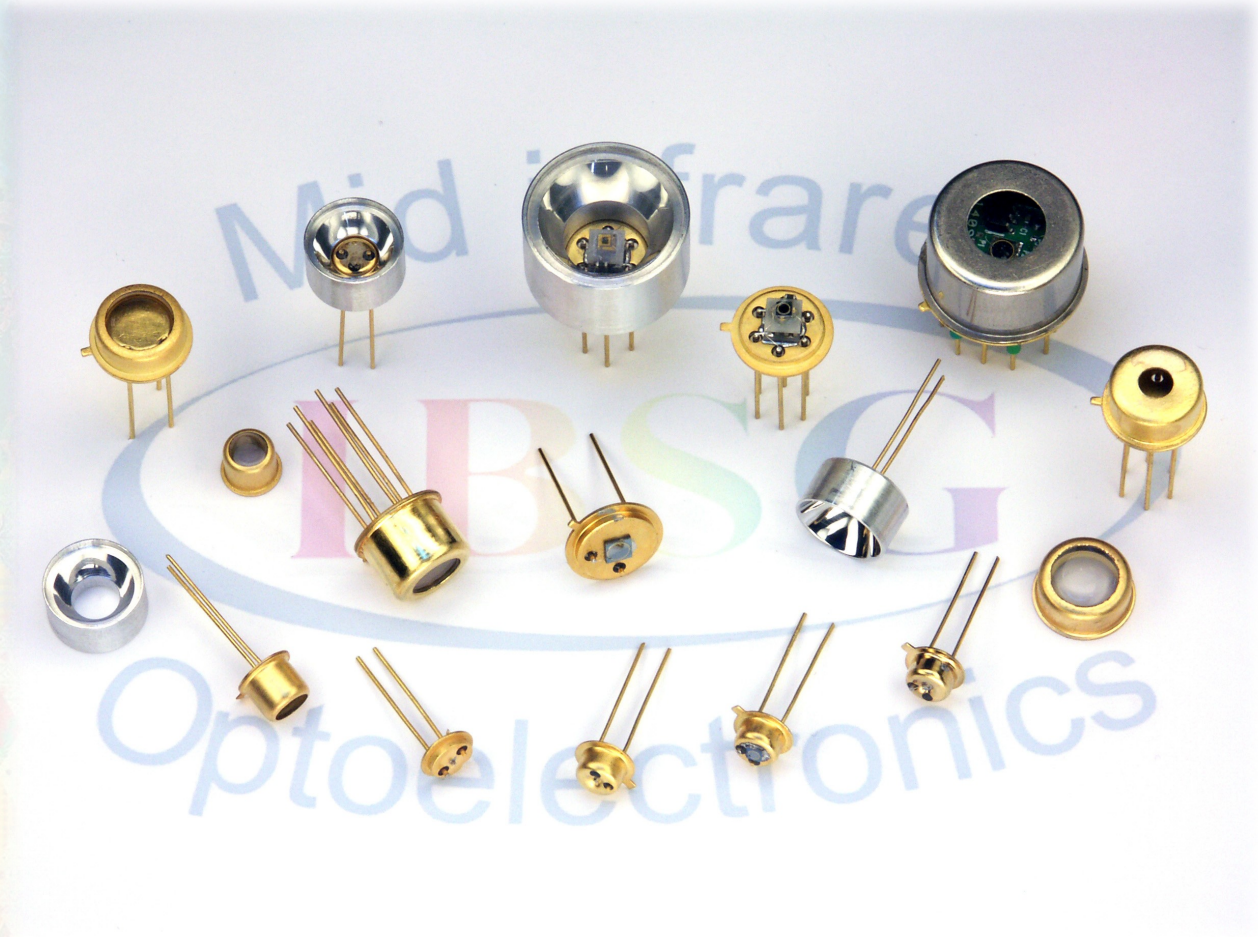
IBSG Co., Ltd.

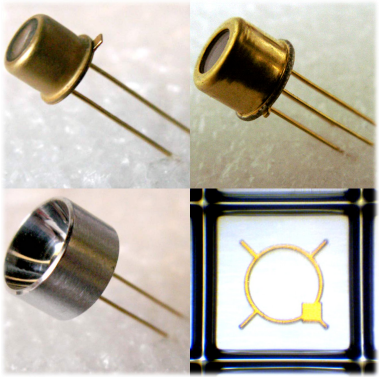
Optoelectronic devices for near- and mid-IR spectral range (0.7- 5.0 μm)



Saint Petersburg, Russia
2014

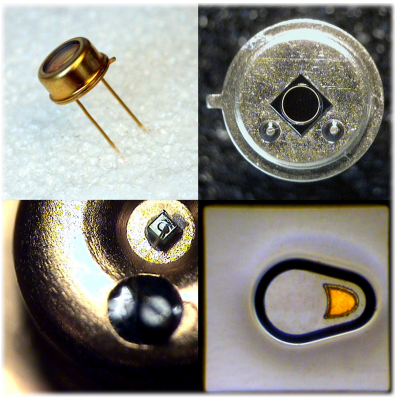
Independent Business & Scientific Group

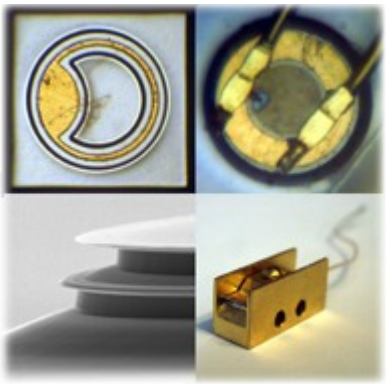
Our products:



LIGHT EMITTING DIODES
0.7 - 4.8 µm

PHOTODETECTORS
2.4; 2.5; 3.6; 4.8 µm





MID-IR LASERS
2.0 - 3.8 µm

ELECTRONIC DEVICES:
LED DRIVERS, PHOTODIODE BUILT IN AMPLIFIER

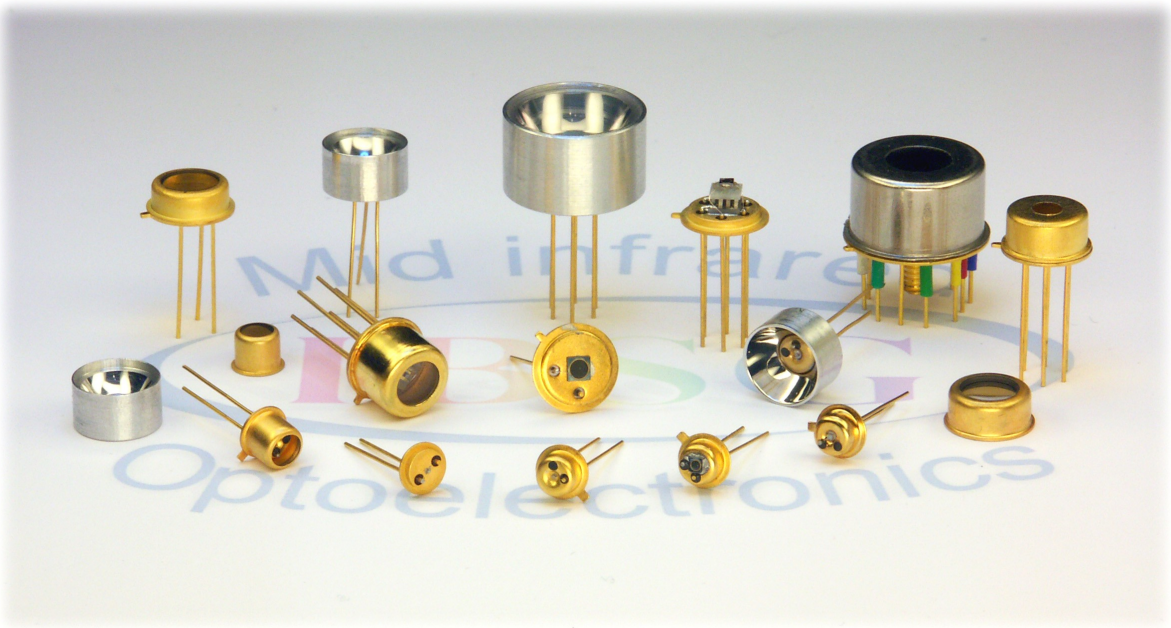
CONTENTS

ABOUT US

IBSG company (Independent Business Scientific Group) was founded in 1991 by a group of the scientists of the Ioffe Physical-Technical Institute of Russian Academy of Sciences. Since the company establishing, Professor Yury P. Yakovlev has been General Director.

Over twenty years experience in domestic and export markets IBSG has became one of the leading developers and manufacturers of optoelectronics devices for mid-Infrared spectral range. The company exports products to more than 15 countries including France, Holland, Poland, USA, Canada, Japan and others. Today the company provides full technological cycle of optoelectronic devices manufacture including heterostructure growth by Liquid Phase Epitaxy (LPE) and Metalorganic Chemical Vapour Deposition (MOCVD), photolithography, assembling and testing.

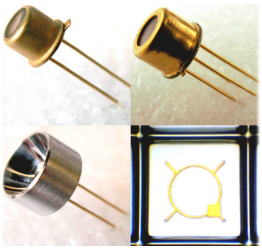
IBSG company manufactures and offers LEDs, lasers and PDs for the mid-infrared spectral range (1600-5000 nm), as well as electronics (LED drivers and PD amplifiers).



Main advantages of IBSG Company:

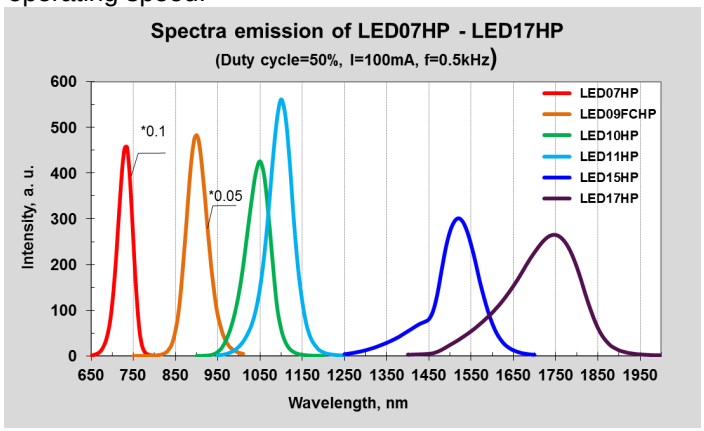
- Twenty years in domestic and export markets.
- Staff of experienced professionals the field of semiconductors and IR optoelectronic devices.
- Joint research with the Laboratory for Infrared Optoelectronics of Ioffe Physical-Technical Institute.
- More than 50 certificates of authorship and patents.
- Full technological cycle for production of IR LEDs, lasers and photodiodes.
- Manufacturing the electronics for IR LEDs, lasers and photodiodes.
- Non-standard solutions and individual approach to each customer.

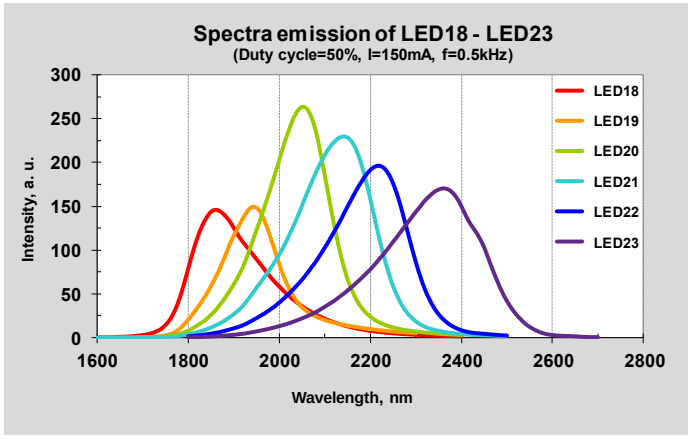
LIGHT EMITTING DIODES (IR SPECTRAL RANGE)

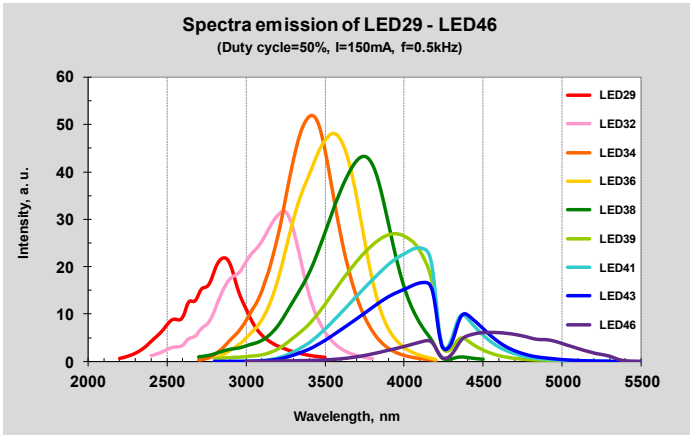


Determining of the composition and the concentration of a substance is an essential part of many industrial processes and widely used in chemistry, biology, geology, space exploration, agriculture, medicine, criminalistics, and other fields. The company IBSG Co., Ltd. in collaboration with the Laboratory for Infrared Optoelectronics of Ioffe Physical-Technical Institute has developed a series of high-performance LEDs covered completely the spectral range of 0.7-5.0 μm. This mid-infrared spectral range is known to contain the absorption bands of water vapor, carbon dioxide, nitrogen-containing molecules (N_2O, NO_2, NH_3), hydrocarbon molecules (methane) and many other organic and inorganic substances. In last decades there is growing demand for sensors controlling the concentration of the gases in the atmosphere or in industrial processes. Another important area of gas sensor application is medicine. Sensitive diagnostics of various diseases can be provided through analyzing a chemical composition of expired air, blood and skin.

