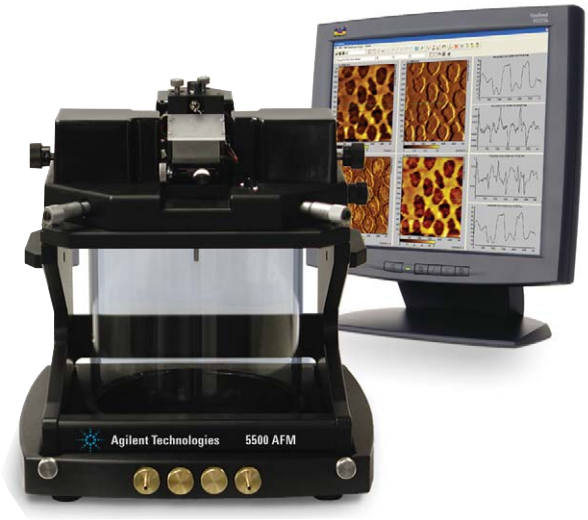
Agilent 5500 AFM

Data Sheet



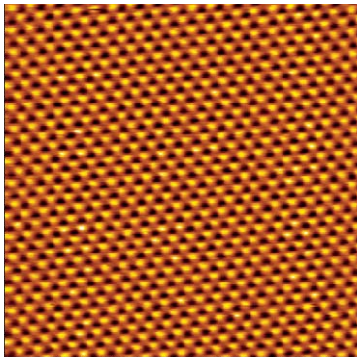


Figure 1. STM image of HOPG showing atomic structure. Scan size: 4 nm.

Features and Benefits

- Exceptional environmental and temperature control
- Superior scanning in fluids, gases, or ambient conditions
- High precision AFM delivers atomic resolution
- The utmost flexibility from a highly modular system
- Convenient vertical sample approach

Applications

- Electrochemistry
- Life science
- Materials science
- Polymer science
- Electrical characterization
- Nanolithography
- Nanografting
- Biotechnology

Overview

The Agilent 5500 is the ideal multiple-user research system for atomic force microscopy. As the high-performance flagship of Agilent's AFM instrument line, the 5500 provides atomic-scale resolution and a wealth of unique technological features, including patented top-down scanning, ultra-precision temperature control, and industry-leading environmental control. It is well suited for life science, materials science, polymer science, electrical characterization, and nanolithography applications.

The intelligent, modular design of the 5500 permits the simple integration of an inverted optical microscope, numerous imaging modes, customizable sample-handling plates, an electrochemistry kit, and a video microscope. In short, the versatile 5500 has been engineered to support almost every scientific AFM capability offered by Agilent Technologies.

Agilent Technologies

Scanners

Agilent's open- and closed-loop scanners (two ranges available: 90 µm x 90 µm, or 9 µm x 9 µm) offer outstanding linearity, accuracy, versatility, and ease of use. These multipurpose, top-down scanners are ideal for imaging in fluids or air and under controlled temperature and environmental conditions. To deliver high-resolution imaging results, a balanced-pendulum design is utilized that eliminates artifacts in the image by keeping the relative position of the laser spot fixed in relation to the cantilever throughout the scan cycle.

STM scanners (9 µm x 9 µm, or 1 µm x 1 µm) are also available for use with the 5500. Agilent's STM scanners deliver excellent results on a variety of conducting materials. These low-current and ultra-low-current STM scanners provide stable imaging at pico-ampere and sub-pico-ampere currents to resolve individual atoms and molecules. STM scanners take advantage of the extreme distance sensitivity of the tunneling current between two conducting electrodes. By measuring the tunnel-current variations as a probe is scanned over a sample's surface, STM is able to deliver the highest-resolution SPM images.

Open access to the scanner and easy alignment of optics help simplify use of the 5500. In addition, easy-to-load scanner nose cones make switching imaging modes quick and convenient. The nose cones are made from PEEK polymers, have low chemical reactivity, and can be used in a wide range of solvents. Their easy interchangeability provides tremendous flexibility.

