FT-IR Microscopy

HYPERION II

FT-IR | FPA | IR Laser Imaging Microscope

Innovation with Integrity

Bruker's IR microscope HYPERION has always been synonymous with sensitivity and versatility. For more than 20 years, it pioneered FT-IR imaging and left its mark in countless high-profile publications.

With HYPERION II, we remain true to our reputation as an innovation leader. For the first time ever, FT-IR and QCL technology are combined in a single instrument.

This innovative approach gives scientists and researchers a new, versatile tool to further develop established applications and discover exciting possibilities.

FT-IR Microscopy

The HYPERION II covers all the fundamental techniques beginning with the most widespread use: FT-IR microscopy. It finds use in general research, forensics, failure analysis, life-science and electronics:

- Thermoelectrically and liquid nitrogen cooled MCTs
- Visual and IR contrast enhancement tools
- Wide range of objective lenses and accessories available
- Dedicated ATR objective with integrated pressure sensor

FT-IR Imaging

Take your chemical FT-IR imaging to the next level with focal-plane array (FPA) detector technology. It offers superb spatial resolution and peak sensitivity in all measurement modes:

- True IR imaging by focal plane array technology
- High spatial resolution and full ATR compatibility
- Low-magnification objective lenses for fast chemical overviews
- High-magnification objective lenses to find smallest details

IR Laser Imaging

Bruker's infrared laser imaging modules (ILIM) opens the door to enhance existing and discover brand new applications. The HYPERION II combines QCL technology and FT-IR into one system:

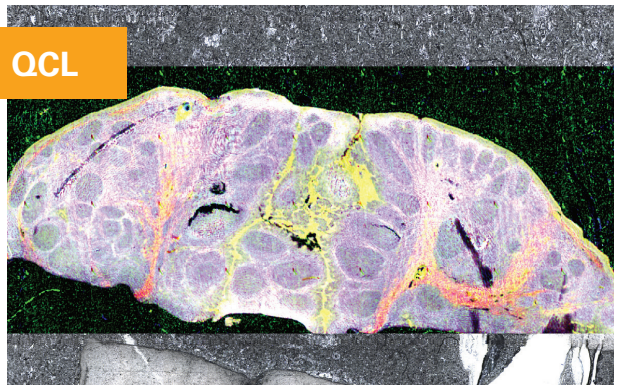
- Create high-contrast IR images at unprecedented speed
- Seamless combination of FT-IR and QCL measurements
- IR Live Imaging allows observation of samples in real-time
- QCL Imaging in all measurement modes: transmission, reflection and ATR

The HYPERION II is compatible with INVENIO and the VERTEX series FT-IR spectrometers.

Applications of Infrared Microscopy

Life Science

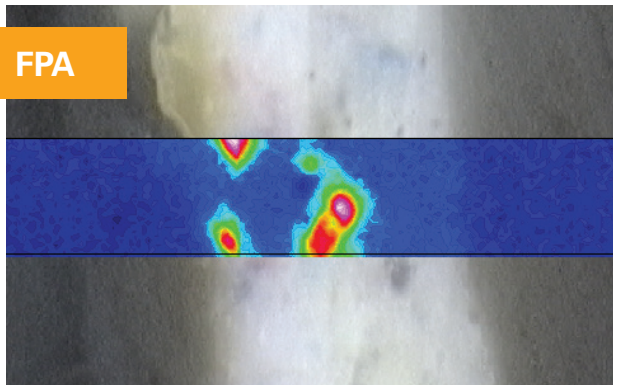
QCL



The potential of QCL technology for life science is huge. This microtome section of tonsil tissue was analyzed by superimposing the IR laser image on the visual data.

