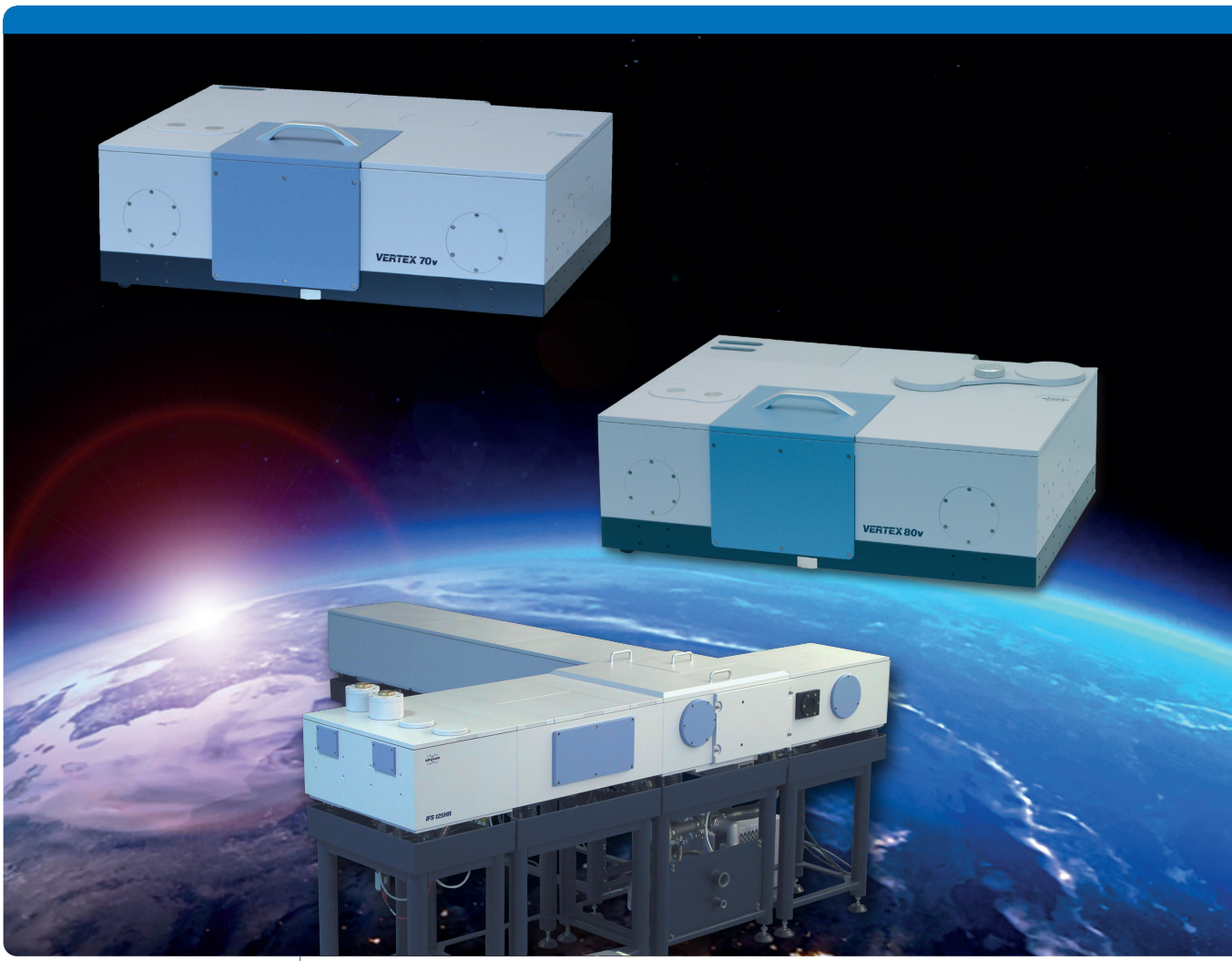


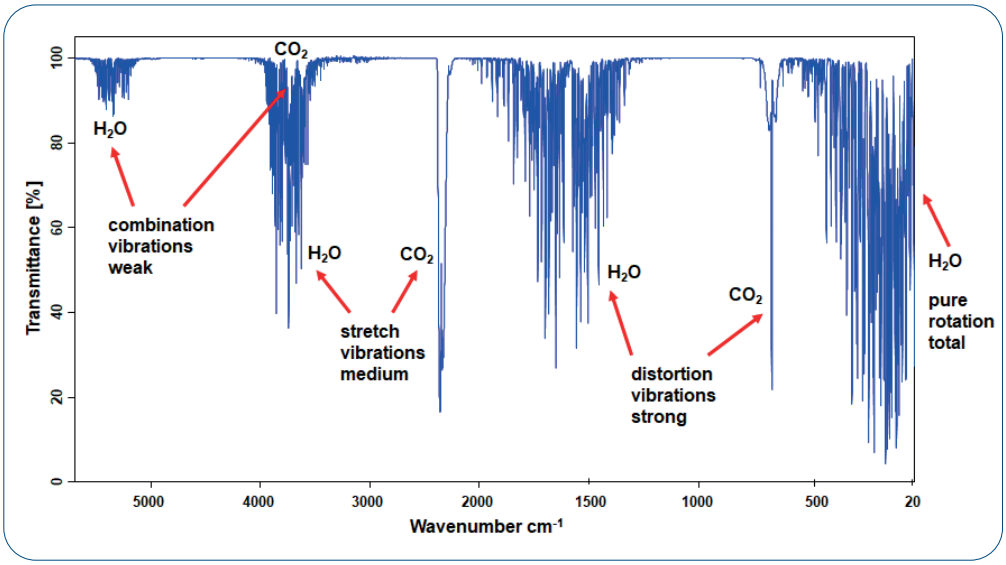
FTIR Spectroscopy under Vacuum

stand out from surrounding

Innovation with Integrity

FTIR

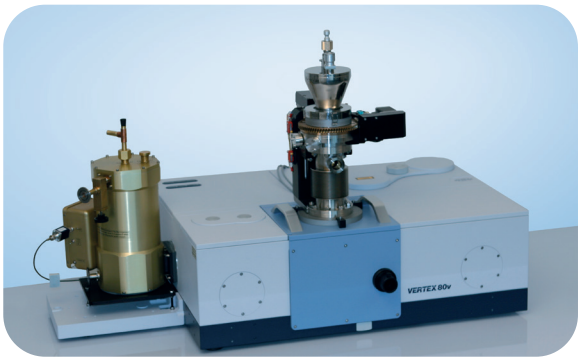
Vacuum spectrometers are the culmination of Bruker's expertise in FTIR technology over more than 40 years. The VERTEX series vacuum spectrometers VERTEX 70v and VERTEX 80v provide peak performance for demanding research applications requiring peak sensitivity or time resolution, high spectral resolution, multiple spectral range and utmost flexibility. For atmospheric research the IFS 125HR vacuum spectrometer provides unique ultra high resolution capabilities.



Atmospheric absorption in the MIR and FIR/THz region.

The different vibration and rotation modes of water vapour and carbon dioxide in the lab air exhibit intense absorption bands in the whole MIR (mid infrared) and FIR/THz (far infrared / terahertz) spectral range (see figure). Especially in the FIR region, the pure rotational modes of atmospheric water vapor can even lead to total absorption of the IR light. The most common method of reducing these effects is to purge the optics bench as can be done for the VERTEX 80 and INVENIO series FTIR spectrometers. However, even "dry" purge air always contains residual moisture and CO_2, causing significant atmospheric artifacts which effectively limit sensitivity. In particular for demanding R&D measurements in mid and far infrared it can therefore be difficult or even impossible to obtain adequate results. Only vacuum spectrometers can completely overcome these inherent limitations.

A long list of applications strongly benefits from or even requires vacuum optics, such as FIR spectroscopy, time-resolved step-scan experiments, photoluminescence measurement in MIR region, FTIR in ultra-high vacuum apparatus, low temperature spectroscopy, semiconductor/material science, matrix isolation spectroscopy, solid state physics, meta materials development, ultra-thin layer characterization, spectroelectrochemistry, detector and source characterization, synchrotron adaptions etc.