MAC Mode

Agilent's patented MAC Mode provides the industry's best performance for imaging in fluids and imaging soft samples, allowing researchers to image submolecular structures that cannot be resolved with any other AFM technique. MAC Mode is particularly useful in application areas that require high resolution and force sensitivity, such as biology, polymers, and surface science. AAC mode is included with MAC Mode.

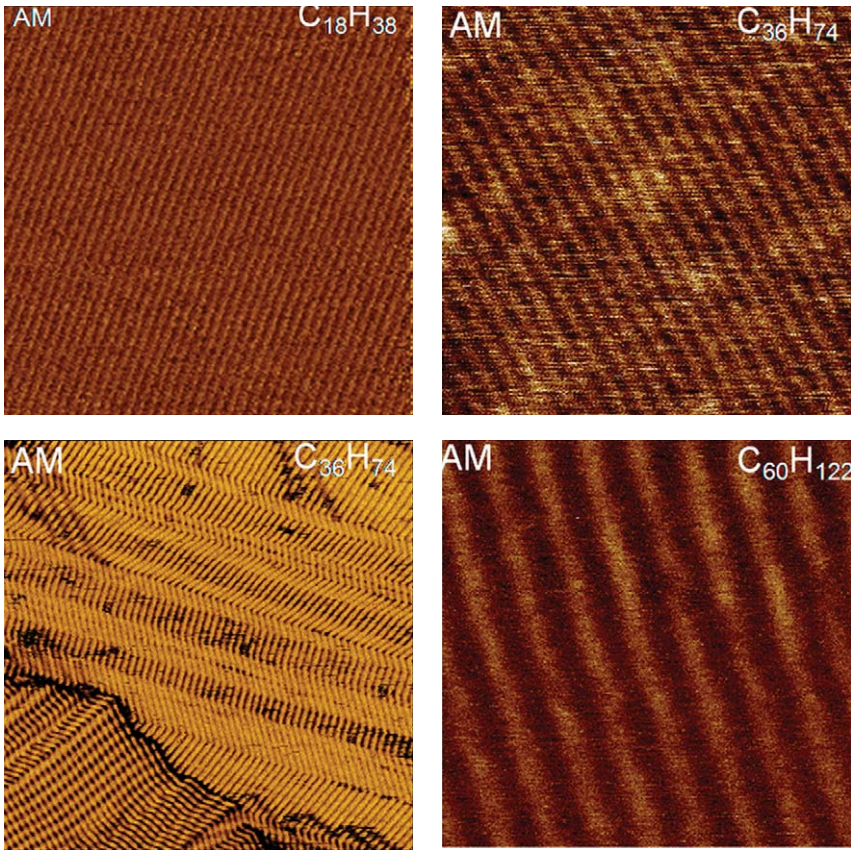


Figure 2. AFM images of normal alkanes on graphite obtained in amplitude modulation mode.

MAC Mode III

Patented MAC Mode III provides three user-configurable lock-in amplifiers, affording researchers virtually limitless application possibilities and unprecedented speed. It also provides two expansion slots. 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 piezo force, 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.

Temperature Control

Agilent's temperature controller uses a patented thermal insulation and compensation design to deliver the industry's most precise temperature control. It allows imaging during temperature changes and is fully compatible with all imaging modes, including those utilized in fluid. The temperature controller's design isolates the sample plate from the rest of the 5500 system. An insulated ceramic fixture protects the surrounding apparatus from the effects of heating or cooling, thus providing the most precise, stable temperature control available. Temperature control is offered with heating up to 250°C and cooling down to -30°C.