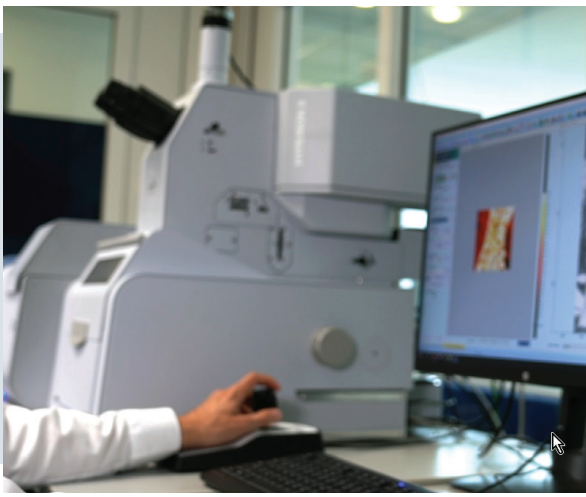
Pharmaceuticals

FPA



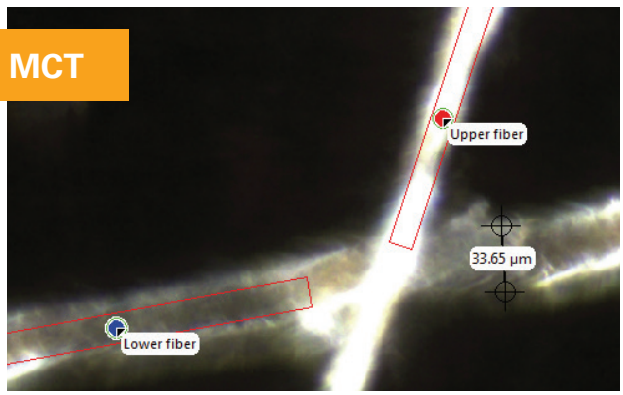
Determining the ingredients of a mixture has never been so easy. In this case, a pharmaceutical pellet was analyzed for impurities. The impurity (red) stands out clearly from the API matrix (blue).

- Use FT-IR and QCL in any measurement mode: transmission, reflectance, and ATR.
- Amazing live IR imaging view: explore your sample through the eyes of the spectrometer in real-time.
- Access spectral range extensions (VIS/NIR) and utilize emission or fluorescence spectroscopy.



Forensics

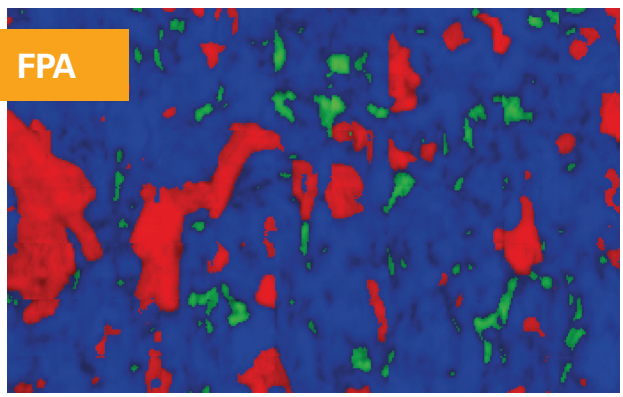
MCT



IR microscopy is an outstanding tool for forensic science. In this case, fibers were examined to obtain clear evidence of their origin. Knife-edge apertures ensured optimal spectral quality.

Polymers

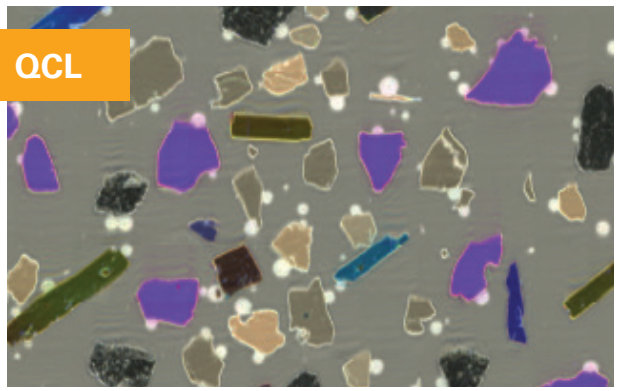
FPA



Composition, thickness and homogeneity of this polymeric material is easily assessed by µ-FT-IR. False-color image shows: POM (blue), PTFE (green) and Aramide (red).

Geology

QCL

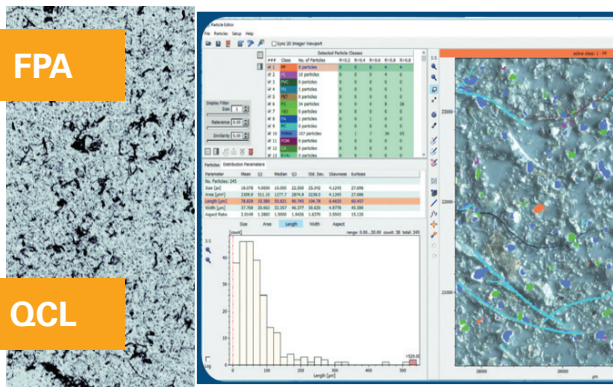


Infrared laser imaging readily evaluates minerals and geochemical properties. The example above shows the differentiation of various oxide minerals based on their reflectance properties.

