



Atomic Force Microscopes

Park Systems

Nanotechnology Solutions Partner



XE-WAFER



Nanotechnology Solutions Partner



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XE-WAFER

Automated

Industrial AFM for In-line Wafer Inspection and Metrology.

Park Systems introduces the industry's lowest noise, fully automated industrial AFM, the XE-Wafer. The completely automated AFM system is designed for high resolution surface roughness, trench width, depth and angle measurements on 200 mm & 300 mm wafers with sub-nanometer precision in a 24/7 production environment. Our True Non-Contact Mode™ enables non-destructive measurements even on soft structures such as photoresist trench surfaces.

1 Artifact-Free Metrology by Crosstalk Elimination

- Unique decoupled XY scanning system provides a flat scanning stage
- Flat and linear XY scan removes artifacts from background curvature
- Accurate feature measurements with industry leading gauge statistics
- Superior tool to tool matching

2 True Non-Contact Mode™ Imaging

- Less tip wear for prolonged high-quality and high-resolution imaging
- Immunity from parameter-dependent results observed in tapping imaging
- 10 times or longer tip life for general purpose & defect imaging

3 Precision Nanometrology Measurements

- Surface roughness measurement below 1Å RMS roughness
- Provides the precision angle measurement accuracy of less than 0.1 degrees
- Low noise floor enables surface flatness measurements for long range CMP metrology

4 High-Throughput Inline Automation

- Automatic data acquisition and analysis of angles, roughness, and trench features
- Cleanroom compatible with remote control (SECS/GEM) interface
- Automatic tip exchange (optional)
- Equipment Front End Module (EFEM) for automatic wafer handling (optional)
- Long range traveling stage for CMP profiling (optional)

5 Nanotechnology Solutions Partner

- Trusted partnership with customers to meet fast their changing requirements
- Application specific solutions that maximize throughput
- Modular software and hardware platform enable flexible application development



PROBLEMS

Process engineers in the hard disk and semiconductor industries currently use costly FIB/SEM instrumentation to acquire roughness, side-wall angle, and height measurements in nanoscale dimensions. Unfortunately, FIB/SEM is destructive, slow, and has a high cost per measurement.

PARK SYSTEMS SOLUTION

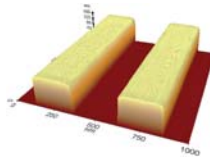
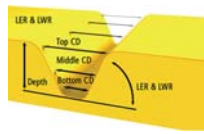
The XE-Wafer is a fully automated industrial AFM that can acquire surface roughness, depth, and angle measurements on 200 mm & 300 mm wafers with speed, precision, and value in a production environment.

BENEFIT

The XE-WAFER offers a non-destructive, in-line imaging tool capable of providing high resolution, direct, and repeatable measurements on multiple locations without damaging the sample. The increased precision and ability to monitor line-width roughness will lead allow process engineers to produce devices with higher performance, at a significantly lower cost than FIB/SEM.



APPLICATION

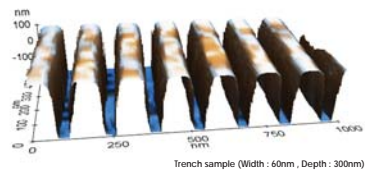
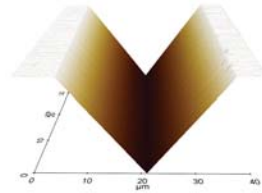


CD Measurements

Superior accuracy and precision nanometrology increases yield while delivering the highest resolution and the lowest gauge sigma value for repeatability and reproducibility.

Critical Angle Measurements

High precision calibration of Z-scan orthogonality provides the angle measurement accuracy of less than 0.1 degrees.



Trench sample (Width : 60nm, Depth : 300nm)

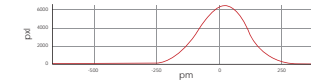
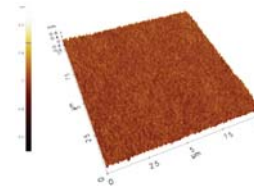
Trench Measurements

Unique True Non-Contact mode™ enables nondestructive in-line measurement of etch features as small as 45nm.



