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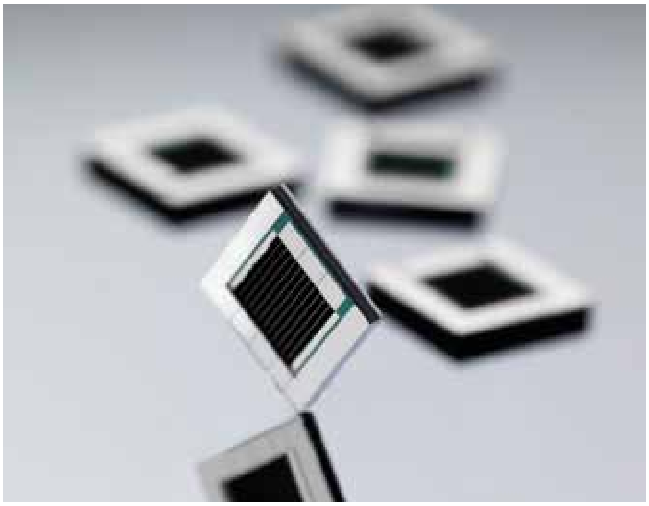
Infrared Sources

Overview

Axetris infrared (IR) sources are micro-machined, electrically modulated thermal infrared emitters featuring true black body radiation characteristics, low power consumption, high emissivity and a long lifetime. The appropriate design is based on a resistive heating element deposited onto a thin dielectric membrane which is suspended on a micro-machined silicon structure.

The sources are packaged in compact cans and are available with protective cap or with reflector. They can be fitted optionally with Sapphire, CaF_2, BaF_2 or Germanium broadband filters.

Axetris IR sources are ideally suited for compact IR gas detection modules where a high emissivity, high reliability and low power consumption are key requirements.



IR Source MEMS chip

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Technology Highlights & Applications

Technology highlights

- True black body radiation (2 to 14 µm)
- High emissivity
- Fast electrical modulation (no chopper wheel needed)
- High modulation depth
- High electrical input to optical output efficiency
- Low power consumption
- Long lifetime
- Rugged MEMS design (passed the requirements of IEC 60721-3-7 Class 7M3, except for BaF_2 and CaF_2 broadband filters)

Measurement principles

- Non-Dispersive InfraRed spectroscopy (NDIR)
- Photo-Acoustic Spectroscopy (PAS)
- Attenuated Total Reflectance spectroscopy (ATR)

Target gases

CO, CO_2, VOC, NO_x, NH_3, SO_x, SF_6, hydrocarbons, humidity, anesthetic agents, refrigerants, breath alcohols

Applications

- **Medical:**

Capnography, anesthesia gas monitoring, respiration monitoring, pulmonary diagnostics, blood gas analysis

- **Industrial:**

Combustible and toxic gas detection, refrigerant monitoring, flame detection, fruit ripening monitoring, SF_6 monitoring, semi-conductor fabrication

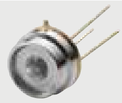
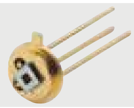
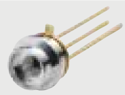
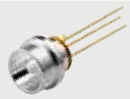
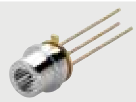
- **Automotive:**

CO_2 automotive refrigerant monitoring, alcohol detection & interlock, cabin air quality

- **Environmental:**

Heating, ventilating and air conditioning (HVAC), indoor air quality and VOC monitoring, air quality monitoring

