HORIBA
Scientific

T64000

Advanced Research Raman System

Raman Spectroscopy Systems

JOBIN YVON
Technology

T64000 Advanced Research Raman System

T64000

Triple stage Raman Spectrometer: The only solution for unprecedented stability and performance!

The T64000 Raman triple grating spectrometer system is ideally suited for high performance Raman research.

It is designed to provide ultimate spectral resolution, high stray light rejection and continuous tuneable Rayleigh filter from UV to NIR.

The patented Plane Aberration Corrected Holographic (PACH) gratings make the T64000 the most optimized Raman system for spatial and spectral resolution delivering a perfect sample image.

The T64000 provides customization capabilities, including a large range of microscopes, accessories, optical components, and sampling capabilities.

The T64000 system is a versatile platform that can be tuned to meet the most demanding applications in the fields of thin films, solid state devices, biological chemistry and techniques such as UV, resonance Raman, photoluminescence and laser fluorescence.

Robust Design

The T64000 has an integrated triple spectrometer design for unprecedented optical stability and performance. The mechanical coupling is rigid and stable, the optical coupling is efficient and throughput is maximized throughout.

The spectral performances related to the laser rejection and spectral resolution are further enhanced as the 1st and 2nd stage gratings are specifically mounted on the same drive axis, eliminating any de-coupling of the grating movement found with simplified individual grating drives.

Ultimate Performance

The T64000 provides inherent tuneability of a triple spectrometer whilst its integrated design guarantees the best performance and long-term stability on the market.
When high performance and flexibility are required for low frequency, very high resolution measurements and large spectral range coverage from UV to NIR, the triple Raman spectrometer system is the only solution.

Focal length: 640 mm (single stage) 3 x 640 mm (triple additive)	**Step size:** 0.00066 nm (with 1800 gr/mm gratings)
Low frequency: < 100 cm^{-1} (single stage) typically 5 cm^{-1} (double filter stage)	**Reproducibility:** better than 1 pixel
Stray light rejection: 10^{-14} at 20 cm^{-1} (514 nm laser)	**Gratings:** 100 to 3600 gr/mm (covering UV-NIR)

Single spectrometer dispersion nm/mm (cm^{-1}/mm) *Triple additive dispersion nm/mm (cm^{-1}/mm)*

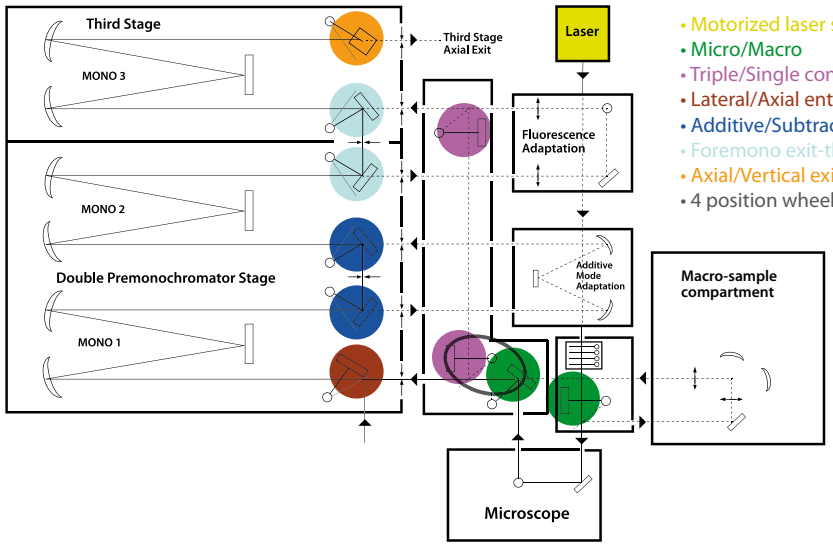
Grating	at 300 nm	at 500 nm	at 800 nm	at 300 nm	at 500 nm	at 800 nm
300	5.11 (567.3)	5.07 (202.7)	5.0 (78.2)	1.70 (189.1)	1.69 (67.6)	1.67 (26.1)
600	2.52 (280.5)	2.48 (99.1)	2.39 (37.3)	0.84 (93.5)	0.83 (33.1)	0.80 (12.4)
1200	1.23 (136.2)	1.16 (46.4)	1.02 (15.9)	0.41 (45.4)	0.39 (15.5)	0.34 (5.3)
1800	0.78 (87.2)	0.70 (27.8)	0.48 (7.46)	0.26 (29.1)	0.23 (9.3)	0.16 (2.5)
2400	0.56 (62.1)	0.44 (17.7)	0.04 (0.56)	0.19 (20.7)	0.148 (5.9)	0.01 (0.19)
3600	0.318 (35.36)	0.107 (4.26)	-	0.106 (11.79)	0.036 (1.42)	-

