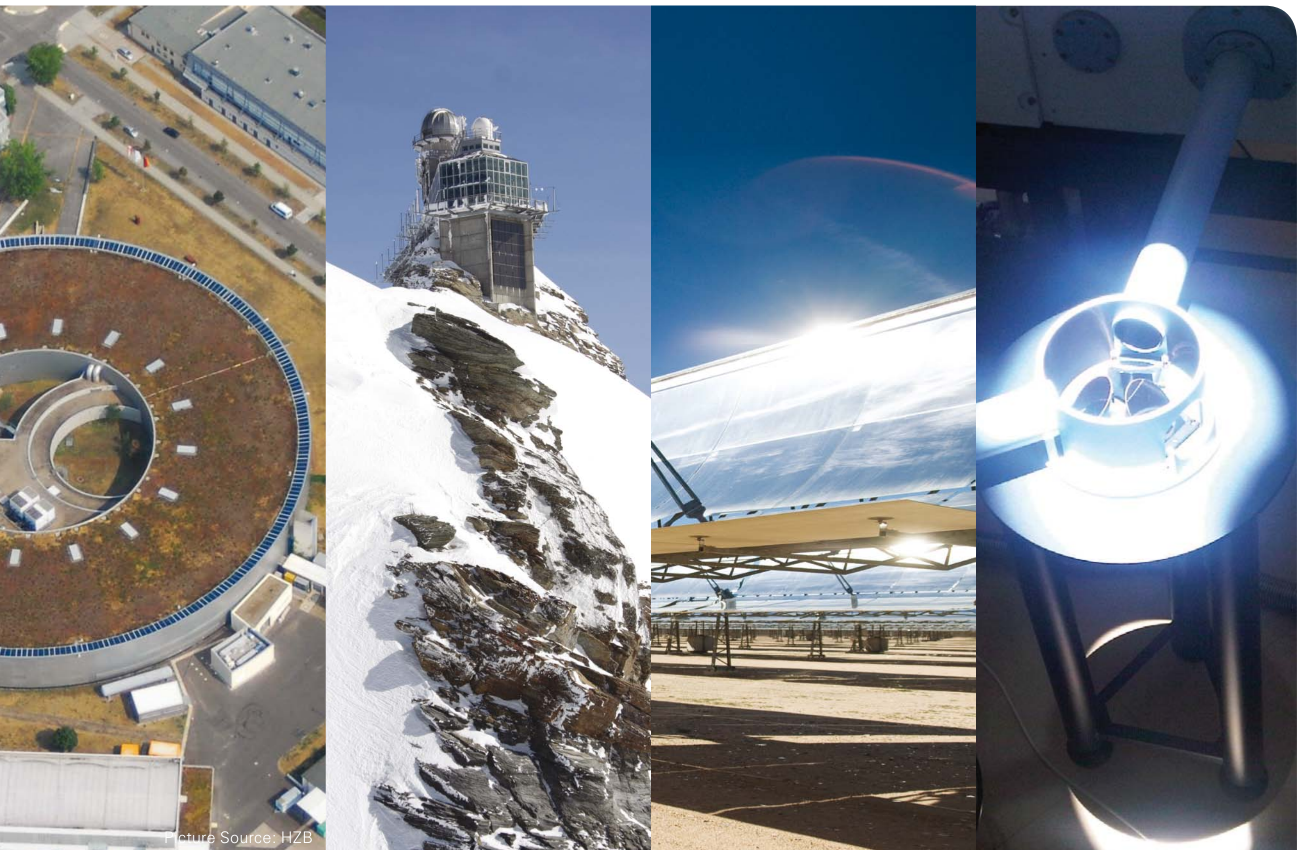
IFS 125HR

- FT-IR Spectrometer for Highest Spectral Resolution

FT-IR

Innovation with Integrity

The Benchmark of Ultra-High Resolution Research FT-IR Spectroscopy



Picture Source: HZB

Three decades ago, Bruker started to set the pace for achieving the highest spectral resolution in FT-IR spectroscopy. The famous IFS 120HR was universally recognized as the winner.

The IFS 125HR is the proud successor of the IFS 120HR offering further spectral resolution enhancement and increased measurement sensitivity over a wide spectral range from 5 cm^{-1} in the far-IR/Terahertz up to 50,000 cm^{-1} in the UV.