Product Portfolio

Type	*WD (top of refl.)/ Power in < 20° angle	Broadband filter	Cap / Reflector	Measurement principles/ Typical application	Product photo
EMIRS200					
TO-39 Chip on Header	No collimation / 12%	No	No	NDIR, PAS / Custom specific absorption cells	
TO-39 Standard TO-Cap	No collimation / 12%	No	CAP 0-53/40-0	NDIR, PAS / STD absorption cells	
TO-39 Low Profile TO-Cap	No collimation / 12.3%	No	CAP 0-45/28-0	NDIR, PAS / STD absorption cells	
TO-39 Standard Reflector 1	5 – 15 mm / 60%	Yes	REF W-55/40-0	NDIR, ATR / STD absorption cells	
TO-39 Standard Reflector 2	0 – 7 mm / 54%	No	REF W-40/43-0	NDIR, ATR / Short absorption cells	
TO-39 Standard Reflector 3	10 – 30 mm / 82%	Yes	REF W-90/151-0	NDIR, ATR / Long absorbtion cells Ø 10 mm	
TO-39 Standard Reflector 4	No collimation / 15.7%	Yes	CAP W-36/12-0	NDIR, PAS / STD absorption cells	
EMIRS50					
TO-46 Chip on Header	No collimation / 12%	No	No	NDIR, PAS / Customer specific absorption cells	
TO-46 Standard TO-Cap	No collimation / 12%	No	CAP 0-30/25-N-0	NDIR, PAS / Standard absorption cells	
TO-46 Standard Reflector 5	No collimation / 17%	Yes	CAP W14/13-0-0	NDIR, PAS / Standard absorption cells	
TO-46 Standard Reflector 6	10 – 30 mm / 81%	No	REF W57-50-M-00	NDIR, PAS / Standard absorption cells or open path	
TO-46 Standard Reflector 7	5 – 20 mm / 90%	No	REF W30-41-M-00	NDIR / Narrow absorption cells or open path	
Customized Products	Custom	Custom	Custom	NDIR, PAS, ATR / Custom specific absorption cells	

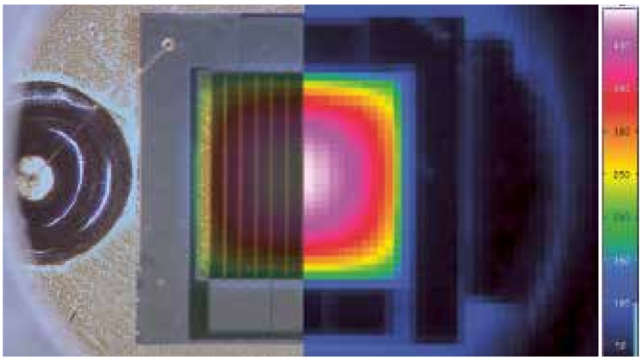
Electrical / Optical Characteristics

Parameter	Unit	Value Min	Value Typical	Value Max	Conditions / Remarks
EMIRS200					
Electrical cold resistance R_{C22}	Ω	35	-	55	
Electrical hot resistance R_{H500C}	Ω	54	-	89	
Heater power P_H	mW	350	450	550	*On-Time state*
Heater voltage V_H	V	4.9	5.6	6.3	*On-Time state*
Heater membrane temperature T_M	°C	330	450	500	
Turn on time τ_{on}	ms	-	18	-	
Turn off time τ_{off}	ms	-	8	-	
Frequency	Hz	5	-	50	
Lifetime	years		10		*At temperature <500°C*
Emissivity ε			> 0.85		*Mean from 2 to 14 µm*
Heater area A_H	mm^2		2.1 x 1.8		
Housing/TO-header temperature	T_{TOH}	40		85	at T_A = 22°C
EMIRS50					
Electrical cold resistance R_{C22}	Ω	22	-	36	
Electrical hot resistance R_{H500C}	Ω	32	-	53	
Heater power P_H	mW	170	187	210	*On-Time state*
Heater voltage V_H	V	2.5	2.7	3.0	*On-Time state*
Heater membrane temperature T_M	°C	330	463	500	
Turn on time τ_{on}	ms	-	10	-	
Turn off time τ_{off}	ms	-	5	-	
Frequency	Hz	10	-	100	
Lifetime	years		10		*At temperature <500°C*
Emissivity ε			> 0.85		*Mean from 2 to 14 µm*
Heater area A_H	mm^2		0.8 x 0.8		
Housing/TO-header temperature	T_{TOH}	40		85	at T_A = 22°C

The on-time state defines the power limitation not the average power. The real values can slightly differ from the shown numbers.

