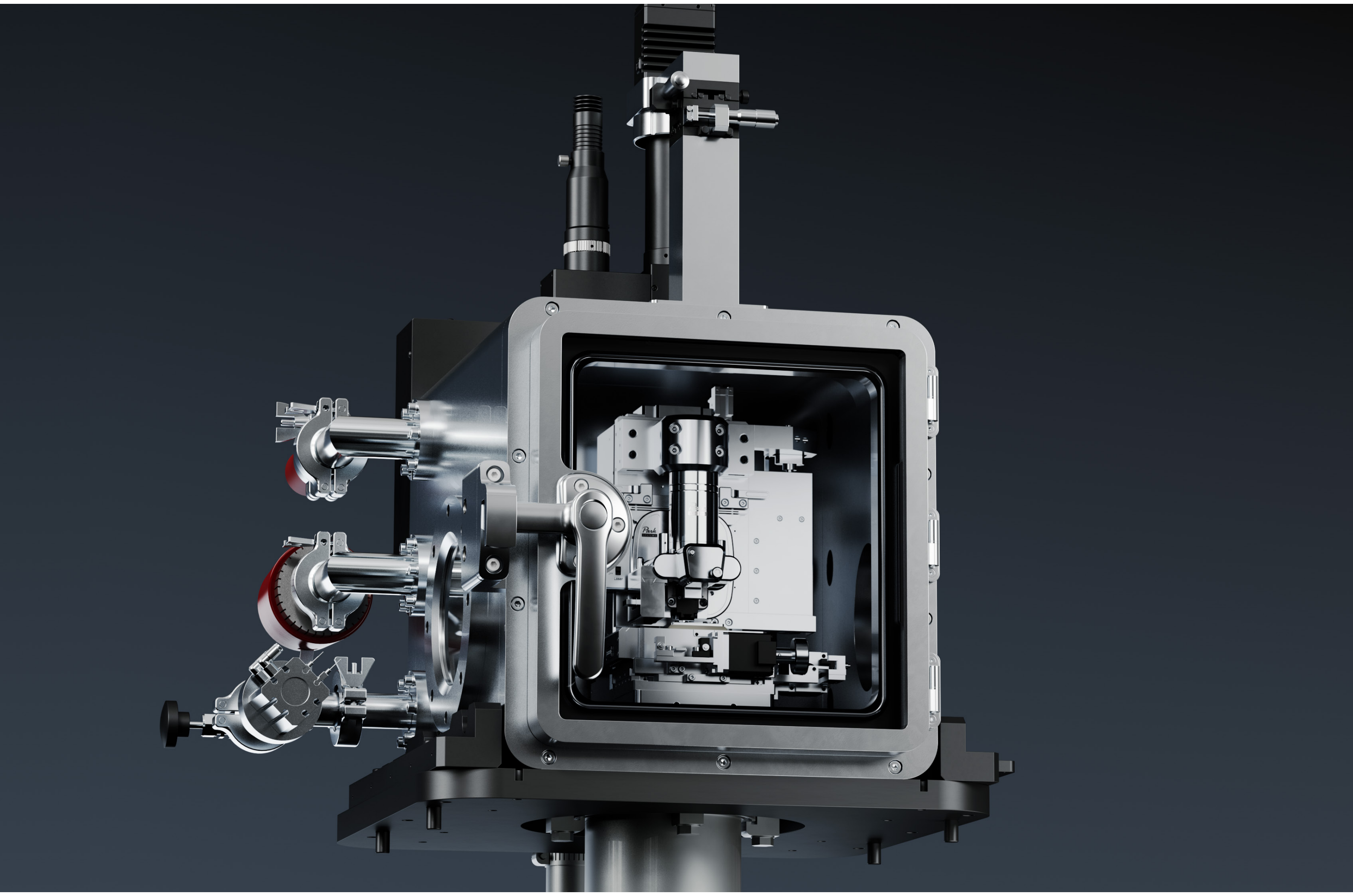
Park NX-Hivac

The Ideal Choice for Failure Analysis and Air-Sensitive Materials Research



NX-Hivac is a high-vacuum atomic force microscope (AFM) engineered for advanced semiconductor and materials research, enabling precise nanoscale analysis of air-sensitive samples. By providing clean and stable measurement conditions, NX-Hivac has established itself as a trusted platform in both academic and industrial laboratories.

At the core of NX-Hivac are Park's proprietary orthogonal scan system and True Non-contact™ mode, enhanced by high-vacuum capability. Together, these technologies protect delicate samples and enable accurate characterization of topographical, mechanical, and electrical properties that are not achievable under ambient or dry nitrogen (N_2) conditions.

From semiconductor devices to air-sensitive materials, NX-Hivac delivers consistent performance and reliable results. With support for advanced modes and features such as automated vacuum control, it offers researchers a comprehensive solution for high-vacuum AFM studies.

