Keysight 5600LS AFM
Exceptional Application Versatility for Large and Small Samples
Data Sheet

System Overview

Whether you work with large or small samples, the Keysight Technologies, Inc. 5600LS large-stage AFM is ready to deliver the atomic-resolution results you need. The modular 5600LS is the world's only commercially available AFM system that allows imaging of both large samples (in air) and small samples (in air, or in liquid under temperature control) with an 8 µm scanner.

The 5600LS utilizes the largest fully addressable and programmable stage on the market, 200 mm x 200 mm, as well as a low-noise AFM design. Samples up to 8" in diameter and 30 mm tall are easily accepted by the 200 mm vacuum chuck. The stage accommodates a 300 mm wafer with repositioning.

To further expand the application versatility of the 5600LS system, new 300mm wafer and multi-sample 2-inch-wafer stages are now available. The 5600LS AFM provides researchers a perfect tool for many nanotechnology applications, including semiconductor, optoelectronics, materials science, and life science studies.

Large and Small Samples

The 5600LS system's programmable, motorized stage enables fast, accurate probe positioning for imaging and mapping both large and small specimens alike. Investigators can precisely locate and identify an area of interest and, with the coordinates stored, automatically reposition the sample quickly and accurately for further study. Multiple locations can be programmed into the system. For ultimate flexibility, the standard 200 mm stage can accommodate either a single large sample or up to nine small samples with vacuum chuck (more can be held with tape), each of whose locations can be programmed into the system for automated, unattended measurement.

Two new sample chucks, one 300 mm and one with cutouts for 12, 2 inch (52 mm) wafers are now available. By repositioning the stage, the 300 mm chuck, combined with new software provides the capability to measure on an intact 300 mm Silicon wafer. Replacing the standard 200 mm chuck, the new 12 position, 2 inch wafer chuck is ideal for the LED and optoelectronic substrate and device measurement.

Features and Benefits

- New 300 mm and multi-sample 2-inch-wafer stages expand application versatility
- Largest fully addressable and programmable stage available (200 mm x 200 mm)
- Special stage adapter allows use of sample plate to image small samples in liquid
- System provides simple point-and-shoot AFM imaging based on optical view
- Atomic-resolution imaging of small sample areas via AFM or STM scanners
- Motorized optical focus affords excellent ease of use
- Submicron positioning delivers outstanding accuracy
- Accurate location mapping (0.5 µm precision) ensures reproducibility
- Exclusive SMM mode offers calibrated electrical measurement capabilities
- PicoScript facilitates scripting to automate instrument setup and control
- Plug-ins allow extension of force-volume and force curves

Applications

- Semiconductor: silicon wafers, devices
- Data storage: CDs, DVDs, hard drives
- Optoelectronics and LEDs
- Biological arrays
- Polymer science
- Materials science

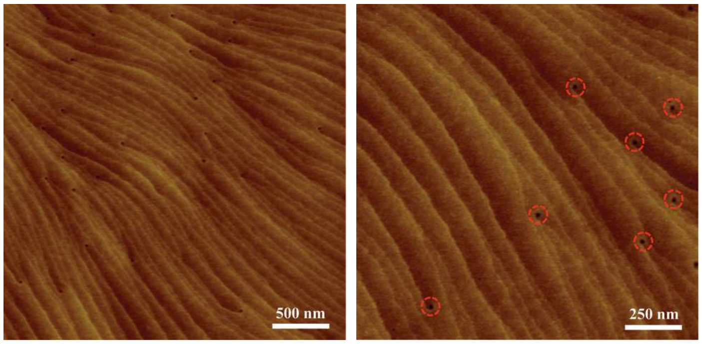


Figure 1. Two topography images of GaN films grown on sapphire. Image on right shows local defects circled in red.

