C147-E018

SHIMADZU
Excellence in Science

Scanning Probe Microscope/Atomic Force Microscope

SPM-Nanoa

SPM-Nanoa™

Scanning Probe Microscope/Atomic Force Microscope

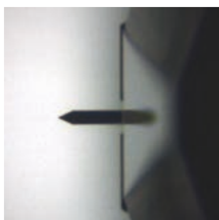
Leading you into the nano world.

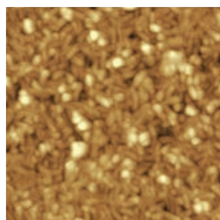
SPM-Nanoa microscopes include an advanced high-sensitivity detection system and automatic viewing functionality as standard features.
That means you can observe what you want to observe in more detail, more easily, and more quickly.
Consequently, SPM-Nanoa microscopes provide powerful assistance for everything from observing the shape of micro areas to measuring their physical properties.

01 Automatic Observation

Adjusts Laser Beam, Adjusts Parameter Settings During Observation, and Performs Image Processing Automatically

P4





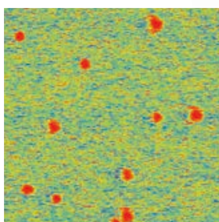
Laser Beam Adjusted Automatically
– Link On –

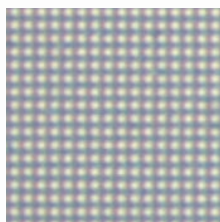
Automatically Set Observation Parameter Settings
– NanoAssist –

02 Extensive Functionality

Capture Sharp Images with Optical Microscopy to SPM Microscopy Modes

P6





Wide Variety of Observation Modes

Search for Targets Easily

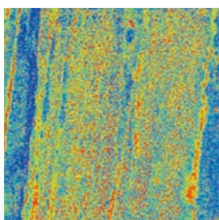
Observe Localized Physical Properties with High Resolution

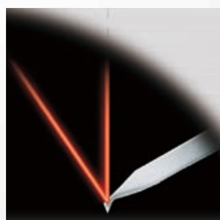
8K Images Enable High-Resolution Observation of Large Areas

03 Saves Time

Various Support Functionality Achieves Fast Observation

P8





High-Throughput Observation and Fast Physical Property Mapping

Simple & Smooth Sample Replacement

Easy and Reliable Cantilever Replacement
– Cantilever Master –

01 Automatic Observation

Adjusts Laser Beam, Adjusts Parameter Settings During Observation, and Performs Image Processing Automatically

Operating time when using standard samples and standard cantilever: about 5 minutes*

* For automatic observation with 1 µm square field of view and 256 × 256-pixel resolution. Operating times can vary depending on the operator.

Previous SPM systems required practice adjusting the light beam, adjusting parameter settings during observations, and processing image data, but the SPM-Nanoa automates those processes to help ensure stress-free operations.

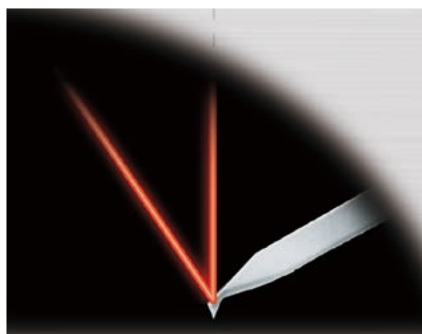
STEP 1 Set up the cantilever.

Easy and Reliable Cantilever Replacement
– Cantilever Master (Option) –

Install cantilevers easily with a mounting jig.

Refer to p. 9 for details

STEP 2 Automatically adjust the laser beam with one click. AUTO



Simply click the [Link On] button to complete the light beam adjustment process.

Laser beam adjusted automatically
– Link On –

The system automates the process of shining the laser onto the back of the cantilever and adjusting the beam so that the reflected light enters the detector. With no steps that require practice, light beam adjustment can be performed identically by anyone.

STEP 3

Simple and smooth sample setting.

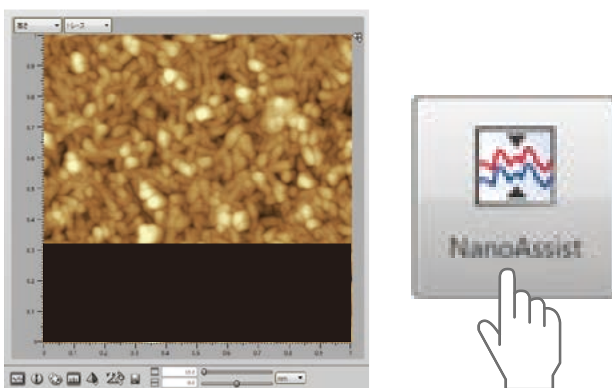
Open the stage with one press of a button on the main unit.

Refer to p. 9 for details

STEP 4

Click once to automatically adjust parameter settings during observation.

AUTO



Simply click the [NanoAssist] button to complete the observation parameter setting process.

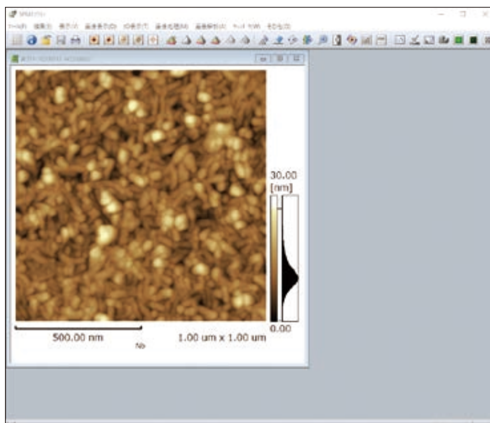
Automatically set observation parameter settings – NanoAssist –

The SPM-Nanoa automates the observation parameter setting process, which previously required expertise. A unique algorithm ensures observation results are not operator-dependent.

STEP 5

Process image data.

