



Agilent MAC Mode III

Extends Agilent AFM Capabilities

Data Sheet



Features and Benefits

- Allows one-pass multichannel detection for EFM and KFM
- Three configurable lock-in amplifiers afford superb versatility
- Multifrequency 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 MAC technique optimized for high-resolution AFM imaging in fluids
- Designed for easy operation in air or fluids
- Operates simultaneously with:
 - Environmental control
 - Temperature 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 electromagnetic response. 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 single-pass imaging with AC mode, Kelvin force microscopy (KFM) or Electric force microscopy (EFM), Piezo force microscopy 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.



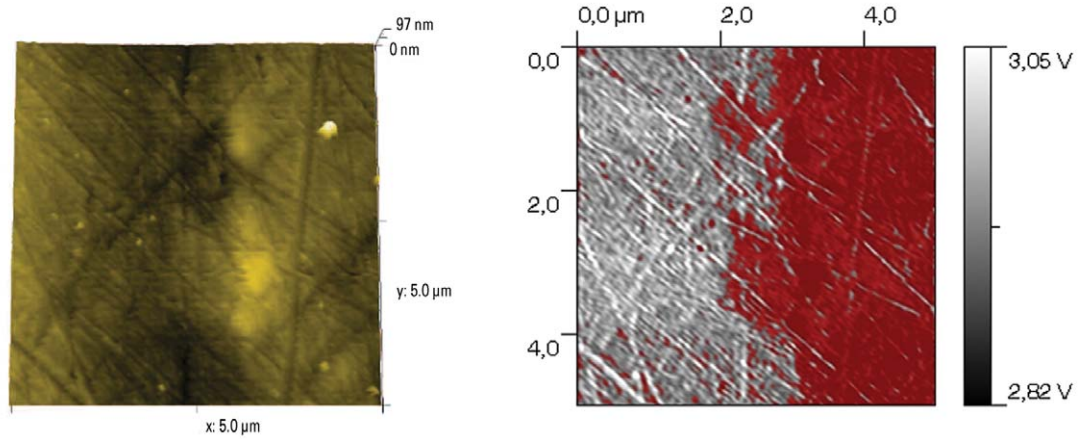


Figure 1. Sample of steel with nickel protective layer. Topography (left) shows surface structure with grains and grain boundaries and KFM image (right) reveals the material properties and defects. (Images courtesy of Voestalpine Stahl GmbH)

Imaging with Higher Harmonics

MAC Mode III has a wide operating frequency, up to 6 MHz, allowing investigation via 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, and PFM. 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.

Imaging with Electrical Single-Pass Microscopy

Agilent's electrical single-pass microscopy (ESPM) mode option leverages the advantages of low-noise electronics and MAC Mode III to enable higher-resolution KFM, EFM, and PFM. By allowing users to customize the signal routing between the MAC Mode III lock-in amplifiers, the mode provides more advanced multifrequency single-pass scanning capabilities.

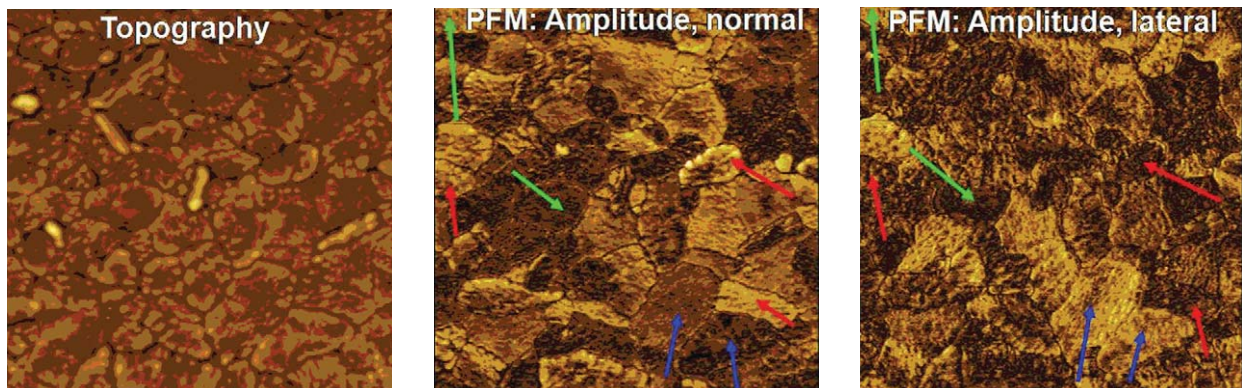


Figure 2. PFM images of SrBiTaO film. In the topography image the contrast covers surface corrugations in the 0-35 nm range. The amplitude contrast in the other images is in relative units.