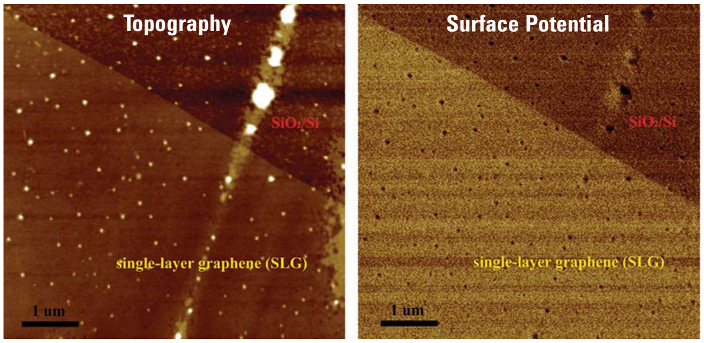


Figure 2. Topography image (left) and surface potential image (right) of single-layer graphene on a silica substrate. Image clearly shows variation between substrate and graphene.

The 5600LS supports Keysight open-loop and closed-loop scanners as well as Keysight STM scanners for unparalleled application flexibility. To provide optimized scanning for a diverse set of applications, both AFM multipurpose scanners are available in two scan ranges. Keysight's large scanner can scan areas up to 90µm x 90µm, whereas a switch to an 8µm x 8µm scanner or the 8µm x 8µm STM scanner lets 5600LS users image a very small sample area that can easily image atomic steps.

Furthermore, a special Keysight stage adapter permits the 5600LS to be utilized with Keysight's standard sample plates thus facilitating the imaging of small samples in liquid. Heating and cooling control is also offered for imaging biological and polymer samples in liquid further extending the utility of the 5600LS.

Innovative Design

The 5600LS combines stable, low-noise AFM imaging with high-speed, very flat, easily reproducible displacement over the stage travel range. The automated tip approach feature of the Keysight atomic force microscope minimizes damage to delicate sample structures. Motorized optical zoom and focus capabilities facilitate the automatic pre-approach, simplifying setting the initial tip-sample separation.

The 5600LS also allows users to perform simple, software-driven, point-and-shoot AFM imaging of an area of interest based on an optical view. AFM images can even be stitched together using Keysight's Pico Image Advanced software package (optional).

A complete 5600LS AFM system includes the microscope, a stage, the video microscope, a scanner, an AFM controller, and the system computer.

Imaging Modes

The 5600LS is compatible with contact mode, acoustic AC mode, phase imaging, STM, LFM, EFM, MFM, force modulation, current sensing, and Keysight's MAC Mode III — a gentle, nondestructive technique for imaging delicate samples in air or liquid.

The MAC Mode III Controller

The Keysight MAC Mode III Controller, provides 3 user-configurable lock-in amplifiers affording virtually limitless application flexibility. Additionally, it has internal expansion capability to allow the future addition of advanced imaging and analytical modes.

Optimized for the Keysight patented single-pass KFM/EFM concurrent imaging, it enables the collection simultaneous topography and surface potential data using a servo-on-height cantilever approach that in insensitive to scanner drift. The single-pass KFM/EFM is particularly useful for measuring dielectric films, metal surfaces, piezoelectric materials, and conductor-insulator transitions.

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.

Scanning Microwave Microscopy (SMM) Mode

The 5600LS is also available with Keysight Technologies' unique SMM mode, which combines the compound, calibrated electrical measurement capabilities of a microwave vector network analyzer (VNA) with the outstanding spatial resolution of

