HORIBA

SignatureSPM
Scanning Probe Microscope

The chemical AFM

JOBIN YVON Technology

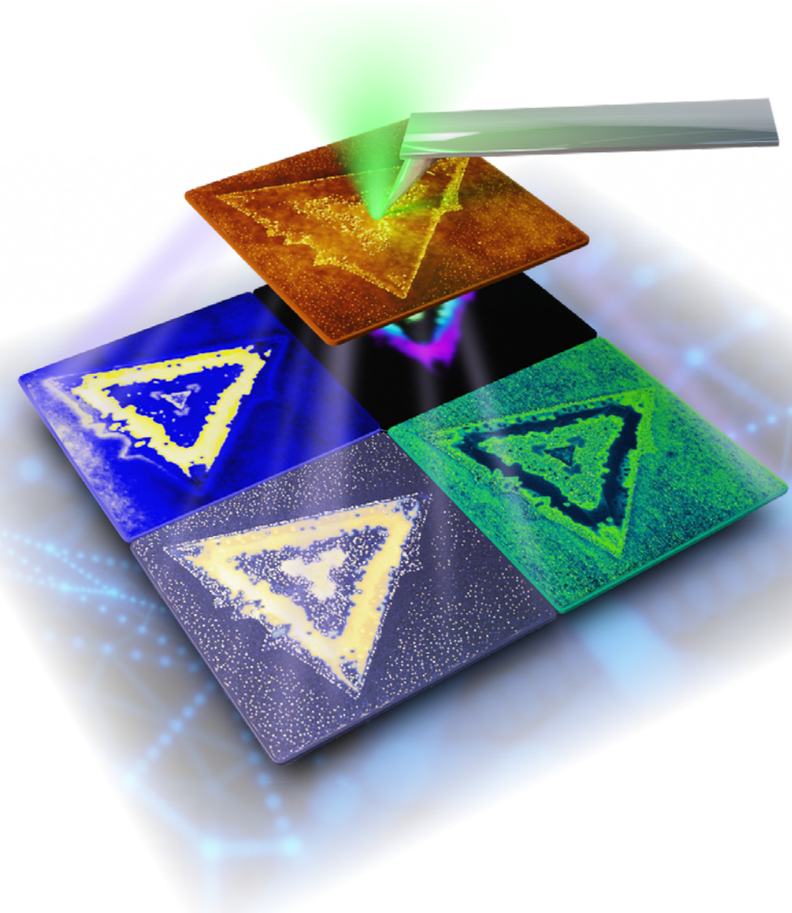
www.horiba.com/

Enhance your AFM with Chemical Signature

HORIBA presents the SignatureSPM, the first multimodal characterization system built on an automated AFM platform and integrating a Raman/ photoluminescence spectrometer, enabling true colocalized measurements of physical and chemical properties.

SignatureSPM will allow you to:

- Retrieve reliable and comprehensive analysis of your sample with **the combined physical and chemical knowledge obtained in a single measurement** (topographic, mechanical, electrical, magnetic, optical, and chemical properties).
- **Shorten time** to results knowledge from reduced sample handling and collecting **colocalized data in real time.**
- Acquire data with **high level of confidence** with true colocalized information, enabling complete **correlation between the different sample properties.**
- Gain easy access to **a powerful complementary chemical characterization tool** for all AFM users.



What is Raman and Photoluminescence Spectroscopy?

Raman spectroscopy analyzes scattered light from a sample illuminated by laser light, revealing molecular vibrations and rotations and providing its unique molecular fingerprint. This technique enables chemical composition analysis, substance identification, and detection of minute impurities.

Photoluminescence spectroscopy studies how materials absorb and re-emit visible light, offering insights into their structure, composition, and properties.

Both techniques are pivotal in unraveling molecular complexities and find diverse applications in chemistry, biology, materials science, nanotechnology, and semiconductors.

What is AFM?