The Strong Benefits of Vacuum Optics

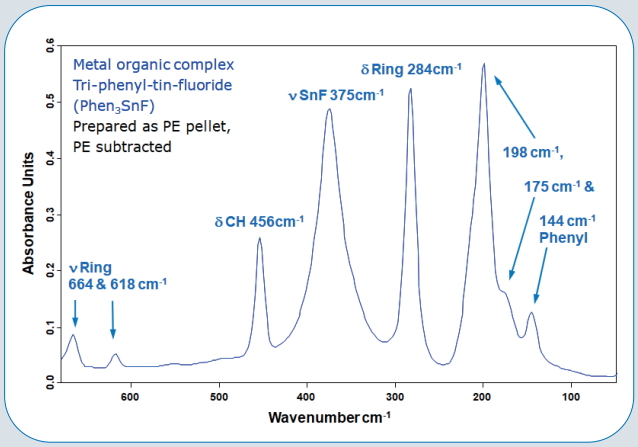
Vacuum Advantages for FTIR Spectroscopy

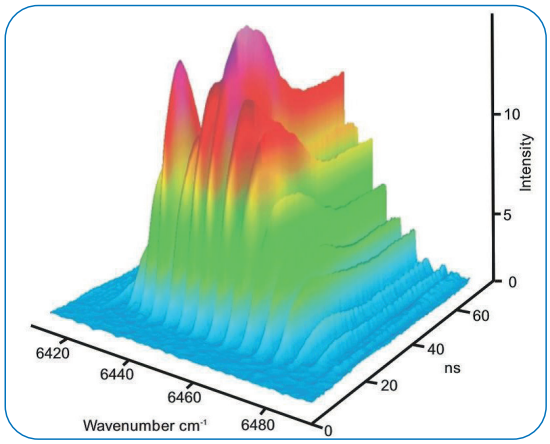
- No atmospheric absorbance masking weak spectral features or interfering with high spectral resolution features
- No temperature fluctuation influenced by environment
- No problems caused by fluctuations of the dry air purge supply
- Cast aluminum housing of the optics bench provides highest stability and reproducibility
- Utmost sensitivity and best effective step-scan performance

Applications

FIR Spectroscopy

Vacuum optics eliminate the strong atmospheric absorption in the FIR/THz region and strongly enhance signal throughput. Already RT FIR DTGS detector and standard globar source provide superior sensitivity down to 50 cm^{-1} (see example measured with VERTEX 80v, multilayer beam splitter and 8 cm^{-1} spectral resolution, using 1 single scan lasting < 2 seconds). With water-cooled Hg arc source this range is extended down to 10 cm^{-1} and even 5 cm^{-1} can be reached with VERTEX 80v and IFS 125HR applying liquid He cooled bolometer and optimized FIR BMS.



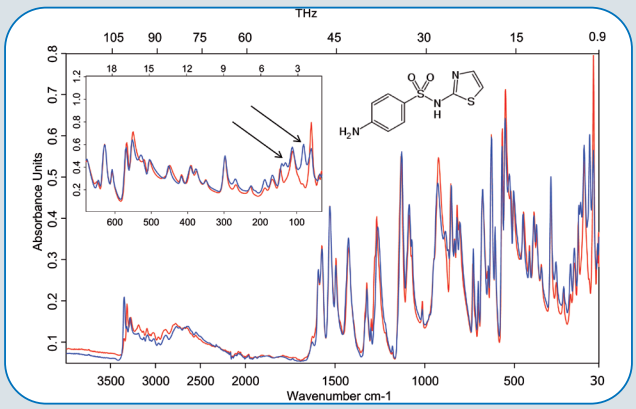


Time-Resolved Step-Scan Experiments

For time-resolved step-scan[1] measurements of repeatable kinetics, the refractive index inside of vacuum instruments is perfectly stable, resulting in a unique stepping accuracy superior to any purged FTIR spectrometer. VERTEX 80v is the gold standard for step-scan experiments, since its UltraScan interferometer enables an effective mirror position accuracy < 1 nm and an unmatched stepping rate up to 50 steps per second. The example shows the time resolved emission spectrum of a laser pulse with temporal resolution in the low ns range and excellent spectral resolution.

