Electrically modulated IR Source EMIRS200

Features

- Thermal black body source
- Broad band IR emission
- Electronically pulsed, no moving parts
- Fast heating and cooling rates
- Wide modulation frequency band
- Low power consumption
- Long term stability
- Compact packaging TO39, 3 pins

Applications

- Infrared spectroscopy
- Non dispersive infrared detection
- Photacoustic gas detection

Product Summary – principle of operation

The EMIRS200 is a versatile thermal infrared light emitter. The emission can be directly modulated by varying the electrical input signal. This device is best suited to replace existing, mechanically chopped lamp solutions, thus eliminating moving parts. Conventional lamps with Tungsten filaments work under vacuum and are therefore encapsulated in glass. This protection is no longer transparent for wavelengths exceeding 5 µm and limits their application range. The EMIRS200 exhibits a broadband IR emission from NIR to 20 µm.
The EMIRS200 is based on a silicon chip using advanced microstructure fabrication technologies. It consists of a thin film resistor supported on a thermally and electrically insulating membrane. The heating relies on the Joule effect in the microfilament. The low thermal mass of the supporting membrane structure permits to heat and cool the microfilament with very short time constants of 11 ms and 17 ms respectively. This allows a fast direct modulation of the emitted infrared light. A unique patented technology allows manufacturing of highly reliable modulated IR sources with true black body characteristics and very high emissivity. Emissivity higher than 0.9 is achieved for wavelengths up to 15 µm.

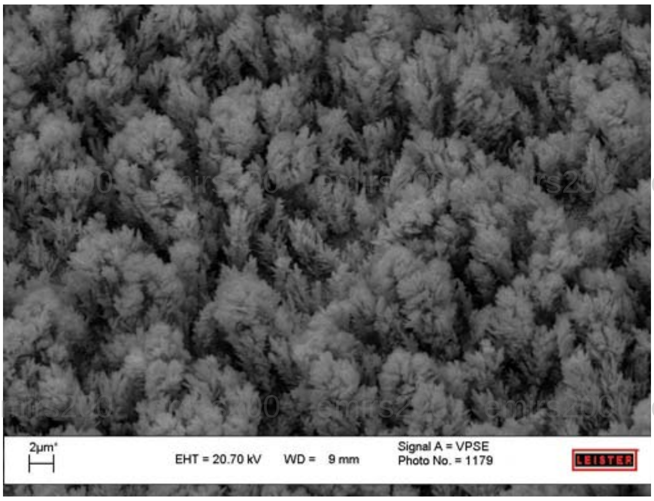

Figure 1: SEM view of the structures enhancing the emissivity of the device.

The main characteristic of heat radiation is that absorption and emission are equal when the device is at thermal equilibrium. This means that the higher the absorption, the higher the emissivity. The emissivity of the EMIRS200 microfilament is enhanced by creating a random surface structure as shown in figure 1. Incoming light is absorbed by this surface resulting in a low reflectivity. This is the reason why the EMIRS200 sources appear black and exhibit an excellent emissivity close to 1.

Absolute maximum ratings

Characteristics	Rating	Unit
Electrical input power (peak)	600	mW
Cold resistance	55	Ohm
Case temperature (cw, 600 mW)	90	°C
Operating Temperature	-20/+85	°C
Storage temperature range	-40 /+125	°C

Electrical/Optical characteristics (T_c=25°C)

Parameter	Min	Typ	Max	Unit	Conditions
Cold Resistance	35	45	55	Ω	
Hot Resistance		72		Ω	450 mW
Electrical input power		450	600	mW	end of heating cycle
Operating voltage		5.7	6.3	V	450 mW
Operating current		80	90	mA	450 mW
Heating time constant		11		ms	
Cooling time constant		17		ms	
Peak emission wavelength		4.0		µm	450 mW
Emissivity	0.9	0.95			VIS to 15 µm
Lifetime (measured)		>40'000		hours	50% duty cycle, 30 Hz, 450 mW, ongoing measurement
Lifetime (calculated)		> 10		years	As above, based on accelerated lifetime measurements.
Heating area		2.1x1.8		mm^2	
Case Temperature		47		°C	50% duty cycle; 450 mW

Operating conditions

The source can be operated in continuous (cw) or in pulsed mode. Its fast heating and cooling time constants of 11 ms and 17 ms respectively make it ideal for detection schemes that rely on a modulated light source, such as photoacoustic detection and phase sensitive techniques for the suppression of DC components and the reduction of 1/f noise.

