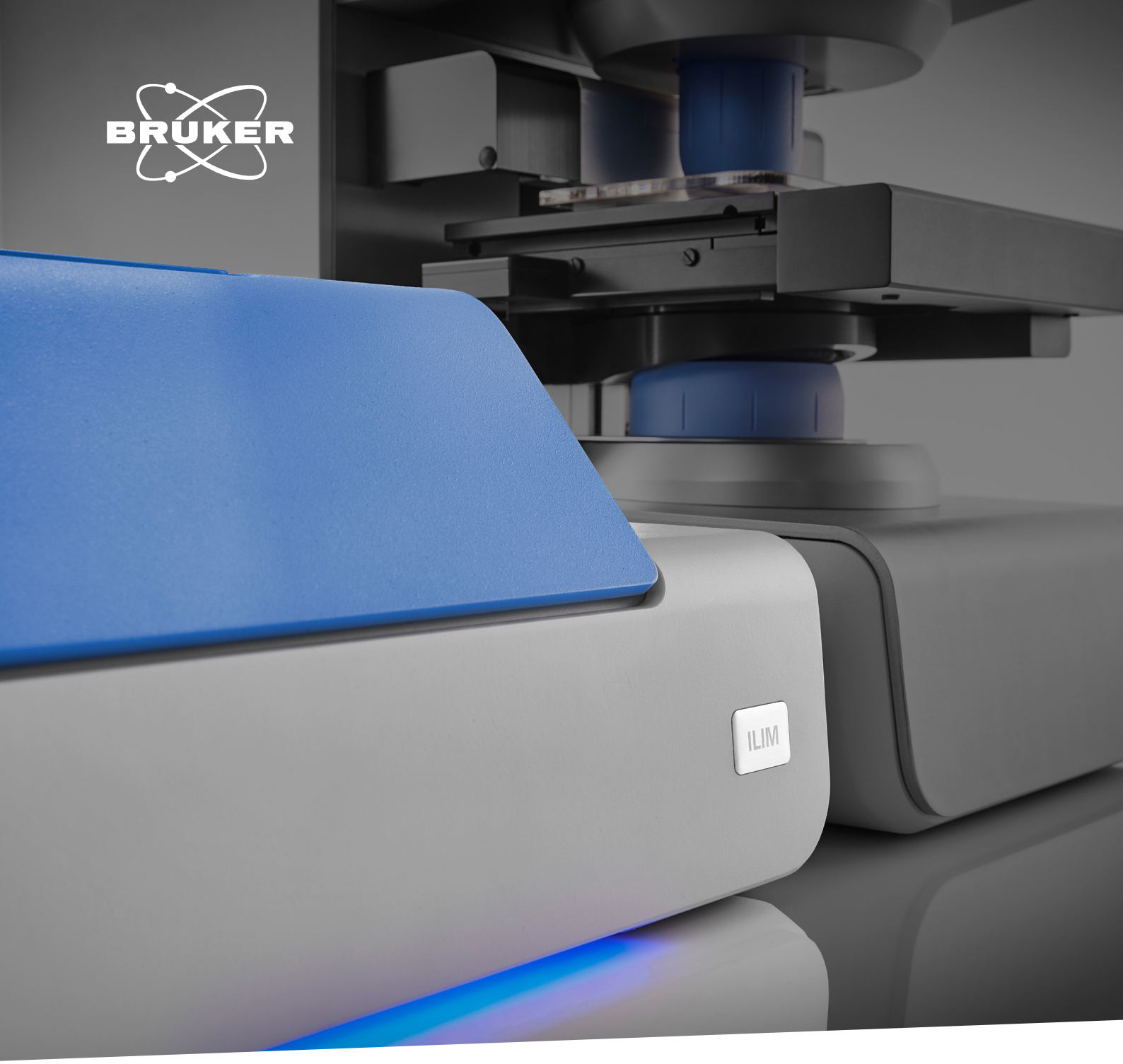


HYPERION II AND LUMOS II

INFRARED LASER IMAGING MICROSCOPY

Light Speed for Chemical Imaging.

