Agilent MAC Mode III

Extends Agilent AFM capabilities

Data Sheet

Features and Benefits

- Allows one-pass multi-channel detection for EFM & KFM
- Three configurable lock-in amplifiers afford superb versatility
- Multi-frequency range–up to 6 MHz allowing higher harmonic modes
- Built-in Q-control further enhances the resonance peak
- Includes acoustic AC (AAC) mode option
- Patented technique optimized for high-resolution AFM imaging in fluids
- Designed for easy operation in air or fluids
- Operates simultaneously with:
  - Environmental control
  - Temperature control
  - Electrochemical control
  - Controlled fluid exchange

Overview

Agilent's patented MAC Mode III is a gentle, nondestructive technique for atomic force microscopy (AFM) that has been designed for imaging extremely delicate samples. MAC Mode III is particularly useful in areas that require high resolution and force sensitivity, such as biology, polymers, and surface science. Built on field-proven technology, MAC Mode III significantly extends AFM capabilities. MAC Mode III allows researchers to image submolecular structures for local mechanical properties and electro magnetic response technique. It offers the best control available for oscillating probe technology, thereby providing far better resolution in fluids than other techniques.

MAC Mode III provides three user-configurable lock-in amplifiers, enabling researchers in a single pass to image in AC Mode, Kelvin force microscopy (KFM) or electric force microscopy (EFM) and higher harmonic modes of the cantilever-all simultaneously. MAC Mode III also provides two expansion slots.

Lock-in amplifier technology is utilized to precisely determine the oscillation amplitude and phase response of the cantilever, resulting in excellent force regulation and high-quality phase images. This amplifier technology eliminates spurious responses that may be generated by a cantilever-holding mechanism, the surrounding fluids, or the sample itself. Thus, there is less system noise and the cantilever can be operated at much smaller amplitudes. Subsequently, sample damage is decreased, probe sharpness is preserved, and resolution is greatly improved.

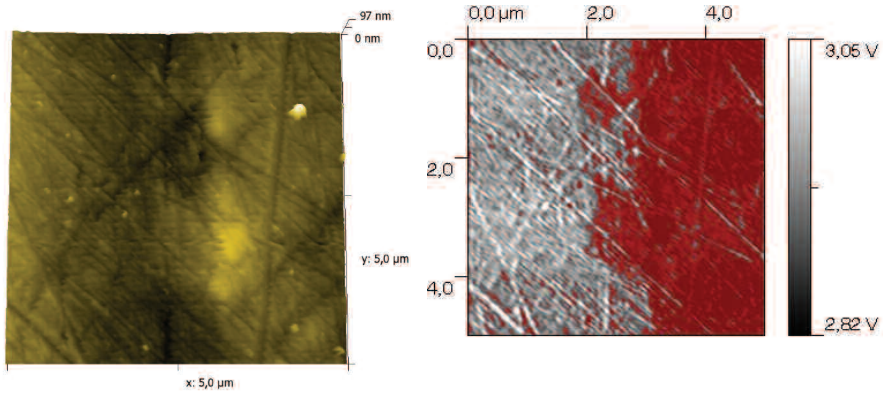
Imaging with Higher Harmonics

MAC Mode III has a wide operating frequency – up to 6 MHz enabling scientists to investigate higher harmonic modes. This enables scientists to use the fundamental resonance frequency of the cantilever and lock-in, or to use higher resonance modes of the cantilever. Higher harmonic imaging provides contrast beyond that seen with fundamental amplitude and phase signals. This technique can be utilized to collect additional information about mechanical properties of the sample surface.

Imaging with KFM/EFM

MAC Mode III allows single-pass imaging concurrent with KFM/EFM. Simultaneous, high-accuracy topography and surface potential measurements are enabled by a servo-on-height cantilever approach that is not susceptible to scanner drift. KFM/EFM is especially useful for measuring dielectric films, metal surfaces, piezoelectrics, and conductor-insulator transitions.

