NRS-5500/7500

Laser Raman Spectrometer

JASCO

NRS-5500/7500

Certified technology and experience over 50 years

It has been fifty years since JASCO developed 1st generation Raman spectrometer. We have been researching and developing various Raman spectrometers continuously.
Our Raman spectrometer evolves with development of optical design and device technology to meet requirements and demands in various scientific fields.
Our mission is to keep proposing high quality and advanced performance Raman system now and future.

History of JASCO Raman spectrometer

1968 1st generation Raman spectrometer R-1000

R-1000

R-300

1970s Success in downsizing Raman spectrometer system R-300
Microscopic Raman spectrometer system with micro computer R-800

R-800

1980s World's first Microscopic mapping Raman spectrometer system NR-1000
Multi-channel detector (MCD) installed in Raman spectrometer system
Crystal axis analysis system for Si stress evaluation (RMP-1000)
A rigid honeycomb optical bench was adopted
R&D100 Awards (USA, RMP-1000, NR-1100)

NR-1000

RMP-1000

1990s CCD detector mounted on Raman spectrometer system (NR-1800)
Automated Raman spectrometer system
Complied system with safety standard Class 1 for laser
Simultaneous observation of the aperture image, observation image, and laser beam

NR-1800

2000s High-precision rotary-encoder was adopted for grating driving mechanism
Good Design Award (Japan, NRS-3000 series)
DSF (Dual Spatial Filtration) was adopted (NRS-5000/7000 series)
Automatic switching of wavelength and optical elements
Laser-scanning high-speed imaging system

NRS-2000

NRS-2100

2016 NRS-5500/5600/7500/7600 series

2017 IQ Frame function for IR microscope and Raman microscope

NRS-3000

2018 IQ Raman NAV

2019 MIX observation unit

NRS-5500

NRS-5500/7500 is designed as the highest performance Raman spectrometers based on combined technologies with excellent optical design [極], mechanical design [匠], and usability software [臨].

NRS-5500

Research grade confocal Raman microscope

f300-mm monochromator

Maximum spectral resolution of 1 cm^{-1}

NRS-7500

World-class flagship model

f500-mm monochromator

Maximum spectral resolution of 0.7 cm^{-1}

極 — KIWAMI —

Excellent optical design for high spatial resolution

- High spatial resolution optical system approaching the diffraction limit: laser beam introduction system
- Confocal optical system with low stray light and high sensitivity

➔ High spatial resolution, and high sensitivity measurement achieved with stray light reduction

匠 — TAKUMI —

Highly reliable mechanical design to make it possible for optical stability

- A rigid honeycomb optical base
- Grating driving mechanism control by high-precision rotary-encoder
- Automated switching mechanism and optimum system conditions setting

➔ Excellent system stability makes it possible for highly accurate measurement

臨 — NOZOMI —

Excellent software usability

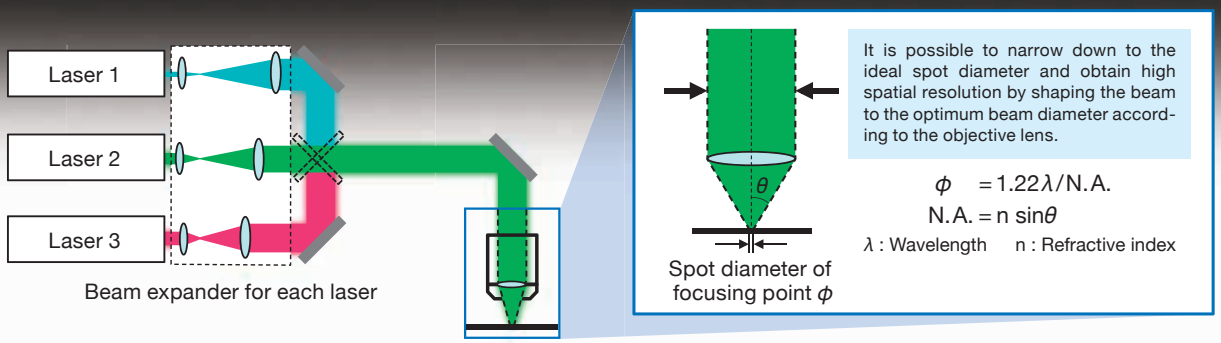
- Suite of features to ease Raman measurements: IQ Raman NAV
- Complex analysis with ease: IQ Frame
- Various dedicated analysis software for each application

➔ Stress-free measurement and analysis

極 -KIWAMI-

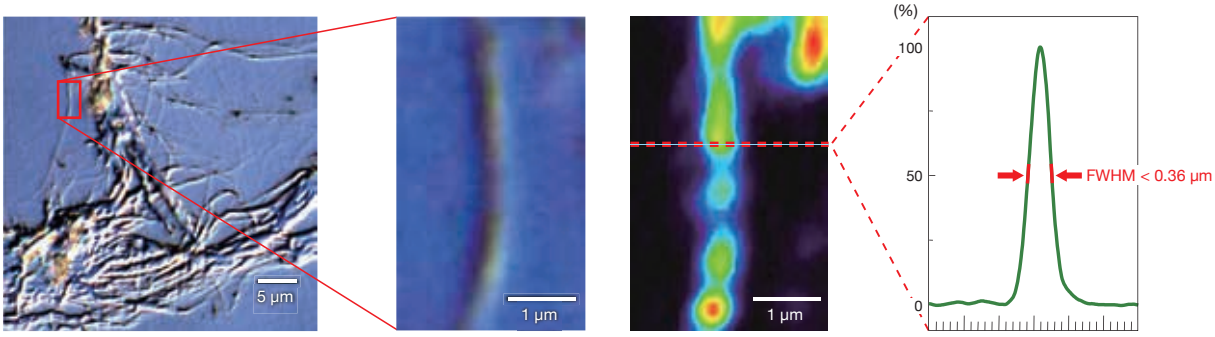
High spatial resolution — Laser adjustment and optimization

NRS-5500/7500 is equipped with a focusing optical system (beam expander) suitable for each laser. Even with multiple lasers, the system introduces each laser into the objective lens under optimized condition and adjusts the laser light on the sample properly.



High spatial resolution — DSF (Dual Spatial Filtration)

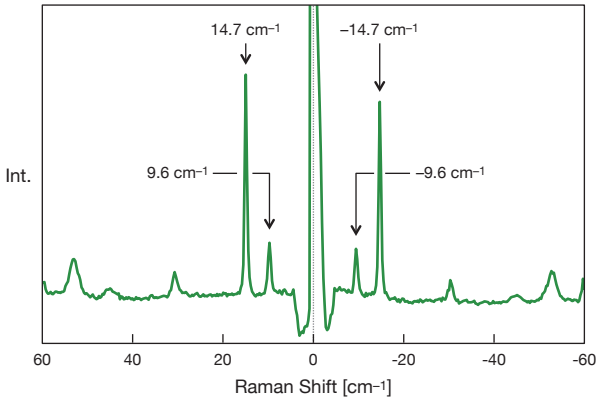
The excellent DSF makes it possible for high spatial resolution close as diffraction limit.



Measurement of carbon nanotube sample
Left : Differential interference observation images
Right : Raman image and signal-intensity cross-section

Measurement in ultra low-wavenumber

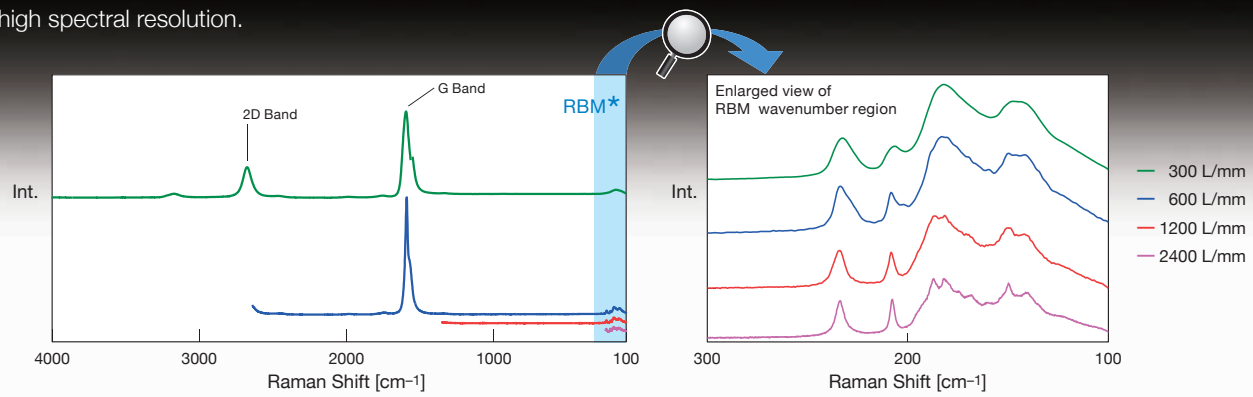
NRS-5500/7500 has capability to install 3 rejection filters, which makes it possible to adjust the incident angle individually. It is dedicated filter makes performance maximum even measurement in ultra low wavenumber region.



Raman spectrum of L-cystine

Automatic grating switching mechanism

The NRS-5500/7500 can automatically switch four diffraction gratings through software operation. It is possible to select the diffraction grating to match laser without optical adjustment. By using different diffraction gratings, it is possible to measure in wide wavenumber region at once, and to also possible to measure with fine and detail even in small wavenumber region with high spectral resolution.