The heating element exhibits a high TCR value. This means that a current flowing through the resistor induces a self-heating of the element and therefore an increase in the resistor value. The data in figure 2. show the typical rise in resistance with increasing electrical power.

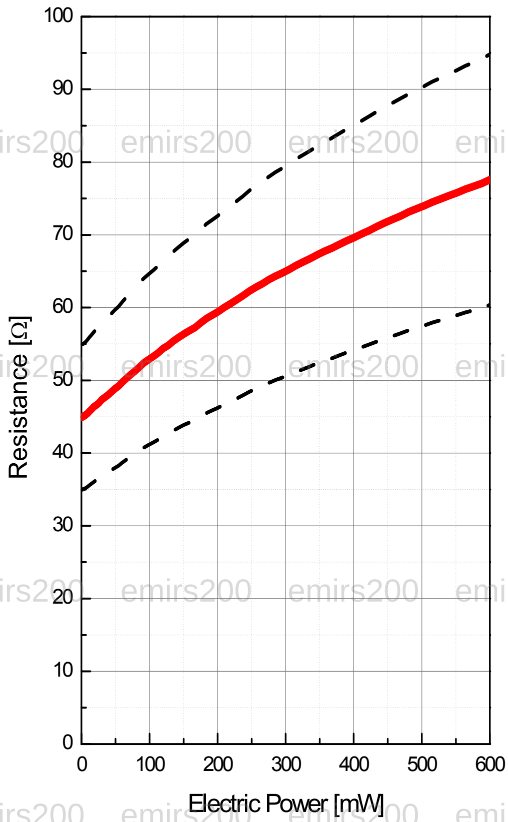

Figure 2: Typical increase of the source resistance as a function of the electrical heating power in thermal equlibrium. The dashed lines indicate the range for the specified minimum and maximum cold resistance values.

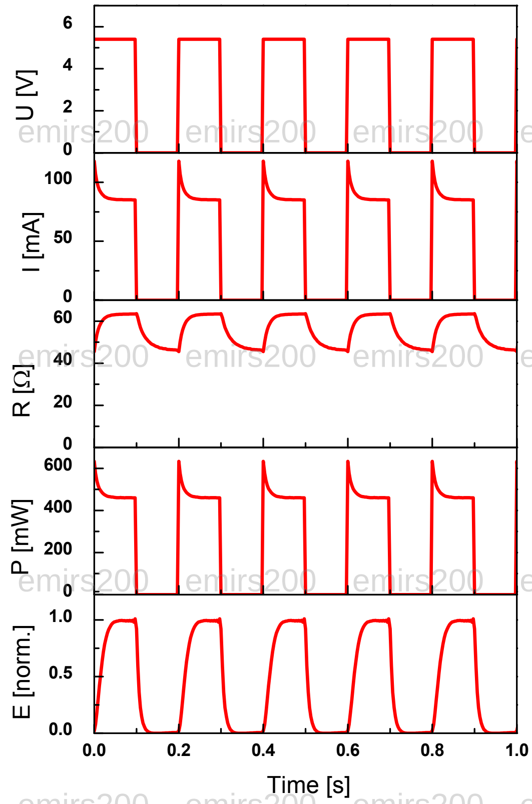

Figure 3: Time evolution of the driving voltage (V), current (I), resitance (R), electrical power (P) and total IR emission (E) of a typical IR source in pulsed mode (voltage driven).

The source can be e.g. driven with a square wave in constant voltage or in constant current mode. The time evolution of the various parameters during a square wave modulation with constant voltage is depicted in figure 3. Due to the lower resistance at the beginning of the heating cycle, the current and the input power exhibit an overshoot. Therefore the constant voltage mode supports slightly faster heating rates compared to the constant current mode.

The frequency response of the total IR emission in figure 4 has been measured with a driving square wave voltage of constant amplitude. The modulation depth is defined as the amplitude of the sine component at the fundamental frequency of the driving square wave. A modulation depth of 50% is achieved at 24 Hz. The modulation depth can be further enhanced significantly in a constant temperature mode, i.e. the drive voltage is increased for higher frequencies to maintain the same peak temperature at the end of the heating cycle. This mode works best for asymmetric duty cycles with shorter heating periods.