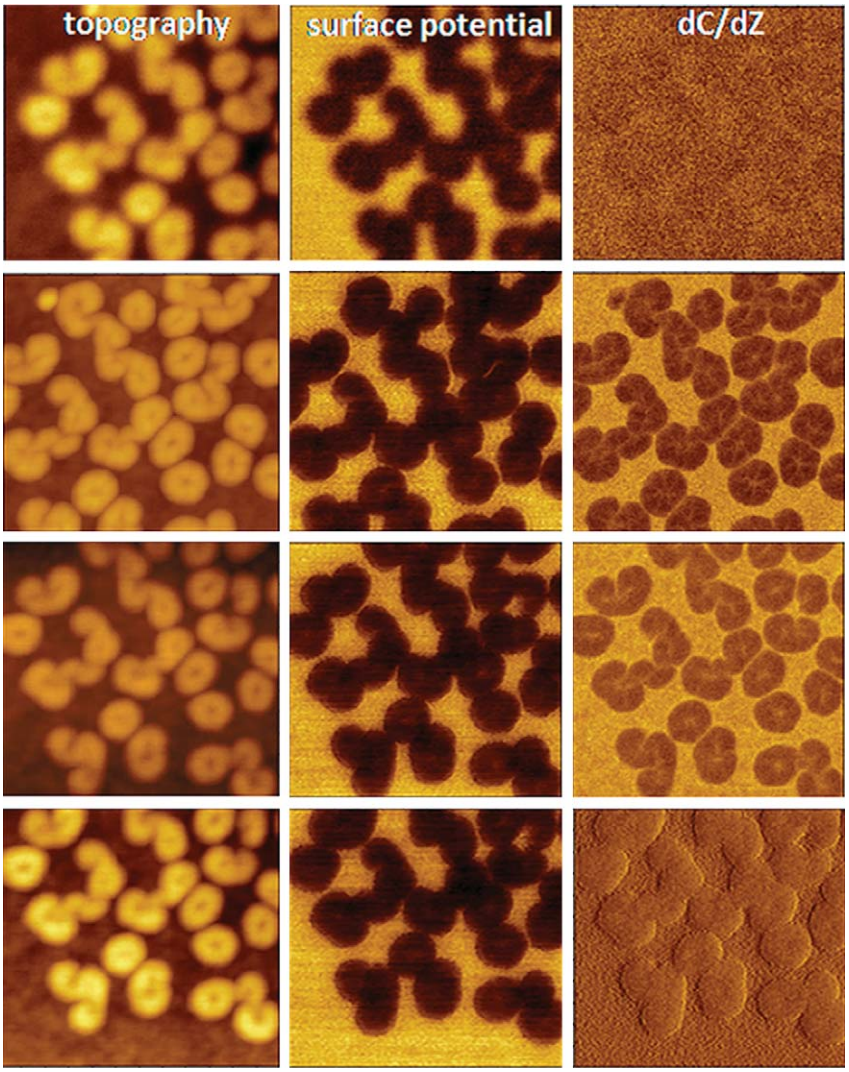


Figure 3. Topography, surface potential and, dC/dZ and dC/dV images of $F_{12}H_{20}$ adsorbates on Si. The images were obtained in the AM-FM mode. Scan area 300 nm. The contrast covers the height and potential changes in the 0–200 nm and 0–1 V ranges. The contrast of dC/dZ maps is in relative units. The images in the columns from top to bottom were obtained respectively at the probe-sample distances of 1 nm, 7 nm, 15 nm, and 30 nm.

Environmental Control

Agilent's industry-leading environmental isolation chamber (EIC) has been specifically designed to meet the many requirements of intricate, demanding atomic force microscopy and scanning probe microscopy research. The EIC mounts directly to the 5500 and provides a hermetically sealed sample compartment that is completely isolated from the rest of the system. Eight inlet/outlet ports permit the flow of many different gases into or out of the sample area.

Agilent scanners reside outside the EIC, so they are protected from contamination, harsh gases, solvents, caustic liquids, and other damaging experimental conditions. With the EIC, humidity levels can be controlled, oxygen levels monitored and controlled, and reactive gases easily introduced into and purged from the sample chamber.

Figure 4. 5500 AFM with environmental chamber.