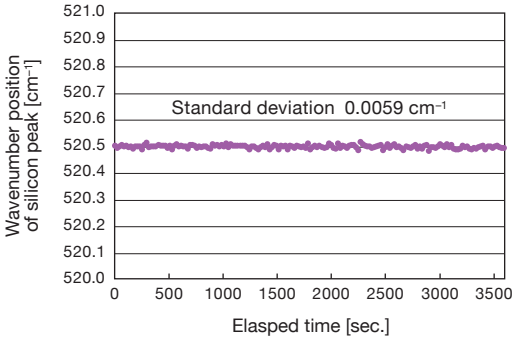


Measurement of carbon nanotubes using different gratings (NRS-7500)

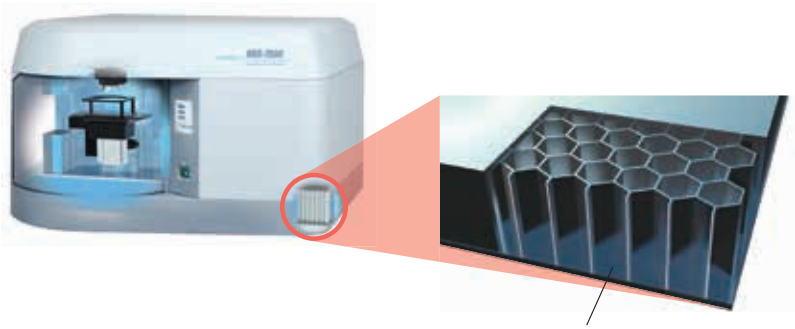
*RBM (Radial Breathing Mode) : Vibration of the distributuon for diameters of single-walled carbon nanotube.

Rigid honeycomb optical base for stable measurement

The optical system supported by the aluminum honeycomb bench housing provides both stability and repeatability of measurements. In the stress measurement of Si, which is sensitive to environmental temperature changes and system rigidity, a peak shift of 0.01 cm^{-1} or less can be detected.



Time-course data of silicon peak



User friendly and safety sample chamber with wide clearance and electric door

IEC60825-1: Complies with Class 1 of laser product safety standards.
In addition, interlock control of laser irradiation enhances safety.
Electric door reduces vibration.

Inside of sample chamber
(without sample holder and base)

臨 -NOZOMI-

Excellent usability: NRS series

The steps of micro Raman measurement are mainly to set the sample (始), observe (観), targeting the measurement position (狙), measure (測), and analyze (解). JASCO Spectra Manager has excellent usability to handle each process.

SET

- ✓ Various sample stages
- ✓ Automatic switching of optical system / Auto-Alignment
- ✓ Autofocus

OBSERVE

- ✓ Observation functions for difficult-to-see samples
- ✓ Automatic adjustment to "brightness for viewing" after switching the objective lens
- ✓ Omnifocal function for height irregularities

TARGETING

- ✓ Same points measurement with ease using IQ Frame
- ✓ Automatic recognition of measurement position in real time
- ✓ Targeting measurement position by size, shape, and color

MEASURE

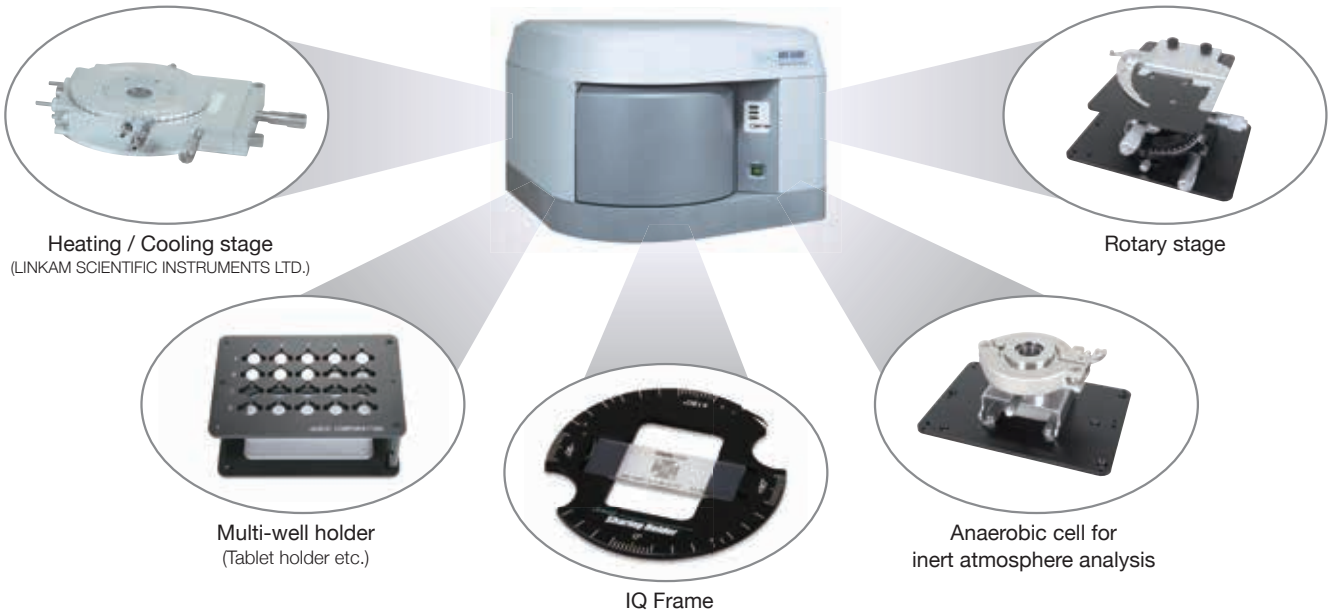
- ✓ One-screen-setting of measurement parameters
- ✓ Qualitative analysis simultaneously while measurement
- ✓ 3-step procedure for fluorescence elimination
- ✓ 2D and 3D sample images

ANALYZE

- ✓ Unknown sample identification - One click to search function
- ✓ Acquiring component distribution image by simple operation
- ✓ Statistical analysis usability of component distribution image

Various sample stages

Various stages are available to support various measurement purposes.

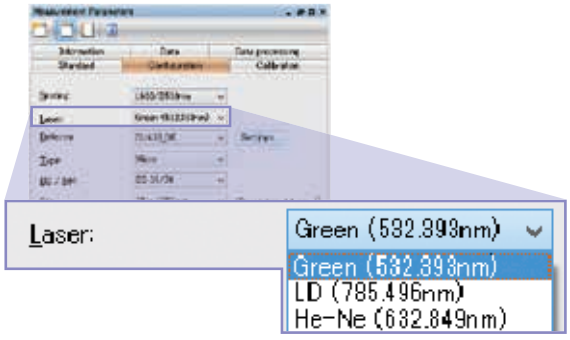


Automatic switching of optical system / Auto-Alignment

The laser, beam splitter/dichroic mirror, diffraction grating, slit (aperture), and detector can be switched easily.
Optical axes of the laser light and Raman optical path can be adjusted automatically.

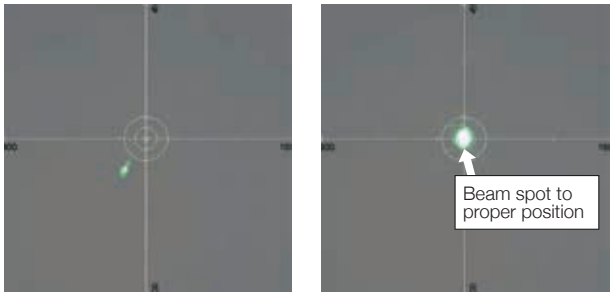
Auto-switching of optical system

Easy pull-down setting on software



Auto-Alignment

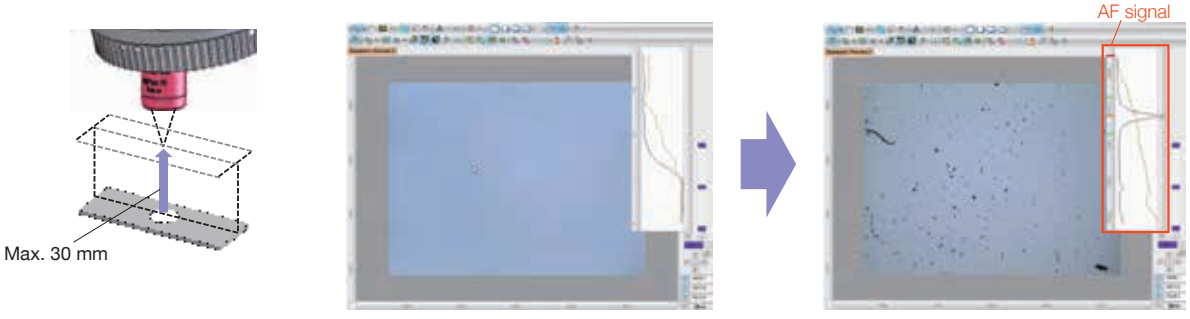
Optimizing the laser beam spot on the sample



Before After

Autofocus

After setting the sample, autofocus is completed with one click. The stage drives up to 30 mm for focusing.