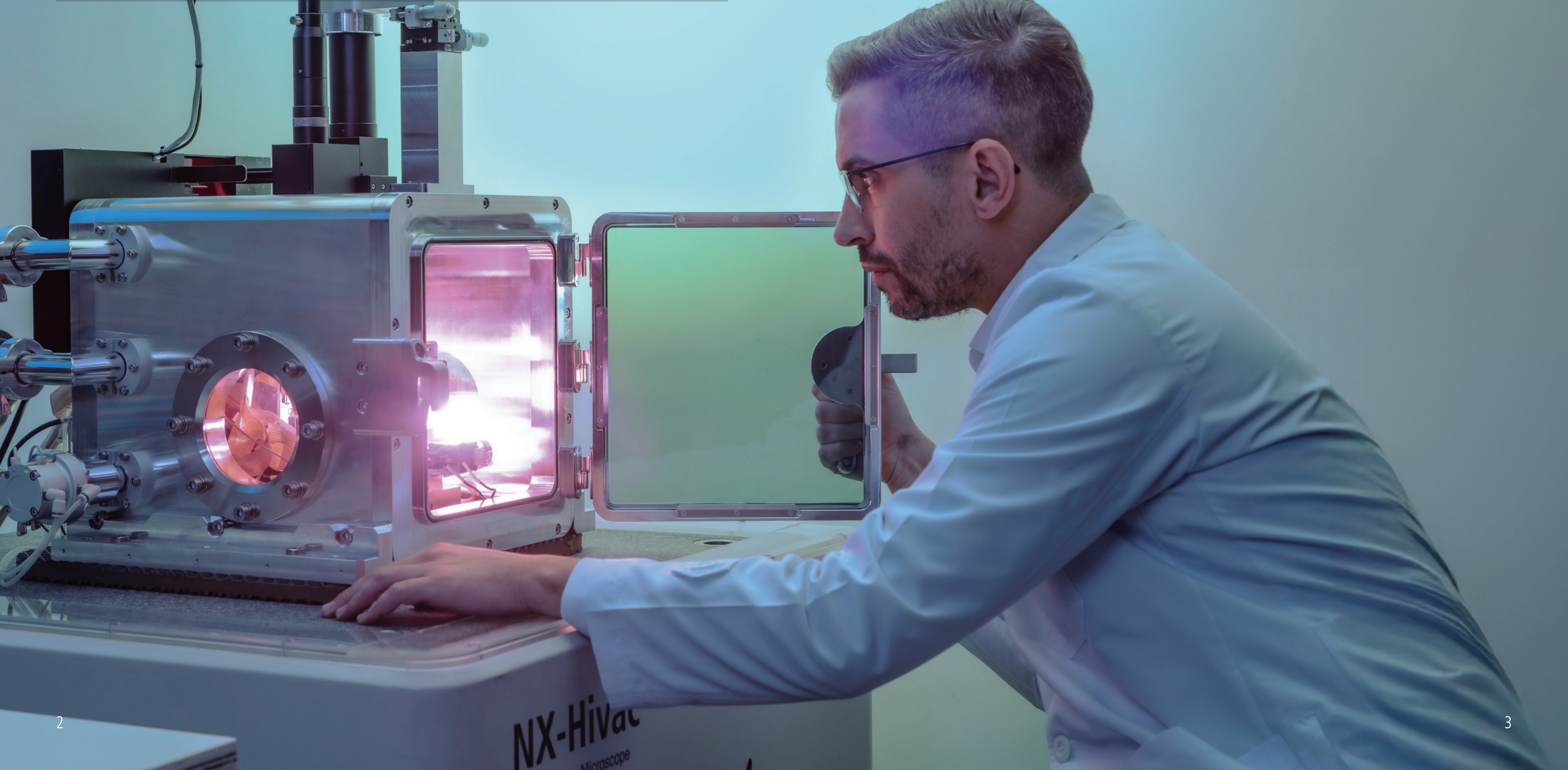
NX-Hivac – Key Features

High-Vacuum AFM Capabilities

- Stable High-Vacuum Environment
- Air-Sensitive Material Property Analysis
- Motorized Photodetector (A–B) Alignment
- Automated Vacuum Control
- Multi-Sample Loading without Breaking Vacuum

Outstanding AFM Performance

- True Non-Contact™ Mode
- Orthogonal Scan System
- Fast Z-Servo Speed
- Easy Probe Exchange
- Comprehensive Selection of AFM Modes



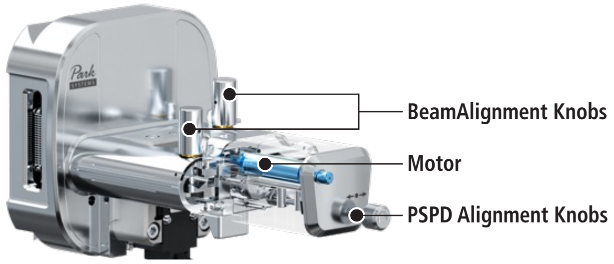
Park NX-Hivac
Specialized for Air-Sensitive Materials

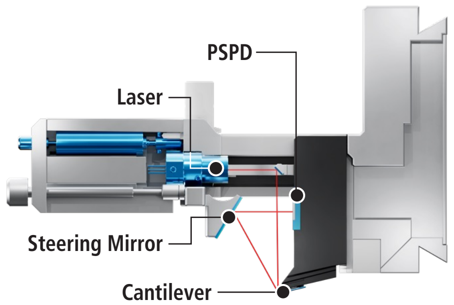
NX-Hivac High-Vacuum Control

NX-Hivac provides a high-vacuum environment for reliable nanoscale measurements.
By eliminating environmental interference, it enables advanced research beyond ambient or dry nitrogen (N_2) environments.
The chamber reaches a vacuum level of 10^{-5} Torr in less than five minutes, with an internal volume of 250 mm × 320 mm × 270 mm.

Motorized Photodetector (A–B) Alignment

The system employs a superluminescent diode (SLD) for low-coherence illumination, minimizing optical interference and enhancing image clarity. Precise beam positioning is achieved through direct X–Y control using beam and position-sensitive photodetector (PSPD) alignment knobs. For added convenience, the PSPD A–B axis alignment can be performed under vacuum without opening the chamber.

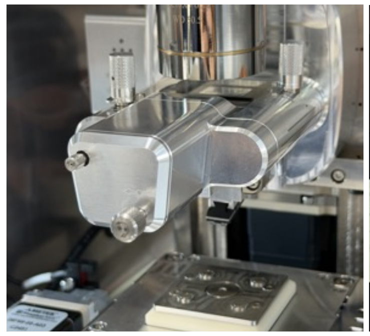




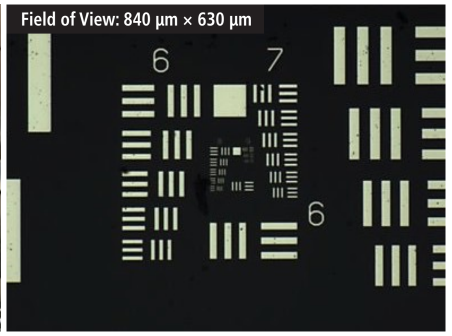
On-Axis Optical Microscope

The high-power on-axis optical microscope provides a clear view of the sample surface. A software-controlled LED light source illuminates the sample surface for better observation.