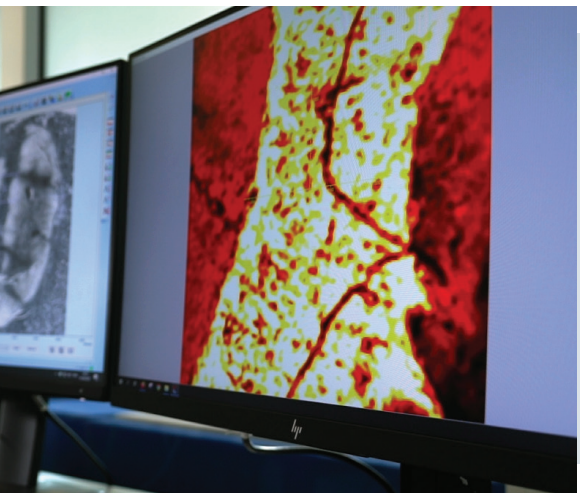
Microplastics

FPA

QCL



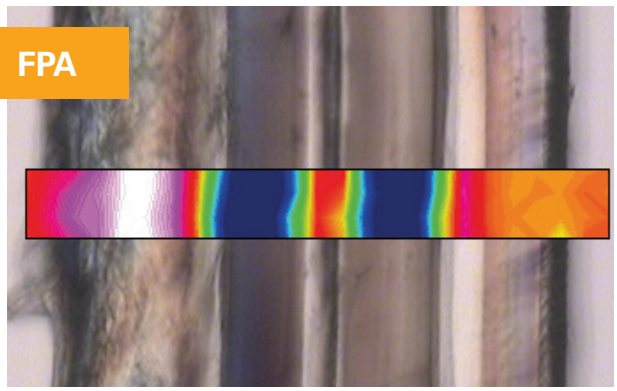
FT-IR imaging is the gold standard in microplastics analysis but IR laser imaging is catching up fast. Left: IR laser image; Right: automated microplastics analysis.



- Highest flexibility and spectral performance are the key features of HYPERION II.
- Make your instrument more sustainable by choosing a high-sensitivity thermoelectrically cooled MCT.
- Easy customization for applications through a wide range of accessories and objective lenses.

Multi-Layer

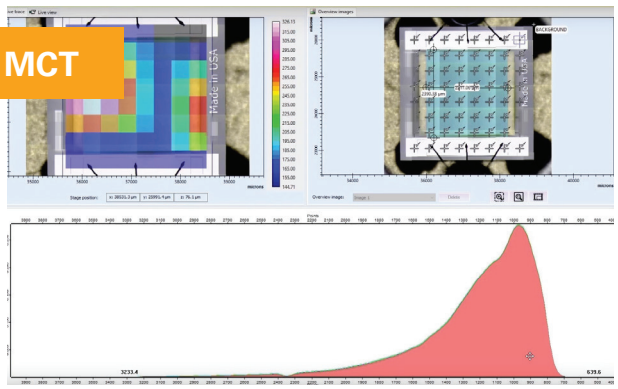
FPA



IR imaging makes it easy to analyze laminates and multilayer structures. This multilayer paint chip was examined using high-resolution ATR imaging to determine the cause of a car accident.

Sensor Technology

MCT

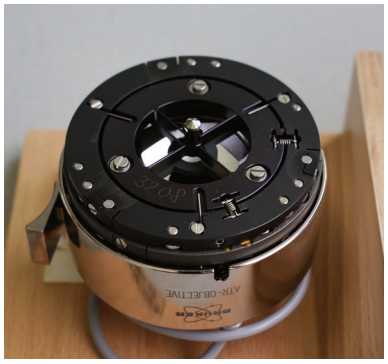


The quality and emission behavior of IR emitters (e.g. voxels or LEDs) can be check by µ-FT-IR. The above picture shows an inhomogeneous radiation distribution of an LED.