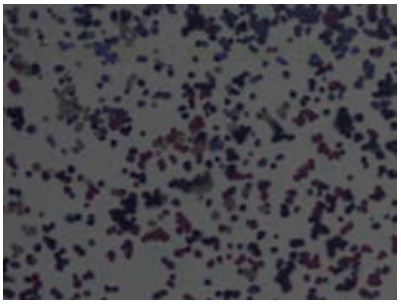
Driving stage Focusing complete

Observation functions for difficult-to-see samples

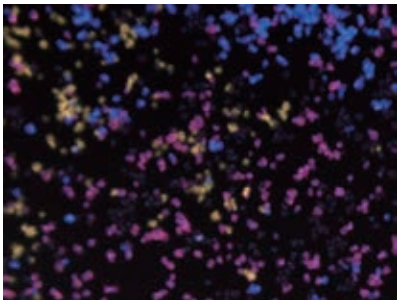
Darkfield observation/MIX observation

Darkfield observation is effective for observing samples with tints and fine irregularities. MIX observation function combined with brightfield and darkfield observations makes it easier to see difficult-to-see sample than single observation.

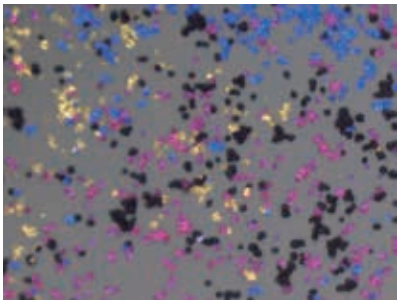
Printer toner



Brightfield
Unclear color



Darkfield
Clear color



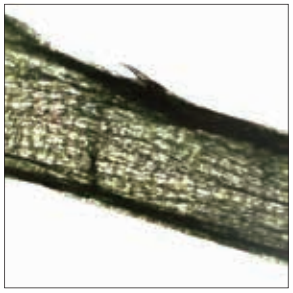
MIX observation
Colored and black particles can be observed simultaneously

Transmitted illumination

For observing buried objects and highly transparent samples.

Plant stem

Brightfield

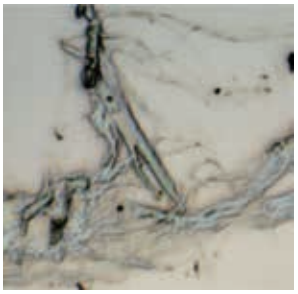


Transmitted illumination

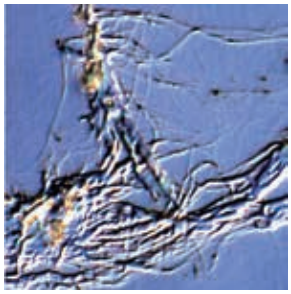
Differential interference observation

By using differential interference, minute irregularities can be emphasized.

Carbon nanotube



Brightfield



Differential interference observation

Polarized light observation — Reflection

Due to the effect of regular reflection light on the film surface, the printed surface inside which is difficult to see in bright field observation can be clearly observed.

Food package

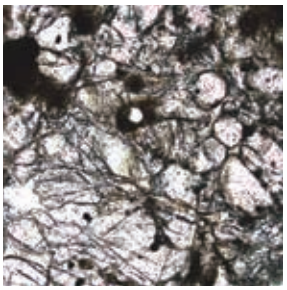
Brightfield

Polarized

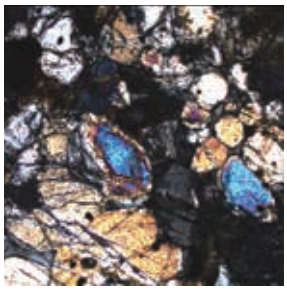
Polarized light observation — Transmission

Single crystals, minerals and foreign matters in polymer films can be observed by using of polarized light.

Rock flakes



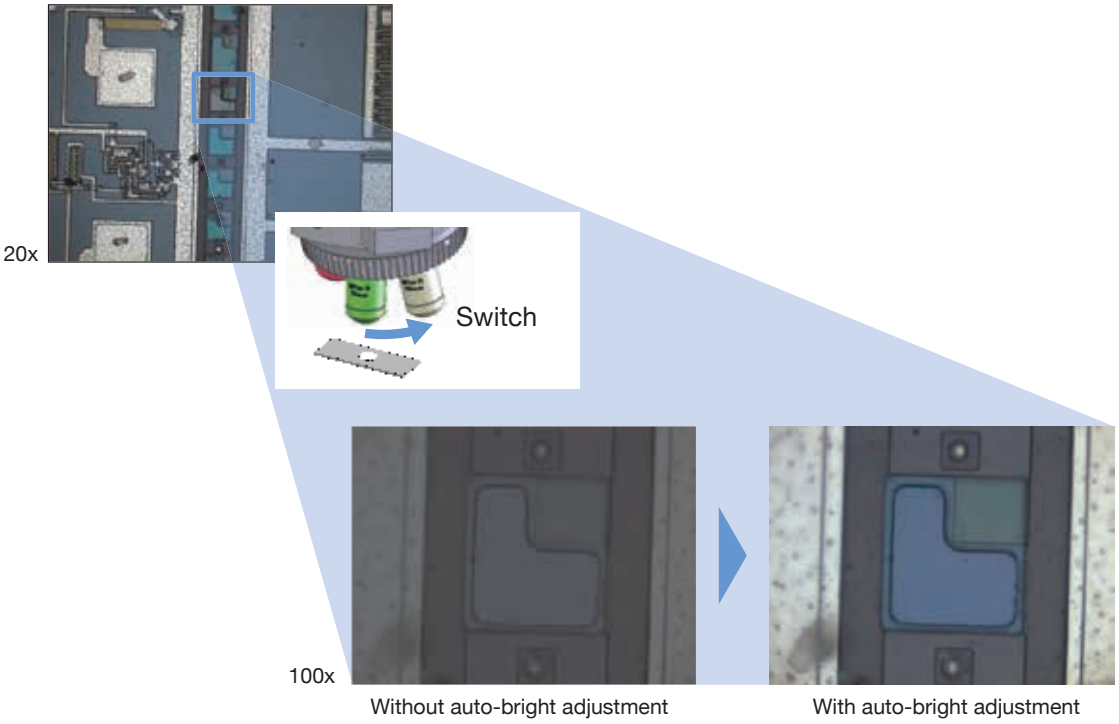
Parallel Nicols



Crossed Nicols

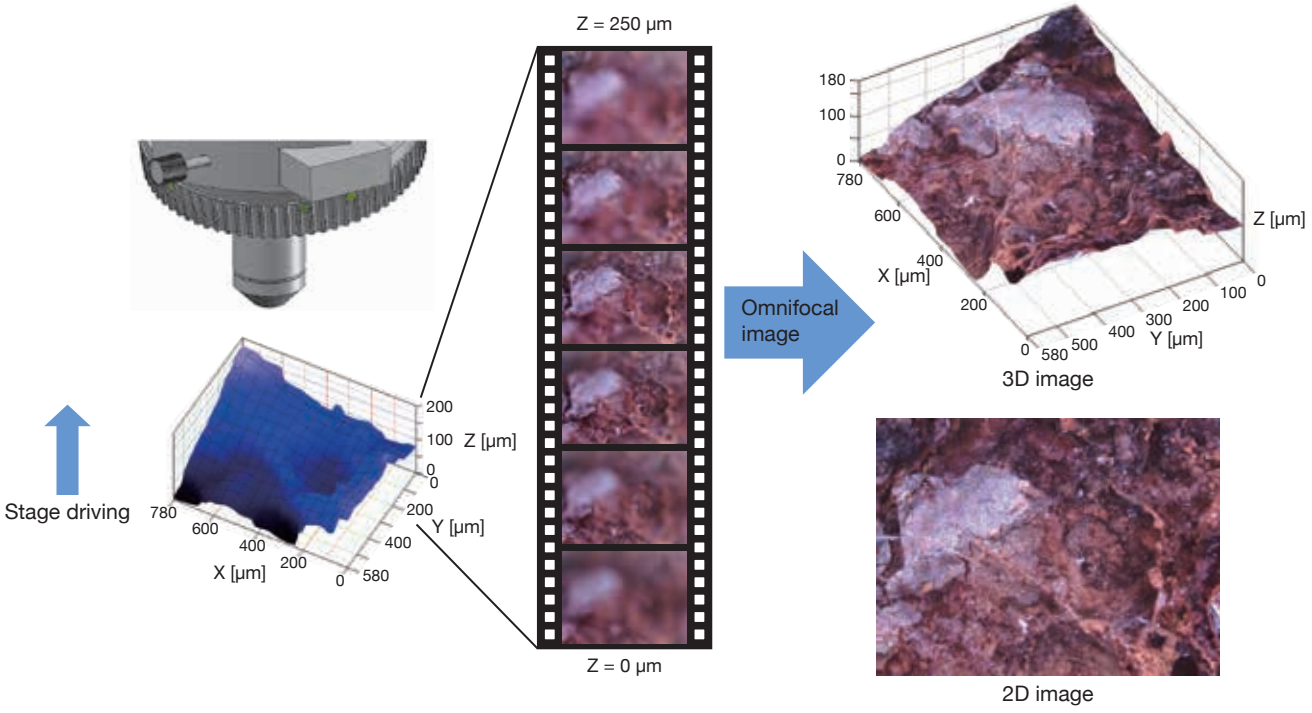
Automatic adjustment to "brightness for viewing" after switching objective lens

When the objective lens is switched, the brightness changes automatically. Observation image can be displayed in optimized bright without blown-out highlights and blocked up shadows.