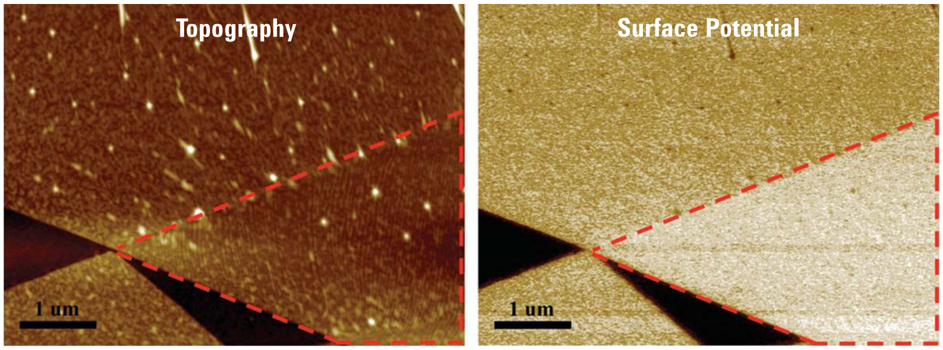
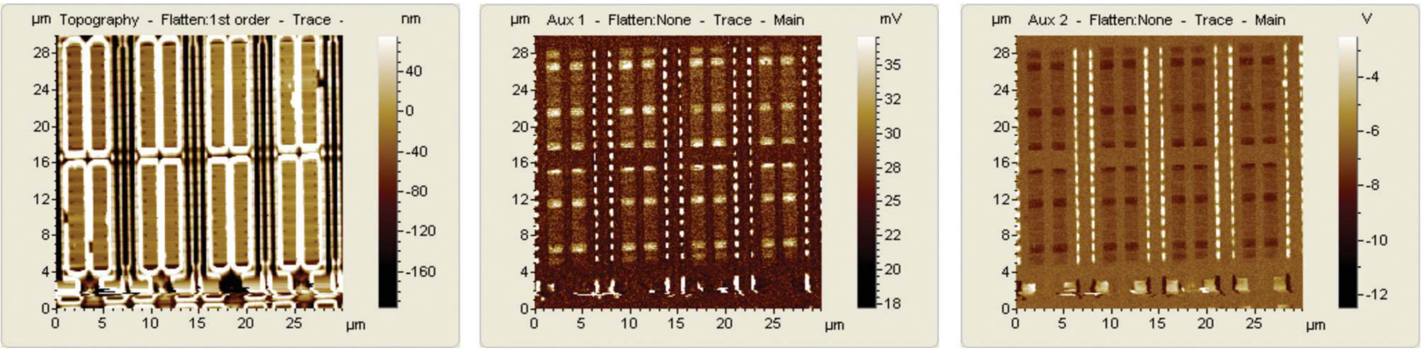


Figure 3. Topography images (left) and surface potential (KFM) image (right) of few-layer graphene. The high resolution single pass KFM image shows there is some coupling between the surface structures of graphene materials and their electrical properties. Shown are some particularly fine surface features that look like wrinkles or ripples in the area marked by the dotted red lines in the topography image and a corresponding increase of surface potential in the same area.

Positive bias Topography dC/dV Amplitude dC/dV Phase



Negative bias

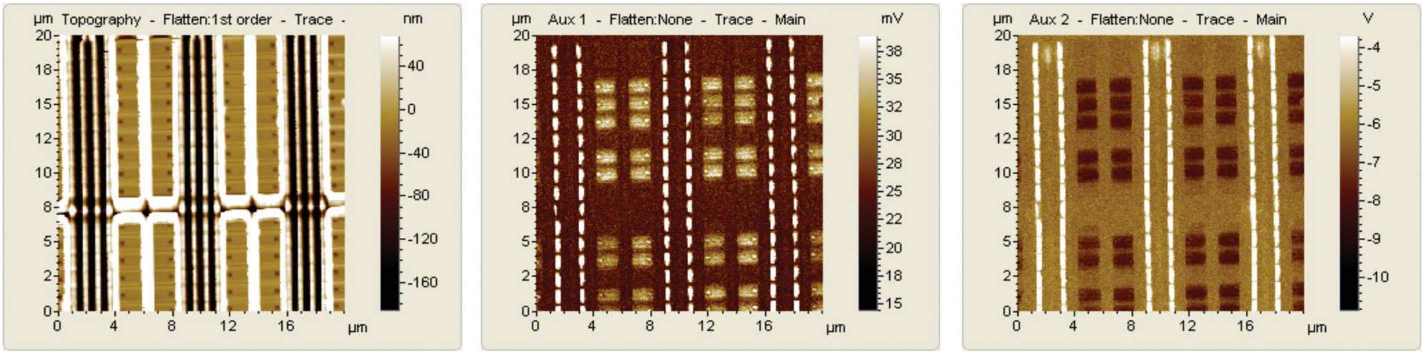


Figure 4. SMM imaging of EEPROM cells at positive and negative DC bias.

an atomic force microscope. SMM outperforms the traditional AFM scanning capacitance mode (SCM) by offering both calibrated as well as quantitative results with the highest sensitivity and dynamic range.

