EDINBURGH INSTRUMENTS

RESEARCH GRADE

RAMAN MICROSCOPE

RMS1000

EDINBURGH INSTRUMENTS

Edinburgh Instruments has been providing high performance instrumentation in the Molecular Spectroscopy market for almost 50 years.

Our commitment to supplying the highest quality, highest sensitivity instruments to our customers has now expanded to developing and manufacturing the best Raman microscopes for all research and analytical requirements.

As always, Edinburgh Instruments delivers world-class customer support and service throughout the lifetime of our instruments.

MOLECULAR SPECTROSCOPY SINCE 1971 ● Photoluminescence ● Raman ● UV-Vis ● Transient Absorption

BIOSCIENCES PHARMACEUTICALS CHEMICALS POLYMERS NANOMATERIALS

RMS1000 RAMAN MICROSCOPE

The RMS1000 Raman microscope is an open architecture research grade confocal Raman microscope. It has been designed so it can be adapted to almost any modern, state-of-the-art Raman application.

> **“THIS HIGH-END RESEARCH TOOL HAS BEEN BUILT WITH NO COMPROMISES; RESULTING IN A SYSTEM THAT STANDS ALONE.”**

This high-end research tool has been built with no compromises, resulting in a system that stands alone in both specification and ease of use. Applications beyond Raman, such as time-resolved fluorescence microscopy and fluorescence lifetime imaging, are all possible with the versatile RMS1000.

KEY FEATURES

- **Integrated and External Lasers –** up to 5 internal computer-controlled lasers for ease of use and reduced footprint. External laser integration for advanced Raman and Fluorescence measurements
- **Five-Position Grating Turrets –** for unrivalled spectral resolution from <0.1 cm^{-1} and coverage over 5 cm^{-1} - 30,000 cm^{-1}
- **Two Spectrograph Options –** standard compact and long focal length spectrographs available for ultimate resolution, sensitivity, and stray light rejection
- **Truly Confocal –** multiple position pinhole for high spatial resolution, fluorescence and background rejection and application optimisation
- **Four Simultaneous Detectors –** up to 4 detectors can be installed, including high efficiency TE-cooled CCDs, EMCCDs, InGaAs and more
- **Internal Standards and Auto-Calibration –** to ensure the highest quality data you can trust, at all times
- **Ramacle® Software –** a powerful software package for complete system control, data acquisition, and data analysis, with complete ease of use
- **Photoluminescence Microscopy, Time-Resolved Measurements, Fluorescence Lifetime Imaging –** extend the Raman capabilities to fluorescence and beyond

PRECISION
RAMAN

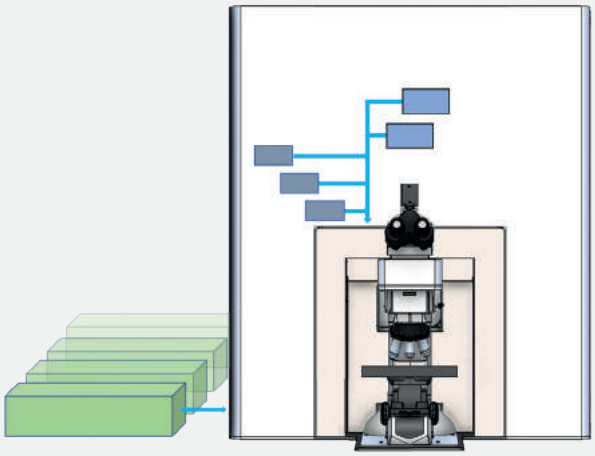
COSMETICS | SEMICONDUCTORS | ART & MUSEUM | FORENSICS | GEOLOGY

LASER BEAM PATH – LASER CHOICE

The open architecture design of the RMS1000 offers a versatile and customisable laser beam path and a maximum choice of lasers. Once configured, all hardware selections and measurement options are fully automated.

“USE ALTERNATIVE LASER WAVELENGTHS TO DISCRIMINATE RAMAN SIGNALS EFFECTIVELY FROM FLUORESCENT BACKGROUND.”

- Up to 5 fully integrated lasers of compact design
- Multiple external lasers of larger footprint
- Accurate laser power attenuation
- Laser line rejection filters with excellent performance, allowing for low wavenumber measurements
- Fully software controlled operation, no manual switching of sources and optical components



RECOMMENDED LASER SOURCES

GENERAL PURPOSE
532 nm | 638 nm | 785 nm

SEMICONDUCTORS
325 nm | 473 nm | 532 nm

PHARMACEUTICALS
532 nm | 638 nm | 785 nm

NANOMATERIALS
532 nm | 638 nm | 785 nm

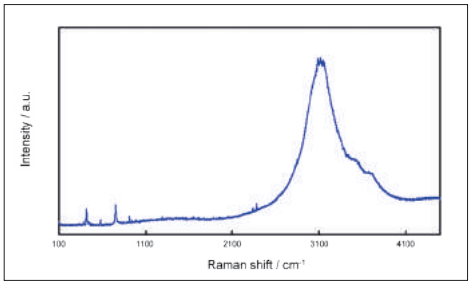
BIOSCIENCES
785 nm | 830 nm | 1064 nm

POLYMERS
532 nm | 638 nm | 785 nm

GEOLOGY
532 nm | 785 nm

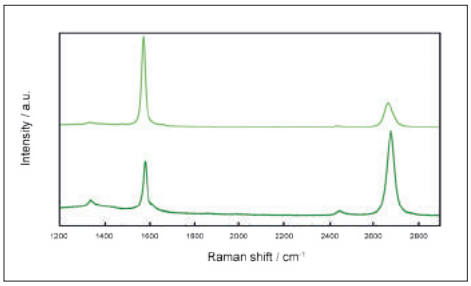
SEMICONDUCTORS: 325 nm

UV Raman analysis of GaN materials provides both Raman and photoluminescence data which can be used to detect defects in the material. This facilitates monitoring and improvement of manufacturing processes and device performance.



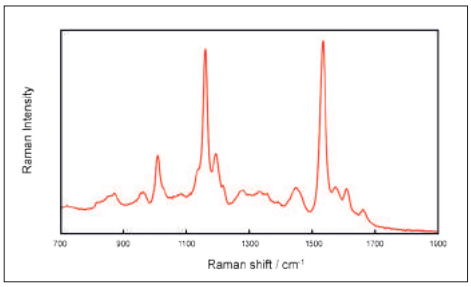
NANOMATERIALS: 532 nm

Confocal Raman is ideal for characterising the electronic structure of graphene. Graphene has 2 major bands (1580 cm^{-1} and 2680 cm^{-1}). The ratio of these peaks changes in dependence of the number of layers.