Innovation with Integrity

Understanding the Technology

Infrared Laser Imaging (ILIM) is a fundamentally different measurement approach compared to FT-IR imaging. Once the key differences become clear, it is easy to grasp the extensive benefits of this new technology - and take advantage of them.

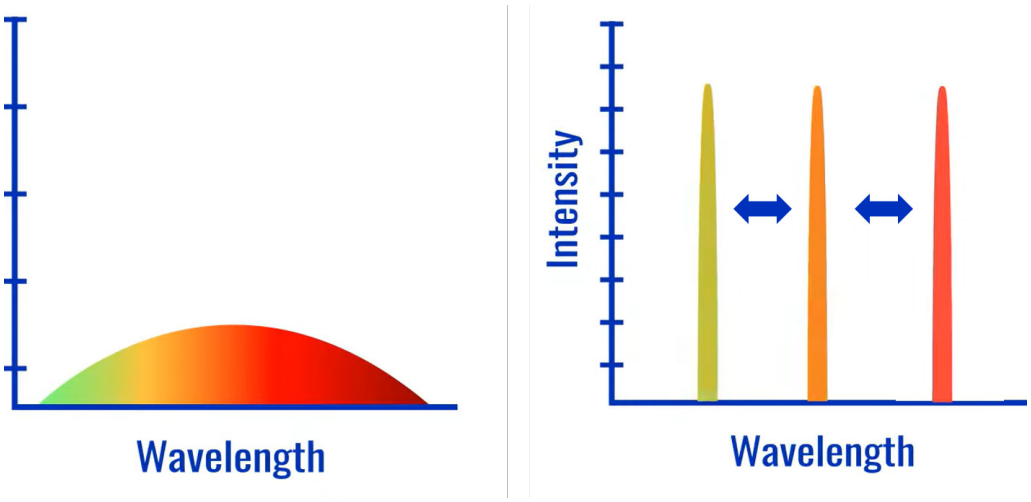


Fig. 1
Left: Schematic emission profile of a thermal source. Right: Tunable emission of a QCL.

Traditional FT-IR microscopy and imaging rely on a thermal source, that emits with low intensity across a broad spectral range (Fig.1, left), allowing the measurement of the full wavenumber range at once. The relatively low intensity requires very sensitive detectors that often require liquid nitrogen as a coolant.

IR Laser Imaging (ILIM) is based on a quantum cascade laser (QCL), that emits at one discrete wavenumber at a time, but with much higher intensity (Fig.1, right). To collect an IR spectrum, the QCL sequentially scans through its wavenumber range rapidly, measuring at each wavenumber. In imaging, the high intensity QCL source can be used to illuminate larger sample areas, allowing the use of an uncooled imaging detectors to reach unprecedented IR imaging speeds.

Technical Specification	FT-IR	Infrared Laser Imaging
Source	Thermal source (black body radiation)	QCL (monochromatic, tunable IR laser)
Data Collection	▪ All wavelength at once ▪ Collection of full spectra	▪ Sequential wavelength acquisition ▪ Imaging at fixed wavelengths ▪ Imaging at defined spectral ranges
Spectral Range	Full MIR spectral range	MIR fingerprint

Table 1
Differences between FT-IR and IR Laser Imaging (ILIM).

But why is IR imaging so powerful? And why is speed of acquisition such an important factor? The following example illustrates both. In cancer research, thin sections of biological tissue are examined to detect diseased cells and study cancer progression.

Visual microscopy (Fig.2, left) does not provide sufficient contrast and requires the tissue to be treated with staining agents prior to inspection. In contrast, IR imaging delivers the neccessary chemical information for cancer detection without any staining or labeling (Fig.2, right).

