LUMOS

- FTIR Microscopy made easy

FTIR

Innovation with Integrity

LUMOS: A Clear Vision

● Fully Automated FTIR Microscope

LUMOS is a stand-alone FTIR microscope with full automation. It is designed to combine best performance for visible inspection and infrared spectral analysis with highest user comfort.

Due to the motorization and networking of all moveable components inside the LUMOS, the system provides a high degree of automation. The intuitive software of the LUMOS guides the operator step by step through the process of data acquisition. At each step the user interface only provides these functions appropriate to proceed.

Due to its motorized ATR crystal all IR measurements, even those in ATR mode, are performed automated with the LUMOS.

Although the LUMOS is designed to be operated by non-experts for routine applications, its exceptional sensitivity makes it also very suitable for high demanding applications.

- Stand-alone FTIR microscope with full automation
- Very comfortable and easy to use
- Motorized ATR crystal (ATR = Attenuated total reflection)
- Large working distance; allowing ample space for sampling
- High quality in both, IR and VIS range

LUMOS: Highly Intelligent

Fully Automated FTIR Microscopy for Ease of Use

The LUMOS is a stand-alone microscope with an FTIR spectrometer perfectly integrated into its optical design. The major goal for the development of the LUMOS was to accomplish a very easy and comfortable to use but highly performing instrument. The outcome is a system where all components are motorized and electronically coded, ensuring highest user comfort. Due to the automation the LUMOS reaches a high degree of intelligence leading to an extremely intuitive work flow. A major innovation is certainly the motorization of the ATR crystal in the objective. Due to this unique feature the system switches from transmission or reflection into the ATR mode without interaction of the operator, and is capable of measuring fully automated sample and background spectra even in ATR mode.

For Your Convenience the LUMOS Includes:

- Motorized ATR crystal
- Motorized transparent knife-edge aperture
- Motorized condenser
- Motorized Vis polarizer+analyzer (option)
- Motorized stage (option)
- Motorized z-drive
- Motorized switch between IR and Vis mode
- Motorized change of numerical aperture in IR and Vis mode
- Electronic recognition of stage plates

Utilizing this high degree of motorization and electronic recognition the LUMOS software guides the user very efficiently through the process of data acquisition avoiding faulty operations or wrong procedures. All functions of the LUMOS are software controlled and the user interface presents the operator always only those functions which may be useful for the next step.

The LUMOS includes an 8x objective which is used for measurements in transmission, reflection and ATR. In transmission and reflection the ATR crystal is inserted into the objective. For data acquisition in ATR the crystal is positioned into the IR focus by an encoded piezo drive. An integrated pressure control ensures the constancy of the pressure applied from the crystal to the sample which is essential for mapping and imaging experiments. Three different pressure steps can be software-selected in order to achieve highest performance for all types

of samples ranging from very soft to very hard. For background measurements the ATR crystal is driven into the focus position without sample contact. Due to this motorized crystal ATR measurements of sample and background are performed fully automated with the LUMOS. Since the ATR crystal is made from Germanium with a high refractive index (nGe=4) even dark samples can be analyzed. If the crystal is damaged by structures on a sample which are smaller and harder than the crystal tip, it is easily exchangeable by the operator.

The LUMOS provides plenty of space for the sample and a large working distance. In combination with the good accessibility of the sample stage these features are very helpful for the user during sample positioning.

Sample Positioning

The extraordinary large space between objective and stage as well as the excellent access to the sample stage make the operation of the LUMOS highly comfortable.

The working distance of the objective is 30 mm. Samples with a thickness of up to 40 mm can be placed on the sample stage for investigation without any changes in the hardware. Due to the flatness of the motorized stage and the large space between stage and objective the sample positioning is very convenient. The area on the motorized stage which can be addressed for microscopic investigations is clearly marked.

Sample Stage

For the LUMOS both manual and motorized sample stages are available. The motorized xy-stage is required if the sample needs to be analyzed automatically at different positions or if infrared images shall be acquired. Due to its large adjustment range (75 x 50 mm) and its high adjustment accuracy (0.1 µm) this stage is very suitable for analyzing even larger areas at high lateral resolution. This stage can be controlled by joystick or software according to the personal preferences of the operator.