AUTO



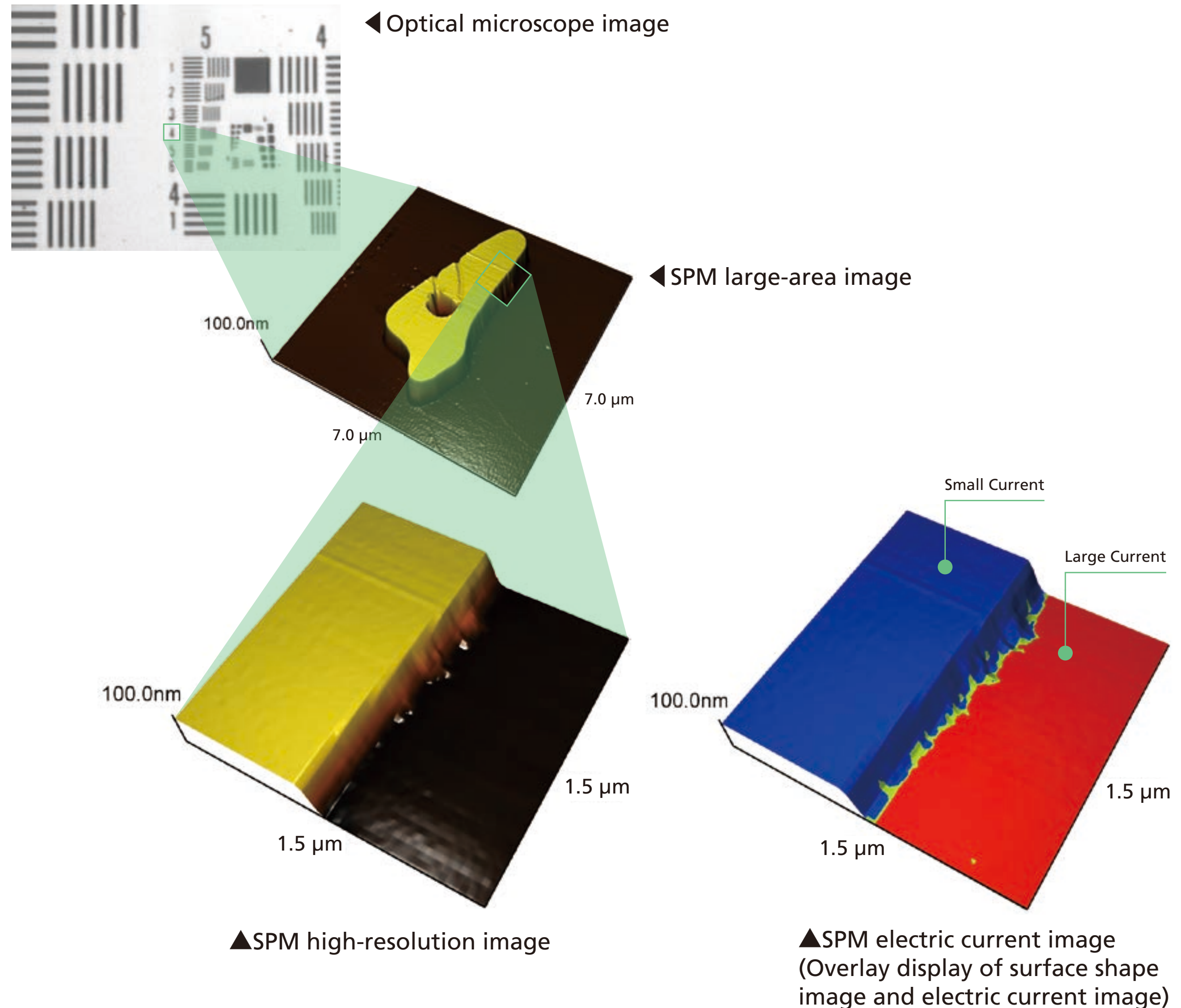
Automatically corrects the orientation angle of acquired images.

02 Extensive Functionality

Capture Sharp Images with All Modes from Optical to SPM Microscopy

Targets can be searched by an optical microscope, and magnified observation is facilitated by SPM.
Other physical property information can be obtained with the same field-of-view as the surface shape image.

Sample: SiO_2 patterns on Si



▲SPM high-resolution image

▲SPM electric current image
(Overlay display of surface shape image and electric current image)

Wide Variety of Observation Modes

Supports a wide variety of observation modes, from observing shapes to mapping physical properties based on force curve measurements.
That means physical properties can be evaluated with high resolution.

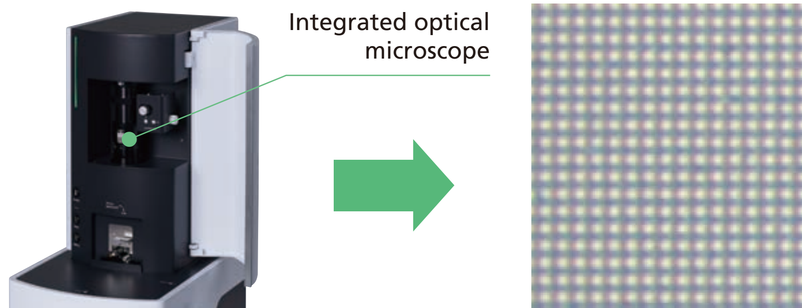
Shape	Mechanical Properties	Electromagnetivity	Machining
Contact Mode	Phase Mode	Electric Current Mode*	Vector Scanning*
Dynamic Mode	Lateral Force Mode (LFM)	Magnetic Force Mode (MFM)*	
	Force Modulation Mode	Surface Potential Mode (KPFM)*	**Atmospheric Control**
	Nano 3D Mapping Fast*	Piezoelectric Force Mode (PFM)*	Observation in Liquid*
		STM*	

* Optional

Search for Targets Easily

Targets can be searched for easily in sharp optical microscope images without vibration effects.
The SPM-Nanoa combines a high-performance optical microscope and SPM unit in a single integrated system.

■ View Test Patterns

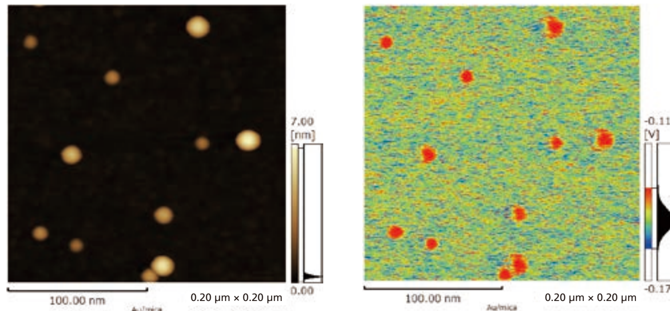


With the integrated optical microscope (left), the periodic structure of a 3 μm interval on the sample surface can be clearly observed.

Observe Localized Physical Properties with High Resolution

The deformation of extremely soft samples or differences in the mechanical or electrical properties of samples can be observed with high resolution, even if such characteristics are localized.

■ KPFM Mode Observation of Gold Nanoparticles on Mica Substrate

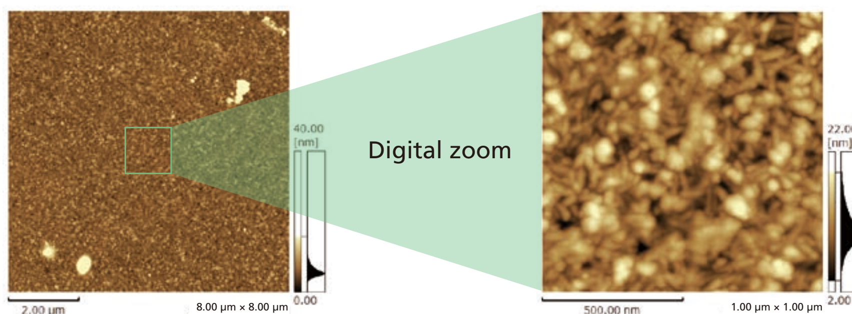


This shows a surface potential image (right) acquired with the same field-of-view as a 0.2 μm shape image (left).