Height irregularities by omnifocal image

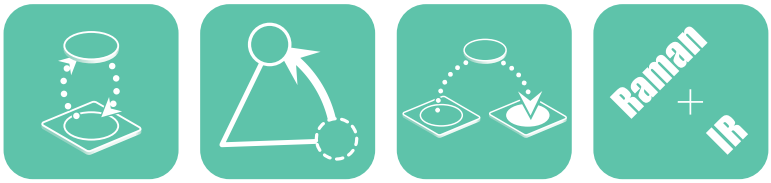
Even if the depth of field is shallow and overall focus is not adjusted, the stage is moved continuously in the Z-direction to obtain omnifocal image about focused area. By using of coordinate of Z-axis about focused area, 3D image can be displayed.



Same points measurement with ease using IQ Frame

By using of IQ Frame, it is possible to measure samples in the same point and same area with ease based on registered information as stage coordinate and observation image when Raman measurement.

IQ Frame



See p.18

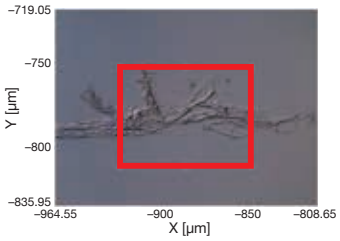
Reload measurement

In case of re-measurement after measurement and analysis, IQ Frame can adjust the measurement position in micron order using of registered parameters.

Re-set IQ Frame

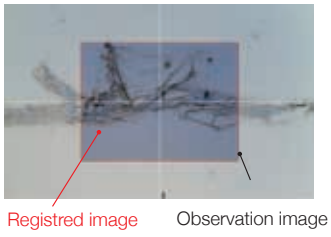
Re-set IQ Frame

Set measurement area



Specify the image area from registered image matched on previous measurement

Auto alignment

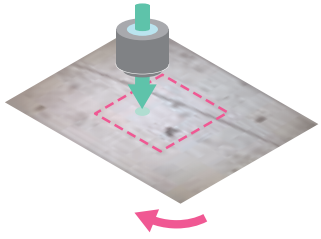


Based on registered stage coordinate information and image matching, stage moves to the same measurement position as registered information.

Sample rotation

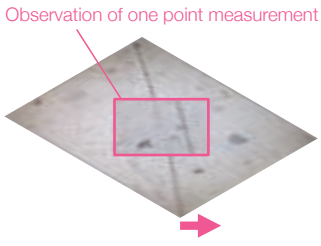
The position can be adjusted easily by rotating the sample during polarization measurement.

Sample rotation



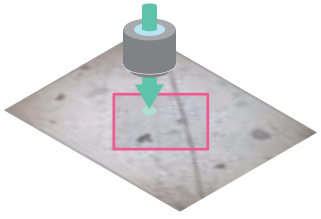
Rotate sample after measurement

Stage movement



Stage moves to calculated measurement coordinates from the rotation center coordinates and rotation angle

Image matching

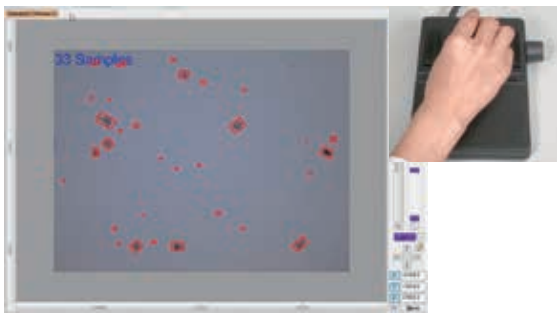


Minute deviations are corrected with the image matching function

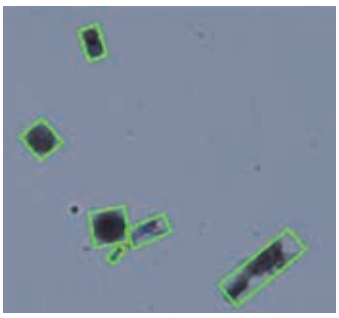
TARGETING THE MEASUREMENT POSITION

Automatic recognition of measurement position in real time

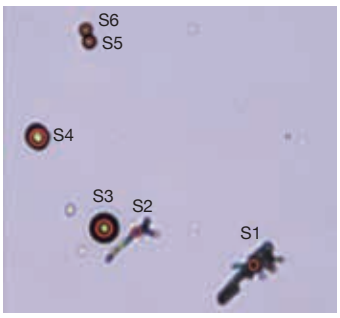
Candidates for measurement position are automatically recognized in real time and displayed along with the measurement position on the observed image. These recognized points can be registered as measurement position at once.



Real time sample recognition while moving stage



Automatic recognition
of measurement position



Batch processing
of measurement position

Targeting measurement position by shape and color

Advanced Search NAV

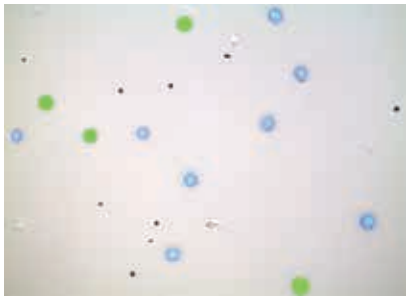
Characteristics such as size, circularity, and color of those recognized samples can be measured. It is possible to target measurement position in details by setting parameters concerning such characteristics.

Targeting by size (■ Detection parts)

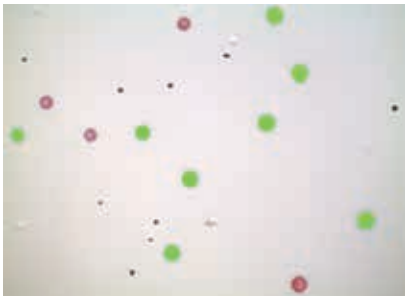
Detection of small-size samples

Detection of large-size samples

Targeting by color (■ Detection parts)

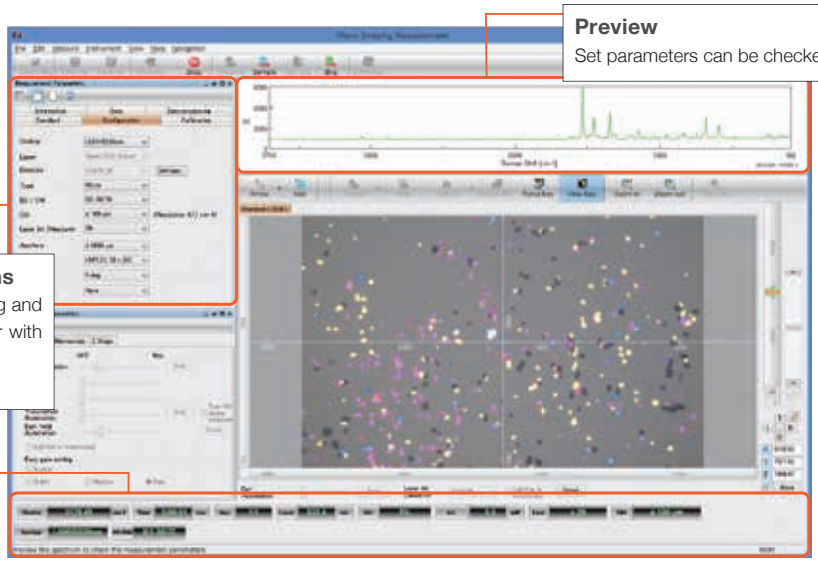


Detection of red-colored samples



Detection of blue-colored samples

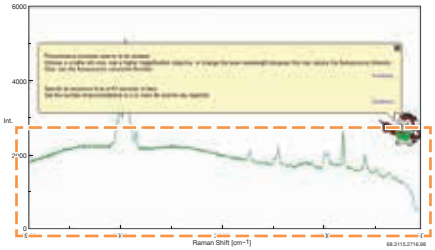
One-screen-setting of measurement parameters



Measurement screen

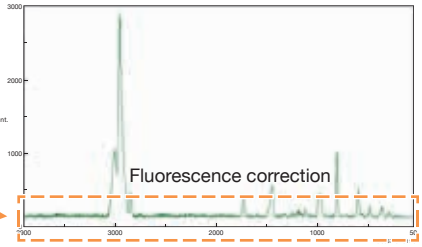
User advice function

User advice appears in real time about parameter setting considered based on the spectrum shape displayed in the preview. The spectrum after changing parameters can also be confirmed in real time.



Fluorescence emission seems to be present.
Choose a smaller slit size, use a higher magnification objective, or change laser wavelength because this may reduce the fluorescence intensity.
Also, use the fluorescence correction function.

Specify an exposure time of 41 seconds or less.
Set the number of accumulations to 2 or more for cosmic ray rejection.



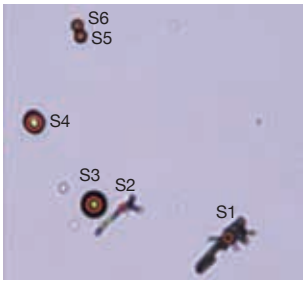
Other advice items

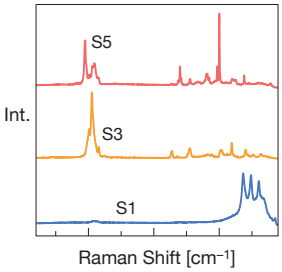
- Optimal exposure time, accumulation time
- Sample is damaged by laser
- Peak does not appear
- Fluorescence decays
- CCD detector ...etc.