BIOSCIENCES: 785 nm

Raman spectrum taken from a grain of buttercup pollen, showing Raman peaks from carotenoid species as well as proteins and amino acids which can be used to identify species. 785 nm excitation was chosen to minimise fluorescence background.

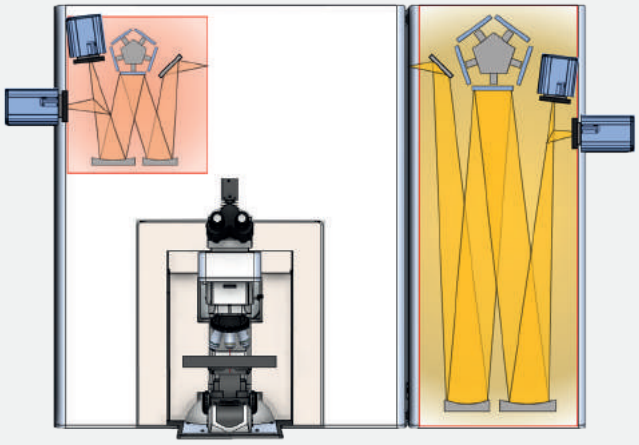


RAMAN SCATTER PATH – SPECTROGRAPH CHOICE

The RMS1000 features a versatile and configurable Raman scatter path with all hardware options fully computer controlled. Two spectrograph versions are available for standard research and the most demanding applications.

"MATCH THE FOCAL LENGTH OF YOUR SPECTROGRAPH TO THE REQUIREMENTS OF YOUR DEMANDING RESEARCH."

- Standard and/or long focal length spectrograph with multitude of camera and grating options
- Integrated variable pinhole turret
- Piezo-controlled beam alignment
- Integrated and external viewing camera for widefield observations



STANDARD SPECTROGRAPH

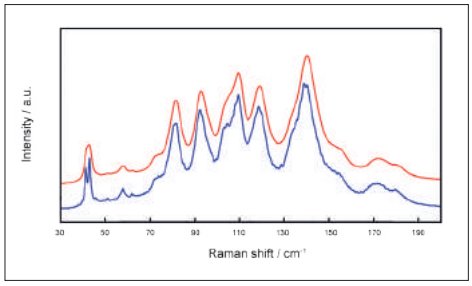
- Compact, integrated
- Suitable for most Raman applications
- With turret of up to 5 gratings
- With exit ports for up to 2 detectors

LONG FOCAL LENGTH SPECTROGRAPH

- Large, attached
- For the most demanding Raman applications requiring extra high resolution and additional stray light rejection
- Particularly useful in combination with UV excitation
- With turret of up to 5 gratings
- With exit ports for up to 2 detectors

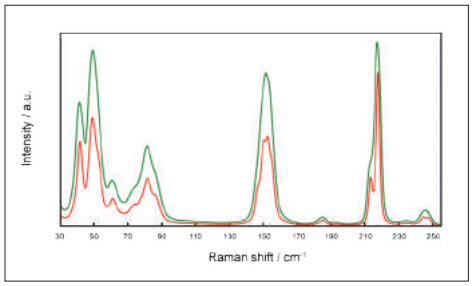
SPECTROGRAPH CHOICE

Raman spectrum of L-histidine, measured with standard spectrograph (red) and long focal length spectrograph (blue). The background reduction and the increased spectral resolution for the measurement with the long focal length spectrograph are evident.



PRECISION SLITS

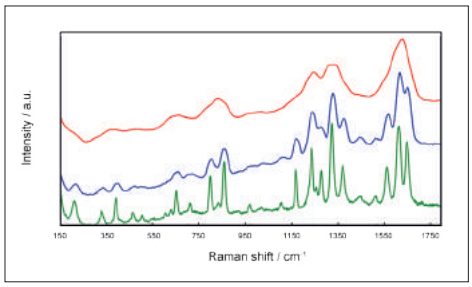
Both spectrograph options are fitted with a high precision slit that is quasi-continuously adjustable. The spectra demonstrate the capability of controlling the resolution by the slits. The example of Raman scans of sulphur with 100 µm slit (green) and 20 µm slit (red), clearly show the better resolved band structures with the smaller slit width.



FIVE POSITION GRATING TURRET

Raman spectra of paracetamol, taken with 300 g/mm (red), 600 g/mm (blue) and 1800 g/mm (green) gratings. A wide selection of gratings to match the excitation laser is available for use with both spectrographs.

The wide selection of gratings, together with the option for spectral stitching, allows for user optimisation over the entire spectral range.



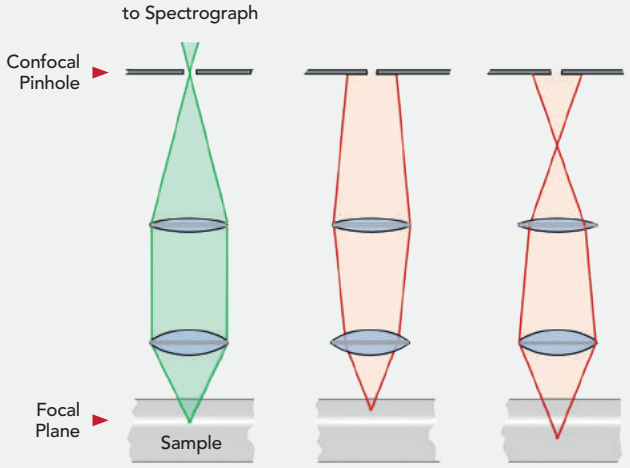
CONFOCAL RAMAN MICROSCOPY

Due to its true confocal design, the RMS1000 offers excellent 2D mapping, depth profiling, and 3D mapping capabilities and provides close to diffraction-limited spatial resolution.

“DO NOT GO WITH A COMPROMISED OPTICAL DESIGN! GO FOR TRULY CONFOCAL!”