8K Images Enable High-Resolution Observation of Large Areas

Detailed structures can be observed even in images of large areas. High-resolution observation is achieved with up to 8K (8192 × 8192) pixels.

■ Observation of Vapor-Deposited Metal Coating



Field-of-View: 8 μm
Data points: 8,192 × 8,192

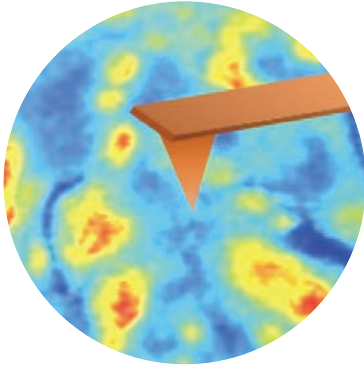
Field-of-View: 1 μm
Data points: 1,024 × 1,024

03 Saves Time

Various Support Functionality Achieves Fast Observation

Observation times have been significantly shortened with faster observation and physical property-mapping processes. Simple sample and cantilever replacement processes ensure the system can be prepared for observations quickly.

Three functions enable significantly shorter observation times.



High-Throughput Observation
Fast Physical Property Mapping

Simple & Smooth Sample
Replacement

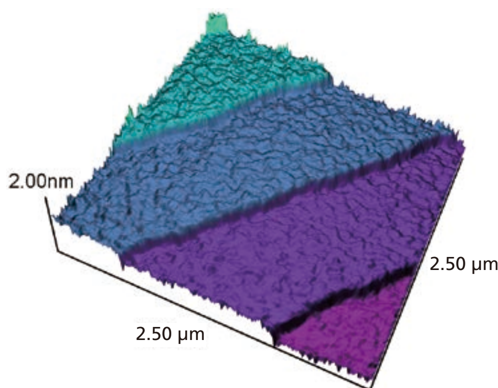
Easy and Reliable
Cantilever Replacement

High-Throughput Observation
Fast Physical Property Mapping

The data acquisition time required for observation and mapping physical properties has been significantly shortened by using a high-throughput scanner that achieves a fast response and by optimizing the control algorithm.

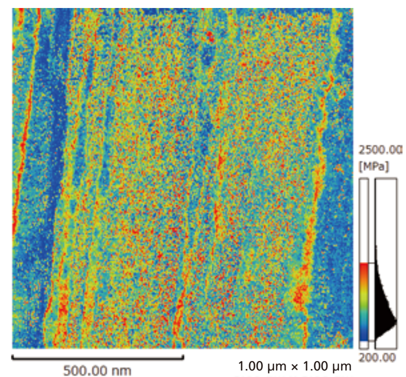
About 25 sec. for observation*

Observation of TiO_2 Atomic Steps



About 21 min. for observation*

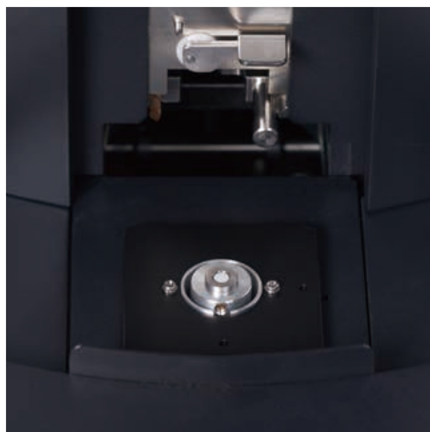
Mapping Elastic Modulus of High Density Polyethylene



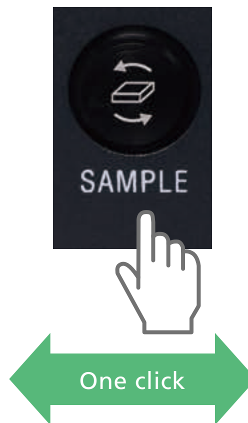
* Actual observation times will vary depending on parameter settings.

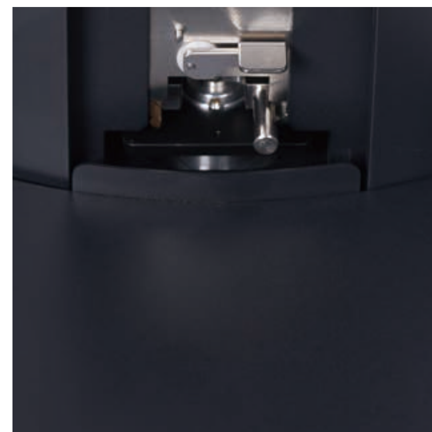
Simple & Smooth Sample Replacement

Samples can be placed and removed by opening/closing the stage with a single click. Because the system maintains the laser beam position, samples can be observed immediately after replacement.