On-Axis Optical Microscope



Vision from NX Optics

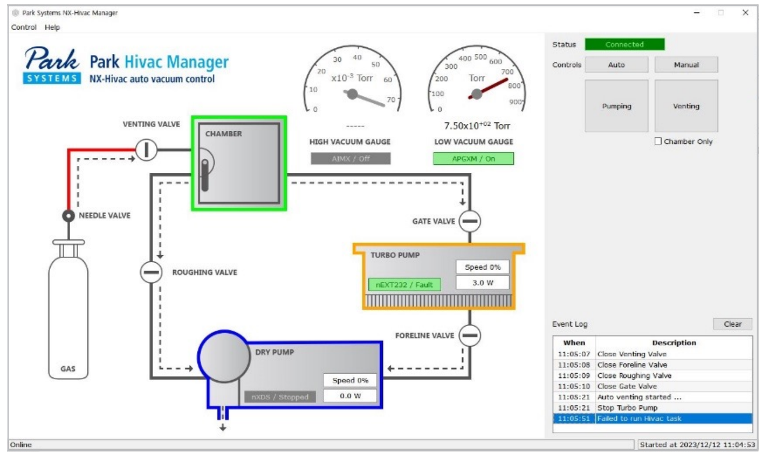


Low-Outgassing Chamber Materials

NX-Hivac chamber is constructed from materials optimized to minimize outgassing under high-vacuum conditions. This design reduces pump-down time and helps maintain a stable vacuum environment, ensuring consistent and reliable measurement performance.

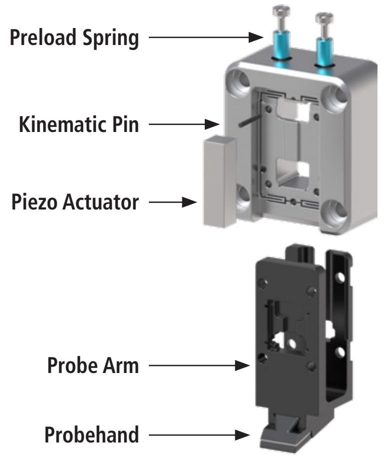
Hivac Manager

Park Hivac Manager streamlines vacuum operation into a fast and effortless process with one-click pumping and venting. The software clearly visualizes each step of the sequence and automates the workflow, reducing operator workload and improving overall efficiency.

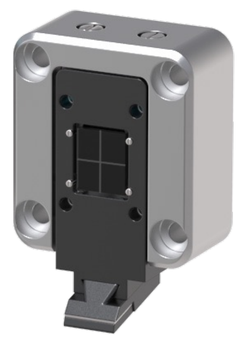


Improved Z Scan Straightness

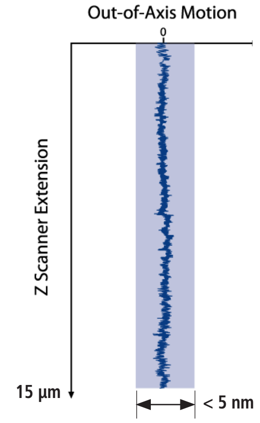
Park NX series Z scanner maintains straightness within 0.1% across the usable range, with out-of-axis motion under 5 nm even at a full 15 µm extension. Its compact assembly, combining a preload spring, kinematic pin, and piezo actuator, minimizes drift and ensures accurate vertical motion for reliable, distortion-free nanoscale measurements.



Z Scanner Assembly



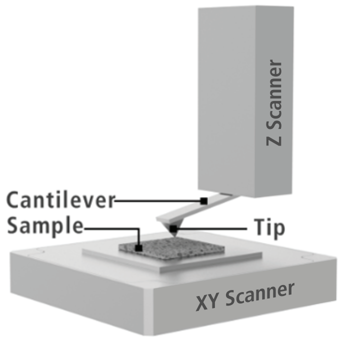
Out-of-Axis Motion



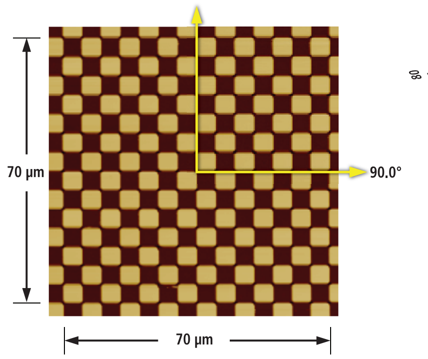
Park AFM Technology

Orthogonal Scan

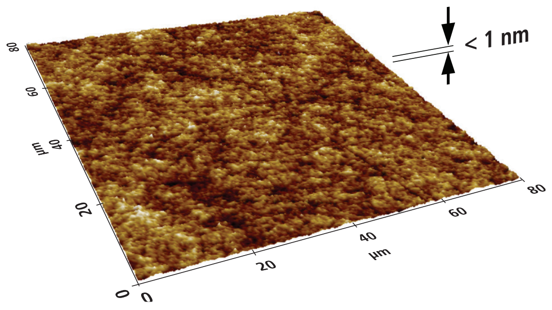
Conventional AFMs with tube scanners suffer from out-of-plane motion and axes crosstalk, resulting in image distortion, especially over large scan areas. NX-Hivac, like all Park AFMs, employs an advanced orthogonal scan system featuring a flexure-guided architecture: a 2D flexure scanner moves the sample in the XY plane, while a separate 1D flexure scanner independently controls the probe's Z-axis motion. Equipped with low-noise optical sensors for XY feedback and an ultra-low-noise strain gauge sensor for Z control, this separated scanner system ensures highly orthogonal, linear scans with minimal out-of-plane motion and fast dynamic performance.



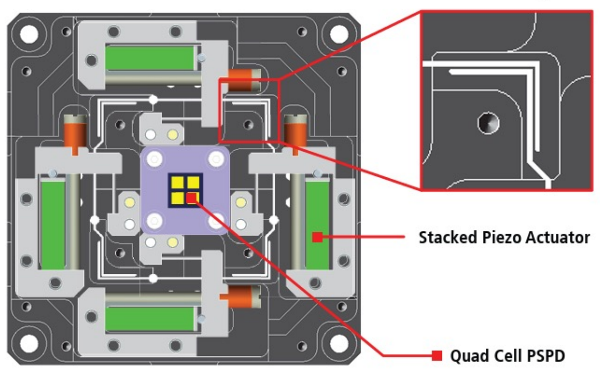
10 µm Pitch Calibration Grating



Optical Flat (80 × 80 µm)



Inside View of XY Scanner

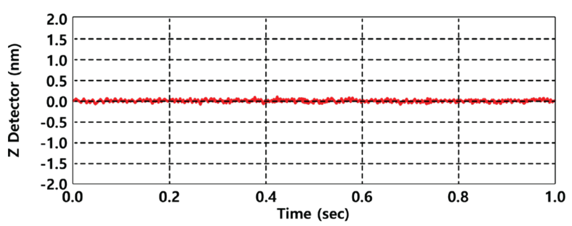


The XY scanner is designed to achieve flat, purely horizontal motion without vertical interference by using stacked piezo actuators and flexure hinge structures. A position sensor is located at the center of the scanner to provide direct feedback for servo control, minimizing positioning errors across the scan area. This design ensures consistent accuracy and stability, even when scanning large samples.