The KFM/EFM capabilities reside within the MAC Mode III / AAC box. This fully integrated, self-contained solution eliminates cable clutter and the need for additional external boxes and circuits.

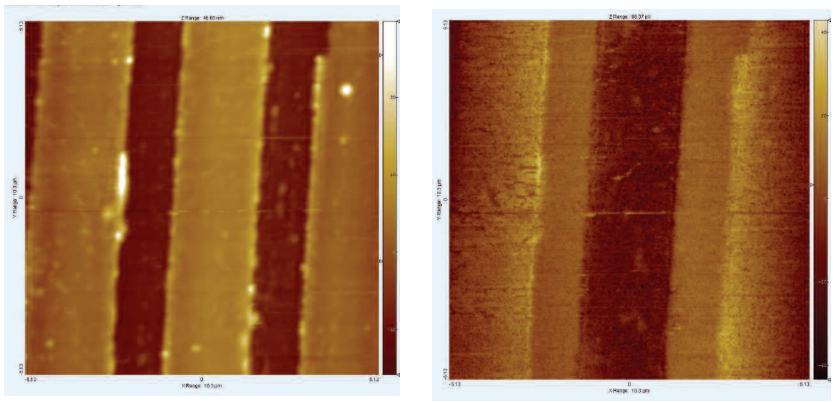


Topography KFM

Figure 1.
Sample of steel with nickel protective layer. Topography (left) shows surface structure with grains and grain boundries and KFM image (right) reveals the material properties and defects.
(Images courtesy of Voestalpine Stahl Gmbh)

Imaging with Force Modulation

MAC Mode III also enables researchers to perform vertical or lateral modulation studies and delivers a unique plot of the oscillating amplitude vs. frequency in contact. This capability allows easy optimization of the detection sensitivity for a broad range of cantilever spring constants.

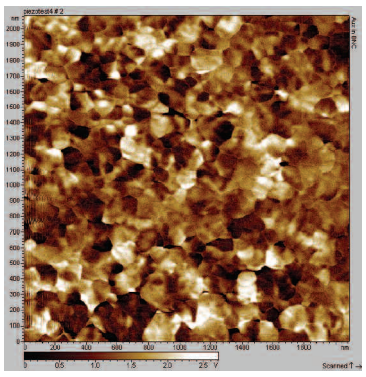


Topography EFM

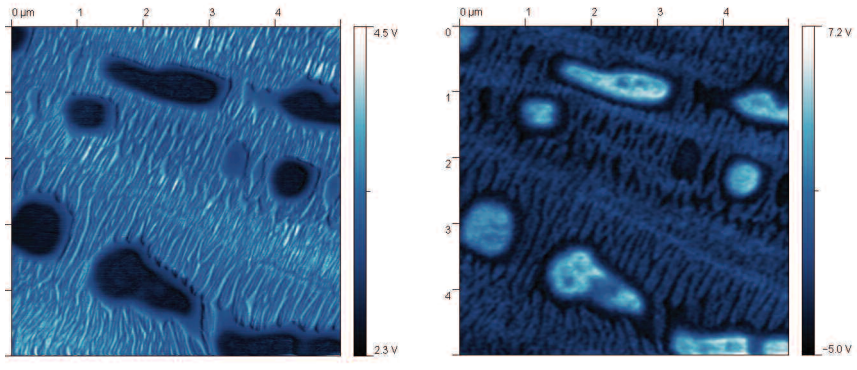
Figure 2. AC mode images of a conducting strip on an insulator substrate. Alternative strips are biased with -0.5V, the rest of the strips are grounded. The topography image (left) show the strips. EFM image (right) shows that middle strip is biased negatively. Scan size 5 x 5 µm.

Imaging Soft Samples

MAC Mode III provides life science researchers a highly useful tool for AFM imaging. It gently handles delicate soft samples and samples in fluids, including living cells and cells in changing fluid environments.