High Precision CMP Profile Measurement

A combination of low system noise with a very flat profiling capability, Park Systems provides an unprecedented CMP profiling application for the wafer manufacturing industry.



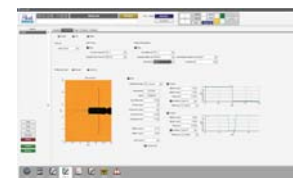
Sub-Nano Roughness Measurements of Substrates & Media

Industry's lowest system noise, combined with the innovative True Non-Contact Mode™, the most accurate roughness measurement can be obtained for the flattest of the substrate and media samples details of the defect.

FEATURES

Fully Automated Pattern Recognition

Utilizing a powerful combination of high resolution digital CCD camera and pattern recognition software, a fully automated pattern recognition and alignment is made possible for user applications.



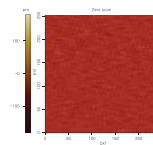
Automatic Measurement Control

Automated software makes the XE-WAFER operation effortless. Measurement recipes provide multi-site analysis with optimized settings for cantilever tuning, scan rate, gain, and set point parameters.

Industry's Lowest Noise Floor

To detect the smallest sample features and image the flattest surfaces, Park Systems has engineered instruments which hold the industry's lowest noise floor specification of < 0.5Å. Noise floor data is determined using a "zero scan". With the cantilever in contact with the sample surface, the system noise is measured at a single point under the following conditions:

- 0 nm x 0 nm scan, staying in one point
- 0.5 gain, in contact mode
- 256 x 256 pixels

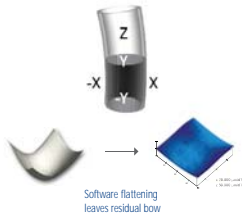


Typically 0.3 Å rms or lower

Region	Mid(μm)	Mean(μm)	Rpzi(μm)	Rqzi(μm)	Ra(μm)
Red	0.000	-0.011	359.496	30.025	15.177

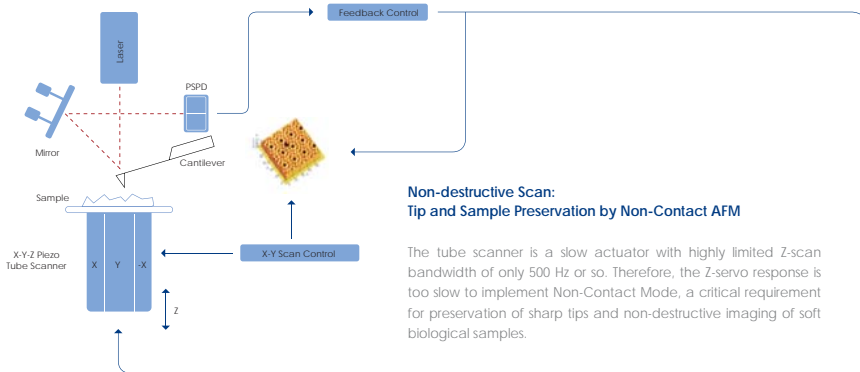
CROSSTALK ELIMINATION (XE)

Challenges of Accurate AFM Measurement



Artifact Free Imaging: Flat XY Scan Without Scanner Bowing

The conventional AFM uses a piezoelectric tube for the x-y-z scanner, where x-y motion relies on the bending of the tube. The bending motion, however, introduces background curvature and therefore causes z position errors. Conventional systems regularly use software flattening to hide the background curvature: this can be an impossible task since the amount of curvature depends not only on scan size and scan speed, but also on x-y offset, z position, etc. Therefore, even after software flattening, a flat surface does not "look" flat as shown in the figure.

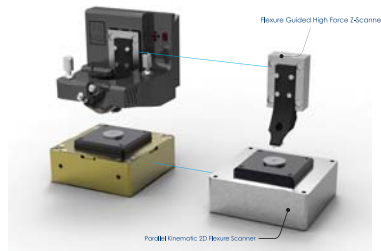


Non-destructive Scan: Tip and Sample Preservation by Non-Contact AFM

The tube scanner is a slow actuator with highly limited Z-scan bandwidth of only 500 Hz or so. Therefore, the Z-servo response is too slow to implement Non-Contact Mode, a critical requirement for preservation of sharp tips and non-destructive imaging of soft biological samples.