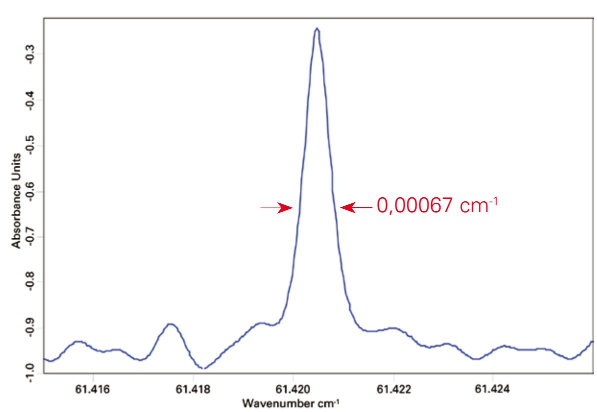
IFS 125HR System Design

The need for High Resolution

Whether you are studying the composition of the stratosphere on top of Germany's highest mountain, the 2,964 meter Zugspitze, or the structure of gaseous molecules in your own research laboratory, you need the highest sensitivity at the highest resolution possible.

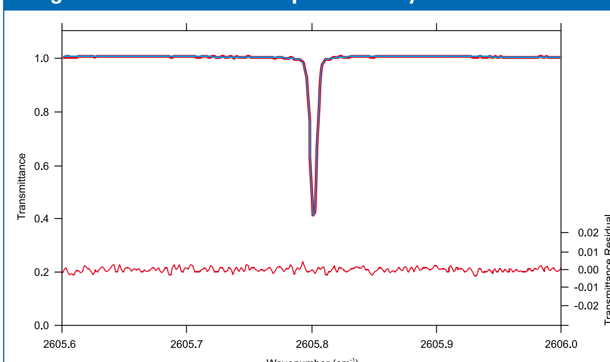
Studies of physical-chemical primary processes require very high spectral resolution to derive the true molecular quantum motion from the absorption spectra.
In addition, high resolution FT-IR spectroscopy is ideal for investigating changes in stratospheric gas concentrations due to its sensitivity and selectivity.

Highest Resolution Line Width



Demonstration of the achievable line width at half height of 0.00067 cm^{-1} using the CO pure rotational absorption in the far IR by using a 20 cm path length gas cell, 50 co-added scans and a liquid He cooled bolometer detector.

High Resolution Line Shape Accuracy



HBr absorption line measured (red) in the MIR spectral range at 0.0035 cm^{-1} resolution, showing the very close agreement with the calculated (blue) line shape. The residual difference spectrum (red bottom) was ca. 15 times enlarged in the transmittance scale.

Superior Instrument Features

- Outstanding resolution across the entire spectral range that demonstrates a resolved line width better than 0.0007 cm^{-1}
- Optical path difference up to 11 m; resolving power of better than 10^6
- Wavenumber precision of 10^{-7} relative (corresponds to the stability of the reference HeNe laser)
- Highest measurement sensitivity and instrument stability from 5 cm^{-1} in the far-IR/THz up to 50,000 cm^{-1} in the UV
- Permanently aligned retro reflector interferometer
- Double-sided interferogram acquisition up to 50cm optical path difference (OPD)
- Vacuum optics bench evacuable to < 0.02 hPa
- Vacuum level in the 10^{-4} hPa range achievable by utilizing a turbo molecular pump
- Modular optics design with two sample channels
- Compact version without sample compartment for emission or solar absorption measurements
- Up to three internal sources and six permanently installed detectors
- Easy and reproducible detector and beamsplitter exchange
- Parallel 2-channel 24-bit data acquisition

Advanced Electronics Technology

The IFS 125HR is a fully digital FT-IR spectrometer. Its modular design provides the highest flexibility and at the same time the highest instrument performance. The data acquisition is based on free running delta-sigma ADCs with true 24-bit dynamic range, which are integrated into the detector preamplifier electronics. The advanced DigiTect™ technology prevents external signal disturbance and guarantees the highest signal-to-noise ratio.

Dual channel data acquisition is an integral part of the new electronics and can easily be set up through software control. AC- & DC-coupled signals of the same detector can be achieved with no special hardware required. Utilizing two detectors and a dichroic beamsplitter or a sandwich detector (e.g. InSb/MCT), parallel data acquisition in two different spectral ranges is possible.