- True confocal design with a software controlled confocal pinhole turret
- More than 10 confocal pinhole sizes under 100 µm
- Rejection of unwanted background
- Ultimate control for superior Raman mapping contrast and spatial resolution
- Optical sectioning and depth profiling of the sample by rejecting out-of-focus light

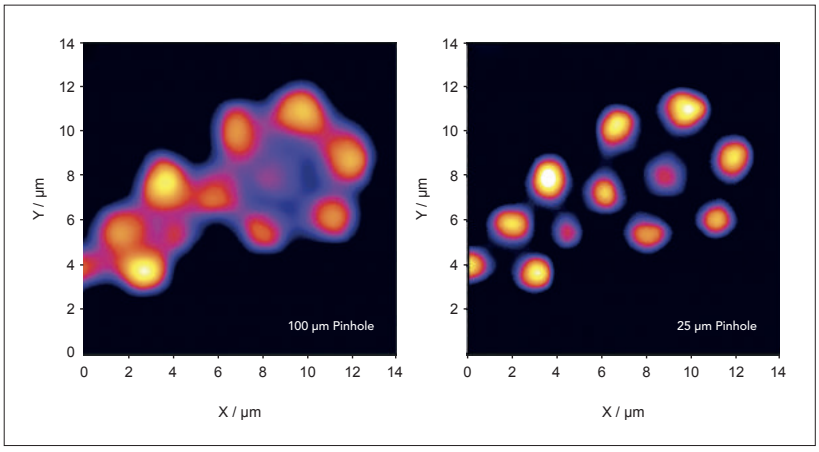
detected radiation — rejected radiation



IMPROVEMENT OF SPATIAL RESOLUTION

The confocal pinhole design significantly enhances the contrast of 2D Raman maps due to better spatial selection and better discrimination from unwanted signal surrounding the focus point.

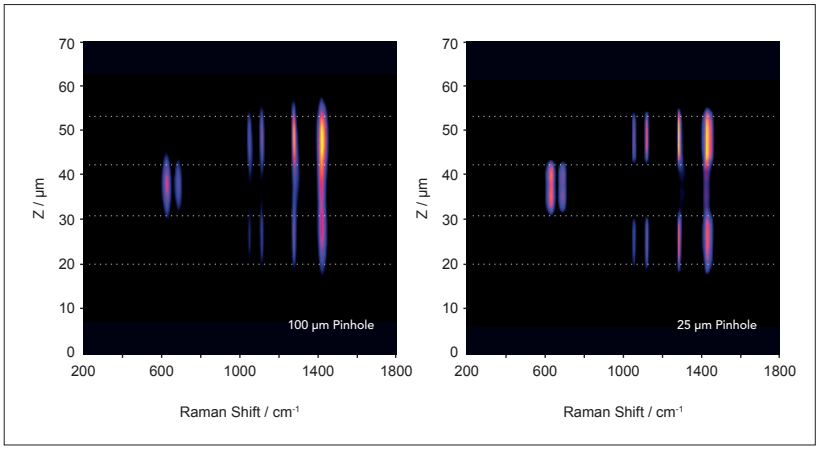
The example shows a 2D Raman map of a cluster of 3 µm sized polystyrene beads on a silicon substrate. The comparison between 100 µm and 25 µm confocal pinholes shows the improved image quality that truly confocal detection can achieve.



DEPTH PROFILING

A confocal pinhole design is an essential requirement if the ‘Z-dimension’ of the sample is to be investigated. With true confocality, volumes within the sample can be ‘viewed’ by the detector.

This measurement, taken on a PET-PVC-PET multilayer polymer sample, shows how the Raman spectrum changes when the focus is moved through the depth of the sample with fixed X and Y positions. The reduction of the pinhole size clearly demonstrates the enhancement of contrast in the ‘Z’ dimension.



RAMAN MAPPING

The RMS1000 comes with Raman Mapping that has been central to the design from concept to completion. Raman Mapping truly adds a different dimension to this high-end Raman Microscope.

"BEST PERFORMANCE RAMAN MAPPING: CONFOCAL, WITH HIGH SPEED AND HIGH DATA ACCURACY."

Mapping the Raman spectra within a sample space provides previously unavailable information about the chemical and physical differences across a sample. This can confirm the identity and presence of specific components, and reveals their location and distribution within the sample.

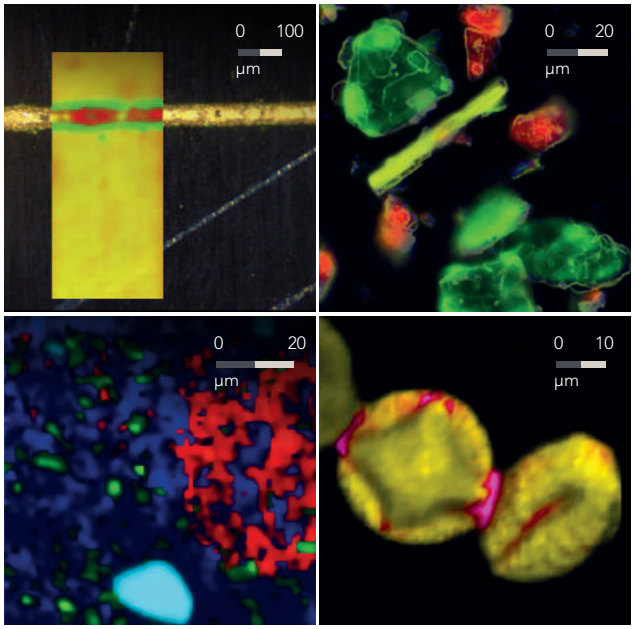
The RMS1000 generates Raman maps using a motorised stage for sample scanning, which permits finely controlled movement in the X, Y and Z planes. Line scans, plane maps, and volume maps can be created. Auto-focus options help tracking of uneven surfaces and sample planes.