Despite of progress in the development of chemical and adsorption gas sensors, optical sensors have many advantages such as high selectivity, stability in aggressive environments, high operating speed.

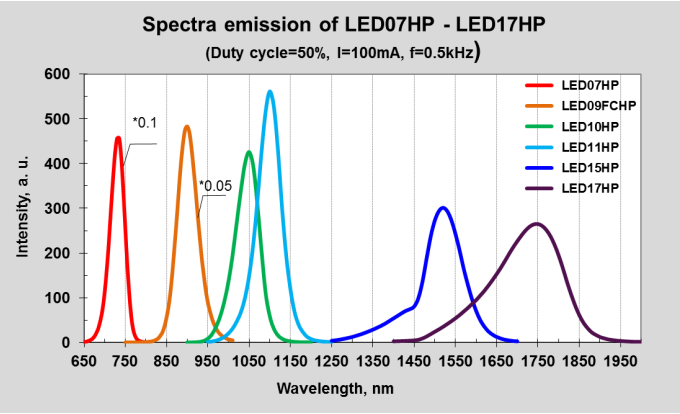






Mid infrared IBSG Optoelectronics

HIGH-POWER LEDs (0.7 - 1.74 µm)

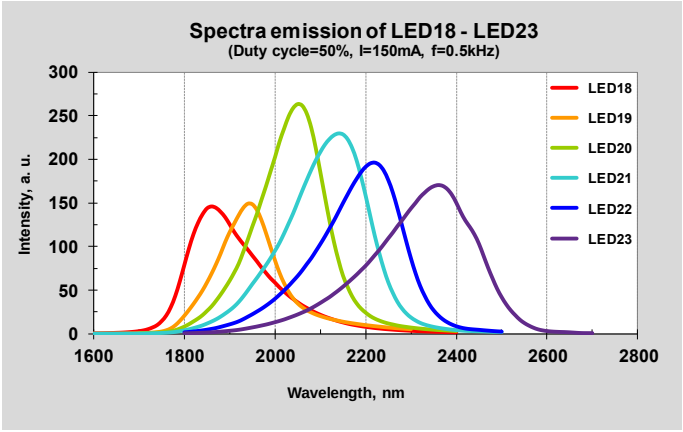


High-power LED11HP – LED17HP (FWHM = 60-200 µm) for the gas detection in the spectral range of 0.7-1.74 µm have been developed. The LEDs demonstrate an output power up to 55 mW in CW mode and 350 mW in pulsed mode, respectively.

LEDs 0.7-1.7 µm		Wavelength (mm)			FWHM (nm)		Optical Power (mW)				Forward Voltage (V)*	Switching Times (ns)	I_{max} (mA)		Operating Temperature (°C)
							QCW (100mA)*		Pulse (1A)**						
Series	Model***	Min	Typ	Max	Min	Max	Min	Max	Min	Max			QCW	Pulse	
LED20	LED07HP LED07HP-PR LED07HP-PRW LED07HP-TEC LED07HP-TEC-PRW	0.72	0.73	0.74	35	55	25	55	150	350	1.6 ~ 2.0	10 - 30	150	1500	-30...+50
	LED09FCHP LED09FCHP-PR LED09FCHP-PRW	0.86	0.9	0.93	50	70	15	45	90	270	1.4 ~ 1.7				
	LED10HP LED10HP-PR LED10HP-PRW LED10HP-TEC LED10HP-TEC-PRW	1.02	1.05	1.07	60	80	3.5	6.0	20	45	0.9 ~ 1.3				
	LED11HP LED11HP-PR LED11HP-PRW LED11HP-TEC LED11HP-TEC-PRW	1.09	1.10	1.15	60	80	4.5	9.0	28	55	1.2 ~ 1.7				
	LED15HP LED15HP-PR LED15HP-PRW LED15HP-TEC LED15HP-TEC-PRW	1.51	1.53	1.55	90	150	2.5	5.0	10	20	0.5 ~ 0.8				
	LED17HP LED17HP-PR LED17HP-PRW LED17HP-TEC LED17HP-TEC-PRW	1.71	1.74	1.77	150	200	2.3	4.5	9	18	0.5 ~0.8				

* - repetition rate 0.5 kHz, pulse duration 1 ms, fill factor 50%, current 100 mA
** - repetition rate 0.5 kHz, pulse duration 2 ms, fill factor 0.1%, current 1 A
*** - LEDXXHP – LED model in TO-18 package with a cap
LEDXXHP-PR – LED model in TO-18 package with parabolic reflector PR
LEDXXHP-PRW – LED model in TO-18 package with parabolic reflector and window W
LEDXXHP-TEC – LED model in TO-5 package with thermocooler TEC and a cap
LEDXXP-TEC-PRW – LED model in TO-5 package with thermocooler TEC, parabolic reflector PR and window W
LEDXXHP-SMD – LED model in SMD 3528 (on a request from the customer)

LEDs (1.8 - 2.4 µm)



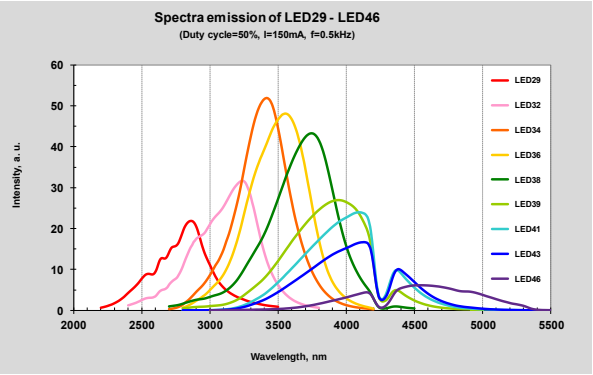
Characteristic absorption bands of a number of important chemical compounds, such as water, methane, carbon monoxide, acetone, etc. lie in the spectral range of 1.8-2.4 µm. LEDs based on GaSb and GaInAsSb, AlGaAsSb solid solutions are sources of spontaneous radiation in this spectral range. Such light sources are widely used for environmental monitoring, communication systems and medicine.

LEDs 1.8-2.4 µm		Wavelength (mm)			FWHM (nm)		Optical Power (mW)				Forward Voltage (V)*	Switching Times (ns)	I_{max} (mA)		Operating Temperature (°C)
							QCW (200mA)*		Pulse (1A)**						
Series	Model***	Min	Typ	Max	Min	Max	Min	Max	Min	Max			QCW	Pulse	
LED20	LED18 LED18-PR LED18-PRW LED18-TEC LED18-TEC-PRW	1.83	1.85	1.90	100	200	0.7	1.1	4	6	0.5 ~ 1.5	10 - 30	220	2000	-30...+50
	LED19 LED19-PR LED19-PRW LED19-TEC LED19-TEC-PRW	1.92	1.95	1.97	100	200	0.8	1.2	4.4	6.6	0.5 ~ 1.5				
	LED20 LED20-PR LED20-PRW LED20-TEC LED20-TEC-PRW	2.02	2.05	2.07	150	250	0.8	1.2	4.4	6.6	0.5 ~ 1.0				
	LED21 LED21-PR LED21-PRW LED21-TEC LED21-TEC-PRW	2.10	2.15	2.19	150	250	0.8	1.2	4.4	6.6	0.5 ~ 1.0				
	LED22 LED22-PR LED22-PRW LED22-TEC LED22-TEC-PRW	2.19	2.25	2.29	150	250	0.8	1.2	4.4	6.6	0.5 ~ 1.0				
	LED23 LED23-PR LED23-PRW LED23-TEC LED23-TEC-PRW	2.30	2.35	2.39	170	270	0.6	1.0	4.4	5.5	0.5 ~ 2.5				

* - repetition rate 0.5 kHz, pulse duration 1 ms, fill factor 50%, current 200 mA
** - repetition rate 0.5 kHz, pulse duration 2 ms, fill factor 0.1%, current 1 A
*** - LEDXXHP – LED model in TO-18 package with a cap
LEDXXHP-PR – LED model in TO-18 package with parabolic reflector PR
LEDXXHP-PRW – LED model in TO-18 package with parabolic reflector and window W
LEDXXHP-TEC – LED model in TO-5 package with thermocooler TEC and a cap
LEDXXP-TEC-PRW – LED model in TO-5 package with thermocooler TEC, parabolic reflector PR and window W
LEDXXHP-SMD – LED model in SMD 3528 (on a request from the customer)

Mid infrared IBSG Optoelectronics

LEDs (2.7 - 4.7 µm)

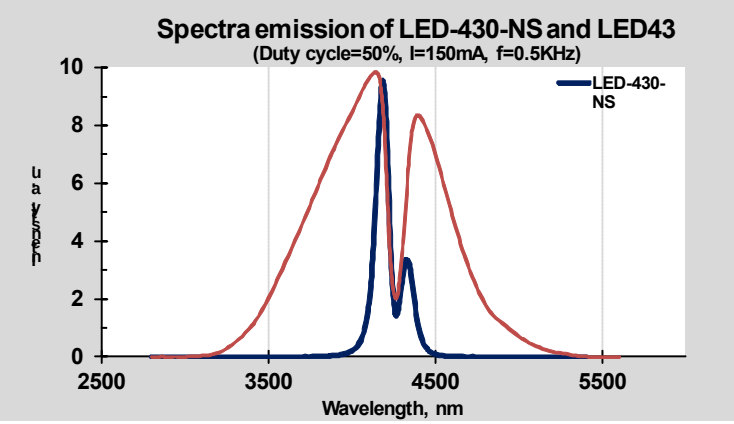


Mid-infrared LEDs is known to be prospective light sources for gas sensors. The characteristic absorption bands of a number of hydrocarbon compounds, natural gases lie in the wavelength range of 2.7-4.7 µm. The InAsSb/ InAsSbP heterostructures are used for manufacturing LEDs emitting in this spectral range The InAsSb/InAsSbP heterostructures are used for manufacturing LEDs emitting in this spectral range.

LEDs 2.7-4.7 µm		Wavelength (mm)			FWHM (nm)		Optical Power (mkW)				Forward Voltage (V)*	Switching Times (ns)	I_{max} (mA)		Operating Temperature (°C)
							QCW (200mA)*		Pulse (1A)**						
Series	Model***	Min	Typ	Max	Min	Max	Min	Max	Min	Max			QCW	Pulse	
LED30	LED29 LED29-PR LED29-PRW LED29-TEC LED29-TEC-PRW	2.8	2.84	2.9	300	500	6	40	30	180	0.7 ~ 1.2	30 - 50	220	2000	-30...+50
	LED32 LED32-PR LED32-PRW LED32-TEC LED32-TEC-PRW	3.2	3.24	3.3	400	700	10	35	45	160	0.3 ~ 0.5				
	LED34 LED34-PR LED34-PRW LED34-TEC LED34-TEC-PRW	3.32	3.4	3.46	400	600	25	45	115	200	0.3 ~ 0.5				
	LED34HP LED34HP-PR LED34HP-PRW LED34HP-TEC LED34HP-TEC-PRW	3.32	3.4	3.46	300	500	45	80	200	360	0.3 ~ 0.5				
	LED36 LED36-PR LED36-PRW LED36-TEC LED36-TEC-PRW	3.5	3.58	3.7	400	600	20	40	90	180	0.2 ~ 0.4				
	LED38 LED38-PR LED38-PRW LED38-TEC LED38-TEC-PRW	3.7	3.75	3.85	500	700	20	40	90	180	0.5 ~ 0.8				
	LED39 LED39-PR LED39-PRW LED39-TEC LED39-TEC-PRW	3.85	3.92	3.95	550	750	15	30	70	135	0.5 ~ 0.8				
LED40	LED41 LED41-PR LED41-PRW LED41-TEC LED41-TEC-PRW	3.95	4.05	4.1	700	750	15	35	70	160	0.2 ~ 0.4				
	LED43 LED43-PR LED43-PRW LED43-TEC LED43-TEC-PRW	4.1	4.15	4.3	700	1000	8	26	35	120	0.2 ~ 0.8				
	LED46 LED46-PR LED46-PRW LED46-TEC LED46-TEC-PRW	4.4	4.6	4.66	800	1100	4	12	20	55	0.3 ~ 0.8				

* - repetition rate 0.5 kHz, pulse duration 1 ms, fill factor 50%, current 200 mA
** - repetition rate 0.5 kHz, pulse duration 2 ms, fill factor 0.1%, current 1 A

LEDs WITH NARROW SPECTRUM (2.7 - 4.7 µm)



IBSG company has developed IR LEDs with the narrow spectrum (FWHM=100-160 nm) applied for the detection of gases in the spectral range of 2.7-4.7 µm. The intensity maximum of the LED emission spectra coincides with the absorption line of the detected gas. The position of the intensity maximum does not depend on temperature.