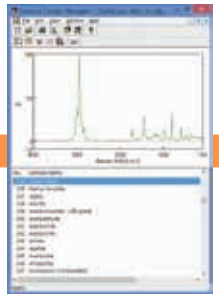
Qualitative analysis simultaneously with measurement

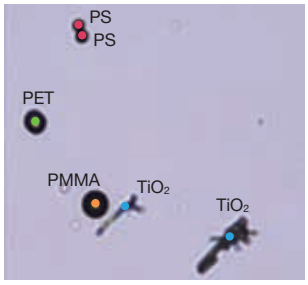
Advanced Search NAV

The acquired spectrum is collated with the JASCO original database, and the sample name of top listed is displayed on the observed image.









Ovservation image and spectrum data

Spectrum search

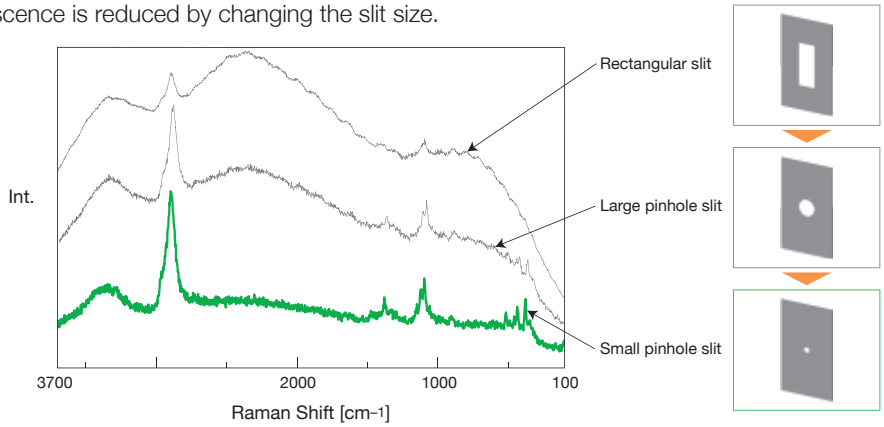
Search result

3-step procedure for fluorescence reduction

In general, Raman spectrum can be affected by fluorescence level. Fluorescence reduction is important factor to measure Raman spectra sensitively.

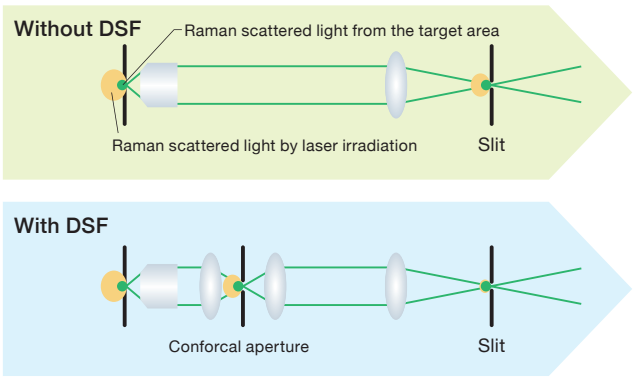
Step 1 Changing slit size

The effect of fluorescence is reduced by changing the slit size.

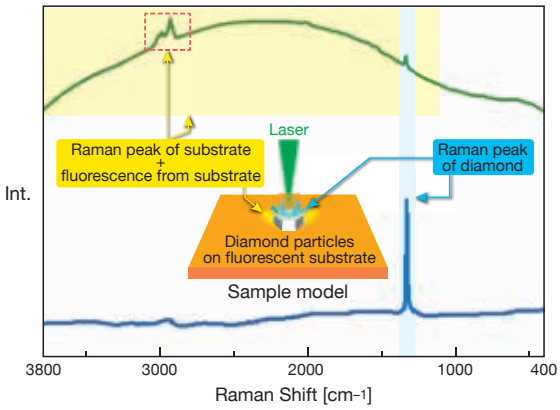


Step 2 Using DSF (Dual Spatial Filtration)

DSF (confocal aperture and pinhole slit) supports to detect Raman signal only from measurement position (focal plane) only.



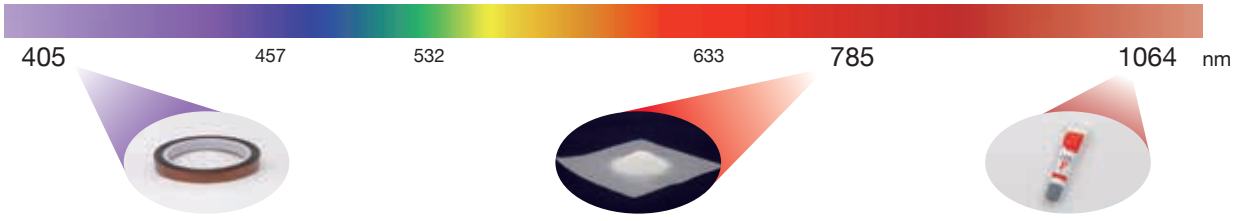
Optical system with or without DSF

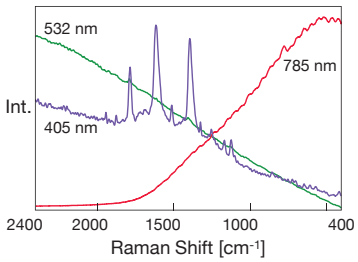


Fluorescence reduction by DSF
Approximately 1 µm diamond on fluorescent plastic plate

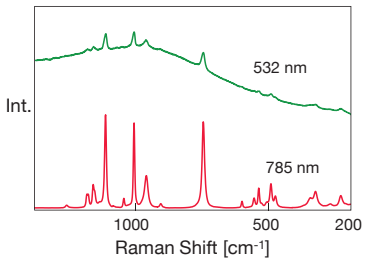
Step 3 Switching Ex wavelength

Use of a laser with a different excitation wavelength reduces fluorescence from a sample.

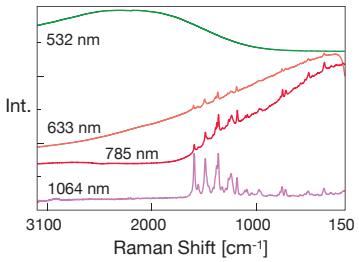




Polymer film (Polyimide)



Food additive (Sodium tripolyphosphate)

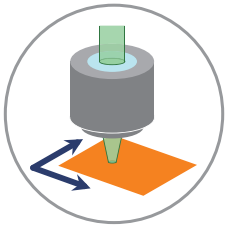


Pigment

Capturing a sample with "2D" and "3D"

Suitable method can be selected from following four measurement methods depending on nature of the sample and target of measurement.

2D sample image



High-speed imaging QRI

QRI (Quick Raman Imaging) is the combined technology with high-speed and high-accuracy stage and high-speed data acquisition CCD detector, it is possible to obtain imaging data of more than tens of thousands measurement position in a few minutes. This method is useful for a wide range of samples with millimeter to sub-micron sizes.

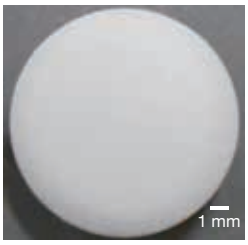
Faster imaging in wide area

The QRI reduces measurement time significantly for wide range of sample imaging measurement.

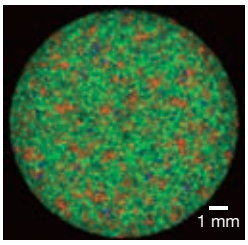
Details in narrow area

In order to analyze a sample microstructure, the sample measurement at small intervals and high-speed scanning of the sample stage allow the high-spatial resolution and high-resolution images to be obtained in short time.

Pharmaceutical tablet

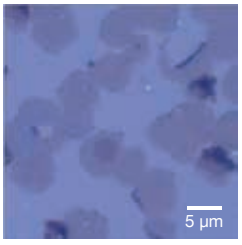


Observation image
Measurment points : 32761
Exposure time : 10 msec

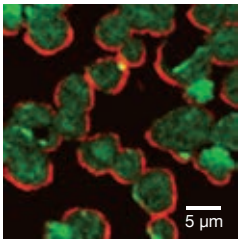


Acetaminophen
Etenzamide
Caffeine

Graphene



Observation image
Measurment points : 10201
Exposure time : 1 msec



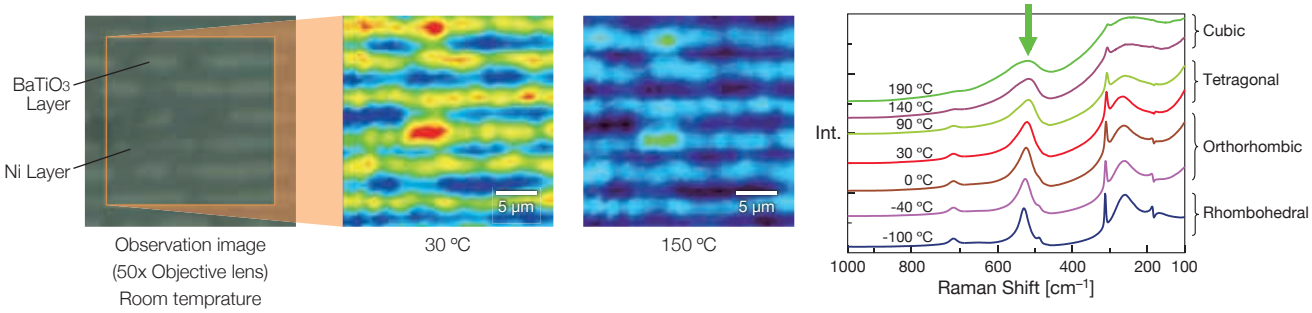
D band
G band

Laser scanning imaging SPRIntS

SPRIntS is a laser scanning imaging method. This method is useful when measuring fluid samples or when using immersion lenses or heating stages.