Material sciences
Investigate how structure, stress and strain vary across a sample

Biology and life sciences
Image tissues, whole cells or their components without the need for dyes and stains; or locate Raman and SERS tags

Pharmaceuticals
Identify ingredients and analyse their distribution in drug development and drug production

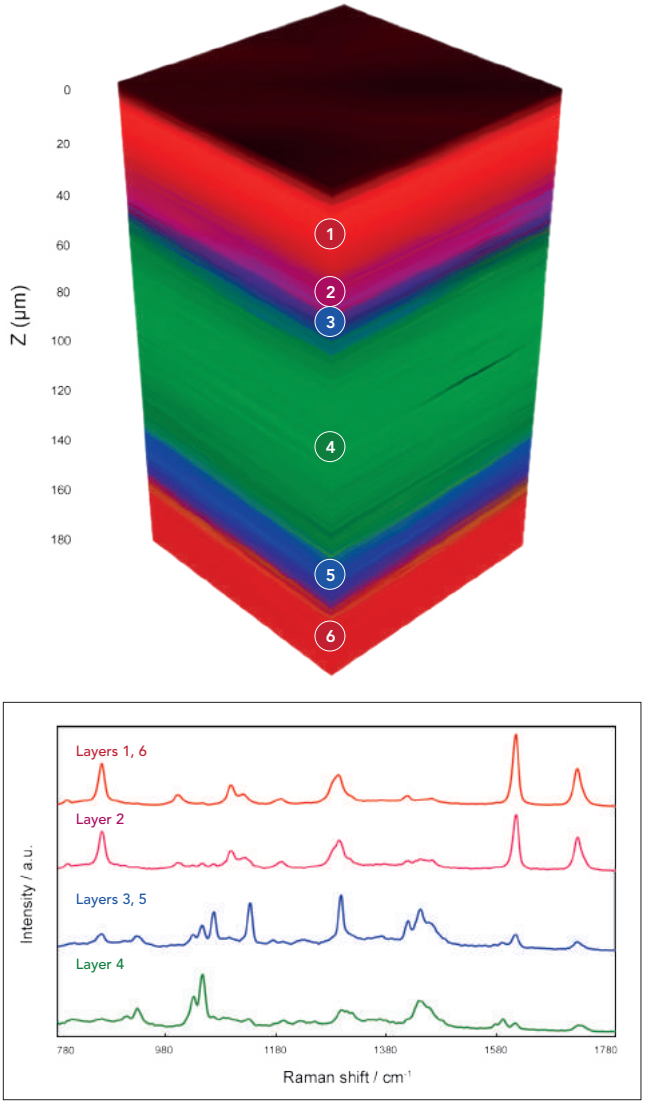
2D RAMAN MAPPING



2D Raman maps of a silicon solar cell (top left) and a mixture of amino acid crystals (top right), both shown overlaid with their respective darkfield microscope images. 2D Raman maps of toothpaste (bottom left) and pollen grains (bottom right).

Effective Raman mapping sets special requirements for hardware and software. The fastest and most sensitive array detectors, EMCCDs, should be considered, together with a fast scan stage and proven and tested software that can acquire and process vast data sets with high accuracy and in the shortest possible time.

3D RAMAN MAPPING



3D confocal Raman map of a transdermal patch. Spectra were collected at 10 µm steps in X and Y axes and 1 µm steps in Z axis resulting in a stack of 188 2D Raman maps. The volume render shows the separate layers of the patch; the representative spectra reveal the identities of poly(ethylene terephthalate) (red), PET/polyisobutylene (pink), polyethylene (blue) and the active ingredient (green).

FLEXIBILITY IN MICROSCOPY

PUSHING THE BOUNDARIES IN RAMAN SCIENCE

The RMS1000 is available with either an upright or an inverted confocal microscope for Raman research in material and biological sciences.

The microscopes can be configured with reflective and/or transmitted light illumination and have options for all modern visualisation and contrast enhancement techniques. There is space for fluorescence illuminators, scan stages and advanced sample holders, such as temperature stages and pressure cells.

