Atomic Force Microscopes

Park Systems

Nanotechnology Solutions Partner

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Atomic Force Microscopes
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XE-HDM
Decoupled XY & Z Scanners

Automatic Defect Review AFM for Hard Disk Media and Substrates

The XE-HDM is a general automated industrial XE-series AFM, with features specifically designed to address hard disk media, substrate analysis, and other industrial applications. With capabilities Automatic Defect Review (ADR) and Sub-nano Roughness Analysis, the XE-HDM combines the superb performance of the XE-series with the high throughput and high accuracy demanded by the hard disk media industry and beyond.

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™ and Longer Tip Life Reduces Cost of Ownership
   - 10 times or longer tip life for general purpose & defect imaging
   - Less tip wear for prolonged high-quality and high-resolution imaging
   - Minimized sample damage or modification
   - Immunity from parameter-dependent results observed in tapping imaging
3. Automatic Defect Review for Media and Substrates
   - Automated survey scan of defects mapped by optical inspection tools
   - Automated zoom-in scan of specified defects
   - Automated profiling of imaged defect types
   - Automated analysis of imaged defects
   - HGA fixture and sample tilting stage (optional)
4. Nanotechnology Solutions Partner
   - Trusted partnership with customers to meet the fast changing requirements
   - Application specific solutions that maximize throughput
   - Modular software and hardware platform enable rapid response

AUTOMATIC DEFECT REVIEW

PROBLEMS

For researchers working with in hard disk media and other flat substrates, the process of identifying nanoscale defects is time consuming with conventional tools, hindering throughput.

PARK SYSTEMS SOLUTION

Park Systems XE-HDM is an automatic defect review AFM that speeds and improves the way defects in HDD substrates and media are identified, scanned, and analyzed.

BENEFIT

The new XE-HDM significantly increases throughput for the defect review process; test runs with real defects demonstrate a 10x increase in throughput for defect review in an automated process when compared with more traditional methods of defect review.

SUB-NANO ROUGHNESS

PROBLEMS

Suppliers to the HDD industry are developing ultra-flat substrates to address the ever-increasing need for reduced slider flying height. However, there has never been a metrology tool capable of providing accurate and reliable measurements for the sub-nanoscale roughness of these substrates.

PARK SYSTEMS SOLUTION

By delivering the industry lowest noise floor (less than 0.5 A) and combining it with True Non-Contact Mode? the XE-HDM makes it possible to acquire consistent, repeatable, and reproducible sub-nanoscale roughness measurements.

BENEFIT

The XE-HDM makes it possible for the substrate & media manufacturers to monitor the flattest substrates being developed for the HDD industry.

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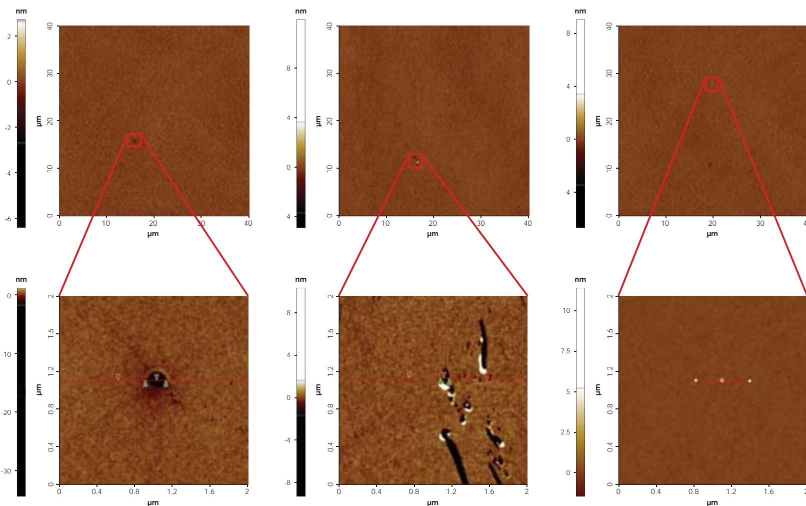
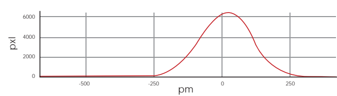
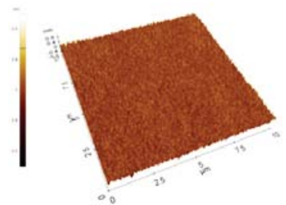
APPLICATION