The IFS 125HR Optics Bench

Double Beam Sample Compartment

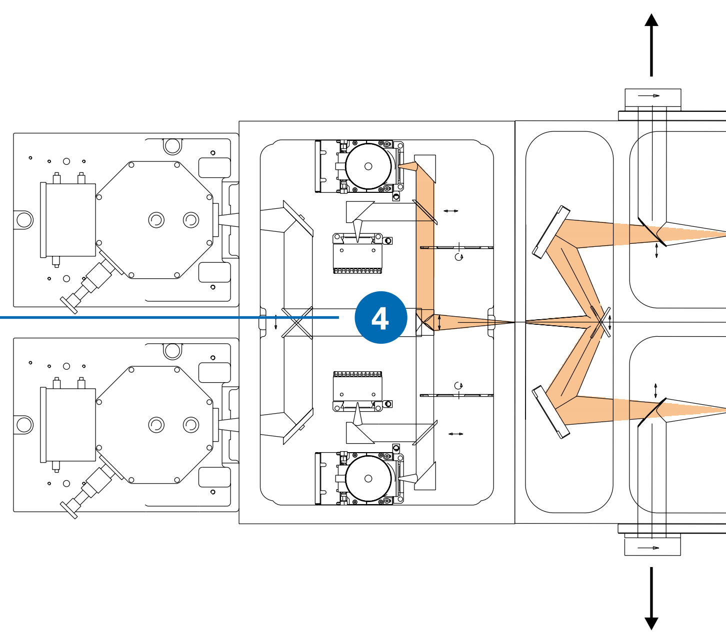
There are two large chambers with focused beams which accommodate a wide variety of sampling accessories including long path gas cells and cryostats. To enhance flexibility, each sample chamber can be equipped with an additional exit port. Flaps isolate the sample compartment to preserve vacuum in the rest of the optics during sample change or accessory installation. At the sample position, a one-to-one image of the input aperture is provided.

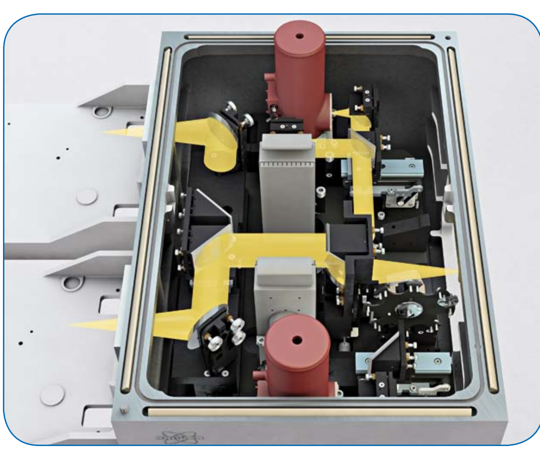
The Detector Compartment

The detector compartment can house up to four internal and two external detectors. All six detector positions are accessible by beams from either sample chamber and detector selection is under computer control. Up to four liquid nitrogen cooled or room temperature detectors with Bruker's DigiTect™ technology can be mounted internally. The external positions provide room for large liquid helium cooled detectors such as far-IR bolometers or special high sensitivity mid-IR detectors such as Si:B or Ge:Au.

For emission studies, a separate detector chamber may be mounted at the collimated beam exit port of the interferometer to maximize energy throughput in the NIR/VIS/UV range. The system includes a closed-loop coolant system for the sources and a vacuum pump which evacuates the bench to a level of <0.02 hPa. Alternatively, the entire optics bench may be purged with dry, clean air or nitrogen. A much lower vacuum level in the 10^{-4} hPa range can be achieved by connecting a turbo molecular pump to an optional large flange below the scanner chamber.

