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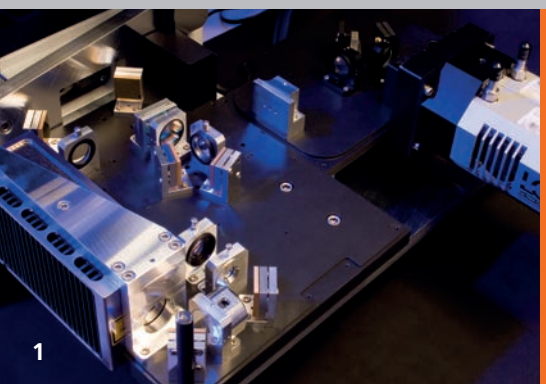
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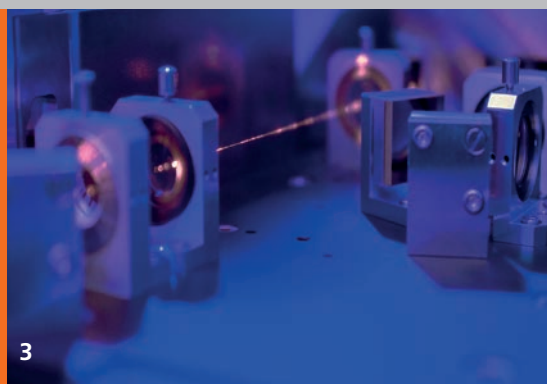
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1 *Fraunhofer IPM Raman module.*
2 *Raman spectroscopy allows for single-cell characterization and identification.*
3 *Recalibration-free optical setup optimized for biological applications.*

RAMAN SPECTROSCOPY

CHARACTERIZATION AND IDENTIFICATION OF SINGLE CELLS AND BACTERIA

Raman spectroscopy

Raman spectroscopy is a well known tool in the identification of chemical or pharmaceutical compounds. However, the high information density of a Raman spectrum may also be used to record fingerprints of giant mixtures of chemicals such as cells or bacteria. Spectra can be recorded of submicron objects and be used for identification or characterization.

Cell characterization

Raman spectra may be used to characterize the status of a cell line. You can analyze parameters such as

- Cell type
- Cell vitality
- Cell cycle
- Cell differentiation

by comparing sample Raman spectra to a database of spectra taken under known conditions. If necessary, chemometric analysis may support information harvesting.

Pathogen identification

Even sub-micron-particles can provide a Raman spectrum that may easily be used for their identification. With a proper sample preparation, intelligent image processing and spectral analysis the system may be used for the automated identification of pathogens e.g. in

- Tissue engineering
- Biopharmaceuticals
- Quality control of water.

A database of known pathogens serves as the training set and is used for identification. However, even unknown contaminations may be detected and classified as critical.

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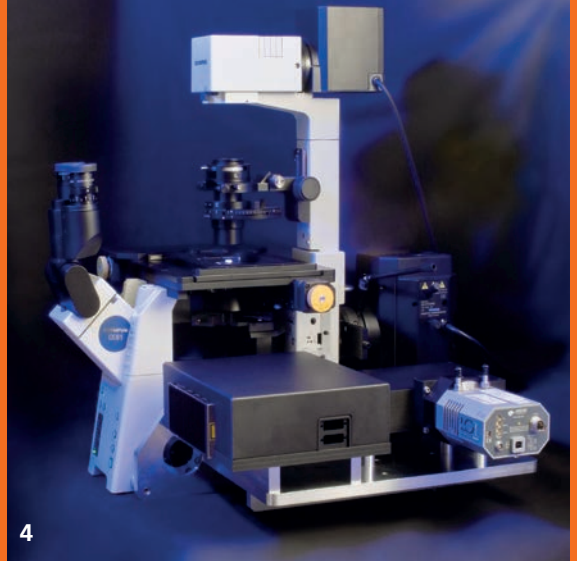
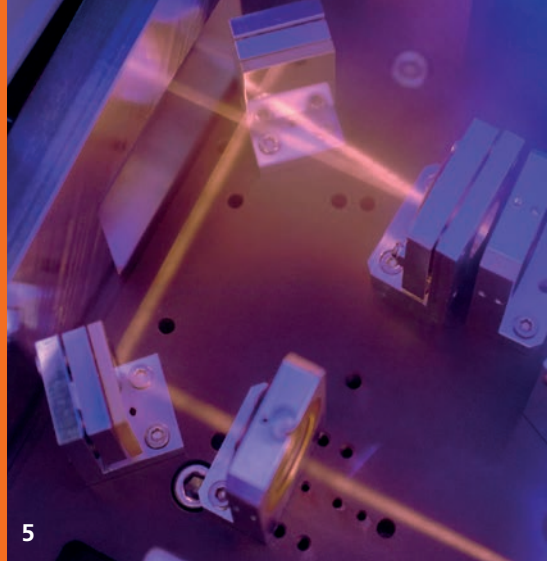




