C147-E010

Access to your success

SHIMADZU

SPM-9600

Shimadzu Scanning Probe Microscope

Entering Unknown Nanoscopic Regions

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Entering Unknown Nanoscopic Regions

Scanning probe microscope (SPM) is a generic term used to describe a microscope that scans sample surfaces with a microscopic probe to provide high-magnification three-dimensional images. A new generation of SPM, the SPM-9600 symbolizes the evolution of products well known for their rapid observations and simple operation.

Features of the SPM-9600

Higher Quality Images

Newly-improved circuits provide 40% more digital processing than previous Shimadzu SPMs. State-of-the-art signal processing using the newly developed Variable Bandwidth Digital Filter (VBDF) ensures clear, higher quality images. This next-generation SPM is a major step forward, moving from basic observations towards measurement.

Wide Variety of Measurement Modes

Contact, dynamic, and phase modes are all included as standard features.
Easily upgrade the SPM-9600 by adding additional measurement modes such as force modulation, magnetic force (MFM), current, and surface potential (KFM). Connect expansion units for nano-indentation or Q-control systems, and even add environmental control.
Whether you are a novice or an experienced user, the SPM-9600 meets all your application requirements.

Easy Operation

A key SPM-9600 feature is its easy-to-use software interface.
Automated functions ensure operation is easy, even for first-time users. Thanks to a highly vibration and noise-resistant design, the SPM-9600 can rapidly observe a wide variety of samples, without worrying about air drafts.

Contents

Observation Procedure

1 Introducing the Sample

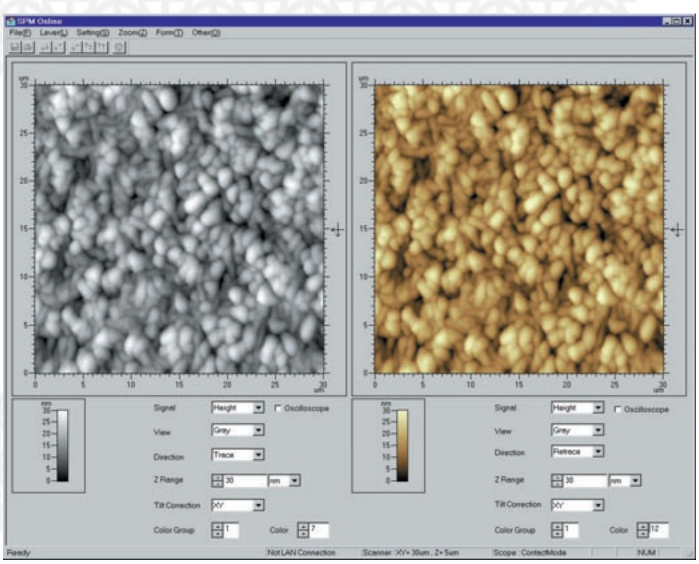
Featuring a patented head-slide mechanism (Japan patent 2833491), the standard-type head can accept samples up to a diameter of 24 mm x 8 mm. Simply place the sample on the head and start the observation process.

2 Fully-Automatic Approach via a Single Mouse-Click

One click of the mouse starts a fully-automatic approach, without damaging the cantilever. (Patent pending)

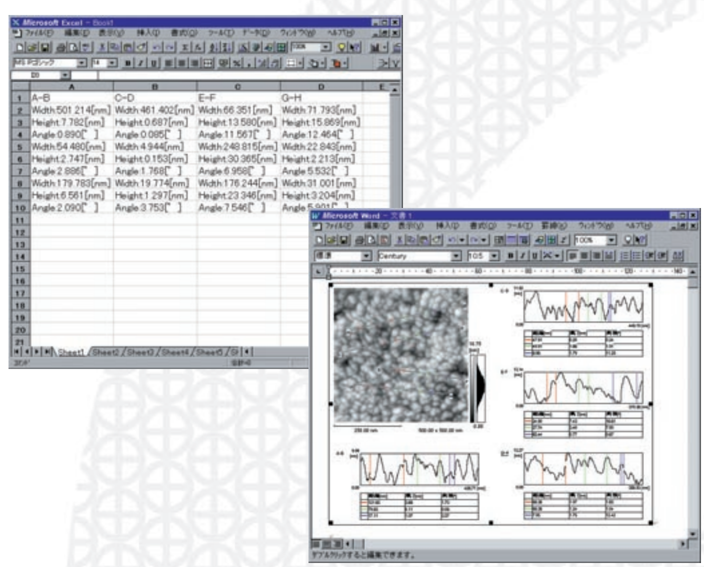
3 Starting Observation

After the approach is completed, scanning starts automatically. Observation conditions can be adjusted during scanning to rapidly achieve target images. Functions such as observation-parameter memories and online profiles ensure anyone can operate the SPM-9600.



4 Data Output

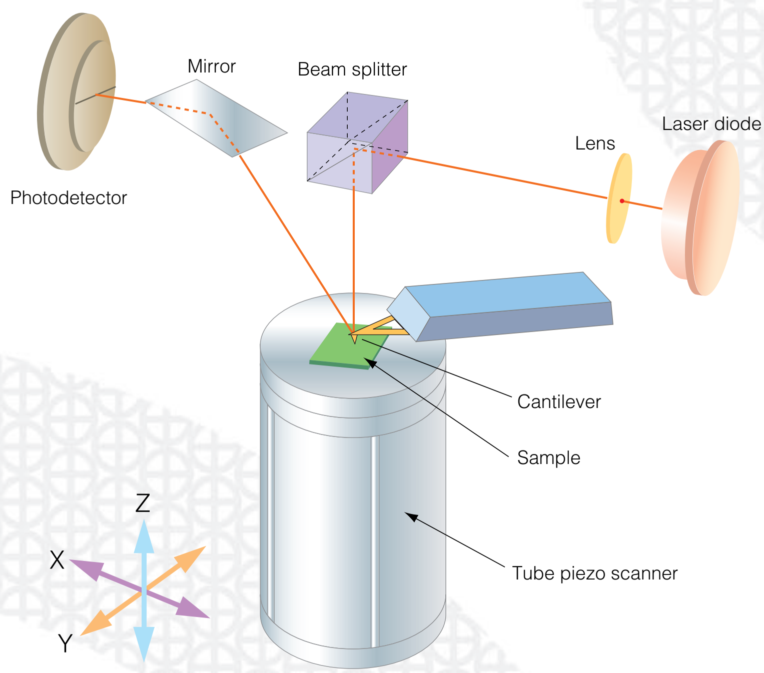
Image processing, analysis, and output are all performed using Windows® software screens.
The SPM-9600 includes comprehensive software for shape analysis and for calculating roughness and measurement scales. All images and numeric data can then be used by other Windows® applications, such as Word and Excel.



Scanning Probe Microscope Operating Principle

Scanning Probe Microscope (SPM) is a generic term used to describe a microscope that makes high-magnification observations by scanning a microscopic probe over the surface of a sample and detecting certain mutual interactions between the probe and the sample surface. Various types of SPM are available, including the scanning tunneling microscope (STM) and the atomic force microscope (AFM).
The mutual interaction detected by an STM is the current flowing between the probe and the sample, while the AFM detects forces acting between the probe and the sample.

High-accuracy scanning of either the probe or the sample is controlled in three dimensions by a scanner equipped with piezoelectric elements. With an SPM, normally the probe scans the sample surface (XY plane) using a pre-programmed method - usually raster scanning. Feedback control of the distance between the probe and sample surface (Z-axis height) keeps the detected mutual interaction at a constant level in order to trace the sample surface. During scanning a computer is used to read the amount of Z-axis feedback (voltage output to scanner) of each XY position and then processes this information to generate a topographic (3D) image of the sample surface.



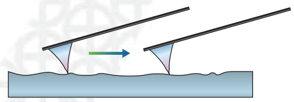
AFM Operating Principle

Multitude of Measurement Modes

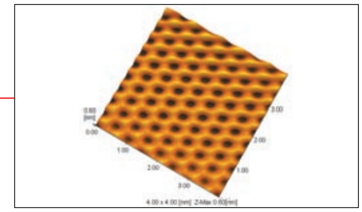
Description of Basic Modes (P/N 211-39650-92)

Contact Mode AFM

In this mode, the probe scans the sample surface while feedback control maintains the repulsive force between the cantilever and sample at a constant level. This standard AFM operation mode achieves maximum image resolution.

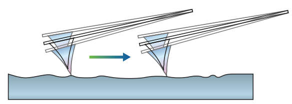


Atomic image of mica
(using a desk-type air-spring vibration damper)

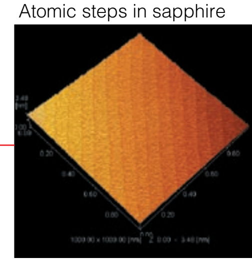


Dynamic Mode AFM

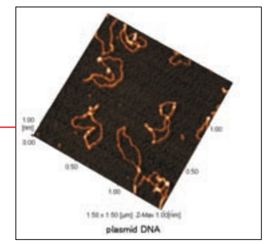
When vibrated at close to its resonant frequency, the cantilever's vibration amplitude will change as the vibrating cantilever tip approaches the sample surface. While maintaining a constant vibration amplitude, this phenomenon is used to move the cantilever and acquire vertical displacement information.



Atomic steps in sapphire

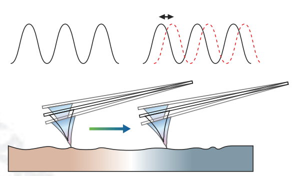


Plasmid DNA

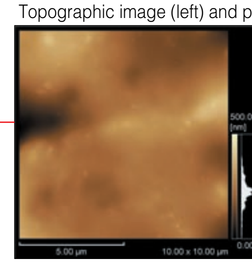


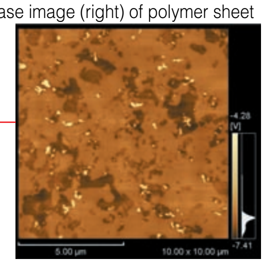
Phase

Phase delay is detected during scanning in dynamic mode. This is used to visualize differences in sample surface properties.