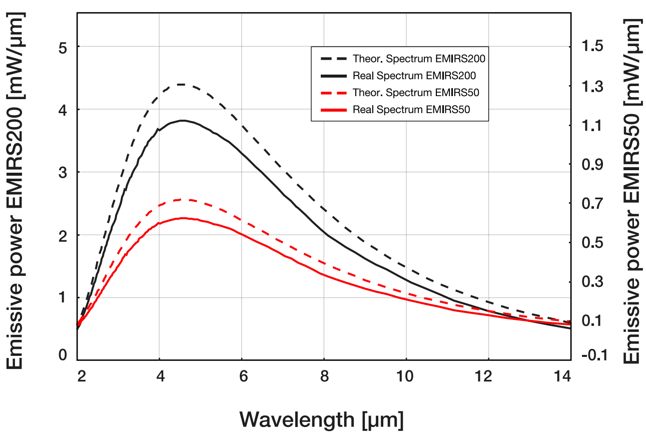
Benefits

- True black body radiation (wavelength from 2 µm to 14 µm)



Microscopic image of the MEMS chip packaged on a TO39 header (left).
Temperature distribution of the heated membrane (right).

Black Body Spectra

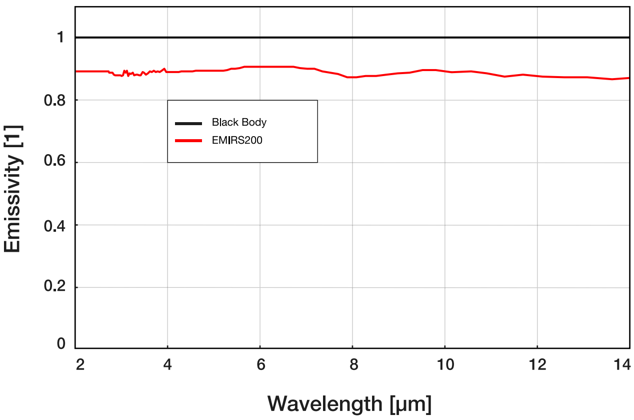


- High emissivity

A unique thin film process creates a pure black body structure with emissivity close to 1.

Black dendritic surface structure

Spectral emissivity

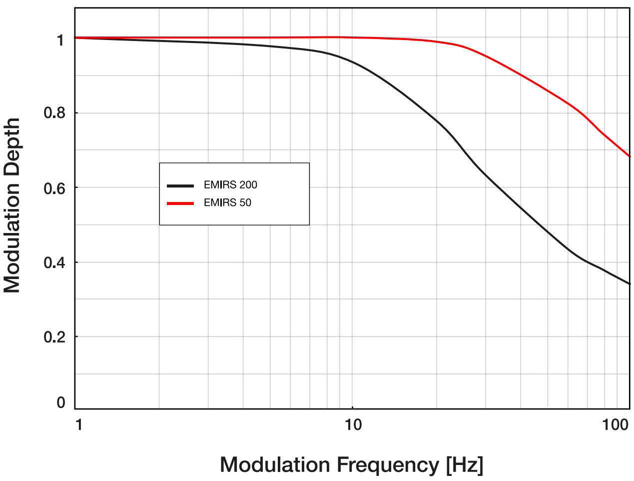


- Fast electrical modulation and high modulation depth

MEMS technology offers the possibility to achieve thin and low-mass membrane with short time constant, enabling IR-source to be modulated at high frequency with high modulation depth.