Ready for Any Sample Objective Lenses

3.5x IR Objective

Provides broad spectral range and low chromatic aberration and distortion. Lenses are made from IR transparent material and provide high IR throughput to achieve excellent signal to noise.



20x ATR Objective

Offers clear sample viewing and high infrared throughput. Internal pressure sensor reproducibly ensures optimal contact between the sample and the crystal during data acquisition.

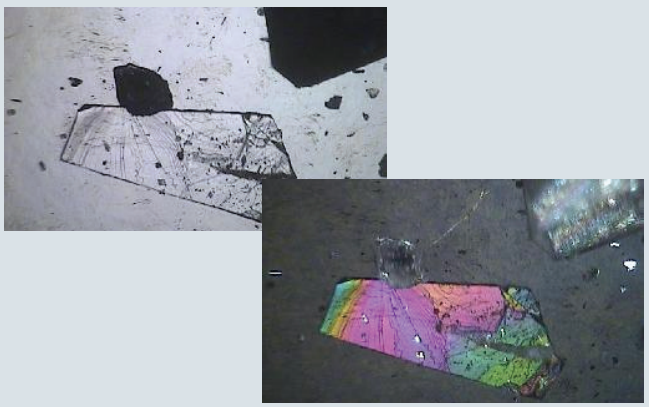
15x Grazing Angle Objective

Designed for the microanalysis of thin coatings on metallic substrates with extremely high sensitivity. Retains the polarization characteristics of the applied infrared beam.

Visualization Tools

The first step of any microscopic analysis is visual inspection and location of regions of interest. For this, the HYPERION II packs multiple tools to enhance the visual quality of your analysis. It offers:

- 5 MP CMOS camera and binocular (optional)
- Contrast irises ("Köhler" apertures)
- Darkfield and fluorescence illumination
- Visual and infrared polarizers
- Autofocus functionality

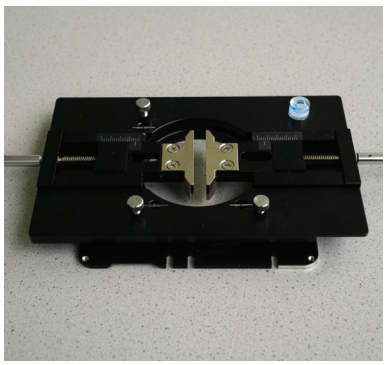


Sample Compartment

The sealed sample compartment estabishes stable experimental conditions for sensitive and demanding samples. For infrared laser imaging (QCL), the compartment doubles as a laser safety enclosure to protect the user from hazardous radiation.

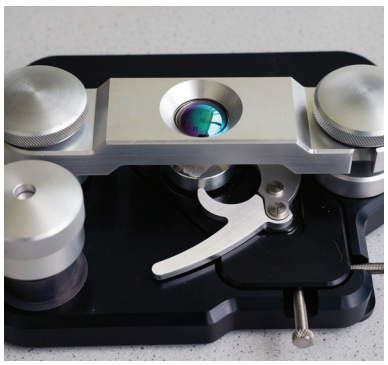
- Stable atmospheric conditions
- Allows continuous flow of inert gas or dry air
- Required for ILIM, optional for FT-IR
- HYPERION II is a laser safety class 1 product

Full Flexibility Sampling Accessories



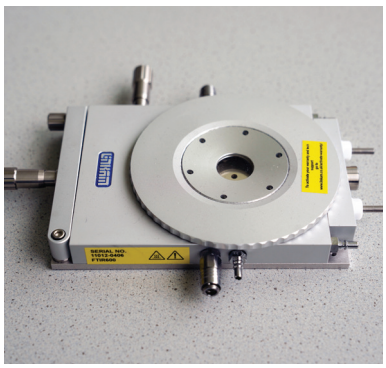
Universal Sample Holder

Holds round and unevenly shaped samples such as tablets, minerals, etc. in the desired position and allows sample tilt for correcting oblique sample orientations.



Macro ATR Imaging

Enables microscopic IR analysis of sticky, brittle or particularly soft specimen by clamping them to a large Germanium ATR crystal with a tip size of about Ø 1000 µm.



Temperature Controlled

Performs thermal experiments. This precise heating and cooling stage covers a temperature range from -196°C up to 600°C to study the behavior of samples exhibiting polymorphism or decomposition.