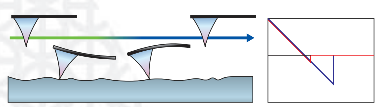
Topographic image (left) and phase image (right) of polymer sheet





Force Curve

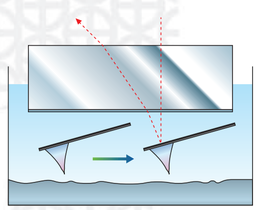
While the distance between the probe and the sample surface is changed, forces acting on the probe are measured and graphically displayed.



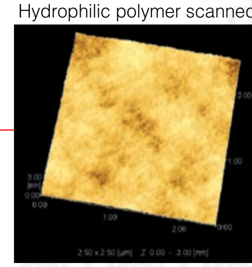
Other Modes (Optional)

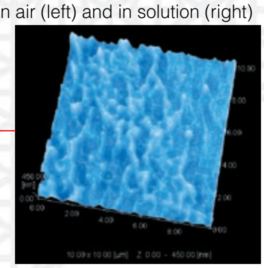
In-Solution Observation

The sample is attached to the bottom of a small Petri dish that is filled with solution. While submerged in the solution, the cantilever scans the sample to acquire AFM images .



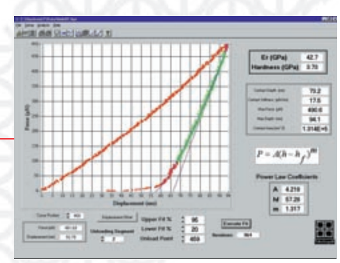
Hydrophilic polymer scanned in air (left) and in solution (right)

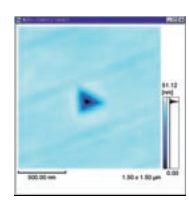




Ultramicro-Hardness Testing (Nano-Indentation)

This mode performs hardness measurements of materials, including thin films, and produces observations of the resulting indentations.





Micro-Hardness Measurement
Nano-indentation and micro indentation

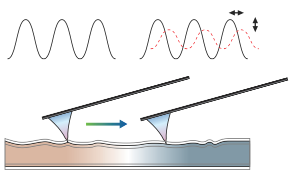
Micro-Scratch Testing

This mode performs scratch testing of materials, including thin films, and produces observations of the resulting scratches.

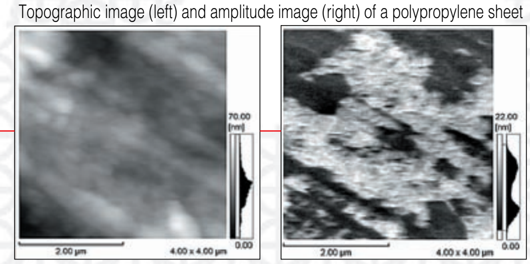
Description of Full-Modes (P/N 211-39673-92)

Force Modulation

During contact-mode scanning, the probe is repeatedly pressed against the sample and the response is detected separately as amplitude and phase. This is used to visualize differences in sample surface properties.

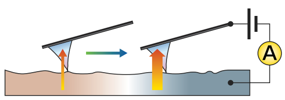


Topographic image (left) and amplitude image (right) of a polypropylene sheet

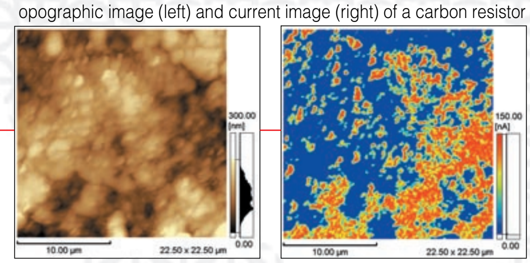


Current

A bias voltage is applied across the probe and sample during contact-mode scanning and the resulting electric current flow is detected. The distribution of this current is displayed visually.

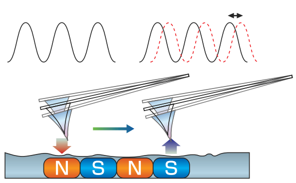


opographic image (left) and current image (right) of a carbon resistor

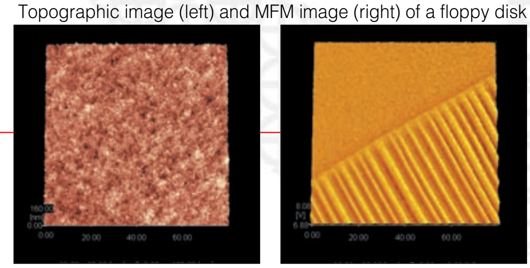


Magnetic Force (MFM)

A magnetized probe is scanned at a constant distance from the sample surface. Magnetic forces due to the leakage field are detected and magnetic information about the sample surface is displayed visually.

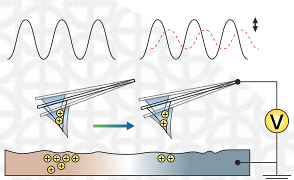


Topographic image (left) and MFM image (right) of a floppy disk

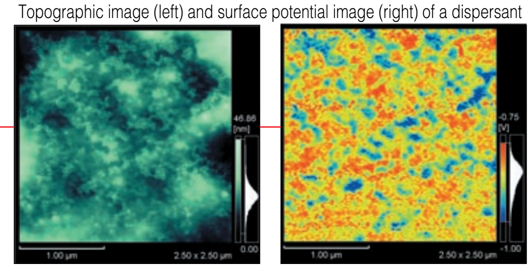


Surface Potential (KFM)

Alternating voltage is applied to a conductive cantilever. The electromagnetic forces acting between the sample surface and the cantilever are detected to measure the potential across the sample surface.

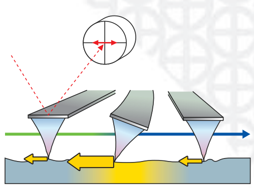


Topographic image (left) and surface potential image (right) of a dispersant



Lateral Force (LFM)

While the cantilever is scanned perpendicular to its longitudinal axis, the twisting of the cantilever due to lateral forces (friction forces) is measured and displayed visually.



Observation Examples

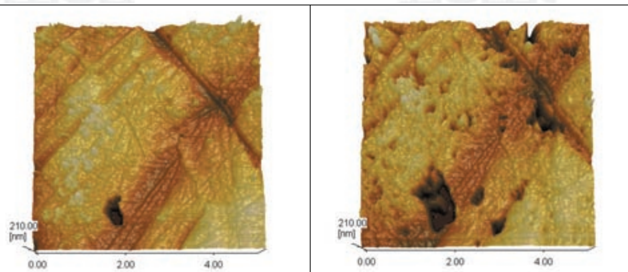
Higher Quality Images

Newly-improved circuits achieve 40% greater digital processing than previous Shimadzu SPMs. State-of-the-art signal processing using the newly developed Variable Bandwidth Digital Filter (VBDF) ensures clear, higher quality images. This next-generation SPM is a major step forward, moving from basic observations towards measurement.

Metals

Plate Copper

Surface shape changes were observed in-situ during an electrochemical reaction on a copper plate. Cyclic voltammetry from –600 mV to 800 mV was repeated three times in a solution of 1 mM KCl and 5 mM $CuCl_2$ using an electrochemical solution cell and an electrochemical controller.

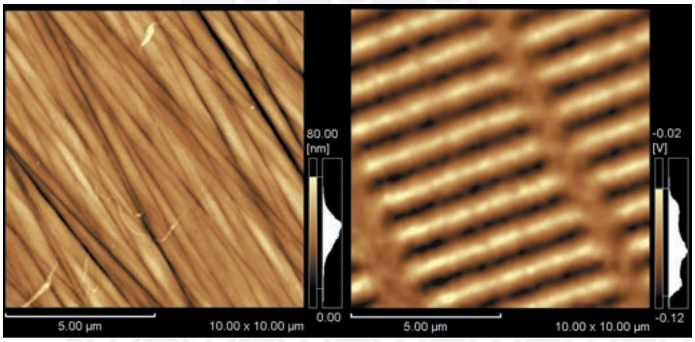


5.00 x 5.00 [µm] Z-Max 210.00[nm]
①Cu in 1mM KCl, 5mM CuCl2

5.00 x 5.00 [µm] Z-Max 210.00[nm]
②CV × 3 -600mV～+800mV 100mV/sec

Hard Disk

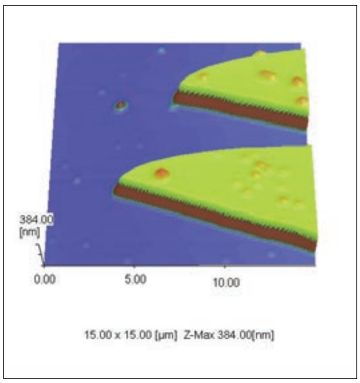
The topographic image (left) shows the texture formed on the substrate. The MFM image (right) shows the magnetic information over the same viewing field.
(Using MFM system.)



Thin Film

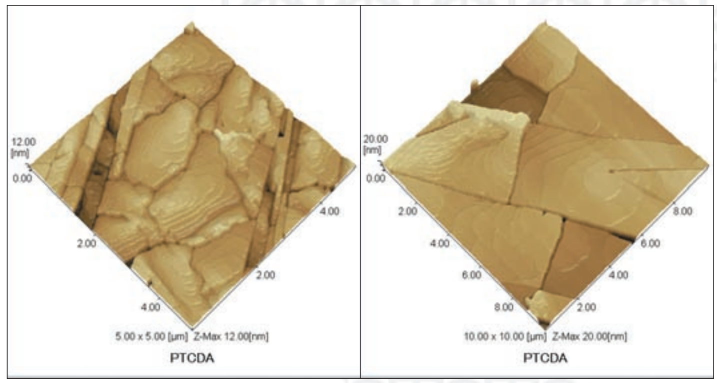
Carbon Thin Film

This image shows an approximately 250 nm-thick carbon thin film that was formed on a glass substrate by vacuum deposition. The boundaries between the substrate and thin film resemble islands in a sea.



