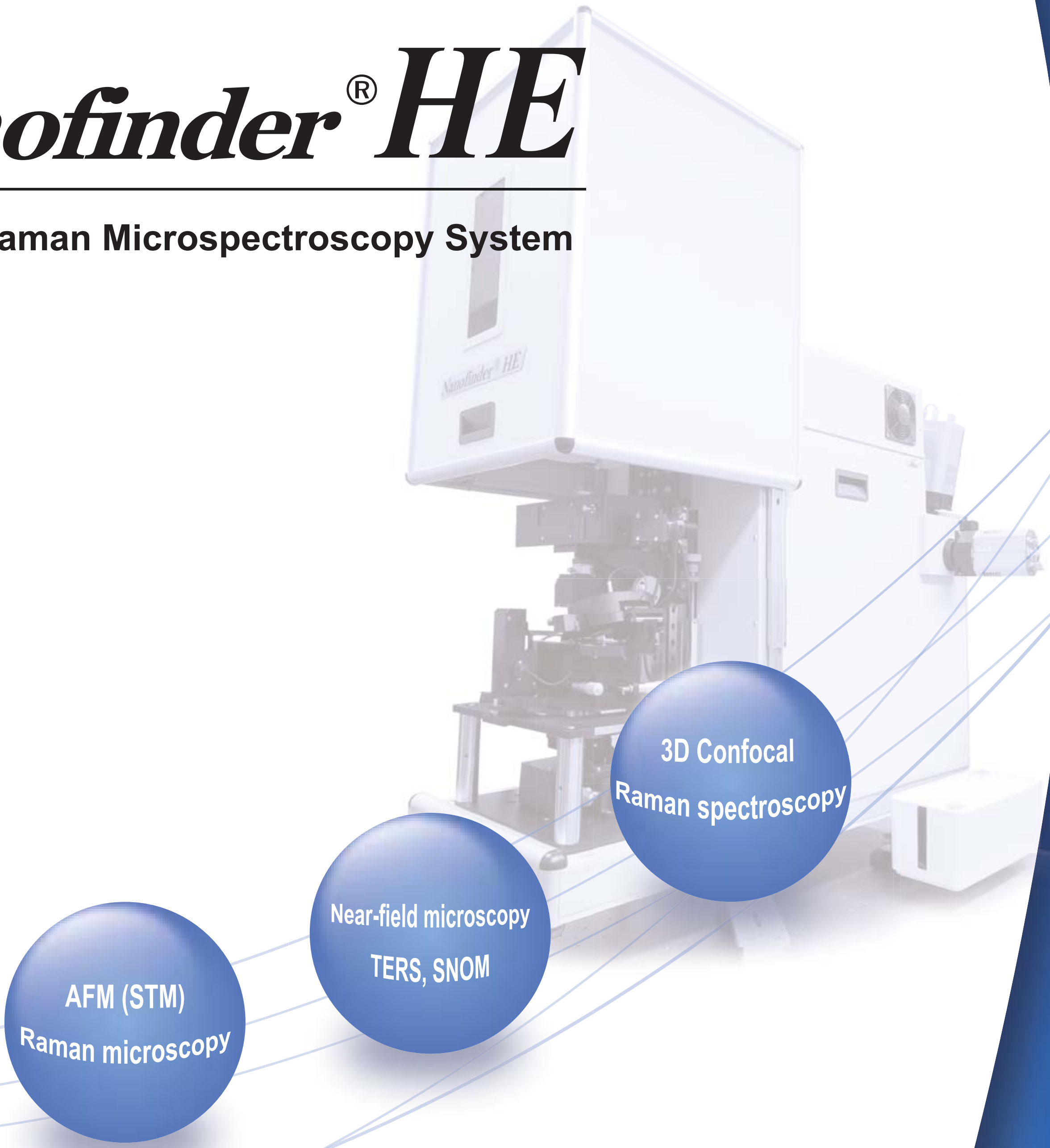
Nanofinder® HE

3D Laser Raman Microspectroscopy System



株式会社 東京インスツルメンツ
TOKYO INSTRUMENTS, INC.

Contents

AFM-Raman High End spectroscopy system

AFM-Raman

AFM-Raman configurations: reflection and transmission
Simultaneous measurement of surface topography and confocal Raman imaging*
High speed: < 3 ms / point (with simultaneous full spectrum and AFM signal saving)*

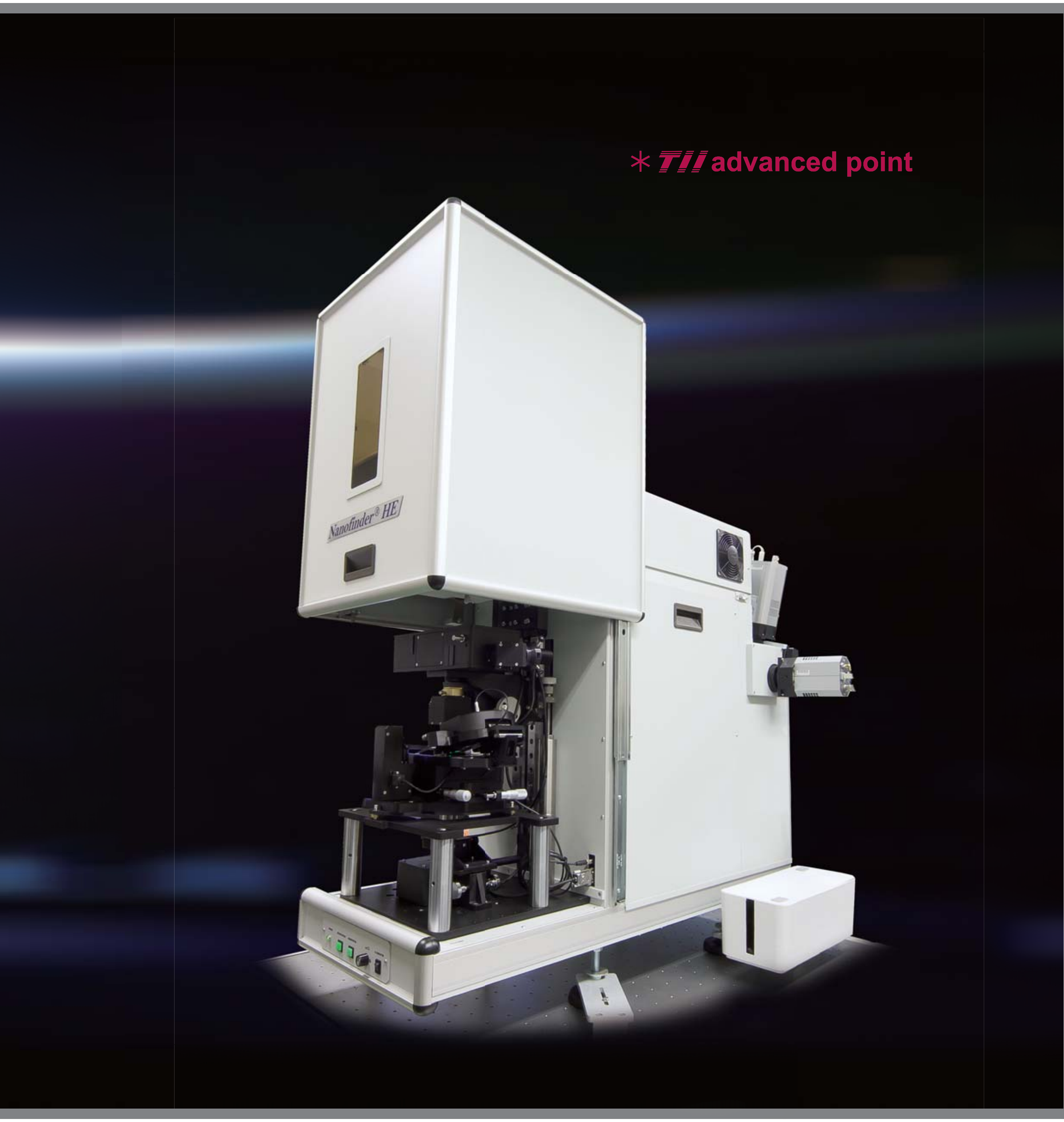
Near-field Imaging

TERS(Tip Enhanced Raman Spectroscopy)
SNOM (Scanning Near Field Optical Microscopy)
Spatial resolution: < 80 nm by near-field technology

3D Confocal Raman Microscopy

High sensitivity: Detection of weak 4th order Si peak (1 min.)*
High spatial resolution:Below 180 nm lateral, 400 nm axial (with immersion objective lens)*
High mapping speed:< 3 ms / point (with full spectrum saving)*