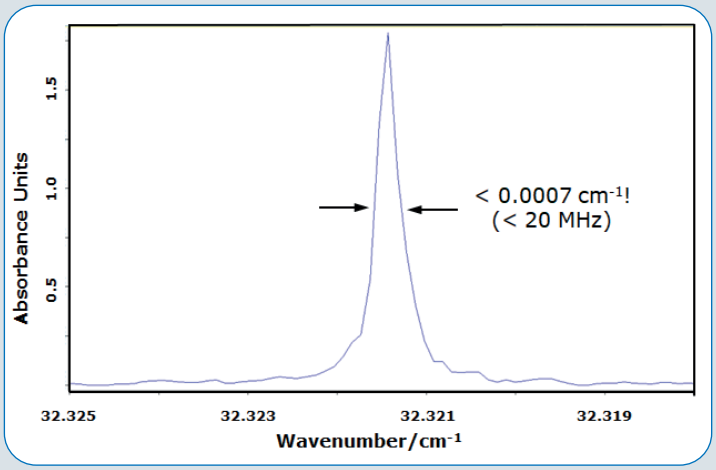
Bruker FM - MIR and FIR in One Go

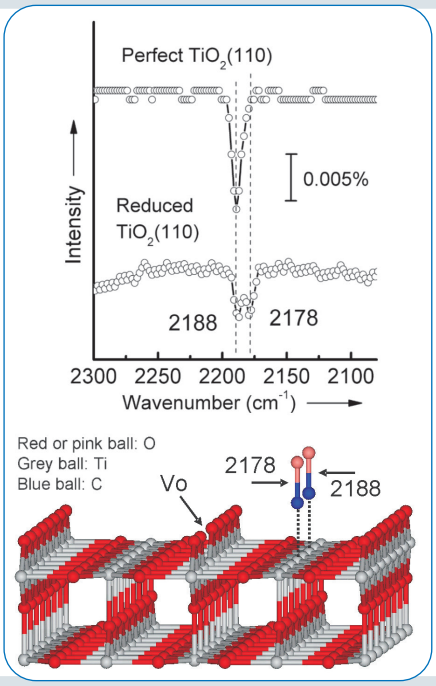
For VERTEX 70v the unique Bruker FM technology gives access to the complete MIR and FIR range in one single measurement without exchange of optical components[2]. Bruker FM simplifies your daily work, is a time saver and provides valuable additional FIR information for numerous applications, e.g. inorganic and organometallic chemistry, semiconductor R&D, polymer studies, polymorphism or matrix isolation spectroscopy. In the example the differentiation of two antibiotic sulfathiazole polymorphs was only possible by different FIR bands in the region of 100 cm^{-1}. Without FM technology, two separate measurements, exchange of at least two components and double working time would be necessary.



VerTera THz Extension for VERTEX 80v

The unique verTera THz option extends the VERTEX 80v to the world's first and only combined FTIR/continuous wave THz spectrometer. Spectral range down to 3 cm^{-1} (0.09THz) and resolution < 0.0007 cm^{-1} (20 MHz) without the need of cryogenically cooled components [3] provide amazing possibilities, e.g. for: polymer research, gas spectroscopy, polymorphism (pharma, drugs etc.) or solid state & semiconductor physics. The example shows the ultra-high resolved SO_2 gas spectrum at a pressure of about 2mbar.