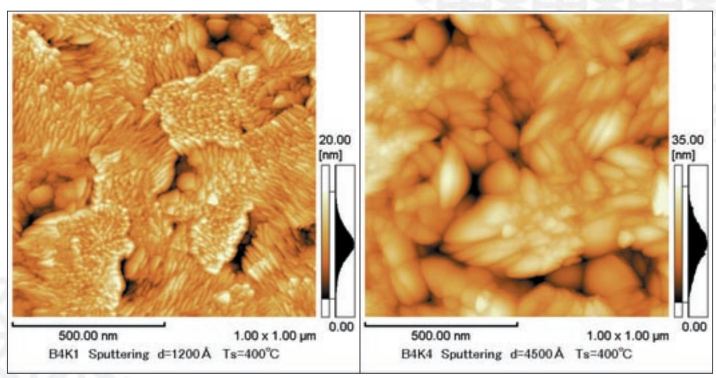
PTCDA Thin Film

These images show an organic thin film (perylene-3, 4, 9, 10-tetra-carboxylic-dianhydride) grown epitaxially on a graphite surface. Layer growth is apparent. Approximately 0.3 nm steps can be clearly observed.
(Courtesy of Dr Hoshino, Faculty of Science, Kyoto University)



ITO Thin Film

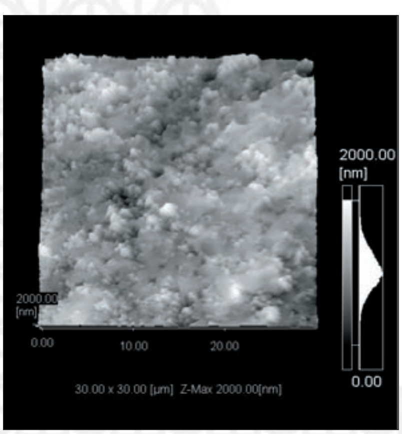
The surface shape of ITO thin film –– known as a transparent, conductive film –– varies due to how the film was produced. Factors include the film deposition method used, film thickness, and substrate temperature.
Comparison of two ITO films with film thicknesses of 120 nm (left) and 450 nm (right) clearly shows greater crystal grain growth as film thickness increases.
The grain-subgrain structure peculiar to the sputtering method is clearly apparent.
(Courtesy of Dr Shigesato, Department of Chemistry, Faculty of Science and Engineering, Aoyama Gakuin University)



Ceramics

Ceramic Fracture Plane

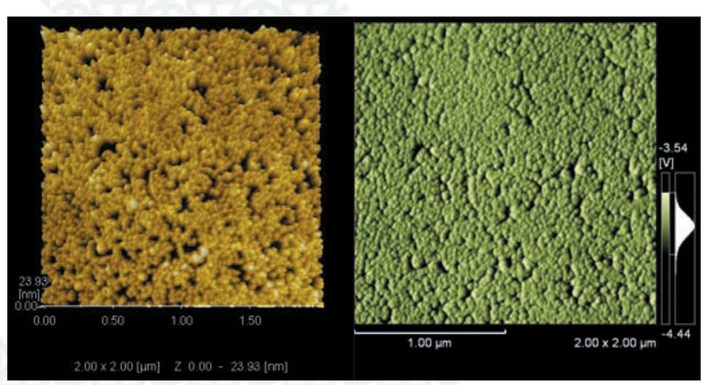
The intergranular fracture is clearly visible.



Paper

Glossy Inkjet Paper

The silica powder used in the uppermost coating of the paper can be seen in the topographic image (left). The phase image (right) shows particles from several nanometers to tens of nanometers even more clearly.

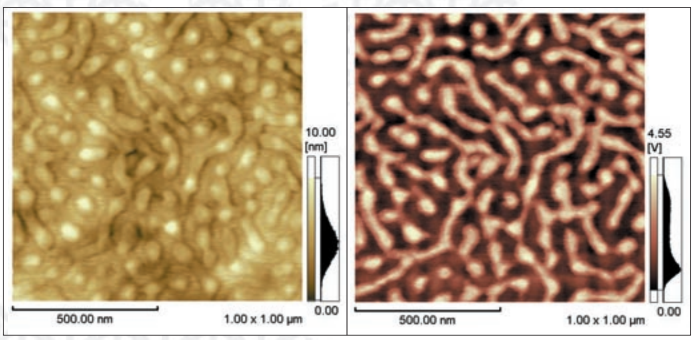


Observation Examples

Polymers

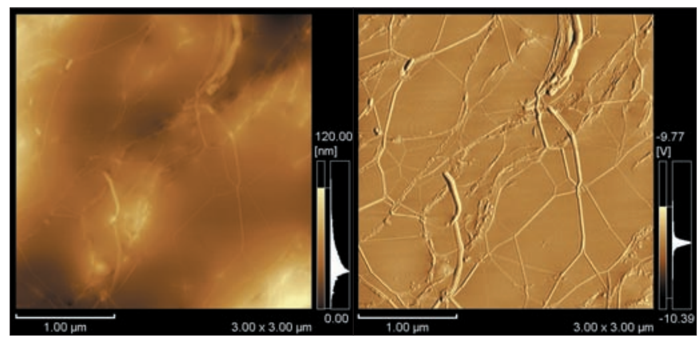
Styrene-Butadiene Blocked Copolymer

The topographic image (left) is not clear, however, the phase image (right) clearly delineates the styrene and butadiene phases.



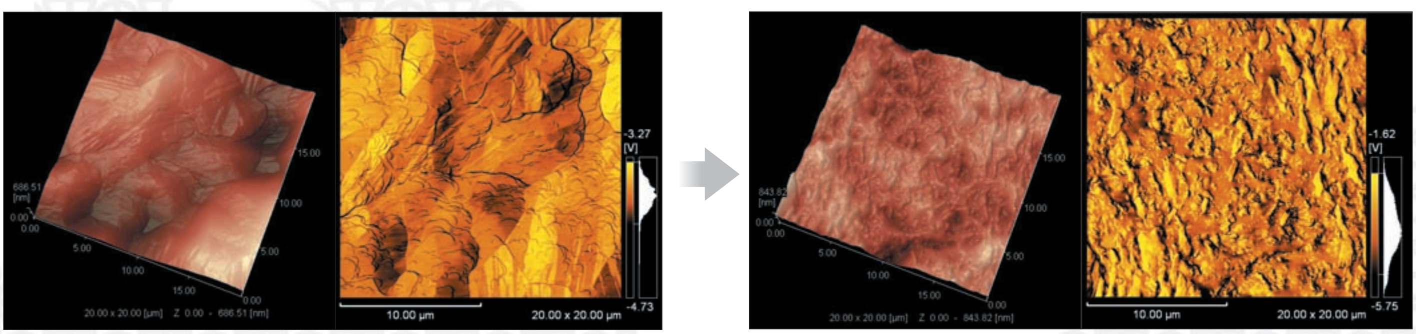
SWNT and Polymer Composite Materials

The topographic image (left) shows the single-phase carbon nanotubes (SWNT) in the polymer becoming unbundled and spreading like a network. The phase image (right) shows this phenomenon even more clearly.
(Courtesy of Aida Nanospace Project, Japan Science and Technology Agency)



Stretched Polymer Films

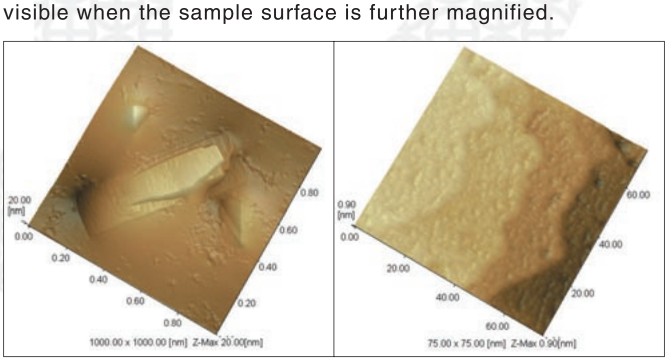
A polymer film was observed before and after stretching. The direction of stretching approximately matches the vertical axis of the image. The topographic image is at the left and the phase image is at the right.
A scale-like structure is apparent in the surface layer before stretching. After stretching, this surface layer has peeled away to reveal the layer below.



Powders

Zeolite

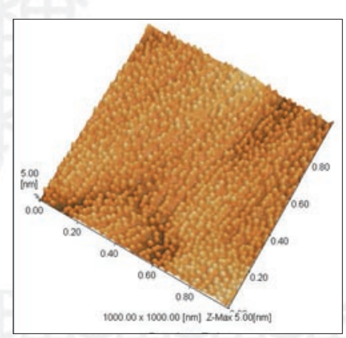
The left-hand images show square-shaped zeolite powder. Minute powder samples embedded in resin are easy to observe. The atomic step of several angstroms is clearly visible when the sample surface is further magnified.