2 **Upright microscope**
Standard spectrograph

1 **Inverted microscope**
Standard spectrograph

FLEXIBILITY IN RESOLUTION

FOR ADVANCED RAMAN RESEARCH

3 Inverted microscope

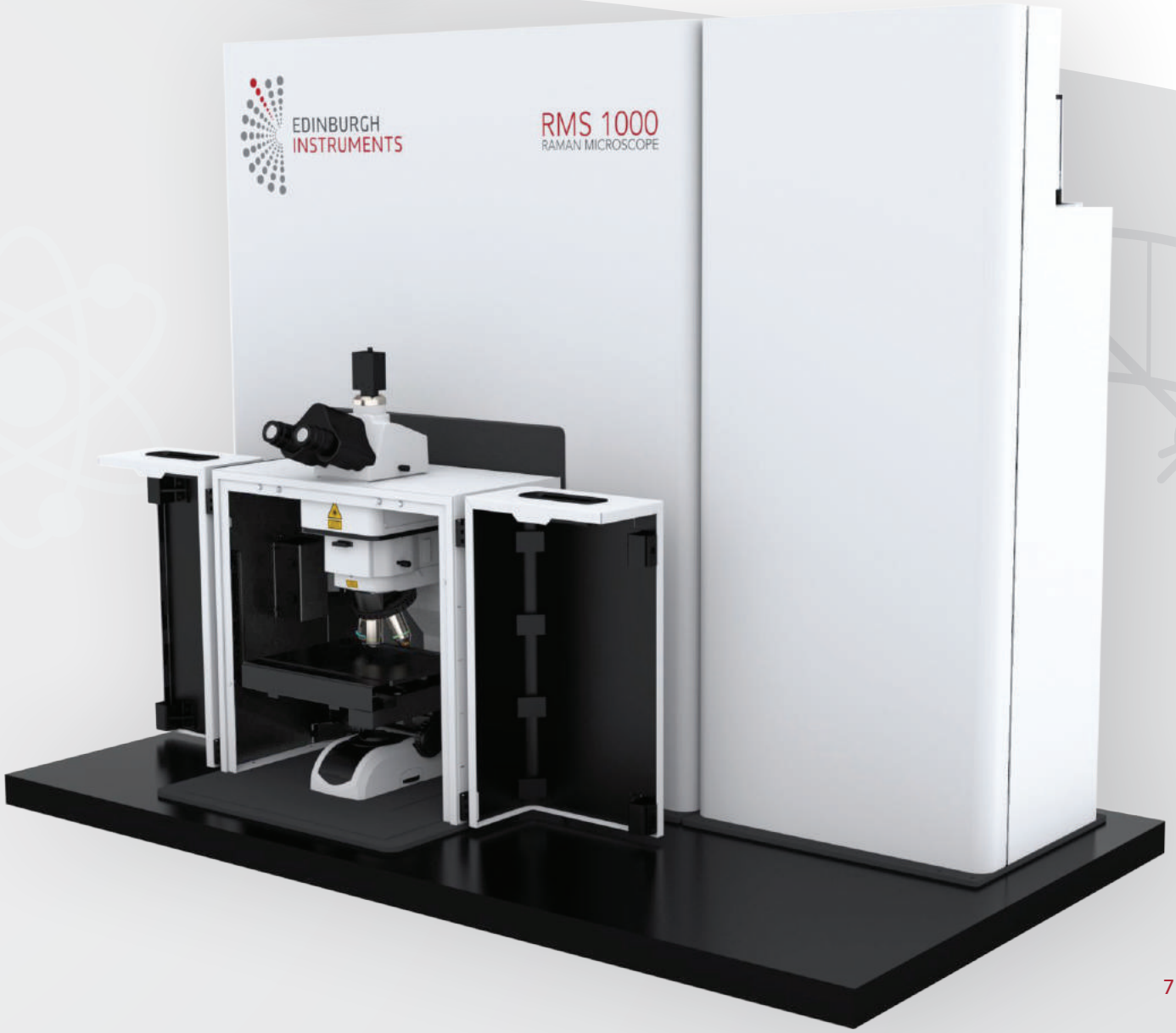
Long focal length spectrograph

For applications that require ultimate spectral resolution or ultraviolet wavelength excitation, the RMS1000 can integrate a second long focal length spectrograph.

Both the standard and long focal length spectrographs can contain 5 gratings on an interchangeable grating mount for ultimate flexibility over spectral resolution and spectral range.

4 Upright microscope

Long focal length spectrograph, laser safety enclosure



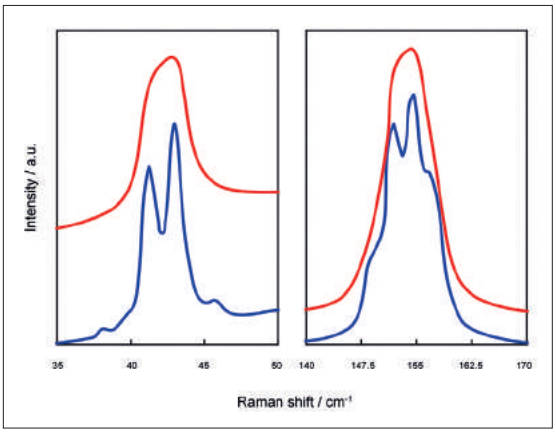
RMS1000 PERFORMANCE

SPECTRAL RESOLUTION

The RMS1000 provides high resolution Raman spectra.

The optical path of the RMS1000 has been optimised with narrow-band lasers, superior flat-field optics, a choice of two high quality spectrographs, and high performance pixel matched cameras; all to achieve the best spectral resolution for the user. High spectral resolution over a broad range is possible by stitching together spectra in a single measurement process within Ramacle software.

The RMS1000 can easily identify complex Raman spectra and Raman bands in close proximity due to its industry-leading spectral resolution from <0.1 cm^{-1}.



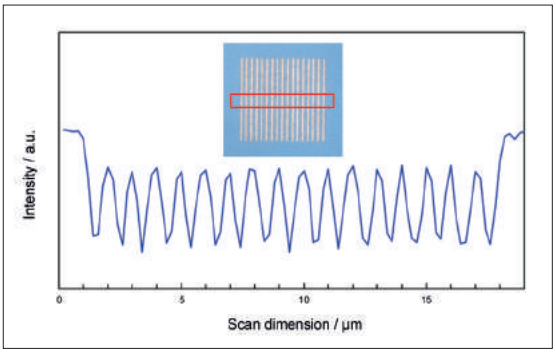
Spectral resolution with standard (red) and long focal length (blue) spectrographs for histidine (left) and sulphur (right)

SPATIAL RESOLUTION

The truly confocal RMS1000 has exceptional spatial resolution allowing features of <1 µm to be resolved.

The wide choice of objectives and the adjustable pinhole for spatial filtering provides excellent flexibility and allows spatial resolution to be optimised depending on sample requirements.

Highly spatially resolved Raman maps can be acquired and superimposed over the white light sample image recorded by the integrated CMOS camera.

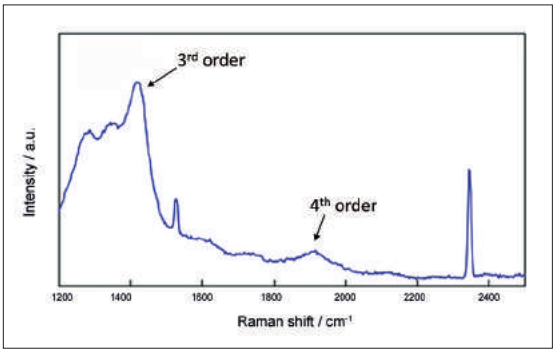


Reference sample with 1 µm thick silicon lines spaced by 1 µm thick gold/chromium lines. The silicon 1st order Raman signal at 520 cm^{-1} has been recorded with 200 nm steps (blue trace). Laser excitation at 785 nm. Inset: White light image taken with internal camera with the scanned region highlighted (red)

SENSITIVITY

High signal sensitivity in a Raman microscope comes as standard in the RMS1000. The confocal design makes it easy to detect extremely weak Raman signals, by focusing on the signal of interest and minimising unwanted superimposing non-Raman signals including stray Rayleigh scatter background and fluorescence.

Detection of the 4th order silicon band at 1940 cm^{-1} provides evidence of the instrument's excellent sensitivity.

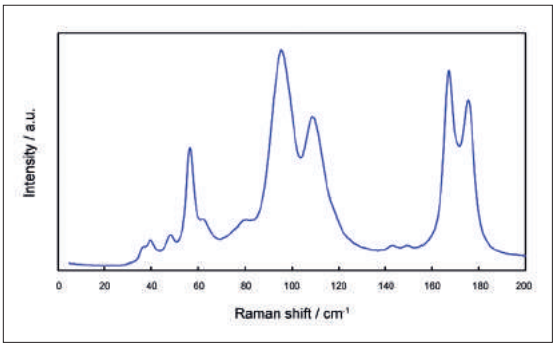


Silicon, excited with 532 nm laser

LOW WAVENUMBER PERFORMANCE

The RMS1000 is equipped with high quality edge filters which ensure that spectra with very small Raman shifts from the laser line can be detected. These relatively weak Raman peaks are often hidden but can be reliably detected with the RMS1000. The filters used in the RMS1000 offer the narrowest transition widths to remove Rayleigh scattered light from measurements and guarantee very low wavenumber Raman bands down to 5 cm^{-1}*.

