0855
sales@madcitylabs.com
www.madcitylabs.com
2524 Todd Drive, Madison Wisconsin 53713 USA
Visit our website for your local Mad City Labs distributor.