Low Z Detector Noise

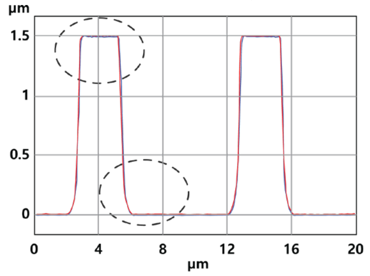
The Z detector has a noise level of less than 0.02 nm, enabling height measurements with sub-nanometer accuracy, down to 0.1 nm. Unlike conventional Z voltage mapping, which often overshoots at stiff walls, the Z detector provides precise, conformal surface tracing.

Z Detector Noise

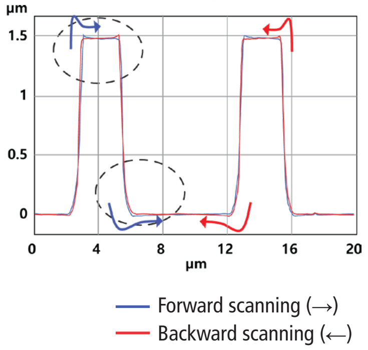


0.02 nm (rms), 1 kHz BW

Z Detector (Height)

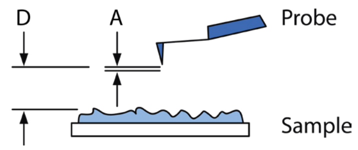


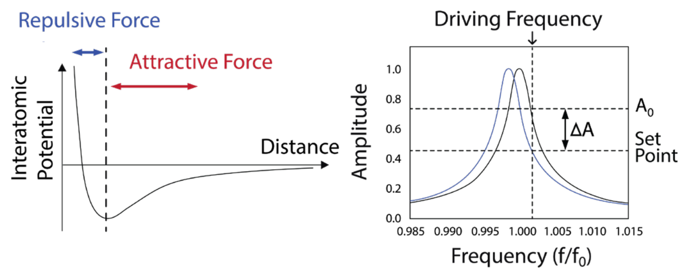
Z Voltage



True Non-Contact™ Mode

NX-Hivac features True Non-contact™ mode, a proprietary technology exclusively offered by Park Systems. True Non-contact mode obtains topography by detecting the attractive van der Waals force between the AFM tip and the sample surface.



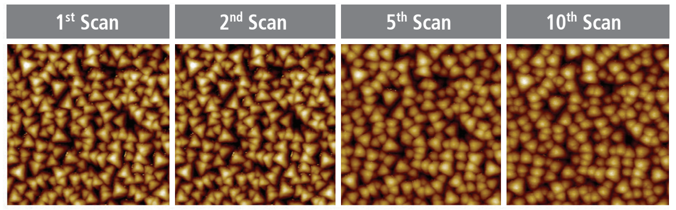


In True Non-contact mode, the tip oscillates at a frequency slightly higher than its resonance frequency, where the amplitude-frequency curve has its steepest slope.

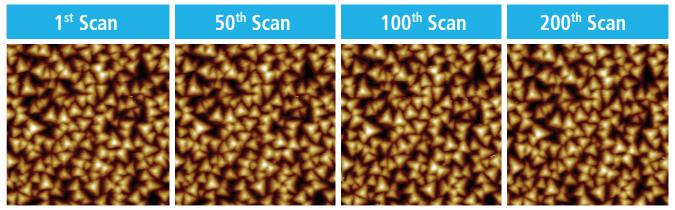
As the tip approaches the sample, the attractive force causes a downshift in the effective resonance frequency, leading to a decrease in oscillation amplitude at the driving frequency. The Z-servo maintains this new amplitude as the set point, keeping a constant tip-sample interaction while the tip scans in the XY direction.

An important advantage of True Non-contact mode, compared to tapping mode, is the prevention of tip wear and sample damage. The results of repetitive scans on a chromium nitride (CrN) tip-checking sample show that while the tapping mode image became blurry after just a few scans due to tip wear, the True Non-contact mode image remained sharp even after 200 scans.

Tapping Mode



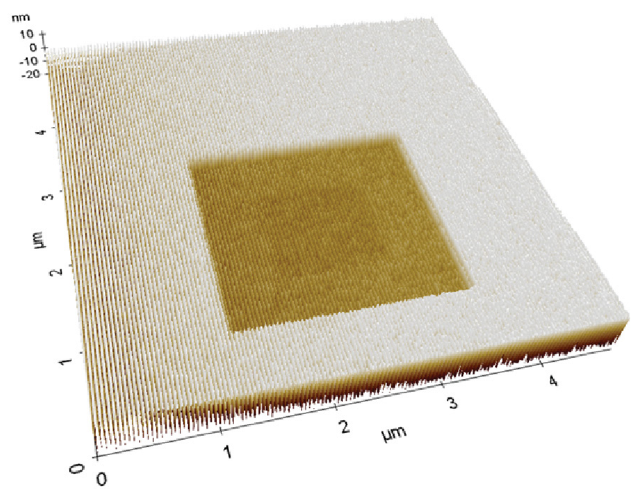
True Non-Contact Mode



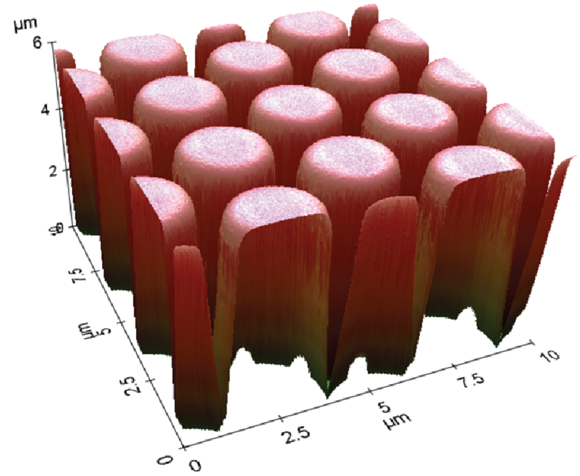
True Non-contact mode can measure soft and sticky samples as well as the most delicate and brittle samples, which cannot be imaged with tapping mode AFM. The image below is the topography of an unbaked photoresist acquired with True Non-contact mode, showing damages induced by electron beam irradiation during SEM scanning.