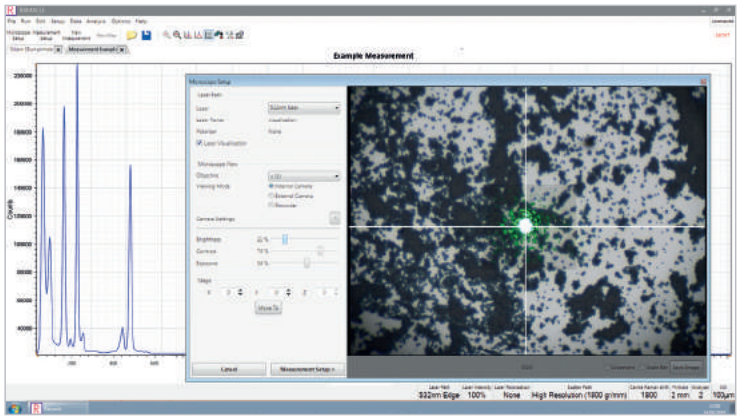
* with low wavenumber attachment



Triptycene, excited with 785 nm laser using the standard spectrograph

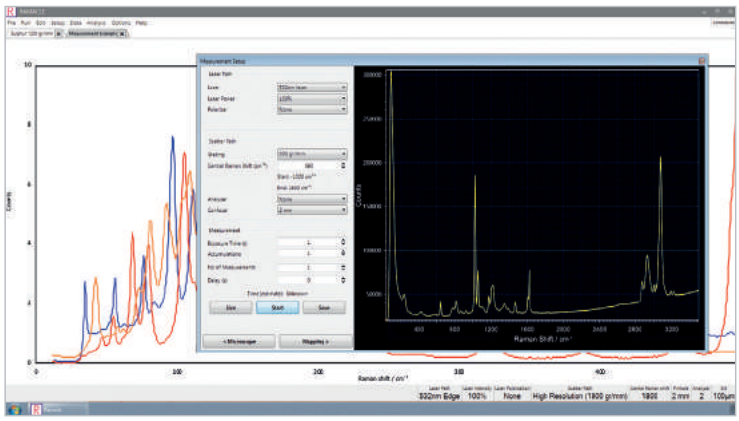
RMS1000 SOFTWARE – RAMACLE

Ramacle is an exceptional software package written for complete instrument control and data handling on the RMS1000 system. It controls all RMS1000 functions with a straightforward design concept. It focuses on all modern Raman spectroscopy applications, while at the same time, provides a user-friendly interface with 'ready to publish' outputs.



The software provides control of the RMS1000, visualisation, data acquisition, analysis and presentation whether it is used for generating Raman spectra or with advanced upgrades such as Raman mapping.

Ramacle enables sample visualisation, live signal monitoring and parameter optimisation before every measurement. The instrument status and signal are displayed and constantly updated during measurements.



Data generated by Ramacle have a proprietary file format. This contains all measurement and instrumental properties, allowing the user to retrieve important information whenever needed and ensures data traceability. Simple input and output functions provide compatibility with a host of third-party data analysis or presentation packages.

KnowItAll™ Raman Identification Pro spectral library is available for material identification and advanced analysis. Data acquisition methods such as single measurements, multiple and accumulated scans, kinetic scans and generation of maps (accessory dependent) are implemented by intuitive and user-friendly wizards.

RAMACLE KEY FEATURES

- Selection of laser and scatter optical pathways
- Selection of excitation wavelength, gratings and exposure time
- Sample and laser focus visualisation
- Programmed attenuator and shutter
- Single, accumulated and kinetic spectral acquisitions (Raman and Photoluminescence)
- Spectral correction
- Selection and scans of internal calibration standards and automated calibration correction
- Data operations such as arithmetic, scaling, normalisation and baseline subtraction
- Cosmic ray removal, cropping, smoothing
- Automated laser alignment
- ASCII / CSV data import / export function
- Paste options for presentations and publications

FEATURES INCLUDED WITH UPGRADES

- Mapping features - map setup, collection and data analysis
- Fully motorised stage - XYZ control through joystick and software
- Autofocus
- Fluorescence lifetime measurements
- Polariser and analyser selection and control
- Detector selection
- Laser rejection filter selection
- External camera selection and visualisation

SPECIAL FEATURES AND OPTIONS

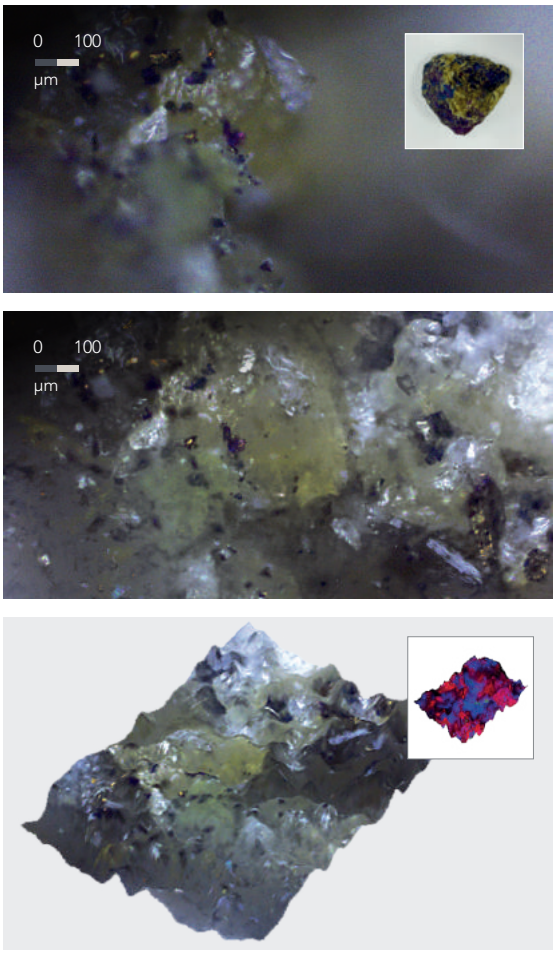
AUTOFOCUS

Maintaining optimum focus on samples with rough or uneven surfaces can be handled with ease using Ramacle's autofocus tools. Live autofocus tracking ensures that the microscope image is kept in perfect focus every time the stage is moved.

When tracking the surface of an object the autofocus facility reduces the time taken up by manual focusing; for surface Raman mapping the autofocus tool is practically irreplaceable as it handles even the most challenging surface tracking tasks.