AFM, or Atomic Force Microscopy, is a high-resolution imaging technique that detects surface features using a sharp probe attached to a cantilever. As the probe scans the sample surface, the signal variations resulting from sample/probe interactions are recorded to create an image. AFM is versatile, allowing evaluation of mechanical, electrical, piezoelectric, magnetic, or thermal properties. It is widely used in nanoscience and nanotechnology research.

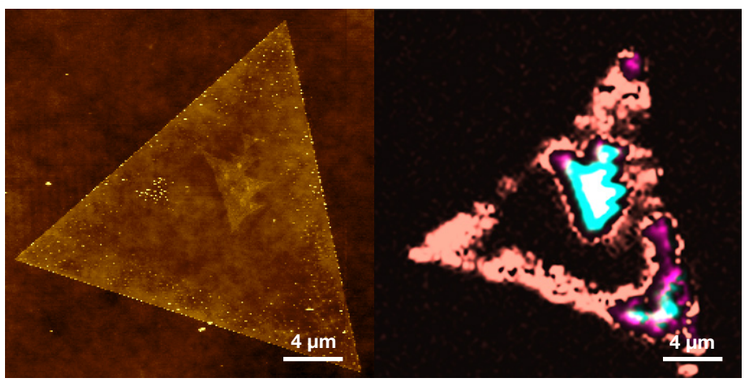
Exploring the Boundaries of Possibility

Unleashing the Power of Colocalized Data for Comprehensive Analysis and Breakthrough Discoveries

2D Materials

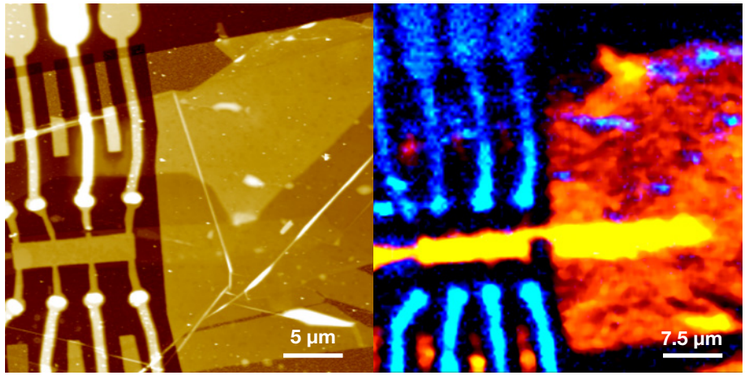
Reveal the structural and chemical properties of various 2D materials by combining high-resolution AFM imaging with precise chemical signatures obtained from Raman and photoluminescence spectroscopy. Gain comprehensive insights into their composition and electronic behavior.