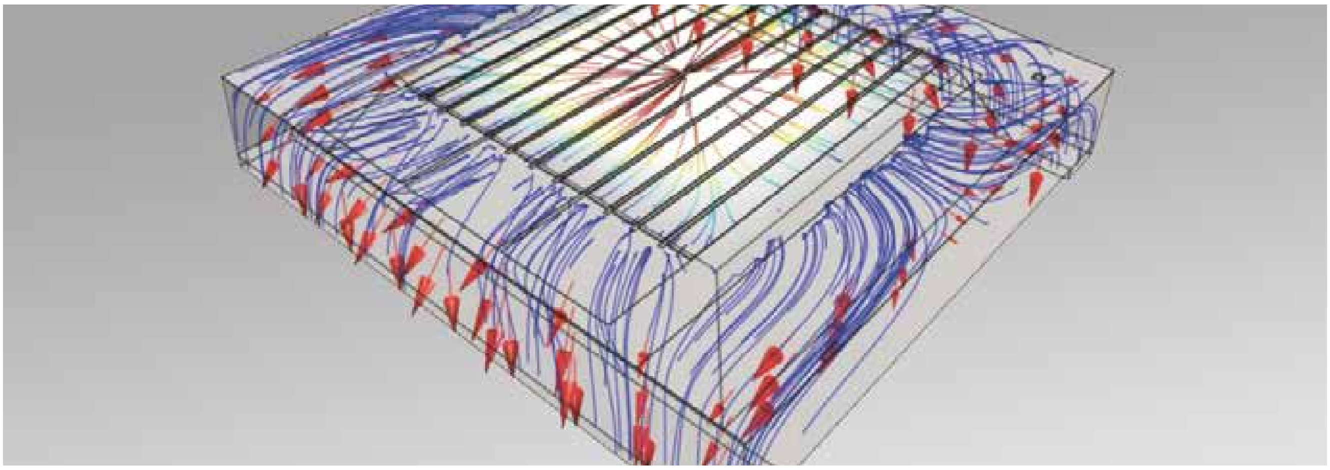
Front and backside of the IR Source MEMS chip
EMIRS200 (left), EMIRS50 chip (right)

Modulation Depth vs. Frequency



Driven with a constant voltage square-wave drive and measured with a high speed broadband detector.

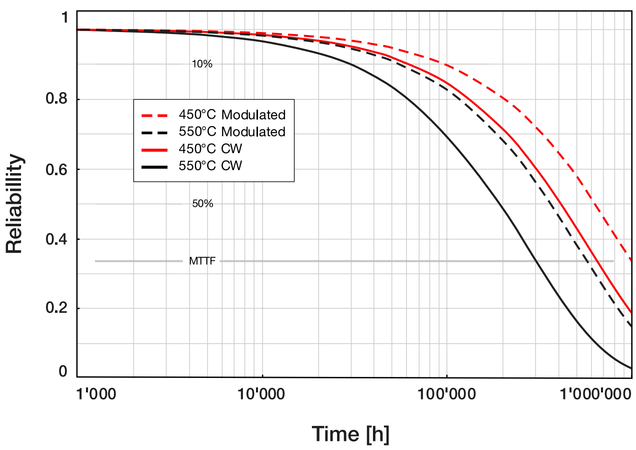
• High electrical input power to optical output efficiency
Due to the black surface, the IR source has excellent electrical to optical conversion efficiency. The black body surface guarantees maximized emissivity while the thin membrane is responsible for optimized heat flux.



Efficiency optimization by heat flux simulation.

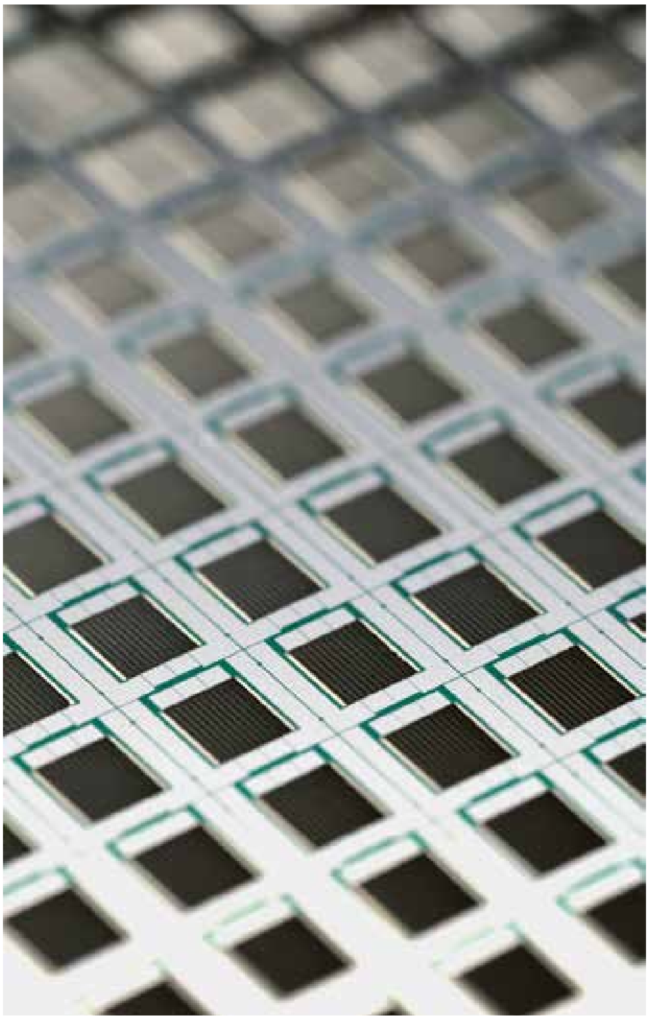
• Reliability of the MEMS structure
The semiconductor MEMS manufacturing technology guarantees high reliability and quality of the IR sources. In addition to the strict quality control system during wafer-level manufacturing, every single IR source is subjected to a final burn-in and test.