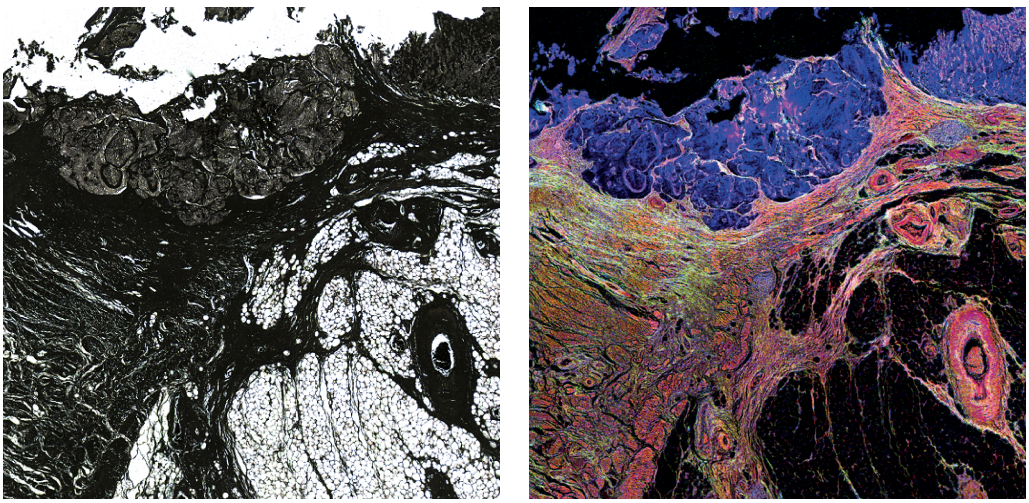


Fig. 2
A visual image (left) provides general information about the tissue architecture. Chemical imaging (right), however, reveals the entire molecular and morphological contrast intrinsically and without staining or labelling.

This field of research routinely images samples around 1 cm² in size at the highest spatial resolution possible. This demands measurement speeds that exceed the capabilities of even the fastest FT-IR imaging microscopes available today.

IR laser imaging, however, is a game changer in this regard. It gives access to a much faster measurement of the MIR fingerprint. If only chemical images based on single absorbtion bands are required, the speed advantage is even further increased.

Table 2 makes it **very** clear: we are entering a new era. Chemical IR imaging speeds of up to 270 mm² per minute are finally achievable, which is simply **unprecedented**.

Table 2
Comparison of the fastest commercial FT-IR imaging microscope (LUMOS II) vs. the fastest IR laser imaging microscope (LUMOS II).

Specification	FPA FT-IR	ILIM
Spectra per Scan	1,024 (FPA: 32 x 32)	249,600 (FPA: 520 x 480)
Detector Type	LN-cooled FPA	uncooled FPA bolometer camera
Pixel Resolution	5 µm per pixel	4.3 µm per pixel
IR Field of View	0.16 mm x 0.16 mm	2.20 mm x 2.04 mm
Spectra Acquisition Speed	900 per second	62,400 per second
Area Scanning Speed	1.6 mm² per minute	67 mm² per minute (MIR fingerprint) 270 mm² per minute (single wavenumber)