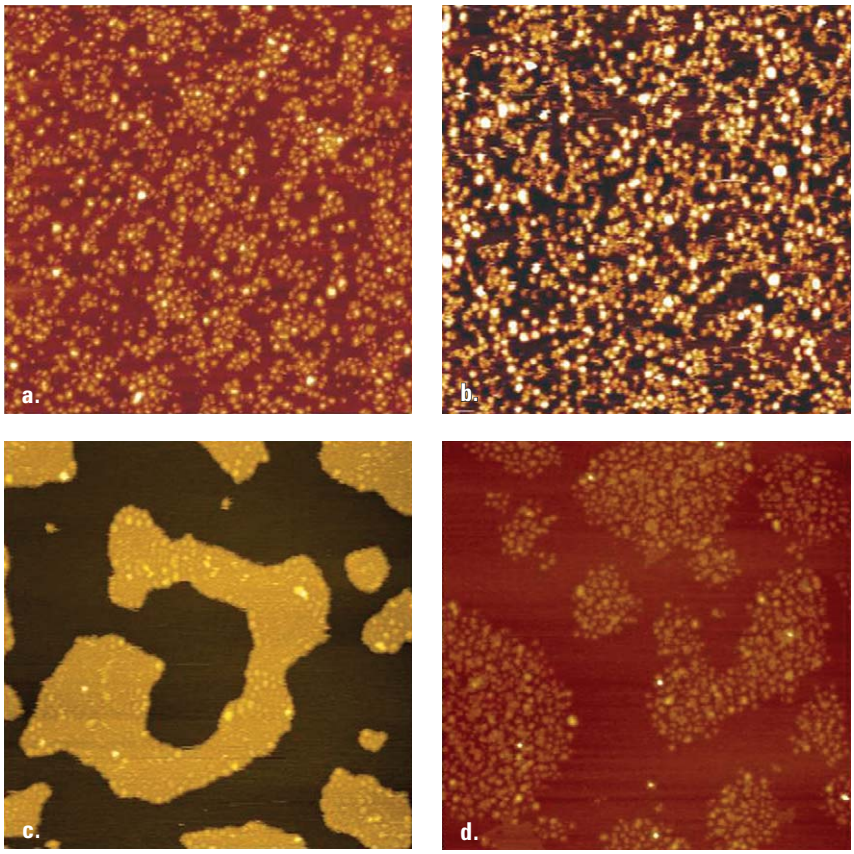


Figure 5. Topography images of multiarm star block copolymer macromolecules at low humidity (a), at high humidity (b), at high humidity after 12 hours (c), and at low humidity again (d). Scans are 2 micron.

Sample Plates

The unique design of Agilent's sample plates delivers superior sample stability and ease of use. Magnetic suspension provides easy loading and eliminates mechanical drift. The stand-alone plates permit simple sample mounting and application-specific plate customization. A modular design allows the plates to be used with an unparalleled number of options, such as open liquid cells, flow-through cells, salt-bridge cells (electrochemistry), Petri dishes (live-cell imaging), and glass microscope slides.

Figure 6. Sample plates: high temperature plate (left), coverslip and liquid cell plate (middle), Petri dish plate (right).

Electrochemical SPM

Agilent's electrochemical SPM option includes a complete kit for high-resolution in situ EC-SPM experiments. Electrochemical SPM offers a low-noise potentiostat/galvanostat for *in situ* EC-STM and EC-AFM. When combined with temperature control, it is possible to obtain valuable information about electrochemical processes that would otherwise be inaccessible. The addition of environmental control allows imaging with no dissolved oxygen in either aqueous or non-aqueous solutions.