Spectral Range Extensions and Detectors

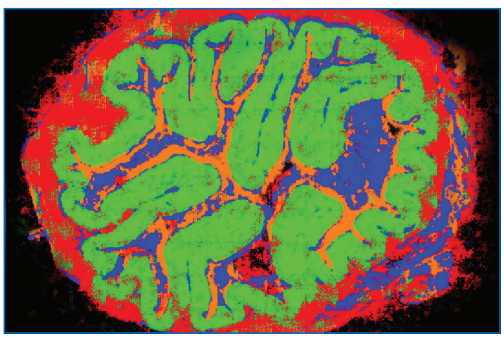
One of the many strengths of the HYPERION II is the adaptability to the analytical requirements. Equipped with a wide variety of detectors, it can cover a very broad spectral range, from the visible (VIS, up to 20.000 cm^{-1}) to the far-infrared (FIR, down to 150 cm^{-1}).

In addition to the manual, easily interchangeable knife edge and iris apertures, aperture wheels and automated, software-controlled knife-edge apertures are also available. The HYPERION II can be equipped with up to two detectors in parallel, where the switching between positions is controlled by the software.

OPUS IR Software

Our all-in-one software OPUS provides the fundament for optimal measurements and evaluations. The user-guided software interface makes microscopic investigations an easy task for users of any skill level.

- Spectral contrast calculation during IR image recording
- Autonomous IR image analysis by Bruker´s adaptive K-means clustering
- Create RGB images, 3D cluster analysis, PCA analysis, machine learning and much more.
- Correlate your visual and IR data in 2D and 3D
- Select spectra by similarity from 3D data files
- Use smart filter options to interpret data
- Full feature-compatibility with QCL
- Python interface for increased evaluation flexibility, allows user to develop and use their own methods



Localize different components and points of interest of your sample completely automated. The above image shows the Result of k-means cluster algorhithm of an FT-IR Image with 2 million spectra. Everything was determined automatically within around 10 seconds.

Combining FT-IR and QCL Technology

It is often implied that both techniques are interchangeable - a popular misconception. Since FT-IR and infrared laser imaging both have distinct and unique advantages, a combination of both into one instrument is the optimal choice.

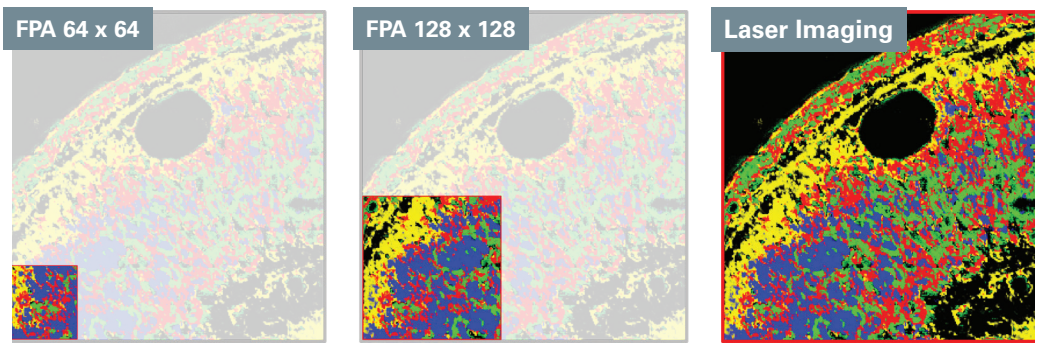
Fundamental Differences:

Technical Specification	FT-IR	Infrared Laser Imaging
Source	Globar (black body radiation)	Monochromatic (tunable MIR laser)
Data Collection	All wavelength at one Collection of full spectra	Sequential wavelength acquisition Imaging at fixed wavelengths Imaging at defined spectral ranges
Spectral Range	Full MIR spectral range	MIR fingerprint

Focal-Plane Array vs. Infrared Laser (QCL) Imaging:

Technical Specification	FT-IR Imaging by FPA		IR Laser Imaging
Simultaneuos Spectra	4096 (64x64 FPA)	16.384 (128x128 FPA)	Up to 90.000 (300x300 pixel)
Spectral Range	MIR	MIR	950 - 1800 cm^{-1}
Pixel Size	0.5 - 11 µm/pixel	0.5 - 11 µm/pixel	0.2 - 4.9 µm/pixel
Field of View @ 3.5x	730x730 µm	1460x1460 µm	1460x1460 µm
Full Spectrum Speed at 16 cm^{-1}	400 spectra/second	800 spectra/second	30.000 spectra/second
Full Spectrum Imaging at 16 cm^{-1}	32 minutes/cm^2	16 minutes/cm^2	3 minutes/cm^2
Single Wavelength Imaging	-	-	6.4 mm^2/second 15 seconds/cm^2

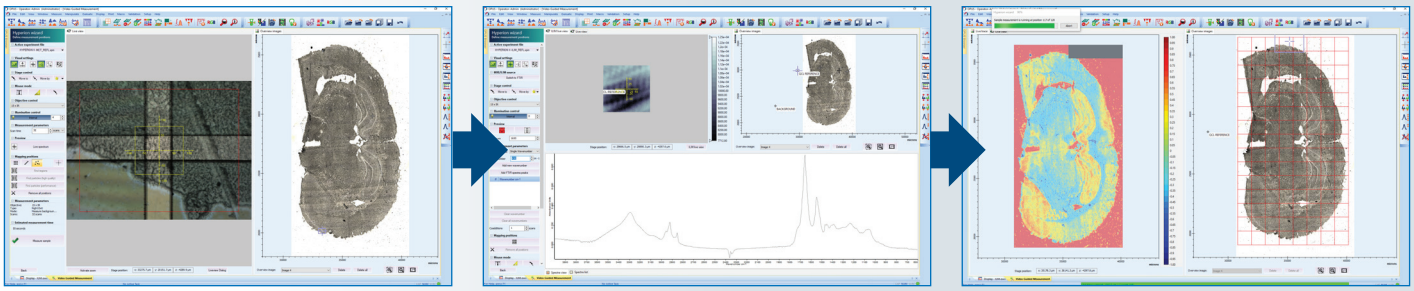
Sample Area Imaging Comparison



These images clearly show the speed advantage of infrared laser imaging compared to FT-IR FPA imaging. In a **full spectral scan** (16 cm^{-1}) and one minute these areas can be imaged: 64x FPA = 2 mm^2, 128x FPA = 4 mm^2, IR Laser= 32 mm^2. Alternatively, a **single wavenumber scan** could be applied, reducing the required analysis time to about 6 seconds for the same area. With this mode you can cover 380 mm^2 sample in ~1 minute, emphasizing the speed advantage.

FT-IR and QCL. In one easy workflow.

In conclusion, only a practical combination of both can achieve the best results. Fortunately, the HYPERION II can be considered both: an exceptional FT-IR imaging microscope and an ambitious QCL microscope.



ROIs for an FT-IR measurement are defined on the visual image

Peaks are selected for infrared laser imaging

A chemical Image is recorded in seconds!

Note: This process can also be turned around: IR Laser Imaging is used to prescreen a sample quickly and only collect FT-IR spectra at seleted regions of interest.

Spatial coherence artifacts? Never with HYPERION II.

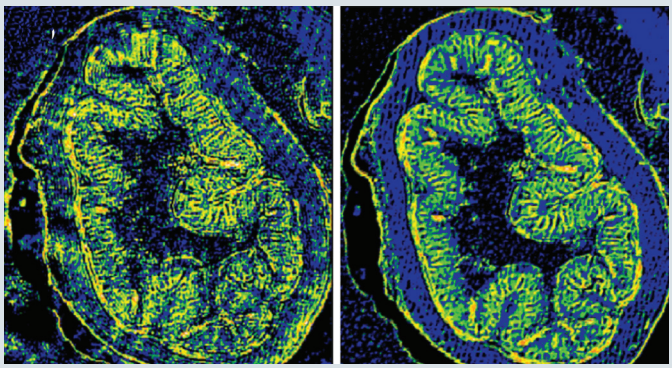
This image shows a comparison between visual and IR Laser Image. Thanks to the patented* coherence reduction the IR Laser Image is virtually artifact free and exhibits the same quality as the visual one.
HYPERION II delivers unprecedented Image quality for IR Laser Imaging.

Whether in transmission, reflectance or attenuated total reflectance in combination with MCT, FPA or QCL. With the HYPERION II you can always rely on crisp and clear images and pristine data. Our patented*, hardware-based coherence reduction enables users to acquire razor-sharp infrared images without Interference artefacts – for the first time in QCL based imaging.