Lifetime Reliability Plot



Lifetime reliability plot for IR Sources in modulated mode with 10Hz (EMIRS200), 30Hz (EMIRS50) with a typ. duty cycle of 62% (dashed line) and CW mode (solid line).

The Mean Time To Failure (MTTF) for membrane breakage of the IR source is based on a statistical analysis of lifetime data collected from several years of reliability testing. Reliability of the membrane breakage depends greatly on the type of packaging, the electrical input power and the operating mode.

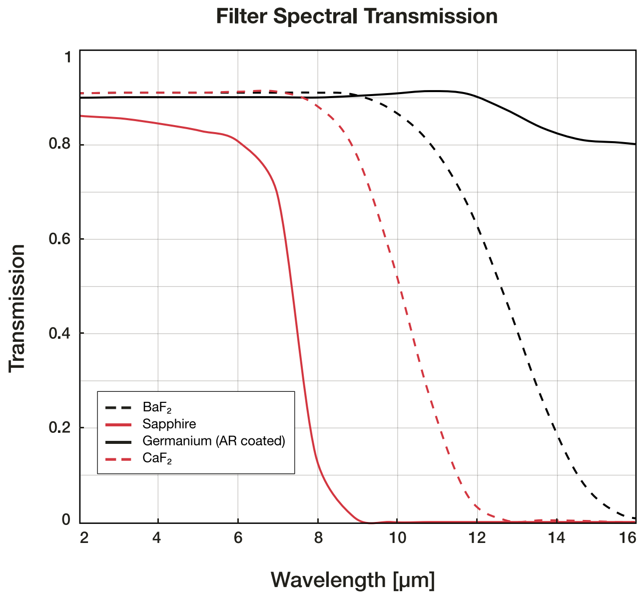


Processed wafer of IRS MEMS-based chips before dicing

Benefits of broadband filters

- Complements detector filter
- Eliminates background signal and improves S/N ratio
- Protects the IR source in harsh environments
- Prevents parasitic influence of the sample gas (for tightly sealed broadband filter installation)

IR source with broadband filter



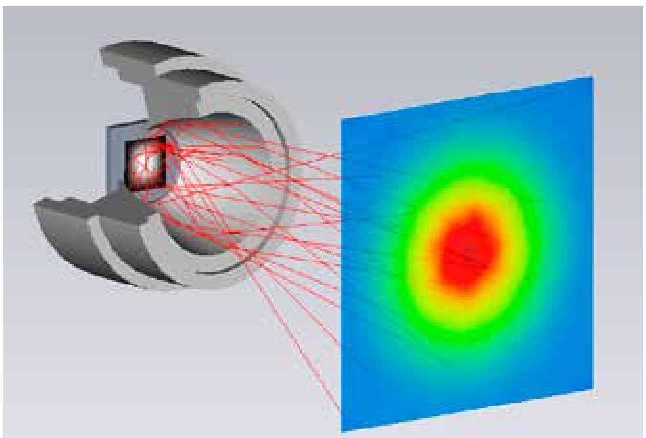
Transmission curves for the different filter types.