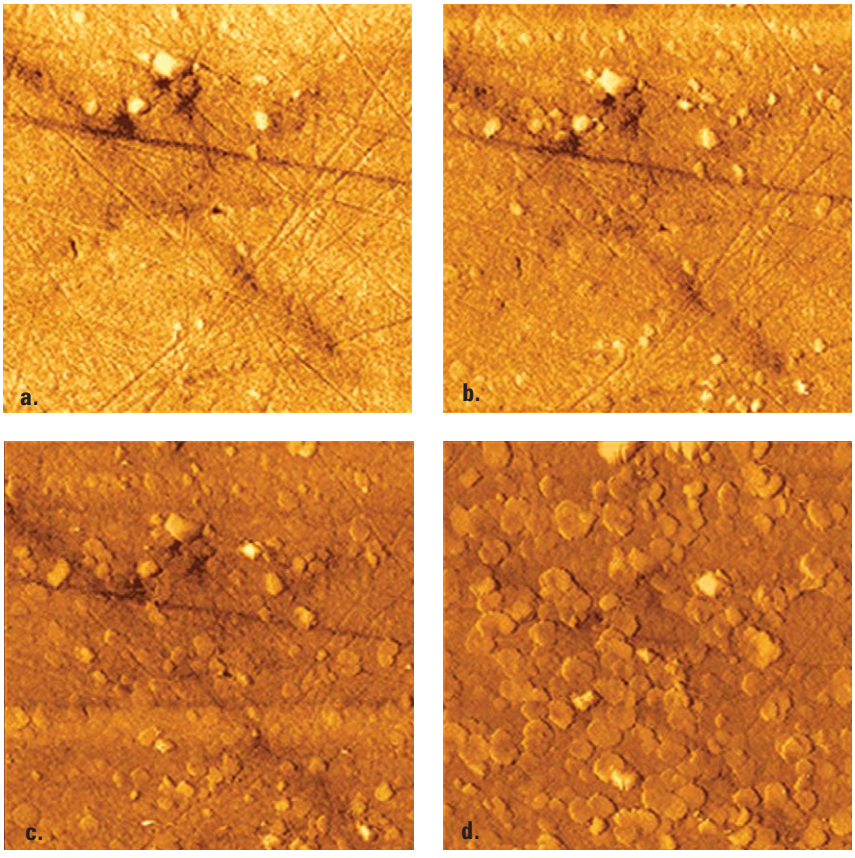
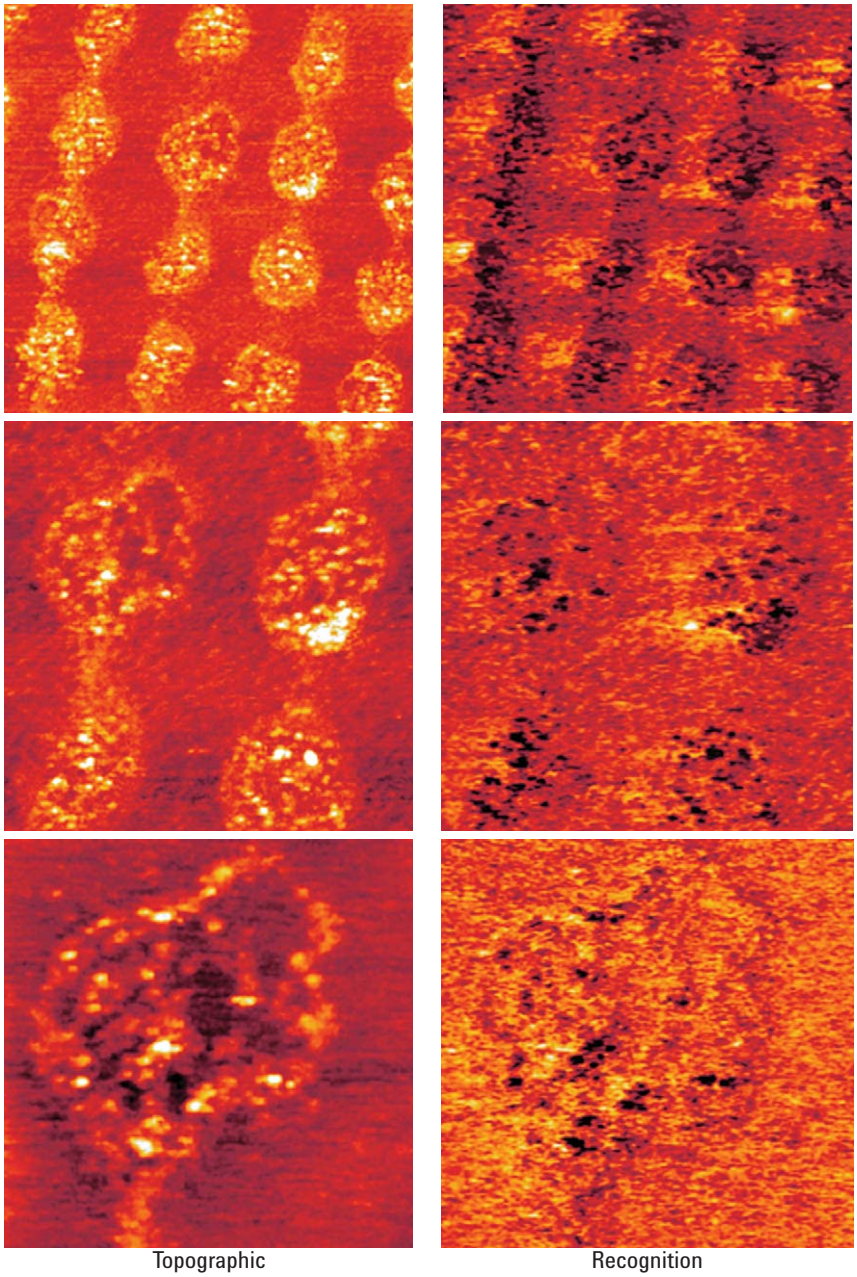