Working with IR Laser Imaging

We want to shed more light on applications that can benefit from IR laser microscopy and imaging. Especially when routinely scanning large area samples, IR laser imaging can shine and outperform FT-IR imaging.

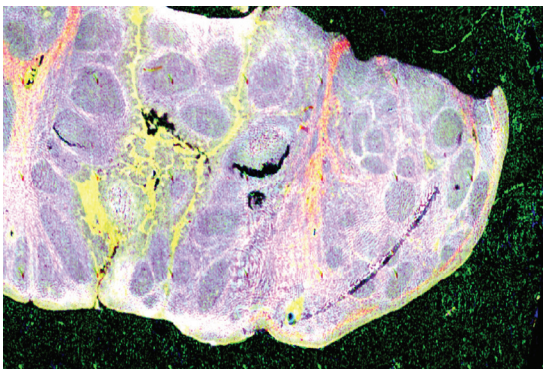
The impressive result of Bruker´s patented hardware spatial coherence reduction technology:
Two IR-laser images of the same sample, a standard IR laser image (left) and one with spatial coherence reduction (right). The HYPERION II supresses spatial coherence before it even happens, so you always get amazing IR images in any application.



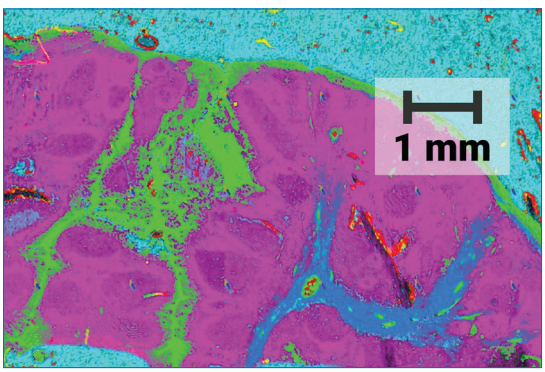
FULL COHERENCE REDUCED COHERENCE

Use-Case #1: Tissue Imaging

IR spectroscopy is well suited to study biological tissue. It permits insight into the biochemical composition of tissues from plants, animals and humans without the use of staining agents. Until now, IR spectroscopy was limited in throughput due to the measurement time.



But IR laser imaging changes things. Infrared laser imaging with the HYPERION II is more than 14 times faster than a comparable FPA FT-IR measurement, even when recording full spectra. The speed advantage becomes even more impressive when measuring only discrete wavenumbers. The secret lies within the much higher power density of an IR laser compared to a traditional thermal MIR source. As a result, excellent IR spectral data can be collected at a fraction of the time.



The image on the left shows another milestone in imaging technology. Artificial intelligence driven, next generation data evaluation algorithms, such as Bruker´s exclusive Adaptive Chemical Imaging (ACI) can autonomously create IR chemical images from raw spectral data. IR images showing the contribution of components based on the spectral variations are created extremely fast. Even large samples, such as the shown tonsil tissue microtome section with >3 million spectra, are analyzed in a few minutes.

In IR laser imaging, the acquisition mode is very important and has a great influence on the measurement and data collected. The HYPERION II offers the following IR laser imaging modes in the MIR fingerprint region (1800-950 cm $^{-1}$):

- **IR live imaging** permits real-time chemical imaging at video frame-rates to find regions of interest or follow reactions.
- **Imaging at discrete wavenumbers** focuses on specific wavenumbers instead of full spectra and allows to speed up the acquisition process significantly.
- In a **spectral sweep scan** a spectral range is selected and spectra are generated by a continuous sweep of the laser. The resulting spectra are equal to FT-IR in the given spectral range.
- With the **discrete scan** a selected spectral range is recorded by stepwise tuning of the laser, resulting in higher wavenumber accuracy but longer acquisition time.