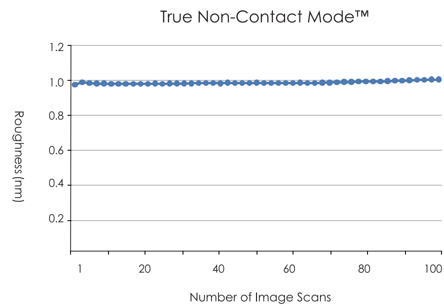


Automatic Defect Review for Substrates & Media

Using the defect location map provided from a Candela™ tool, the XE-HDM automatically goes to the defect location and images the defects in two steps: a larger, survey scan image to refine the location and then a smaller, zoom-in scan image to obtain the details of the defect.



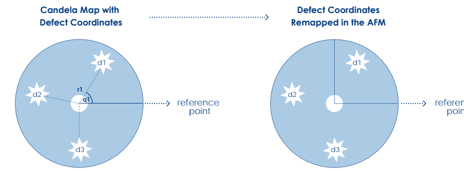




Sub-Nano Roughness Measurements of Substrates & Media

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

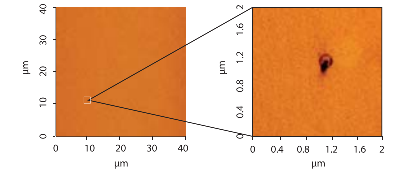


Transferring Candela™ Defect Maps to AFM

Utilizing a proprietary remapping technique, the defect map obtained from a KLA Tencor Candela™ tool can be accurately transferred to the AFM, allowing full automation for high throughput defect imaging.

Automated Search Scan & Zoom-in Scan

Optimized scan parameter allows for a two step scan: a fast, low resolution search scan to find the defect, and then a high resolution zoom-in scan to obtain defect details. Parameters of scan size and scan speed are adjustable to match user's needs.



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.

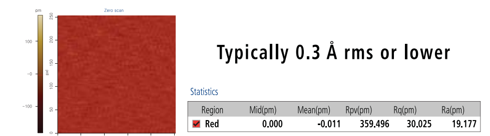
Automatic Measurement Control

Automated software makes the XE-HDM 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



Region	Mid(pm)	Mean(pm)	Rpv(pm)	Rq(pm)	Ra(pm)
Red	0.000	-0.011	359.496	30.025	19.177

XE-HDM
Decoupled XY & Z Scanners

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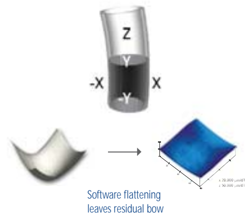
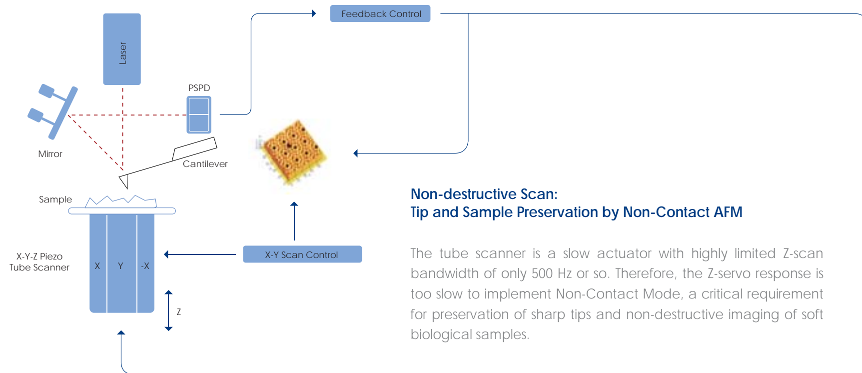
CROSSTALK ELIMINATION (XE)

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.

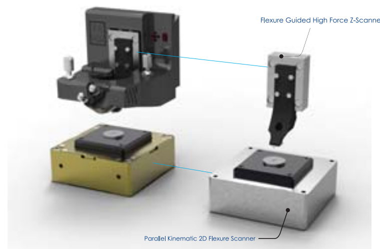


Non-destructive Scan: Tip and Sample Preservation by Non-Contact AFM

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™.