Using precise control of the motorised stage Z position, and using image analysis feedback, the height variations of the sample is mapped accurately. This information is then used for the Raman surface mapping. For true representation of data, the surface topography is displayed in 3D for the brightfield image and the Raman surface map.

The sample topography information can also be displayed as a 2D image where all points are displayed in perfect focus simultaneously (focused stitched) for intuitive navigation across the sample surface.



The autofocus capability is shown on the example of a chalcopyrite rock. The top picture shows a brightfield microscopic image of the rock shown in the insert. It is evident that only a small fraction of the overall image is in focus.

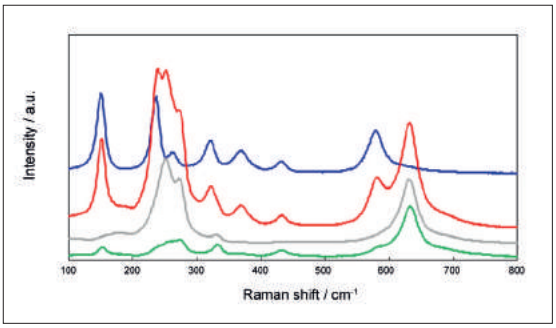
The picture in the middle shows the 'flattened' image of the same surface as above with autofocus correction. All surface points are sharp in focus.

The bottom picture shows a 3D representation of the same surface. The Z-coordinates for each surface point are used when Raman mapping to this surface is applied. The Raman map (insert) reveals structural changes across the surface.

POLARISED RAMAN SPECTROSCOPY

Optional accessories in the RMS1000 allow the user to control the polarisation of both the excitation light and the Raman scattered light. Polarisation dependent spectra can provide insights into the symmetry of vibrational modes, as well as the orientation of samples such as single crystals, polycrystalline samples, and anisotropic materials.

For example, lithium niobate spectra can be acquired using 4 different polarisation configurations. The modes present, as well as their intensity and position, vary significantly between the spectra.

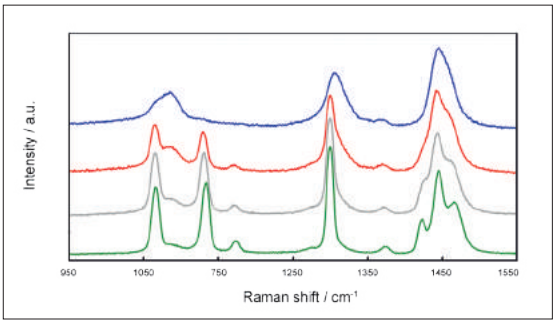


Raman spectra showing the different polarisation states of lithium niobate, excited with 532 nm laser

TEMPERATURE MEASUREMENTS

The RMS1000 is compatible with a wide range of sample stages allowing for precise control of the environmental conditions for the sample.

Raman thermometry can be performed over a broad temperature range using heating/cooling stages. With nitrogen and helium cryostats measurements at temperatures as low as 77 K and 4 K, respectively, can be performed. Heating stages of up to 600 K have been used. Most temperature stages are compatible with Raman mapping.



Raman spectra of polyethylene monitored during heating from 30°C to 145°C. Showing the change from crystalline (green) to amorphous phase (blue)

THE ADDED BENEFIT: FLUORESCENCE AND PHOTOLUMINESCENCE

2D PHOTOLUMINESCENCE MAPPING

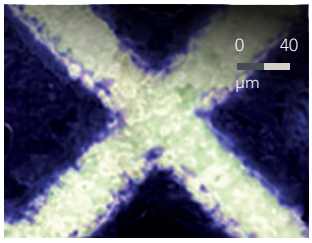
Standard spectral photoluminescence measurements with the RMS1000 are straightforward: Select a low groove density grating from the 5-position grating turret and capture spectra with a typically broader spectral coverage than with standard Raman measurements.

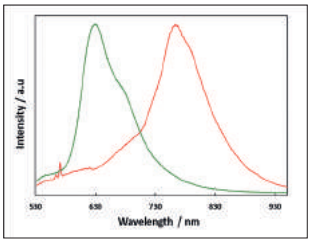
Ramacle provides the option to view the spectra at the wavelength scale, and spectrally corrected, requirements that are typical for fluorescence and photoluminescence, but less common in Raman spectroscopy.

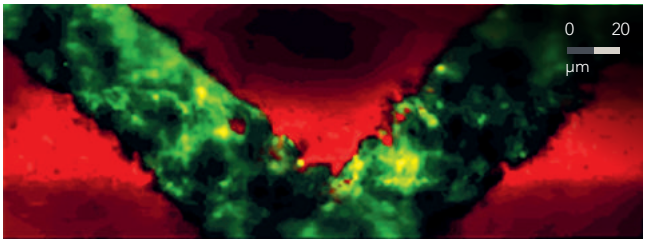
The picture below shows security features of a section of a banknote. Brightfield image (left), photoluminescence map (right) and photoluminescence spectra of the two security dyes (middle).

- Single point fluorescence and photoluminescence spectra and lifetimes with high spatial resolution
- Fluorescence and photoluminescence maps
- Fluorescence Lifetime Imaging (FLIM)
- Photoluminescence Lifetime Imaging (PLIM)

Ultimately, the RMS1000 can be configured with pulsed lasers, TCSPC or MCS* timing electronics, and single photon counting detectors for fluorescence lifetime measurements or decay measurements in the nanosecond time scale. Spatial mapping of this type of measurements will result in FLIM or PLIM images, respectively.





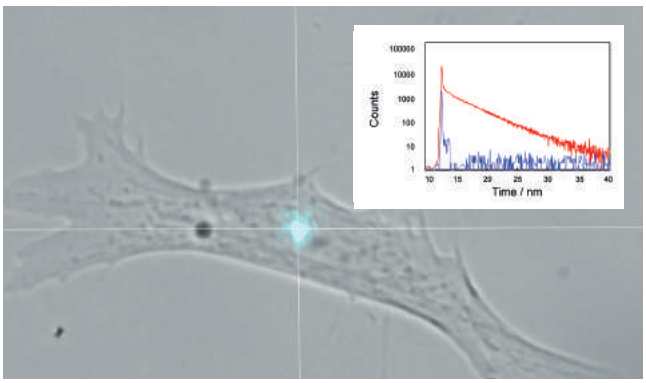


Brightfield image of a banknote security feature (left); emission spectra of the two security inks (centre) Photoluminescence map of the security feature (right)

FLUORESCENCE LIFETIME MEASUREMENTS

Fluorescence lifetime measurement at a single point of the field of view are possible using integrated pulsed lasers and a suitable dichroic filter from the filter turret. The emission wavelength of detection is selected by the spectrograph. The TCSPC electronics provides temporal (lifetime) resolution with picosecond accuracy.