Semiconductors

Quantum Dots

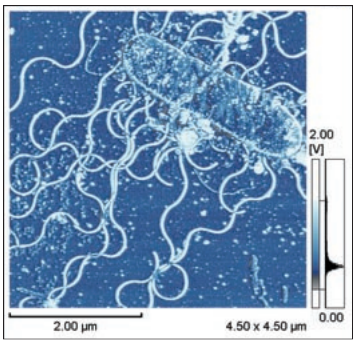
This image shows $In_{0.7}Ga_{0.3}As$ quantum dots MBE-grown on a 2 degrees-off GaAs (100) substrate. The AFM image offers important optoelectronic information about the quantum dots, including density, shape, and ordering.
(Courtesy of M.J. da Silva and Prof. A.A. Quivy, University of Sao Paulo)



Cells

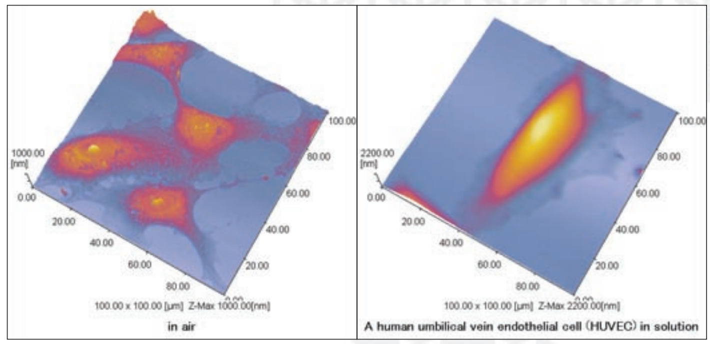
Lateral Flagella of Marine Bacteria

This image shows a bacteria culture (Vibrio alginolyticus 9) adsorbed on a cover glass and air-dried. The phase image shows the flagella at high contrast.
(Courtesy of Dr. Kogure, Ocean Research Institute, University of Tokyo)



Human Umbilical Vein Endothelial Cell (HUVEC)

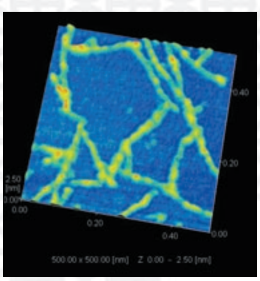
These are images in atmospheric air (left) and in a culture solution (right). A smooth cell surface is apparent in the culture solution. In the sample in air, however, holes have opened up, the cell has collapsed due to drying, and the nucleus has swollen.
(Using a Petri-dish-type solution cell.)
(Courtesy of Dr. Sugimoto and Dr. Takemasa, Department of Anatomy, Nippon Medical School)



Proteins

Fibroin protein

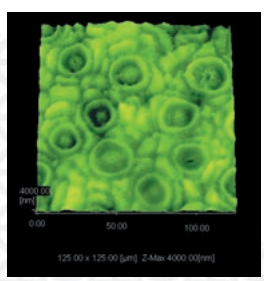
Fibroin protein from silk was refined and spread over a mica substrate. The fibrous elementary fiber and bead-like structures of fibroin can be observed.
(Courtesy of Dr. Takayuki Nagashima, Tokyo University of Agriculture)



Plants

Zelkova Leaf

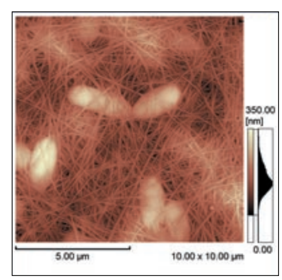
This image shows the stomata on the underside of the leaf.



Fibers

Cellulose

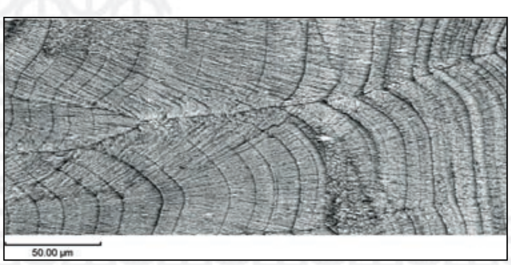
This image shows the cellulose fibers in nata de coco and the Acetobacter xylinum that creates them. It can be seen clearly how the fibers, which are only a few tens of nanometers thick, cross over each other.
(Courtesy of Prof. Azuma, Faculty of Agriculture, Kyoto University)



Teeth and Bones

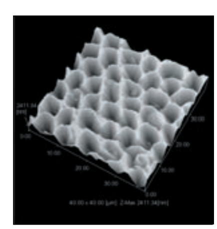
Bonito Otolith Cross Section

This image shows the otolith rings. As there are traces of growth in these rings, important data can be acquired concerning the migratory movement and growth of bonito and tuna.
(Courtesy of Mr. Tanabe, Tohoku National Fisheries Research Institute)



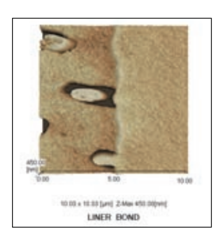
Honeycomb-like Structures in Teeth

This image shows the enamel surface of a tooth that has been etched with acid. Due to the difference in apatite crystals in the enamel, a crude honeycomb-like structure is formed when teeth are etched. This can be observed in a solution similar to that in the oral cavity. (Using a Petri-dish-type solution cell.)
(Courtesy of Dr. Nagamine DDS, Ph.D, Department of Operative Dentistry, Okayama University)



Tooth and Resin Joint

The boundary between the tooth dentin and the repair joint was imaged in water.
Gentle etching with a phosphoric acid solution reveals the adhesive penetration.
(Using a Petri-dish-type solution cell.)
(Courtesy of Dr. Yamada DDS, Ph.D, Department of Dentistry, Toranomon Hospital)



Environment Controlled Scanning Probe Microscope WET-SPM Series

For SPM Observations in Controlled Environments

The scanning probe microscope SPM-9600 Series can be upgraded to the environment controlled scanning probe microscope WET-SPM Series by adding the optional environment controlled chamber.
A unique feature of the SPM-9600 is the emphasis on working inside the chamber, including Shimadzu's unique sample replacement mechanism, operation from the front panel, fully-automatic approach, and open-head design.

The glove-port-type chamber allows sample preparation (cleaving, washing, drying, etc.) and sample replacement in a controlled environment. The combining of option items provides SPM observations in not only specified gas atmospheres, but also during sample heating and cooling, under controlled humidity and temperature, and during sample gas spraying. The WET-SPM is an innovative system that shows the dynamic world of nanometer-scale surfaces.

Environment Controlled Chambers CH-Ⅱ & CH-Ⅲ (Option)

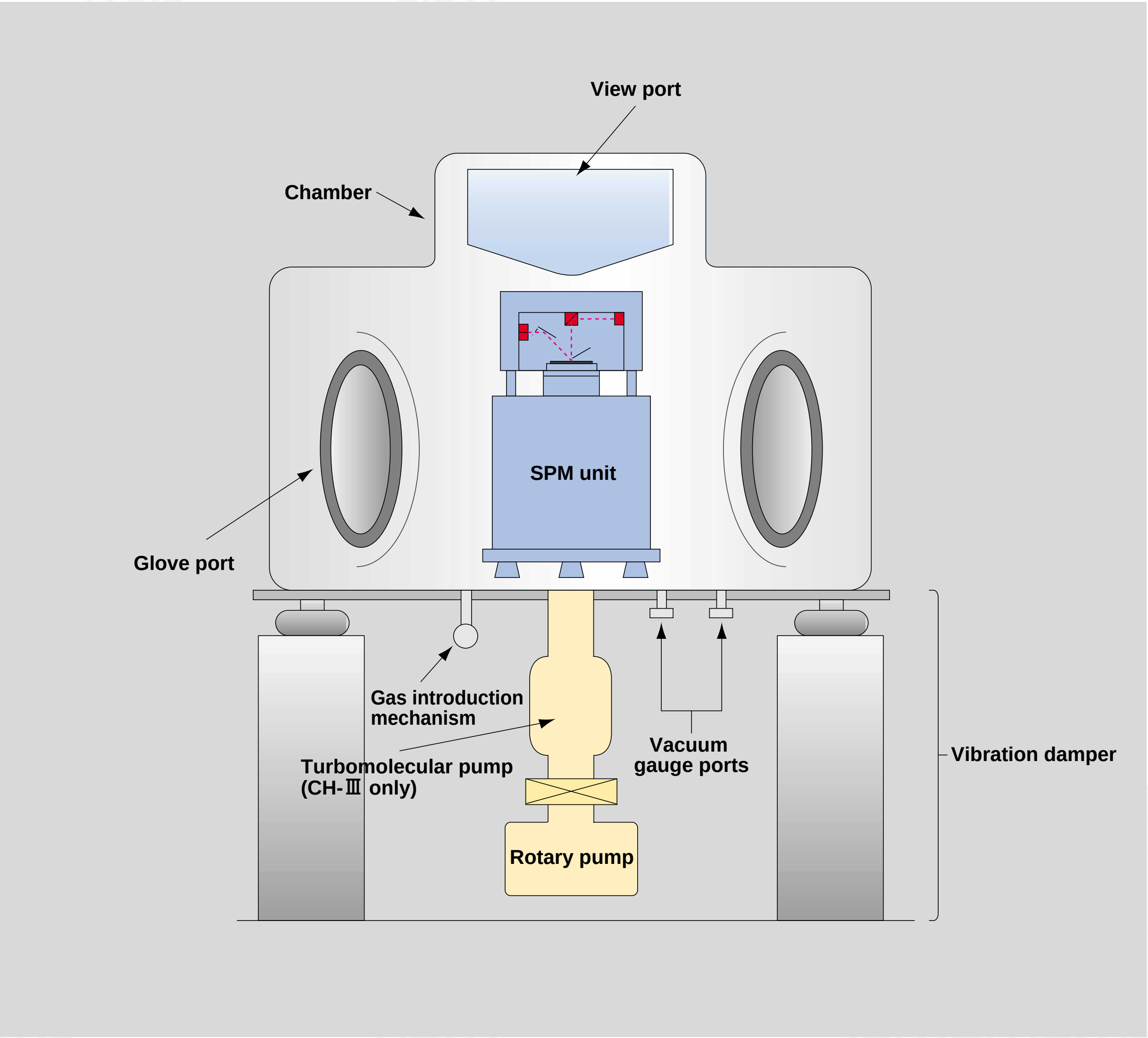
These environment controlled chambers, CH-Ⅱ (without TMP) and CH-Ⅲ (with TMP), were designed specifically for the SPM-9600 series as a glove-port-type chamber system with built-in vibration dampening. The SPM unit can be easily installed into the chamber from the rear. Changing from an ambient-atmosphere SPM to an environment controlled SPM opens the way for a wide range of applications (Japan Patent 2612395, US Patent 5200616). Since both the sample and surrounding environment can be controlled, the SPM can be used to directly observe samples processed in a controlled environment.