Nanofinder® HE



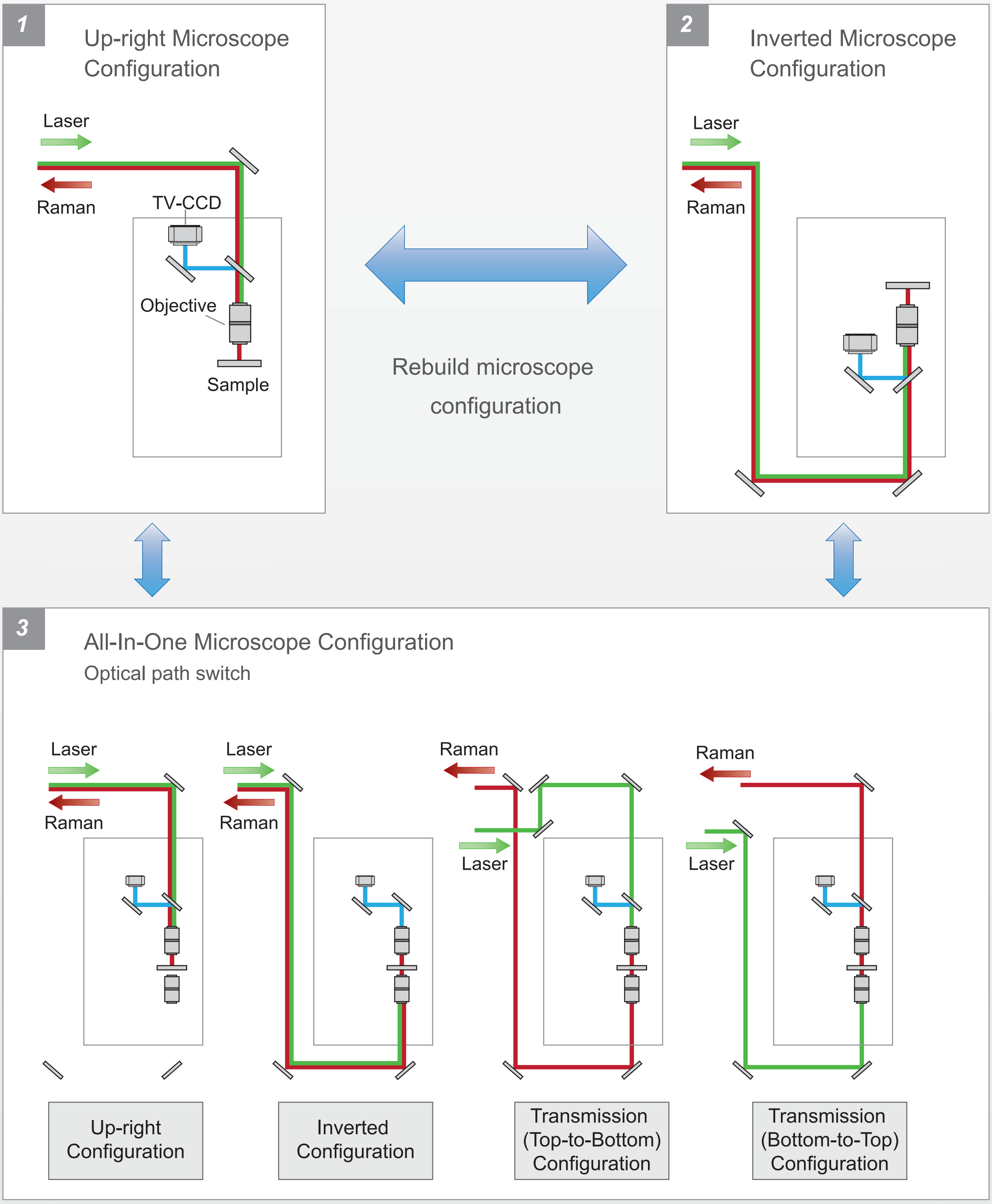
Prototype(The exterior appearance of the product will be slightly different.)

Multi-configuration microscope

Up-right, Inverted, Transmission and Inverted-Transmission*

Built-in microscope configurations are available.

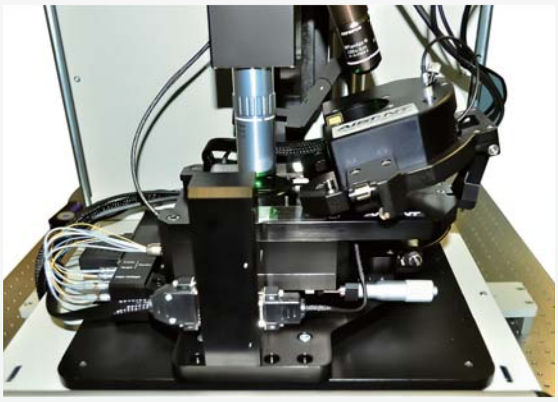
Optical path of laser excitation and Raman signal detection can be changed with 3 sliders.



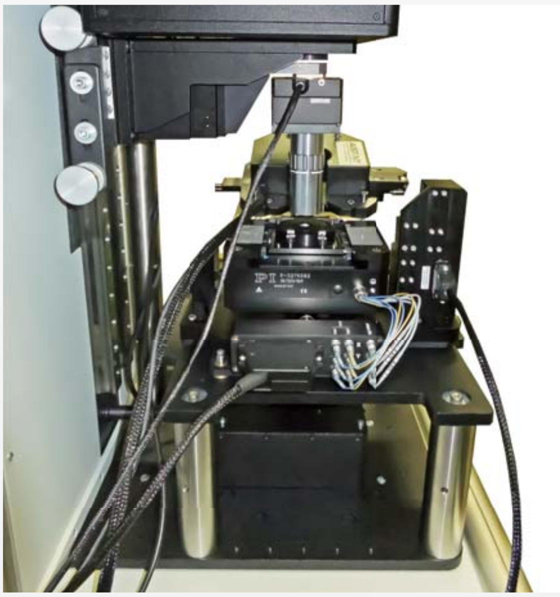
Multiple scanner configurations*

Piezo-stage, Step-motor, AFM, etc. (more than 10 different configurations are available)

Configuration examples

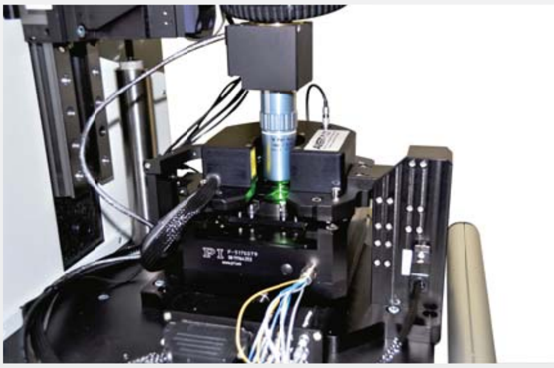


Confocal Raman upright microscope after sliding AFM head



AFM-Raman transmission microscope

AFM-Raman inverted microscope



AFM-Raman upright microscope

Multi-configuration microscope

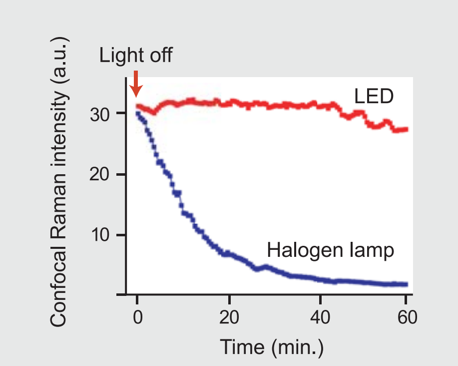
High stability: thermal and temporal

Granite Frame＊

Thermal and temporal stability are achieved due to a granite frame. Optics, spectrometer and microscope are all installed on a single granite frame in order to avoid mechanical drift of sample, confocal pinhole or spectrometer components.

LED Illuminator

LED illuminator with less heat liberation minimizes thermal strain of the microscope system. In case of illumination ON/OFF and light variation it has negligible heating effect.



Influence of illumination heating for measurement stability

Isolated Sample Area

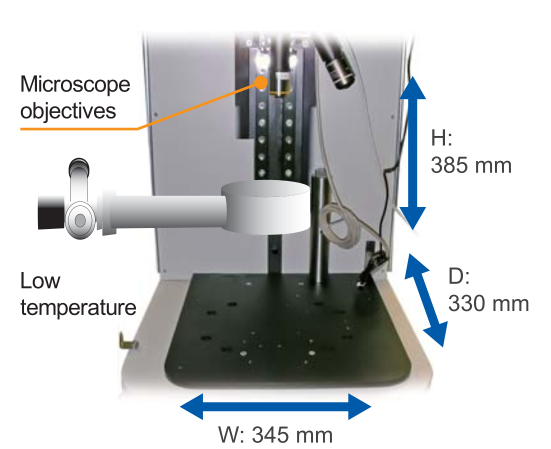
Sample area is protected with a microscope cover. Air flow influence, stray light penetration, acoustical vibrations can be fully suppressed or minimized in the isolated measurement facilities.

Smart Sliding Mechanism

This mechanism enables the user to move the focusing unit smoothly up and down using weight compensation spring and air suspension lever. Positioning reproducibility of the focusing unit is below 1 μm.

Large working space＊amplifies potential applications

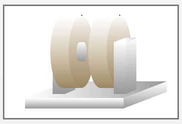
Large working space under the objective lens 345(W)×385(H)×330(D) mm allows the user to install various equipment, such as piezo stage for high resolution Raman imaging, AFM, cryostat, heating&cooling stage, high pressure chamber, magnetic facilities, etc.