SMM mode is particularly suited 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 semiconductor types and does not require a uniform oxide layer.

SMM mode works well on semiconductors, glasses, polymers, ceramics, and metals. Additionally, the technique enables 5600LS users perform high-sensitivity investigations of ferroelectric, dielectric, and piezoelectric materials. Studies of organic films, membranes, and biological samples can also benefit from SMM mode imaging and analysis.

Scanners

Each of Keysight's unique top-down scanners utilizes interchangeable nose cones that enable users to switch imaging modes quickly and conveniently. To deliver high-resolution imaging results, a patented pendulum scanner design eliminates artifacts in the image by keeping the relative position of the laser spot fixed in relation to the cantilever throughout the scan cycle. The open-top design of these scanners allows an unobstructed optical view of the cantilever and sample without sacrificing sample handling. A variety of robust, easy-to-use sample plates are offered in order to facilitate experiments in air, in liquid, or with electrochemistry.

The optional Keysight STM scanner is purpose built to deliver uncompromising STM mode imaging for the discerning user. The scanner is optimized to provide stable imaging at pico-ampere and lower currents to easily achieve imaging of individual atoms and molecules, using the extreme sensitivity of probe distance on the tunneling current. Keysight has consistently delivered the highest resolution images in STM of all the commercially available systems.

Temperature Control

The 5600LS is compatible with Keysight's industry-leading temperature control options. A patented thermal insulation and compensation design enables precise temperature control with excellent stability (±0.1°C or ±0.025°C; from 4°C to 250°C) for high-resolution AFM imaging.

Software

The 5600LS utilizes Keysight's PicoView imaging and analysis software package to let users precisely program the system's stage and perform simple point-and-shoot AFM imaging of an area of interest based on an optical view. Keysight PicoScript is an optional scripting interface package that greatly enhances the capabilities of PicoView. Scripts can be written to automate tasks and create custom experiments. The built in plug-in architecture in PicoView provides unparalleled flexibility for force distance and force volume measurements.

For post-processing data capabilities, Keysight’s easy-to-use Pico Image 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 created on the 5600LS. The analyses are displayed in a “document” that consists of a series 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.

Additional capabilities to address advanced analytical needs can be added with the optional “advanced” and “expert” version. Pico Image is a world-class analysis solution.

AFM Instrumentation from Keysight Technologies

Keysight 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. Keysight’s leading-edge R&D laboratories are dedicated to the timely introduction and optimization of innovative and easy-to-use AFM technologies.

www.keysight.com/find/afm

Specifications

Large multi-purpose scanner	
Scanning range	90µm x 90µm
Z range	8µm
Vertical noise	0.5Å RMS

Small scanner	
Scanning range	8µm x 8µm
Z range	2µm
Vertical noise	< 0.2Å RMS

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

Programmable stage	
Sample size	200mm, 300mm*, 2 inch (52mm) 12 position wafer chuck
Sample thickness	30mm
Repeatability	<500nm accuracy and 500nm bidirectional repeatability
Vacuum chuck	200mm standard
Sample adaptor	For small samples, imaging in liquids

Optics	
Built-in video	2M pixel resolution; 2.5µm optical resolution,top down view, allows point and shoot navigation
Vibration isolation	Active

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

Facilities specifications	
Acoustic noise	< 75dBc
Temperature variation	Does not exceed ± 2°F
Humidity variation	Does not exceed ± 20% RH

* By rotating stage and custom chuck, approx. ¼ of a 300mm wafer can be addressed.

For more information on Keysight Technologies’ products, applications or services, please contact your local Keysight office. The complete list is available at:
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