Unhindered pretreatment inside the chamber is possible thanks to the large viewing port and dual glove ports. Adding the option for in-situ SPM permits real-time investigation of surface changes due to changes in physical parameters such as temperature, humidity, pressure, luminescence, and concentration. The SPM can be easily loaded and unloaded while inside the chamber, allowing it to be used for both ambient atmosphere and controlled environment observations.

This photograph shows a sample system configuration.

Environment Controlled Scanning Probe Microscope WET-SPM Series

Chamber Configuration



Main Specifications

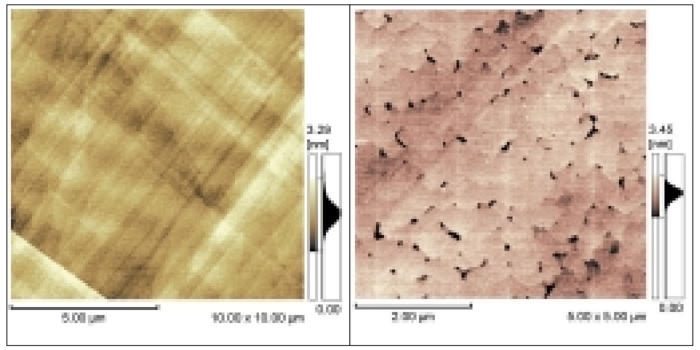
Port	Glove port	2
	Large view port	1
	Unit loading port	1
	Sample loading port	1
	Pumping port	1
	Spare port	4
Pumping System	Rotary pump (160 L/min)	
Pumps Used	Turbomolecular pump (50 L/s) (CH-Ⅲ only)	
Degree of vacuum	(CH-Ⅲ only)	
Gas introduction mechanism	Automatic control	
Current input terminals (7-pin)	16 (including spares)	
Vibration damper	Integrated air-spring vibration damper	

* See page 22 for a list of options available for the CH-Ⅱ & CH-Ⅲ environment controlled chambers.

Gas Atmosphere

Potassium Iodide Single Crystal (001)

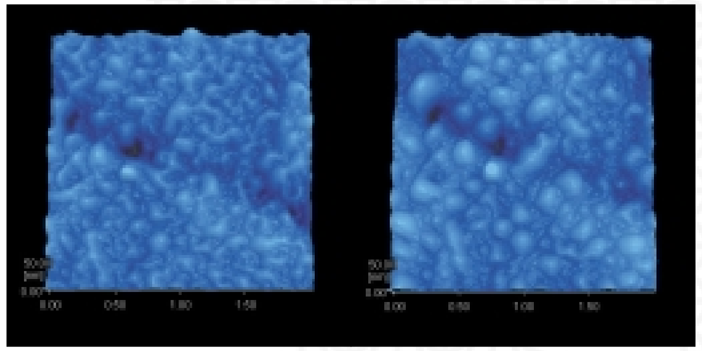
Potassium iodide is highly deliquescent. Cleaving potassium iodide in the presence of argon exposes the uppermost surface layer and permits the observation of atomic steps (left). Furthermore, heating in a vacuum to 400°C causes rearrangement of the surface, allowing [100] steps and etch pits to be observed (right).
(Courtesy of Dr. Yanagi, Faculty of Engineering, Kobe University)



Conduct SPM observations under an atmosphere of inert gas or other specific gas.

Resin

Changes in the surface shape of a resin sample were observed using ambient temperature and humidity control. The surface on the right (40°C, 60% RH) appears swollen in comparison with the surface on the left (28°C, 30% RH).

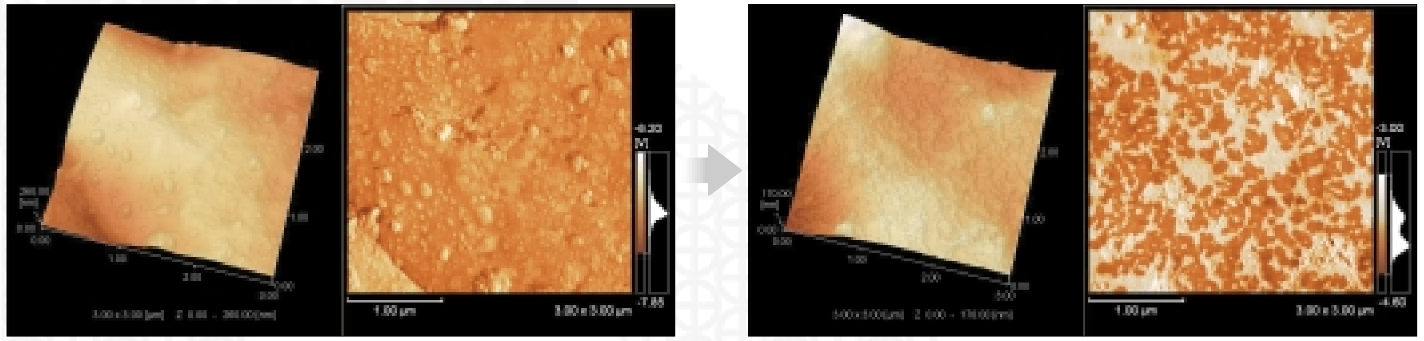


Chamber internal temperature and humidity can be controlled.

Sample Heating

Polymer Film

A special film was observed after heating to 30°C, and to 50°C. In both cases, the topographic image is on the left and the phase image is on the right. No differences can be seen in the topographic images, however, differences are clearly apparent in the phase images. The visible changes indicate changes in viscoelasticity due to heating-induced physical changes in the film.

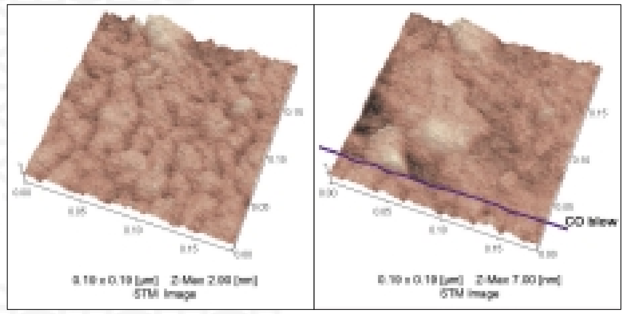


SPM observations can be performed while the sample is heated.

Gas Spraying

Real-time Observation of Changes in a Nickel Surface

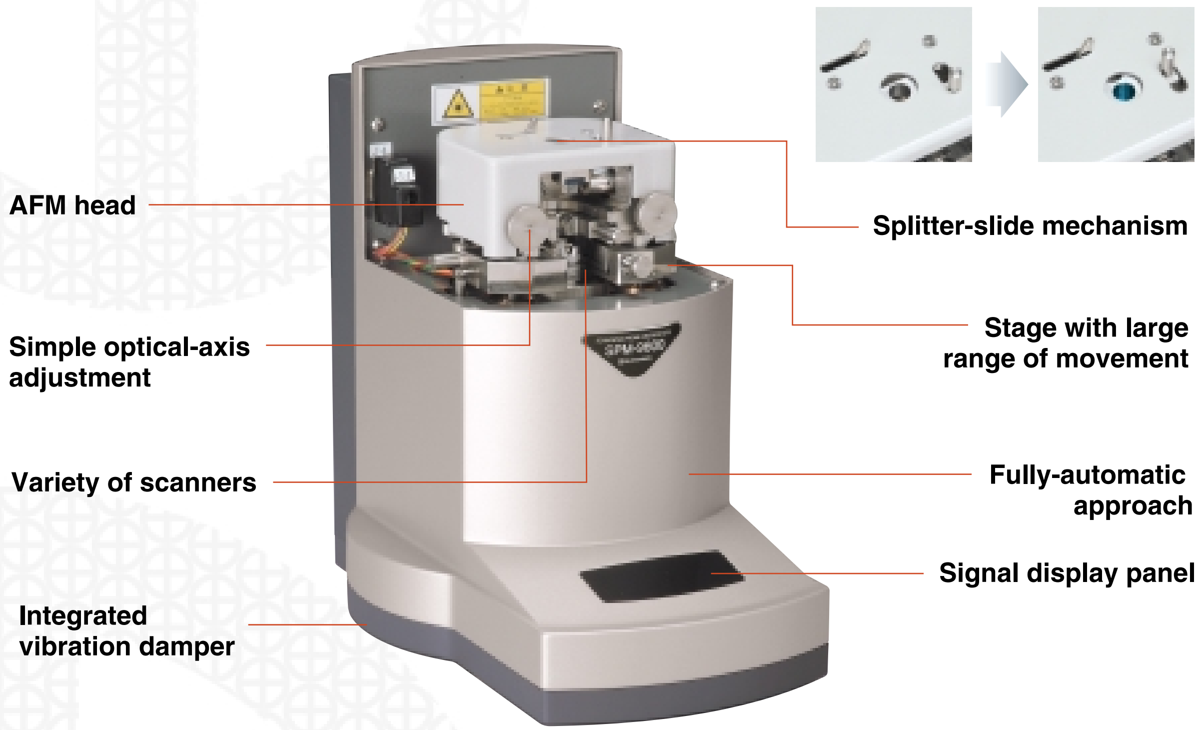
Real-time Observation of Changes in a Nickel Surface
Here, changes in a nickel surface during reaction with a gas were observed in real-time. The image on the left shows the surface in a clean state after reduction. The image on the right shows the change in shape due to carbonyl complex generation after carbon monoxide is blown onto the surface. (Using a gas spray unit and STM head.)
(Courtesy of the National Institute of Materials and Chemical Research)



SPM observations can be conducted during spraying with a designated gas.