Figure 7. Corrosion study of a polished metal surface: rest potential (a), after two cycles (b), after three cycles (c), and after six cycles (d).

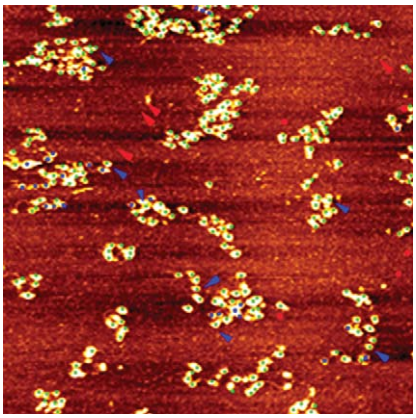
PicoTREC

Agilent's exclusive PicoTREC molecular recognition tool kit is designed for use with MAC Mode. The option includes specialized hardware, electronics, consumables, and accessories. With PicoTREC, researchers can quickly distinguish between species that are engaged in molecular binding events and those that are not engaged in molecular binding events, thus eliminating the need to perform slow and tedious force-volume spectroscopy experiments to get the same results. Scientists can use PicoTREC with the 5500 AFM to explore dynamic properties of biological systems (antibody-antigen, ligand-receptor, drug-receptor, DNA-protein, DNA-DNA, and so forth) by imaging patterns of molecular binding and adhesion on surfaces.



Topographic Recognition

Figure 8. PicoTREC imaging of the micropatterned avidin molecules. Topographic images (above, left), and corresponding recognition images (above, right).



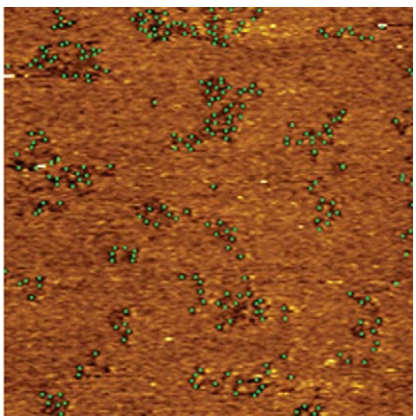


Figure 9. Accuracy and reproducibility using PiocTREC anti-His3 on AFM and chromatin on glutaraldehyde mica. PicoTREC can repeat an experiment in a matter of minutes. In the top image blue indicates misses and red indicates false hits. In the bottom image green indicates hits. There was five minutes between scans and number of hits went down on the rescan (96% to 92%) and the false positive rate was 2.8%.