True Non-contact mode can also scan tall features. By sensing attractive forces not only at the apex of the tip but also along its sides, the Z-servo quickly retracts the tip as it approaches vertical features. With True Non-contact mode, deep holes and tall pillars like molds for nanoimprint can be measured, as in the image below.

Unbaked Photoresist



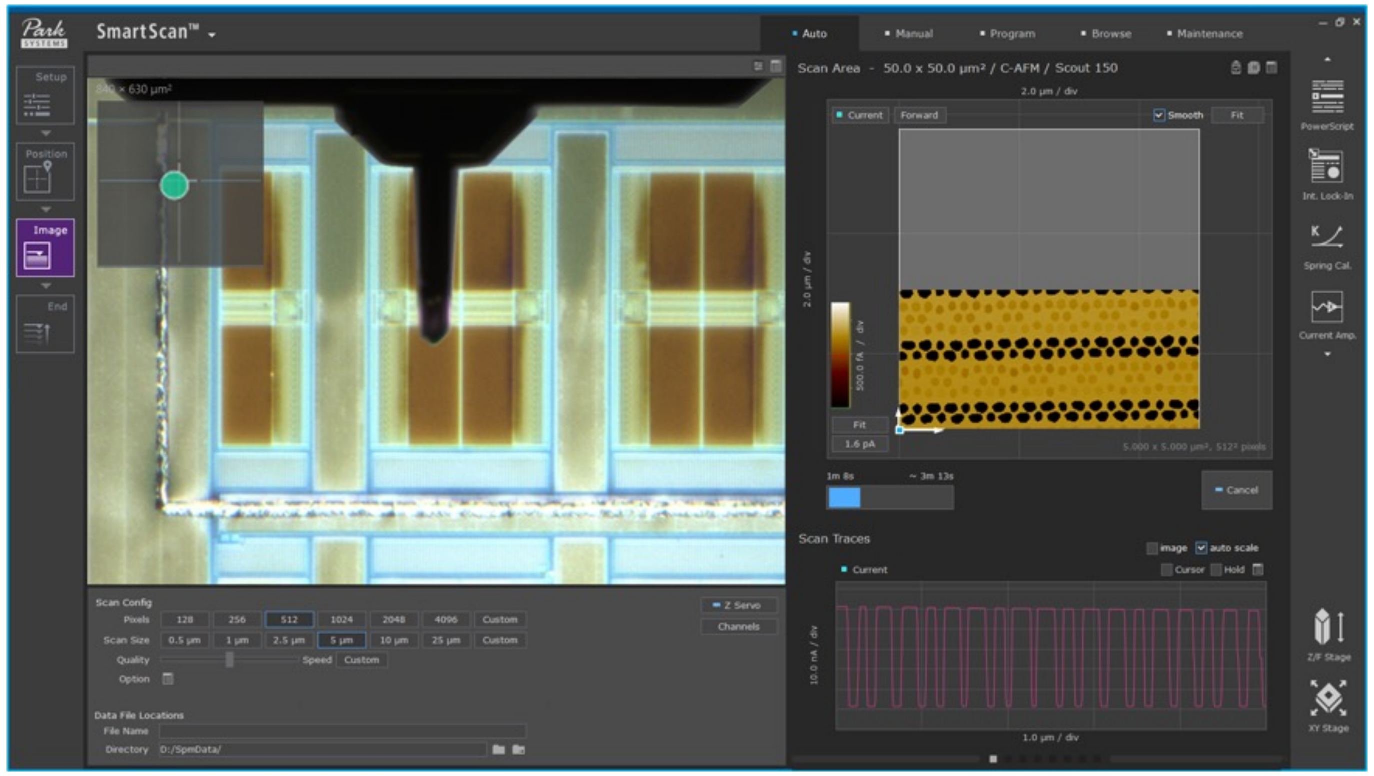
Mold for Nanoimprint



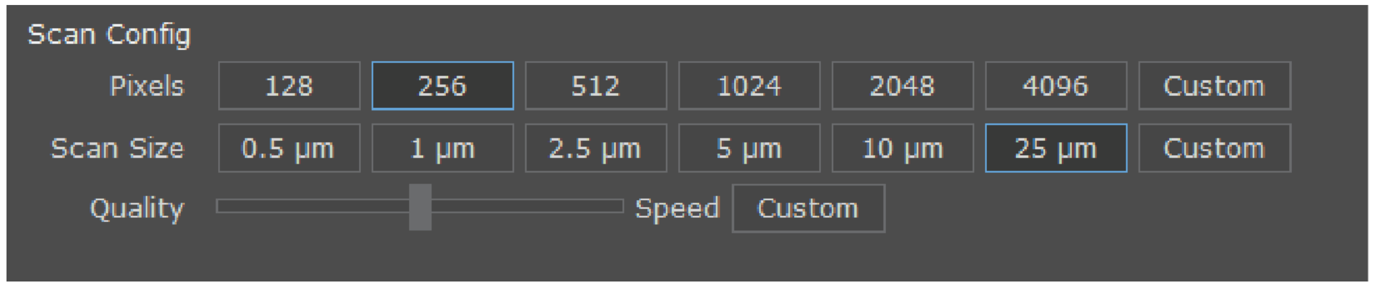
Park SmartScan™

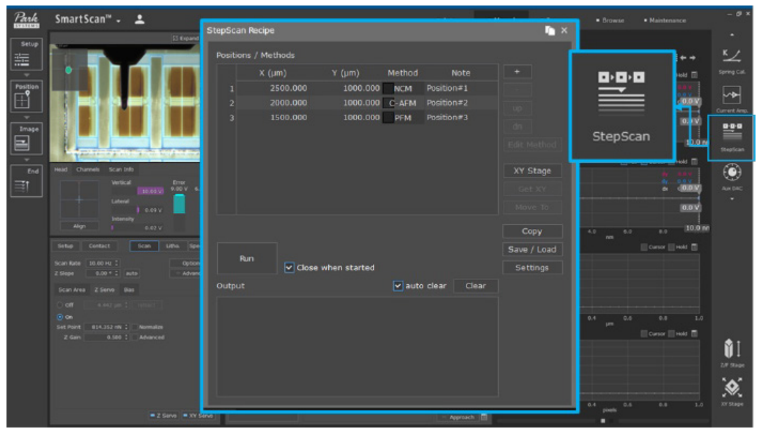
Bringing the Power and Versatility of AFM Technology to Everyone

NX-Hivac comes with Park SmartScan™, an advanced AFM operating software that simplifies image acquisition and enhances usability with its intuitive interface and powerful automation features.