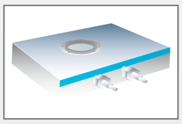


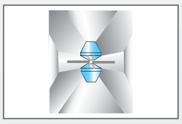
Work space


AFM


XYZ-piezo stage

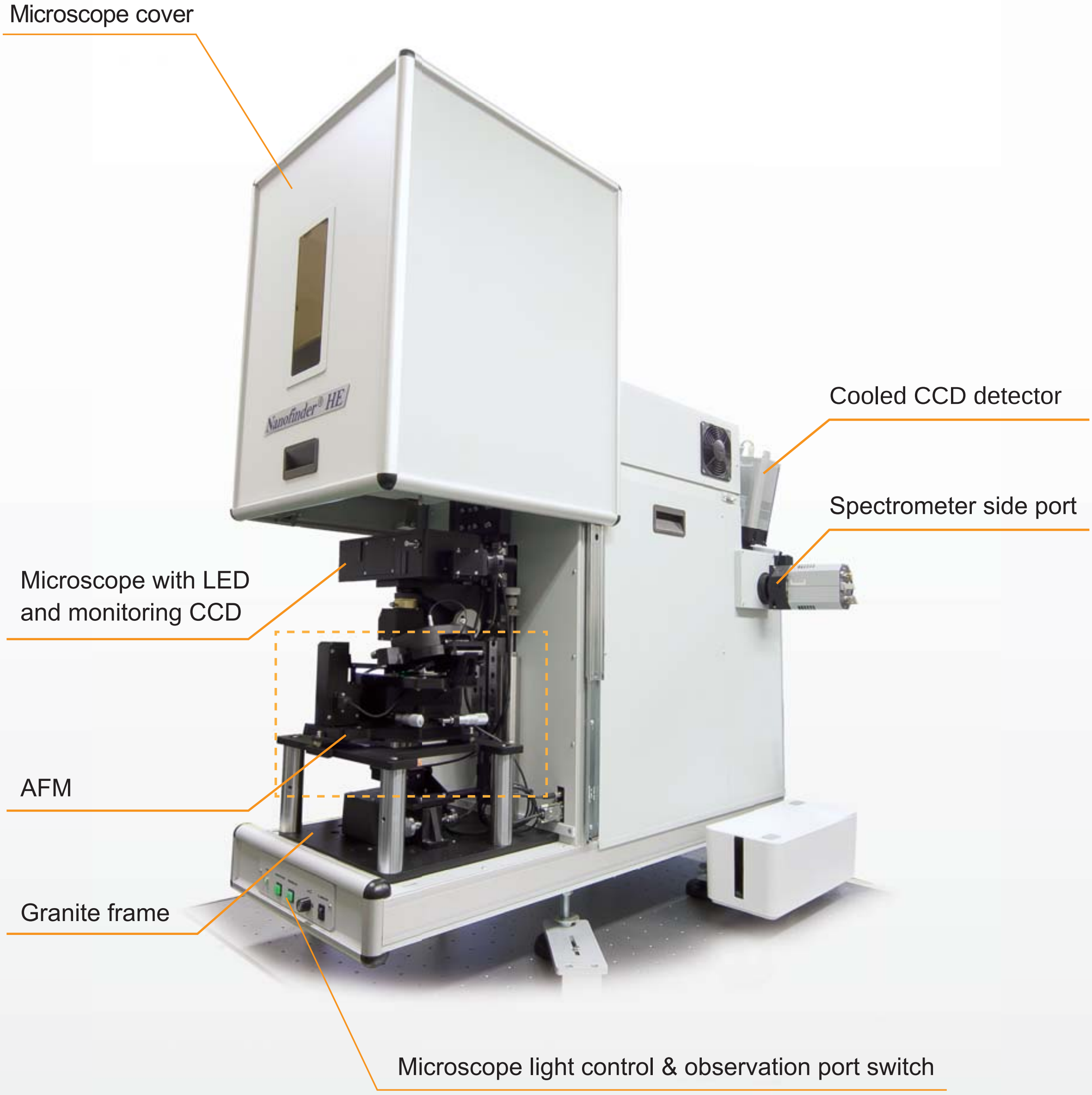

Magnetic field


Heating&cooling stage


High pressure (Diamond anvil cell)


Low-temperature cryostat

Upright microscope configuration(AFM-Raman)



High accuracy of spectral data

Automatic spectral calibration with built-in hollow cathode lamp *

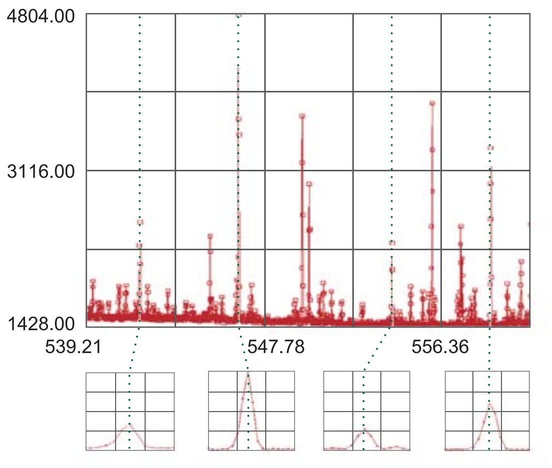
Spectral calibration is performed automatically when the user changes wavelength range or selects a different grating. It is also possible to confirm current device calibration by pressing a single button on the program interface at any time.

Precise calibration algorithm

Based on spectrometer geometry the calibration algorithm ensures spectrum accuracy within 1 pixel of CCD detector.

Rich spectrum of hollow cathode lamp

Precise spectrometer calibration is possible for any grating (including echelle type) at any wavelength range due to large number of spectral lines.



Hollow cathode lamp is applied for spectrum calibration at 550 nm central wavelength. Grating 1800 G / mm.
Green dashed lines show reference table spectral lines.

High spectral resolution

High resolution spectrometer

Focal length of 550 mm.

High aberration quality

Spectral line width (FWHM) of 24 μm on CCD detector can be achieved.

Typical Specification

Spectrometer focal length 550 mm	Grating 1800 G / mm	Echelle Grating 75 G / mm
Spectral resolution	0.8 cm^{-1}	0.25 cm^{-1}
Spectral accuracy	0.43 cm^{-1}	0.1 cm^{-1}

※ at 550nm, with CCD pixel size 16×16 μm

Echelle grating *

Echelle grating grants dramatical increase of spectral resolution by utilizing higher diffraction orders.

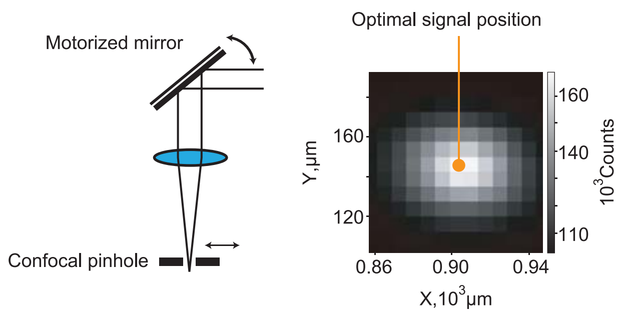
Automatical self alignment

Built-in motorized mirror *

Motorized tilt control ensures exact Raman signal positioning onto a true pinhole. Pinhole consists of 2 independent motorized orthogonal slits.

Computer controlled alignment

Software ensures mapping of Raman signal onto confocal pinhole and placing the signal in optimal position. Fine confocal alignment can be done within 1 min.

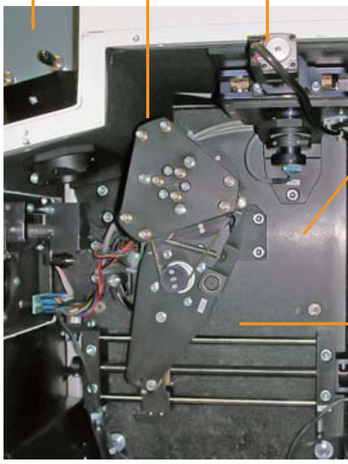


When the mirror is scanned by tilt, the signal moves onto pinhole

Advanced system design

High throughput *

Throughput of optical path from laser to sample and from sample to detector is within 30~40% (taking into account all losses in optical elements, microscope objective lenses, spectrometer).



Spectrometer components are arranged onto granite plate to ensure the highest spectral stability

Polarization option *

High polarization purity is based on Glan-Taylor prisms and motorized high accuracy retardation plates. Glan-Taylor prism in the detection channel has motorized control for inserting it in and removing it from the optical path as well as selection of polarization orientation.

Motorized exchangeable optics for UV, VIS and NIR *

Laser beam expanders in illumination channel and objectives for confocal pinhole in detection channel are prealigned in motorized turrets for fast and easy automatical switching.

Fully motorized excitation laser switching

4 excitation laser wavelengths can be switched with step-motor control of laser mirror positions, retardation plates turret, beam expanders turret and edge-filters turret. Full system configuration can be saved and automatically recovered.

3D Confocal Raman

Advantage of the Nanofinder® HE is the ultrafast 3D Raman imaging based on scanner-detector synchronization with the highest sensitivity and the highest spatial resolution. It is achieved by employing a high throughput optical system, fast and high sensitive CCD detector and high accuracy piezo stage .

3D Confocal Raman Points

- Highest Sensitivity*
- Highest Spatial Resolution (XY < 200 nm)*
- Highest Speed Up to< 3 ms / point (full spectrum saving)*

Highest Sensitivity*

High sensitivity of Nanofinder® HE is confirmed by its ability to clearly reveal the 4th-order Si Raman overtone within short exposure time (Fig.1).
Intensity of the Si Raman peak at 520 cm^{-1} (1st-order) is usually strong, but higher overtones show much weaker signal. Therefore, detection ability of higher orders of Si Raman peak may be considered as a sensitivity benchmark of a Raman spectroscopic system.
High sensitivity of Nanofinder® HE permits the user to minimize the excitation laser power and, therefore, to avoid sample modification or damage.

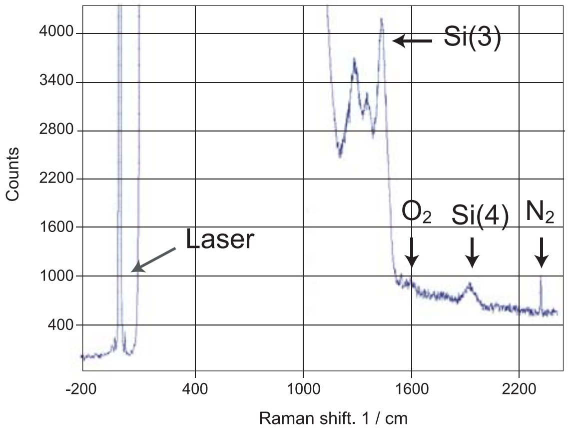


Fig. 1 Si Raman spectrum of the higher order overtones
■ Measurement conditions:
Excitation laser 8.6 mW@473 nm, measurement time 60 sec
Microscope objective lens : 100×0.95

Highest Spatial Resolution*

Laser Confocal mapping image of Si / SiO_2 line&space sample is shown in Fig. 2. Mapping is done in XZ direction (X-axis along the sample surface, Z - orthogonal to the sample surface). Data show a lateral resolution (edge response, when signal rises from 10% to 90%) of 170 nm and an axial resolution (FWHM of reflection from sample surface profile) of 380 nm with water-immersion microscope objective lens.

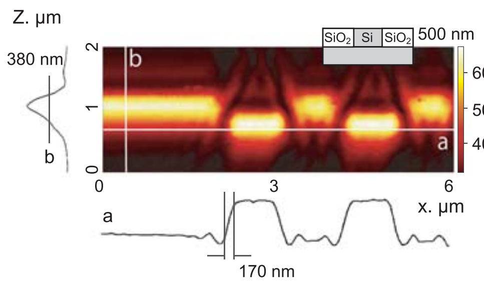


Fig. 2 Laser confocal image of Si / SiO_2 line&space 1μm / 1μm.
■ Measurement conditions:
Excitation laser 473 nm, Pinhole 18μm, mapping step 50 nm,
Microscope objective lens : 150×1.25.