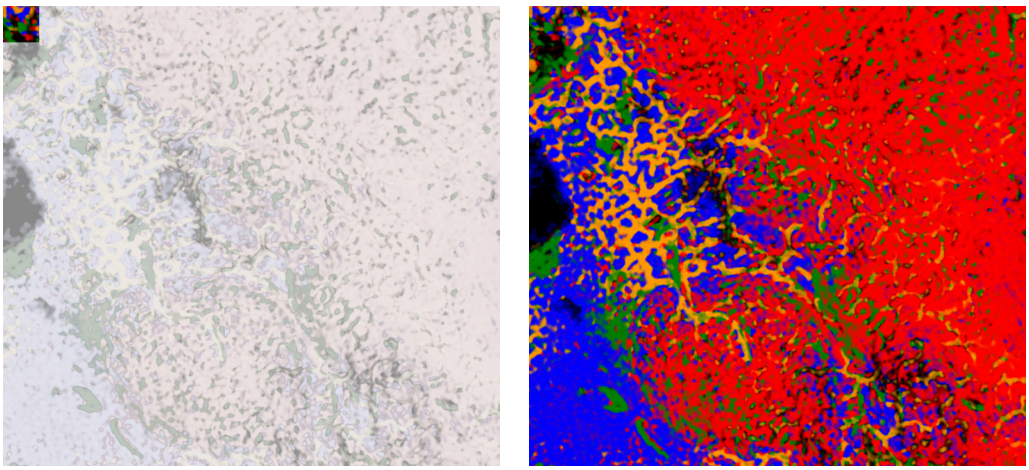


Fig. 3
Comparison of field of view of LUMOS II in FT-IR imaging (left) and ILIM (right).

To put it in numbers: the ILIM offers two orders of magnitude increase in speed and field of view, when compared to traditional FT-IR imaging (Fig. 3). The reason lies within the unique combination of radiation source and detector:

- The high intensity of a QCL allows to illuminate a very large area simultaneously
- The widefield IR bolometer camera provides an extremely large field of view

This way, ultra-high measurement speed is achieved. Usually, this speed increase comes at a price, as a laser is a coherent light source, which can lead to interference artefacts in the created images. But not so for Bruker's ILIM systems.

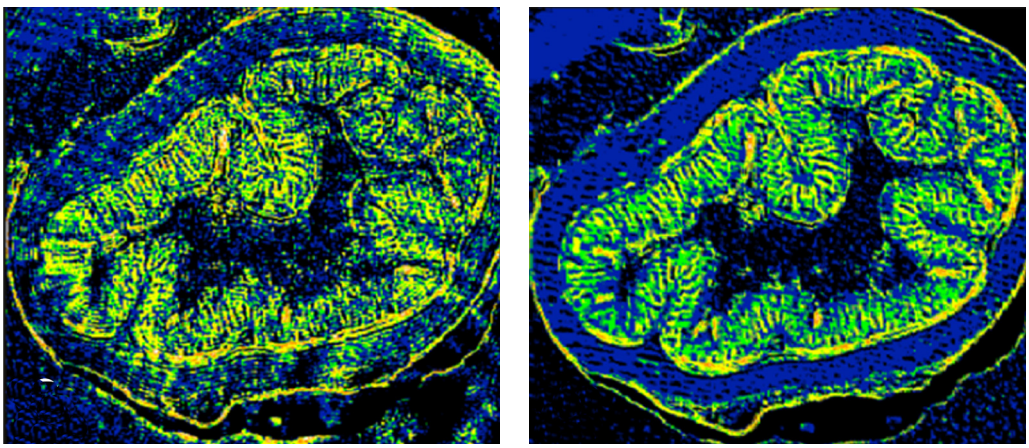


Fig. 4
Spatial coherence effects blur the chemical image on the left side. In contrast and thanks to Bruker's spatial coherence reduction, the finer details on the right image are much easier to distinguish and coherence artefacts are successfully suppressed.

We solved this problem

Bruker came up with a patented technology called „spatial coherence reduction." This is why our IR Laser Imaging not only outperfoms in terms of speed but also imaging quality.

Our patented Infrared Laser Imaging (ILIM) technology for LUMOS II and HYPERION II reduces the spatial coherence of the laser beam and allows to create stunning IR images of excellent spectral quality.

With this technology, we not only reap the benefit of extremely high-imaging speeds, but have created something spectroscopists have long sought after: „Infrared Eyes" that immediately detect a samples chemistry.

ILIM Adds +1 to Your Application Skills

Infrared laser imaging (ILIM) is an incredible opportunity to develop new applications in any field where FT-IR FPA imaging seemed to slow. With the HYPERION II, you are perfectly prepared to give definite answers to complex analytical questions and new discoveries, powered by the ultimate versatility of FT-IR and ILIM in one device.