In conventional AFM systems, users must manually adjust numerous parameters, such as Z servo gains, force set point, and XY scan speed, often through trial and error. SmartScan eliminates this complexity by allowing users to choose only three parameters: pixel density, scan size, and quality vs. speed preference. Then, all other settings are automatically optimized in real time by analyzing sample geometry and obtaining the best possible AFM images. SmartScan reduces the operational burden and makes high-quality imaging accessible to users of all experience levels.





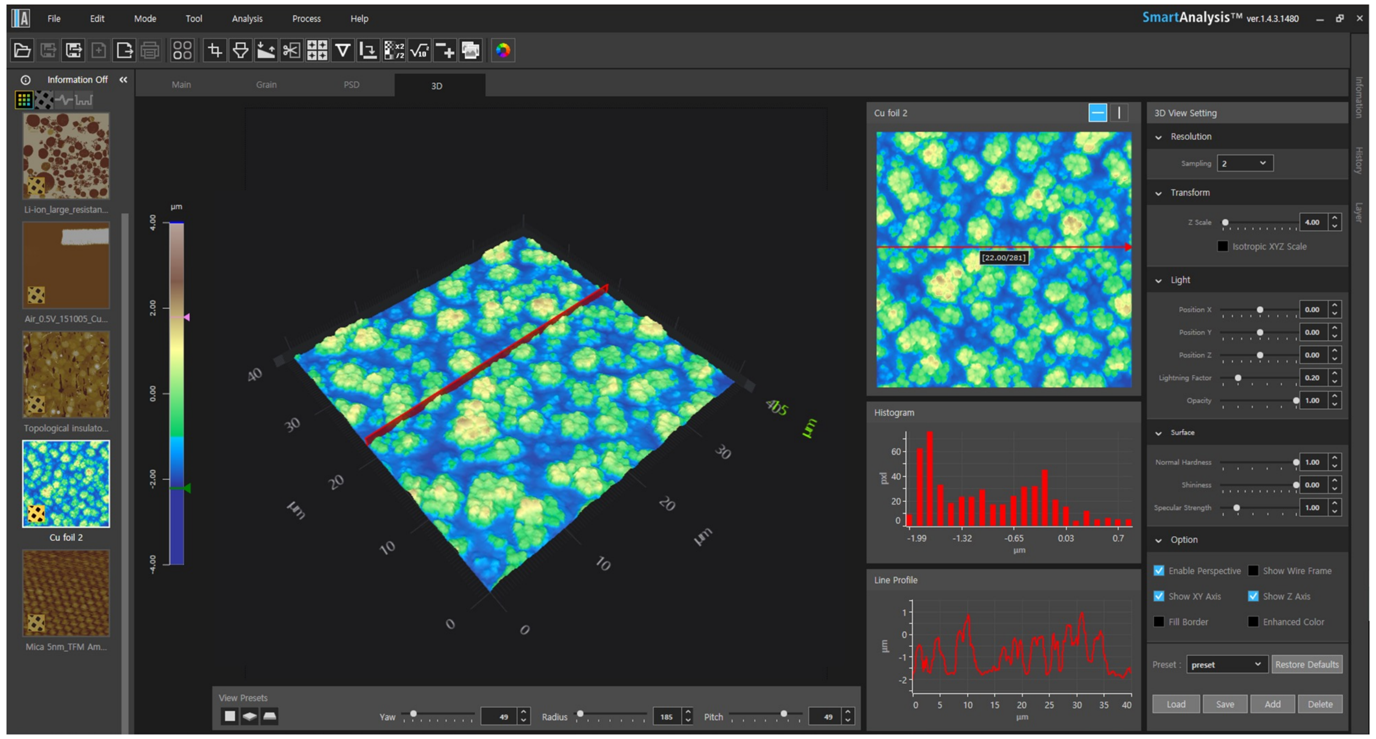
StepScan™

StepScan™ is an advanced Park SmartScan feature to pre-define measurement locations and recipes for efficient and consistent data acquisition.

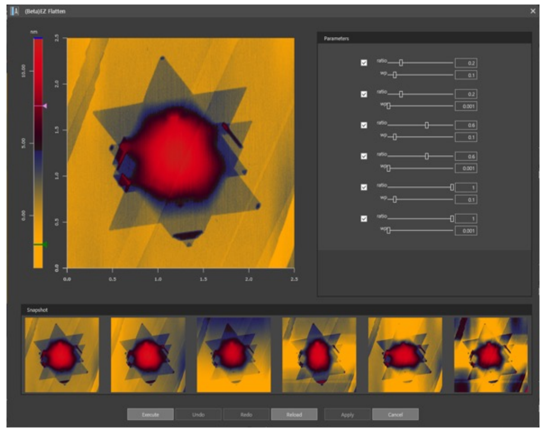
Park SmartAnalysis™

Streamlining AFM Data Workflow

Scan data from NX-Hivac can be analyzed with Park SmartAnalysis™, a powerful AFM image analysis software that enables fast image processing, comprehensive data analysis, and efficient result publication.



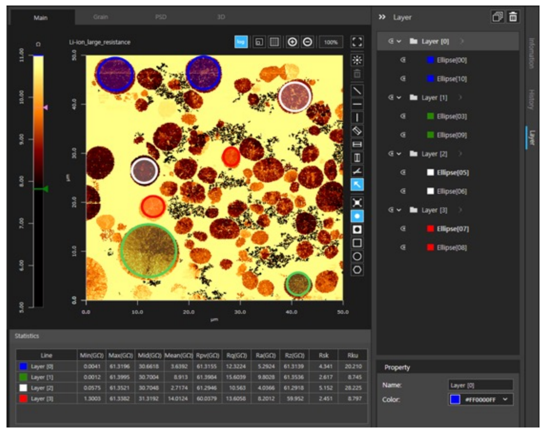
Graphene on HOPG Topography
Postprocessed with EZ Flatten



EZ Flatten

Postprocessing AFM data to correct artifacts such as noise, sample tilt, and surface irregularities is a manual, tedious, and time-consuming task. SmartAnalysis simplifies this process through the EZ Flatten function. With six automatically flattened results using different flattening parameter sets, users can choose the version that most accurately represents the data.