High Speed*

Employing the cutting-edge EMCCD detector, Nanofinder® HE provides sample measurement with the highest sensitivity, the highest accuracy and the highest speed (up to<3 ms), saving full Raman spectra at every mapping point. TII advanced technology solutions give the fastest scanning procedure in the closed-loop mode.

About 25 seconds are required to implement mapping with 100×100 points (X,Y).

3D image with 100×100×30(X×Y×Z) : 300,000 points in ultra-fast scan mode takes only 12.5 min (for comparison, point-by-point mapping mode takes about 2 hrs 45 min for the same image resolution.)

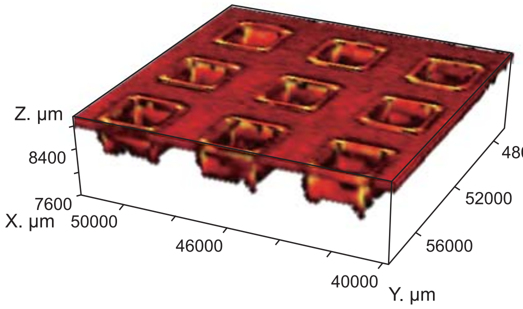


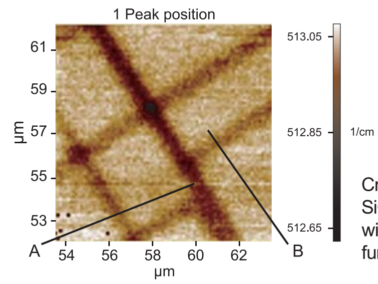
Fig. 3 3D Raman image of Si/SiO_2 sample (at 520 cm^{-1}).

■ Measurement conditions:

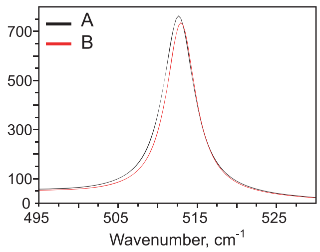
Excitation laser 473 nm, 10 mW, 64×64×16 points, time 3.5 min,Microscope objective lens: 100×0.95

2D Raman Imaging examples

Cross-Hatch pattern of stress distribution of Si grown on SiGe virtual substrate

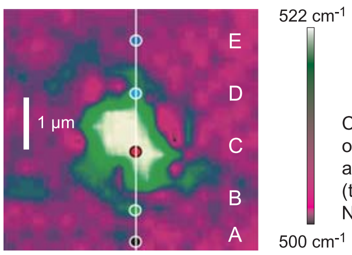


Cross-hatch pattern of SiGe film strain obtained with Raman shift imaging function.



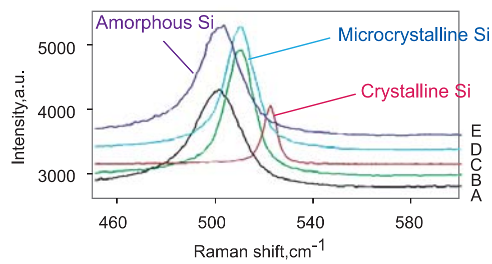
Raman shift between the darkest "A" and the brightest "B" spots of the image is 0.4 cm^{-1} only. Combination of Echelle grating (hardware) and spectral line fitting (software) provides the unique ability for high quality fine Raman shift (sample strain) imaging with resolution below 0.03 cm^{-1}

Measurement of Amorphous Si thin film crystallization

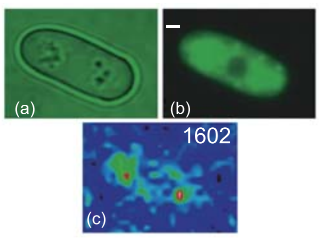


Crystallization condition of each point of amorphous Si thin film (t:60 nm) illuminated by Nd:YAG laser (532 nm).

Data by courtesy of Prof. S. Horita, Japan Advanced Institute of Science and Technology

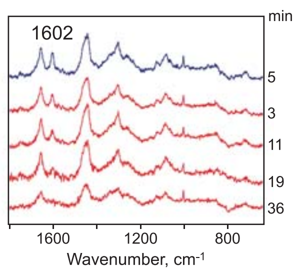


Study of metabolic activity in the living cell.



Yeast cell. Microscopic image (a), fluorescence GFP image (b). Raman image at 1602 cm^{-1}(c) shows distribution of highly metabolic-active mitochondria.

Data by courtesy of Prof. Hiro-o Hamaguchi.National Chiao Tung University



Raman peak at 1602 cm^{-1} shows degradation in time in metabolic activity due to suppression of respiration by added KCN.

3D Confocal Raman

Practical Data Analysis＊

During the mapping procedure, 2D or 3D image cross-sections can be observed in real time.

The Nanofinder® HE unique software has advanced abilities to display and analyse data. Various data processing and presentation tools are available. The Nanofinder® HE software can easily handle huge volumes of 3D mapping data with full Raman spectrum at every point.

Saving measurement time & optimize experimental conditions＊

Usually it takes a lot of trial measurements to determine appropriate experimental conditions to get good quality mapping images.The Nanofinder® HE software real time display provides the possibility to analyze data during the measurement. Fast data visualization allows fast parameter adjustment, area exchange and measurement restarting.

Data analysis capability＊

During the mapping procedure, all spectra from every measurement point (X,Y,Z) are stored in the computer memory. Nanofinder® HE software provides various imaging functions＊, such as Raman peak intensity, peak shift, peak bandwidth, etc. Built-in image calculator provides more sophisticated functions for visualization, such as image filtering, image subtraction, peak intensity ratio, etc. Deconvolution and curve-fitting functions can enhance spatial and spectral resolution.

Imaging data analysis＊

Measured 3D data can be easily examined from arbitrary angles＊(Fig. a). Position and orientation of 2D cross-sections can be also arbitrary selected (Fig. b, d).

1D cross-sections provide distance measurement and intensity plot profiling (and other imaging functions) along arbitrary directions (Fig. c,f). The pointing tool shows Raman spectra at specified mapping points (Fig. g). Multiple color schemes provide powerful tools for impressive image coloration.

3D Raman images of self-assembled liquid crystal (Raman intensity image at 1136 cm^{-1})

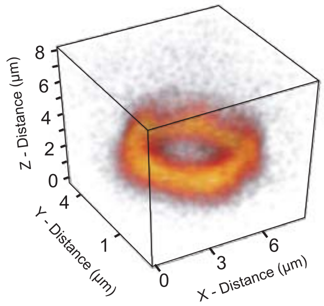


Fig. a
3D Raman image

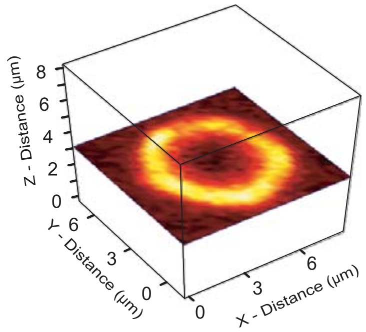


Fig. b
X-Y cross section image
in depth direction

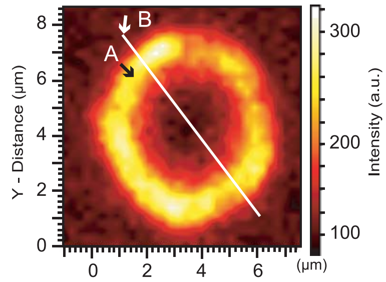


Fig. c
Top view of the X-Y cross section

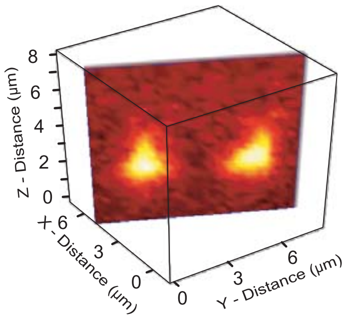


Fig. d
Image 2D cross-section
at arbitrary place and angle

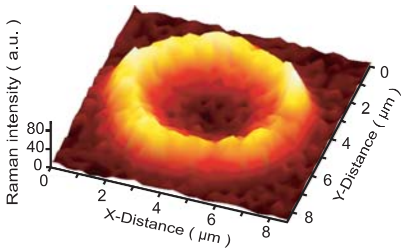


Fig. e
Quasi 3D image of intensity
expressed by color and height

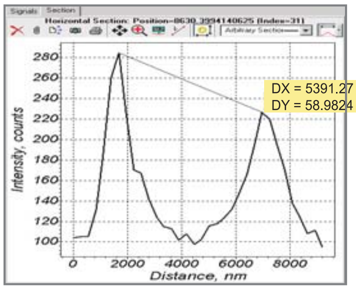


Fig. f
Cross-section intensity profile
and distance measurement
along the white line B in Fig. c

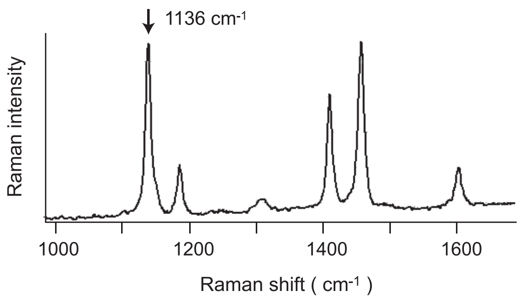


Fig. g
Raman spectrum of self-assembled liquid crystal
(Point A in Fig. c)

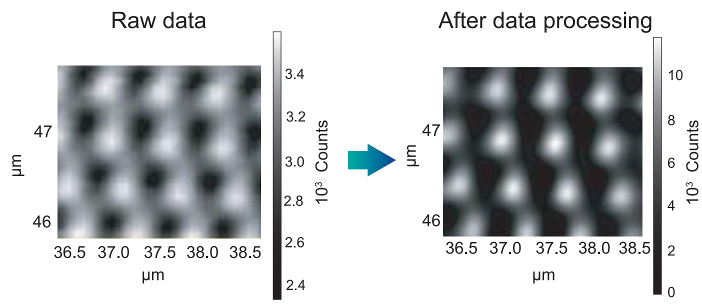


Fig. h
Example of 2D image deconvolution application
(Si device). Shape correction and sizes decreasing
are clearly observed.