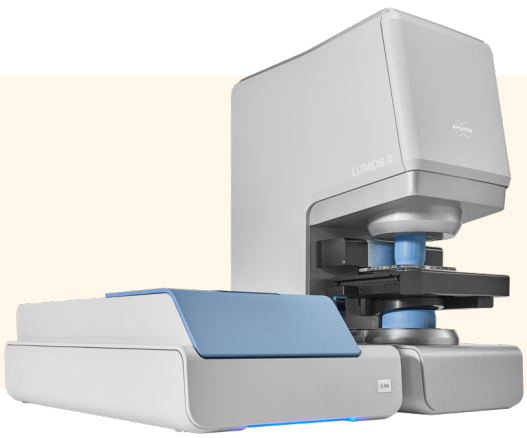
But for some applications, ILIM has already proven as a robust method that delivered extraordinary results.[1,2,3] For those applications, we built the LUMOS II as an honest, straightforward ILIM workhorse. Our ApplicationPlus™ ensure seamless and easy operation to go from sample to insight within a few minutes. That's the power of hardware and software that was designed in tandem.

HYPERION II ILIM for Discovery

- Combines FT-IR and IR Laser Microscopy
- TRANS, REFL, and ATR
- Wide range of objectives and accessories
- 90,000 spectra simultaneously
- Full flexibiltiy for high-end research
- Access to FT-IR benchtop spectrometer
- FT-IR / QCL workflow

LUMOS II ILIM for Translation

- Dedicated IR Laser Imaging
- TRANS and REFL
- Specialized optics for IR imaging
- 249,600 spectra simultaneously
- Full automation for routine imaging
- Compact easy-access design
- End-to-end application workflows



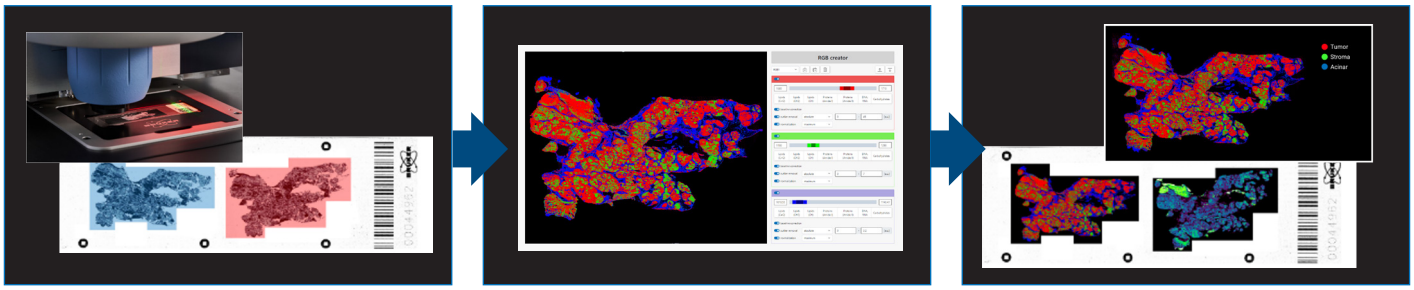
Literature

[1] Multimodal analytical tools for the molecular and elemental characterisation of lesions in brain tissue of multiple sclerosis patients. Talanta. 2024, 270:125518. doi: 10.1016/j.talanta.2023.125518.

[2] A multimodal view at cancerous liver tissue by chemical bioimaging and image segmentation strategies. ChemRxiv. 2023; doi:10.26434/chemrxiv-2023-85hbd

[3] Deep MALDI-MS Spatial 'Omics guided by Quantum Cascade Laser Mid-infrared Imaging Microscopy. bioRxiv 2023.12.14.571637; doi: https://doi.org/10.1101/2023.12.14.571637

Dedicated Workflow. Faster Results.



Sampling & Acquisition
Follow robust and automated acquisition methods to acquire reproducible ILIM data at scale.

Evaluation
Use our AI driven algorithms or develop your own analysis pipelines to process and visualize your data.

Results & Reporting
Generate "teaching images" for seamless interfacing with other imaging modalities. Create high-quality figures for publications.