Stage Open

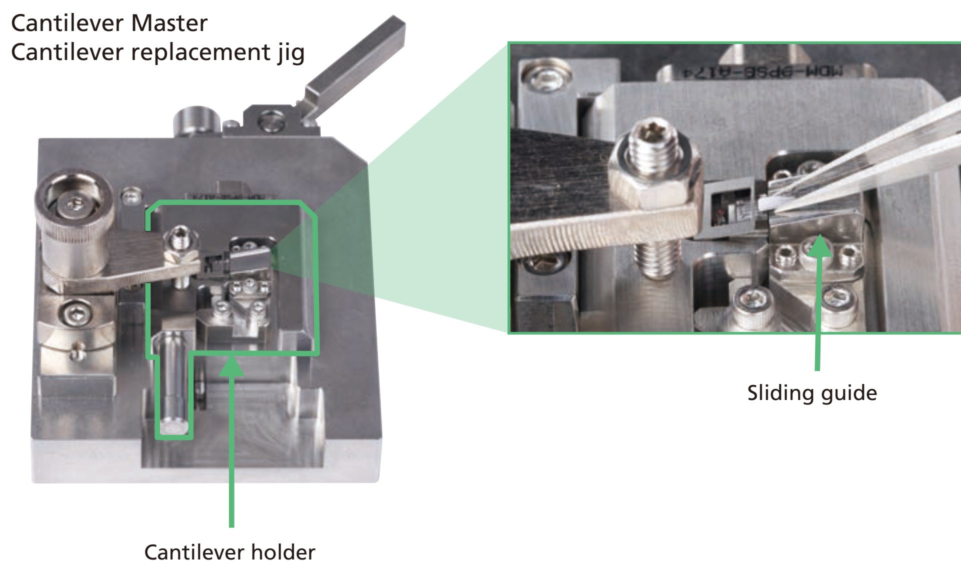




Stage Closed

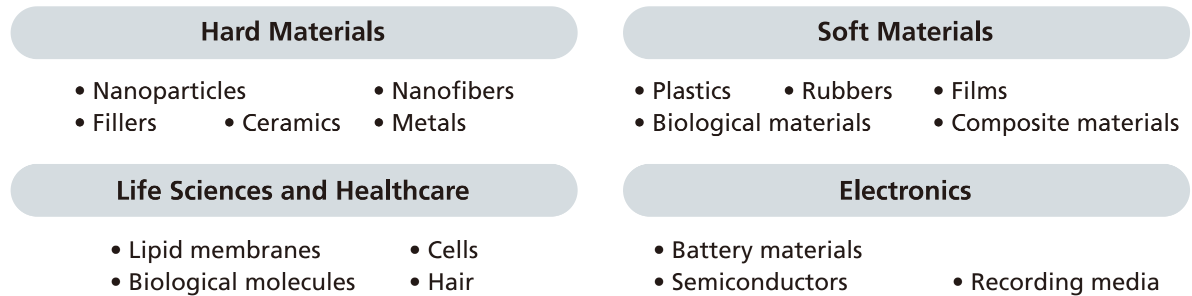
Easy and Reliable Cantilever Replacement – Cantilever Master (Option) –

Cantilevers can be installed by simply placing the cantilever in the specified position and then sliding it along the guide. That ensures cantilevers can be replaced easily and reliably even by operators not used to using tweezers.

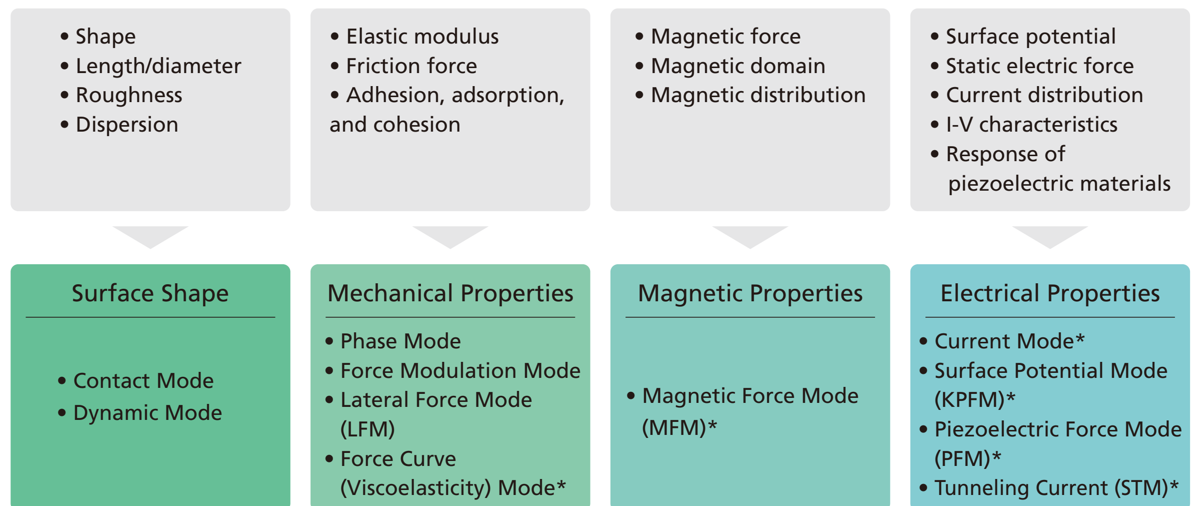


Application Software

Application software for a wide variety of samples, from soft to hard materials, can provide powerful help for observing what you want to observe.



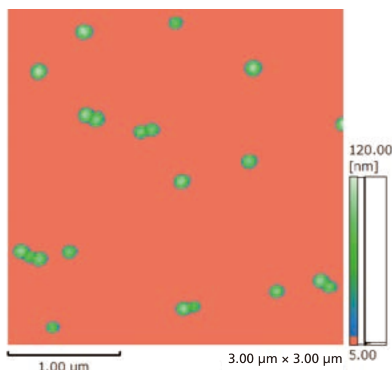
What do you want to observe?



* Option

Hard Materials

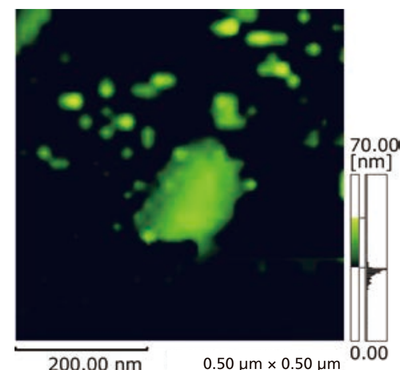
Silica Nanoparticles



Observation of silica nanoparticles confirmed uniformity of nanoparticle sizes.

Life Sciences and Healthcare

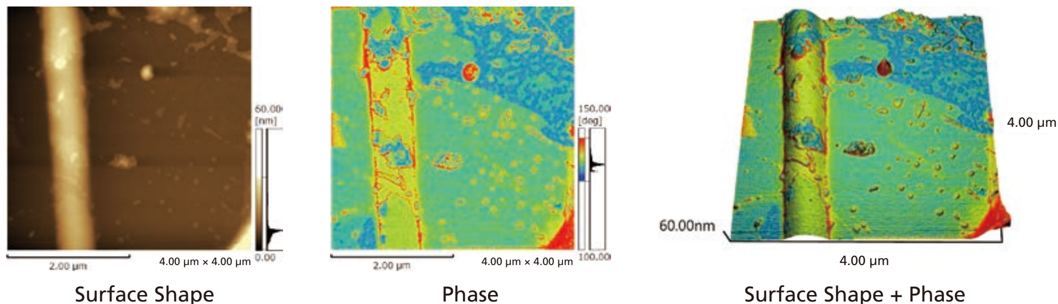
Extracellular Vesicles



The large particles shown in the center are extracellular vesicles. With the ability to not only observe shapes, but also evaluate mechanical properties, the system is expected to be useful for identification and Drug Delivery System (DDS) research for exosomes, liposomes, and typical polymer micellization pathogens, and other applications (using Nano 3D Mapping Fast).