Images courtesy of Dr. Stuart Lindsay based on results generated in his lab by Dr. Hongda Wang at ASU.

Software

The 5500 utilizes Agilent's PicoView, an imaging and analysis software package that offers 3D rendering capabilities. PicoView allows complete control of all scanning parameters and provides the flexibility required for more complex experiments. An integrated script editor and sample scripts are also included.

For additional interactive post-processing capabilities, Agilent's easy-to-use Pico Image Basic imaging and analysis software package includes all of the features and functions required to build a basic surface analysis report on multi-layer measurement data that is input from the 5500. The document consists of a set of frames containing surfaces, profiles extracted from surfaces, the results of applying filters and other operators, analytical studies, and 2D and 3D parameters. A measurement identity card, screen notes, and illustrations can be added to each document. Pico Image Advanced and Expert packages are also available.

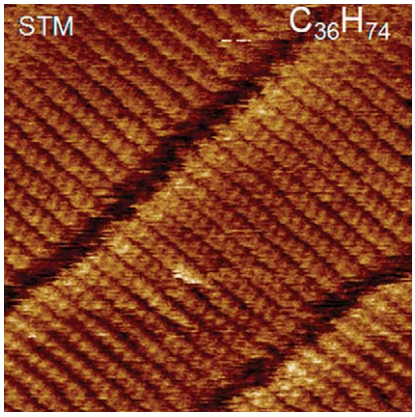


Figure 10. STM image of $C_{36}H_{74}$ alkanes on graphite. Scan size: 8 nm.

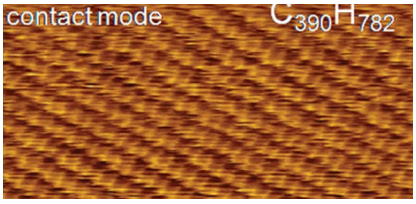


Figure 11. AFM images of $C_{18}H_{38}$ and $C_{390}H_{782}$ lamellae on graphite obtained in the contact mode. The spacings, which are related to the lamellae and individual chains, are distinguished in the image of $C_{18}H_{38}$ lamellae (left). The zigzag pattern along the closely packed alkane chains is seen in the image of the ultra long alkane – $C_{390}H_{782}$ (right).

Ultra High Resolution Imaging on the 5500

The Agilent 5500 not only provides the researcher flexibility and modularity but also the highest imaging resolution. The 5500 has excellent signal-to-noise characteristics, low thermal drift and excellent control of the tip-sample forces. Figures 9-11 are just a few of the sub-100 nm features seen in a variety of polymers.

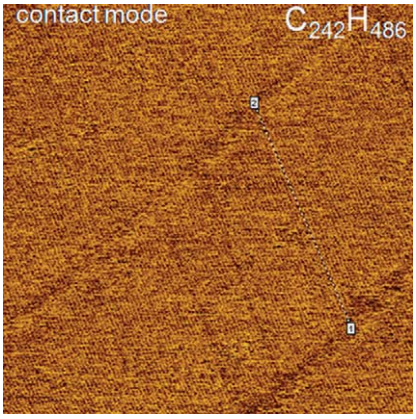


Figure 12. AFM images of $C_{242}H_{486}$ lamellae on graphite obtained in the contact mode. Several slightly twisted lamellae were detected in the images of $C_{242}H_{486}$, A number of linear defects caused by the missing chains or their parts are also distinguished in the100 nm image (left). The individual alkane chains, which are extended betweenthe edges of the lamellae, are also noticed in the 55 nm image (right).

Specifications

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 plate
Optics	Navitar video camera
Vibration Isolation	Available
Controller	
Input	Ten 16-bit channels
Drive	5 channels ± 215 V, 24-bits
Output	Four 24-bit channels, ± 10 V
Interface	USB
Power	100 - 120 VAC or 220 - 240 VAC 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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