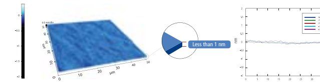


Mechanical Design	Features	Advantages
Decoupled XY and Z Scanners	XY scanner only moves the sample and the Z scanner drives the probe	Flat XY Scan Without Scanner Bow
2D XY Flexure Scanner	Minimal Z Runout (Out-of-plane Motion)	Highly Linear and Orthogonal XY Scan
High Force Z Scanner	Large Z Servo Bandwidth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

ACCURATE AFM RESULTS BY CROSSTALK ELIMINATION (XE)

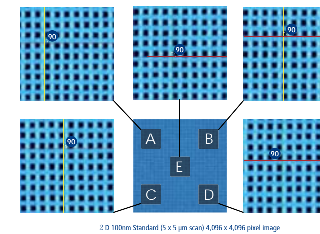
Artifact Free Imaging

- ☑ 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.



2 D 100nm Standard (5 x 5 μm scan) 4,096 x 4,096 pixel image

Highly Linear and Orthogonal XY Scan

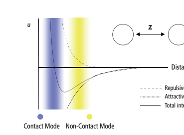
The flexure XY scanner decouples the X and Y scan motion so that the coupling between X and Y movement is minimized regardless of scan locations, scan rates, and scan sizes. Position sensors provide linear feedback control for the high accuracy and high precision measurements.

Non-destructive Scan

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

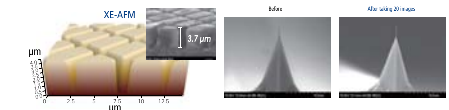
True Non-Contact Mode™ is Now a Reality

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.

XE-HDM Decoupled XY & Z Scanners

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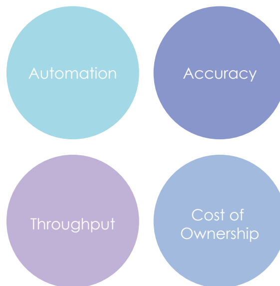
AFM SOLUTIONS

Data Storage

HDD-Optimize™

The HDD-Optimize™ is the state-of the-art product solution program for the hard disk drive (HDD) industry who, until now, had very limited choices for industrial grade in-line inspection tools. Under the systematic approach of the program, Park Systems ensures rapid alignment and performance of its automated AFM solutions with the specific requirements of its HDD customers, matching the highest resolution AFM in the world with the lowest gauge sigma value for repeatability and reproducibility.

Technology leaders in the hard disk drive (HDD) industry have chosen Park Systems as their AFM solutions partner to enable next-generation hard drive design and manufacturing.



Accuracy Like Never Before

Shrinking form factors are driving the need to design at the nanoscale level in the hard disk drive. 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 500-800% gain in throughput for defect review of media and substrates , where automated defect identification with raw data and partnership process enables successful defect analysis, and programmable data density for high-throughput feature measurement, where we enable much faster measurement of the tiny writer pole on individual HDD sliders by selectively focusing on critical areas with high-resolution imaging.

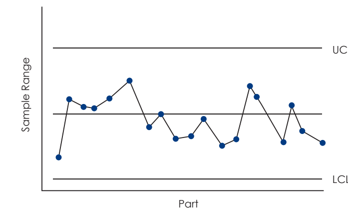
Cost-Effectiveness Like Never Before

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 complete automation, faster imaging, and longer tip life.

We cut costs by replacing spatially limited optical profilers with high resolution imaging and fully automated AFM, and by replacing slower and expensive SEM with efficient, automatic, and affordable 3D AFM for industrial in-line manufacturing.

Also, we significantly 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 True Non-Contact Mode AFMs maintain tip quality resulting in the lower total cost of ownership.