Soft Materials

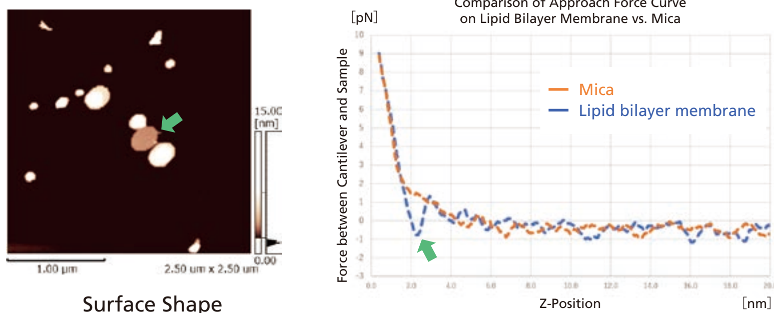
■ PVP/CNF Composite Materials



Surface Shape Phase Surface Shape + Phase

A water mixture of cellulose nanofiber (CNF) and polyvinylpyrrolidone (PVP) was observed electrospun onto a silicon substrate. The surface shape image shows the cylindrical shape of the fibers and the phase image shows physical property differences of CNF and PVP fibers as differences in contrast.
(Sample source: Professor Nakai, Graduate School & Faculty of Bioresources, Mie University)

■ Lipid Membranes

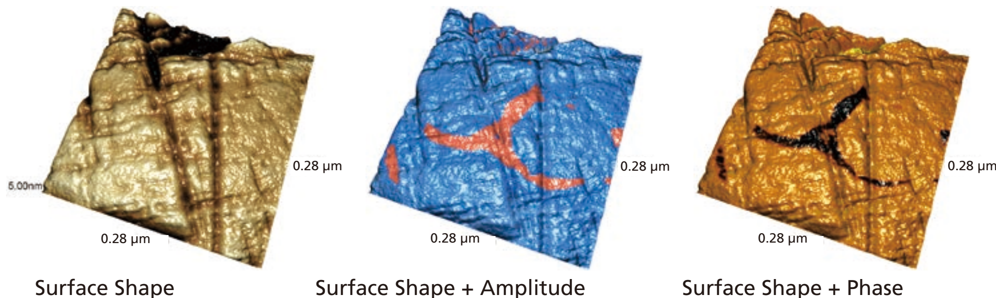


Surface Shape

A patch-shaped lipid membrane about 6 nm thick was observed (arrow) near the center of the surface shape image (left). The force curve acquired from on top of the lipid membrane (right) indicates the variations in force generated as the probe penetrated the membrane.

Electronics

■ Single $BaTiO_3$ Crystal



Surface Shape Surface Shape + Amplitude Surface Shape + Phase

$BaTiO_3$, a strong dielectric, was observed using the piezoelectric force mode (PFM).
The amplitude and phase images clearly show the polarized domain structure.

Additional information, such as more recent examples of observation data, applications, and a list of scientific articles, is also available on the SPM Data Room website.

https://www.shimadzu.com/an/products/surface-analysis/spm-data-room/index.html

SPM Data Room Search

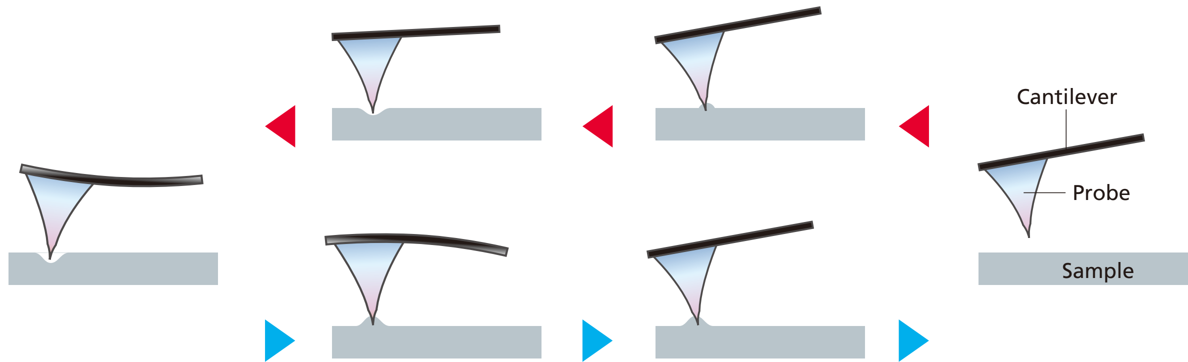
Nano 3D Mapping™ *Fast*

Optional

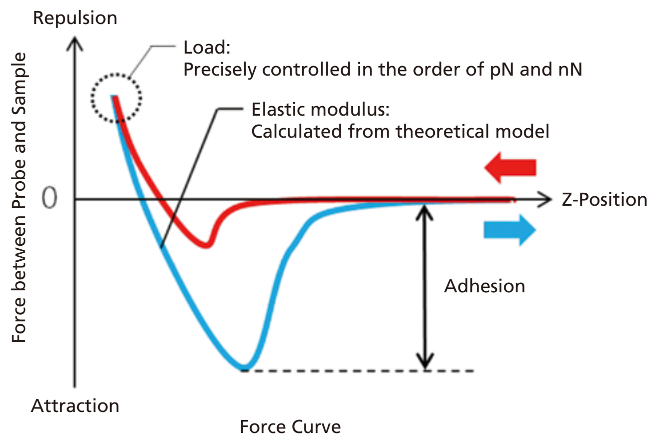
—Fast Physical Property Mapping—

The mechanical properties of materials can be evaluated by measuring the force (force curve) acting on the cantilever probe as its distance from the sample surface is varied.
The faster measurement system enables high-speed mapping of physical properties.

Force Curve Measurement



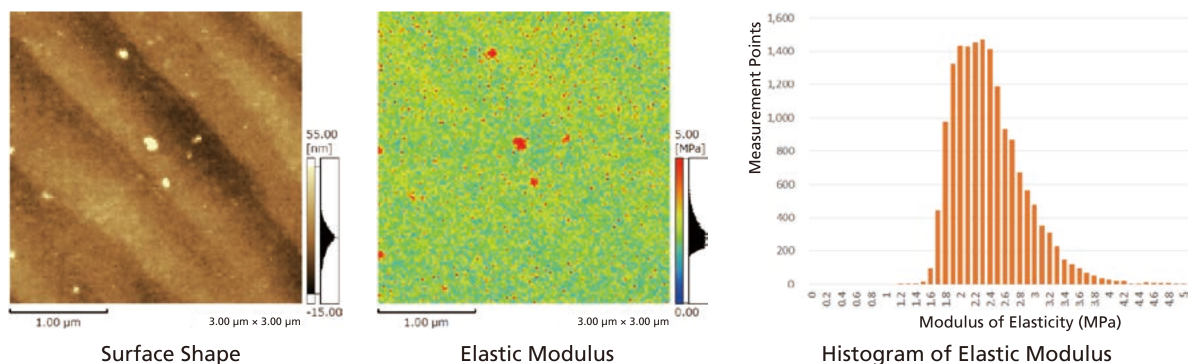
Cantilever Responses to Forces During Force Curve Measurements



Force Curve

By acquiring a force curve at various points on the sample surface, the physical properties in the XY-plane can be mapped.
This is especially useful for evaluating the mechanical properties of thin films that are difficult to measure even with a nanoindenter or soft materials with a hardness between about a few kPa and 1 GPa.