This example using a tissue sample illustrates one thing above all: ILIM is a complete solution for every application it supports: tissue, tablet and particle analysis. Hardware and software are in perfect sync, so that the extreme speed advantage of the measurement actually reaches the user.

Our dedicated ILIM workflows provide a complete solution for routine IR imaging applications, such as the analysis of tissues, tablets and particles. A combination of application-specific hardware accessories, such as specialized, electronically coded sample holders, and tailored end-2-end software workflows provides a high degree of automation, high throughput and superb user experience. The smooth synchronization of hard- and software allows users to focus on the results, not the operation. Depending on the application, tailored, turnkey solutions are available for data evaluation. Users further benefit from a standard interface to integrate their own custom analysis algorithms into the workflow.

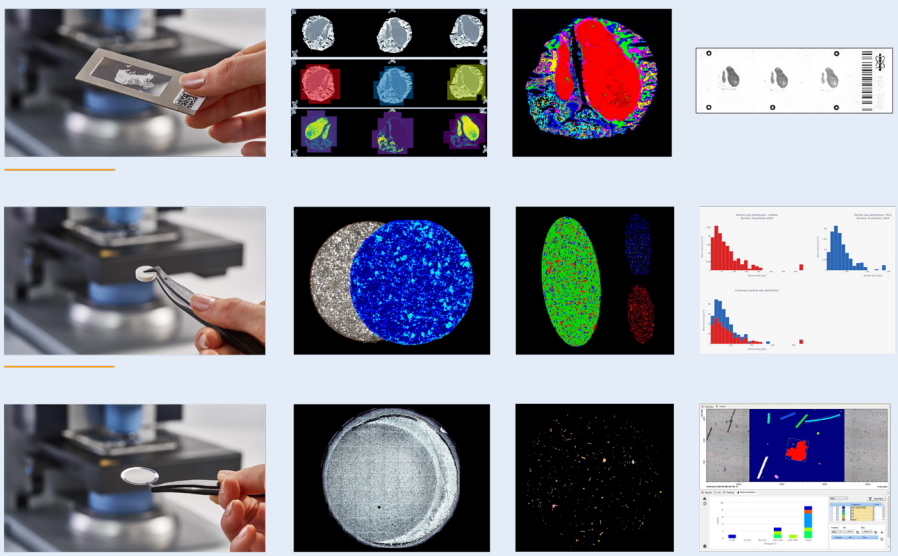
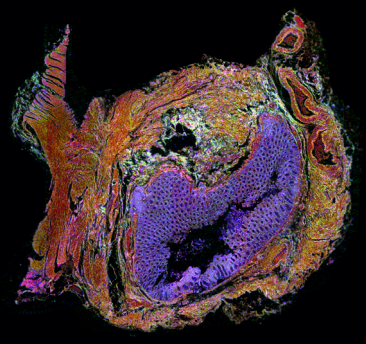
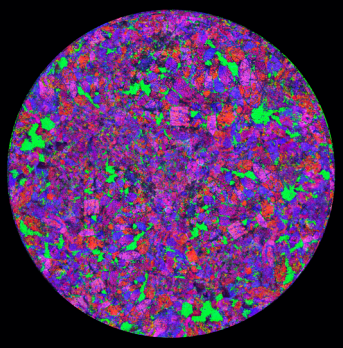
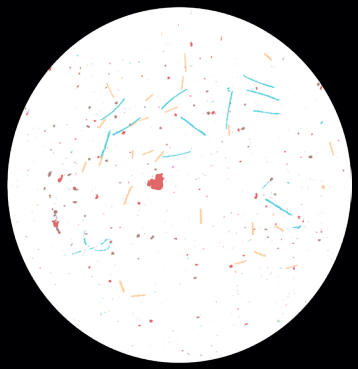


Fig. 5
For each sample, the measurement procedure is shown from left to right for common sample types. From left to right: Sampling, sample measurement, evaluation, and reporting.