PFM Phase image of domains on a thin film of ferroelectric
(courtesy Louis Pacheco, Scientec, Fr.)



Topography Phase

Figure 3. PDES(Left) Phase Image, (right) 2nd harmonic phase image

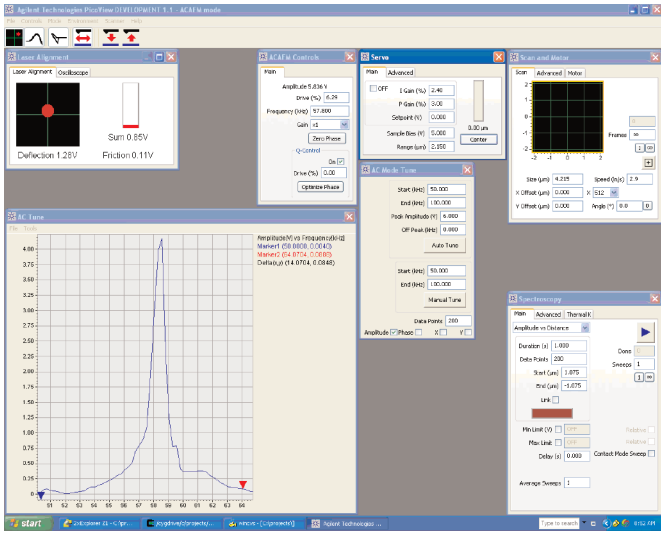


Figure 5. AC Mode tuned with Q-control.

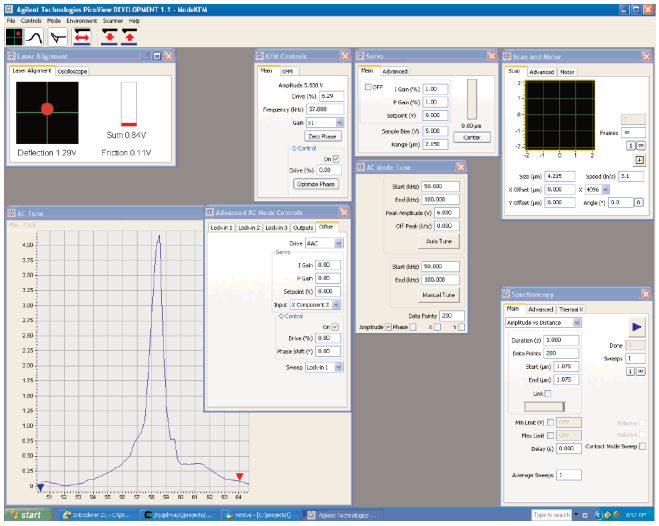


Figure 6. Advanced AAC interface with fully configured Q-control.

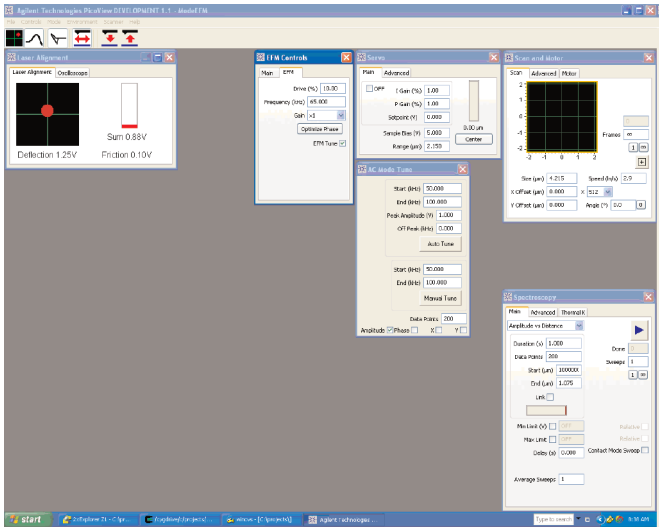


Figure 7. Simplified EFM interface.