Lithium-ion battery electrode Resistance
Multiple Areas of Interest Assigned



Multilayer Analysis

Users can analyze and compare multiple areas of interest at once using a polygonal freeform area drawing tool. Unlike conventional AFM data analysis software that allows inspection of one region at a time, SmartAnalysis provides various metrics for all selected areas simultaneously.

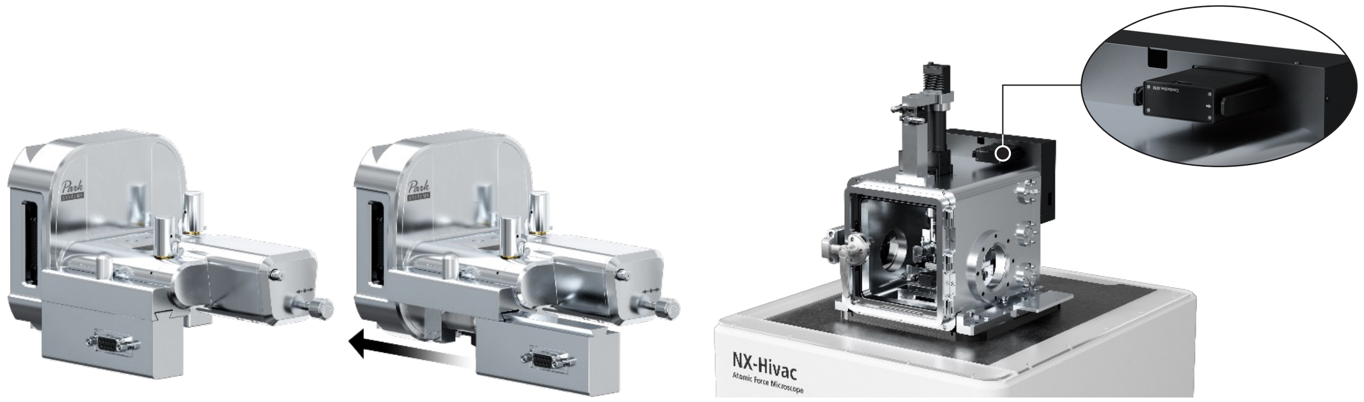
Park NX-Hivac
Additional Features

Broadest Range of AFM Modes and Options

NX controller integrates four built-in lock-in amplifiers, allowing advanced modes such as KPFM and PFM to be performed in a single scan instead of the conventional double-pass method. This significantly improves measurement efficiency. With the Head Extension Module (HEM), even more advanced capabilities become available, including Heterodyne KPFM and Contact Resonance PFM.

Easy Hardware Setup for Advanced Modes

NX AFM heads integrate seamlessly with Head Extension Modules (HEM), enabling a wide range of advanced imaging modes. Option modules plug directly into the expansion slot, simplifying setup for additional capabilities. Park NX series AFM features a modular design, ensuring compatibility with options across its product line.

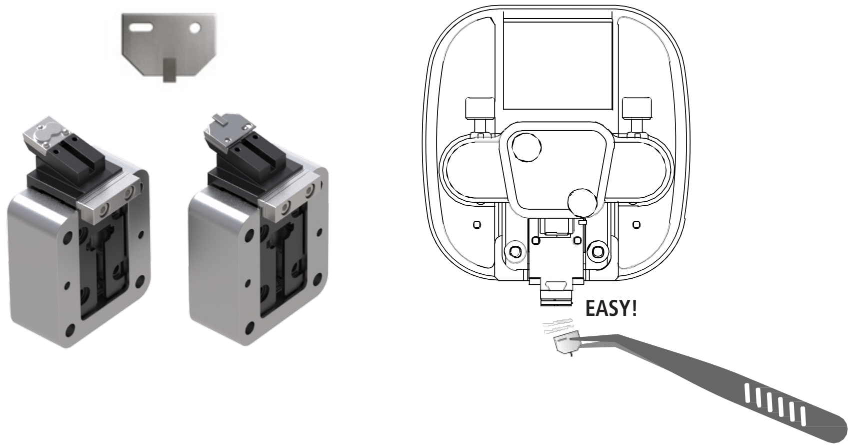


Pre-Mounted Probe

AFM probe exchange can be challenging, even for experienced users, often resulting in cantilever breakage. Park AFM addresses this by using pre-aligned probe chip carriers with kinematic mounting points, ensuring reliable and consistent tip positioning.

The NX head's Z scanner features three precision balls for kinematic mounting, complemented by magnets at the base to ensure a secure, reliable, and repeatable mounting position.

Probe Chip Carrier



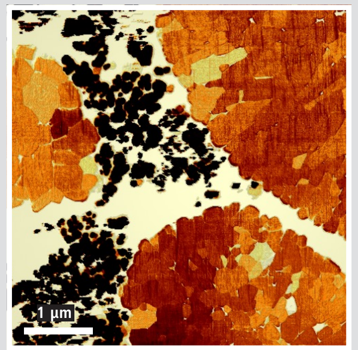
Multiple Sample Mount

NX-Hivac accommodates up to four coupon-sized samples, allowing efficient sequential measurements without breaking vacuum. Its magnetic mount enables quick and easy sample loading with metal disks, keeping samples securely attached for stable and reliable results across various sample types.

Park NX-Hivac
Designed for Your Applications

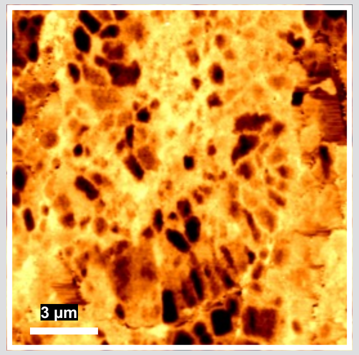
Park NX-Hivac offers precise measurements for air-sensitive samples, making it the ideal solution in research applications.

Energy & Advanced Materials



Lithium-Ion Battery Electrode

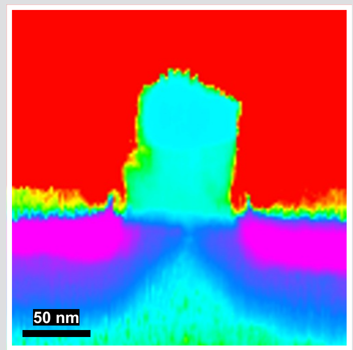
A lithium-ion battery electrode was analyzed using Scanning Spreading Resistance Microscopy (SSRM). The resistance image reveals clear contrast across the electrode surface, with a peak-to-valley difference of about 61.4 GΩ.



