Agilent
5420 SPM/AFM Microscope

Data Sheet

Introducing
The Agilent Technologies 5420 Scanning Probe Microscope (SPM)

Figure 1. The Agilent 5420 SPM/AFM.

Features and Benefits

- Scientific-grade instrument delivers high resolution
- New design provides improved performance
- New electronics and techniques offer high-resolution KFM/EFM
- Cost-effective platform offers simple upgrade path
- Excellent educational instrument with course curriculum

Applications

- Materials science
- Polymers
- Electrical characterization
- General surface characterization
- Nanolithography

Overview

Based on the popular Agilent 5400 platform, the Agilent 5420 SPM/AFM is a high-precision instrument that has been re-engineered to provide lower noise, better performance, and greater versatility. Featuring a new ergonomic design and improved electronics, this scientific-grade microscope delivers atomic-scale resolution at a remarkably affordable price, making it an ideal choice for education as well as research.

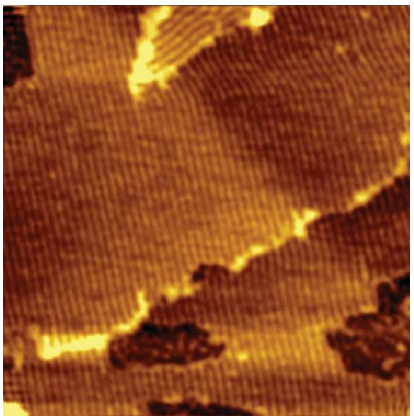

Figure 2. Topography image of C60 obtained in AAC mode. Scan size 200 nm.

The 5420 microscope offers advanced new electrical characterization capabilities. One technique, Electrical single-pass mode (ESPM), takes full advantage of the 5420's use of new low-noise electronics to enable high-resolution Kelvin force microscopy (KFM), electric force microscopy (EFM), and piezo force microscopy (PFM). And, Agilent's unique scanning microwave microscopy (SMM) mode, allows highly sensitive calibrated electrical and spatial characterization.

The 5420 offers educators an exceptional opportunity to introduce their students to many powerful SPM/AFM techniques. The microscope will be delivered with an undergraduate course curriculum and samples for teaching labs. To help ensure optimal utility for users whose needs change and grow over time, the 5420 provides a simple upgrade path.

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System Components

The Agilent 5420 SPM/AFM is a modular laboratory solution that offers an open or closed-loop 90 µm X-Y and Z scanner (a 9 µm scanner is also available), a new low-noise controller, a variety of modes, a high-resolution color camera, a computer, and two monitors.

Rigid materials, a rigid frame, and the 5420 microscope's new ergonomic design provide vibration-free operation and a short mechanical path for noise reduction. A new stage design also reduces noise, as well as thermal drift. The 5420's compact scanner employs a patented balanced-pendulum design to minimize X-Y coupling, significantly reducing creep and hysteresis.

The 5420 microscope's newly redesigned controller uses improved electronics to minimize noise and optimize functionality. The controller has two 32-bit DSPs, five 24-bit DACs for X-Y and Z scan-axis positioning, ten 16-bit data acquisition channels, and four 24-bit DAC outputs.

For low-interference imaging, the 5420 utilizes a low-coherence laser with a small spot size. The positioning of the laser on the scanner ensures that the laser is always focused on the same spot on the cantilever,

Figure 3. Open, easy access to scanner and sample plates. Shown: adaptor plate for high resolution imaging.

providing absolute accuracy in very sensitive measurements (e.g., force measurements) and helping to eliminate imaging artifacts.

Software

Agilent's 32-bit Windows®-based PicoView is a highly stable software package that offers real-time 3D rendering capabilities. PicoView, along with user-level scripting (C++, Python, MathWorks MATLAB, National Instruments LabVIEW), allows control of scanning parameters and provides the flexibility required for more complex experiments. An integrated script editor and sample scripts are also included with the scripting development kit (SDK).