The picture (right) displays the wide field with the selected laser spot for excitation. The insert shows the fluorescence lifetime measurement (red) together with the instrumental response function (blue) which was measured by replacing the sample with an ultra-fast decaying fluorophore (4-DASPI).

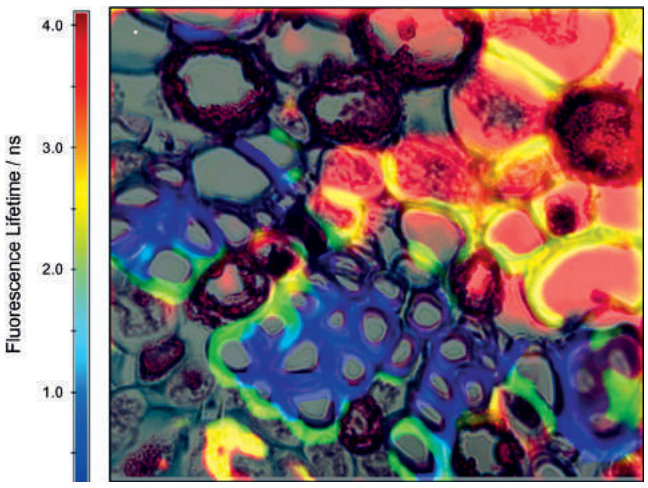


FLUORESCENCE LIFETIME IMAGING

Fluorescence lifetime images (FLIM) can be created using the scan stage mapping facility that comes with the RMS1000. Instead of a Raman spectrum, a fluorescence lifetime measurement is obtained for every point of the image. The powerful Ramacle software will process all fluorescence decays and will produce a map (or image) of the average lifetime or other lifetime parameters.

The picture to the right shows a FLIM image of a stained pine tree section, superimposed to the brightfield image.

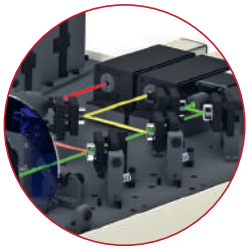
* TCSPC – Time-Correlated Single Photon Counting; MCS – Multi-Channel Scaling



UPGRADE OPTIONS

LASERS

The RMS1000 is built with flexibility in mind. A choice of excitation lasers (internal or external to the system) and associated laser rejection filters (both edge and notch) are available. Additionally picosecond pulsed diode lasers (EPL series) can be added if fluorescence measurements are required.



SPECTROGRAPHS

The RMS1000 can be fitted with both standard and enhanced focal length spectrographs. This allows the system to be configured for ultimate spectral resolution, maximum optical throughput, low wavelength and ultraviolet spectral ranges, or for highly sensitive measurements.

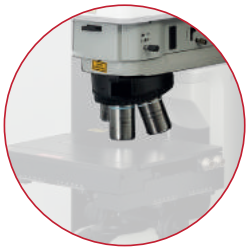
DETECTORS

A choice of CCD, EMCCD and InGaAs detectors are available with a maximum of 4 detectors being integrated per system. For fluorescence lifetime measurements, single photon counting detectors can also be integrated.

MICROSCOPE ACCESSORIES

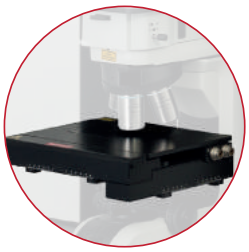
The RMS1000 uses either an upright or inverted microscope platform which is compatible with all standard microscopy applications.

Brightfield, darkfield, polarised light, differential interference contrast (DIC) and fluorescence accessories are all available. A large choice of high-quality objectives, high-performance visualisation cameras, collimators and illuminators can be added to the microscope at any time.



SAMPLE STAGES

Manual or motorised stages are available. The motorised stage allows automated XYZ Raman and fluorescence maps to be obtained and generated through Ramacle. Autofocus and heating/cooling of samples is also available.



ACCESSORIES AND LASER SAFETY

Other accessories such as a polarisation kit, cuvette holder, and a Class I laser safety enclosure are also available to further expand the capabilities, flexibility and safety of your RMS1000 system. Coupling to other fluorescence spectrometers is also possible.

SPECIFICATIONS – RMS1000

LASERS		Up to 5 integrated narrow-band lasers: 532 nm, 638 nm, 785 nm typically used
		Additional lasers from UV to NIR are available. External lasers can be integrated
		Laser selection is fully computer-controlled
		Associated laser rejection filters included, fully computer-controlled
SPECTROGRAPHS	Wavelength Range	200 nm - 2,200 nm
	Gratings	5-position grating turrets
	Slits	Continuously adjustable, fully computer-controlled
SPECTRAL RESOLUTION		From <0.1 cm^{-1} (depending on grating, laser and CCD selection)
SPATIAL RESOLUTION	XY (lateral), Z (axial)	0.25 µm, <1 µm (depending on laser and microscope objective)
SPECTRAL RANGE		5 cm^{-1} * - 30,000 cm^{-1} (*with low wavenumber attachment)
CONFOCAL IMAGING		Adjustable confocal pinhole, fully computer-controlled
DETECTORS	CCD Detector	High sensitivity ultra low noise spectroscopy CCDs
		1650 x 200 pixels, TE-cooled -60°C (standard)
		2000 x 256 pixels, TE-cooled -60°C (enhanced sensitivity / spectral range)
	Optional Second Detector	EMCCD detector, 1600 x 200 pixels, TE-cooled -100°C (fast response time)
		InGaAs array, 1024 pixel, TE-cooled -90°C, up to 2,200 nm
SOFTWARE	Ramacle®	Comprehensive all-in-one, intuitive software package
	Optional	Chemometric, spectral library packages
FLUORESCENCE	Spectral	With low resolution grating and integrated CCD
	Lifetime	With picosecond pulsed lasers, TCSPC electronics, fast photon counting detectors
		Spectral and lifetime fluorescence mapping is also available
LASER SAFETY	Without Laser Enclosure	Class 3B (depending on external laser source)
	With Laser Enclosure	Class 1
DIMENSIONS	W x D x H	From 975 mm x 610 mm x 1170 mm
	Weight	From 114 kg

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