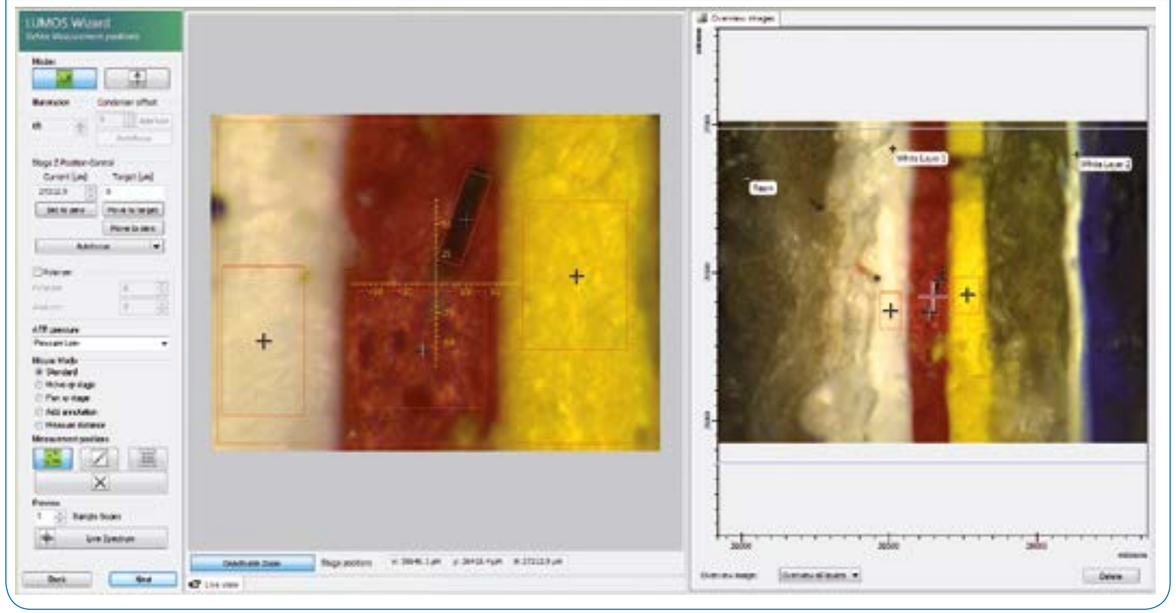
The central plate of the motorized stage includes reference positions for automated background measurements in transmission and reflection (not required for ATR). It also provides a structure which is used for the automated self-calibration of the optics inside the LUMOS.

For the fixation of a sample in a certain position special mounting holders are available. The motorized stage of the LUMOS is further compatible to chambers which allow controlling the temperature and the pressure at the sample during the microscopic investigation.

• High Comfort and Ease of Use

The LUMOS is a very compact stand-alone FTIR microscope. Its dimension (width x height x depth) is just 30 x 64 x 52 cm, requiring less space than conventional FTIR microscopes.

Software



The intuitive software of the LUMOS guides the user through the microscopic IR-measurement procedure. A function bar on the left hand side presents only those options useful for the next step. The central window shows the live camera image of the sample. Captured VIS images of the sample are selectable in the overview window on the right. Measurement positions with individual lateral resolution can be set regularly (lines, grids) or irregularly (see red frames in live and overview image). Annotations can be made on demand at any position of interest.

Visual Inspection

The LUMOS includes an 8x objective which is used in transmission, reflection and ATR mode. It realizes a very large field of view (FOV: 1.5 x 1.2 mm) at a high numerical aperture. The optics of the LUMOS is specifically matched to this objective resulting in a high imaging quality without aberrations. To achieve a high depth of field for the visual inspection of a sample, but also highest sensitivity for the IR analysis, the applied numerical aperture is automatically changed between IR and Vis mode. The LUMOS is further equipped with two independent, adjustable LED sources for a bright and homogeneous illumination in transmission and reflection. The optical aberration of Cassegrain-Objectives in FTIR microscopes (field curvature) is corrected for the LUMOS by a patented integrated transfer optics. This accomplishes a very high image sharpness across the full field of view. “Köhler apertures” are implemented to maximize the contrast of the visible images. In order to recognize also very small structures in the sample a digital zoom allows increasing the magnification from 8x to 32x. All images are captured by a fast and highly resolving digital CCD camera. Motorized rotatable polarizer and analyzer are available as an option to distinguish samples exhibiting birefringence.