Unique Capabilities

- Ultra-low frequency measurements < 5 cm^{-1}
- Very high spectral resolution down to 0.15 cm^{-1}
- Large spectral range coverage from UV to NIR
- Confocal micro/macro sampling capabilities
- Continuously tuneable Rayleigh filter from UV to NIR
- Stokes/Anti-Stokes device for measuring both Raman ranges very close to the laser lines (down to 10 cm^{-1})
- Automated Raman mapping and fast imaging
- LabSpec Spectroscopy Suite

Ultimate Flexibility

The T64000 leverages HORIBA Jobin Yvon's core expertise in gratings, monochromators and detectors design to deliver a unique level of functionality and performance.
Appropriate gratings, detectors and sampling optics are selected to design the T64000 Raman system to best suit your application needs.



- Motorized laser selection
- Micro/Macro
- Triple/Single configuration
- Lateral/Axial entrance
- Additive/Subtractive mode
- Foremono exit-third stage entrance
- Axial/Vertical exit
- 4 position wheel: Macro/Micro/Triple/Single

- Three stage monochromator with optics, aperture and coupling optimized for perfo-mance and stability
- Multiple entrance and exit ports
- Multiple motorized switching mirrors
- Multiple laser choices from deep UV to NIR
- Confocal microscopes or macro chamber rigidly cou-pled to the spectrometer
- A large choice of options and components, eg., gratings, detectors and sampling optics enabling operation from the UV to the NIR

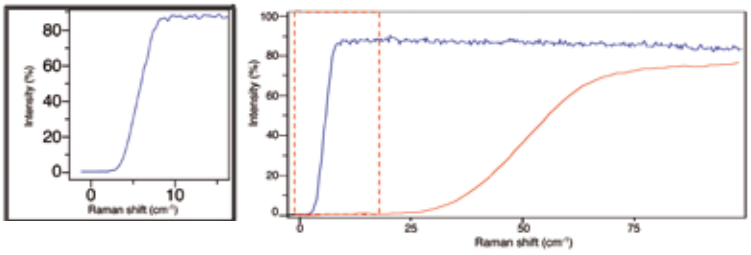
Flexible Design for Multiple Applications

Three Configurations in Use

The T64000 triple stage spectrometer allows choice of single and triple spectrometer operation modes (double subtractive + spectrograph or triple additive configuration). It offers ultimate performance in terms of low frequency measurements and ultra-high spectral resolution. The single spectrometer configuration is ideal for standard analyses where speed of measurement is important. Switching between configurations is simple, and fully software controlled.