SPM Unit

Chamber Configuration



One-Touch Sample Replacement

Front loading of the sample is easy thanks to the wide-type sample loading unit and Shimadzu's patented head-slide mechanism (Japan Patent 2833491).

AFM Head

The standard-type sample head accepts samples up to 24 mm diameter x 8 mm.
The head can be easily attached or detached using either magnets or screws.

Simple Optical-Axis Adjustment

This dial is used to adjust the laser's optical axis. All adjustments can be made at the front of the instrument, while watching the signal display panel. Adjustment is usually required only after the cantilever is replaced.

Integrated Vibration Damper

A gel-type damper is integrated into the compact body. As a result, observations at a magnification of 100,000x are possible when the unit is placed on top of a standard desk and the high-rigidity AFM head is installed.

Splitter-Slide Mechanism

The splitter-slide mechanism removes the beam splitter from the optical path to produce clear optical-microscope images. Observations from directly above are useful for determining the observed view field.

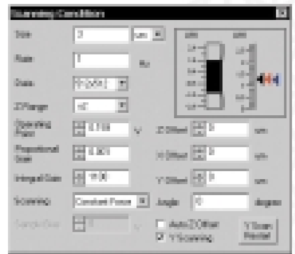
Wide-Range Movement Stage

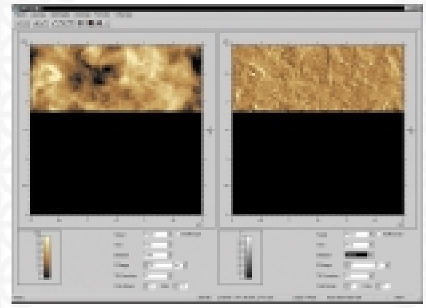
The AFM head can move up to 6 mm in the X and Y directions. (Standard AFM head)

Real-time Operation Using Windows®

Online Applications

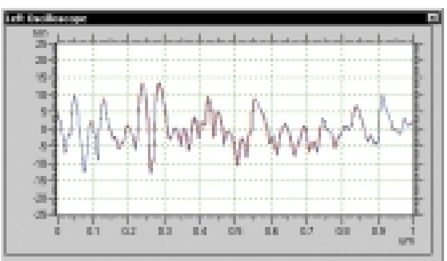
Windows® provides a familiar English-language interface, and an integrated single-monitor display allows anyone to use the instrument with ease.





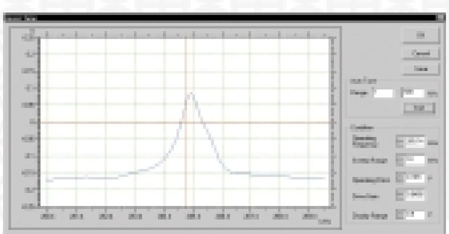
Scan Profile Display

Real-time display of the signal profile during scanning allows checking of the scanning status and the observation screen at the same time.



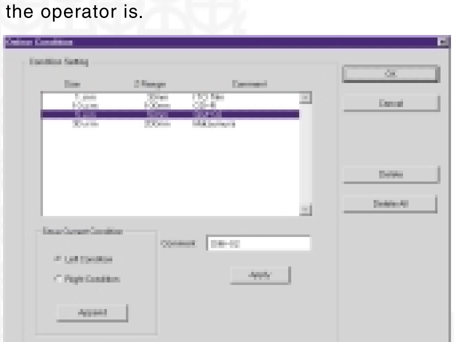
Lever Tuning

During cantilever excitation the resonance point can be measured and the operating point can be automatically set. Only a few, simple operations are required to measure and display the resonance point, and save it in real-time.



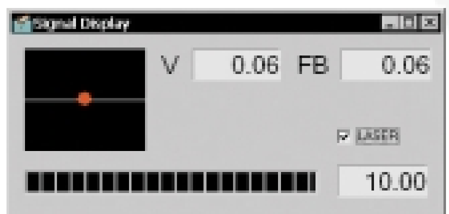
Saving and Loading Observation Conditions

Observations can be saved and reloaded later, allowing observations of identical samples under identical conditions, regardless of who the operator is.



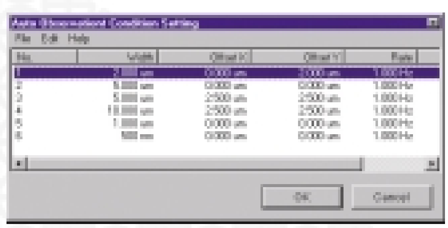
Signal Display

Photodetector signals can also be checked using the monitor. The laser can also be turned on or off from this display.



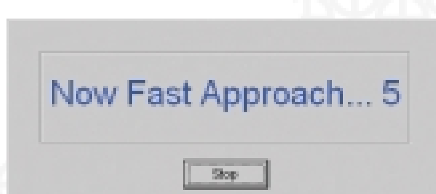
Continuous Auto Observation

Images can be captured sequentially according to preset parameters. The cantilever ascends automatically when all measurements are complete, permitting unattended automatic operation.



Operation Status Display

A single glance of this display shows the cantilever position and error messages and indicates the status of the SPM-9600.



Y Scanning Restart Function

Even if observation conditions are changed during scanning, this function allows subsequent imaging to be restarted immediately.

Cantilever Probe Protection Function

To protect the probe tip and the sample, the cantilever automatically ascends if the surface is very uneven.

Z Offset Auto Tuning

Measurement range is optimized for Z-axis surface-shape displacement. This maintains the optimum measuring range and provides continuous high-resolution vertical measurement.

High-Resolution Digital Control

X and Y axes are controlled at normal 16-bit accuracy, regardless of the scanning range. The Z axis is controlled at up to 26-bit accuracy. Feedback control via a digital signal processor provides flexible control.

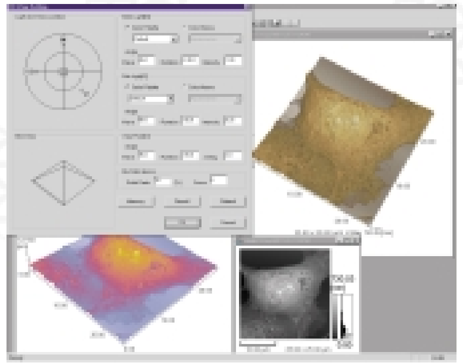
Input Signals

Four input signal channels can be monitored simultaneously, and this can be increased to seven signal channels by adding options. Unused input signal ports can be used as desired.

Comprehensive Image Display, Processing, and Analysis Software

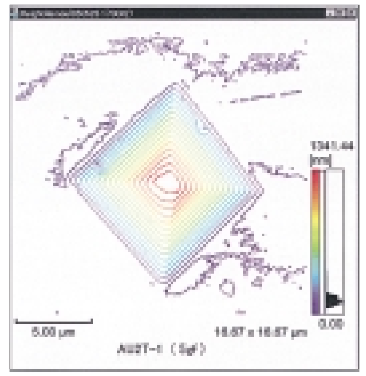
Three-dimensional Display

Size, view angle, display colors, and gloss can be set as desired for the three-dimensional image display.



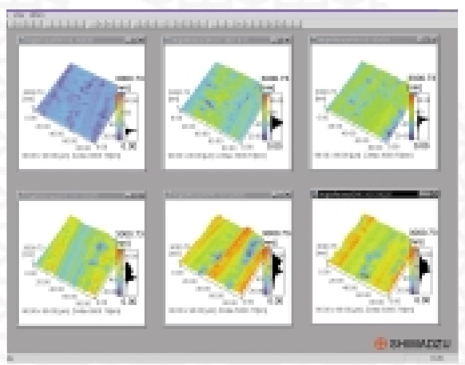
Contour Display

Represents data as contour lines using the designated color palette and number of lines.



Display Range Standardization

Height range can be changed as required and even though multiple data readouts are displayed simultaneously, the height range is standardized to allow comparison of surface roughness at a single glance. (Japan Patent 2770764)



Color Palette

If desired, the display color palette can be easily created and saved. The color tone of each data display can be optimized.

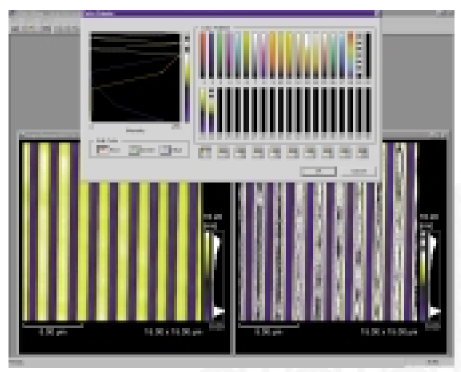
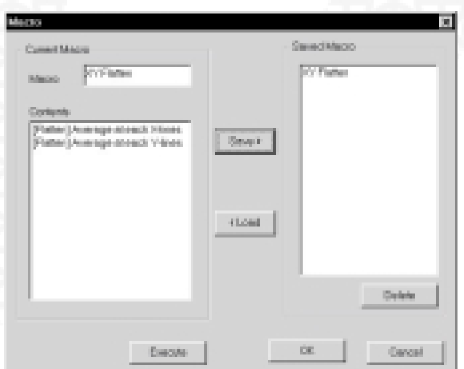


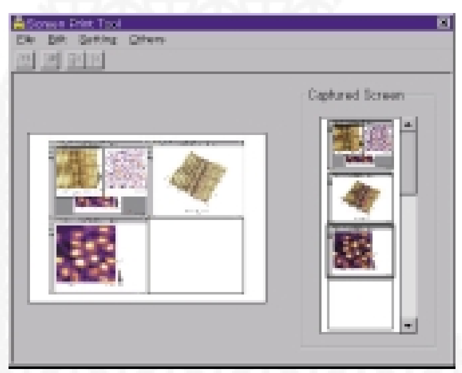
Image-Processing Macros

A sequence of image-processing operations can be saved for subsequent call-up and execution. This allows the same processing to be performed on multiple images by clicking a single button.