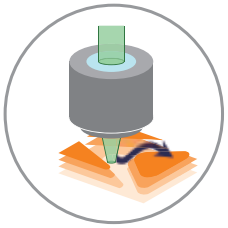
Raman imaging of temperature-dependent measurement without stage driving

In addition to the SPRintS, the heating stage allows the temperature-dependent Raman imaging data to be obtained without driving the stage.
When a cross-section of the multilayer ceramic capacitor was heated and measured, the peak (TO phonon) at 520 cm^{-1} shifted. This result showed that the structure of $BaTiO_3$ changed as the temperature increased.



Color map by peak area at 520 cm^{-1} (left, center), Comparison of spectra at each temperature (right)

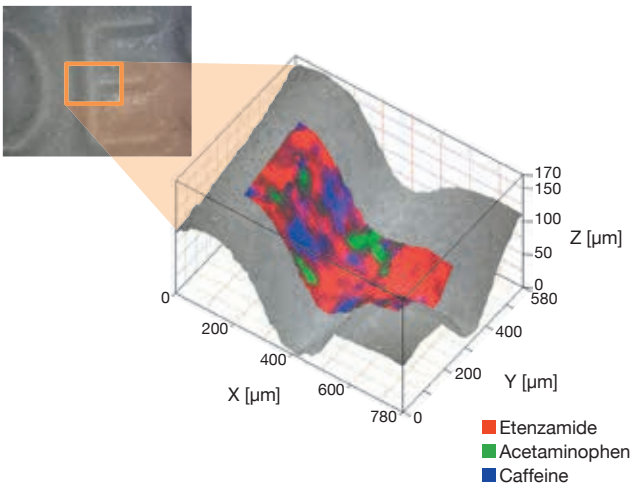
3D sample image



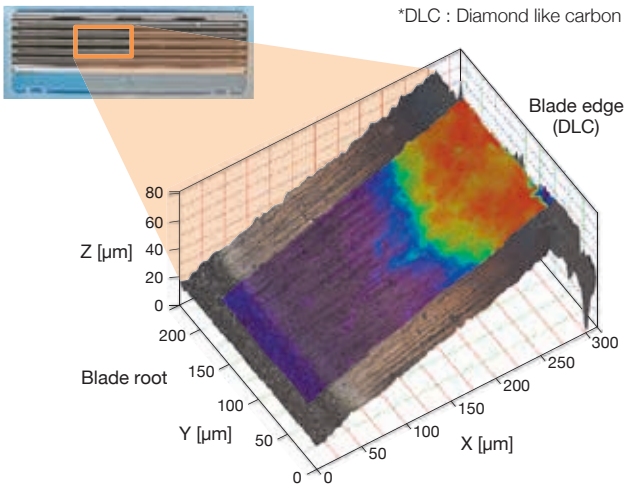
Surface Imaging SSI

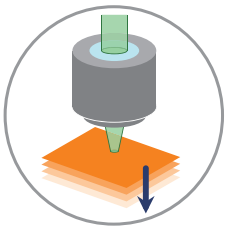
This method is useful when the sample surface is uneven and the height is not constant. The spectrum is measured while scanning the stage in three dimensions based on the sample height information obtained from the omnifocal image (p.9), without the sample pretreatment.

Engraved groove of pharmaceutical tablet



DLC coating distribution on razor edge

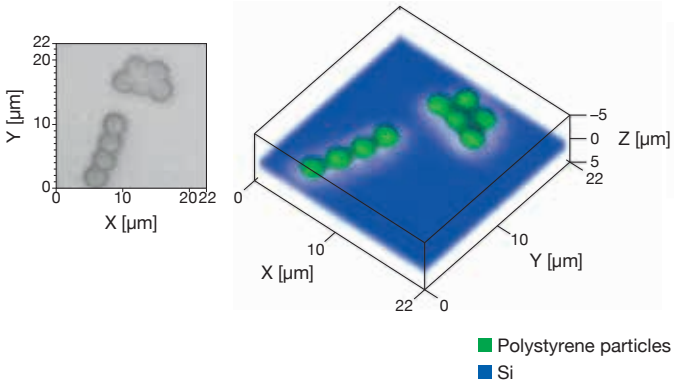




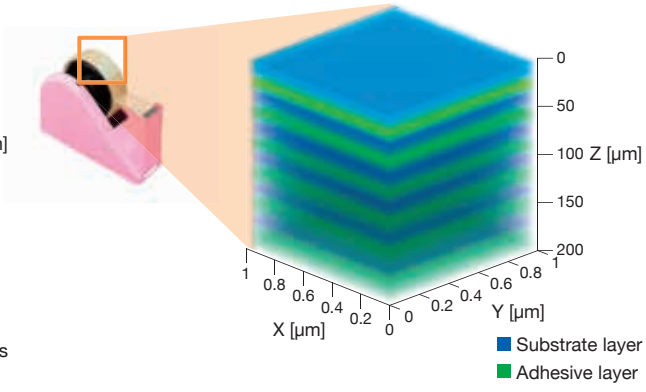
3D Imaging

This method is useful when each layer of multilayer films or a buried foreign matter is analyzed with non-destructive and non-contact measurement. The confocal optical system allows the Raman imaging in the depth of the sample to be obtained.

Polystyrene particles on Si wafer



Scotch tape

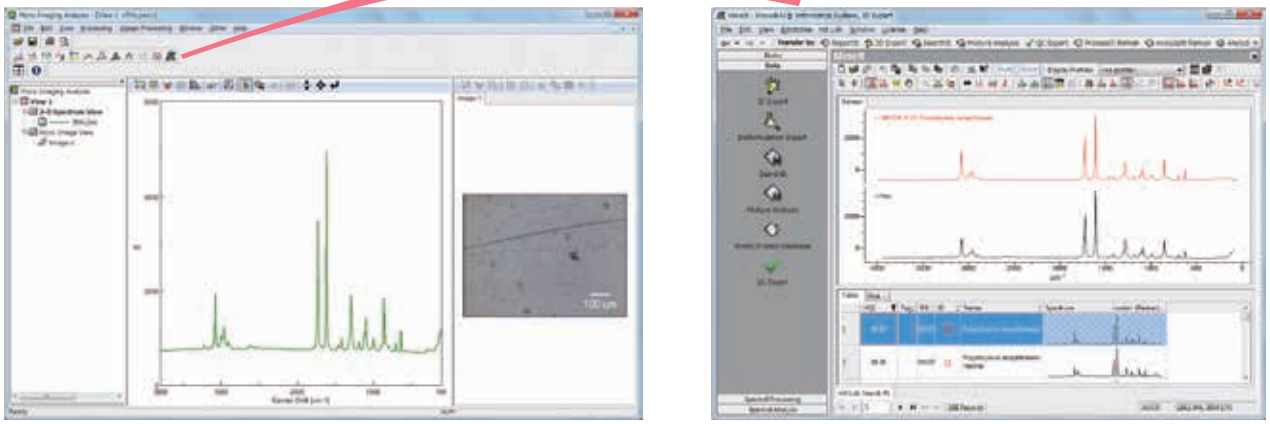


解

Unknown sample identification — One-click to search screen

The NRS-5000/7000 comes standard with KnowItAll from Wiley, which is highly regarded as a data search software. Spectral data are transferred from analysis program of JASCO Spectra Manager to KnowItAll with one-click operation.

Go to search screen



Analysis program　　KnowItAll program

Spectral Databases

KnowItAll standard package includes searching functions of spectrum, peak, structure, and multi-component and also spectral analysis support functions. JASCO original 1300 spectra data of organic compounds are also included as reference data. In addition, Wiley's 25,000 Raman spectra are also available as option.

Multiple Component Analysis

For unknown samples containing multiple components, up to 5 components are identified from 1 spectrum.

AnalyzeIt Raman

Searching for peaks by functional groups.

User database builder

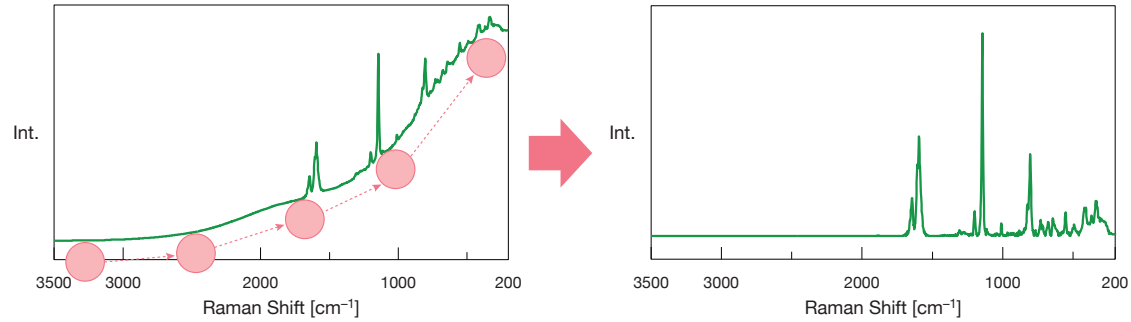
Creating a user-defined database. Registration of sample spectra, structural formulae and physical properties possible.