AFM-Raman

Combination of confocal Raman system Nanofinder® HE with AFM allows simultaneous measurements of AFM topography and Raman confocal image of the same sample area.
Such correlated topography (AFM) and chemical composition (Raman spectroscopy) data are useful for defect evaluation of semiconductor devices, carbon nanotube analysis, foreign material detection, etc. Different AFM modes (e.g., Phase, Lateral Force, Kelvin Probe, conductive AFM or STM) can be performed simultaneously with confocal Raman mapping.

The AFM used with Nanofinder® HE is designed especially for combined operation with this confocal Raman system. With an IR laser wavelength of 1300 nm there is no influence between the AFM feedback control system and the Raman system. The design concept of the AFM was focused on full device automation, easy to use, easy to exchange cantilever or sample, easy combining with confocal Raman system (by hardware and software), high stability and small drift for long time measurements.

AFM-Raman Point

- Simultaneous Same Sample Area Measurement by AFM and Confocal Raman *
  with 1300nm AFM feedback laser there is no crosstalk between AFM and Raman systems
- Different AFM models for various configurations are available.

One AFM head for both:reflection and transmission AFM / Raman geometries*

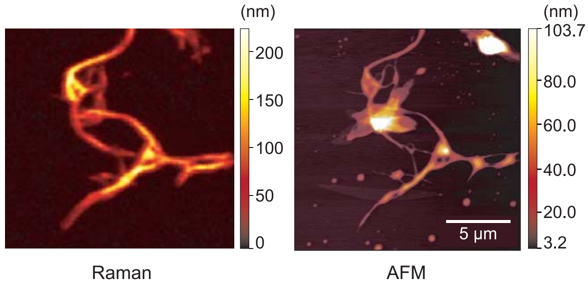
While typical AFM / Raman systems have different AFM heads for Reflection and Transmission configurations (combined with Up-right and Inverted microscopes correspondently), the Nanofinder® HE AFM (CombiScope™1000) uses only a single head and a single built-in microscope for both Reflection and Transmission configurations with the possibility of prompt (without sample and tip position change) switching between them.

Automated alignment mechanism*

AFM measurement can be started promptly after the automated preparation procedures (locating of laser spot on cantilever, positioning sensor adjustment) With fully automated resonance search, feedback control tuning, approaching and landing, even beginners can get the first AFM mapping result within a few minutes after the system start.

Access to sample with high NA objective lenses＊

Especially designed for combined operation with confocal Raman, the AFM of Nanofinder®HE has the best optical access to the sample / probe area: microscope objectives of 100×NA0.7 (from top for opaque samples) and 100×NA1.3 (from bottom for transparent samples) can be applied for simultaneous combined AFM-Raman measurements. As a result, spatial resolution below 50 nm can be achieved in TERS measurement.



AFM-Raman Simultaneous & Same Sample Area Measurement of CNT (Carbon Nano Tube) on cover glass.

■ Measurement conditions
Raman: Excitation laser 473 nm, Microscope objective lens: 100×0.9
AFM: Transmission configuration,Non-contact mode

Advanced sample position adjustment

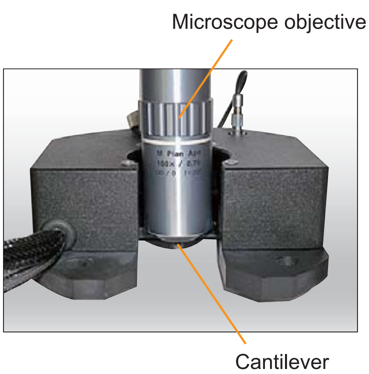
The AFM (SmartSPM™1000) is equipped with motorized XY sample positioning system, which ensures the capability of easy returning to (or switching between) points / areas of interest. Fine closed-loop XYZ piezo-scanner, equipped with capacitive sensors, is used for AFM and confocal Raman mapping. The motorized XY stage provides precise sample positioning and the piezo driven XYZ piezo stage ensures fine mapping images.

Focused laser spot / AFM probe position adjustment

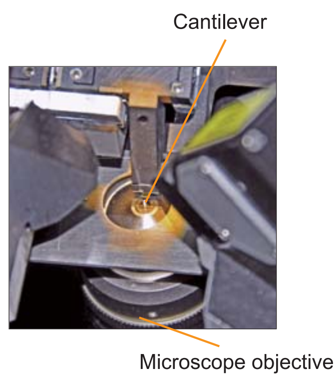
Closed loop objective lens scanner is employed for automatical laser spot / AFM tip apex fine alignment. Preliminary alignment can be done motorized (CombiScope™1000) or manually with microscrews(SmartSPM™1000).

True non-contact mode

True non-contact mode operation is ensured by fast 300 MHz Digital Signal Processor (DSP). Non-contact scanning mode at reduced amplitudes of probe oscillation is optimal for soft samples or delicate AFM probes, avoiding damage of sample or probe due to no sample / probe contact.



AFM-Raman Reflection configuration



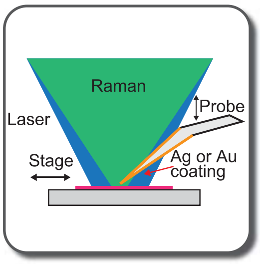
AFM-Raman Transmission configuration

AFM-Raman

AFM - Confocal Raman configurations*

Up-right Microscope Configuration

SmartSPM™1000 with HE002



AFM model:

AIST-NT SmartSPM 1000 with HE002 head

AFM tip and Raman excitation laser beam - both approach sample from top:

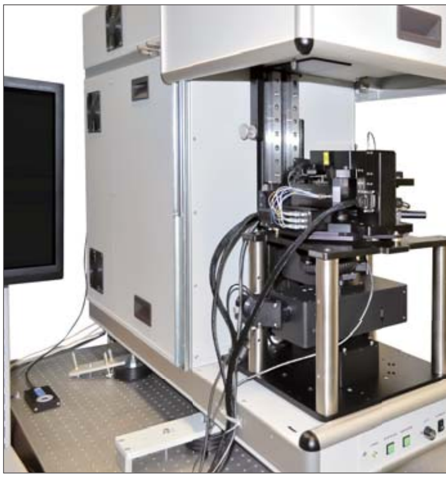
Selection for opaque samples.

Advantages:

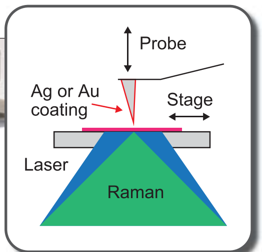
- High resonance frequency scanner (X,Y - 7 kHz; Z-15 kHz).
- True Non-Contact AFM for best performance
- Fastest AFM mapping possible

Applicable to Reflection TERS

Inverted Microscope Configuration



CombiScope™1000 with HE002



AFM model:

AIST-NT CombiScope 1000 with HE002 head

AFM tip approaches from top;

laser beam comes from bottom:

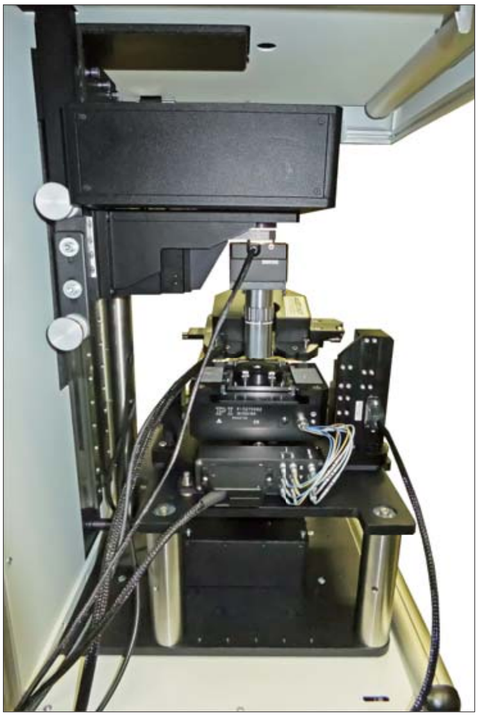
Selection for samples distributed on thin transparent substrates (e.q. microscope cover glass)

Advantages:

- High NA (up to 1.3) microscope objective lenses applicable;
- Operation in liquid possible (for HE001 head);
- Switchable magnification: microscope objective lenses change without sample removing

Applicable to Transmission TERS

All-In-One Microscope Configuration∗ (with Up-right, Inverted, Transmission and Inverted Transmission)



CombiScope™1000 with HE002

AFM model:

AIST-NT CombiScope 1000 with HE002 head

AFM tip comes from the top; laser beam can come from both: top and bottom, beam path change within a few seconds.

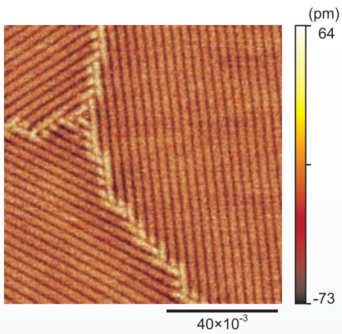
Can work with both: transparent and opaque samples

Advantages:

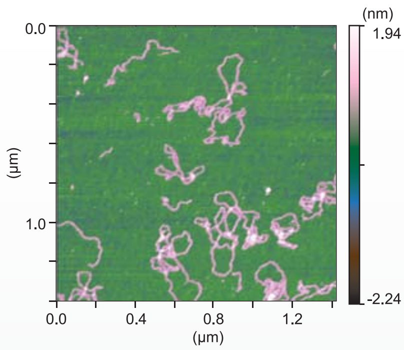
- Universality(Reflection&Transmission geometries possible)
- Transmission SNOM with cantilever based sensors is available

Applicable to both: Reflection and Transmission TERS

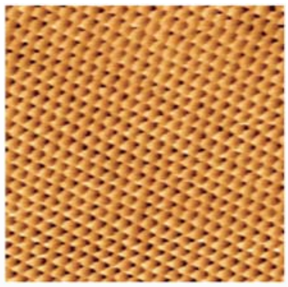
High Grade Scanning Probe Microscope AIST-NT SmartSPM 1000: performance examples



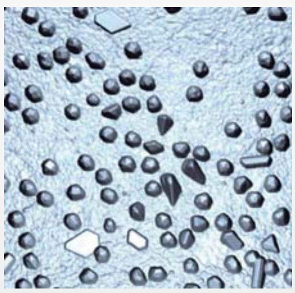
100 nm topography scan of $C_{28}H_{58}$ molecules on HOPG. Z range- 1.3A. Non contact mode.