9-Chamber scanner arm with high precision metal tubes

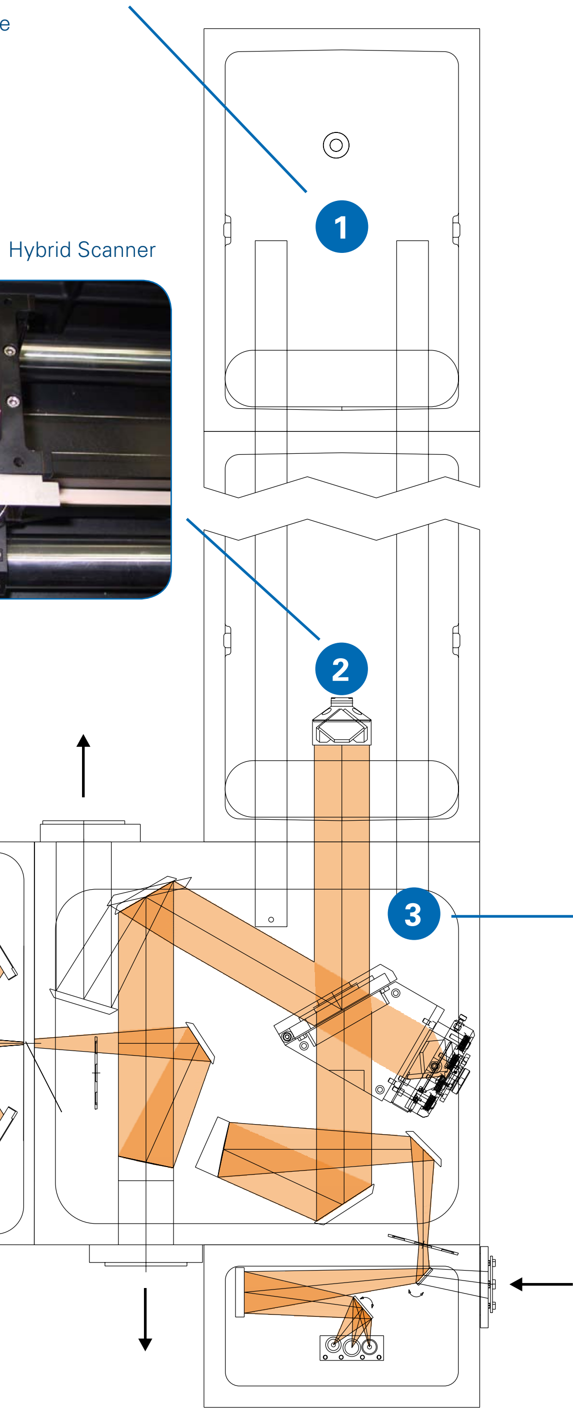




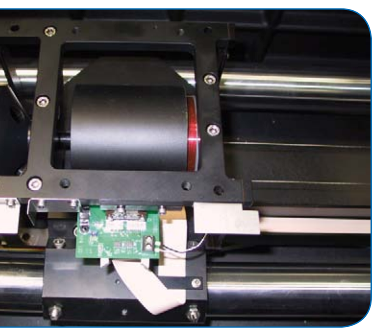
Detector Chamber

Scanner Drive

1. Scanner drive, gear, steel pulling wire and the two supporting metal tubes of the interferometer scanner
2. Hybrid retro reflector interferometer scanner showing the electromagnetic fine tuning drive and scanning mirror
3. View into the interferometer compartment showing beamsplitter, optics and scanning cube corner mirror
4. View into the detector compartment showing the opto-mechanical DigiTect^{TM} detector adaptations together with the computer controlled moveable mirrors for automatic selection of up to 4 internal room or liquid N_2 temperature detectors and for up to 2 external liquid He cooled detectors



Hybrid Scanner

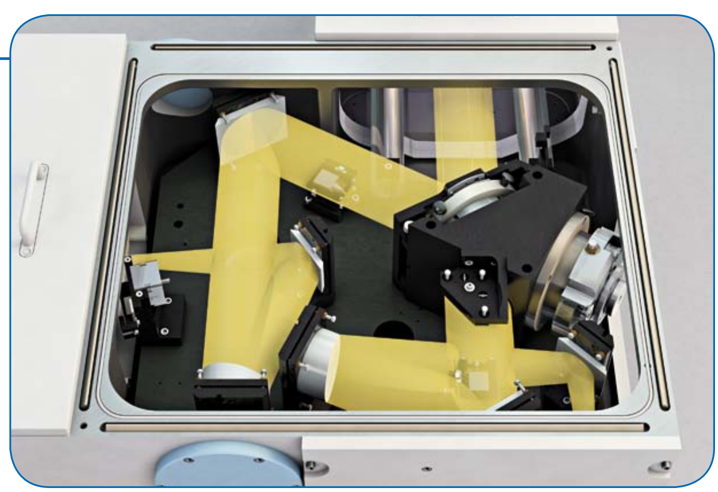


Source Options

The source compartment of the IFS 125HR can accommodate three water-cooled, computer-selected sources. In addition, there is a computer-selectable port for an ultra-violet source or external emission experiments. The source beam exits at a focus to the interferometer compartment. An optional large source chamber provides more flexibility with up to 3 external inputs. Solar light for atmospheric studies is typically fed into the parallel input port of this chamber.