WS_2 flake deposited on SiO_2/Si



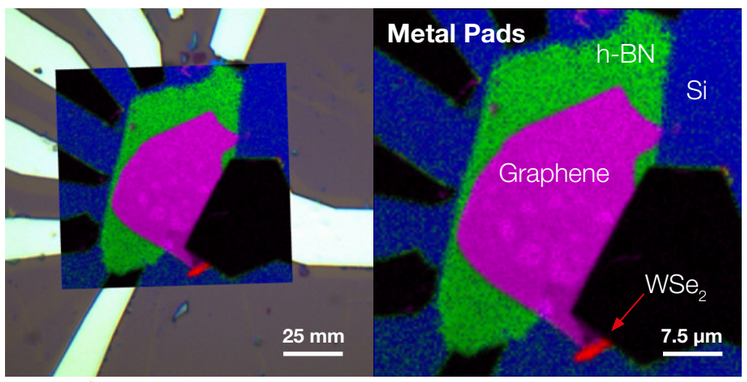
Topography | Photoluminescence

Twisted bilayer graphene



Topography | Raman

$hBN/Graphene/WSe_2$ vertical heterostructure on Si substrate

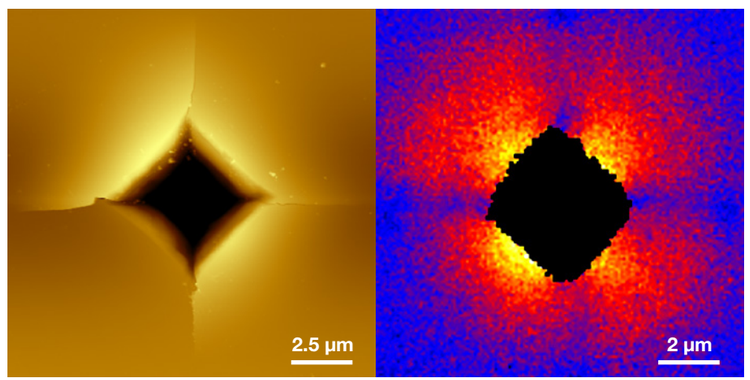


Overlay of Raman map over the optical image | Raman map

Semiconductors & Devices

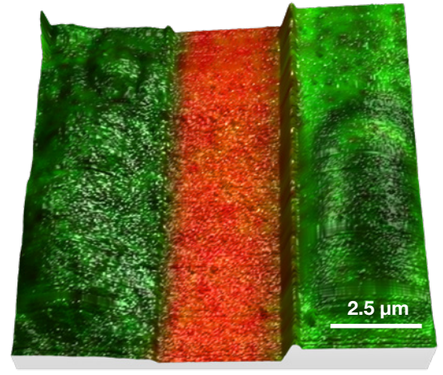
Unlock a deeper understanding of semiconductor materials by seamlessly integrating AFM capabilities with chemical signatures derived from Raman spectroscopy and benefitting from simultaneous characterization of topography, electrical properties, and chemical composition.

Nano-indented Silicon



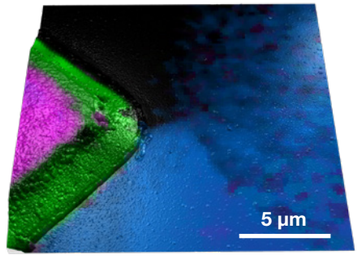
Topography | Stress

AlGaN/GaN High electron mobility transistor (HEMT)

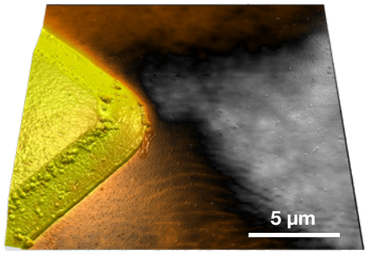


3D overlay of Raman map on surface topography

GaAs solar cell structure



3D overlay of Raman map on surface topography



3D overlay of CPD on topography

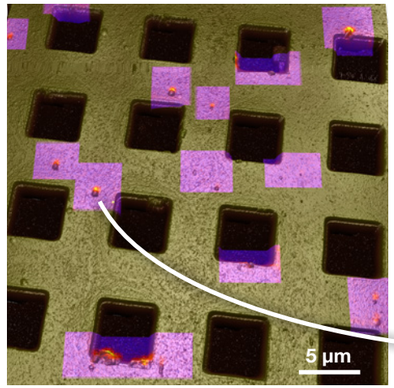
Exploring the Boundaries of Possibility

Unleashing the Power of Colocalized Data for Comprehensive Analysis and Breakthrough Discoveries

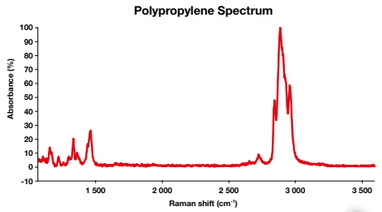
Polymers

Acquire valuable insights into polymer materials by integrating high-performance AFM, which offers characterization of morphology and mechanical properties, with Raman spectroscopy, providing chemical composition analysis.