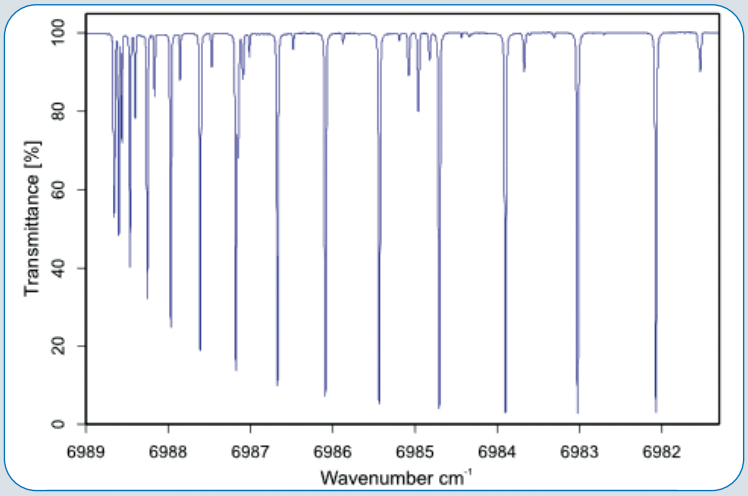


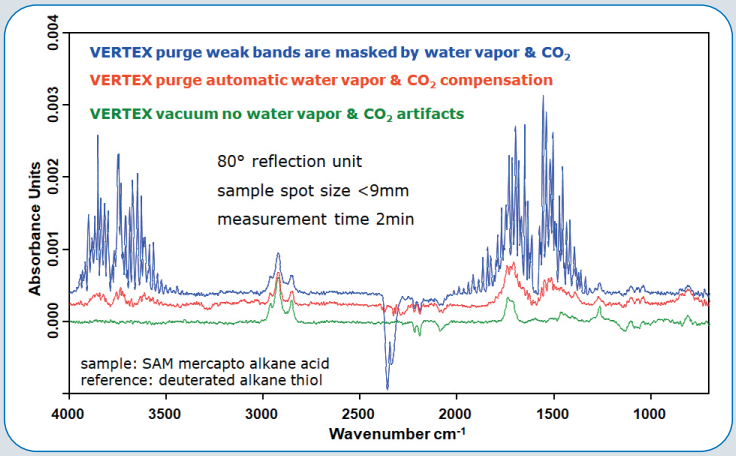
Ultra-High Vacuum (UHV) Adaption

Bruker is highly experienced in specialized UHV-FTIR solutions. We have successfully installed optical adaptions for customized UHV sample chambers of different dimensions and designs, so that e.g. transmission, specular reflection, (PM) IRRAS can be realized for almost all sample forms under UHV. The example spectra, recorded in a customer UHV chamber at the Institute of Functional Interfaces (IFG) at Karlsruhe Institute of Technology (KIT, Germany), prove the outstanding sensitivity of UHV-FTIR. Absorption bands of a sub monomolecular layer with intensity of 10^{-5} absorbance units (au) have been detected in high quality[4].

Highest Resolution Achievable with FTIR

While the VERTEX 80v is the world's highest resolving benchtop FTIR spectrometer (< 0.06 cm^{-1}), the IFS125 HR even achieves < 0.001 cm^{-1}. High resolution FTIR spectroscopy is ideal for gas spectroscopy, such as the investigation of stratospheric gas concentrations with the IFS125HR. The example shows overtone CO_2 absorption bands in NIR region. Many other applications, e.g. low temperature solid state research or the characterization of laser sources, benefit as well from the unmatched resolution and sensitivity of Bruker vacuum spectrometers.



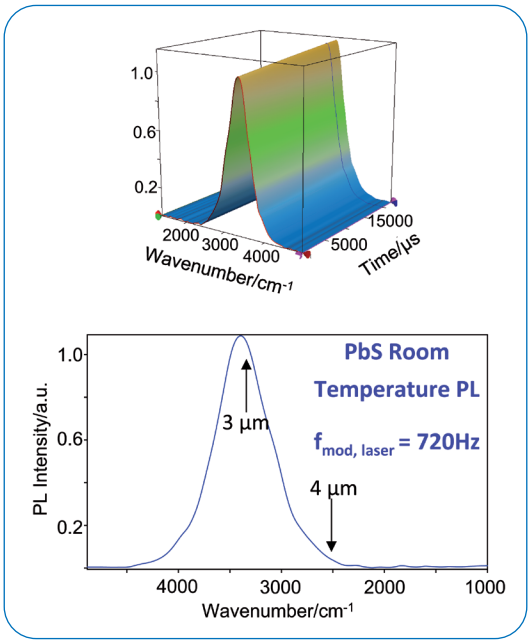


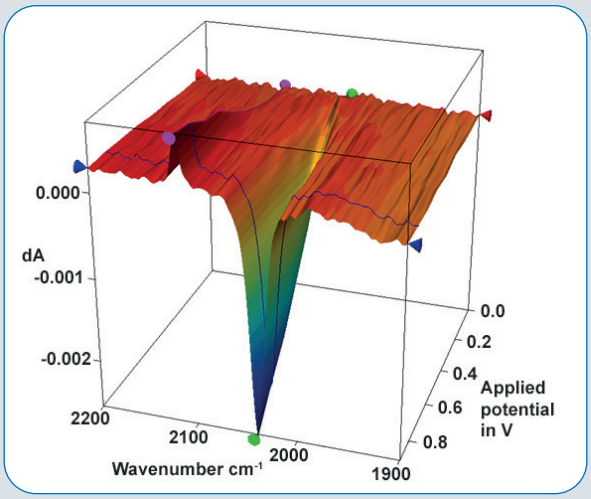
Characterization of Ultra-Thin Layers

Ultra-thin layers measured via IRRAS require highest instrument sensitivity, since their weak absorption bands are e.g. in the order of 10^{-3} au for monomolecular layers or even 10^{-5} au on dielectric substrates. The example of a self-assembled monolayer on Au substrate emphasizes the strong vacuum benefit: for measurement in a purged spectrometer and subsequent data manipulation by atmospheric compensation, remaining artifacts limit sensitivity. Only the result measured in a vacuum spectrometer provides maximum information and sensitivity.