Hardware and software

The Fraunhofer IPM Raman system is based on an Olympus IX81 inverted microscope and integrates the additional Raman optics via the instrument's right sideport. With no limitations to the instrument's conventional operational modes (transmissive or reflective light, phase contrast, DIC or fluorescence microscopy) the Raman spectrometer allows the additional recording of Raman spectra at sub-micrometer points in the microscopic image. The rigid, free-beam-access with no fiber-optic components ensures superior throughput and high beam quality.

Different configurations with 532 nm or 785nm excitation wavelength and spectrograph layouts recording up to 3,500 cm^{-1} provide flexible, problem-oriented solutions. The Raman attachment is driven by a self-sufficient control box; full computer control is also provided.

The Raman microscope's full software control allows for the easy setup of complex analytical systems. Within a joint project of three Fraunhofer-Institutes (IGB, IBMT and IPM) an automated sterility control system for aqueous solutions was established: milliliters of liquid are filtered through a membrane with 500 nm holes, critical particles held back by this membrane are detected by image processing and ultimately guided under the Raman laser for recording a spectrum. In combination with a cell and pathogen database, these particles are identified and sterility is determined.

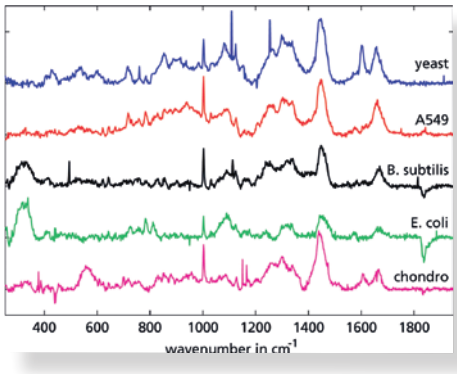
Custom system development

The spectroscopic system outlined above may easily be adapted to your needs. Different microscopic platforms, alternative Raman laser wavelengths and powers, and extended spectral ranges are straightforwardly implemented.

Additionally, Fraunhofer IPM is your competent partner for an extended adaptation to your measuring needs including solutions for sample preparation, data analysis (image processing, chemometrics) and technical evaluation.

4 *Fraunhofer IPM Raman module attached to an Olympus IX81 inverse microscope.*

5 *Notch filter-based Raman spectrometer.*



Single-cell Raman spectra of different organisms used for identification or characterization.

Technical Specifications	
Raman laser wavelength	785 nm / 532 nm
Laser power	120 mW (785 nm) / 50 mW (532 nm); optionally higher
Spectrograph layout	0–3,500 cm^{-1} / 0–2,000 cm^{-1}
Spatial Raman resolution	400 nm with NA=1.2 WI objective
Spectral resolution	3 cm^{-1} (depending on spectrograph layout)
Microscope	Olympus IX81, easily adaptable to different setups
x/y stage precision	< 1µm