The Interferometer

The permanently aligned interferometer has a 30° angle-of-incidence. The narrow angle-of-incidence makes more effective use of the beamsplitter in addition to reducing beam polarization effects. The beam is split to the fixed and moving cube-corner retro reflectors of the modified Michelson interferometer. The moving mirror is translated on a hybrid bearing whose design ensures beam integrity over the extremely long optical path difference, which can be up to 11 meters.



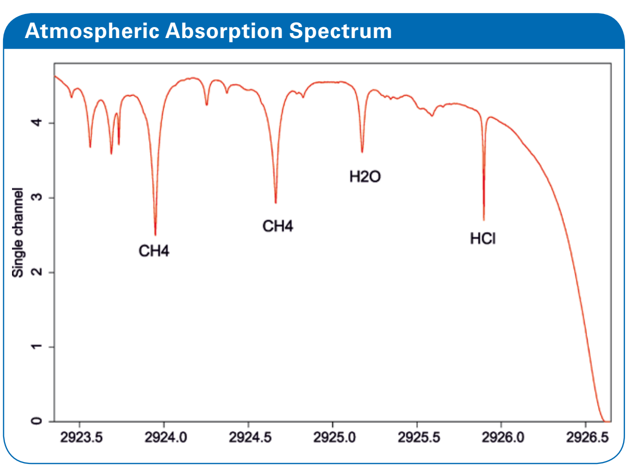
Interferometer

IFS 125HR Atmospheric Pollutant Analysis

Using the Sun as the IR source

Atmospheric CO_2 has rapidly increased since the industrial revolution. High resolution FT-IR spectroscopy is ideal for investigating changes in stratospheric gas concentrations due to its sensitivity and selectivity. The sun serves as the infrared source and the composite optical density due to all absorbers along the optical path to the spectrometer is measured at a given wavelength.

Compact IFS 125HR (w/o sample compartment) in a 20´ freight container, as used for atmospheric measurements. Courtesy of Dr. D. Feist, MPI for Biogeochemistry, Jena



Typical solar absorption spectrum, showing some atmospheric constituents. The special line shape - with a broad base and a narrow tip - allows retrieving information about the vertical distribution of the species.

Areas of Applications

Atmospheric Research

- Stratospheric trace gas analysis
- Absolute line strength and band shape of atmospheric gases
- Radiative transfer through the atmosphere

Physical Chemistry

- Ro-vibrational spectroscopy
- Determination of molecular dynamics
- Structural analysis of small molecules
- Spectroscopy of molecular crystals at low temperatures
- Matrix isolation studies

Solid State Physics

- Single crystal impurities at low temperature
- Magneto optical splitting
- Terahertz (THz) high resolution

Careful analysis of the lineshape even allows a concentration profile versus altitude to be obtained. Like the famous Jungfraujoch Observatory in Switzerland, many high altitude research centers around the globe house high resolution Bruker FT-IR spectrometers, for field emission measurements since the 1980s. Besides additional instrument features, the very high accuracy of the instrument line shape and the outstanding wavelength precision are the major reasons that new reference spectra of the HITRAN and IUPAC data collection are measured using the IFS 125HR.