Mapping the Elastic Modulus of Styrene-Butadiene Rubber



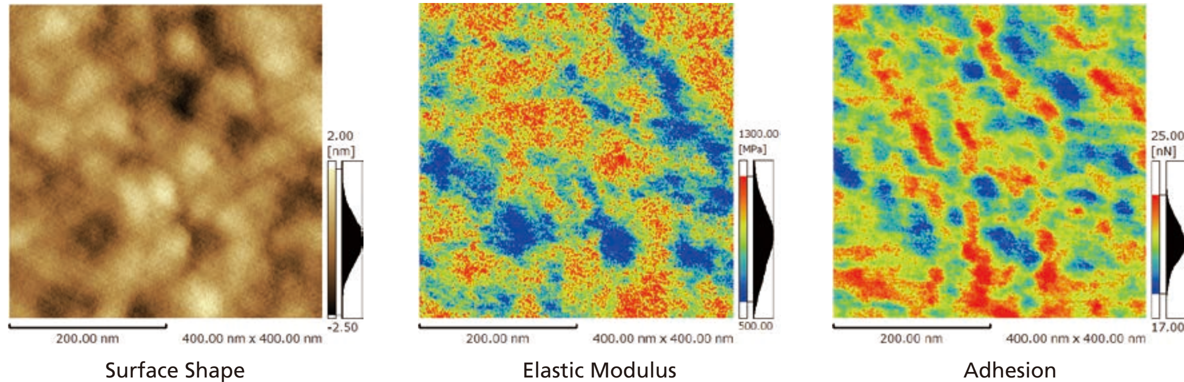
Surface Shape | Elastic Modulus | Histogram of Elastic Modulus

Mapping the elastic modulus of styrene-butadiene rubber (after Soxhlet extraction) allowed evaluating the uniformity of the material based on the elastic modulus histogram.
(Sample source: Professor Nakajima, Department of Chemical Science and Engineering, Tokyo Institute of Technology)

Visualization of Nano-Scale Elastic Modulus and Adsorption

The elastic modulus can be evaluated quantitatively by applying a theoretical model for calculating elastic modulus to the force curve obtained by measuring the micro-forces acting between the probe and sample. The force distribution can also be visualized in the vertical direction for nano-scale three-dimensional mechanical analysis.

■ Mapping the Physical Properties of Polymer Films

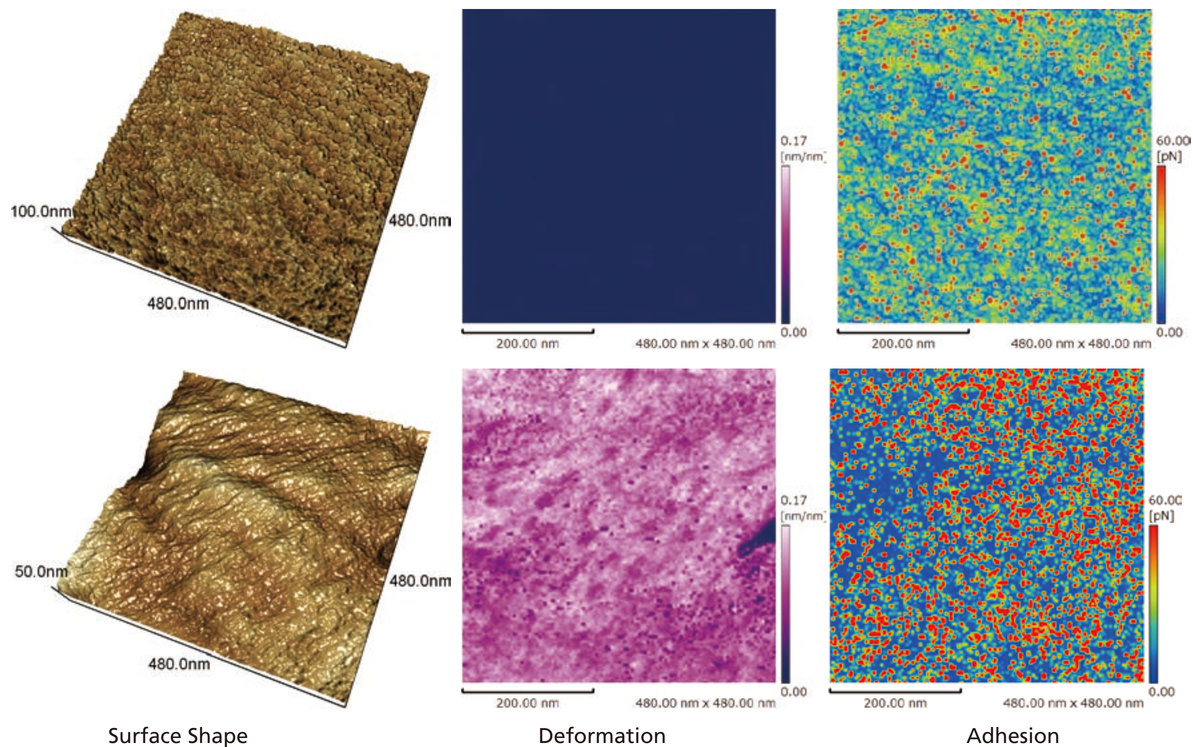


Surface Shape | Elastic Modulus | Adhesion

Mapping polymer film surface properties clearly showed how elastic modulus and adhesive forces were distributed in patches several tens of nanometers in size.
(Sample source: MORESCO Corporation)

Mechanical Property Comparison of Different Samples

■ Measuring the Shape of Contact Lenses



Surface Shape | Deformation | Adhesion

Physical properties were mapped for two different types of contact lenses, made by different manufacturers, measured in an artificial tear solution. The map shows differences in surface properties of the two samples. The upper contact lens deforms more easily and exhibits uniform adsorption forces.

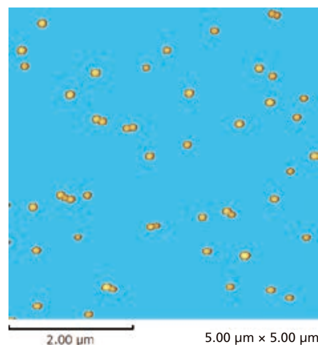
Particle Analysis Software

Optional

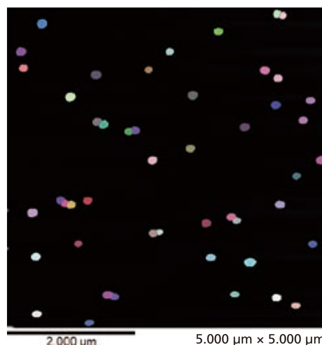
This application software can be used for a wide range of samples, from soft to hard materials, to provide powerful help for observing what you want to observe.