XE Technology: Park Systems' Answer to Accurate AFM Measurement

Challenges of accurate AFM measurement calls for a completely new approach in the design of an AFM. Park Systems developed the Crosstalk Eliminated (XE) AFM based on decoupled flexure scanners where the XY scanner only moves the sample and the Z Scanner drives the probe. The XE-AFM fundamentally removes the scanner bowing, hence attaining flat XY scan, and dramatically improves the Z-servo response, resulting in superb tip preservation by True Non-Contact Mode™.

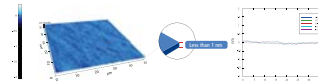


Mechanical Design	Features	Advantages
Decoupled XY and Z Scanners	XY scanner only moves the sample and the Z scanner drives the probe	Flat XY Scan Without Scanner Bow
2D XY Flexure Scanner	Minimal Z Runout (Out-of-plane Motion)	Highly Linear and Orthogonal XY Scan
High Force Z Scanner	Large Z Servo Bandwidth	Enabling True Non-Contact Mode™
Super Luminescent Diode (SLD)	Low Optical Coherence	Eliminates Optical Interference

ACCURATE AFM RESULTS BY CROSSTALK ELIMINATION (XE)

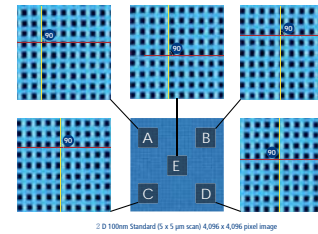
Artifact Free Imaging

- ✓ Low residual bow
- ✓ Results less dependent on scan location
- ✓ No need for software processing (raw data)
- ✓ Accurate height measurements and sample imaging



Flat XY Scan Without Scanner Bowing

The Crosstalk Elimination (XE) fundamentally removes the scanner bowing, hence attaining flat XY scan with out-of-plane motion less than 1 nm regardless of scan locations, scan rates, and scan sizes. It shows no background curvature even on scans of the flattest samples such as that of an optical flat as shown in the figure, also with various scan offsets. Thus, the XE-AFM enables very accurate height measurement and precision nanometrology for the most challenging problems in research and industry.



Highly Linear and Orthogonal XY Scan

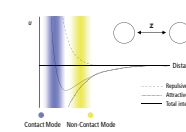
The flexure XY scanner decouples the X and Y scan motion so that the coupling between X and Y movement is minimized regardless of scan locations, scan rates, and scan sizes. Position sensors provide linear feedback control for the high accuracy and high precision measurements.

Non-destructive Scan

- ✓ Less tip wear for prolonged high-resolution imaging
- ✓ Immunity from parameter-dependent results
- ✓ Minimized sample damage or modification
- ✓ Imaging of soft sample surface

True Non-Contact Mode™ is Now a Reality

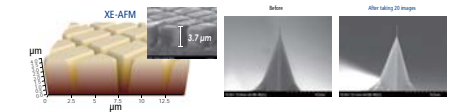
True Non-Contact Mode™, one of the distinctive advantages only realized by Park Systems' Crosstalk Eliminated (XE) AFM, is a powerful method that enables AFM users to image and measure samples.



In True Non-Contact Mode™, the tip-sample distance is successfully maintained at a few nanometers in the net attractive regime of inter-atomic force. The small amplitude of tip oscillation minimizes the tip-sample interaction, resulting in superb tip preservation and negligible sample modification.

Longer Tip Life and Less Sample Damage

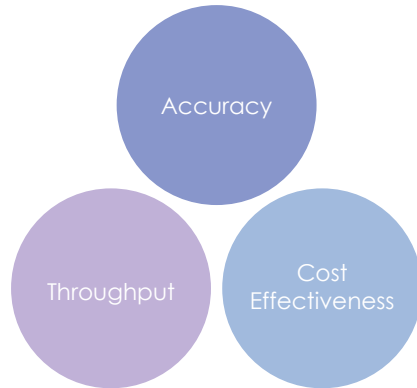
The sharp end of an AFM tip is so brittle that once it touches a sample, it becomes instantly blunt and limits the resolution of an AFM and reduces the quality of the image.