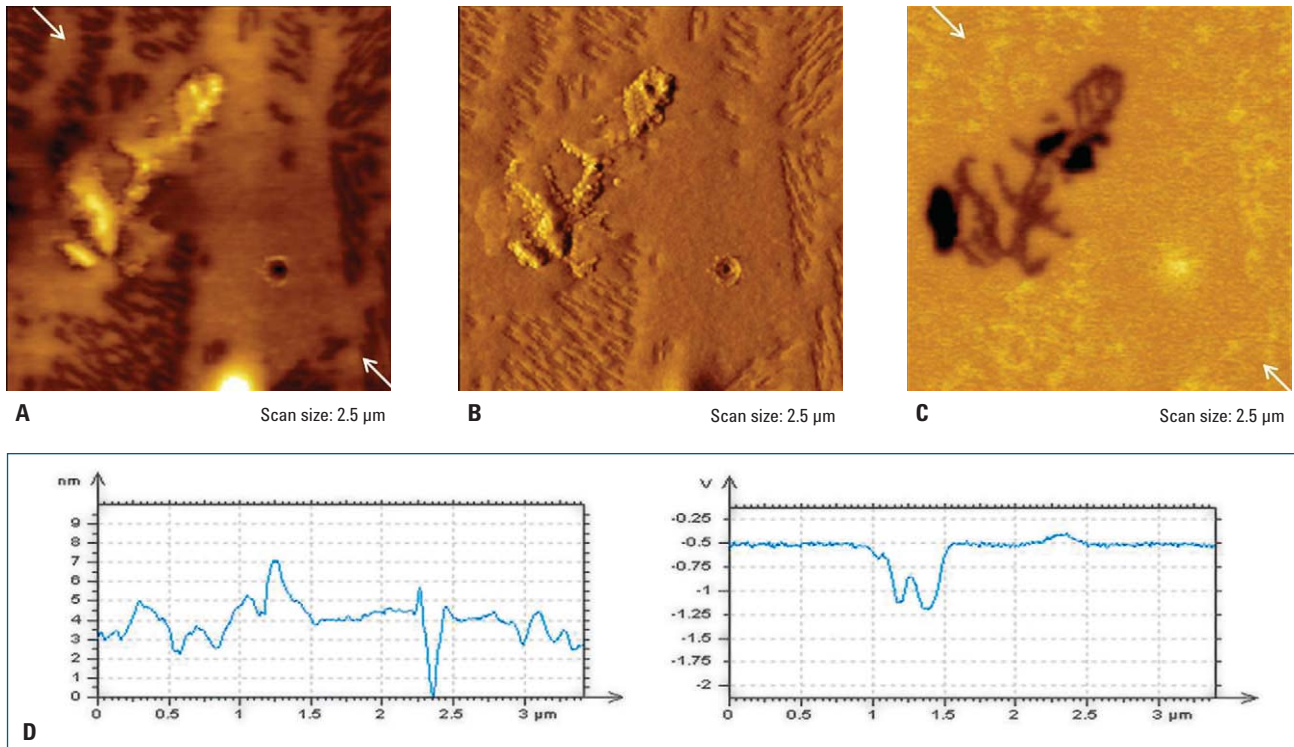


Figure 3. The topography (A), phase (B) and surface potential (C) images of $F_{14}H_{20}$ adsorbate on graphite. The cross-section profiles taken along the directions shown with white arrows in (A) and (C) are presented in the top and bottom parts of (D), respectively.

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.

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.

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 proprietary magnetic 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.

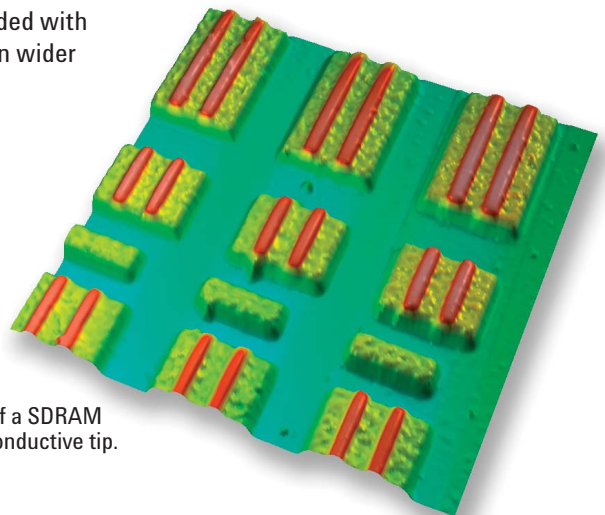


Figure 4. KFM image of a SDRAM image with a 70 KHz conductive tip.

Mac Mode III 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:	200 Hz to 6 MHz; -3 dB
Lock-in amplifier outputs:	Amplitude, Phase, X, and Y (I, Q)
Output bandwidth:	Nine software-selectable bandwidth values: 80 Hz, 100 Hz, 200 Hz, 500 Hz, 1 kHz, 2 kHz, 5 kHz, 10 kHz, 20 kHz
Frequency resolution:	0.009 Hz
Drive amplitude:	16-bit resolution; 0.3 mV
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

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