TissuePlus™

This workflow offers a complete toolset for high throughput tissue analysis. Dedicated sample holders facilitate transmission or reflection measurements, the workflow ensures a maximum automation and easy operation. **TissuePlus™** includes batch-processing for multiple samples on the same slide and allows interfacing to other analysis methods (e.g. MALDI) in multimodal studies.

TabletPlus™

This workflow provides a convenient platform for routine imaging of pharmaceutical tablets. The sample holders are tailored for a streamlined, reproducible analysis. Use smart software to setup product-specific, standardized workflows based on machine-learning classification algorithms, automatically delivering detailed statistical information on sample composition and API distribution.

ParticlePlus™

This workflow comes with matching sample holders for convenient placement of up to two loaded particle filters plus reference for measurements in transmission or reflection. The software bases its quick and easy particle identification on robust machine learning models or correlation methods, depending on the application. Particle statistics and comprehensive reports are automatically created.

Trust the experts:

» "We have been working in the field of tissue imaging and spectral pathology for over 20 years. One of the key barriers to clinical adoption is the long measurement times for full hyperspectral imaging of large areas of tissue. A sample set consisting of nearly 1500 prostate tissue cores, that took 3 months to measure on our old instrument, was measured in just two days on the Bruker ILIM system. This is a game changer!"

Peter Gardner, Ph.D., Professor of Analytical and Biomedical Spectroscopy, University of Manchester

» "Bruker's ILIM's speed of analysis is what we have been waiting for to use IR imaging to guide our multimodal tissue analysis workflows. This opens up new avenues in many research projects."

Carsten Hopf, Ph.D., Director, Center for Mass Spectrometry and Optical Spectroscopy, Chair, Institute of Instrumental Analytics and Bioanalytics, Professor of Bioanalytics and Drug Discovery, Mannheim University of Applied Sciences

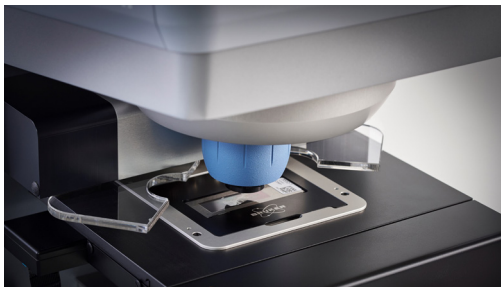
» "By leveraging this (ILIM's) advanced measurement approach to analyze battery electrodes at a fundamental level, we have accelerated progress in green energy technology."

Dragonfly Energy, Lithium battery technology company, United States of America.

dragonfly® ENERGY

Pioneers Need the Best Support

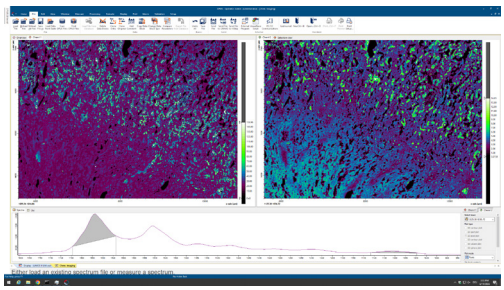
Infrared laser imaging is a new and exciting technology with incredible potential. We help users unlock this potential by outstanding service and application support. Keep in touch with our engineers and scientists to make the most of your application.



Our hardware? Simply mighty.

We follow a simple philosophy in our hardware design. We believe that high-quality automation is the best way to achieve maximum robustness, reliability, and ease-of-use.

Our instruments feature extensive system intelligence and self-tests to assure highest performance and ease of operation. Together with customer-centric service solutions, your system never lets you down.



Our software? Mighty simply.

OPUS can be perfectly tailored to your needs and features classical as well as AI-based evaluation tools to speed up analysis of any sample you might encounter.

Our progress never stops. That's why we decided to keep our workflows dynamic. With our modern, subscription-based licensing model, users can benefit from improvements and extensions and are always up to date.

Laser class 1 product.
For Research Use Only. Not for Diagnostic Procedures.

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Bruker Optics is ISO 9001, ISO 13485, ISO 14001 and ISO 50001 certified.

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