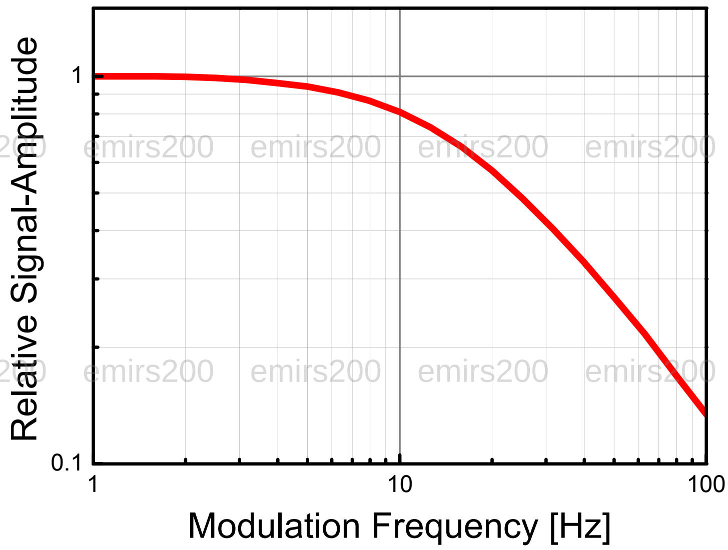

Figure 4: Signal modulation depth of the total IR emission as a function of modulation frequency (square wave voltage with constant amplitude, 50:50 duty cycle).

Emission spectrum

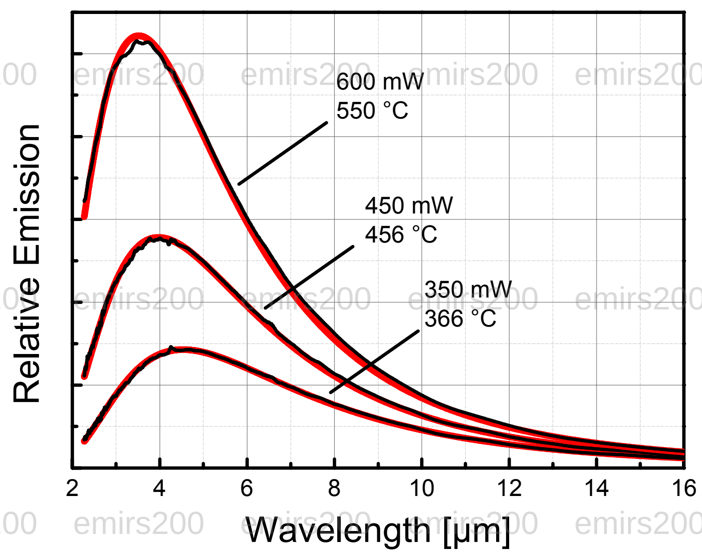

Figure 5: Typical emission spectra of the EMIRS200 for different electrical input powers.

The EMIRS200 exhibits true black-body characteristics. The emission spectra in figure 5 have been measured with a Fourier transform IR spectrometer for different electrical power levels. The measured curves have been fitted with a Planck distribution function. The spectra show excellent agreement with the theoretical black body emission. The extracted source temperature varies from 350°C to 550°C, the peak wavelengths are situated at about 3.5 µm to 4.5 µm.

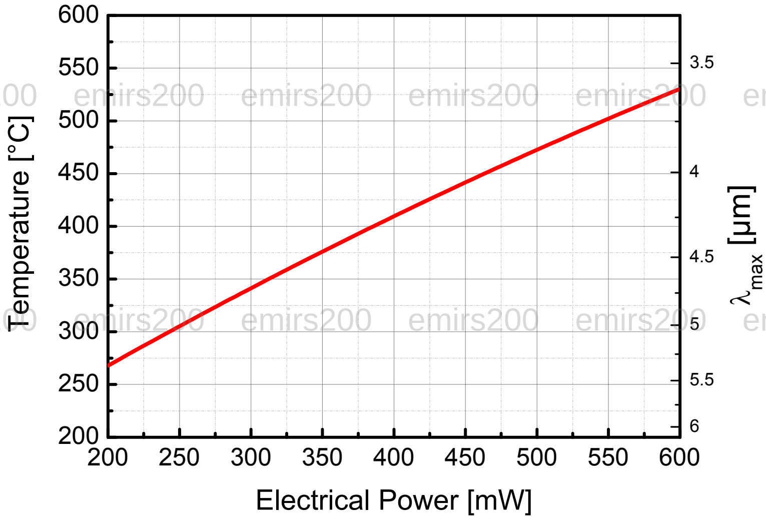

Figure 6: Source temperature and corresponding peak wavelength λ_{max} versus electrical power as extracted from the emission spectra.