LEDs 2.7-4.7 µm		Package	Wavelength (mm)	FWHM (nm)	Optical Power (mkW)*	Forward Voltage (V)*	I_{max} (mA)		Operating Temperature (°C)	Storage temperature (°C)
Series	Model***						QCW	Pulse**		
LED30	LED-270-NS	TO-18	2.74	230	3 - 5	0.6 - 1.0	200	2000	-30...+85	-40...+100
	LED-305-NS	TO-18	3.05	140	6 - 10	0.4 - 0.8				
	LED-305-NS-TEC	TO-5	3.05	140	6 - 10	0.4 - 0.8				
	LED-315-NS	TO-18	3.15	140	8 - 14	0.3 - 0.6				
	LED-321-NS	TO-18	3.21	140	5 - 9	0.3 - 0.6				
	LED-332-NS	TO-18	3.32	200	15 - 22	0.3 - 0.6				
	LED-334-NS	TO-18	3.34	200	12 - 24	0.3 - 0.6				
	LED-340-NS-TEC	TO-5	3.40	200	15 - 22	0.3 - 0.6				
	LED-390-NS	TO-18	3.90	140	15 - 22	0.4 - 0.7				
LED40	LED-430-NS	TO-18	4.30	200	1.5 - 4	0.25 - 0.4				
	LED-465-NS	TO-18	4.65	200	1.0 - 2.5	0.25 - 0.4				

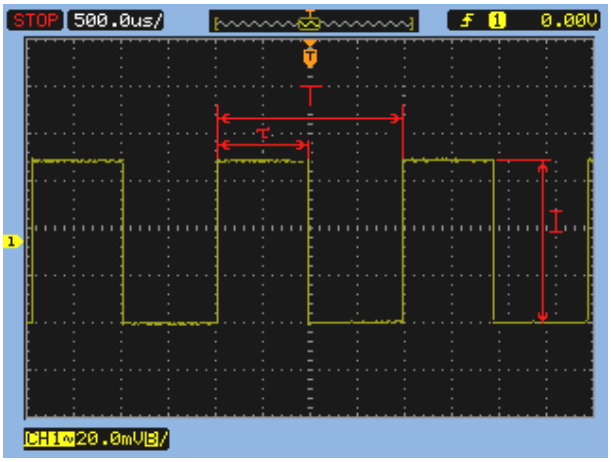
* - repetition rate 0.5 kHz, pulse duration 1 ms, fill factor 50%, current 200 mA
** - repetition rate 0.5 kHz, pulse duration 2 ms, fill factor 0.1%
***- LED-XXX-NS – the narrow spectrum LEDs model in TO-18 package with parabolic reflector PR and filter W
LEDXXX-NS-TEC – the narrow spectrum LEDs model in TO-5 package with thermocooler TEC, parabolic reflector PR and filter W

Mid infrared IBSG Optoelectronics

WORK PARAMETERS

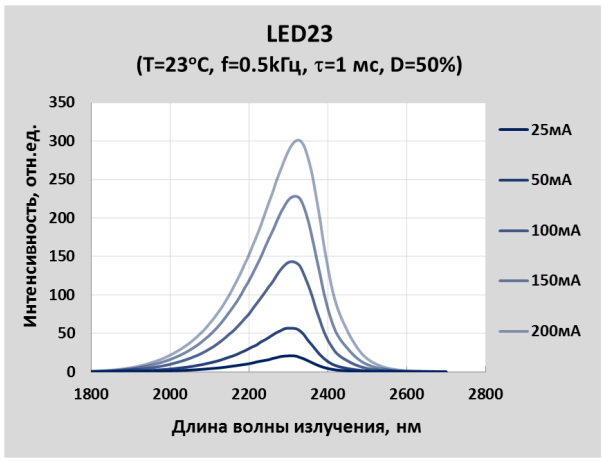
Quasi-CW Operating Mode

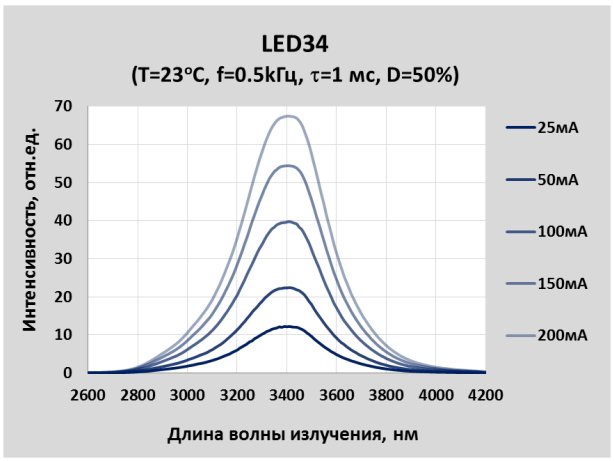
Standard regime of operation:



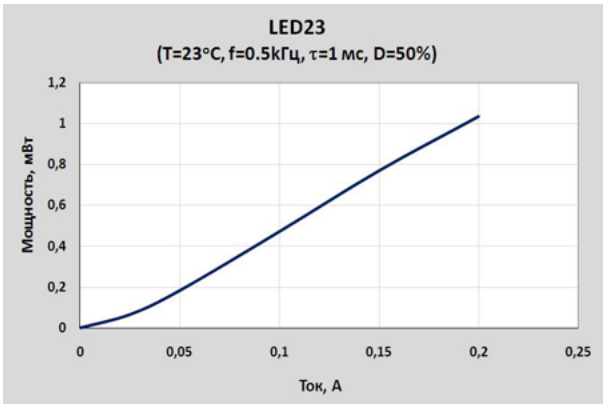
Repetition rate: f = 0.5 - 16 kHz
Pulse spacing: T = 62 - 2000 µs
Pulse duration: τ = 31 - 1000 µs
Current: I = 25 - 220 mA

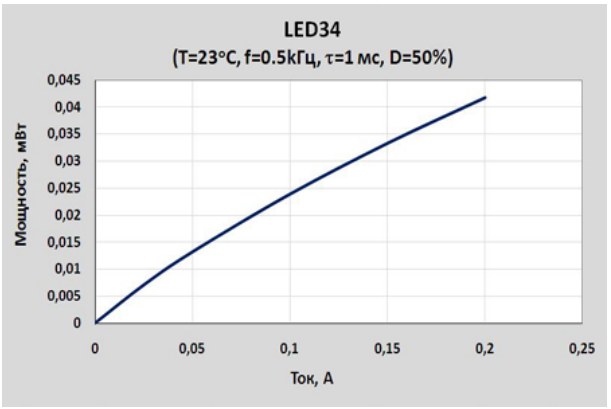
Electroluminescence spectra of LEDs at different currents





Optical power vs. Current

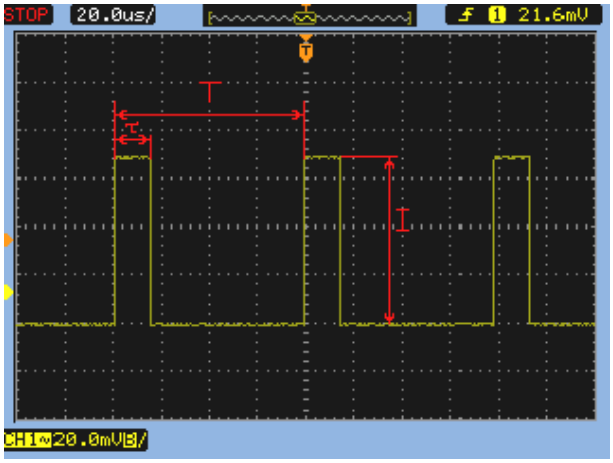




WORK PARAMETERS

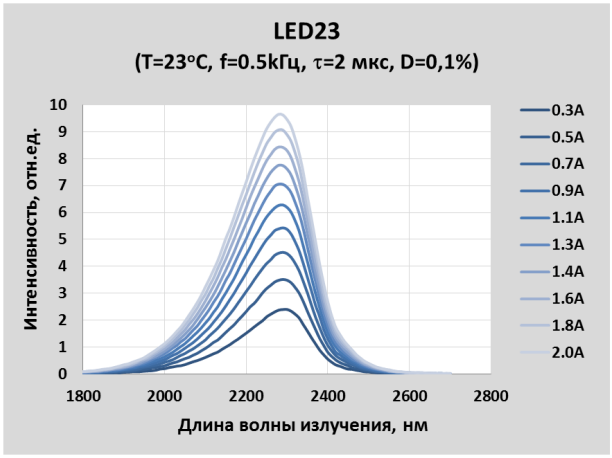
Pulse Operating Mode

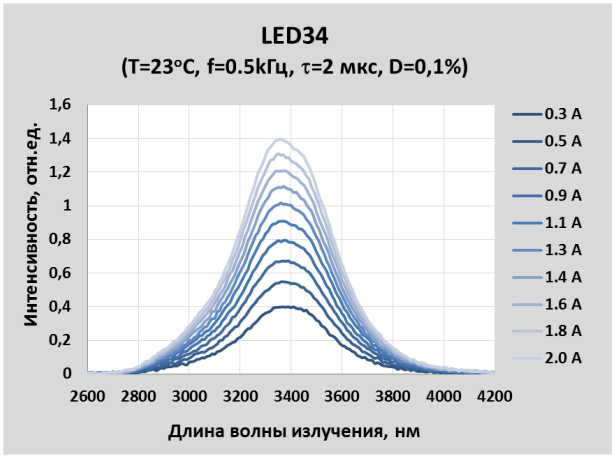
Standard regime of operation:



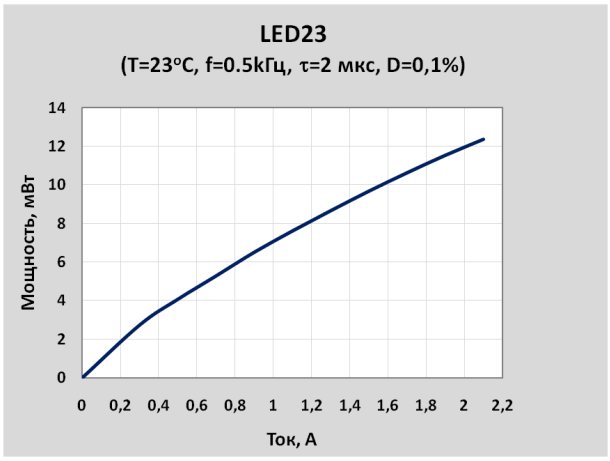
Repetition rate: f = 0.5 - 16 kHz
Pulse spacing: T = 62 - 2000 μs
Pulse duration: τ = 0.6 - 20 μs
Current: I = 0.2 - 2 A

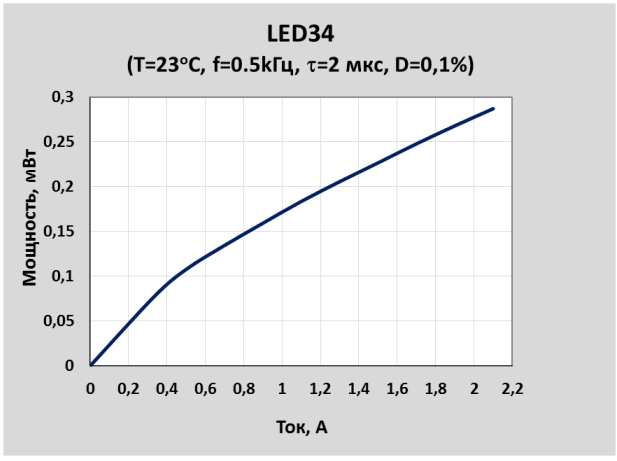
Electroluminescence spectra of LEDs at different currents