Ease of Use

Open access to the scanner and sample plates (Figure 3), along with easy alignment of the microscope's newly improved optics, simplifies the use of the Agilent 5420 SPM/AFM. The scanner mounts quickly and is held in place with a clamp closure. In addition, the scanner's easy-to-load nose cones allow fast, convenient switching between imaging modes. These nose cones are made from PEEK polymers, have low chemical reactivity, and can be used in a wide range of solvents. Their straightforward interchangeability provides tremendous flexibility. Agilent also offers a new AC Mode nose cone made from next-generation Techtron PPS. This innovative nose cone has a 12° angle and can be used with all commercially available conductive cantilevers.

The 5420 scans at speeds up to 48 Hz and can scan as many as 8 images simultaneously (4096 x 4096 pixels). USB standard connectivity allows the microscope to be run from a laptop computer.

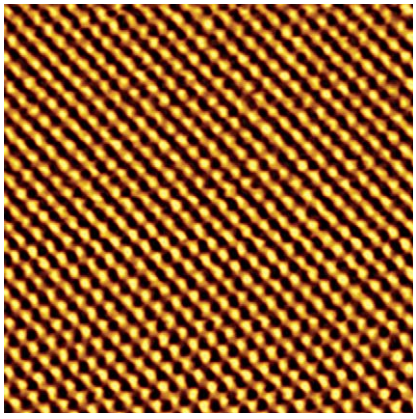


Figure 4. STM image of atomic lattice of HOPG. Imaged in isolation chamber. Scan size 5 nm.

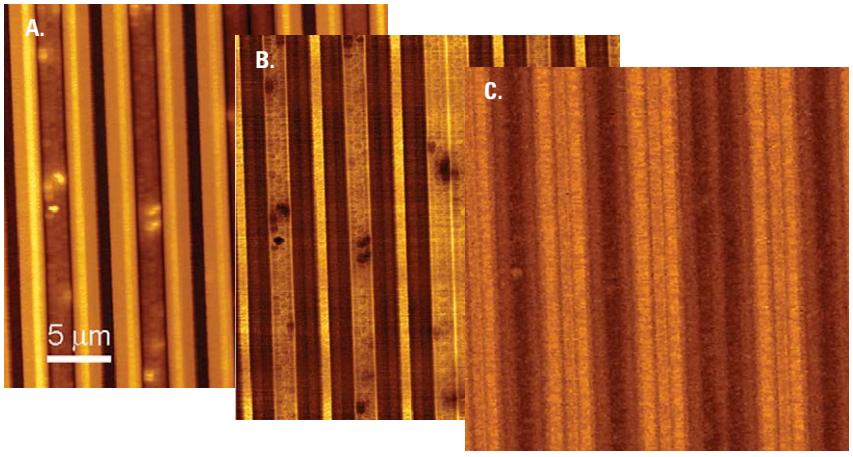


Figure 5. Simultaneous topography (A), capacitance (B), and dC/dV (C) images of SiGe transistor device. Both capacitance and dC/dV images resolved the underneath dopant structures not seen in the topography. Images obtained with 5420 in Scanning Microwave Microscopy (SMM) mode.

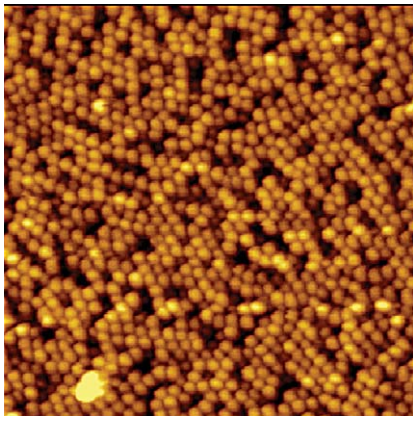
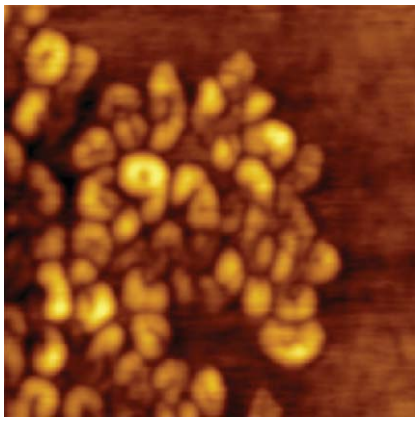


Figure 6. MAC Mode image of Ferritin. Scan size 400 nm.