Mid IR Photoluminescence (PL)

PL is an important analysis method in semiconductor sciences and optoelectronics. While NIR PL measurements are rather straightforward, two additional challenges appear in the MIR region: first, the stronger atmospheric disturbances cannot be compensated since PL means single channel spectroscopy. Second, thermal background radiation masks the weak MIR PL signals. Both problems can be overcome by VERTEX vacuum configurations applying amplitude modulated step-scan. The example shows the room temperature MIR PL of PbS[5], measured with VERTEX 80v, vacuum PL module and modulated 1064 nm excitation.





Spectroelectrochemistry Combined with Rapid Scan

Combination of FTIR and electrochemistry offers insight in molecular changes and reaction processes of the studied molecules in conjunction with the electrochemical response. A Bruker reflection unit for electrochemical cells allows to monitor surface changes of the working electrode and to investigate electrolytes via ATR. While the entire IR beam remains under vacuum, the user has full access to the electrochemical cell from top. The absence of atmospheric disturbances results in significantly higher sensitivity, especially in the finger print region. The example 3D plot shows the oxidation of a ferricyanide solution for potentials from 0 V to 0.8 V.

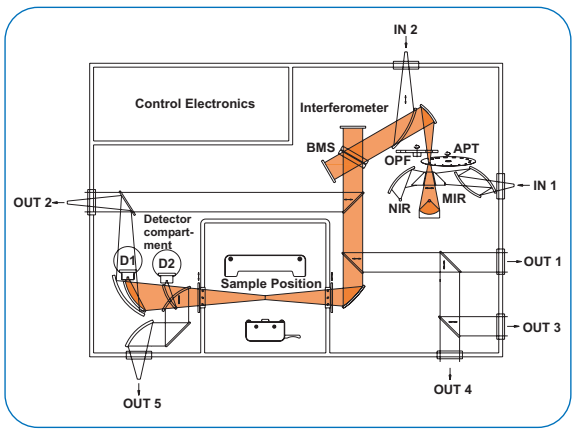
Vacuum Instruments and Features

VERTEX 80v

The VERTEX 80v can cover an extremely broad spectral range from 5 cm^{-1} in FIR/THz region, through the mid IR, near IR, visible and ultraviolet ranges all the way up to 50,000 cm^{-1}. With UltraScan™ interferometer, TrueAlignment™ and optional 4-pos. beam splitter changer, spectral ranges can be easily handled. For advanced applications a resolution better than 0.06 cm^{-1} is achievable even in the VIS range, corresponding to a resolving power > 300,000:1. Completed by highest flexibility and sensitivity, as well as unrivaled time resolution performance, VERTEX 80v represents the gold standard of FTIR spectroscopy.

VERTEX 70v

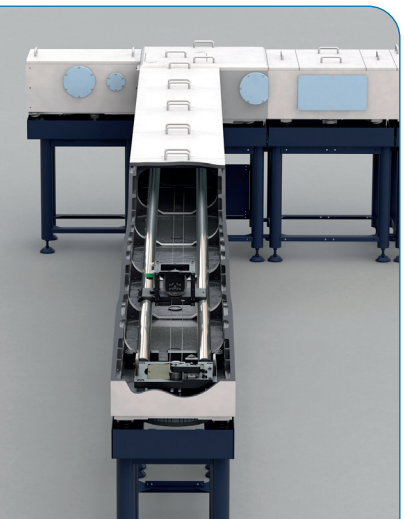
The heart of the VERTEX 70v is Bruker's permanently aligned wear-free RockSolid™ interferometer utilizing cube-corner mirrors. VERTEX 70v can optionally cover the spectral range from 10 cm^{-1} in FIR to 28,000 cm^{-1} in UV. The most used spectral range from 6,000 cm^{-1} to 50 cm^{-1} is even accessible in a single step measurement with the standard IR source and the unique BRUKER FM far and mid IR technology.