For softer samples, the tip will damage the sample and also result in inaccuracies of sample height measurements. Consequently, preserving tip integrity enables consistent high resolution and accurate data. True Non-Contact Mode™ of the XE-AFM superbly preserves the tip, resulting in much longer tip life and less sample damage. The figure, displayed in 1:1 aspect ratio, shows the unprocessed raw data image of a shallow trench isolation sample imaged by the XE-AFM, whose depth is also confirmed by scanning electron microscope (SEM). The same tip used in the imaging of the sample shows no tip wear even after taking 20 images.

Semiconductor

With its ability to accurately measure critical dimensions in the micrometer to nanometer regime, Atomic Force Microscope (AFM) is becoming the tool of choice for applications involving surface roughness, trench depth, and line width characterization of various samples features and materials.



Accuracy Like Never Before

Shrinking form factors are driving the need to design at the nanoscale level in the semiconductor markets. Traditional metrology tools have lacked the accuracy needed for nanoscale design and manufacturing. Park Systems has met this challenge in industrial metrology with enabling breakthroughs.

- Crosstalk Elimination (XE) enables artifact-free and non-destructive imaging
- New 3D AFM enables high resolution imaging of sidewall or undercut features

Throughput Like Never Before

AFMs that have enabled nanoscale design have traditionally not been fast enough for use in production quality control. All that has changed with Park Systems revolutionary gains in throughput enabling AFMs for use in automatic in-line manufacturing.

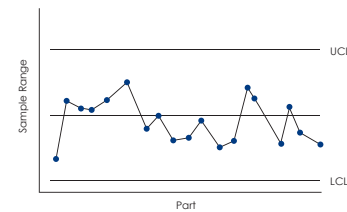
These include automatic tip exchange where our novel magnetic approach has a 99% success rate, higher than traditional vacuum techniques. Also, full access to raw data and a true partnership with customers are required for any process and throughput optimization.

Cost-Effectiveness Like Never Before

Accuracy and throughput in nanometrology must be delivered in a cost-effective solution to move successfully from research to inline manufacturing. Park Systems have met this cost challenge with industrial AFM solutions that address the need for faster, efficient automation and longer tip life.

We cut costs by replacing slower and expensive SEM with efficient, automatic, and affordable 3D AFM for industrial in-line manufacturing. To pinpoint defects in new designs, manufacturers today need 3D information to characterize trench profiles and sidewall feature variation. Modular AFM platform allows rapid software and hardware changes, enabling cost-effective upgrades and better optimization for the most complex and demanding measurements in production quality control.

Also, we lower the cost of ownership with at least 200% longer AFM tip life. The tapping forces of conventional AFMs cause faster tip wear, but our In True Non-Contact Mode™ AFMs maintain tip quality resulting in the lower total cost of ownership.

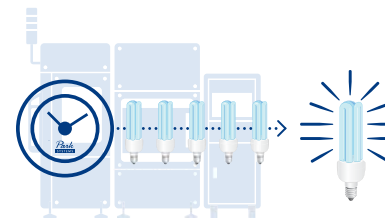
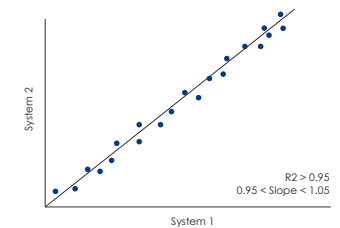


Gage Repeatability and Reproducibility

Due to the ever-decreasing size of components, manufacturers now require the highest level of quality control. Park Systems can provide 1 gage sigma (σ) of less than 1 Angstrom.

Correlation

Thanks to its revolutionary platform designed for industrial metrology, the XE-AFM will correlate with any existing Park industrial AFMs that have been previously used for manufacturing, inspection, analysis, or research.