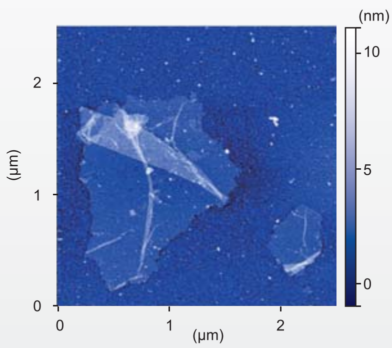
1.4 micron topography image of the Plasmid DNA. Semicontact mode in buffer solution.



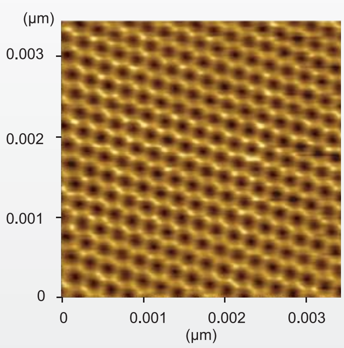
Atomic Resolution on HOPG, LFM. 3nm scan. No filtering in Fourier space.



Topography image of 130 nm Ag nanoparticles immobilized on the metal surface.



Single layer flakes of Graphene Oxide deposited on functionalized mica. AFM topography image.



Atomic resolution STM image of HOPG using unique 100×100 microns scanner. Constant Current mode.

Tip-Enhanced Near-field Raman Microscopy

Tip-enhanced Raman spectroscopy (TERS) is a novel method for getting Raman spectra/images with high spatial resolution far beyond the diffraction limit of light. Near-field light is generated at the tip apex of a metal coated sharp probe (10～30 nm). Tokyo Instruments, Inc. commercialized the world's first reflection TERS imaging system .

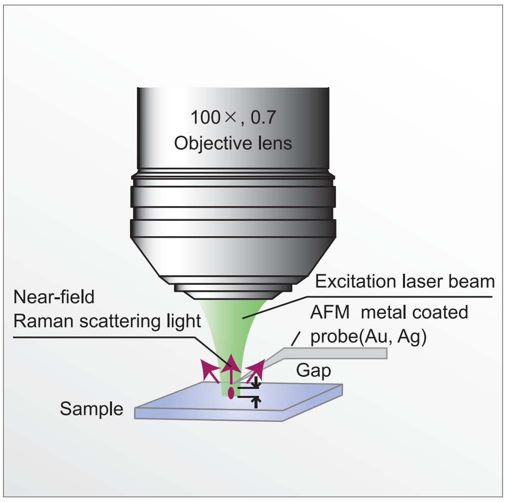
Tip-Enhanced Near-field Raman Microscopy

TERS:Tip-Enhanced Raman Spectroscopy

High spatial resolution < 50 nm by near-field Raman spectroscopy with AFM metal coated probe

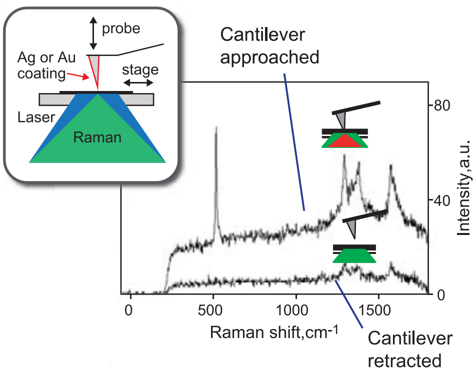
Measurement principle

The basic system configuration for TERS is similar to AFM-Raman combined system. AFM probe for TERS is a Si tip coated with noble metal (Au or Ag) instead of bare Si probe used for just combined AFM-Raman measurements. First, the AFM probe approaches the sample surface. Then a closed-loop scanning system realizes exact coincidence of the tip apex and the focused laser spot. In appropriate conditions, the localized surface plasmon is generated at the tip apex of the probe. It may enhance the Near Field Raman signal up to thousands times from an area of 10～30 nm around the tip apex. Therefore Raman spectra and images can be measured with a spatial resolution beyond diffraction limit.



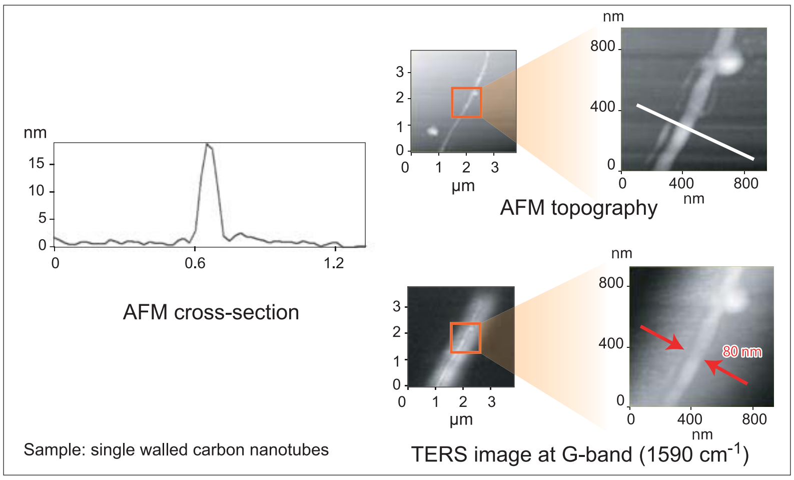
Transmission TERS

Transmission TERS is the choice when samples (for example, carbon nanotubes or biological cell) are distributed on microscope cover glass.



TERS in a single point

Sample:
PPN polymer nanoparticles (50~100 nm), deposited on microscope cover glass.
Sample and data
by courtesy of Dr.S.Nishio. Tohoku University.



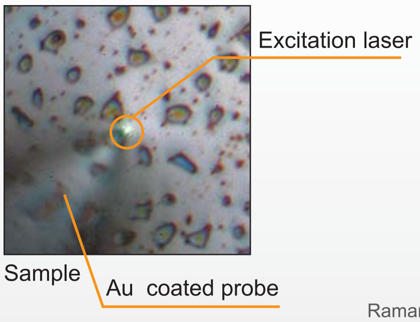
Simultaneous AFM topography and TERS mapping

Reflection TERS

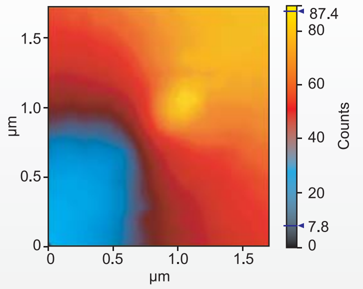
Reflection TERS is the only way to measure opaque samples. It can be applied for low-dimensional samples such as carbon nanotubes, distributed on Si substrate. Graphene, various nano crystals, strained Si structures are also candidates for TERS measurements in reflection geometry.

Laser spot-AFM tip position adjustment

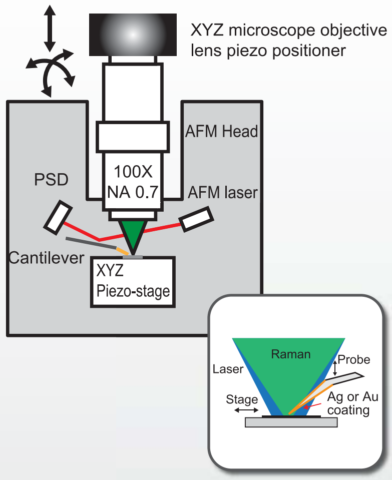
In TERS measurement, the laser spot must be focused exactly on the specific point on the AFM tip apex. A closed-loop piezo-scanning system can arrange exact positioning of the laser spot and the AFM tip.



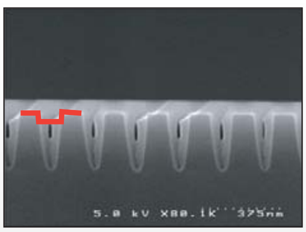
■Microscopic image of the area around the AFM tip apex. Sample is visible even beneath the AFM probe because of very high NA of the microscope objective lens (0.7).



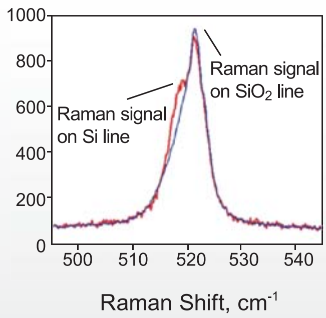
Raman image, obtained by laser spot mapping with objective lens scanner relative to AFM tip apex. Tip is in contact with Si uniform wafer surface. Si peak intensity at 520 cm^{-1} is used for Raman intensity imaging. It is clear to see Si wafer Raman enhancement point in specific laser spot position.