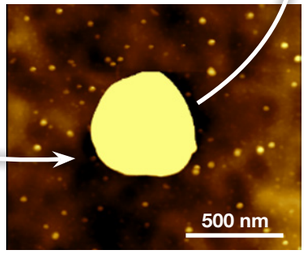
Nanoplastic particles from seawater on grid filter



Multi-area Raman maps overlaid on topographic image

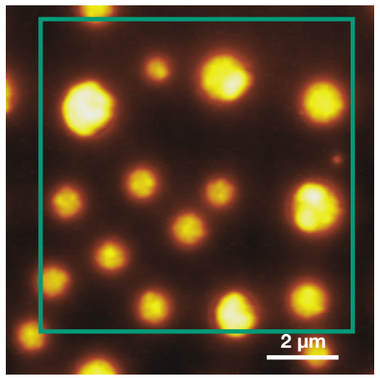


Signature Raman spectrum

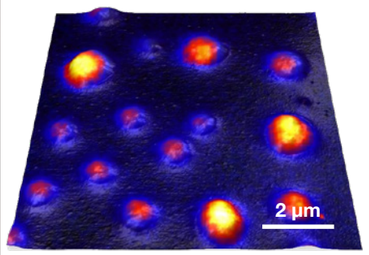


Topograpy of a single nanoplastic

Polystyrene/Low Density Polyethylene (PS/-) film



Topography

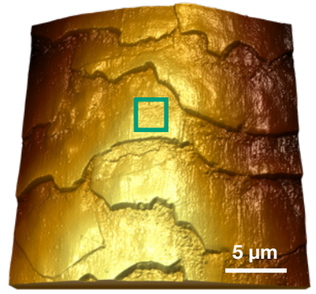


Raman map overlaid on 3D topographic image

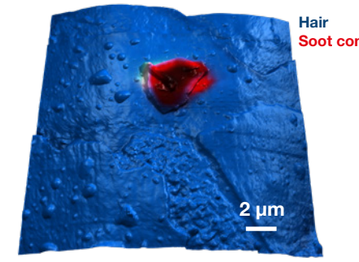
Cosmetics

Enhance cosmetic formulation development by leveraging the power of AFM and Raman spectroscopy, enabling precise characterization of ingredient distribution, formulation stability, and chemical interactions within cosmetic products.

Hair

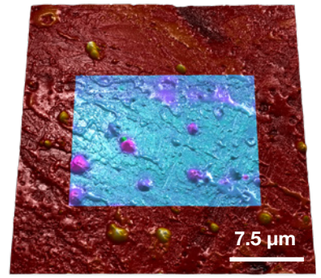


Topography



Raman map overlaid on topographic image

Sunscreen lotion on skin

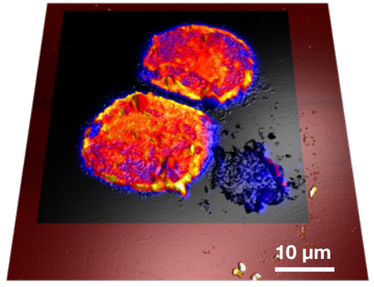


Raman map overlaid on topographic image

Life Science

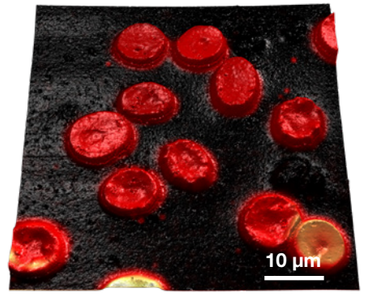
Push the boundaries of life science research with an integrated AFM-Raman solution, providing simultaneous analysis of cellular structures, biomaterials, and biochemical interactions.

Breast cancer cells fixed on quartz



Colocalized Raman image overlaid on 3D topography

Blood cells



Colocalized Raman image overlaid on 3D topography

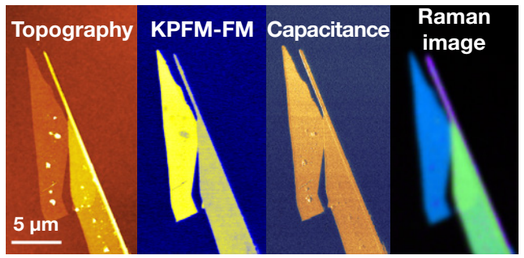
Enhanced characterization capabilities for complete characterization

Minimal learning period as well as the very quick start of measurements (less than 5 minutes!) makes the SignatureSPM a perfect solution for multi-user facilities.