PARK SYSTEMS RELIABILITY

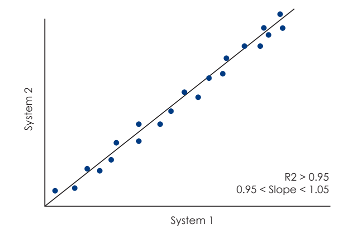


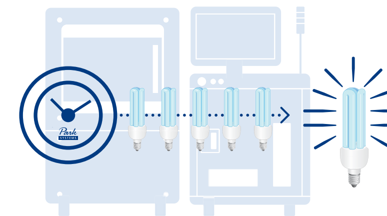
Gage Repeatability and Reproducibility

Due to the ever-decreasing size of components, manufacturers now require the highest level of quality control. Park Systems can provide 1 gage 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.



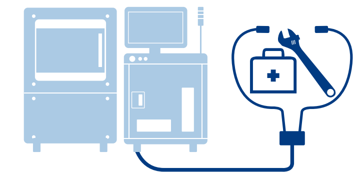


System Uptime

Our engineers and scientists adopted the most rigorous industry standard of product development to ensure the highest level of system reliability. The XE-HDM 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.



XE-HDM
Decoupled XY & Z Scanners

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XEA & OPTIONS

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 × 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

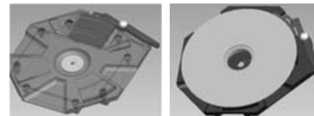
XEI is the AFM image processing and analysis program. The powerful processing algorithms make the analysis easy and streamlined. With its most advanced and versatile imaging features, XE users can obtain essential and critical information from their experiment.

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

Options

Double-sided Sample Chuck

A non-damaging sample chuck allows user to finally analyze both sides of a substrate or media sample. State of the art design allows a firm hold of a substrate or media sample without a vacuum to hold it down.

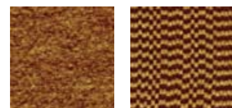


Non-damaging Customized HGA Fixture

HGA fixture can be custom built to firmly fit a specific HGA design provided by the customer, providing the most stable fixture in the industry. The non-damaging fixture allows users to easily load and unload the entire HGA, without causing any damage to the HGA. HGA then can be dismounted, and further tested. Up to 5 HGA samples of the same type can be mounted at the same time.

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.

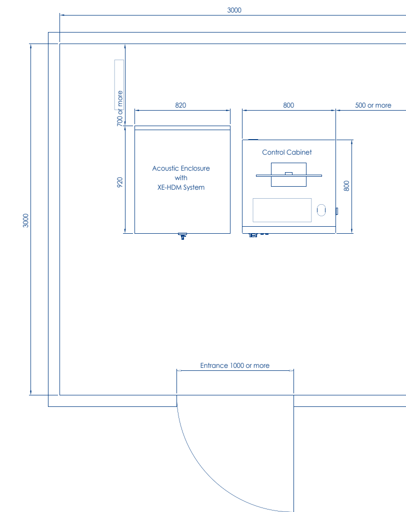


Magnetic Force Microscopy

It is vital for HDM manufacturers to study the magnetic domain distributions in a fabricated magnetic structure. Magnetic Force Microscopy (MFM) images magnetic domains by measuring the spatial variation of the magnetic force. Park Systems AFM can acquire both a topographic and magnetic image that correlates to the sample under investigation.

SPECIFICATIONS

Footprint



• System Specification

Motorized XY stage:
travels up to 150 mm × 150 mm, 1 µm resolution
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 × 100 µm (high voltage mode)
10 µm × 10 µm (low voltage 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

Floor Vibration:
< 0.5 µm/s
(10 Hz to 200 Hz w/ Active Vibration Isolation System)
Acoustic Noise:
>20 dB attenuation w/ Acoustic Enclosure

• Dimension & Weight

Acoustic Enclosure:
820(w) × 920(d) × 1460(h)
600 kg approx. (incl. basic XE-HDD System)
Control Cabinet:
800(w) × 800(d) × 1000(h)
160 kg approx. (incl. controllers)
System Floor Space:
1720(w) × 920(d)
Ceiling Height:
2000 or more
Operator Working Space:
2400(w) × 2450(d), minimum (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: -60 kPa
Power Supply Rating:
100/120 V/ 208~240 V, single phase, 15 A (max)
Total Power Consumption:
2 KW (typical)
Ground Resistance:
Below 100 ohms

* Specification for upgrade packages
(media, slider, wafer) also available, contact Park Systems for more information

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