Optical power vs. Current

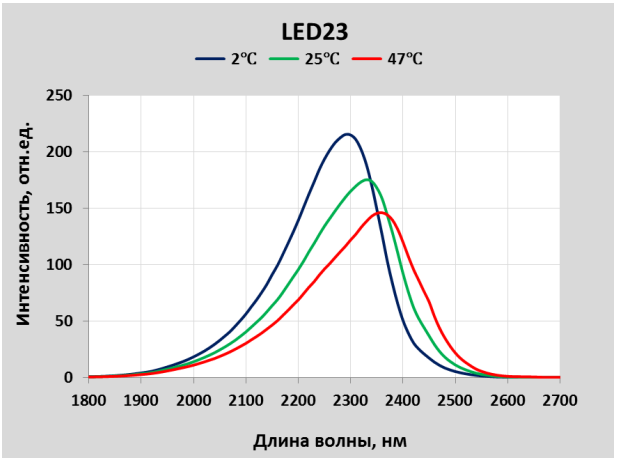


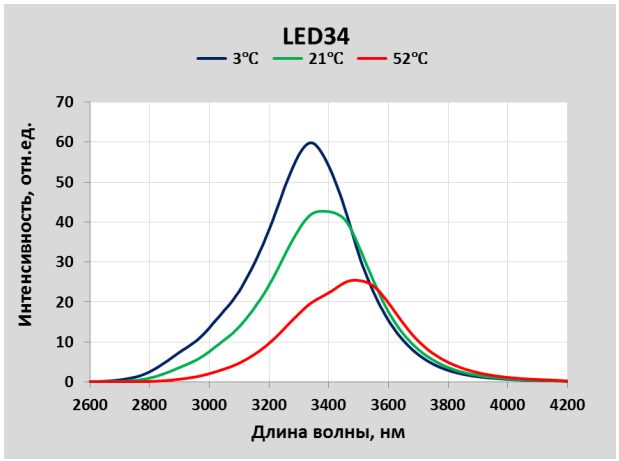


WORK PARAMETERS

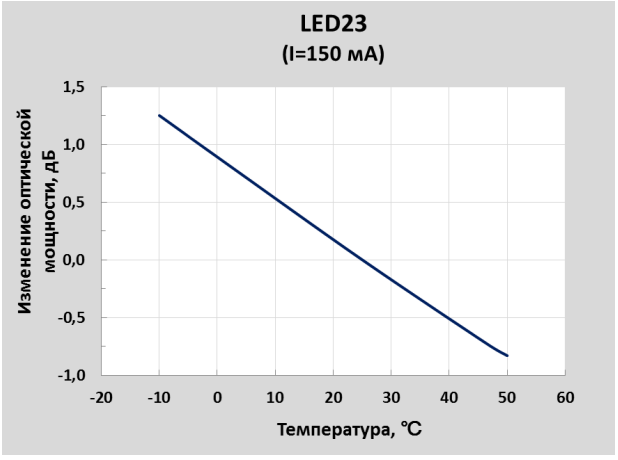
Temperature dependences

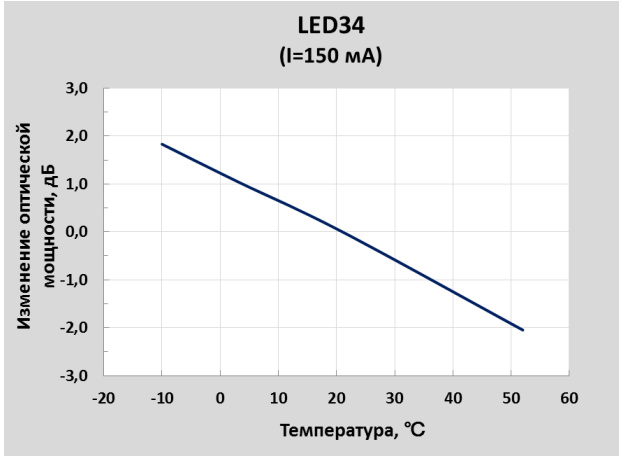
Electroluminescence spectra of LEDs at different temperatures (I = 150 mA, f= 0.5 кHz, D = 50 %)





Optical power vs. temperature

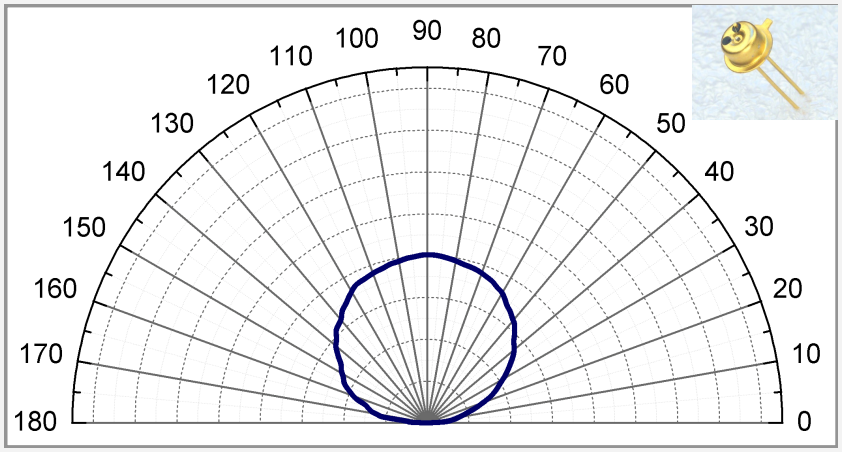




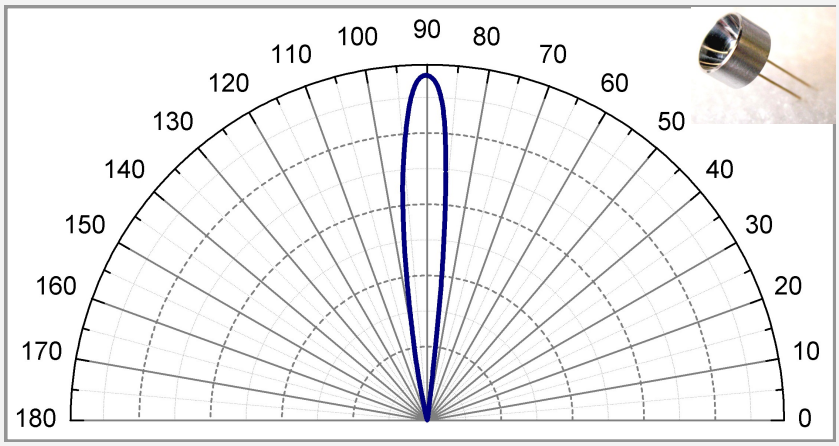
WORK PARAMETERS

Field Pattern

Without parabolic reflector



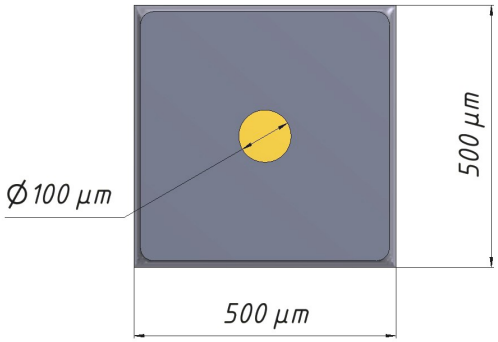
With parabolic reflector

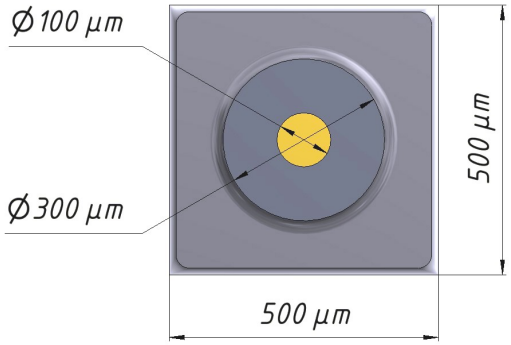


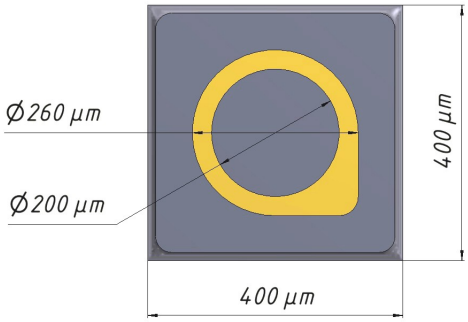
Mid infrared IBSG Optoelectronics

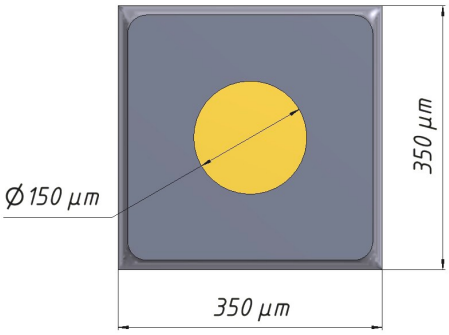
CHIP DESIGN

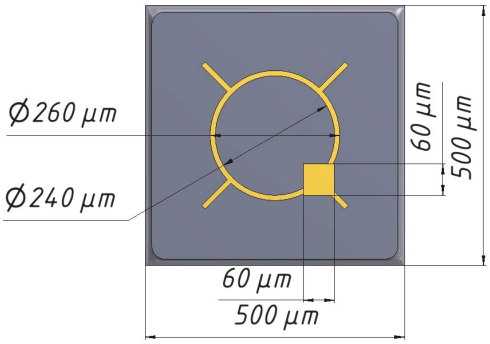
Standard designs



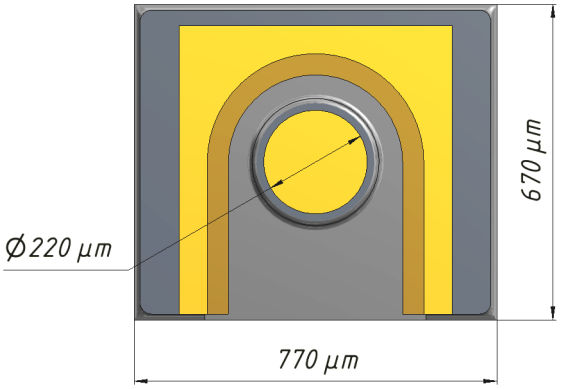


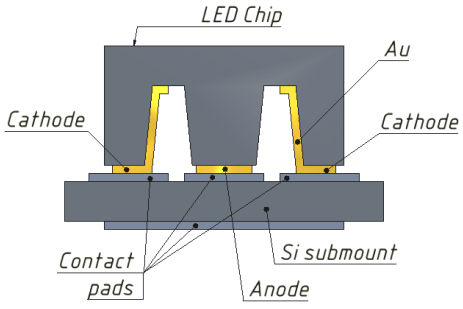






Flip-chip design (by request)