All AFM modes included with no additional units or costs

All modes are included in the basic package:

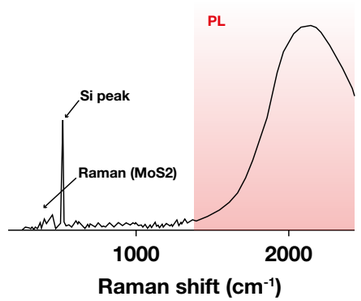
- Kelvin Probe Microscopy
- Piezo Response Force Microscopy
- Magnetic Force Microscopy
- Nanolithography
- Force-curve Measurements



Wide range spectrometer optimized for Raman and photoluminescence

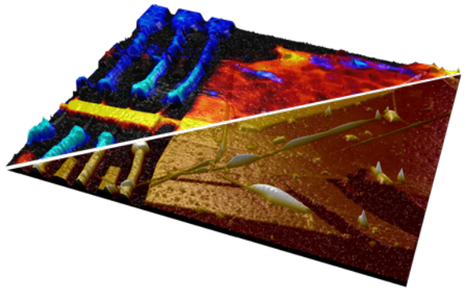
Designed for spectroscopy imaging, the spectrometer of the SignatureSPM ensures a minimal light loss with its achromatic design and impressive 95% light reflectivity. It provides a unique capability to perform accurate and efficient Raman and PL measurements thanks to its versatility that can accommodate up to 3 gratings for a wide spectral range covering.

It features an exclusive 68 mm x 68 mm diffraction grating, which fulfills the reflective area on the detector and maximizes the throughput.



True co-localized measurements with "Probe away"

For colocalized AFM-Raman/PL measurements, the AFM cantilever can partially obstruct the excitation laser. The software command "Probe away" is used to move the cantilever away from the sample's surface utilizing the AFM stepper motor designed for automated alignment. Consequently, fully unobstructed confocal Raman maps are obtained, eliminating the AFM tip shadowing effect. With the "Probe back" command, the AFM tip will automatically return to its previous analysis point on the sample's surface.

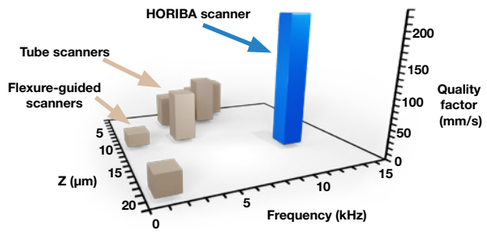


Direct pathway to cantilever apex with high optical access

The optical pathways for AFM and spectroscopy are completely separated. Such separation enables free choice of the Raman/photoluminescence (PL) laser wavelength and simplifies the whole system adjustment. The user can easily re-focus the high aperture objective (up to 100x, 0.7 NA) without any additional re-adjustment of the AFM laser-to-cantilever setup. Such a high numerical aperture (NA) objective enables confocal detection of optical signals from the sample surface in a wide spectral range and the minimum size of excitation laser spot area for high optical spatial resolution. It also provides a very high magnification to visualize the AFM tip for better accuracy in positioning.

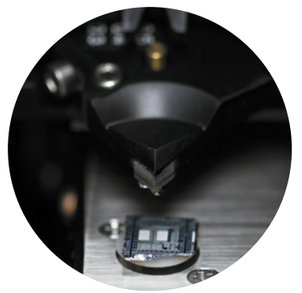
AFM for large scans and molecular resolution

The SignatureSPM offers exceptional AFM performance with its stability and speed. Featuring a 100 x 100 x 15 micron-range scanner, it achieves large scans and molecular resolution, prioritizing stability through fast response time, low noise, low drift, and metrological traceability. With resonant frequencies exceeding 7 kHz in XY and more than 15 kHz in Z, the scanner offers one of the industry's highest speed systems. Optimized control algorithms, supported by the advanced digital controller, enables unprecedented scanning speeds and high-resolution imaging, even during online speed changes.