Application specific design options

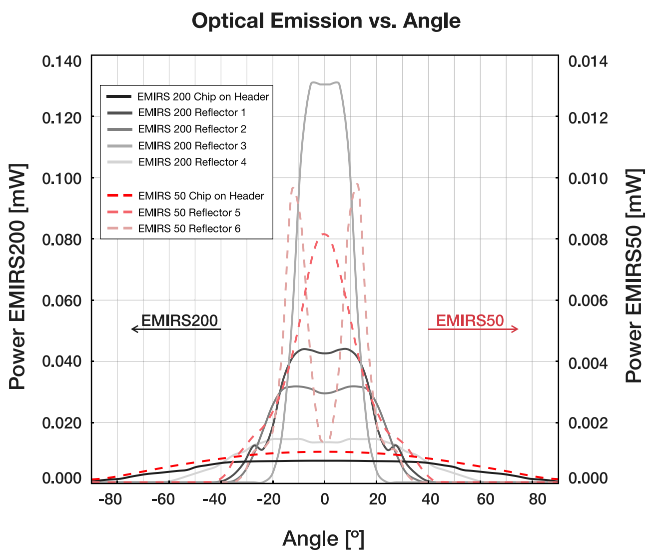
Axetris offers customized IR sources. Packaging, reflector designs and filter types can be configured for OEM customers to meet their specific product needs. The reflector for example, optimizes the angular distribution of radiation and, therefore, the optical signal.

Custom Reflector

- Optimization of the emission distribution with Zemax



Reflectors collimate IR radiation on axis. (red: high emission density per area; blue: low emission density per area).

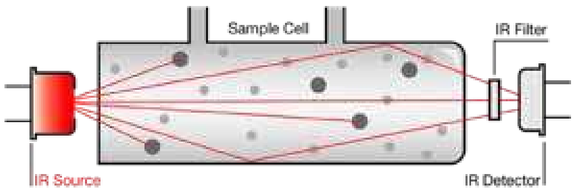


Angular radiation distribution with standard cap and reflectors.

Main Measurement Principles

Non-Dispersive InfraRed (NDIR) principle

Non-Dispersive InfraRed spectroscopy utilizes a broadband infrared source covering the entire wavelength spectrum needed to measure a large variety of gases. The specific wavelengths desired to measure the gas(es) of interest are selected with narrow band pass filters. The radiation is absorbed by the gas resulting in a signal decrease which is proportional to the gas concentration inside the sample volume. Thermopiles or pyroelectric detectors are commonly used for this spectroscopy technique.



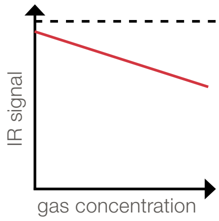
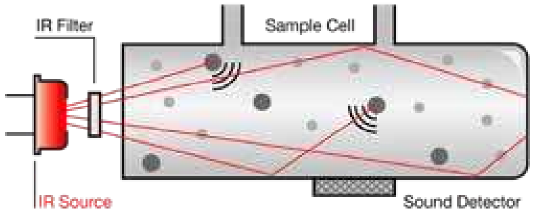
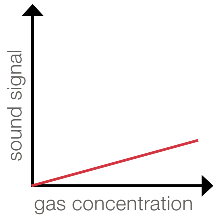


Photo-Acoustic Spectroscopy (PAS) principle

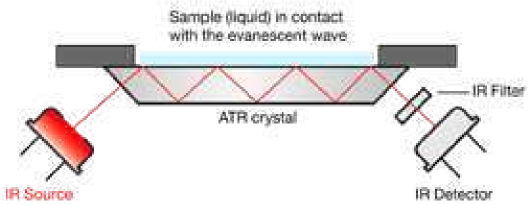
When infrared radiation is absorbed, the absorbing gas is heated. This heating causes a thermal expansion which, in turn, is responsible for a pressure increase in the sample volume. When the radiation is switched off, the gas cools down and the pressure decreases accordingly. With a pulsed IR source, a pressure wave e.g. soundwave is created which can be detected with a microphone. The higher the concentration of the gas of interest (appropriate wavelength has to be chosen with filters), the higher the signal. PAS is not limited to gases but can also be applied to liquids and solids.