Triple subtractive configuration for low frequency measurements whatever the laser wavelength

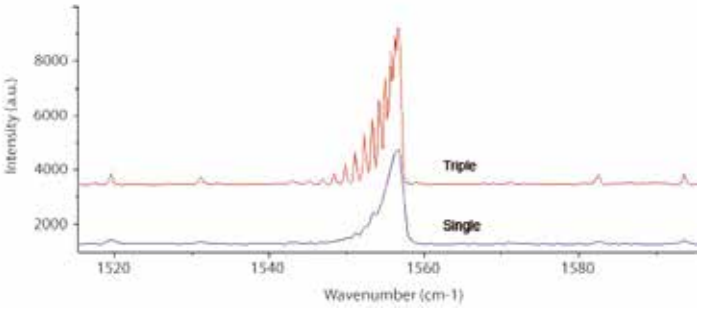
Excellent stray light rejection can be achieved when the double subtractive filtering mode is used. This configuration allows spectra of low frequency bands very close to the laser line (typically down to 5 cm^{-1}) over a broad wavelength range. Application examples include LAM modes in polymer chains, superlattice modes in semiconductors, RBM modes in carbon nanotubes, low frequency modes in proteins, of micro-crystallites, etc.



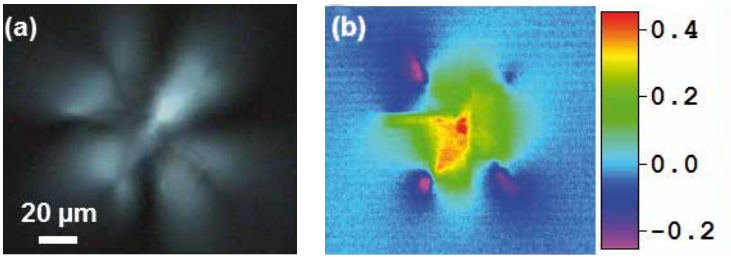
Comparison of laser rejection between a typical edge filter (red curve), and the T64000's double subtractive monochromator (blue curve).

Triple additive configuration for ultra-high resolution < 0.15 cm^{-1}

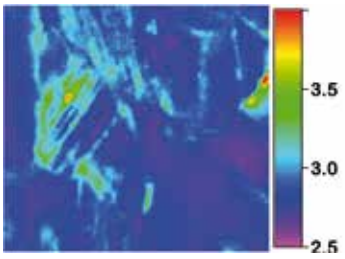
With the use of the ultra-high resolution triple additive configuration, it is possible to very accurately study the position of Raman bands and achieve the best band separation. This is of particular importance for the measurements of stress in semiconductor materials such as GaN, SiC, diamond, etc., where stress shifts in the order of 0.1 cm^{-1} are often induced. The high resolution also offers the level of accuracy required for the authentication and certification of materials for Raman standards.



Rotational modes of air obtained with the triple additive and single configurations.



Study of residual strain around grown-in defects in CVD diamond single crystals. (a) Birefringence image, (b) Raman strain map. (Courtesy of Michel Mermoux et al., Phys. Status Solidi A, 208, No. 9, 2038-2044 (2011).)



Peak width image of the diamond Raman line from a non-doped polycrystalline diamond film, recorded with 244 nm excitation. (Courtesy of A. Crisci et al, Diamond & Related Materials, 17, 1207-1211 (2008).)

Single spectrograph configuration for high optical throughput

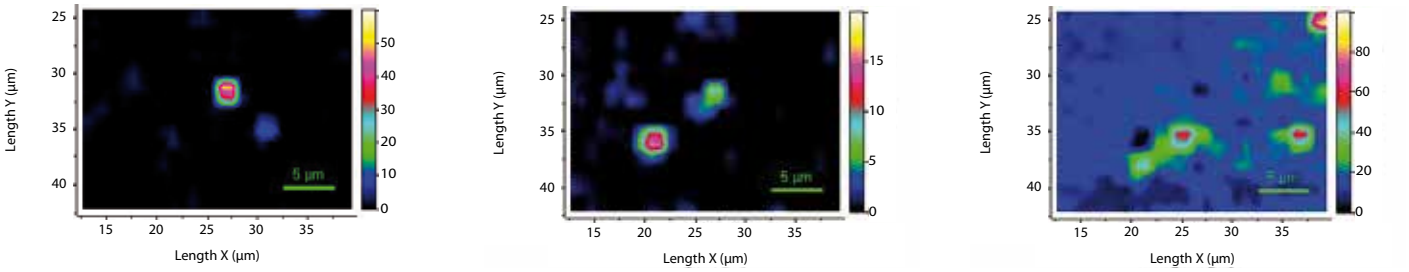
The direct spectrograph entrance allows the T64000 system to be used with edge or notch filter technology and as a more conventional single spectrometer based system. The high throughput of optical components enhances measurement speed, making it ideal for Raman mapping, weak scattering samples, fluorescence, photoluminescence measurements and even remote probe forms of analysis.