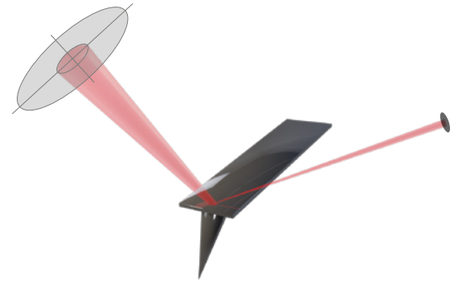
Quick and repeatable cantilever adjustment

Seamless tip exchange can be done regardless of the operator and with unmatched reproducibility. As soon as a new cantilever of the same, or even different type, is installed, the same spot (within a few microns repeatability) on your sample surface can be easily found and scanned without any extra searching steps.



Automated AFM registration system adjustment

The alignment of the laser, cantilever, and photodiode is fully automated, eliminating the need for user intervention, and meticulously engineered for seamless integration with optical spectroscopy. It is an extremely fast adjustment to do before starting AFM measurements.



No interference between AFM laser and spectroscopic measurements

The infrared AFM laser diode does not interfere with the visible Raman/PL excitation lasers and eliminates any parasitic influence on visible light-sensitive biological, semiconductor and photovoltaic samples.

SignatureSPM spec sheet

SignatureSPM Measuring Modes		
Basic modes	• Contact AFM • Semicontact AFM • True Non-contact AFM • Top Mode	• Phase imaging • Dissipation Force Microscopy • Contact AFM in liquid (optional) • Semicontact AFM in liquid (optional)
Electrical modes	• Single / Double pass Kelvin Probe Force Microscopy (KPFM) AM and FM • Single / Double pass Electric Force Microscopy (EFM) • Piezo Response Force Microscopy (PFM) • PFM with High Voltage (optional)	• PFM-Top mode™ • Conductive AFM (optional) • Conductive AFM High Voltage (optional) • I-Top mode™ (optional) • Photocurrent Mapping (optional) • Volt-ampere characteristic measurements (optional)
Nanomechanical modes	• Lateral Force Microscopy (LFM) • Force Modulation Microscopy (FMM) • Force Curve Measurement (Force Distance (F-D) Spectroscopy and Mapping)	• Findent (Fast Force Distance (F-D) Mapping) • Nanolithography • Nanomanipulation
Spectroscopy	• I/V Spectroscopy (optional) • I/V Spectroscopy mapping (optional)	• Switching Spectroscopy PFM • Switching Spectroscopy PFM mapping
Special modes	• Single / Double pass Magnetic Force Microscopy (MFM) • Tunable Magnetic Field (optional)	• Shear-force Microscopy with tuning fork (ShFM) • Normal-force Microscopy with tuning fork
Other	• Scanning Tunneling Microscopy (STM) (optional)	• Scanning Tunneling Spectroscopy (optional)
Colocalized optical spectroscopy	• Confocal Raman and Spectroscopy • Photoluminescence imaging and Spectroscopy	• Probe away mode
Modes compatible with light illumination	All AFM modes are compatible with colocalized illumination and optical spectroscopy	

SignatureSPM Scanner and Base	
Sample scanning range	100 µm x 100 µm x 15 µm (+/-10%)
Non-linearity	XY < 0.05%, Z < 0.05%
Noise	• < 0.1 nm RMS in XY dimension in 100 Hz bandwidth with capacitance sensors on • < 0.02 nm RMS in XY dimension in 100 Hz bandwidth with capacitance sensors off • < 0.1 nm RMS in Z dimension in 1000 Hz bandwidth with capacitance sensor on • < 0.03 nm RMS in Z dimension in 1000 Hz bandwidth with capacitance sensor off
Resonance frequency	XY 7 kHz (unloaded); Z 15 kHz (unloaded)
Open loop XY drift	< 0.5 nm / min
Maximum sample size	40 mm x 50 mm, 15 mm thickness
Motorized sample positioning range	5 mm x 5 mm
Motorized approach range	17 mm

SignatureSPM AFM Head	
Laser wavelength	1300 nm. No registration laser influence on photovoltaic measurements or on biological sample
Fully motorized	4 stepper motors for cantilever and photodiode automated alignment
Access	Free access to the probe for additional external manipulators and probes
Illumination	Illumination intensity is software controlled