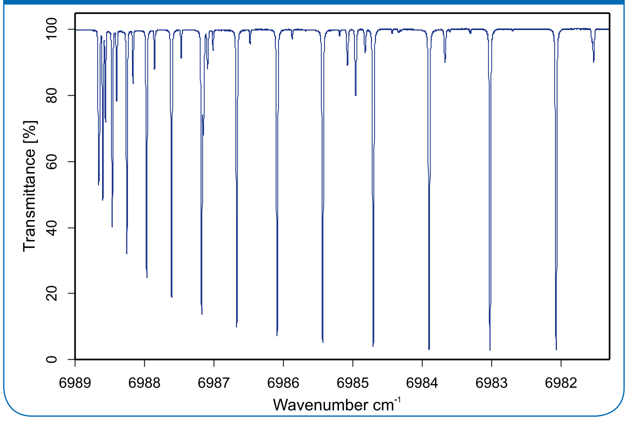
Research Applications

IFS 125HR's wide range of internal and external accessories provides any solutions needed for the most demanding research studies. Dedicated long path gas cells and low temperature cryostats provide unlimited research possibilities. The multiple input ports allow dedicated emission applications and coupling with external coherent lasers or very brilliant radiation sources for example from electron synchrotrons or free electron lasers. High magnetic field cryostats, ultra high vacuum (UHV) chambers for in-situ chemical vapour deposition (CVD) or molecular beam epitaxy (MBE) studies, and reaction gas cells can be connected to the instrument utilizing the multiple exit beams.

Multipath Gas Cell

IFS 125HR Research Applications

NIR High Resolution Gas Phase



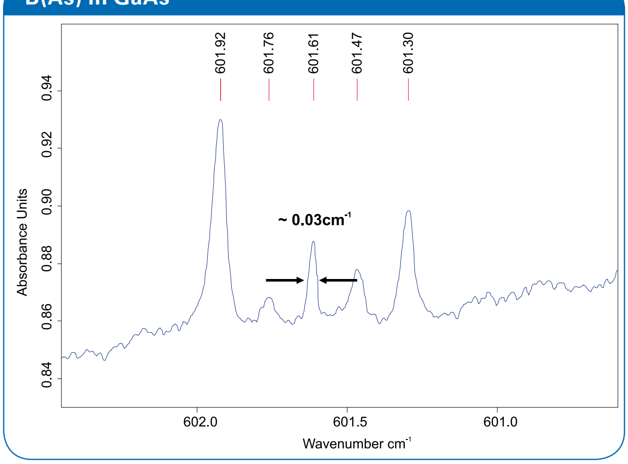
Overtone CO_2 absorption band head measured with 20 m path length, 18 hPa pressure, at 0.01 cm^{-1} spectral resolution in the near IR spectral range using a LN_2 cooled InSb detector, CaF_2 beam splitter and tungsten source.

Solid State Cryogenic Analysis

Highest resolution data are not only interesting for gas phase samples, but also for single crystalline materials at low temperature. By the adaptation of liquid He/N_2 or cryogenic liquid free, low vibration pulse tube cryostats, sample temperatures of less than 10 K are achievable. Common applications are the quality control of semiconductor material like GaAs.

In addition, the external adaptation of cryo-magnetostat systems allow low temperature measurements in the mid and far IR spectral ranges at high magnetic fields up to 11 Tesla.

B(As) in GaAs

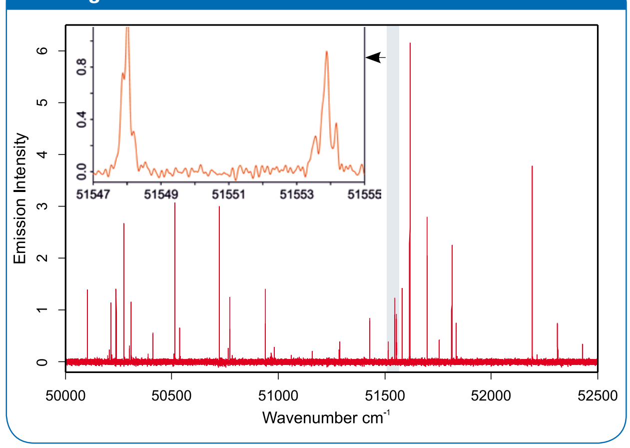


Low temperature measurement of a semi-isolating GaAs single crystal sample at <10 K and 0.01 cm^{-1} spectral resolution showing the Boron impurity at the As site. A wide-band liquid N_2 cooled MCT and 350 scans have been used for data aquisition.

Emission Measurements

Even in the visible and ultraviolet (UV) short wavelength spectral ranges, the Fourier transform advantages of wavelength precision and high resolution are present. Therefore Bruker has designed the IFS 125HR for upgrade into this interesting spectral range, where electronic transitions can be studied which are not accessible in the IR. Data compatibility and upgradability make the IFS 125HR an ideal measurement tool for the short wavelength range as well.