Workflow and Software

The LUMOS is controlled by the OPUS software; an easy-to-use and powerful spectroscopy software which assists the full process from data acquisition via data processing and data evaluation to data reporting.

OPUS-Video guides the user step-by-step through the process of data acquisition. With this user interface the operator performs the visible inspection of the sample, defines the measuring positions, lateral resolution and acquisition time, determines the mode of measurement and starts finally the automated measurement. OPUS-Video presents at each step only those functions which are appropriate to use next, guaranteeing a comfortable workflow and high efficiency. All components of the LUMOS are motorized and software-controlled. The full data acquisition including the background and sample measurement is performed automatically in transmission as well as in reflection and ATR mode.

A measurement results in a single file including visible images, spectral data and information about the sample and the experiment. Also evaluation and visualization of the resulting data is performed in OPUS. Even large mapping and imaging data can be processed very easily in OPUS and many univariate- and multivariate methods for data evaluation are available. A wide variety of 2D/3D views with IR images in 2D or 3D on top or next to the video images of any sample is provided. Spectral data can be analyzed by integration of certain bands, 3D cluster analysis or principal component analysis (PCA) to determine the chemical composition or to investigate the chemical homogeneity in a sample. For identification of certain components a library search with individual spectra from IR-mapping/imaging data or the multi linear regression of full IR-images with reference spectra can be performed.

Extended spectral data bases for many different classes of substances are available in OPUS, so that the operator can identify substances, where no reference spectrum is available in the lab.

All different types of views in OPUS can easily be exported in high quality to many different formats.

Powerful Core Technology

High Performing Interferometer

The LUMOS is a stand-alone FTIR microscope with an integrated FTIR spectrometer. The heart of each FTIR spectrometer is the interferometer. The LUMOS uses a permanently aligned RockSolid™ interferometer. This incorporates dual retro-reflecting gold coated cube corner mirrors in an inverted double pendulum arrangement for maximum efficiency and sensitivity. A wear free flexible pivot bearing is located at the center of mass.

As the incoming and the reflected light beam are always exactly parallel in cube corner mirrors, the RockSolid™ interferometer is permanently aligned and extremely insensitive against mirror tilts, vibrations and thermal effects.

Cube Corner mirrors are immune to mirror tilt. By design both, the incoming and reflected light beam are exactly parallel. This is the fundamental principle of Bruker Optics' permanently aligned RockSolid™ interferometer.

Typical data

ATR-mapping of a paint chip (4cm^{-1} spectral resolution, 16 sec acquisition time/position). Apertures were set according to the visual features of the individual layers. The upper right view shows the measured positions with the respective aperture settings (red rectangles). Positions selected for spectrum display are color coded according to the spectra shown in the lower spectra view. The intensity of the carbonyl band at the different measurement positions is displayed as 3D column plot in the upper left view revealing a high content of this component in the red layer. Quantification was performed by band area integration as indicated by the marked area in the spectra view. The plot was created by using the graphics export function in the OPUS software showing the 3D data as displayed on the screen.

Macro Sampling

Although the LUMOS is a stand-alone FTIR microscope it is still not limited to the spectroscopic analysis of micro samples. For the investigation of larger samples a MACRO UNIT is available to be connected to the left side of the LUMOS. The MACRO UNIT allows the use of all QuickSnap™ sampling modules of the compact FTIR spectrometer ALPHA. Various QuickSnap™ modules for transmission, diffuse and specular reflection as well as attenuated total reflection (ATR) provide sampling flexibility for almost all kinds of solid, liquid and gaseous samples. With a touch of a button, the QuickSnap™ sampling module can be demounted from the instrument and be exchanged by another.

All QuickSnap™ modules are electronically recognized. As soon as any QuickSnap™ module is inserted in the MACRO UNIT a test routine is started to assure full performance and a suitable parameter set is loaded. The operator simply starts the sample measurement when the sample is placed on the active module.