SignatureSPM Options
Conductive unit (Current range 100 fA ÷ 10 µA / 3 current ranges (1 nA, 100 nA and 10 µA) switchable from the software)
Liquid cell / Electrochemical cell
Heating module (heating up to 300°C / Temperature stability 0.1°C)
STM holder
Signal Access Module

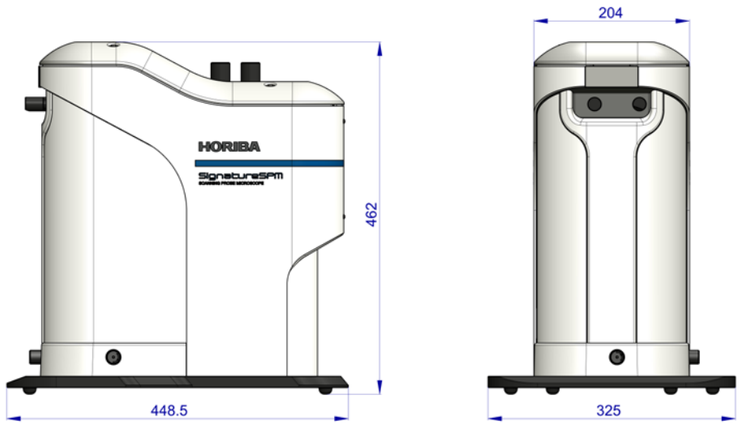
Spectroscopy general specifications		
Optical access	Capability to use top plan apochromat objectives (Mitutoyo)	
	• 10x, NA = 0.28 • 20x, NA = 0.42 • 50x, NA = 0.55 • 100x, NA = 0.7	
Optical coupling	Fiber coupling	Optical fiber with metallic shielding: Ø = 50 µm - L = 5 m.
Spectral range	UV-VIS-NIR	150 nm to 1500 nm
Built-in Lasers	Up to 2	Selectable between 532 nm or 785 nm. Manual control
Laser filters	8	0,01%, 0,1%, 1%, 3%, 10%, 25%, 50%, 100%
Laser power control	Down to 0.01%	Dielectric edge and notch
Number of gratings	3	3 gratings fully computer-controlled turret (150 / 600 / 1800 grooves/mm)
Open Electrode CCD (Standard) *Other detectors available upon demand.	HORIBA Syncerity™ or equivalent	HORIBA manufactured, high efficiency versatile deep-cooled (-60°C) open electrode CCD - Recommended for large groups and multi-user facilities, multi laser configurations. 1024 x 256 pixels, 26 µm width

Raman general specifications	
Low wavenumber cut-off	at 532 nm excitation wavelength 60 cm^{-1} with 1800 grooves/mm
	at 785 nm excitation wavelength 50 cm^{-1} with 1800 grooves/mm
Spectral resolution FWHM	at 532 nm excitation wavelength with Syncerity 2.75 cm^{-1} with 1800 grooves/mm
	at 785 nm excitation wavelength with Syncerity 0.825 cm^{-1} with 1800 grooves/mm
Spatial resolution	XY lateral resolution < 0.5 µm Z axial resolution < 2 µm

Software & User Experience	
Omega	• Automatic alignment of registration system • Automatic configuration and presetting for standard measuring techniques • Automatic cantilever resonance frequency adjustment • Macro language Lua for programming user functions, scripts and widgets • Capability to program controller with DSP macro language in real time without reloading control software • Spring constant calibration (Thermal method)
LabSpec6 Software	• LabSpec 6 for Raman acquisition, browsing, data and image pre-processing, statistical analysis and chemical identification (see LabSpec 6 datasheet) • Light version and complete version are provided

Other specifications	
Dimensions W x H x D (mm)	449 mm x 310 mm (SignatureSPM) /417 mm x 422 mm (spectrometer)
Weight (kg)	17 kg
Safety	Built-in laser safety class 1
Warranty	2 years as standard

Dimensions (mm)



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