Multi technique

Raman spectroscopy, infrared spectroscopy, and complementary methods can be combined. Search using both methods, and extract search results with high scores in both methods. Enables more accurate sample identification through this method.

Data processing function to improve analysis accuracy

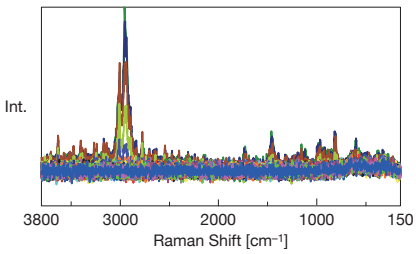
To improve the accuracy of database search, spectral data processing is important before search. JASCO has developed a unique correction method (Japan Patent No. 5363050) for fluorescence which greatly affects search accuracy. This method allows anyone to easily eliminate fluorescence emitted from a sample. This processing can be used when previewing a sample spectrum and applied in real time during sample measurement.

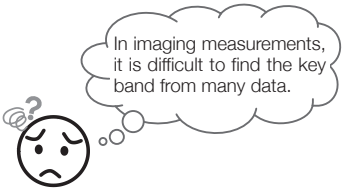


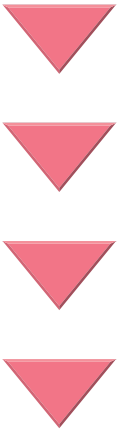
Rotate the sphere to separate the fluorescent component

Acquiring "component distribution image" by simple operation

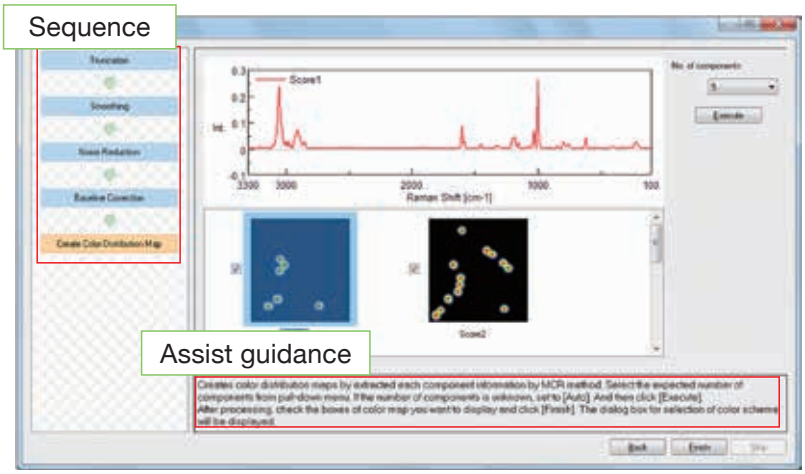
It is possible to create chemical images such as peak height, area, half width, correlation coefficient, and multivariate analysis with ease. In addition, color-coded diagrams can be created by using the analysis wizard function according to the sequence and assist guidance.

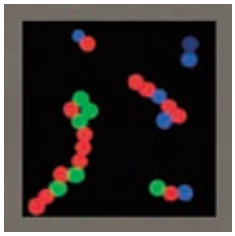


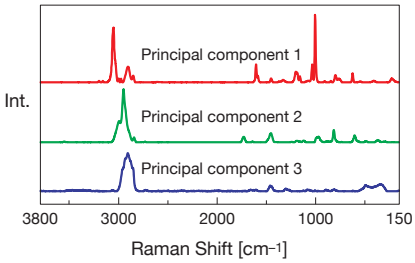


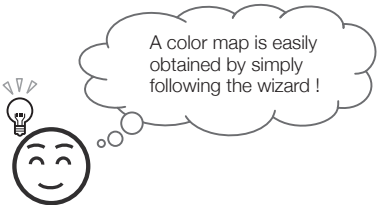


Sequence



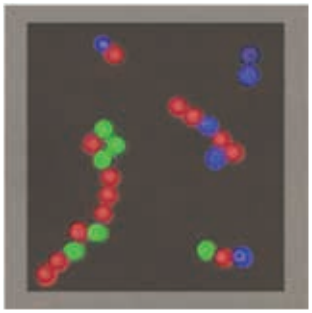


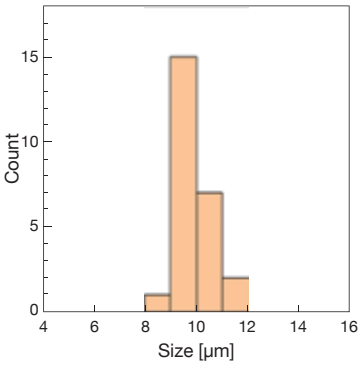




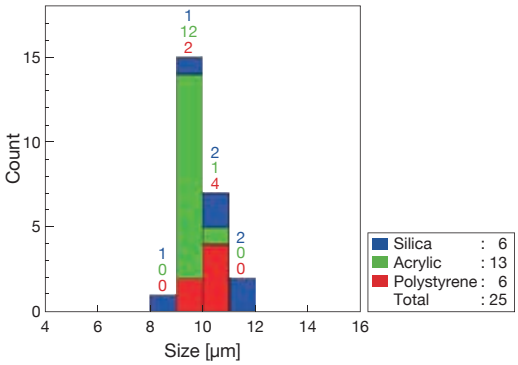
Statistical analysis of component distribution image

It is possible to acquire shape and color information about sample from color-coded diagrams and observation images by using the JASCO Particle Analysis program.
Histograms, frequency distributions, and correlation distributions can be created based on the obtained information.
Furthermore, the histogram can be edited as stacked histogram for each component.





Histgram



Stacked histogram for each component

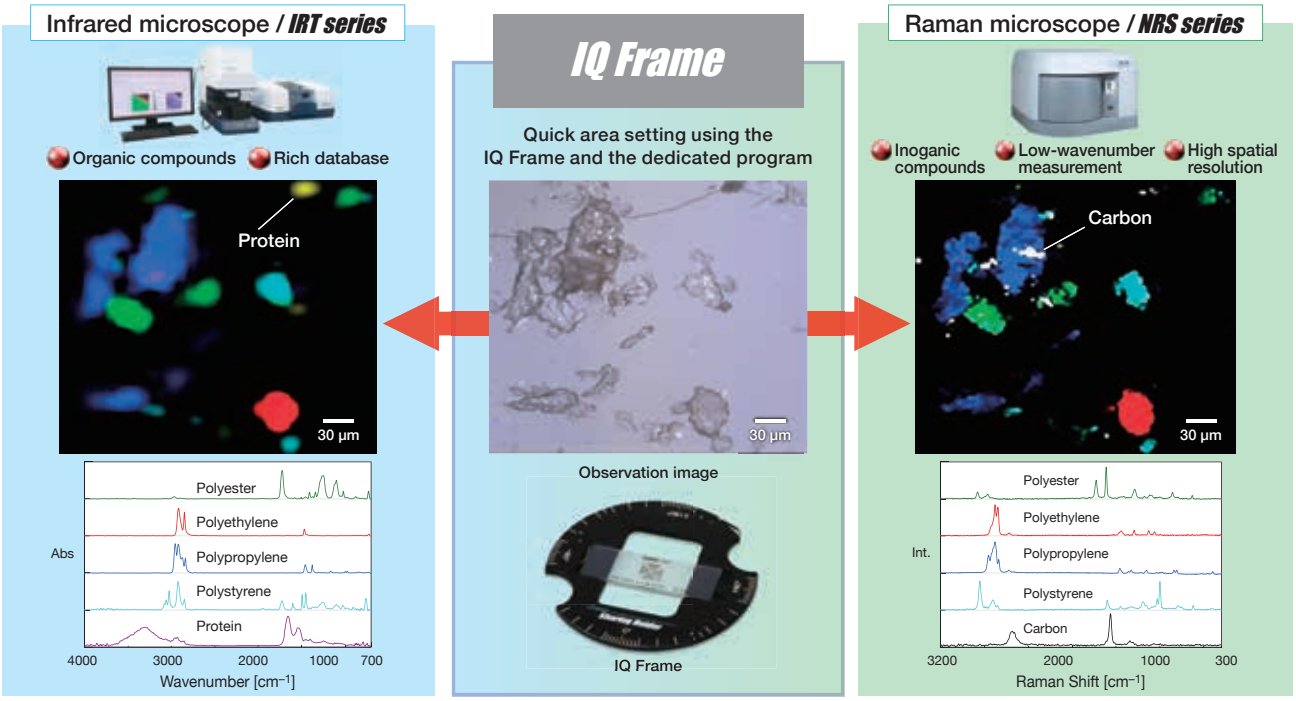
Applications

Foreign material

IR and Raman combined analysis

NRS-5500/7500

It is possible to measure same area on sample in both IR microscope system and Raman microscope using the IQ Frame.