Benefits of high stray light rejections

Notch and edge filter technologies provide a very good solution for laser rejection in many applications.
However, there are acknowledged limitations to the use of these filters for work with tuneable sources and for work very close to the laser line. Even with specially developed low frequency accessories, it is still often impossible to obtain reliable data at 10, 20 or 30 cm^{-1} for many difficult samples.

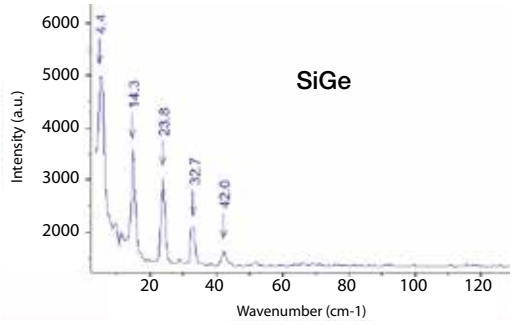
Resonance Raman

For resonance Raman applications, the inherent tuneability of a triple spectrometer enables filtering at all wavelengths. Carbon nanotubes, SERS, haem centres and bio-molecules can benefit from using tuneable sources and filters to match resonance conditions. The structural variations and distribution maps shown below were generated on SWCNT islands using confocal Raman mapping.



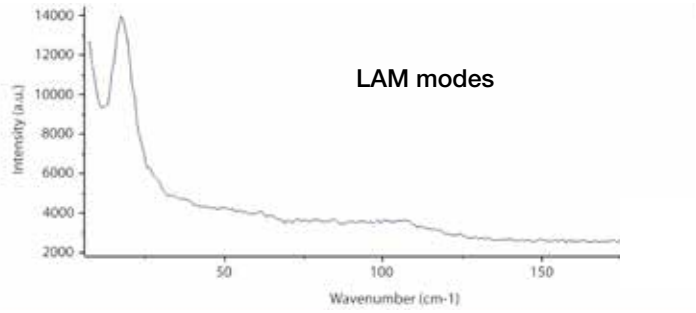
Semiconductors

The SiGe superlattice spectrum was recorded on T64000 in double subtractive mode. It shows spectral bands as low as 4 cm^{-1} from the laser line.



Polymers

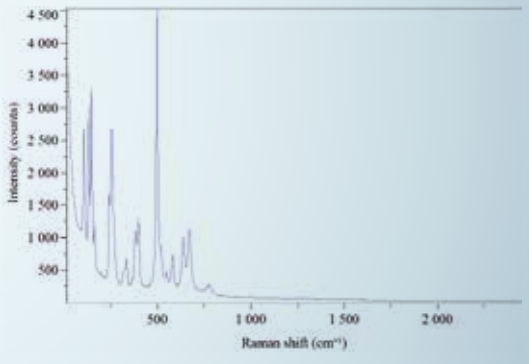
The spectrum below shows the characterization of low frequency LAM modes of a polymer matrice.



UV Raman Spectroscopy

The T64000 has many benefits for deep UV Raman measurements.