Task Statistically analyze the diameter and length of many nanoparticles or nanofibers.

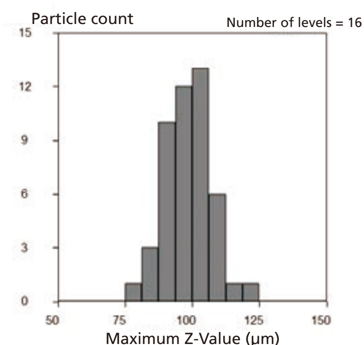
Silica Nanoparticle Size Analysis



Height Image

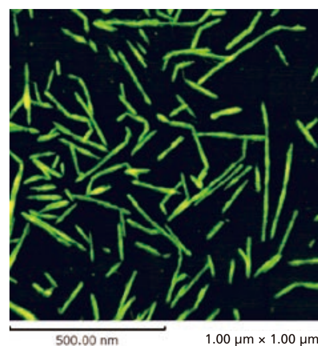


Fiber Isolation

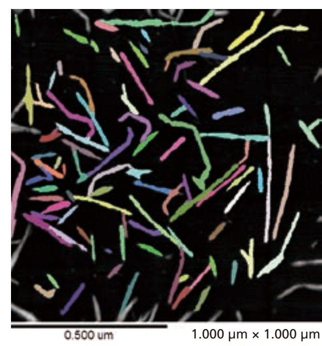


Histogram of Particle Size Distribution

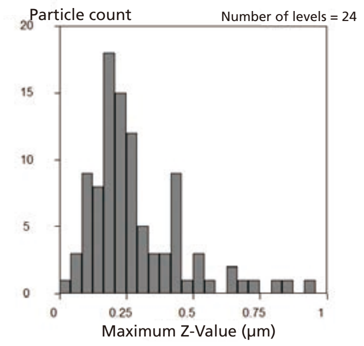
Fiber Length Analysis of Cellulose Nanofibers



Height Image



Fiber Isolation



Histogram of Boundary Length Distribution

This allows isolating numerous nanoparticles and nanofibers from observation data and calculating their diameter, boundary length, or other characteristic quantities. Fiber length is calculated as half the boundary length. Because it can statistically determine characteristic quantities for numerous samples, it can also be used for shape-based quality control applications.

Characteristic Quantities

No.	Quantity
1	Center of gravity X-coordinate
2	Center of gravity Y-coordinate
3	Absolute maximum diameter
4	Pattern width
5	Horizontal Feret diameter
6	Vertical Feret diameter
7	Circular radius (excluding holes)
8	Circular radius (including holes)
9	Mean radius
10	Variability of mean radius
11	Minimum distance between centers of gravity
12	Boundary length
13	Boundary length of convex hull
14	Maximum Z-value
15	Minimum Z-value
16	Mean Z-value
17	Mean Z-value of particle boundary
18	Area excluding holes
19	Area including holes
20	Surface area
21	Volume
22	Pattern orientation
23	Angle of principal 2D moment of inertia
24	Volume ratio
25	Area ratio
26	Flatness
27	Roundness
28	Roughness
29	Thinness

Statistical Quantities

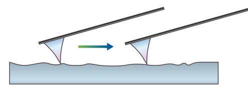
No.	Quantity
1	Mean
2	Standard deviation
3	Mean length
4	Mean area
5	Mean volume
6	Total
7	Maximum value
8	Minimum Value
9	Label number for maximum value
10	Label number for minimum value
11	Range
12	Particle count

Wide Assortment of Expansion Functionality

Shape

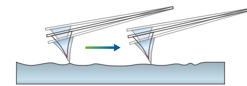
Contact Mode

Surface shape is observed by scanning with the amount of cantilever bending kept constant.



Dynamic Mode

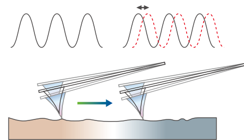
Surface shape is observed by scanning with the amplitude of cantilever oscillation kept constant.



Physical Properties

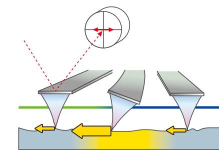
Phase Mode

This mode observes the surface viscoelasticity distribution by detecting the phase shift delay in cantilever oscillation.



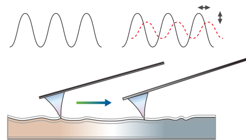
Lateral Force Mode (LFM)

This mode observes the horizontal forces (friction forces) by detecting cantilever torsion.



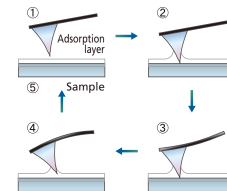
Force Modulation Mode

This mode observes the distribution of viscosity and elasticity by separating the cantilever response into amplitude and phase components.



Nano 3D Mapping™ Fast Optional

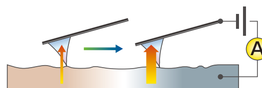
This calculates the elastic modulus, adsorption forces, or other properties of sample surfaces based on force curve measurements and then observe the distribution of those values.



Electromagnetivity (Optional)

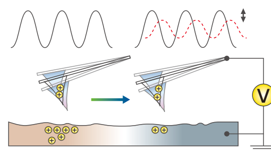
Current Mode

Electrical properties of surfaces are observed by detecting the current flowing through the cantilever.



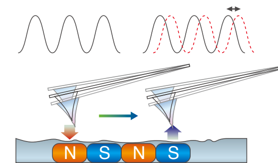
Surface Potential Mode (KPFM)

Surface electric potential is observed by detecting the static electric force acting on the cantilever.



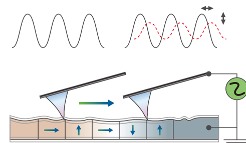
Magnetic Force Mode (MFM)

Surface magnetic domain distribution is observed by detecting the magnetic force acting on the cantilever.



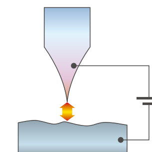
Piezoelectric Force Mode (PFM)

Surface polarity distribution is observed by detecting the piezoelectric response to electrical signals.



STM

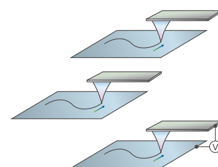
Surface shape is observed by scanning the metal probe with the tunneling current kept constant.



Machining (Optional)

Vector Scanning

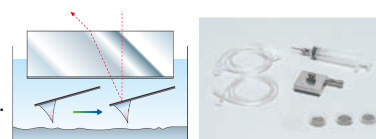
In this mode, surfaces can be scanned based on user-specified scan settings, such as direction, speed, load, and applied voltage.



Atmospheric Control (Optional)

Observation in Liquid

Contact, dynamic, and phase modes can be used in a liquid atmosphere.