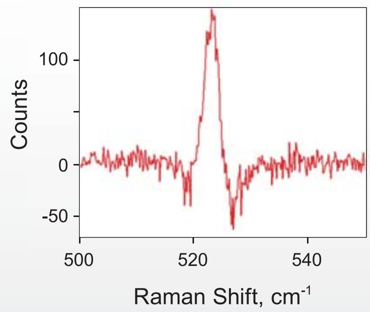


TERS in a single point



100 nm L/S

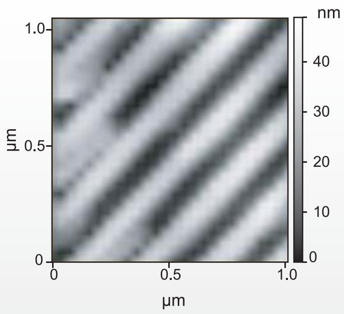




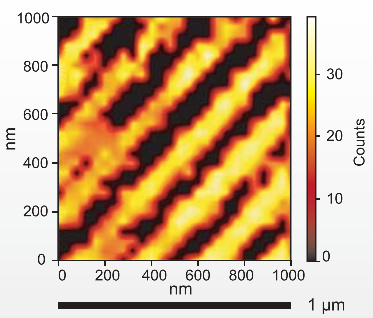
Sample: Si/SiO_2 Line&Space 100 nm

Differential signal (TERS)

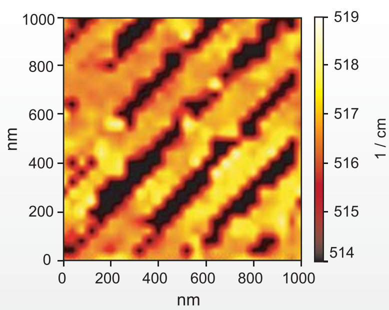
Simultaneous topography TERS intensity and Stress mapping



AFM topography



TERS intensity at about 520 cm^{-1} (Si main peak)



TERS Raman Shift (Si main peak)

Detailed specifications

System configuration

All-In-One device	opto-mechanical unit, spectrometer, microscope, multilaser system and controller are integrated in a single case
Granite frame	exclusive optical system stability
Multi-configuration microscope	Up-right, Inverted, Transmission - reconfigurable Bright and Dark-field, Fluorescence observation modes; Microscope objective lens turret, TV-CCD camera
Scanner	Piezo stage（X-Y-Z）or (X-Y) Stepping Motors or Atomic Force Microscope (AFM)
Excitation Raman laser	up to 3 built-in plus 1 external port
Spectrometer	assembled on granite base plate, f=55 cm, 2 exit ports, 3 motorized gratings on exchangeable turret
Detector	for VIS Raman cooled CCD or EMCCD, for NIR Raman or PL: InGaAs, for Fluorescence Lifetime: APD with TCSPC
Computer, LCD	2 monitors in AFM configuration
Software	advanced Nanofinder®software set

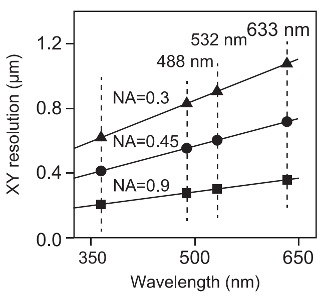
3D confocal Raman spectroscopy

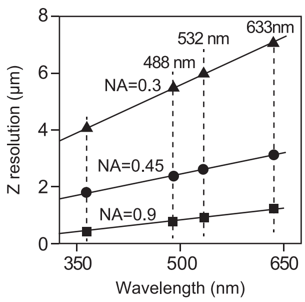
Mapping range	100×100×20 μm with piezo-stage ∗Standard for AFM combined. Larger range stages up to 300×300×100 μm are also available.
Mapping speed	< 3 ms / point (full spectrum saving)∗With EM CCD ADC 3 MHz.

● Spatial resolution(typical):

Laser Wavelength (nm)	473	532	785
Objective lens 100×0.95（air）			
XY (nm)	200	220	500
Z (nm)	500	550	850
Objective lens 150×1.25（water）			
XY (nm)	180	220	—
Z (nm)	400	450	—

*For laser line : XY-edge responce 10~90 %, Z-surface responce FWHM



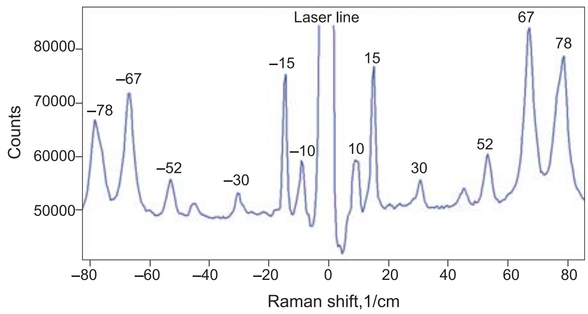


Spatial resolution of true confocal Raman microscopy systems depends on laser wavelength.

● Raman shift measurement range

Laser Wavelength (nm)	473	532	785
Wavenumber range (cm^{-1}) with BR-DD CCD	＜150～＞4,000	＜60～＞4,000	＜60～＞3,000

*Low frequency Raman option (<10 cm-1) available.
*Detection channel optical path throughput correction option available.



● Spectral resolution: spectral line FWHM

Grating (G/mm)	1800	75 (Echelle)
Resolution（cm^{-1}）	0.8	0.25

*Under the following conditions:
1. At the CCD center. 2. Central wavelength 550 nm. 3. CCD pixel size 16×16 $μm^2$.

● Spectral accuracy: within 1 pixel of CCD.

Grating (G/mm)	1800	75 (Echelle)
Accuracy（cm^{-1}）	0.43	0.1

*Under the following conditions:
1. Central wavelength 550 nm. 2. CCD pixel size 16×16 $μm^2$.

*Specifications are subject to change without notice.

Excitation lasers

Wavelength range	244 nm～1.06 μm
Number of built-in lasers	max 3
Port for external laser	Yes

● Standard built-in laser set (CW for Raman)

Laser wavelength (nm)	473	532	785
Power (mW)	20	50	80
Spatial mode	TEM_{00}	TEM_{00}	TEM_{00}
M^2	＜1.1	＜1.1	＜1.2
Spectral line width (MHz)	＜10	＜10	＜50
Polarization contrast	＞100：1	＞100：1	＞100：1

● Picosecond diode lasers for FLIM

Wavelength range	375 ～ 640 nm
Pulse width	40 ～ 90 ps
Repetition rate	20 ～ 80 MHz

Spectrometer

Optical scheme	Czerny-Turner
Focal length	550 nm
Entrance slit	2 motorized crossed slits, independent control, width 0～2 mm
Exit ports	2
Motorized turret	with 3 gratings
Grating choice	150, 300, 600, 1200, 1800, 2400 3600 G / mm, Echelle(75 G / mm)

Grating (G / mm)	600	1800	75 (Echelle)
Range on CCD (nm)	75.5	21.4	4.8
(cm^{-1})	2509	708	159
Dispersion (nm / pixel)	0.047	0.0134	0.0031
(cm^{-1} / pixel)	1.55	0.44	0.1

*Under the following conditions:
1. Central wavelength 550 nm. 2. CCD pixel size 16×16 $μm^2$.
3. CCD width is 1600 pixels.

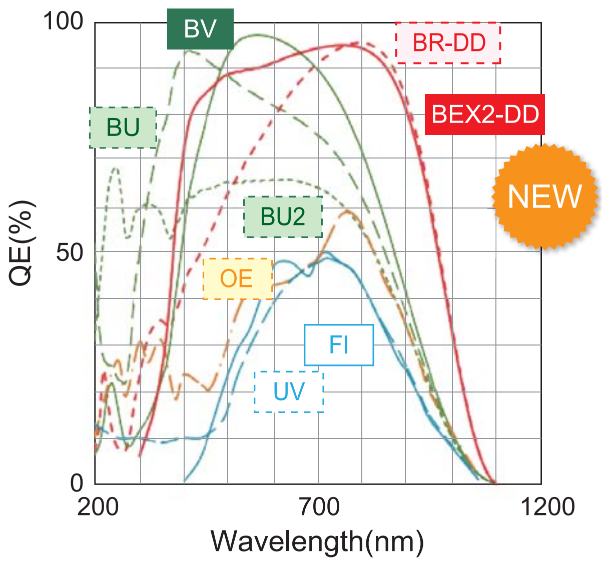
● Automatical spectra calibration : with built-in hollow cathode lamp.

● Granite base plate: for thermal and temporal stability

● Detectors

Cooled CCD (EMCCD) detector (main).	Maximum cooling: -100℃ (water), -80℃(air)
DU970P EMCCD	High-end model with electron multiplying ability High speed 3MHz ADC.Recommended for high speed and high sensitivity measurement.
DU920P CCD DU940P CCD	High speed 3MHz ADC. Recommended for high speed measurement.
DU401A CCD DU420A CCD	100kHz ADC. Low cost model

	Active (pixels)	Pixel size ($μm^2$)	BU / BU2	BEX2-DD	BV	BR-DD	FI	OE	UV	UVB
DU970P EMCCD	1600×200	16×16			●		●		●	●
DU920P CCD	1024×255	26×26	●	●	●	●		●		●
DU940P CCD	2048×512	13.5×13.5	●		●		●		●	●
DU420A CCD	1024×255	26×26	●	●	●	●		●		●
DU401A CCD	1024×127	26×26			●	●	●			



Typical Quantum Efficiency (at 20℃)
scplace with new sating

● Cooled InGaAs array detector

Wavelength range	800 nm ～ 2.2 μm
Active pixels	1024×1 (512×1)
Pixel size	25×250 μm^2
Maximum cooling	−90℃ (water), −70℃ (air)

● APD (Avalanche Photo Diode): for photon counting or FLIM (Fluorescence Lifetime Imaging)

Wavelength range	350 ～ 900 nm
Timing resolution	40 ～ 60 ps
TE cooling	Yes

Opto-Mechanics

Laser holder unit	With beam expander, laser line filter,retardation plate for original polarization orientation setting:max 3 pcs
Laser shutter/Spectrometer shutter	computer controlled
Motorized mechanism for excitation laser switch	YES
Motorized laser power control ND filter wheel	OD 0 ～ 6
Motorized beam expanders exchange wheel	4 positions
Excitation polarization cleaning	Glan Taylor prism
Motorized polarization orientation control	λ/2, 4 positions
Motorized edge-filter exchange	4 positions
Motorized polarization control in detection	Glan-Taylor prism
Motorized input-output mechanism	For Glan-Taylor prism
Motorized input-output mechanism	For hollow cathode calibration lamp
Motorized mechanism for focusing to pinhole objective change	3 positions for UV, VIS and NIR objectives
Motorized mirror for adjustment of Raman signal onto confocal pinhole	YES
Motorized mirror for adjustment of laser beam on sample	YES
Options for mirrors	coating, optimized for 350 ～ 1100 nm Al mirrors for 244 ～ 2300 nm range