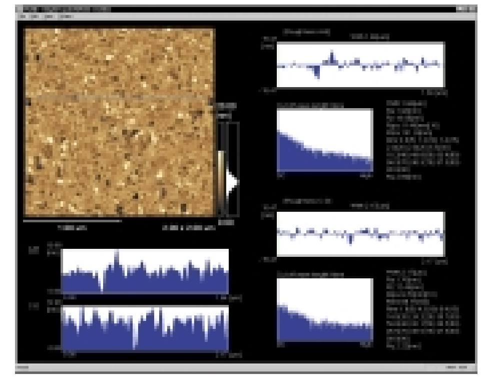
Screen Print Tool

Up to four screens –– 3D displays or analysis results –– can be freely formatted and output to a printer.



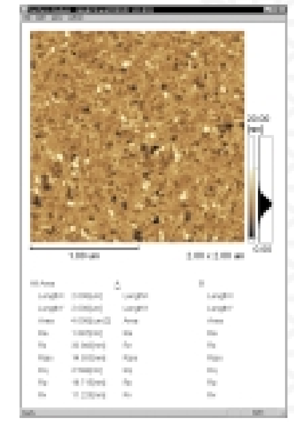
Cross-Sectional Analysis

Up to four cross-sectional curve profiles between two arbitrary points can be displayed. Each curve can be analyzed (distance, height difference, and angle) in up to three sections. In addition, average roughness and maximum height can be determined.



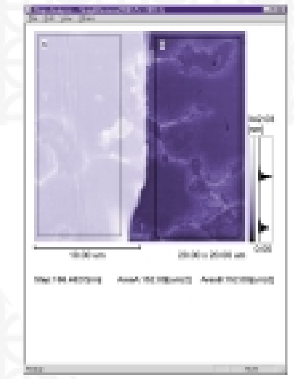
Surface Roughness Analysis

Analyzes surface roughness over two-dimensional regions.



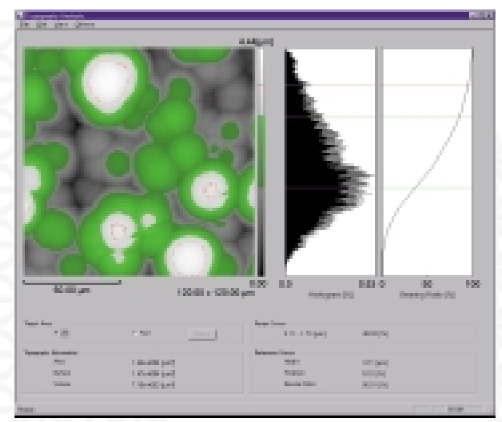
Average Step Measurement

Determines the average height for two specified regions (lines or surfaces) and measures the height difference.



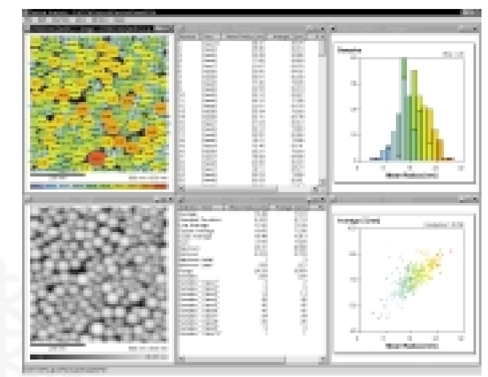
Configuration Analysis

Analyzes the histogram and bearing ratio to calculate the area, surface area, and volume of a specified region.

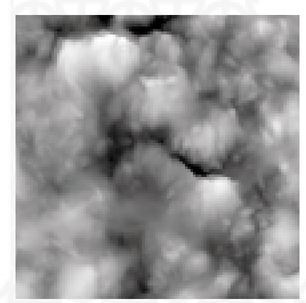


Particle Analysis Software (Option)

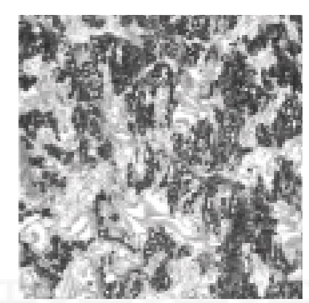
Extracts particle or hole shapes from image data to determine the feature values of individual particles. Can statistically process these feature values in order to classify the particles. Twenty-nine feature values are provided, including radius, area, volume, and circumference. Useful for grain-shape analysis and counting protrusions.



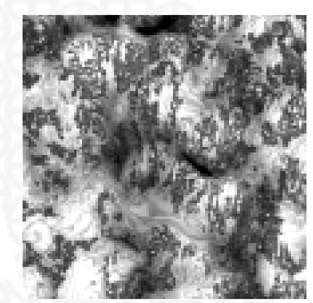
Operations Between Images



Shape image



Phase image



Addition of shape image and phase

Allows the use of this data in other applications for a variety of processing and analysis.

Main Specifications

1. SPM Unit

Measuring modes	Basic mode specification	Contact, Dynamic, Phase
	Full mode specification	Contact, Dynamic, Phase, Force Modulation, Current, Magnetic Force (MFM), Surface Potential (KFM), Horizontal Force (LFM)
Resolution	Horizontal	0.2 nm
	Vertical	0.01 nm
AFM head	Displacement detection system	Light source/optical lever/detector
	Light source	Laser diode (650 nm, 1 mW max., ON/OFF)
	Detector	Photodetector
Scanner	Drive	Tube piezo element
	Max. scanning range (XYZ)	30 µm x 30 µm x 5 µm (standard)
		125 µm x 125 µm x 7 µm (option)
		55 µm x 55 µm x 13 µm (option)
Stage	Max. sample size	24 mm dia. x 8 mm
	Sample replacement method	Head-slide mechanism
	Sample fixing method	Magnetic
	Head travel range	6 mm x 6 mm
Z-axis coarse feed	Method	Automatic, using stepping motor
	Max. travel range	10 mm
	Min. step width	21.4 nm
Signal display panel	Displayed quantity	Full luminescence (digital display)
Vibration damper	Anti-vibration base	Built into SPM unit

2. Controller

Scan controller	X/Y-axis output	±210 V, continuous 16-bit accuracy
	Z-axis output	±210 V, max. 26-bit accuracy
Feedback controller	Control system	Digital DSP control
Communications interface	Protocol	TCP/IP

4. Standard Accessories

Sample holders	Standard type	1 set (10)
Cantilevers	For contact mode	1 set (34 chips)
	For dynamic mode	1 set (10 chips)
Standard samples	Precision grating	1
	Vapor-deposited niobium plate	1
Maintenance parts	Tools	1 set
Instruction manual		1 set
Backup media		1

* Refer to SPM-9600 Standard Specifications for details.

3. Software

Online measurements	Input signal	4 channels (simultaneous measurement) 7 channels (option)(simultaneous measurement)
	Scanning direction	Trace/retrace (simultaneous measurement possible) Angle setting can be changed.
	Scanning range	0.1 nm to max. scanning range (depending on scanner type) Offset setting can be changed Online zoom
	Scanning speed	0.0151Hz to 100Hz
	Number of measured pixels	512 x 512, 256 x 256, 128 x 128, 64 x 64, 32 x 32
	Data size	544KB, 160KB, 64KB/screen
	Z-axis output settings	Sensitivity, offset (automatic adjustment available) Operation monitor display
	Displays during scanning	Variable Shade Image (Top View) 3D Display (Shade, Mix) Settable Z-Axis Range Switch Display Colors (400 Types) Oscilloscope Display (Window Display) Real-time tilt correction
	Cross-section profile display	Display of online measured length and online profile between any two points
	Status display	Displays the operating status of the main unit.
	Formatted observation	Save and load measurement parameters.
	Calibration	Independent calibration of each axis (X, Y, and Z)
	Y scanning	ON/OFF switching, restarting, change start position (top, middle, bottom)
	Automatic observation	Max 256 settings
	Lever tuning	1 kHz to 500 kHz (automatic adjustment available)
	Amplitude/phase detection	1 kHz to 500 kHz
	Signal display	Full laser luminescence (numeric and indicator display) High-low difference (numeric display) Feedback quantity (numeric display) Left-right difference (numeric display)(option)
Online measurements	Multiple screen display	Max. 40 screens
	Image display	Variable Shade Image (Top View) - permits length measurements Pseudo-3D Display, 3D Display Light source, view angle, and gloss settings for 3D-image display/Contour display Create, edit, and select color palettes Change Set Z-Axis Range setting / Set Z-Axis Units Reduced display/enlarged display / Create icons Measurement Parameter Display / Image processing history display
	Line display	Comment entry and display Overlay, tiling, overwriting Line colors can be changed.
	Image processing	Reduced display/enlarged display/Create icons Tilt correction, Noise line elimination Local filter, Frequency filter Image enlargement, inversion, and rotation
	Image analysis	Resolution conversion, Line extraction, Macro functions / Cross-section profile analysis / Line roughness analysis Surface roughness analysis / Shape analysis / Average step measurement / Power spectrum analysis / Self-correlation analysis / Fractal analysis / Line data length-measurement analysis / Line data roughness analysis
	File output	DIB formant (bitmap) TIFF format / ASCII format
	Maintenance	Changing group name/data name Deleting, copying, moving, and searching data Creating and deleting folders
Screen print tools	Capture	Screen capture
	Layout	Select 1, 2, or 4 screens

Main Options

To Adjust Optical Axis and Align Observation Field

Optical Microscope Unit with CCD

P/N 211-39474-91

Allows observation of the sample and cantilever tip from directly overhead. CCD camera supplied allows observations to be displayed on the PC monitor. Images can be saved or processed. 70x magnification is provided on the PC monitor. (Additional magnification is possible with an external monitor.)