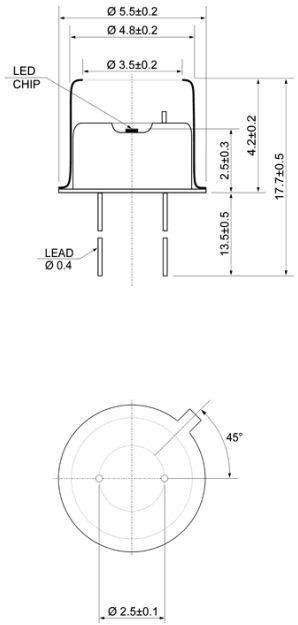




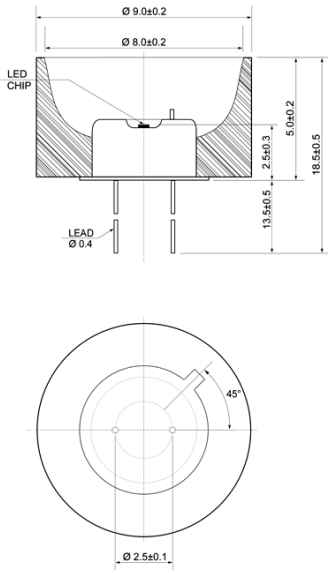
PACKEGES

TO-18

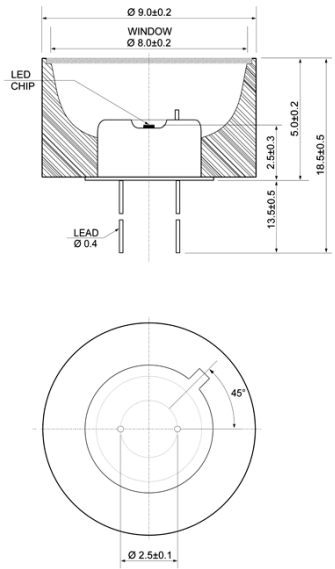
LEDXX



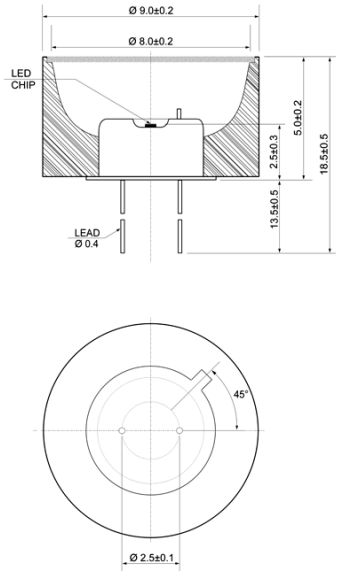
LEDXX-PR



LEDXX-PRW



LED-XXX-NS

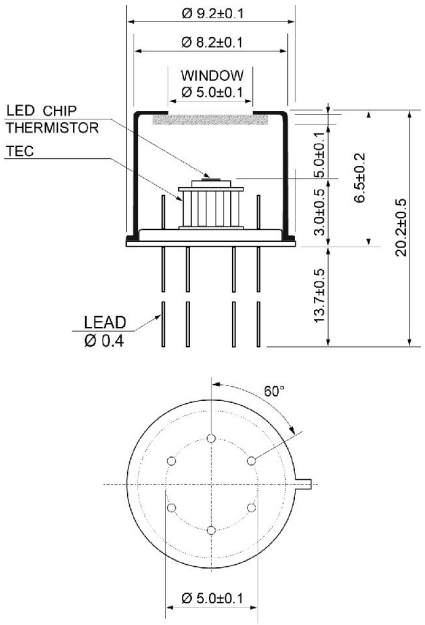


Mid infrared IBSG Optoelectronics

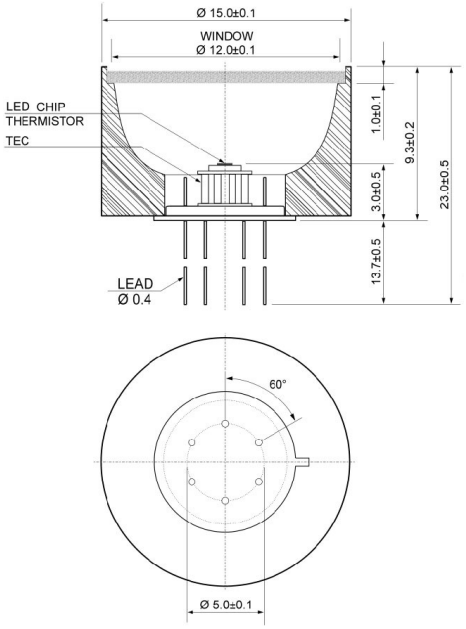
PACKEGES

TO-5

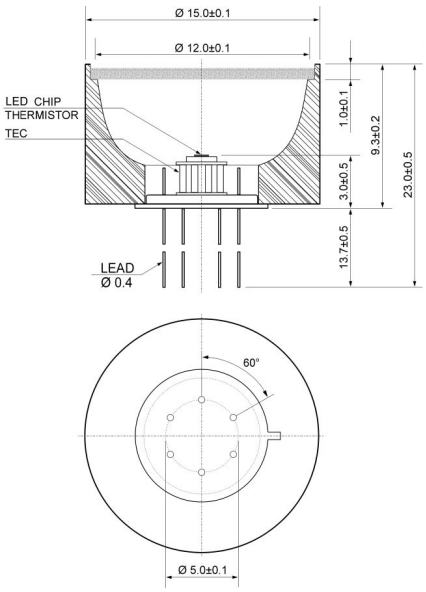
LEDXX-TEC



LEDXX-TEC-PRW



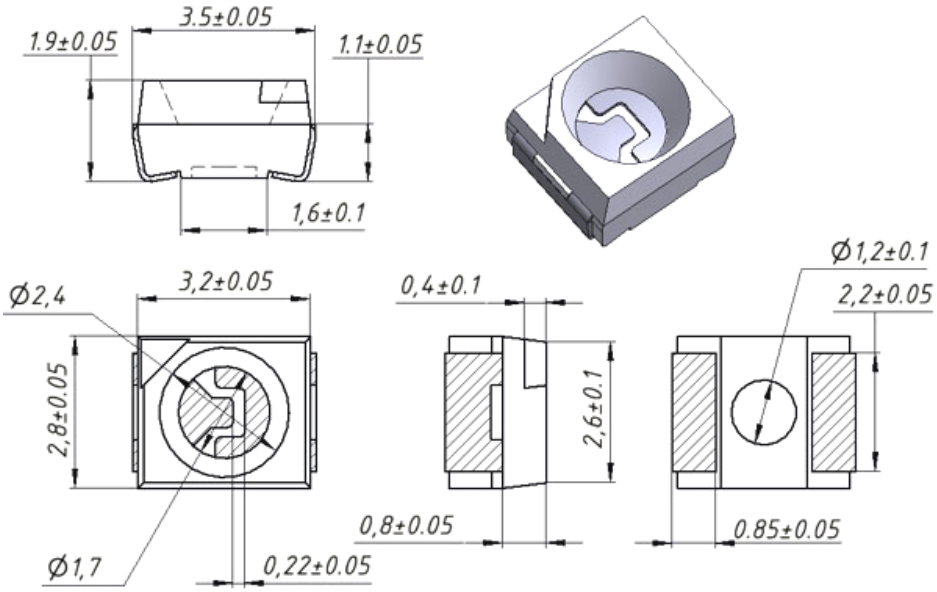
LED-XXX-NS-TEC



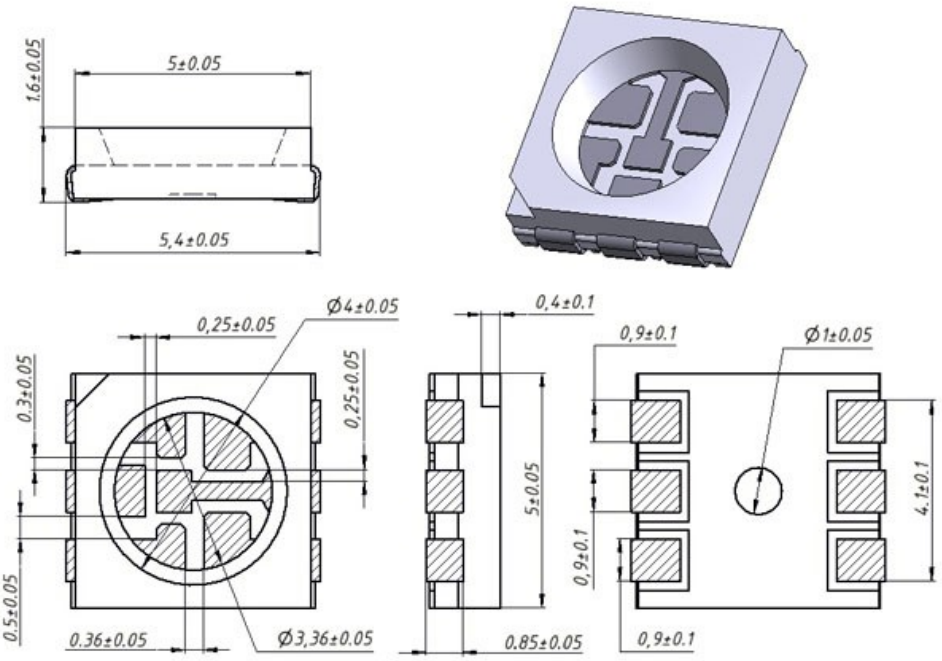
PACKEGES

SMD

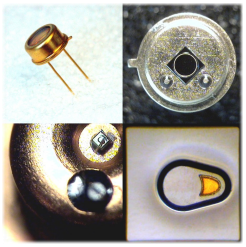
SMD 3528



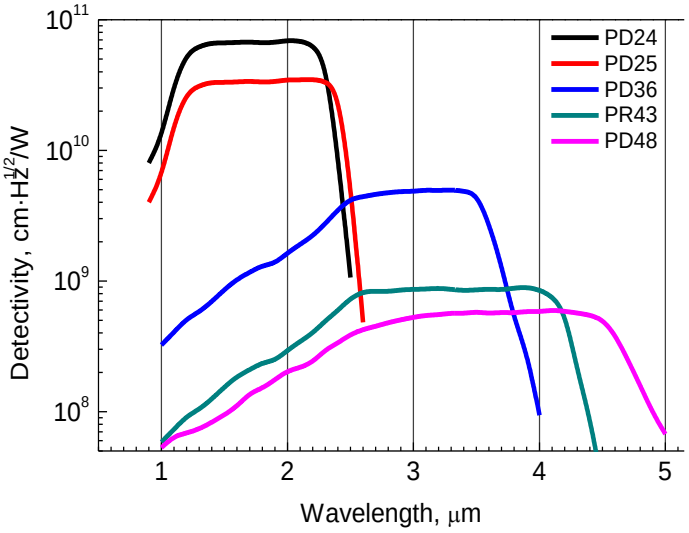
SMD 5050



PHOTODIODES (IR SPECTRAL RANGE)



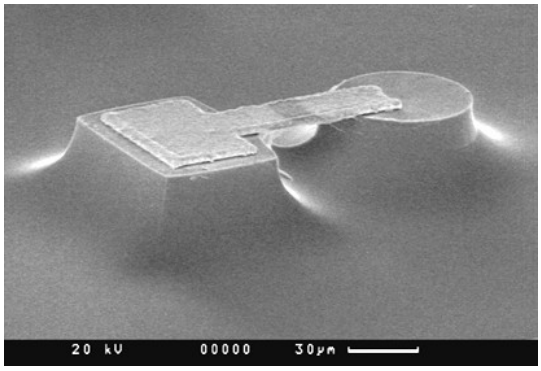
The company IBSG Co., Ltd. in collaboration with the laboratory of Infrared optoelectronics of Ioffe Institute develops and manufactures infrared photodiodes for the spectral range of 2-5 μm. These photodiodes can be applied in cases of environmental monitoring, gas analysis, medicine, etc. With the continued development of manufacturing processes, one of the most important approaches for the preservation of the environment is environmental monitoring. Monitoring includes the task of spectral analysis of the atmosphere in the wavelength range of 2-5 μm, in which there are many absorption lines of industrial gases and other harmful substances. In this spectral range are absorption lines of the water and its vapors, and such gases as ethylene, methane, acetone, sulfur dioxide, carbon monoxide, carbon dioxide, etc. Sensors for CO_2 (4.25 μm) and CO (4.7 μm) determination, which using the manufactured by IBSG Co., Ltd. photodiodes, are also needed for monitoring of exhaled air in medical diagnostics. The unique combination of high performance, high values of detectability and room operating temperature allows the use of the photodiodes and photodiodes-based equipment in a number of applications where the counterparts have inferior parameters or do not meet the operating conditions. It is possible to design sensitive optical sensors for scientific and industrial purposes using the "LED-photodiode" optopairs which are manufactured by the company IBSG.

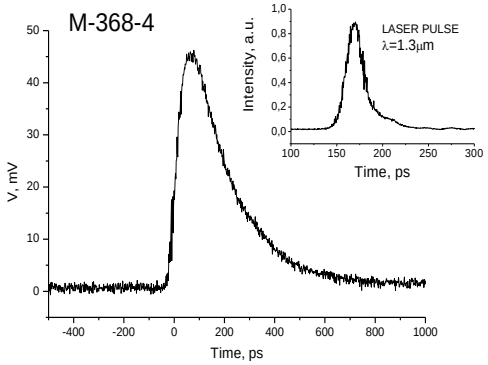


Photodiode models

PDXX-XX – PD model in TO-18 package;
PDXX-XXX-HS – fast PD model in SMA package;
PDXX-XX-HS – fast PD model in TO-18 or TO-46 package;
PDXX-XX-PR – PD model in TO-18 with parabolic reflector PR;
PDXX-XX-PRW – PD model in TO-18 package with parabolic reflector PR and quartz or sapphire window W;
AMPXX-XX – PD model in TO-5 package with thermocooler TEC and a cap;
AMPXX-XX-PRW – PD model in TO-5 package with thermocooler TEC, parabolic reflector PR and quartz or sapphire window W;
AMPXX-XX – PD model with build-in amplifier AMP and thermocooler TEC;
PDXX-XX-NS – PD model with narrow spectrum (NS);
PDXX-XX-WS – PD model with wide spectrum (WS);
PRXX – photoconductive cell model in TO-5 package.

FAST AND ULTRAFAST PHOTODIODES (0.8 - 2.4 μm)





Fast and ultrafast IR photodiodes for the wavelength range of 1.0-2.4 μm have been developed by IBSG Co., Ltd in collaboration with the laboratory of Infrared opto electronics of Ioffe Institute. These GaSb/GaInAsSb/GaAlAsSb-based photodiodes have a separated photosensitive pad (50 or 100 μm in diameter) and a contact pad which are connected by bridge-like frontal contact. The main advantage of the GaSb/GaInAsSb/GaAlAsSb heterostructure is high crystalline quality of epitaxial layers with low density of dislocations (10^4 cm^{-2}). The doping level of the active GaInAsSb layer (up to 10^{14}-10^{15} $см^{-3}$) makes it possible to reach low capacity and high response speed for PDs.

Fast photodiode PD24-01-HS demonstrates self capacitance as low as 0.5-1.9 pF at a reverse bias of 3.0 V due to low doping level of the active GaInAsSb layer (up to 10^{14}-10^{15} $см^{-3}$). The response speed of the *p–i–n* photodiodes was studied under conditions of their excitation by radiation pulses of a semiconductor laser operating at λ=1.3 μm with a pulse full width at half maximum (FWHM) of 25 ps. The response speed has a value of $\tau_{0.1\text{-}0.9}$=130–150 ps. The bandwidth of photodiodes is 2 GHz .

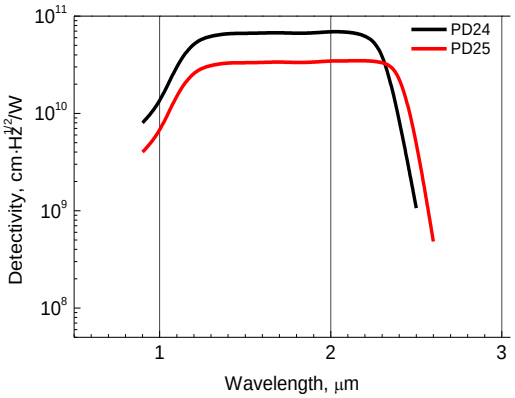
Ultrafast photodiode PD24-005-HS has self capacitance as low as 0.5-0.9 pF at a reverse bias of 3.0 V due to low doping level of the active GaInAsSb layer (up to 10^{14}-10^{15} $см^{-3}$), as well as unique design of a chip with a separated photosensitive pad (50 or 100 μm in diameter) and a contact pad which are connected by bridge-like frontal contact. The response speed of the *p–i–n* photodiodes was studied under conditions of their excitation by radiation pulses of a semiconductor laser operating at λ=1.3 μm with a pulse full width at half maximum (FWHM) of 25 ps. Speed of response has a value of $\tau_{0.1\text{-}0.9}$=50-100 ps. The bandwidth of photodiodes reaches 5 GHz. Photodiodes exhibit low magnitude of reverse dark current (I_D=200-1500 nA) at reverse bias U = –(0.5–3.0) V, high values of current monochromatic sensitivity S_I=1.10-1.15 A/W and specific detection ability $D^*(\lambda_{max},1000,1)=0.9\cdot10^{11}$ $W^{-1}/Hz^{1/2}\cdot cm$ in the spectral interval of 2.0-2.2 μm.