- The high stray light rejection enables lower frequency Raman bands below 100 cm^{-1} to be observed even in the deep UV (244 nm). It can provide a complete spectral analysis not limited in its scope or range.
- The tuneability of the double filter stage enables all the various deep UV frequencies to be accessed easily, (eg. 227-290 nm), hence, optimizing resonance enhancement for particular species of components (eg. proteins from DNA).
- The specialized UV-VIS microscope option is adapted to working over a broad spectral range, without the need for optics to be removed or replaced. It preserves the high spatial discrimination across the wavelengths.
- The 640 mm focal length spectrometer maintains a standard to high spectral resolution even with deep UV excitation. The achievable 1.4 cm^{-1} far exceeds the typical 4 cm^{-1} UV resolution of small benchtop systems.



HfO_2 layer on a silicon substrate, analyzed with 244 nm excitation.

Sampling Capabilities for Versatile Raman Analysis

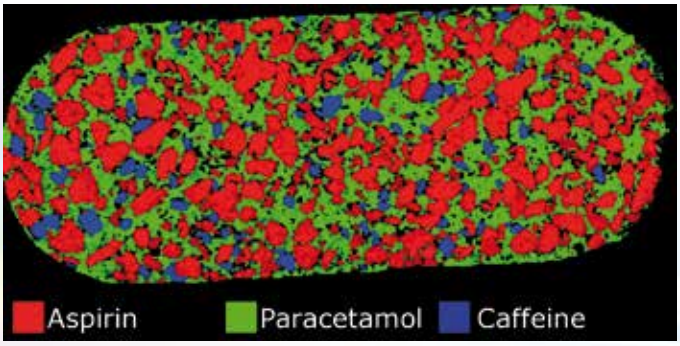
Confocal Microscopy

The T64000 can be configured with standard upright, inverted or free-space confocal microscopes to serve a large range of applications. Their high spatial resolution makes it possible to analyze a small sample area or volume down to the micron scale. Localization, distribution, crystallinity, phase properties and more can be imaged with high accuracy.

Upright, Inverted and Free-Space Microscopes

- The upright microscope is widely used for materials analysis.
- The inverted microscope is ideally suited for life science research, where tissue and live cells are frequently analyzed within culture media.
- The free-space microscope (right) provides a unique level of access. Large cryostats (liquid helium-cooled), sample environment equipment (diamond anvil cells) and similar devices can be easily accommodated.

Free-space microscope.



Macro-mapping of component distribution on a pharmaceutical tablet, 48 081 points, total time 535 s.

Ultra-Fast Confocal Imaging

- The DuoScan™ imaging technology uses high precision, rastering mirrors to create variable sized laser macro-spots, and allows nano-step mapping from deep UV to NIR.
- The SWIFT™ module offers unique ultra-fast Raman mapping capabilities. High resolution images can be acquired in seconds, and macro-areas can be imaged with micro-resolution.

Off-Axis Illumination

The off-axis device relies on a separate side-arm with steering optics enabling laser light injection with an oblique or grazing incidence, thereby eliminating most of the Rayleigh scattering which is reflected out of the acceptance cone of the collection optics. This device improves the T64000 performance for low frequency measurements.

Off-axis device.

Macro Chamber

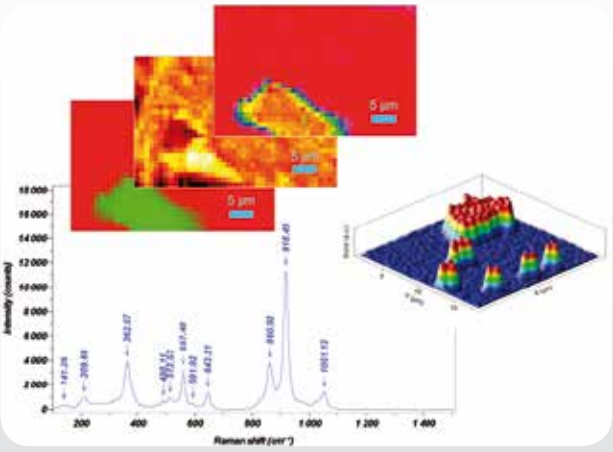
The macro chamber allows large samples to be measured. It can be used in the UV-NIR regions, with interchangeable optics covering adjustable collection from 90° to 180° geometries. Various sample holders and mounts for bulk cryostats are available.