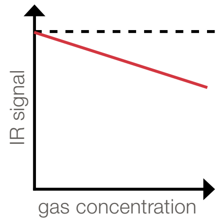




Attenuated Total Reflectance (ATR) principle

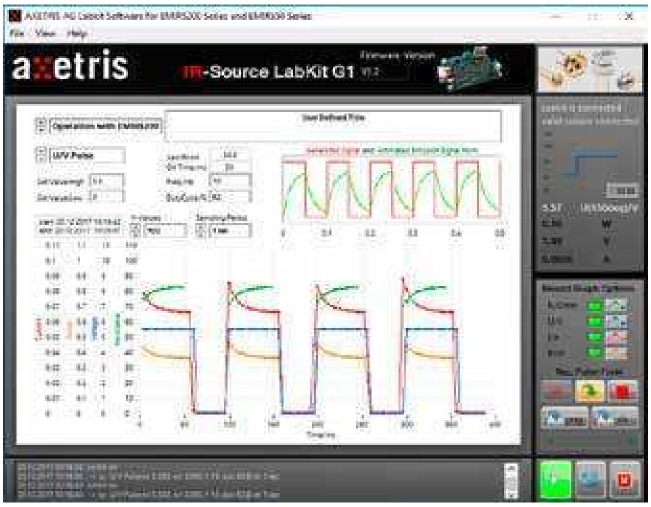
When radiation is totally reflected from an interface a small part of it will be transmitted into the adjacent medium. This evanescent wave experiences an exponential decay with penetration depths in the order of the wavelength. The amount of light that is coupled into this evanescent wave depends on the difference of refractive indices of the two adjacent media. In ATR spectroscopy, a crystal made of a high refractive index material serves as the light guiding medium. The sample, usually a liquid, is brought into contact so that the evanescent wave can interact with it. The appropriate wavelength is chosen with a narrow band pass filter. Depending on the state or quality of the sample, more or less light is coupled out and the signal on the detector then changes accordingly. Line arrays of thermopiles or pyroelectric detectors are frequently applied in these setups.





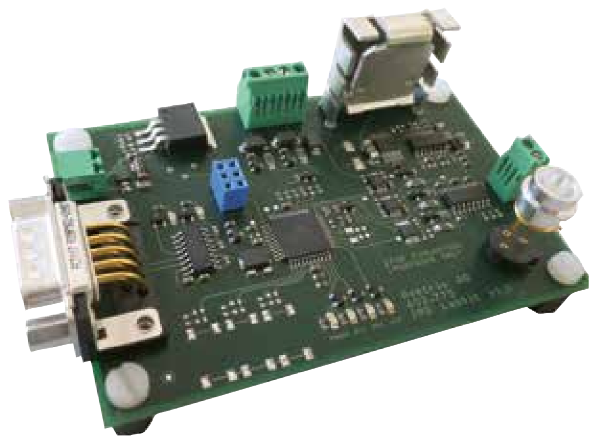
IRS LabKit

- Faster and easier design-in of Axetris IR Source family EMIRS200 and EMIRS50
- Very efficient tool for evaluating the ideal drive mode for achieving the best signal/noise ratio
- Quick and easy start-up and measurement within minutes
- Includes everything you need



Graphical User Interface (GUI)

- Simple Graphical User Interface (GUI) based on LabVIEW software
- Set and update all drive parameters live from the GUI
- Live diagram plots for data display and recording
- Visualized drive mode limitations (recommendations)
- Export of bitmap and Excel data


IRS LabKit driver board

- Direct connection to a PC with RS232 protocol and USB
- TO socket and connector for external IR source connection
- I/O analog interface for detector synchronization and signal evaluation

Parameter	Unit	Value	Conditions / Remarks
Drive Modes		P / V / I	CW / Wave signal
Power control P	mW	50 – 800	Power regulated
Voltage control V	V	0.5 – 10	Voltage regulated
Current control I	mA	5 – 100	Current regulated
Waveform signal		CW / SQ Wave Signal	
Frequency	Hz	0 (CW), 4 – 50	
Duty cycle	%	5 – 90	
Analog I/O	V	0 – 5	Synchronization of detector circuit, detector signal recording

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