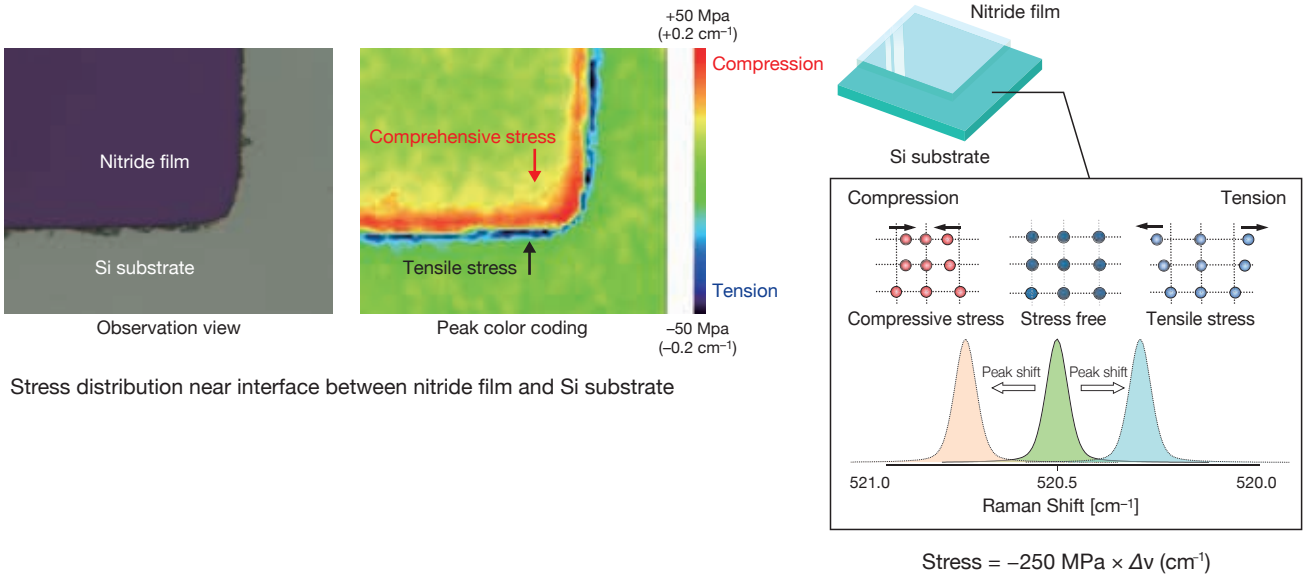


Semiconductor

Silicon —— Small stress-strain analysis

NRS-7500

A peak of silicon slightly shifts if the stress is applied to the silicon. The amount of strain can be calculated by the amount of peak shift. High-accuracy stress measurement is possible by performing simultaneous measurement with Ne lamp (see NOTES.)



Stress distribution near interface between nitride film and Si substrate

Stress = –250 MPa × Δν (cm⁻¹)

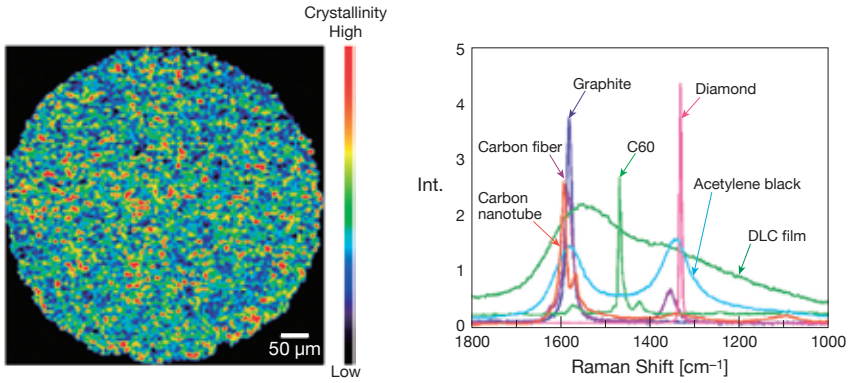
NOTES **Simultaneous measurement with Ne lamp**

A Ne lamp for wavenumber correction is equipped as standard in the spectrometer. It is possible to obtain accurate peak shift based on emission line spectrum of Ne lamp.

Carbon materials

Mechanical pencil lead —— Visualization of crystallinity

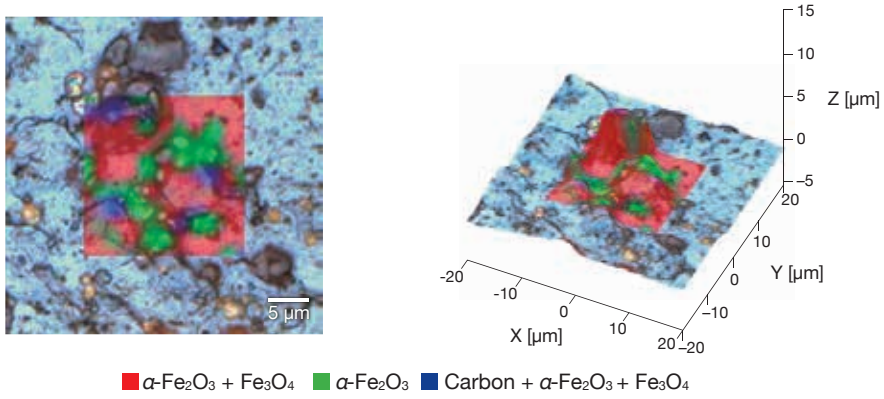
The carbon crystallinity of the cross section of the mechanical pencil lead was visualized by Raman imaging. Raman spectra enabled identification of various carbon materials such as graphite, amorphous carbon, or DLC and evaluation of crystallinity.



Inorganic substance

Iron rust —— Low wavenumber measurement

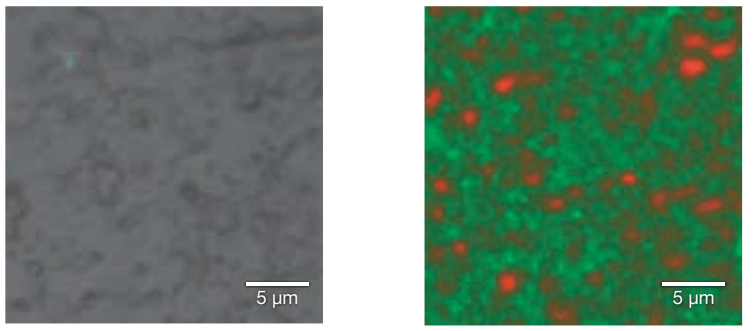
In general, lattice vibrations of inorganic substances or crystals composed of heavy atoms cause peaks in the low wavenumber region. Raman spectra of an iron rust in this region clearly showed structural differences in iron compounds.



Polymer

ABS alloy —— Imaging of sea-island structure

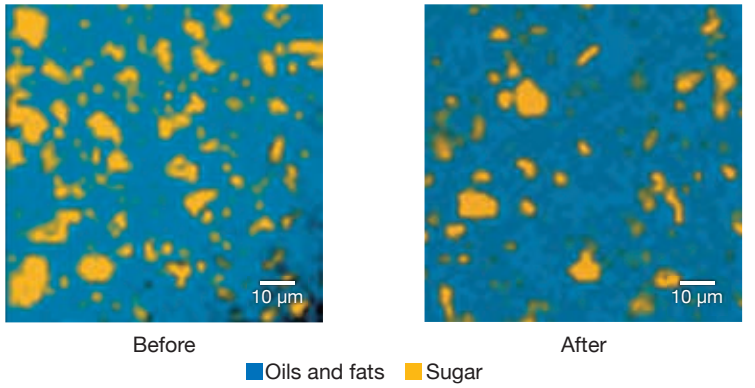
The NRS-5500/7500 system allows micro Raman imaging of the sea-island structure of polymer blends on a sub-micron scale. A visualization of sea-island structure of polymer blends leads to the evaluation of chemical properties such as impact resistance.



Food

White choholate —— State change before and after heating

Heating of chocolate causes the fats and oils on the surface. White chocolate was investigated with Raman imaging and a melting behavior in the chocolate could be clearly seen. Fats and oils, which have a lower melting point than sugar, are more fluid than sugar when heated. Raman imaging revealed the chemical distribution changes in chocolate caused by heat.



JASCO CORPORATION
2967-5, Ishikawa-machi, Hachioji-shi, Tokyo 192-8537 Japan
Tel: +81-42-649-5177 Fax:+81-42-646-4515 Web: www.jasco.co.jp
Japan

JASCO INTERNATIONAL CO., LTD.
11-10, Myojin-cho 1-chome, Hachioji-shi, Tokyo 192-0046, Japan
Tel: +81-42-649-3247 Fax: +81-42-649-3518 Web: www.jascoint.co.jp/english/
Australia, Hong Kong, India, Indonesia, Korea, Malaysia, New Zealand, Pakistan,
Philippines, Russia and CIS countries, Singapore, Taiwan, Thailand, Vietnam

JASCO INCORPORATED
28600 Mary' s Court, Easton, Maryland 21601, U.S.A.
Tel: +1-410-822-1220 Fax: +1-410-822-7526 Web: www.jascoinc.com
Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Guatemala, Mexico,
Paraguay, Peru, Puerto Rico, United States of America, Uruguay, Venezuela

JASCO EUROPE S.R.L.
Via Luigi Cadorna 1, 23894 Cremella (LC), Italy
Tel: +39-039-9215811 Fax: +39-039-9215835 Web: www.jasco-europe.com
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JASCO CHINA (SHANGHAI) CO., LTD.
Room No.D, 10F, World Plaza, 855 Pudong South Road, Pudong New Area, Shanghai, China
Tel: +86-21-6888-7871 Fax: +86-21-6888-7879 Web: www.jasco-global.com
China

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