Nickel-Cobalt-Aluminum Oxide for Lithium-Ion Battery

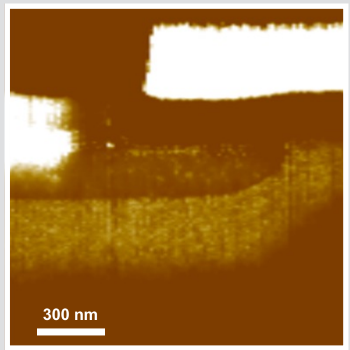
NCA, a widely used cathode material for lithium-ion batteries, was characterized using Kelvin Probe Force Microscopy (KPFM). The work function was measured with a mean value of 4.9 eV, consistent with reference values typically ranging from 4.8 to 5.0 eV.

Semiconductors & Devices

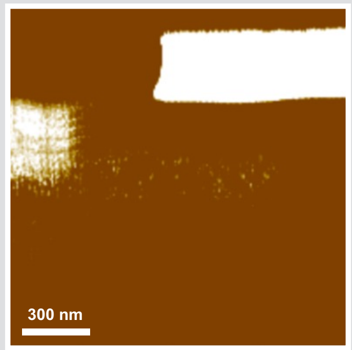


DRAM

A DRAM test structure with a 68 nm channel was characterized using Scanning Spreading Resistance Microscopy (SSRM). The resistance image reveals nanoscale contrast across the channel region, with a peak-to-valley difference of about 27.5 GΩ.



Current in Vacuum condition

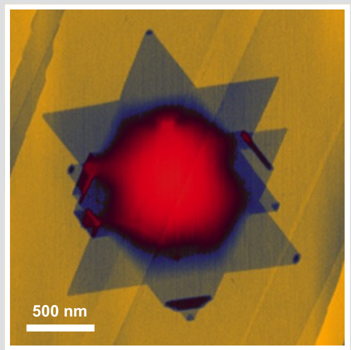


Current in Ambient condition

SiC MOSFET

A SiC MOSFET was characterized using Scanning Spreading Resistance Microscopy (SSRM). The current images measured under vacuum (left) and ambient (right) conditions highlight the improved visualization of electrical properties achievable in vacuum.

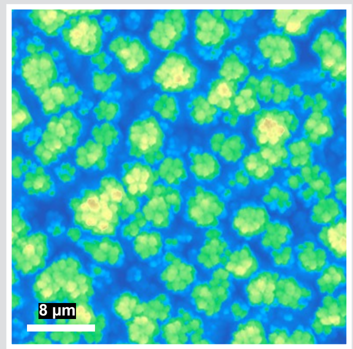
2D Materials



Graphene on HOPG

The graphene layer on HOPG was characterized in True Non-contact mode.
The image clearly shows the step morphology and layered structure of the graphene surface, with a peak-to-valley height of about 16 nm.

Metals



Copper Foil

The copper foil sample, fabricated using a hot embossing technique, was characterized in True Non-contact mode.
The scan image reveals a cauliflower-like surface topography with a peak-to-valley height of about 4.2 µm.

Park NX-Hivac
Technical Specifications

AFM Modes

- Topographic Imaging
  - Contact Mode
    - Constant Height Mode
    - Constant Force Mode
  - True Non-Contact™ Mode
  - Tapping Mode
  - PinPoint™ Mode
  - Fast PinPoint™ Mode
- Mechanical Properties
  - PinPoint™ Nanomechanical Mode
  - Fast PinPoint™ Nanomechanical Mode *
  - Force-Distance (F-D) Spectroscopy
  - Nanoindentation
  - Force Modulation Microscopy (FMM)
  - Dynamic Mechanical Analysis (DMA) *
  - Torsional Force Microscopy (TFM) *
  - Lateral Force Microscopy (LFM)
- Electrical Properties
  - Conductive AFM (C-AFM) *
    - Current-Voltage (I-V) Spectroscopy
  - Scanning Spreading Resistance Microscopy (SSRM) *
  - Scanning Tunneling Microscopy (STM) *
  - Scanning Capacitance Microscopy (SCM) *
  - Piezoresponse Force Microscopy (PFM)
    - Piezoresponse Spectroscopy
    - Off-resonance PFM
    - Contact Resonance PFM (CR-PFM) *
    - Dual Frequency Resonance Tracking PFM (DFRT-PFM) *
  - PinPoint™ Nanoelectrical Modes *
  - Electrostatic Force Microscopy (EFM)
  - Kelvin Probe Force Microscopy (KPFM)
    - Heterodyne KPFM *
    - Sideband KPFM
    - Amplitude Modulation KPFM (AM-KPFM)
  - Microwave Impedance Microscopy (MIM) **
- Magnetic Properties
  - Magnetic Force Microscopy (MFM)
    - Frequency Modulation MFM (FM-MFM)
    - Amplitude Modulation MFM (AM-MFM)
  - Thermal Properties
  - Scanning Thermal Microscopy (SThM) *
    - Temperature Mapping
    - Thermal Conductivity Mapping
- Nanolithography & Manipulation
  - Nanolithography *
  - Nanomachining *

Scanner
- XY scanner (50 µm × 50 µm or 100 µm × 100 µm)
- Flexure-guided high-force Z scanner (15 µm or 30 µm)

Sample Mount
- Up to 4 small samples with magnetic sample chuck
- 10 mm × 10 mm (w × d), up to 20 mm thickness
- Up to 100 mm × 100 mm (w × d) w/o multi-sample chuck

Stage
- XY stage: 22 mm × 22 mm
- Z stage: 24 mm
- Focus stage: 11 mm

Dimension and Weight
- AE (w/ Vacuum Chamber): 800 mm × 950 mm × 1,240 mm
- Vacuum Chamber (Inner): 250 mm × 320 mm × 270 mm
- Desk: 1,410 mm × 810 mm × 740 mm
- Total weight: 450 kg (AFM Body + AE)

On-axis Optical Microscope
- Direct on-axis vision of sample surface and cantilever
- Field of view: 840 µm × 630 µm (w/ 10 × objective lens)
- CCD: 5 M Pixel

High Vacuum Control
- Vacuum Level: Typically, down to 10^{-5} Torr
- Pumping Speed: < 5 min to 10^{-5} Torr

Required Environment
- Required acoustic noise level: Below 65 dB
- Required floor vibration level: VC-D (6.25 µm/sec)
- Power: 1 kW (Maximum)

* Requires additional options
** Consult with Park Systems