Scanners

Piezo-scanner (main)	
Scanning range	100 μm (X-Y-Z)(optional 300×300×100 μm)
Closed-loop	Capacitive sensors
Resolution	5 nm
Repeatability	5 nm
Stepping motors	
Scanning range	50 mm (X-Y)
Resolution	2 μm
Repeatability	2 μm

AFM

Measurement modes	
· Compatible with simultaneous Raman	Contact AFM in air, Semicontact AFM in air,True Non-contact AFM Phase Imaging, Lateral Force Microscopy (LFM),Force Modulation, Single-pass Kelvin Probe, Piezo Response Force Microscopy (PFM) Optional: Contact AFM in liquid, Semicontact AFM in liquid, Conductive AFM STM, Photocurrent Mapping
· Other modes	Top Mode, I-Mode, Magnetic Force Microscopy (MFM), Kelvin Probe (Surface Potential Microscopy), Capacitance Microscopy (SCM), Electric Force Microscopy (EFM), Single-pass MFM/EFM ("Plane Scan"), Force Curve Measurements, PFM-Top Mode, Nanolithography, Nanomanipulation Optional: Volt-ampere Characteristic Measurements
Laser wavelength (for AFM feedback control)	1300 nm
Scanning type	by sample
Control method	XYZ digital closed loop
Interface	USB 2.0
Laser alignment	Fully automated with 4 stepping motors
Tip to sample approach	motorized, fully automated
Fine Raman laser - SPM probe alignment	Microscope objective lens closed loop XYZscanner X×Y×Z = 30×30×15 μm(±10%)(scanning ange depends on objective lens)

	SmartSPM™1000 with HE002	CombiScope™1000 with HE001	CombiScope™1000 with HE002
For combined operation with microscope	Up-right	Inverted	Up-right Inverted Transmission
Change microscope objective between low and high magnification with revolver	YES	No	Up-right:YES Inverted:No
Max. microscope objective NA for combined AFM-Raman operation	100×0.7	100×1.4 Oil	100×0.7 (top) 100×1.4 Oil(bottom)
SPM head positioning (X×Y, mm)	Manual 12.7×12.7	Motorized1.6×1.6 mm Resolution1 μm	Motorized1.6×1.6 mm Resolution1 μm
Sample size (X×Y×Z, mm)	40×50×15	Standard microscope slide and cover glasses	40×50×15
Sample positioning (mm)	Motorized5×5 Resolution1μm	Manual、25×25	Manual, 25×25
Scanning range (X×Y×Z, μm)	100×100×15	100×100×20	100×100×20
Scanner Resonance frequency (unloaded, Hz)	XY: 7000 Z: 15000	XY: 450 Z: 1100	XY: 450 Z: 1100
Maximum scanning speed (line/sec.)	50*	2	2
Registration system noise (nm)	<0.1	<0.03	<0.1
Scanner noise (nm,rms)	XY:<0.1 (Sens.ON) <0.02 (Sens.OFF) Z:<0.04 (Sens.ON)	XY:<0.1 (Sens.ON) <0.02 (Sens.OFF) Z:<0.1 (Sens.ON)	XY:<0.1 (Sens.ON) <0.02 (Sens.OFF) Z:<0.1 (Sens.ON)
Operation in liquid	No	Yes (optional)	No

* With high resonance frequency (1.2 MHz) cantilevers; sample - HOPG, 8 μm scan size.

3Dsoftware

Advanced Nanofinder® HE software pack (Tokyo Instruments original)

OS	Microsoft® Windows7®
Languages support	Japanese, English, Chinese, Korean
Software Pack contents	Main Control and Analysis Nanofinder® HE program "FitPeak" for spectral line with up to 5 Lorentzian or Gaussian curves fitting "Deconvolution" for 1D or 2D data processing AIST-NT SPM control software (in AFM combined configuration)
Control	· Control of all motors in Opto-Mechanics unit · Control of spectrometer ports, turret, wavelength · Control of spectral lamp with automatical calibration function · Control of all detectors and scanners (including AFM scanners) · Possibility to select mapping area directly on TV-CCD microscopic sample image · Simultaneous multidetectors readout during a single scan (including AFM topography and Raman spectroscopy) · Fast scanning algorithm
Analysis integrated	**·Measurements** in point, 1D (scan along random line), 2D, 3D with full spectrum saving in every mapping point **·Spectral analysis with filtering** base line correction, throughput normalization, Lorentzian or Gaussian fitting, spectra calculator **·Image display** point measurement (including time dependence), 1D, 2D, 3D; image rotation, magnification, arbitrary cross-sections **·Image manipulation with coloration, filtering, imaging functions variation** integrated intensity of the spectral peak, peak position shift, line FWHM, fluorescence decay time for FLIM, etc., images calculator.

PC

CPU	Intel core i 7 equivalent
Memory	4GB
HDD	500GB
Drive	Multi drive
Monitor	LCD 23 inch (AFM-Raman→2LCD)

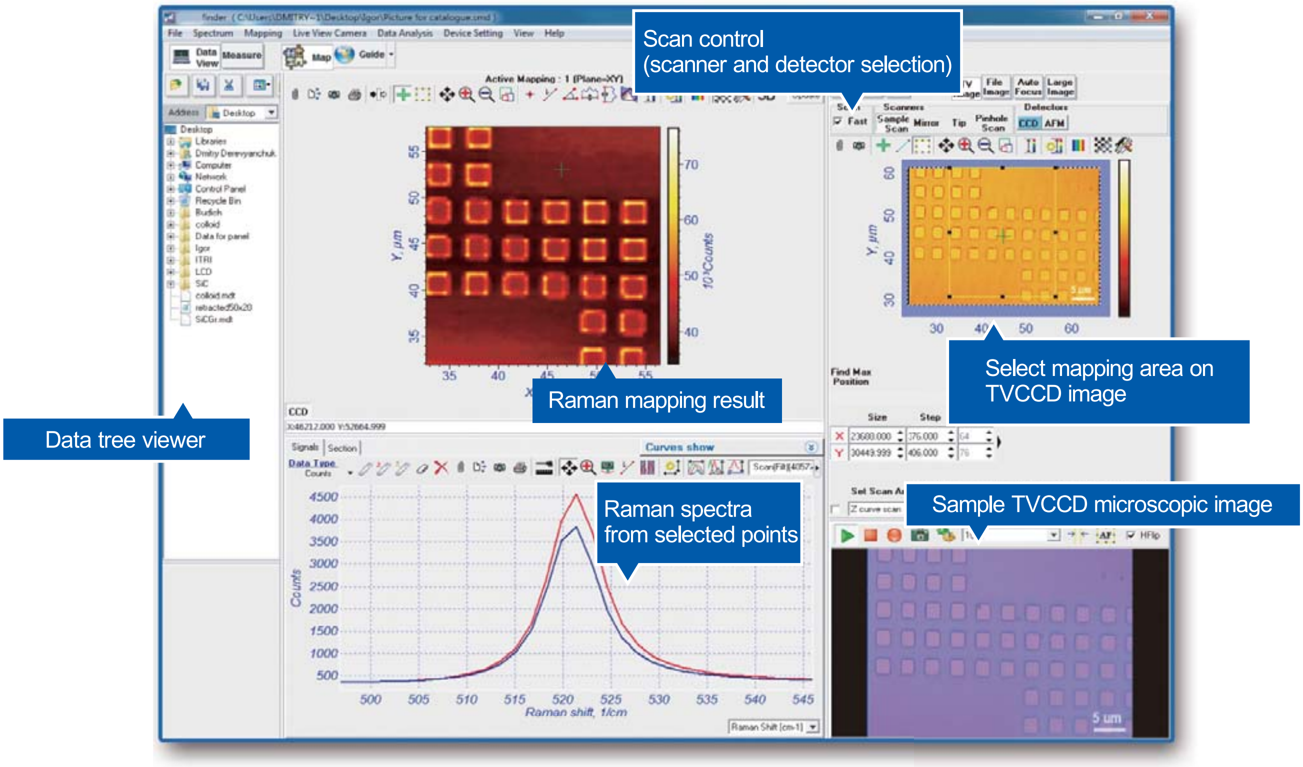
General

Size	512(W)×1000(H)×1215(D)
Weight	240 kg
Optical table	1200×900 mm or 1500×1000 mm (for external He-Ne laser)
Computer rack	700×700 mm
Consumption power	Average 500 VA, Max 1500VA

Measurement Features in Raman Microscopy

- All samples (solids and liquids)
- Non-destructive, non-contact measurements
- Measurement in standard ambient conditions
- No special sample preparation
- High spatial resolution
- Capability of 3D measurement for transparent samples

Nanofinder® HE **main control and analysis program user interface**



Typical applications in Raman spectroscopy

Chemical structure analysis

Strain&stress in crystal, doping effect, superlattice, lattice defect, chemical binding observation
Major samples: semiconductor, organic material, carbon nanotube, fullerene, diamond, jewel, oxide,
various compound semiconductor, thin-film, L-B film, glass, liquid crystal, solar cell etc.

Foreign compound detection

Food, insoluble material in liquid, Si sample, photo mask, plastic, thin film, glass inside etc.

Crystal structure analysis

Crystal layer change, crystallization, amorphous crystallization

Erosion evaluation

Oxidization detection of various metal samples like stainless steel

Investigation & research on coloring, discolored

Photochromic material, functional group identification, painting inspection

Reaction process monitoring (Production process control)

Reaction of polymerization, dissociation, chemical&catalytic reaction, diffusion, melting

Archeology

Ancient potter, glass, paint

Security

Detection&inspection of faked print, counterfeit, drug, chemicals

Biotechnology & medical

Detection of blood serum, indifferent cell, tumor, analysis&diagnosis of bone quality, bone cell,skin change, viable yeast, protein

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