Agilent MAC Mode

Magnetic AC Mode – *The Gentle Touch for AFM*

Data Sheet

Features and Benefits

- Patented technique optimized for high-resolution AFM imaging in fluids
- Intelligent design facilitates simple operation in air or fluids
- DSP lock-in from 200-Hz to 1-MHz ensures true phase and amplitude
- Precise control of cantilever oscillation delivers excellent force regulation and high-quality phase images
- Easy tuning provides a simple resonance peak
- Wide range of operating frequency affords greater versatility
- Acoustic AC mode and true phase included for extended utility
- Convenient access to I/O signals enables finer timing control
- Operates simultaneously with:
  - Environmental control
  - Temperature control
  - Electrochemical control
  - Controlled fluid exchange

Overview

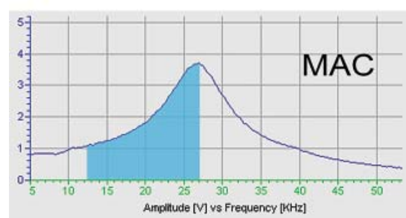
Agilent Technologies' patented magnetic AC mode (MAC Mode) is a gentle, nondestructive technique for atomic force microscopy (AFM) that has been designed for imaging extremely delicate samples. MAC Mode is particularly useful in areas that require high resolution and force sensitivity, such as biology, polymers, and surface science.

MAC Mode allows researchers to image submolecular structures that cannot be resolved with any other AFM technique. It offers the best control available for oscillating probe technology, thereby providing a tremendous benefit for imaging in fluids and imaging soft samples.

With MAC Mode, a magnetically coated cantilever called a MAC Lever is driven by an oscillating magnetic field. The magnetic field is applied directly to the MAC Lever from either above (Top-MAC) or below (MAC Stage) the cantilever.

Digital lock-in amplifier technology is used to precisely determine the oscillation amplitude and phase response of the cantilever, resulting in excellent force regulation and high-quality phase images (Figure 1). The MAC technology eliminates spurious responses that may be generated by a cantilever holding mechanism, the surrounding fluids, or the sample itself.

(a)



(b)

Figure 1. Typical plot of amplitude vs. frequency with AAC (top) and MAC Mode (bottom). MAC Mode operates in the highlighted frequency range and AAC operates only at the frequency indicated by the arrow.

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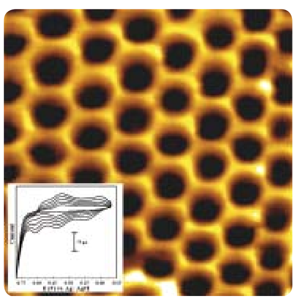
Overview, Continued

Thus, there is less system noise, less confusion in determining the true cantilever resonance, and the cantilever can be operated at much smaller amplitudes. Subsequently, sample damage is decreased, probe sharpness is preserved, and resolution is greatly improved. MAC Mode provides precise measurement and control of amplitude and phase yielding crisp, detailed images without damaging delicate samples.

Used with Agilent's broad selection of high-performance AFM/SPM products, MAC Mode delivers better control and resolution in fluids than other techniques (Figure 2).

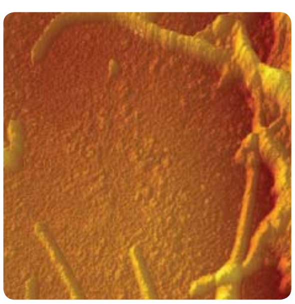
Imaging Soft Samples with the Gentle Touch

MAC Mode provides life science researchers a highly useful tool for AFM imaging. It handles delicate soft samples and samples in fluids, including living cells and cells in changing fluid environments (Figure 3).



4.9 µm x 4.9 µm

Figure 2. Electrochemically generated 2D array of polyaniline.



8.2 µm x 8.2 µm

Figure 3. Human cervical cancer cell in PBS buffer imaged at 27° C.

Imaging Under Temperature Control

MAC Mode can utilize Agilent's temperature control which delivers unparalleled performance and a wide range of temperature stability for high-resolution imaging. This technology combination allows the user to perform phase-transition studies on various materials with exceptional ease. The acoustic AC option, also included with MAC Mode, offers an even wider range of temperatures (from –30°C to 250°C) (Figure 4).