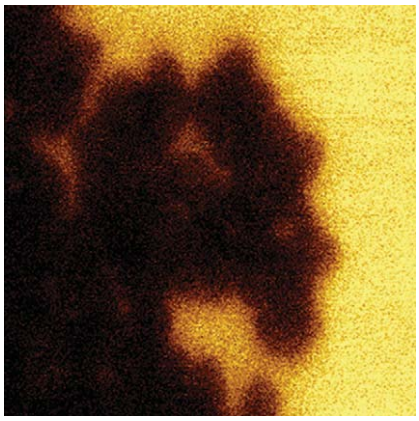


Figure 7. Image of $F_{14}H_{20}$ topography (left) and KFM (right).

Options

Several performance-enhancing options are available for the Agilent 5420 microscope, including a closed-loop X-Y and Z scanner that provides optimum control over the position of the SPM/AFM probe. Scanning tunneling microscopy (via a 10 µm STM scanner) and current-sensing AFM are also offered.

For high-resolution imaging in liquid, Agilent's patented magnetic AC Mode (MAC Mode) is available. MAC Mode, an extraordinarily gentle non-contact AFM imaging technique for imaging in liquid or soft materials. To meet the requirements of intricate experiments, precision thermal control can be added. A new sample plate adapter designed to facilitate in-fluid imaging applications with thermal control is available as well.

The 5420 is compatible with Agilent's MAC Mode III, which provides three user-configurable lock-in amplifiers, affording virtually limitless application possibilities and unprecedented speed. Two expansion slots are also provided with this mode. MAC Mode III has been designed to allow 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.

MAC Mode III also lets researchers 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. In addition to KFM/EFM and PFM, MAC Mode III allows the use of higher resonance modes of the cantilever. Higher harmonic imaging provides contrast different from that seen with fundamental amplitude and phase signals. This technique can be utilized to collect additional information about mechanical properties of the sample surface.

Advanced New Electrical Characterization Techniques

Another option for the 5420 microscope is ESPM Mode, a new low-noise technique that enables high-resolution KFM/EFM and PFM. EPSM Mode allows users to customize signal routing between the MAC Mode III lock-in amplifiers, thus providing more advanced multifrequency scanning. By operating the 5420 in ESPM Mode with a PFM adapter, users can apply PFM signal directly to their sample.

The 5420 is also compatible with Agilent's unique SMM Mode, which combines the compound, calibrated electrical measurement capabilities of a microwave vector network analyzer (VNA) with the outstanding spatial resolution of an atomic force microscope. SMM Mode outperforms traditional AFM-based scanning capacitance microscopy techniques, offering far greater application versatility, the ability to acquire quantitative results, and the highest sensitivity and dynamic range in the industry.

SMM Mode is particularly useful for semiconductor test and characterization. In addition to enabling complex impedance (resistance and reactance) measurements, SMM Mode can be used to acquire calibrated capacitance and dopant density measurements. SMM Mode works on all major semiconductor types and does not require an oxide layer. As well as its ability to work on semiconductors, glasses, polymers, ceramics, and metals, the technique lets 5420 users perform high-sensitivity investigations of ferroelectric, dielectric, and PZT materials. Studies of organic films, membranes, and biological samples can also benefit from the use of SMM Mode.

Specifications

Noise	0.5 Å
Scan Range	90 µm x 90 µm x 8 µm

Scanners

Note: Specifications shown are for open-loop operation. Closed-loop scanners are also available.

Large Multi-Purpose Scanner	
Scanning Range	90 µm x 90 µm
Z Range	8 µm
Vertical Noise	0.5 Å RMS
Small Scanner	
Scanning Range	9 µm x 9 µm
Z Range	2 µm
Vertical Noise	< 0.2 Å RMS

Sample Plate Sizes

Kinematic Mount Translatable Sample Plate	2 mm x 2 mm
Translation Stage	20 mm x 20 mm

Controller

Input	Ten 16-bit channels
Drive	5 channels ± 215 V, 24-bit
Output	Four 24-bit channels, ± 10 V
Interface	USB
Power	100 - 120 V AC or 220 - 240 V AC 1A; 50 - 60 Hz

Facilities Specifications

Acoustic Noise	< 75 dBc
Temperature Variation	Does not exceed ± 2° F
Humidity Variation	Does not exceed ± 20% RH

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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