Optical Microscope Unit

P/N 211-39474-92

Allows direction observation through the ocular lens. 40x magnification (ocular 20x; objective 2x). (Does not include CCD camera.)

Fiber Light

P/N 046-61817-11

Illuminates the sample surface and cantilever tip in order to perform observations with an optical microscope unit.

High Magnification Optical Microscope Unit

P/N 211-39473-91

The CCD camera included allows observations to be displayed on the PC monitor. High-level magnification allows accurate positioning. Images obtained can be saved or processed. Coaxial epi-illumination is used. Magnification from 28x to 525x is provided on the PC monitor. (Additional magnification is possible with an external monitor.)

Optional Scanners

Wide Range Scanner Unit

P/N 211-38401-01

Maximum scanning range (X,Y)
125 µm x 125 µm
Maximum measuring range (Z)
7 µm

Deep-type Scanner Unit

P/N 211-38401-02

Maximum scanning range (X,Y)
55 µm x 55 µm
Maximum measuring range (Z)
13 µm

Narrow Range Scanner Unit

P/N 211-38401-04

Maximum scanning range (X,Y)
2.5 µm x 2.5 µm
Maximum measuring range (Z)
0.3 µm

For Observations in a Solution

Petri Dish Type Solution Cell (Contact Mode only)

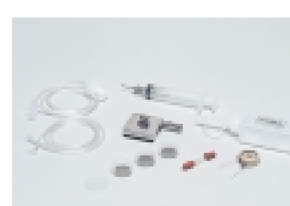
P/N 211-37690

This is an open cell used for AFM observations of samples immersed in a solution. Sample is attached to the bottom of a small Petri dish and scanned while immersed in a solution. Solution cell is glass. Three cells are supplied as standard accessories (two 4 mm deep; one 6 mm deep).

For Observations During an Electrochemical Reaction

Electrochemical Solution Cell P/N 211-38175

This cell is used for AFM observations of sample surface changes while an electrochemical reaction occurs in an electrolytic solution. Cell includes three standard electrodes: working electrode, counter electrode, and reference electrode. Includes a Petri-dish-type solution cell.
(Does not include the separately-ordered Electrochemical Controller (Potentiostat).)



Main Options

Acquiring Information Not Related to Surface Shape (Full-mode Specification)

Force Modulation System

Measures viscoelasticity during contact mode measurements.

Accessories	Si cantilever		1 set (10 chips)

Current System

Measures and displays the current flowing between the sample and probe during contact mode measurements.

Accessories	Special cantilever holder		1
	Cantilever	Si (Pt/r coated)	1 set (10 chips)
	Standard sample	SiO2/Si pattern	1

Magnetic Force (MFM) System

Visualizes magnetic information about the sample surface.

Accessories	Magnet		1
	Non-magnetic tweezers		1
	Cantilever	Si (magnetic coated)	1 set (10 chips)

Surface Potential (KFM) System

Measures surface potential distribution across the sample surface.

Accessories	Special cantilever holder		1
	Cantilever	Si (Pt/r coated)	1 set (10 chips)

Lateral Force (LFM) System

Measures and displays the twisting of the cantilever.

Accessories	Cantilever	SiN	1 set (34 chips)

* To install the above systems the SPM-9600 must be sent to the Shimadzu factory.

For Environmental Control

Environment controlled Chamber CH-Ⅱ (without TMP)

P/N 211-39460-91

Environment controlled Chamber CH-Ⅲ (with TMP)

P/N 211-39460-92

See page 8.

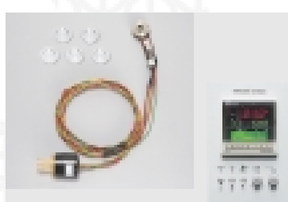
Sample Heating Unit

P/N 211-37970-03

Sample can be loaded into the unit and heated.

Some types of samples can be heated in the atmosphere.

Temperature setting range: room temperature to 300°C (sensor position)



Gas Spray Unit

P/N 211-38135

The gas spray unit is attached to a spare port to spray small amounts of gas on the sample.

- Minimum leakage: 6.7 x 10^{-9} Pa.m^3/s

Chamber Attachable Optical Microscope Unit P/N 211-38125

Chamber Attachable Optical Microscope Unit with CCD P/N 211-38125-04

This microscope offers 20x monocular magnification (ocular lens 20x; objective lens 1x).

CCD camera allows viewing of observation data on the PC monitor. 35x magnification is provided on the PC monitor. (Additional magnification is possible with an external monitor.)

Temperature and Humidity Controller

P/N 211-38050

Controller is attached to environmentally controlled chamber and controls the temperature and humidity inside the chamber.

- Temperature range: room temperature to 55°C
- Humidity range: 5% RH to 80% RH

Sample Heating and Cooling Unit

P/N 211-37970-02

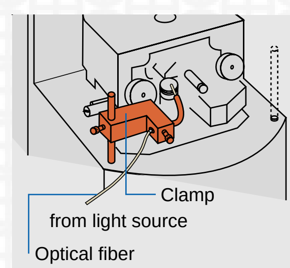
Sample can be loaded into the unit and heated or cooled.

- Temperature range: -90°C to 300°C (sensor position)

Light Irradiation Unit

P/N 211-38195

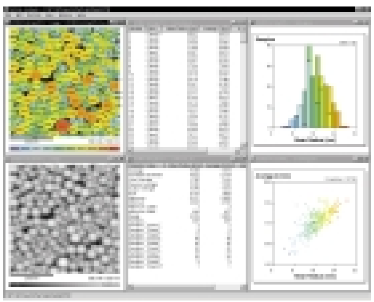
This unit shines light through an optical fiber onto the sample surface. It does not include the light source or the optical fiber. It can be used in the atmosphere.



Optional Software

Particle Analysis Software P/N 211-38151-04

To determine the feature values of individual particles this software extracts particle or hole shapes from image data. A total of 29 feature values are available, including average radius, roundness, surface area, and volume. In addition to list, histogram, and correlation graph displays, a total of 12 types of statistical analysis, including mean and standard deviation are provided. Also, enhanced data partitioning functions are available, to classify particles according to specified feature values and display their classes in color.



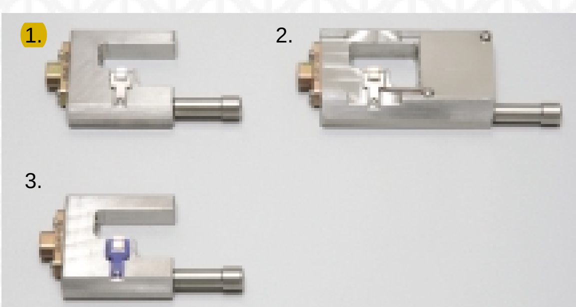
Software License for SPM-9600 (secondary use permitted) P/N 211-39951-92

Purchasing this license allows this software to be used for data processing on a separate, second PC (provided by the user).

Cantilever Holder

1. For contact mode & dynamic mode P/N 211-36343
2. For current system P/N 211-38031
3. For surface-potential (KFM) system P/N 211-36343-01

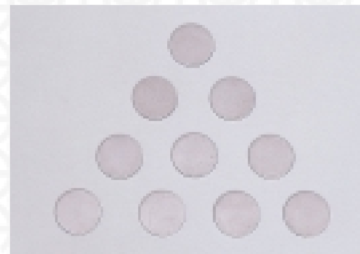
One type (1) cantilever holder is provided as standard equipment.
One of each type of cantilever holder (1), (2), and (3) is supplied with the full mode specification.



Sample Holder

Sample Holder P/N 211-37642

Special-use sample holder. (diameter: 15 mm)
One set includes ten holders.
One set is included as standard equipment.



Desk

Desktop-Use Air-Spring Vibration Damper

An air-spring vibration damper for desktop use or with an environmentally controlled chamber is recommended to eliminate the effects of floor vibrations on SPM observations with a view field of 1 µm or less (greater than 100,000x magnification).

OA Table P/N 088-20096-02

- External Dimensions (mm)
  (W) 1200 x (D) 800 x (H) 700

Consumable Parts

1 Cantilever for contact mode	SiN, set of 34 chips	P/N 239-01402-05
2 Cantilever for LFM	SiN, set of 34 chips	P/N 239-01402-09
3 Cantilever for dynamic mode (standard)	Si, set of 20 chips	P/N 046-39103-12
4 Cantilever for dynamic mode (for soft samples)	Si, set of 20 chips	P/N 046-39105-11
5 Cantilever for MFM (magnetic force) system	Si, set of 20 chips	P/N 046-39103-42
6 Cantilever for current system	Si, set of 20 chips	P/N 046-39103-52
7 Cantilever for force modulation system	Si, set of 20 chips	P/N 046-39103-22
8 Cantilever for surface potential (KFM) system	Si, set of 20 chips	P/N 046-39103-32
9 Cantilever with carbon nanotube probe	Contact your Shimadzu representative for details	

Basic Construction

Installation Specifications

Installation Environment

The following air-conditioning conditions are appropriate for the room where the SPM is installed.

- Temperature: 23°C ± 5°C
- Relative humidity: 60% max.

Power Supply

The following power supply is required to operate the SPM-9600.

- Single-phase 100 – 120 V / 200 – 240 V, 50/60 Hz, 10 A – single circuit
- Grounding resistance: 100Ω max.

Size and Weight of Units

- SPM Unit (W) 180 x (D) 255 x (H) 260, 5.5 kg
- Controller (W) 250 x (D) 420 x (H) 454, 18.5 kg

* Table is not included with the instrument.
* Appearance of actual PC may differ from that shown here.

SPM Data Room

Have a look at information about the by Shimadzu SPM, including sample observations, Application News, Theses, and other information at:

http://www1.shimadzu.com/products/lab/surface.html

JQA-0376

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