Series	Model	Sensitive Area Diameter (μm)	Package	Wavelength Range (μm)	Detectivity $D^*(\lambda_{max},1000,1)$ $(cm\cdot Hz^{1/2}/W)$	Bandwidth Δf (GHz)
PD24 (fast)	PD24-005-HS	0.05	SMA	0.8-2.4	$(5\text{-}9)\cdot10^{10}$	5
	PD24-01-HS	0.1	TO-18			2
	PD24-01-HS*		TO-46			

PDXX-XXX-HS – fast PD model in SMA package;
PDXX-XX-HS – fast PD model in TO-18 or TO-46 package.

Mid infrared IBSG Optoelectronics

PHOTODIODES (0.8 - 2.5 µm)

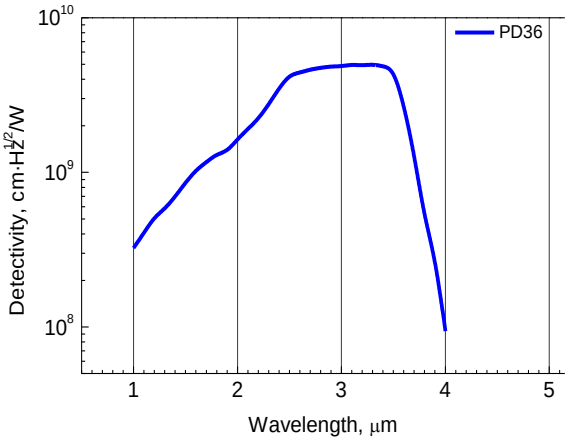


The PD24 and PD25 series of photodiodes for 0.8-2.5 µm spectral range are produced on the base of the GaSb/GaInAsSb/GaAlAsSb heterostructure. The main advantage of this heterostructure is high crystalline quality of etataxial layers with low density of dislocations (10^4 cm^{-2}). The doping level of the active GaInAsSb layer (up to 10^{14}-10^{15} $см^{-3}$) makes it possible to reach low capacity and high speed of response for PDs. Photodiodes are manufactured with the sensitive area diameters from 50 µm to 3 mm. PDs with a sensitive area of 50-100 µm in diameter are fast (ultrafast).

Series	Model	Sensitive Area Diameter (µm)	Package	Wavelength Range (µm)	Detectivity D*(λ_{max},1000,1) ($cm \cdot Hz^{1/2}/W$)
PD24 (fasr)	PD24-005-HS	0.05	SMA	0.8-2.4	$(5\text{-}9)\cdot10^{10}$
	PD24-01-HS	0.1	TO-18		
	PD24-01*		TO-46		
PD24	PD24-01-PR PD24-01-TEC PD24-01-TEC-PR	0.1	TO-18 TO-5		
	PD24-02 PD24-02-PR PD24-02-TEC PD24-02-TEC-PR	0.2	TO-18 TO-5		
	PD24-03 PD24-03-PR PD24-03-TEC PD24-03-TEC-PR	0.3	TO-18 TO-5		
	PD24-05 PD24-05-PR PD24-05-TEC PD24-05-TEC-PR AMP24-05 (with PD24-05)	0.5	TO-18F TO-5 TO-8		
	PD24-10 PD24-10-PR PD24-10-TEC PD24-10-TEC-PR AMP24-10 (with PD24-10)	1.0	TO-18FM TO-5 TO-8		
	PD24-20 PD24-20-TEC PD24-20-TEC-PR AMP24-20 (with PD24-20)	2.0	TO-5 TO-8		
	PD24-28	2.8	TO-5		
PD25	PD25-03 PD25-03-PR PD25-03-TEC PD25-03-TEC-PR	0.3	TO-18 TO-5	0.8-2.55	$(1\text{-}5)\cdot10^{10}$
	PD25-05 PD25-05-PR PD25-05-TEC PD25-05-TEC-PR	0.5	TO-18F TO-5 TO-8		
	PD25-10 PD25-10-PR PD25-10-TEC PD25-10-TEC-PR	1.0	TO-18FM TO-5 TO-8		

- PD24 series for 0.8-2.4 µm spectral range
- PD25 series for 0.8-2.55 µm spectral range

PHOTODIODES (1.5 - 3.8 µm)



The PD36 series of photodiodes for 1.5-3.8 µm spectral range are produced on the base of the InAs/InAsSbP heterostructure. The main advantage of this heterostructure is high crystalline quality of epitaxial layers with low density of dislocations (10^4 cm^{-2}). The doping level of the active GaInAsSb layer (up to 10^{15}-10^{16} $см^{-3}$) makes it possible to reach low capacity and high response speed for PDs. Photodiodes are manufactured with the sensitive area diameters from 100 µm to 2 mm.

Series	Model	Sensitive Area Diameter (µm)	Package	Wavelength Range (µm)	Detectivity $D^*(\lambda_{max},1000,1)$ ($cm \cdot Hz^{1/2}/W$)
PD36	PD36-01 PD36-01-PR PD36-01-TEC PD36-01-TEC-PR	0.1	TO-18 TO-5	1.0-3.6 (3.8)	$(3\text{-}6)\cdot10^9$
	PD36-02 PD36-02-PR PD36-02-TEC PD36-02-TEC-PR	0.2	TO-18 TO-5		
	PD36-03 PD36-03-PR PD36-03-TEC PD36-03-TEC-PR	0.3	TO-18 TO-5		
	PD36-05 PD36-05-PR PD36-05-TEC PD36-05-TEC-PR AMP36-05 (with PD36-05)	0.5	TO-18F TO-5 TO-8		
	PD36-10 PD36-10-PR PD36-10-TEC PD36-10-TEC-PR	1.0	TO-18 TO-5 TO-8		
	PD36-20 PD36-20-TEC PD36-20-TEC-PR	2.0	TO-5 TO-8		

PDXX-XX – PD model in TO-18 package;
PDXX-XXX-HS – fast PD model in SMA package;
PDXX-XX-HS – fast PD model in TO-18 or TO-46 package;
PDXX-XX-PR – PD model in TO-18 with parabolic reflector;
PDXX-XX-PRW – PD model in TO-18 package with parabolic reflector PR and quartz or sapphire window W;
PDXX-XX-TEC – PD model in TO-5 package with thermocooler TEC and a cap;
PDXX-XX-TEC-PRW – PD model in TO-5 package with thermocooler TEC, parabolic reflector PR and quartz or sapphire window W;
AMPXX-XX – PD model with build-in amplifier AMP and thermocooler TEC.

PHOTODIODES (1.5 - 3.8 µm)

Results of independent test by Opto-Electronic Components

Mid infrared IBSG Optoelectronics

OEC Opto-Electronic Components

TÜV ISO 9001

YOUR PARTNER

Test Results — IR detector PD36-03

General

The photodiodes are intended to be used as an alternative to InAs or PbS. Both, InAs and PbS have more and more limited market chances for different reasons. InAs is expensive and limited in availability, PbS requires a chopper and suffers from long term stability. So it is hoped that the new type of detector may show a way into a more reasonable "1µm - 3,5µm detector" future.

Test data

Data in "( )" show manufacturer data, Test data @ +23°C

Parameter	Condition	Detector No 03006	03007	03008	Units
Spectral range		(2,2 – 3,6)	(2,2 – 3,6)	(2,2 – 3,6)	µm
Peak response range		(2,4 – 3,5)	(2,4 – 3,5)	(2,4 – 3,5)	µm
Active area		(0,3) however, it is shadowed by a large bond pad so the useful active area is smaller	(0,3)	(0,3)	mm dia
R-Shunt	10mV	2,3 (1,0) Where does the difference come from?	3,8 (1,4)	3,4 (1,1)	kOhm
Dark current	0,1V	27	10	12,5	µA
	0,2V	66 (80)	28 (60)	36 (80)	µA
	0,4V	400 (230)	150 (180)	280 (230)	µA
	0,6V	1500 (480) ↓ This a very high change	380 (300)	700 (400)	µA
Noise	0V, 1-3 KHz	2,7 ↓	2,3 ↓	2,5 ↓	pA/√Hz
Noise	10mV, 1-3KHz	7 This is a very high change	2,3 good	2,5 good	pA/√Hz
Responsivity	3,4µm, 0,1V bias	(1,1)	(1,1)	(1,1)	A/W
Rise / Fall Time	50 Ohm, 0V 10%-90%	(25)	(25)	(25)	ns, max
Temperature coefficient		(2,7)	(2,7)	(2,7)	nm/°C
D*	(peak, 1-3KHz, 1Hz)	1,08*10E10	1,27*10E10	1,17*10E10	Jones

Other aspects:

a) Using a modulated LED, 900nm some mW, the detectors operated with a trans-impedance amplifier (TIA) show a reasonable output signals

b) Using a the 3 IR LEDs as a light source, 3,6µm some µW, the detectors operated with the TIA are not able to detect a signal. So a special test set-up would be required. Still this is plausible as well.

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TÜV ISO 9001

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Test Results — IR detector PD36-03

c) The R-Shunt data is better than shown in the data sheet. Assuming the data 1,1A/W responsivity is correct, the D* data can be calculated. The D* data appear to be better than the ones for InAs.

d) The detector with the serial No 03006 appears to have a defect / anomally on noise and dark current

e) The detectors are suitable for 0V bias, however, shall be tested for dark current and noise at 0V and 10mV bias for quality assurance reasons

f) a 1mm detector with a TE2 cooler ought to be tested to find out about acciove area and data at various temperature levels thus to verify the suitability of being an alternative to InAs or PbS

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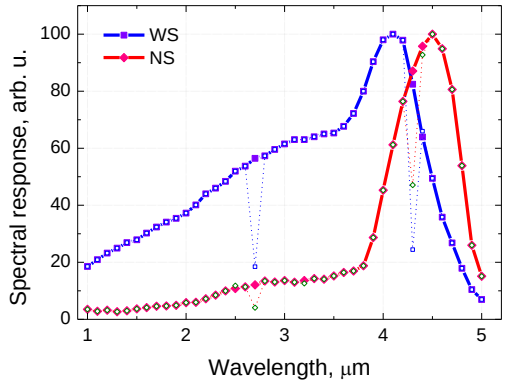
PHOTODIODES (1.0 - 4.9 µm)

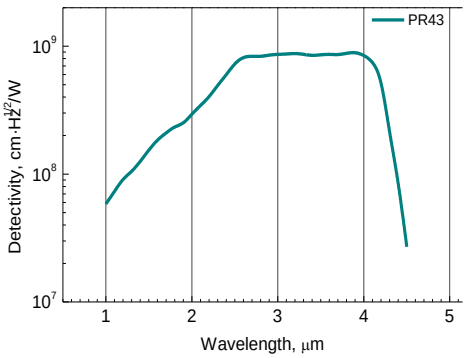


The PD48 series of photodiodes for 1.0-4.9 µm spectral range are produced on the base of the InAs/InAs$_{0.88}$Sb$_{0.12}$/InAsSbP/InAs heterostructure. With the continued development of manufacturing processes, one of the most important approaches for the preservation of the environment is environmental monitoring. Monitoring includes the task of spectral analysis of the atmosphere in the wavelength range of (2-5) µm, in which there are many absorption lines of industrial gases and other harmful substances. In this spectral range are absorption lines of the water and its vapors, and such gases as ethylene, methane, acetone, sulfur dioxide, carbon monoxide, carbon dioxide, etc. Sensors for CO_2 (4.25 µm) and CO (4.7 µm) determination are extremely needed for monitoring of exhaled air in medical diagnostics. The photodiodes of the PD48 series are manufactured with both narrow spectrum (PD48-NS) for 2.5-4.9 µm spectral range and wide spectrum (PD48-WS) for 1.0-4.8 µm spectral range.

Series	Model	Sensitive Area Diameter (µm)	Package	Wavelength Range (µm)	Detectivity D*(λ$_{max}$,1000,1) (cm·Hz$^{1/2}$/W)
PD48	PD48-03-NS PD48-03-NS-PR PD48-03-NS-TEC PD48-03-NS-TEC-PR	0.3	TO-18 TO-18 TO-5 TO-5	2.5-4.9	(5-8)·10^8
	PD48-05-WS PD48-05-WS-PR PD48-05-WS-TEC PD48-05-WS-TEC-PR	0.5×0.5 (square)	TO-18F TO-18F TO-5 TO-5	1.0-4.8	(5-9)·10^8

- PD48 (-NS) for 2.5-4.9 µm spectral range
- PD48 (-WS) for 1.0-4.8 µm spectral range

PHOTOCONDUCTIVE CELL (1.0 - 4.5 µm)

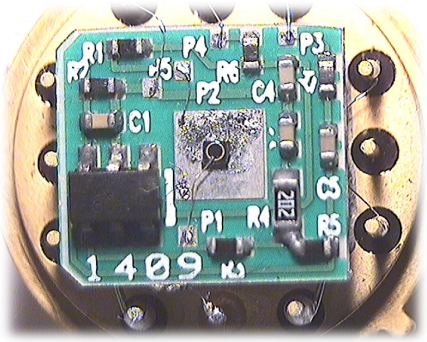


The PD43 series of photoconductive cell for 1.0-4.5 µm spectral range operates in photoconductivity mode at bias voltage.