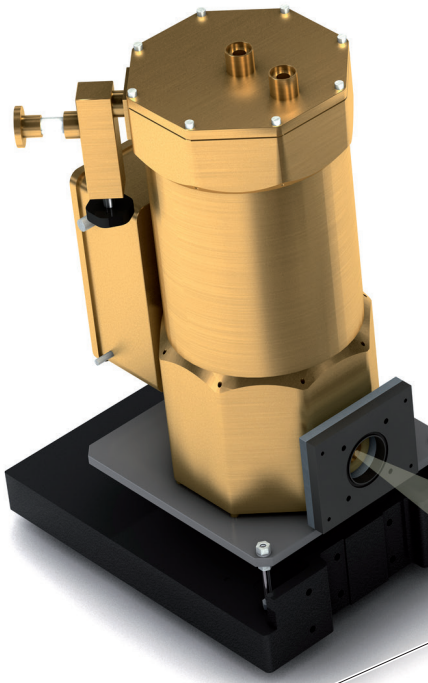


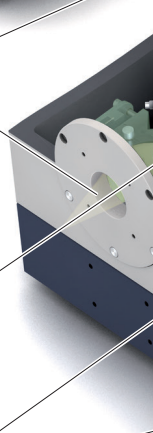
VERTEX 70v beam path.

IFS 125HR

IFS 125HR sets the benchmark for achieving highest spectral resolution in FTIR technique better than 0.001 cm^{-1}. Over a wide spectral range from 5 cm^{-1} in the FIR/THz spectral range up to 50,000 cm^{-1} in the UV region IFS 125HR provides the best resolution with outstanding measurement sensitivity. Vacuum optics bench, advanced electronics, double beam sample compartment, up to 4 internal and 2 external automated detectors, multiple internal and external source options and modified Michelson interferometer ensure beam integrity over the extremely long optical path difference of up to 11 meters. All these features make the IFS 125HR indispensable for atmospheric research[6] and well suited for e.g. high-demanding physical chemistry and solid state physics applications.







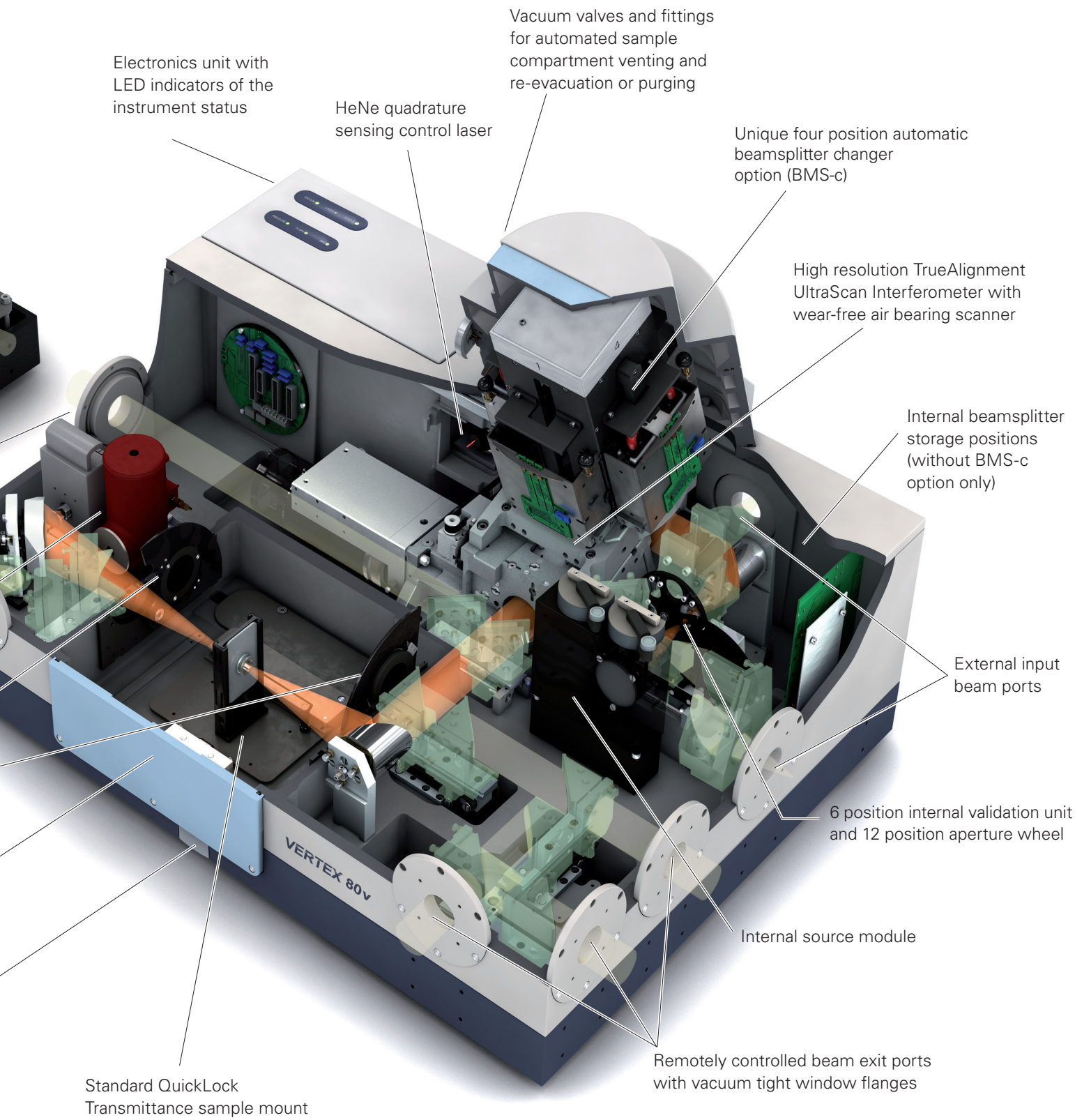
Exit ports or possible positions for externally vacuum tight adapted detectors such as liquid He cooled bolometers for the FIR/THz ranges