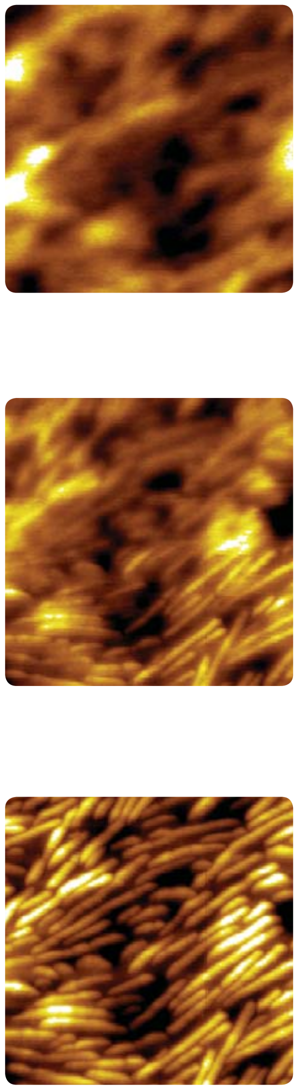


Figure 4. Images of temperature-induced phase transition of polypropylene. Scan sizes: 2 µm x 2 µm.

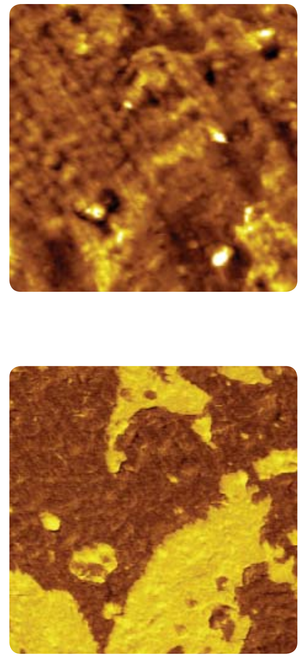


Figure 5. Force modulation images of a two-phase polymer: (a) topography, and (b) amplitude. 10 µm x 10 µm.

Imaging with Force Modulation

MAC Mode 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 wide range of cantilever spring constants (Figure 5).


(a)


(b)

Figure 6. (a) Radiodurance bacteria.

Figure 7. E-Coli bacteria.
Scan size 4 µm.

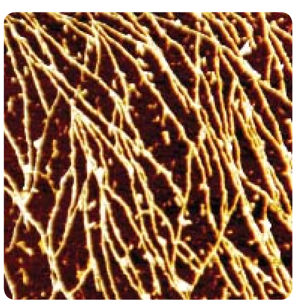
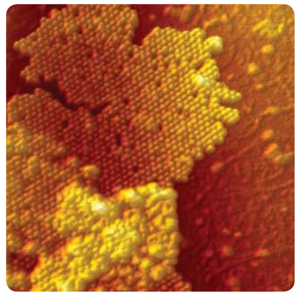
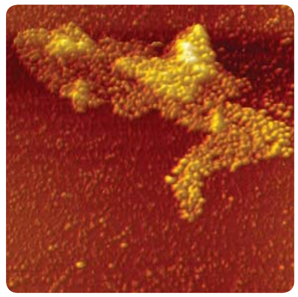
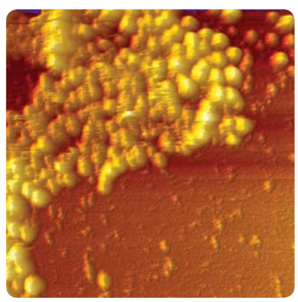


Figure 8. Peptide on Mica.
Scan size 1 µm.


(a)


(b)


(c)

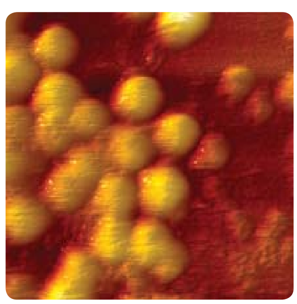

(d)

Figure 9. S-layer: self-assembled protein monolayers (a) in air; highly ordered; (b) in water disordered; (c) zoom of "b" in water: (d) zoom of "c in water.

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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