Series	Model	Sensitive Area Diameter (µm)	Package	Wavelength Range (µm)	Detectivity D*(λ$_{max}$,1000,1) (cm·Hz$^{1/2}$/W)
PR43 (photoconductive cell)	PD43	2.0×2.0 (square)	TO-5	1.0-4.5	(4-9)·10^8 D*(573 K, 1200,100)

Mid infrared IBSG Optoelectronics

PHOTODIODES with BUILT-IN AMPLIFIER for 0.8 - 2.4 µm (AMP24) and 1.0 - 3.8 µm (AMP36) SPECTRAL RANGES



Photodiodes with built-in amplifier AMP24 and AMP36 consist of a photodiode (the diameter of sensitive area is from 0.5 µm to 2.0 mm), an amplifier, a single-stage thermoelectric cooler (TEC) and a thermistor for controlling temperature. Components are mounted in the standard 15.2 mm TO-8 package. AMP24 and AMP36 with multistage TEC can be manufactured on request.

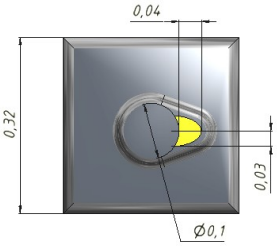
The main advantages of AMP24 and AMP36 are small size and enhanced dynamic range. Fast response makes it possible to detect modulated radiation of laser diodes (LDs) and light-emitting diodes (LEDs). AMPXX allows the detection of an optical signal with bandwidth from 150 GHz to 350 kGHz.

Series	Model	Sensitive Area Diameter, mm	Package	Wavelength Range (µm)	Detectivity ($cm \cdot Hz^{1/2}/W$)
AMP24	AMP24-05	0.5	TO-8	0.8-2.4	$(5\text{-}9)\cdot10^{10}$
	AMP24-10	1.0			
	AMP24-20	2.0			
AMP36	AMP36-05	0.5		1.0-3.6 (3.8)	$(3\text{-}6)\cdot10^{9}$
	AMP36-10	1.0			

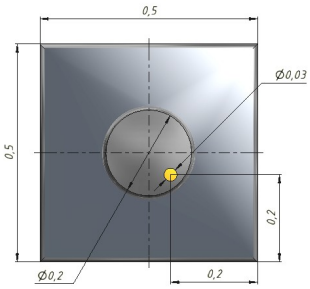
AMPXX-XX (with PDXX-XX) – PD model with build-in amplifier AMP and thermocooler TEC

Photodiode chip design

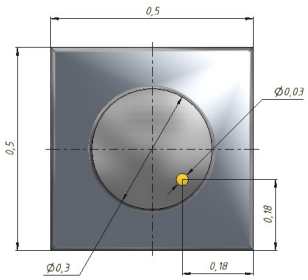
PDXX-01



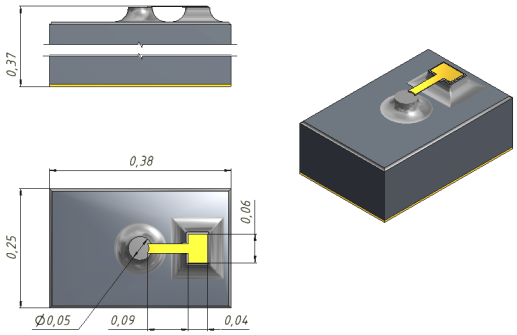
PDXX-02



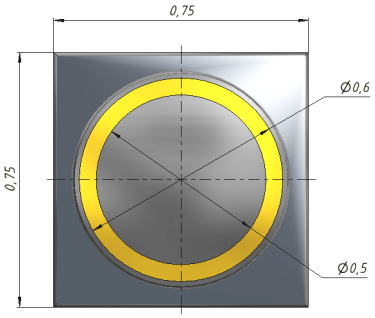
PDXX-03



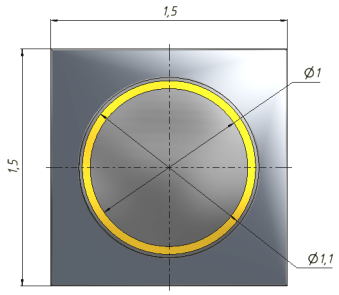
PDXX-005



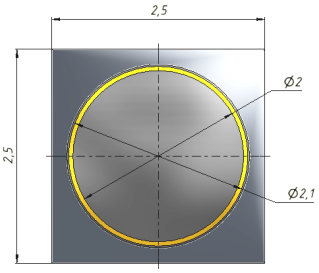
PDXX-05



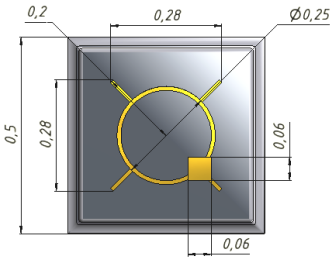
PDXX-10



PDXX-20

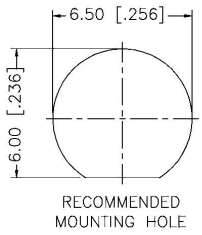


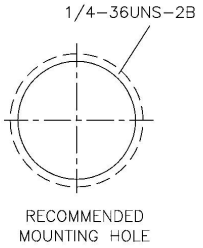
PDXX-05

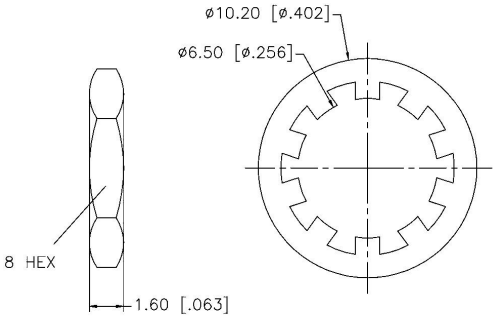


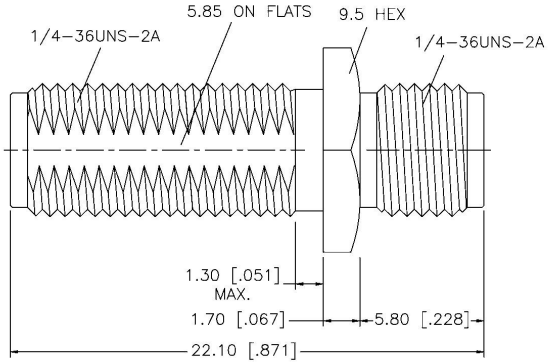
PACKEGES

SMA





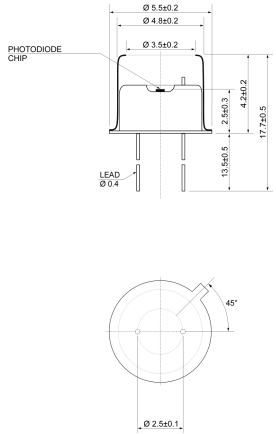




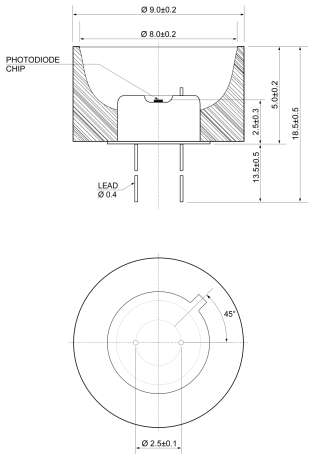
PACKAGES

TO-18

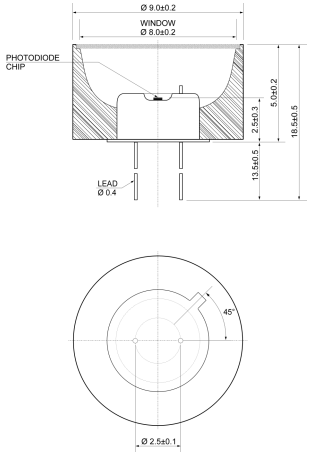
TO-18



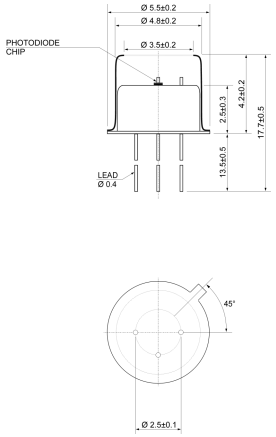
TO-18 (with PR)



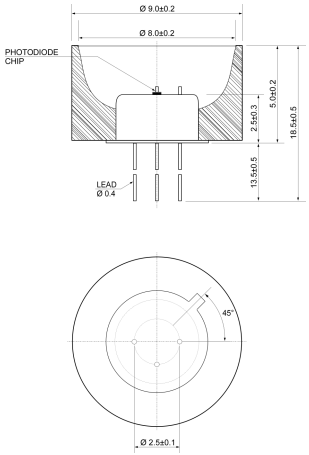
TO-18 (with PRW)



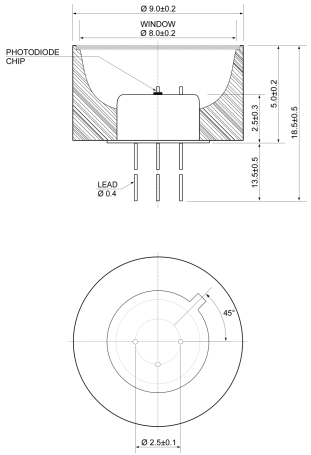
TO-18F



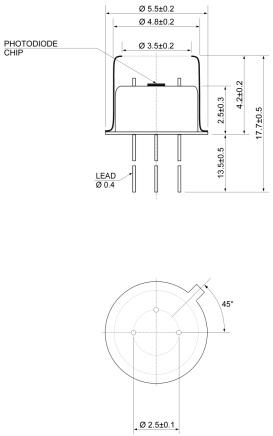
TO-18F (with PR)



TO-18F (with PRW)



TO-18FM



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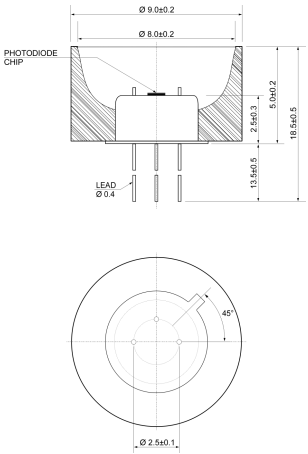

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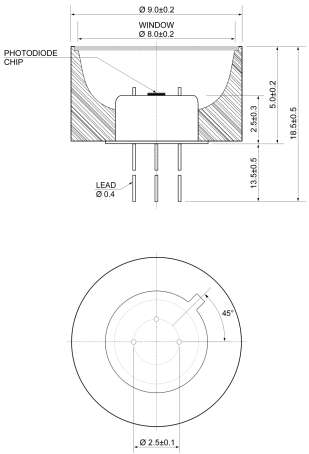
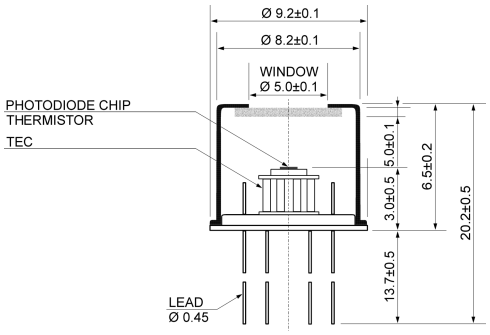
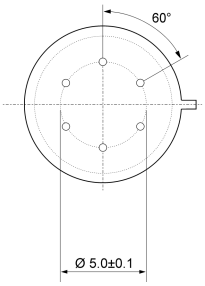


PACKAGES

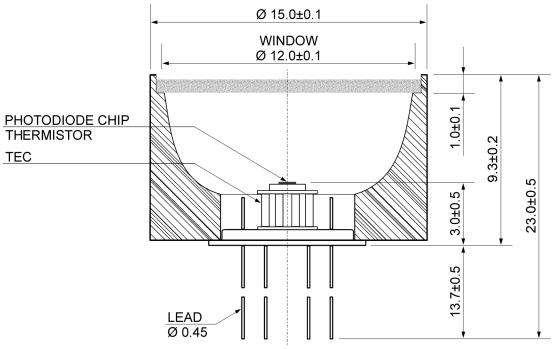
TO-5

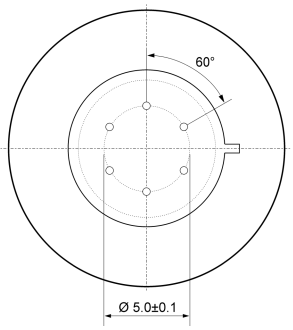
TO-5 (with TEC)