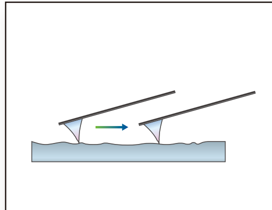
Wide Assortment of Expansion Functionality

Functionality and Expandability for Satisfying a Wide Variety of Requirements

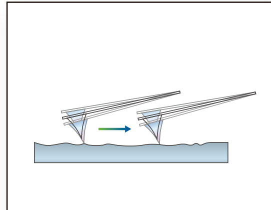
■ Indicates standard specifications □ Indicates optional specifications

Other specifications are also available by special order. For more information, contact a Shimadzu representative.

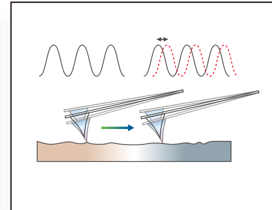
■Contact Mode



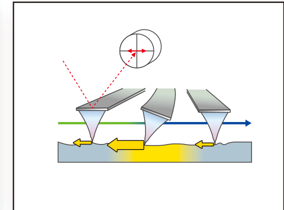
■Dynamic Mode



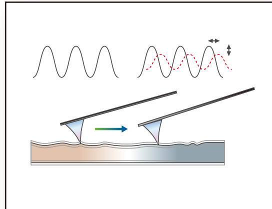
■Phase Mode



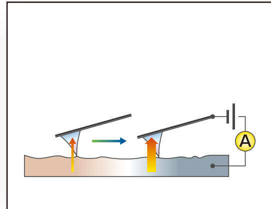
■Lateral Force Mode (LFM)



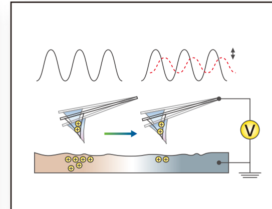
■Force Modulation Mode



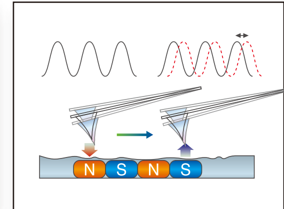
□Current / I-V Mode



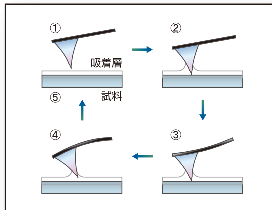
□Surface Potential Mode (KPFM)



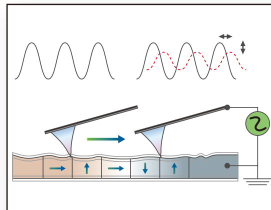
□Lateral Force Mode (MFM)



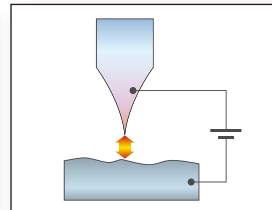
■Force Curve
□Nano 3D Mapping Fast



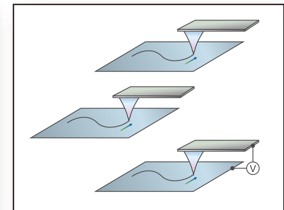
□Piezoelectric Force Mode (PFM)



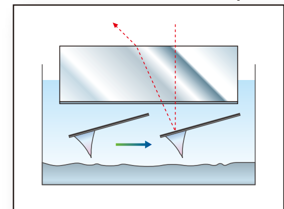
□STM



□Vector Scanning



□Observation in Liquid



■HT Scanner
(10 µm x 10 µm x 1 µm)

□Medium-Range Scanner
(30 µm x 30 µm x 5 µm)

□Large-Range Scanner
(125 µm x 125 µm x 7 µm)

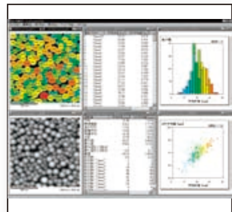
□Deep-Type Scanner
(55 µm x 55 µm x 13 µm)

□Small-Range Scanner
(2.5µm x 2.5µm x 0.5µm)

□Fiber Light

□Cross-Sectional View
Sample Holder

□Particle Analysis
Software



□Active Vibration Damper
□Active Vibration Damper with a Stand

□Cantilever
Mounting Jig

□Static Eliminator

□Computer Table

Wide Assortment of Expansion Functionality

Microscope Unit

Scanner	Max. scanning size (X,Y,Z)
	10 µm x 10 µm x 1 µm (standard)
	30 µm x 30 µm x 5 µm (optional)
	125 µm x 125 µm x 7 µm (optional)
	55 µm x 55 µm x 13 µm (optional)
	2.5 µm x 2.5 µm x 0.3 µm (optional)
Sample Stage	Max. sample size
	ø50 mm x 8 mm
	For 50 mm diameter samples, only the central area can be observed
	Max. stroke
	±5 mm
	When a 40 mm diameter or smaller sample is placed in the center of the scanner

Optical Microscope	Total magnification rate
Observation	About 220 to 1300 times (when maximum displayed on 21.5-inch monitor)

Installation Specifications

Installation Environment

The following air-conditioning conditions are preferable for the installation environment.

Temperature	23 °C ± 5 °C
Relative Humidity	60 % max. (with no condensation)

Power Supply

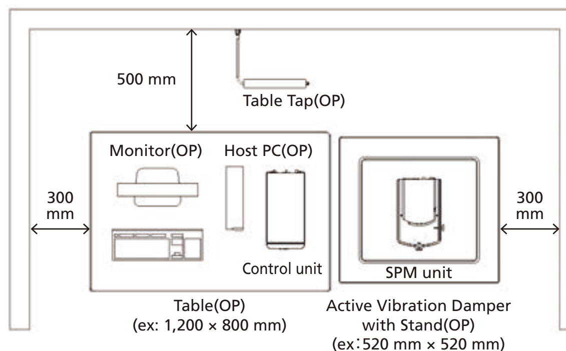
The following power supply is required for operating the SPM-Nanoa system.

Single Phase	100 to 240 V AC, 50/60 Hz, 15 A, one circuit
Ground	Type-D ground (Grounding Resistance: 100 max.)

Size and Weight of Units

The following shows the size and weight of the SPM and control units.

Microscope Unit	W220 x D370 x H520 mm 24 kg
Control Unit	W190 x D400 x H440 mm 14 kg



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- Automated support functions utilizing digital technology, such as M2M, IoT, and Artificial Intelligence (AI), that enable higher productivity and maximum reliability.
- Allows a system to monitor and diagnose itself, handle any issues during data acquisition without user input, and automatically behave as if it were operated by an expert.
- Supports the acquisition of high quality, reproducible data regardless of an operator's skill level for both routine and demanding applications.

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First Edition: February 2021, 3655-09009-PDFIK