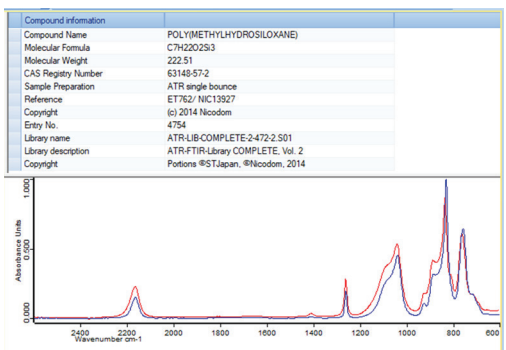
Use-Case #2: Scanning for Contaminants

FT-IR microscopy is a proven method to identify unknown substances and contaminants based on their molecular vibrations. However, this traditionally relies on prior visual localization of the contamination. This can be difficult, especially for transparent impurities (e.g. lubricants), and has up to now prevented assessing the cleanliness of macroscopic samples in their entirety.

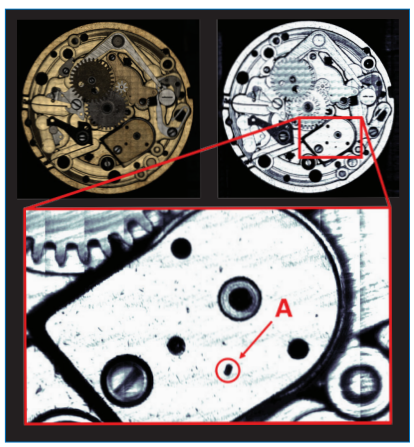
The introduction of IR laser imaging made it finally possible to judge the surface of extremely large samples by their chemical properties in very little time. Use the HYPERION II to collect IR overview images **at the same speed** as you would collect a visual microscopy image, and analyze macroscopic surfaces (tens of cm^2) with micrometer resolution.

In this particular case, a high-quality pocket watch was to be tested for residues of silicone oil. Accordingly, the Si-CH_2 band at 1250 cm^{-1} was selected for the IR laser analysis. The entire sample (30 x 30 mm) was scanned with 5 µm pixel resolution at this discrete wavelength in less than 3.5 minutes. While the visual image shows no sign of contamination, the IR image reveals a significant difference.

The outline of a stain is clearly visible in the IR image and contained to a small area of the watch. Now that we know where the contamination is located, we switch to FT-IR microscopy with a simple mouse click. In total, the analysis took less than 5 minutes and yielded an accurate, reliable result.



Spectral reference library search result using the FT-IR spectrum collected directly at the contamination. Spectrum was collected from 4000 - 600 cm^{-1}.



The visual image on the top left shows no indication of contamination or any presence of residue. The IR image at 1250 cm^{-1} (top right) shows a small contamination. Size and extent of the contamination become clear in the close-up. The watch's entire movement (900 mm²) was analyzed in less than 5 minutes.

HYPERION II at a glance.

About HYPERION II

The Bruker HYPERION II is the first IR microscope that combines cutting edge infrared laser imaging, that enables unrivaled imaging speeds, with classical and versatile FT-IR microscopy in just one single device. Whether you are looking for basic identification routines or high-speed imaging solutions, you'll immediately notice, that there is no way around the HYPERION II.

About Bruker

We want to make your application a complete success. Our Team of scientists and engineers offer tons of practical experience to support you.
We want to earn your trust when it comes to questions regarding the selection of the best equipment for difficult analytical problems. Bruker´s FT-IR devices ensure consistent performance for years to come. During a maintenance situation, you can count on our global network of service engineeres who are ready to deal with any issues quickly and skillfully.

Technical Features:

The HYPERION II is our versatile FT-IR microscope for research and development with flexible accessories and the possibility to combine infrared laser imaging (QCL) and FT-IR in one instrument:

- QCL implementation for infrared laser imaging (laser class 1)
- Focal-plane array for FT-IR Imaging (64x64 or 128x128)
- TE-MCT and broad-, mid, narrow-band LN2-MCTs
- Available objective lenses: 3.5x/15x/36x/74x IR, 20x ATR, 15x GIR, 4x/40x VIS
- Manual/automated knife-edge aperture or aperture wheel
- NIR – FIR Spectral range extension available
- Wide selection of accessories and sample stages: macro-ATR imaging accessory, cooling/heating stage, specialized sample holders, sample compartment, etc.
- Visual enhancement tools and sample stages: darkfield/ fluorescence illumination, VIS/IR polarizers, etc.
- The HYPERION II is compatible with INVENIO and the VERTEX series FT-IR spectrometers.

Covered by one or more of the following patents: DE102004025448; JP-6779982-B2; US-2018157019-AA..
Additional patents pending.

Laser class 1 product.

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