Lifetime

Lifetime tests are permanently ongoing. These are performed for square modulation with 30 Hz frequency and 50 : 50 duty cycle at electrical power levels of 350 mW, 400 mW and 450 mW. Over the measured 40'000 h, no degradation has been observed. The measured intensity variation was within the accuracy of the optical detector (± 5%). The sources have been operated at ambient atmosphere, which indicates that a hermetic sealing of the TO package is not required. The use of the source at maximum ratings may result in a shorter life than operation at lower temperatures. Accelerated tests at higher power levels have been performed. An extrapolation using an inverse power law leads to expected lifetimes of 10 years.

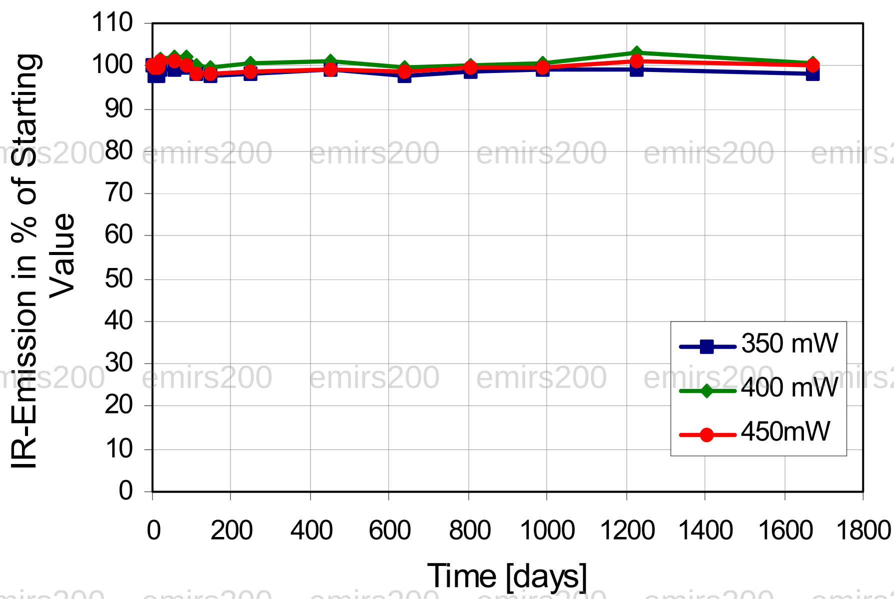

Figure 7: Long-term stability test lasting since more than 40'000 hours with power levels of 350 mW, 400 mW and 450 mW (30 Hz, 50:50 duty cycle).

Case temperature

The temperature of the TO39 header has been measured at different power levels in cw and pulsed mode.

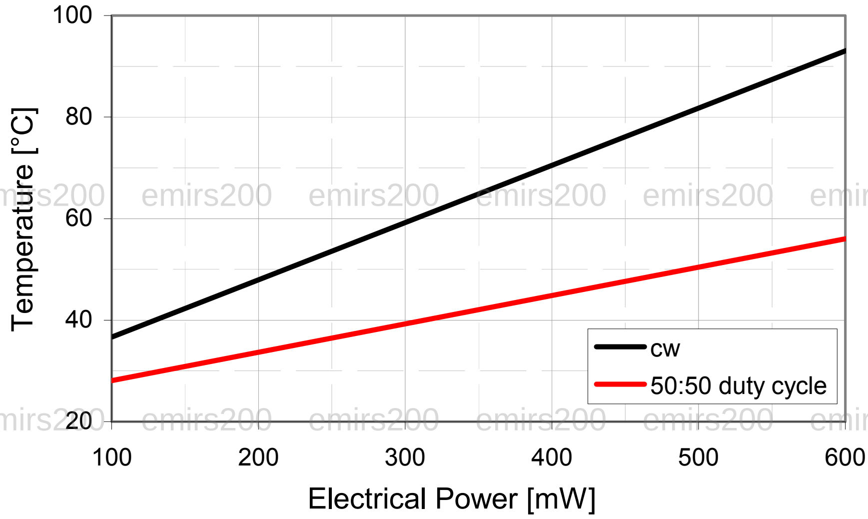

Figure 8: Typical housing temperature (T_c=21°C) versus electrical power for cw and pulsed operation (50:50 duty cycle).