Not Limited to Micro Analysis

The LUMOS is not limited to FTIR microscopic investigations but can also be extended for larger samples with a MACRO UNIT. It is coupled on the left side of the LUMOS to use the QuickSnap™ sampling modules from the compact FTIR spectrometer ALPHA.

Various FTIR sampling modules (transmission, ATR, external and diffuse reflection) are available for the ALPHA and the LUMOS.

Performance Guard

Validation

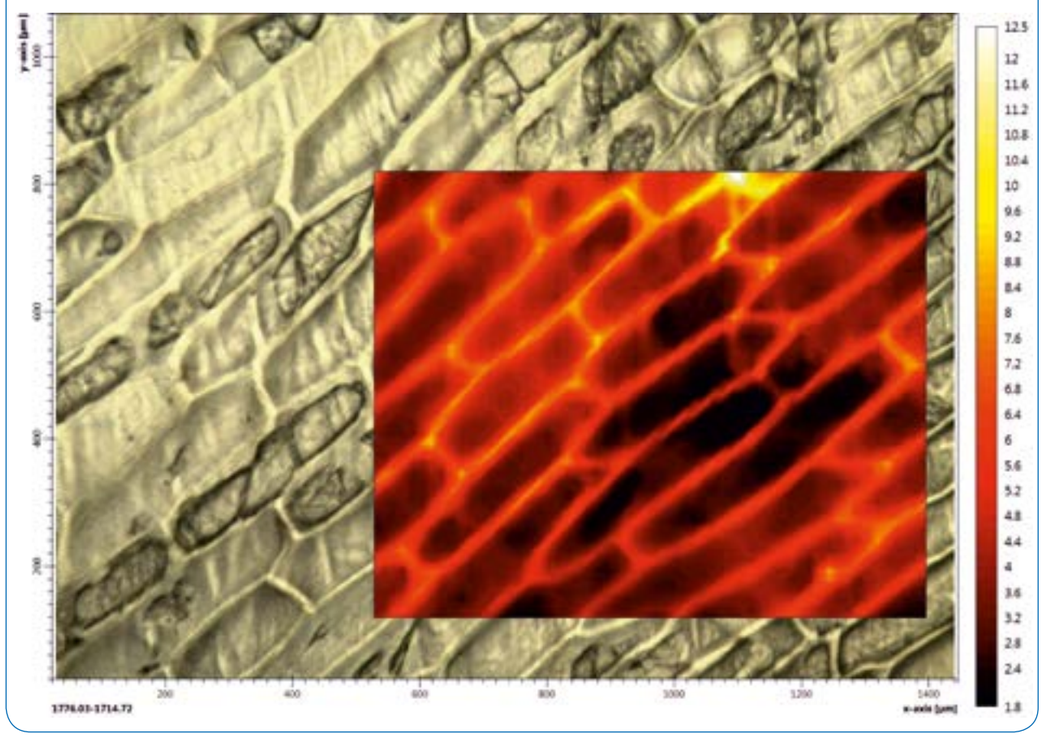
Today many laboratories must comply with extensive regulatory requirements. Bruker Optics offers comprehensive system validation that provides the documentation and procedures needed for an effective compliance. The LUMOS is prepared to fully support any validation requirements; from the installation qualification (IQ) to operational (OQ) and daily performance (PQ) qualification. Bruker Optics´ system validation manual provides all related documentation and guides through all the necessary steps of the validation process. Validation, instrument installation and annual certification are offered by Bruker factory trained, certified service engineers.

The OPUS validation program (OVP) was developed to assist pharmaceutical manufacturers and other regulated companies comply with GMP/GLP/cGMP and provides comprehensive OQ and PQ. All OQ and PQ routines for the LUMOS microscope are fully automated, if it is equipped with the motorized xy stage. A routine for testing the accuracy of the motorized stage is also included. OVP supports for the LUMOS further instrument qualification according to European Pharmacopoeia 2.2.24 and Japanese Pharmacopoeia 2.25. Therefore, a Bruker BRM 1921 MIR transmission standard, equivalent and traceable to the NIST SRM 1921b, is applied, which is included in the internal validation unit of the LUMOS. Test reports for all routines are automatically generated and archived. A status light in OPUS informs the user permanently about the current instrument status. Whenever a component of the LUMOS is out of specification or a test for OQ or PQ has expired, the user will be notified immediately.