Macro chamber.

LabSpec

Spectroscopy Suite

HORIBA Scientific's LabSpec Spectroscopy Suite provides an intuitive, powerful software platform for Raman, photoluminescence (PL) and cathodoluminescence (CL) spectroscopy. It offers complete and versatile functionality for acquisition, processing, analysis, and display of data, in addition to flexible automation solutions.



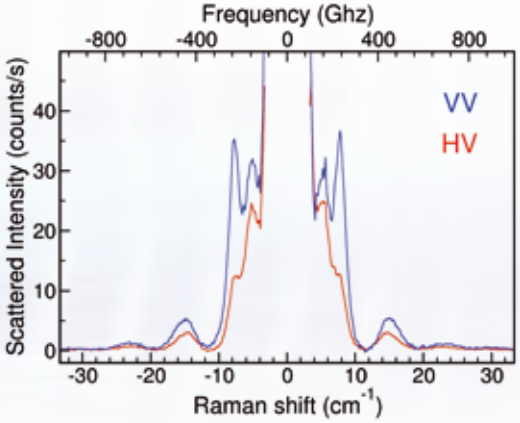
LabSpec operates all components and accessories of HORIBA Scientific's Raman, PL and CL systems. LabSpec allows comprehensive system control, and advanced data acquisition/analysis routines, including fast mapping, kinetic studies, high throughput screening, programmed high temperature and high pressure analysis, and even remote control of the system from another room or your home.

Stokes/Anti-Stokes Device

A Stokes/Anti-Stokes device is available for the T64000, which is designed to allow low frequency measurements of both Stokes and Anti-Stokes data.

This device allows for maximum rejection. For even more flexibility, the Stokes/Anti-Stokes device is composed of three widths to mask the laser wavelength according to its intensity.

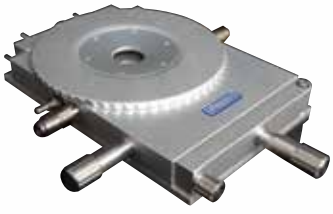
Low frequency Raman scattering by acoustic vibrations of gold nanoparticles with crossed (HV) and parallel (VV) polarizers.
(Courtesy of S. Tripathy from IMRE Singapore and A. Mlayah from CEMES Toulouse.)



Options

A broad range of options and accessories are available to expand the T64000 system including:

- Motorized mapping stages
- Heating/cooling stages, cryostat
- LN_2 or air cooled CCD detectors (back thinned, deep depletion, open electrode, ICCD...)
- Remote sampling probes
- Secondary detectors: IR array, PMT, etc.
- LWD and UV objectives
- Stokes/Anti-Stokes device
- UV, Visible, and NIR laser sources
- Multi-laser bench with motorized laser selection



Experts in Spectroscopy

HORIBA Jobin Yvon, established in 1819, and now part of the HORIBA Scientific segment, is one of the world's largest manufacturers of analytical and spectroscopic systems and components.
The HORIBA Scientific teams are committed to serving our customers with high performance products and superior technical support.

Molecular and Microanalysis

- Raman Spectroscopy
- Fluorescence
- SPRi
- EDXRF
- Forensics

Elemental Analysis

- ICP-OES
- C/S, O/N/H Analyzers
- S & Cl in Oil Analyzers

Surface, Thin Film and Particle Characterization

- Ellipsometry
- Cathodoluminescence
- GD-OES
- Particle Characterization

Optical Components

- Diffraction Gratings
- Spectrometers
- VUV Instrumentation
- Detectors

CE

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