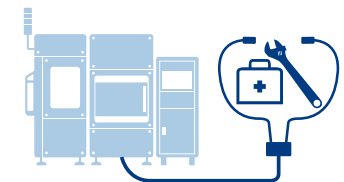


System Uptime

Our engineers and scientists adopted the most rigorous industry standard of product development to ensure the highest level of system reliability. The XE-WAFER can be seamlessly incorporated as either an inline or offline inspection tool with minimal maintenance requirements.

Service & Maintenance

Park Systems is committed to the highest level of service and support, and every effort is made to understand our industrial customers' needs. We place the utmost importance on meeting promised delivery dates, guaranteed quality, and faithful after-sales service.



Software & User Interface



XEA - Industrial Automation & Analysis

XEA is a system software for automation that carries out the AFM measurement of a sample following the preset procedure written in a recipe file. User-friendly XEA architecture provides flexibility to operator to perform various system-wide functions.

- Supports auto, semi-auto, and manual mode
- Editable measurement method for each automated procedure
- Live monitoring of the measurement process
- Automatic analysis of acquired measurement data



XEP - Data Acquisition

All the user controls on AFM measurements are operated through XEP, the data acquisition program. The user-oriented interface provides easy operation of AFM.

- Simultaneous data acquisition of up to 16 images
- Maximum 4096 x 4096 image size
- Dedicated Force-distance and I-V spectroscopy with batch processing
- Cantilever spring constant calibration
- Script-level control through external program (LabVIEW, C++)



XEI - Image Processing and Analysis

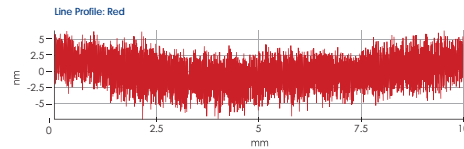
XEI is the AFM image processing and analysis program. The powerful processing algorithms make the analysis easy and streamlined. With its most advanced and versatile imaging features, XE users can obtain essential and critical information from their experiment.

- Image analysis of line profile, region, 3D rendering
- Spectroscopy data analysis module (F-d, I-V)
- Multiple image comparison
- Directly copy/paste to presentation program
- Image overlay of two different images

Options

Long Range Profiler

Less than ±5 nm out-of-plane motion over 10 mm scan.



Automatic Tip Exchange (ATX)

Automatic Tip Exchange performs fully automated tip exchanges in order to seamlessly continue automated measurement routines. It automatically calibrates cantilever location and optimizes measurement settings based on measurements of a reference pattern. Our novel magnetic approach to the tip exchange yields a 99% success rate, higher than the traditional vacuum techniques.

Automatic Wafer Handler (EFEM or FOUP)

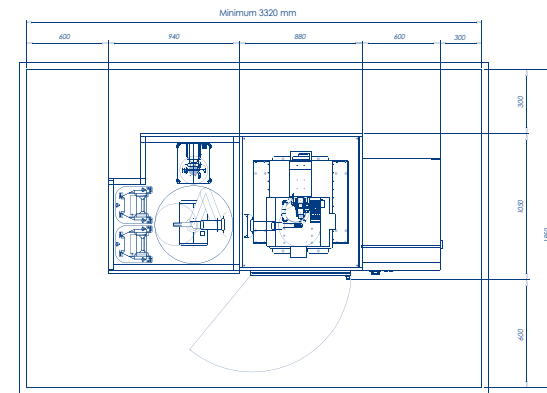
The XE-WAFER can be further customized by adding an automatic wafer handler (EFEM or FOUP or other). The high-precision, nondestructive wafer handler robot arm fully ensures XE-WAFER users to receive fast and reliable wafer measurement automation.



Ionization System

Ionization system effectively removes electrostatic charges. It ionizes the charged objects and is very reliable since the system always generates and maintains an ideal balance of positive and negative ions without causing any contamination to the surrounding area. It also reduces the accidental electrostatic built-in charge that may occur during sample handling.