OVP supports optionally all requirements of the 21 CFR part 11 regulations dealing with data security, data traceability and data integrity.

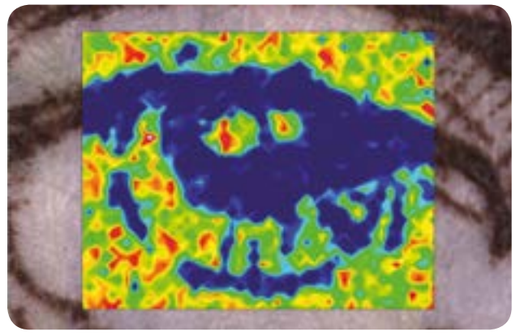
Extended maintenance and service agreements including instrument validation are provided on demand.

IR imaging

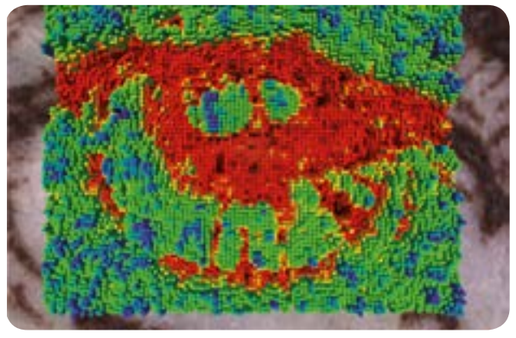


Tissue (onion) measured in transmission with a lateral resolution of 15 µm. IR image shows the lipid content of the cells as a 2D false color plot on top of the visual image.

a)



b)



c)

Infrared image of a postage stamp. The sample was measured in reflection with a lateral resolution of 15 µm. The visual image is shown in (a). The IR image is plotted in false color in 2D (b) and 3D (c) on top of the visual image.

Low Cost of Ownership

Fourier Transform Infrared (FTIR) spectroscopy is a technique which is well established for the chemical identification of any material, but is also very cost-effective. There are typically no consumables required and no expensive components to replace during the life time of the instrument. The LUMOS utilizes a diode laser with a life time of more than 10 years and an infrared light source with a life time of at least 5 years. Its “heart”, the permanently aligned RockSolid™ interferometer, has been designed for a life time of over 10 years.

To facilitate the usage of the LUMOS also in countries with high humidity all included optical window materials and the beam splitter itself are made from ZnSe which is fully inert against water vapor. The LUMOS does not need dry-air purging as often required for conventional FTIR microscopes. The major part of the beam path is encapsulated and dried by desiccating cartridges to minimize the interference of water vapor and carbon dioxide absorption. These cartridges can easily be recycled by the operator and are reusable for the whole life time of the instrument.

To maximize the sensitivity and to realize short acquisition times at high spatial resolution, the LUMOS is equipped with a photoconductive MCT detector with liquid nitrogen cooling. Only 300 ml of liquid nitrogen are required to cool the detector for a full working day. If the access of the operator to liquid nitrogen is limited, the LUMOS can optionally be equipped with a DTGS detector. This will however lead to longer acquisition times and lower spatial resolution.

The compact footprint (width x depth = 30 x 52 cm) of the LUMOS with integrated FTIR spectrometer requires little space in the lab. The utilization of diode lasers, efficiently engineered IR sources, LED lamps and modern electronics result in a low energy consumption of the LUMOS.

Customer Testimonial

"As a premier analytical microscopy lab working across all industries, the FTIR challenges we solve are varied and demanding. Our LUMOS FTIR lets us exceed our customers' expectations. Its ease of operation and smooth workflow have greatly increased our throughput while its sensitivity, repeatability and overall spectra quality has allowed my analysts to routinely impress our clients. The LUMOS Micro FTIR has become an integral and powerful part of my labs' capabilities and success".

John Knowles
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Technologies used are protected by one or more of the following patents:
DE 102004025448; DE 19940981; US 5923422; DE 102012200851; US 8873140
Additional patents pending

Bruker Optics is ISO 9001 and ISO 13485 certified.

Laser class 1 product.

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