Detector compartment with selectable DigiTect positions for room temperature and LN_2 cooled detectors

Optional automatic sample compartment shutters enable quick sample exchange

Removable and vacuum tight sample compartment front cover

External QuickLock accessory release button for easy exchange of internal measurement accessories


Electronics unit with LED indicators of the instrument status
HeNe quadrature sensing control laser
Vacuum valves and fittings for automated sample compartment venting and re-evacuation or purging
Unique four position automatic beamsplitter changer option (BMS-c)
High resolution TrueAlignment UltraScan Interferometer with wear-free air bearing scanner
Internal beamsplitter storage positions (without BMS-c option only)
External input beam ports
6 position internal validation unit and 12 position aperture wheel
Internal source module
Remotely controlled beam exit ports with vacuum tight window flanges
Standard QuickLock Transmittance sample mount
VERTEX 80v

Specifications

	VERTEX 70v	VERTEX 80v	IFS 125HR
Spectral Range	MIR, NIR, FIR/THz, UV/VIS 10 cm^{-1} to 28,000 cm^{-1}	MIR, NIR, FIR/THz, UV/VIS 5 cm^{-1} to 50,000 cm^{-1}	MIR, NIR, FIR/THz, UV/VIS 50,000 cm^{-1} to 5 cm^{-1}
Spectral Resolution	Better than 0.4 cm^{-1}, optional 0.16 cm^{-1}	Better than 0.2 cm^{-1}, optional better than 0.06 cm^{-1}	Better than 0.001 cm^{-1} Resolving power > 10^6
Input Ports	Up to 2	Up to 2	Up to 3
Output Ports	Up to 5	Up to 5	Up to 4
Interferometer	RockSolid™	UltraScan™	Modified Michelson interferometer
Rapid Scan	>70 spectra/sec at 16 cm^{-1} spectral resolution	>110 spectra/sec at 16 cm^{-1} spectral resolution	High-resolution FTIR spectrometer acknowledged by TCCON
Step Scan & Slow Scan	Temporal resolution 6 µs/4 ns Slow Scan: 100Hz (0.0063 cm/s) Phase modulation	Temporal resolution 6 µs/4 ns Slow Scan: 10Hz (0.00063 cm/s) Phase modulation	

Application and Service Support

Bruker is staffed by expert scientists and engineers that have an in-depth knowledge of instrumentation and applications. Our product specialists are available to help you with method development either remotely or in your lab. Brukers spectrometers are designed to provide years of dependable trouble-free operation. Should a problem occur, a network of Bruker companies and representatives throughout the world are ready to respond promptly to your needs. Professional installations and a high standard of post-delivery service are commitments Bruker makes to each of its customers. Remote diagnostics in addition to a variety of service contract packages are available for comprehensive support.

[1] Bruker Product Note T16-01/10 Step-Scan TRS experiments
[2] Bruker Product Brochure FM Technology
[3] Bruker Product Flyer for verTera VERTEX 80v cw Terahertz Extension
[4] Bruker Application Note AN M107 FTIR Spectroscopy in Ultrahigh Vacuum: Surface Science Approach for Understanding Reactions on Catalytic Oxide Powders
[5] Bruker Application Note AN M134 Infrared Photoluminescence Spectroscopy
[6] Bruker Application Note AN120 Atmospheric Applications IFS 125HR

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