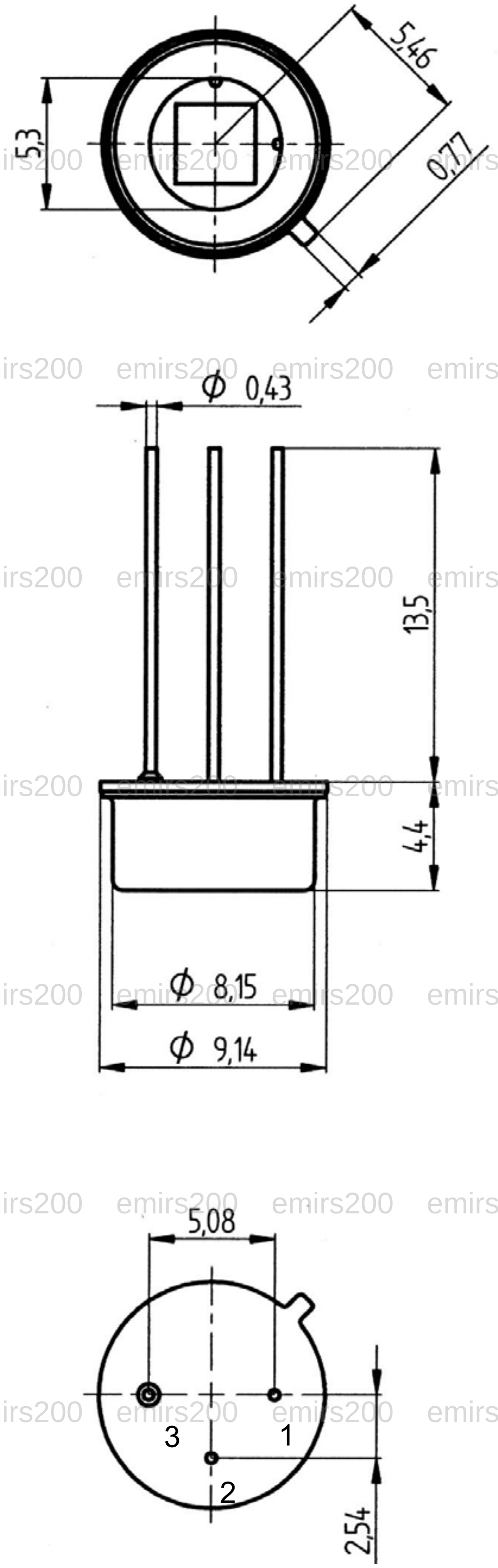

Figure 9: Package outline dimensions (in mm).

Packaging information

The device is supplied in a TO 39 header type package with 3 pins. Pin 1 and 2 are isolated and pin 3 is grounded. A cap with round opening protects the silicon chip. Standard executions are delivered without protective window. Various windows and filters are available on request.

The typical weight of an EMIRS200 is 900 mg.

Soldering

The terminations of the TO39 package consist of Nickel-plated Kovar and gold finish. Hand soldering is mandatory. Cleaning procedures are not recommended as they might reduce the emitting efficiency or even destroy the device.

Pin-Out

Pin	Function
1	Heating resistor Rh
2	Heating resistor Rh
3	Ground

ESD (Electrostatic discharge)

Electrostatic discharge and other current surges can cause deterioration and damage of the IR source. Handling of the device has to be done according ESD rules. Electronic circuitry should be designed to avoid the generation of excessive current spikes when the power is turned on and the device should be protected against electrostatic discharges.

Liability Policy

Technical data and specifications contained herein are subject to change without prior notice.

As any semiconductor device, Process Technologies micro-machined devices have inherently a certain rate of failure. It is the responsibility of the buyer to comply with the standards of safety in making a safe design for the entire system, to protect against injury, damage or loss from such failures.

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