Footprint



System Specification

200 mm Motorized XY stage:
travels up to 275 mm x 200 mm
0.5 µm resolution

300 mm Motorized XY stage:
travels up to ~375 mm x 300 mm
0.5 µm resolution
<1 µm repeatability

Motorized Z stage:
~30 mm Z travel distance
~0.08 µm resolution
<1 µm repeatability

Motorized Focus Stage:
11 mm Z travel distance for on-axis optics
Sample Thickness Allowance:
up to 20 mm

Full scan range Z run-out:
< 2 nm, repeatability <1 nm

COGNEX Pattern Recognition:
pattern align resolution of 1/4 pixel

Scanner Performances

XY Scanner Range:
100 µm x 100 µm (large mode)
50 µm x 50 µm (medium mode)
10 µm x 10 µm (small mode)

XY Scanner Resolution:
1.5 nm (high voltage mode)
<0.2 nm (low voltage mode)

Z Scanner Range:
12 µm (high voltage mode)
1.7 µm (low voltage mode)

Z Scanner Resolution:
< 0.2 nm

Z Scanner Noise Floor:
<0.05 nm (w/ Active Vibration Isolation System)

AFM and XY Stage Control Electronics

Controller Processing Unit:
600 MHz and 4800 MIPS
Signal ADC & DAC:
16-bit, 500 kHz bandwidth, internal lock-in

Vibration, Acoustic Noise, and ESD Performances

Control Cabinet:
800(w) x 800(d) x 1000(h)
160 kg approx. (incl. controllers)
600(w) x 800(d) x 2000(h) tower type
220 kg approx. (incl. controllers)

Wafer Handler (EFEM):
1270(w) x 1720(d) x 2024(h), 300 kg approx

System Floor Space:
1220(w) x 1200(d) w/o EFEM

System Floor Space:
2490(w) x 1720(d) w/ EFEM

Ceiling Height:
2000 or more

Operator Working Space:
4500(w) x 3120(d) (dimension unit: mm)

Dimension & Weight

200mm System:
880(w) x 1050(d) x 2024(h)
w/o EFEM, 800 kg approx. (incl. XE-WAFER main body)
1820(w) x 1050(d) x 2024(h)
w/ EFEM, 1010 kg approx. (incl. XE-WAFER main body)

Control Cabinet:
800(w) x 800(d) x 1000(h)
160 kg approx. (incl. controllers)
600(w) x 800(d) x 2000(h) tower type
220 kg approx. (incl. controllers)

System Floor Space:
1780(w) x 980(d) w/o EFEM

System Floor Space:
3050 (w) x 980 (d) w/ EFEM

Ceiling Height:
2000 or more

Operator Working Space:
3300(w) x 1950(d), minimum (dimension unit: mm)

300mm System:
1220(w) x 1200(d) x 2024(h)
w/o EFEM, 1150 kg approx. (incl. XE-3DM main body)
2490(w) x 1720(d) x 2024(h) w/ EFEM
1450 kg approx. (incl. XE-3DM main body)

Control Cabinet:
800(w) x 800(d) x 1000(h)
160 kg approx. (incl. controllers)
600(w) x 800(d) x 2000(h) tower type
220 kg approx. (incl. controllers)

Wafer Handler (EFEM):
1270(w) x 1720(d) x 2024(h), 300 kg approx

System Floor Space:
1220(w) x 1200(d) w/o EFEM

System Floor Space:
2490(w) x 1720(d) w/ EFEM

Ceiling Height:
2000 or more

Operator Working Space:
4500(w) x 3120(d) (dimension unit: mm)

Facility Requirements

Room Temperature (Stand By):
10 °C ~ 40 °C

Room Temperature (Operating):
18 °C ~ 24 °C

Humidity:
30% to 60% (not condensing)

Floor Vibration Level:
VC-E (3 µm/sec)

Acoustic Noise:
Below 65 dB

Pneumatics:
Vacuum: -80 kPa
CDA: 0.7 Mpa

Power Supply Rating:
208-240 V, single phase, 15 A (max)

Total Power Consumption:
2 KW (typical)

Ground Resistance:
Below 100 ohms