UV High Resolution Emission



Emission spectrum from a Pt hollow cathode lamp measured at a spectral resolution of 0.11 cm^{-1} using a solar blind Photo Multiplier Tube (PMT) detector and 2,500 scans.

Connection to e-Synchrotron Source

New high resolution application possibilities are feasible by the use of synchrotron IR-radiation. In particular, due to its high brilliance and its pulsed structure, fast photoreaction kinetics might be applicable in pump-and-probe experiments, even at high resolution.

Canadian Light Source installation site with the IFS 125HR optics bench and the Ultra High Vacuum (UHV) tubes guiding the IR synchrotron radiation to the spectrometer input port.

• Optical Components & Accessories

	Spectral ranges			
	FIR/THz **5 cm^{-1} - 650 cm^{-1}** **(2 mm - 15 µm)**	**Mid IR** **500 cm^{-1} - 5,000 cm^{-1}** **(20 µm - 2 µm)**	**Near IR** **4,000 cm^{-1} - 12,500 cm^{-1}** **(2.5 µm - 800 nm)**	**Visible/UV** **12,500 cm^{-1} - 50,000 cm^{-1}** **(800 nm - 200 nm)**
Achievable Resolution	<0.0007 cm^{-1}	<0.001 - 0.004 cm^{-1}	<0.004 - 0.012 cm^{-1}	<0.012 - 0.05 cm^{-1}
Sources	Water cooled Hg-Arc and Globar	Water cooled Globar and Tungsten	Water cooled Tungsten	Water cooled Tungsten and air cooled Xe lamp
Beam-splitters	Multilayer and Mylar™ foils of different thicknesses	MIR/KBr	NIR/CaF_2	VIS/Quartz and UV/Quartz
Detectors	RT DTGS/PE, LHe cooled bolometer, Si:B photo diode	Broad, medium and narrow band LN_2 cooled MCT and InSb (with and w/o cold filter), sand-wich InSb/MCT	RT InGaAs, LN_2 cooled InSb (with and w/o cold filter)	Si-diode, GaP-diode, Photo Multiplier (PM) tube
Window Materials	Si, Ge, PE, TPX, CsI, KBr, KRS-5	Si, Ge, ZnSe, CsI, KBr, KRS-5, CaF_2, Sapphire, Infrasil Quartz	Si, ZnSe, KBr, KRS-5, CaF2, Sapphire, Infrasil Quartz	CaF_2, Sapphire, Infrasil Quartz, UV/Quartz
Accessories	Internal direct path and long path gas cells, LHe and LN_2 cryostats, specular reflectance units, external Cryo-Magnetostats, external single and multi reflec-tion long path gas cells, external input ports	Internal direct path and long path gas cells, LHe and LN_2 cryostats, specular reflectance units, external Cryo-Magnetostats, external single and multi reflec-tion long path gas cells, external input ports	Internal direct path and long path gas cells, LHe and LN_2 cryostats, specular reflec-tance units, external single and multi reflection long path gas cells, external input ports	Internal direct path and long path gas cells,LHe and LN_2 cryostats, specular reflec-tance units, external single and multi reflection long path gas cells, external input ports

For more details regarding the IFS 125HR instrument specifications, its optical components and the available accessories please contact your local Bruker Optics office.

Application Support

Whether it is going to be on a mountain top or below sea level, we realize that the IFS 125HR requires attention to detail, when it comes to installation and support. Bruker Optics 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.

Service Support

Bruker Optics 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 Optics makes to each of its customers. Remote diagnostics in addition to a variety of service contract packages are available for comprehensive support.

Bruker Optics
is ISO 9001 certified.

Laser class 2

Technologies used are protected by one or more of the following patents:
US 7034944; US 5923422; DE 19704598

www.bruker.com/optics

Bruker Optics Inc.

Billerica, MA · USA
Phone +1 (978) 439-9899
Fax +1 (978) 663-9177
info@brukeroptics.com

Bruker Optik GmbH

Ettlingen · Germany
Phone +49 (7243) 504-2000
Fax +49 (7243) 504-2050
info@brukeroptics.de

Bruker Hong Kong Ltd.

Hong Kong
Phone +852 2796-6100
Fax +852 2796-6109
hk@brukeroptics.com.hk