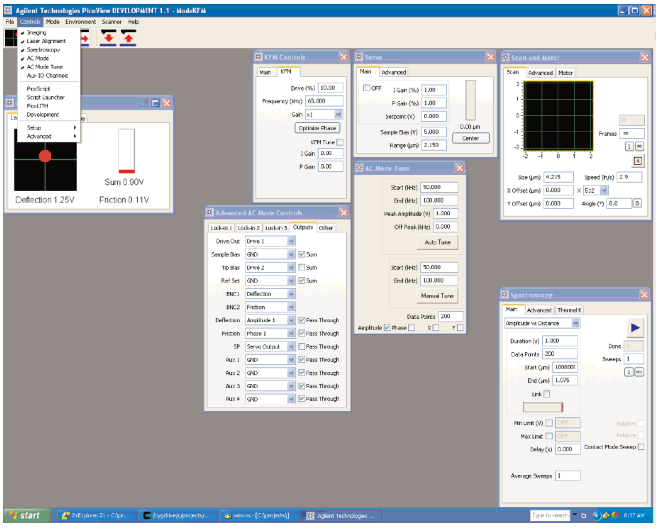
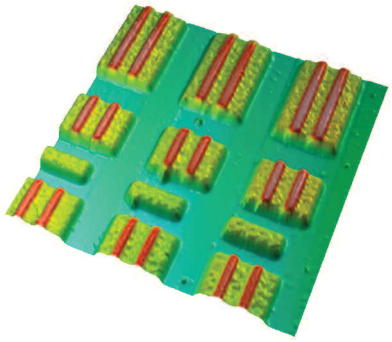


Figure 8. Advanced KFM interface with full configurability of lock-ins.



KFM Image of a SDRAM Images with a 70KHz conductive tip

Imaging under Temperature Control

MAC Mode III with temperature control delivers unparalleled performance, excellent thermal stability, and a wide range of temperatures for high-resolution imaging. This technology combination allows researchers to perform phase-transition studies on various materials with exceptional ease. The AAC mode option included with MAC Mode III offers an even wider range of temperatures.

MAC Levers

In MAC Mode III, a cantilever (called a MAC Lever) coated with a paramagnetic film is driven directly by an oscillating magnetic field. The magnetic field is applied to the MAC Lever either from above (Top-MAC) or below (Bottom MAC sample plate) the cantilever.

Specifications

Three lock-in amplifier modules:	Each module has a full-quadrature lock-in amplifier, auxiliary input, and drive; one of the modules also includes Q-control
Lock-in amplifier output signals:	Can be sent back to the controller on any of seven output channels
MAC Mode III box output signals:	Can be routed to either of two BNC connectors on the back panel
Lock-in amplifier inputs:	Each module has a low-noise programmable gain amplifier with eight gain settings: 1x, 2x, 4x, 8x, 16x, 32x, 64x, 128x
Input frequency range:	200Hz to 6MHz; -3dB
Lock-in amplifier outputs:	Amplitude, Phase, X, and Y (I, Q)
Output bandwidth:	Nine software-selectable values: 80Hz, 100Hz, 200Hz, 500Hz, 1kHz, 2kHz, 5kHz, 10kHz, 20kHz
Frequency resolution:	0.009Hz
Drive amplitude:	16-bit resolution; 0.3mV
Drive phase control:	12-bit resolution; 0.088 degrees
Q-control:	12-bit phase resolution for the Q-control phase shift; 40kHz bandwidth in the 6MHz frequency range; 16-bit drive control
Additional interface slots:	Two additional slots provided

AFM Instrumentation from Agilent Technologies

Agilent Technologies offers high-precision, modular AFM solutions for research, industry, and education. Exceptional worldwide support is provided by experienced application scientists and technical service personnel. Agilent's leading-edge R&D laboratories are dedicated to the timely introduction and optimization of innovative and easy-to-use AFM technologies.

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