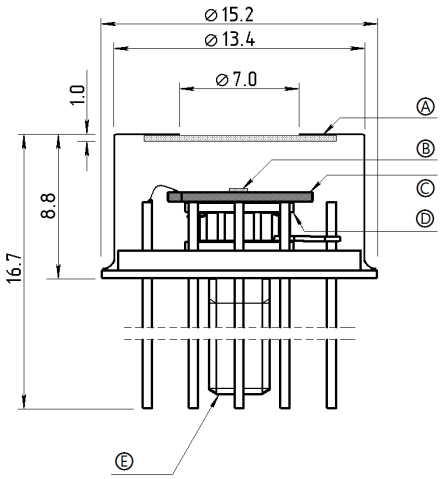
TO-5 (with TEC and PRW)

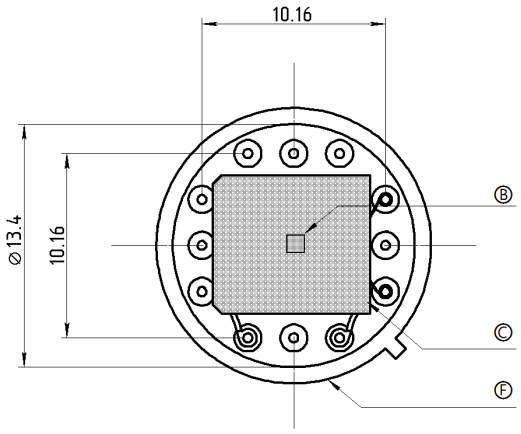




TO-8

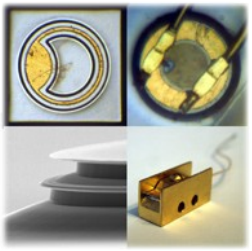
TO-8 (with TEC)





Ⓐ - Window
Ⓑ - Photodiode chip
Ⓒ - Pre-amplifier
Ⓓ - TEC 1MC06-018-08
Ⓔ - 4-40 UNC
Ⓕ - TO-8 12-pin header

LASERS (IR SPECTRAL RANGE)



Laser diodes IR-WGM-20…IR-WGM-30 and FP318…FP360 have been developed for the spectral ranges of 2.00-3.03 μm and 3.04-3.60 μm, respectively. The III-V-based laser heterostructures were grown by LPE MBE and MOCVD techniques in the InAs-GaSb system. The tunable lasers can be applied in DL spectroscopy for measuring the concentration of such industrial and noxious gases as NH_4, H_2S, HCHO, CH_3Cl and others. This type of laser diodes makes it possible to design compact gas sensors with record values of selectivity and sensitivity (at ppb). The models IR-WGM-20…IR-WGM-30 and FP318…FP360 are also promising for medical applications and fiber optics.

FABRY-PEROT LASER DIODES FOR SPECTRAL RANGE OF 2.0 - 2.3 μm

Lasers 2.0 - 2.3 μm	Wavelength (μm)	Threshold current I_{th} (mA)	Operating Temperature T_{op} (°C)		Type of resonator	Package
			QCW	Pulse		
LD-200	1.994	60	20 - 130	20 - 150	FP	TO-8-TEC
LD-200	1.9854	30				
LD-200	2.0009	30				
LD-200	2.0054	30				
LD-230	2.272	60				
LD-230	2.282	40				
LD-230	2.287	50				
LD-230	2.289	30				
LD-230	2.296	40				

WGM LASERS FOR SPECTRAL RANGE OF 2.0 - 2.3 μm

Lasers 3.01 - 3.08 μm	Wavelength (μm)	Threshold current I_{th} (mA)	Operating Temperature T_{op} (°C)		Type of resonator	Package
			QCW	Pulse		
LD-20 W-300	1.98 - 2.04	1.0 - 2.0 (A)	20 - 150	20 - 170	WGM	TO-18, LP
LD-23 W-100	2.22 - 2.27	10 - 70				
LD-23 W-200	2.23 - 2.26	20 - 100				
LD-23 W-300	2.24 - 2.28	40 - 150				

QCW-Mode - repetition rate 8 kHz, pulse duration 62 μs, fill factor 50%
Pulse Mode - repetition rate 8 kHz, pulse duration 2 μs, fill factor 0.1%

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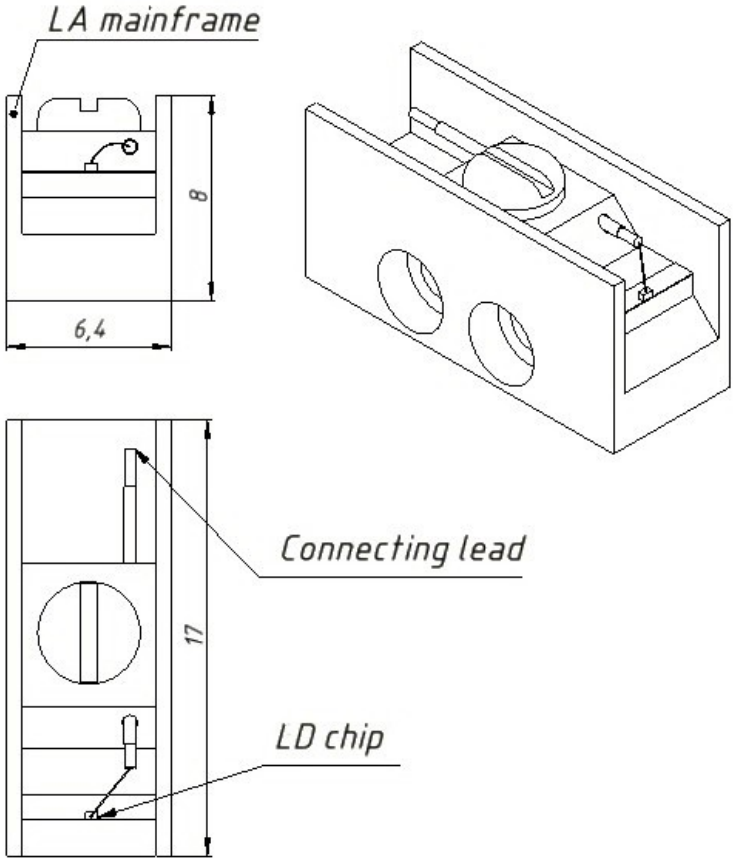
FABRY-PEROT LASER DIODES FOR SPECTRAL RANGE OF 2.9 - 3.6 µm

Lasers 2.9 - 3.6 µm	Wavelength (µm)	Threshold current I_{th} (mA)	Operating Temperature T_{op} (°C)		Type of resonator	Package
			QCW	Pulse		
LD-290	2.94	40	77 - 100	77 - 150	FP	LA
LD-290	2.94	60				
LD-310	3.13	90				
LD-310	3.18	60				
LD-310	3.195	70				
LD-310	3.16	70				
LD-320	3.23	70				
LD-320	3.202	60				
LD-320	3.21	40				
LD-320	3.255	60				
LD-320	3.25	50				
LD-320	3.25	60				
LD-330	3.30	100				
LD-360	3.59	60				
LD-360	3.56	100				

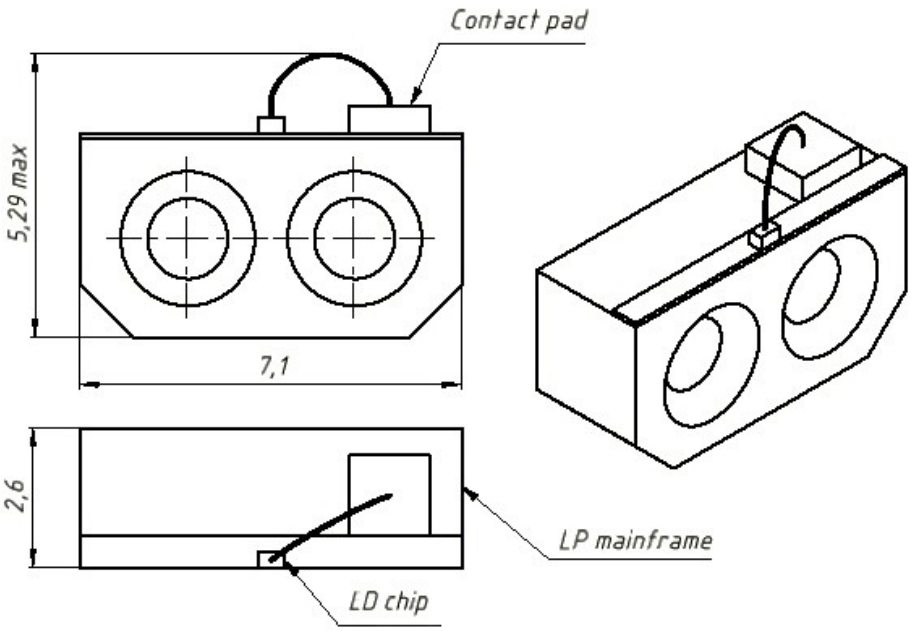
QCW-Mode - repetition rate 8 kHz, pulse duration 62 µs, fill factor 50%
Pulse Mode - repetition rate 8 kHz, pulse duration 2 µs, fill factor 0.1%

PACKEGES

LA



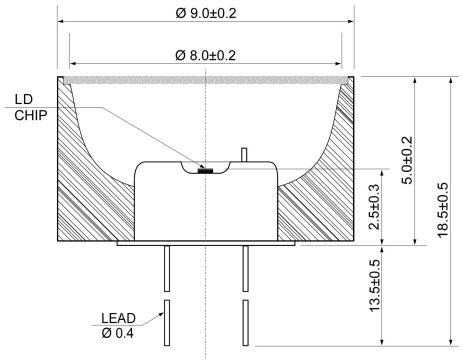
LP

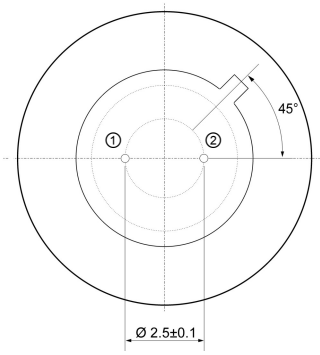


Mid infrared IBSG Optoelectronics

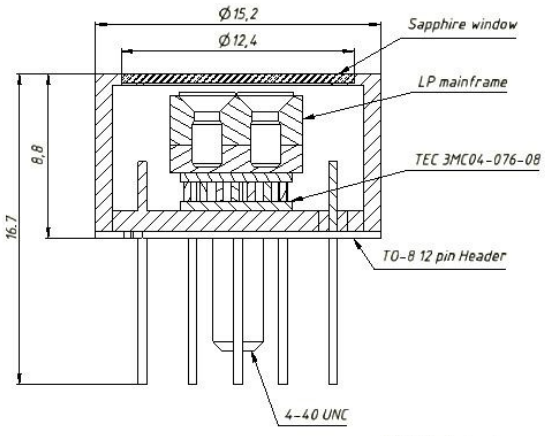
PACKAGES

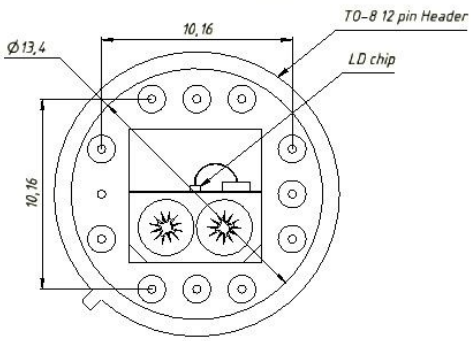
TO-18





TO-8





ELECTRONICS

LED Drivers

Driver	Compatible devices
mD-1c	LEDXX LEDXX-PR LEDXX-PRW
mD-1p	LEDXX LEDXX-PR LEDXX-PRW
D-31M	LEDXX LEDXX-PR LEDXX-PRW
DLT-27M	LEDXX-TEC LEDXX-TEC-PRW
DLT-37M	LEDXX-TEC LEDXX-TEC-PRW

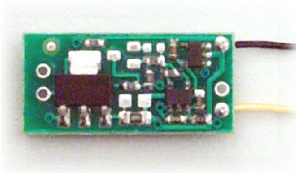
Photodiode Amplifiers

Amplifier	Compatible devices
AM-07M	PDXX-XX PDXX-XX-PR PDXX-XX-PRW PDXX-XX-NS PDXX-XX-WS
AMT-07M	PDXX-XX-TEC PDXX-XX-TEC-PRW PDXX-XX-NS-TEC PDXX-XX-NS-TEC-PRW PDXX-XX-WS-TEC PDXX-XX-WS-TEC-PRW

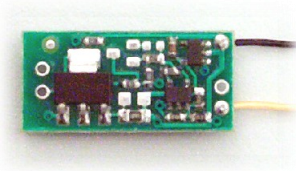
Mid infrared IBSG Optoelectronics

ELECTRONICS

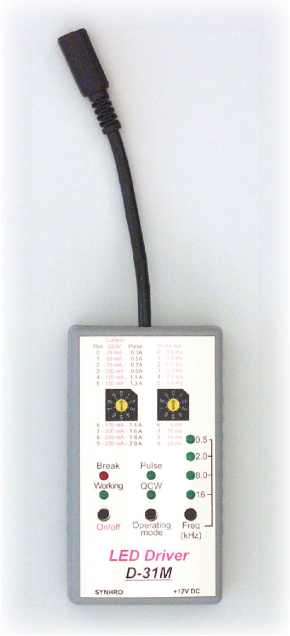
LED Drivers (descriptions)



LED driver mD-1c generates symmetrical unipolar meander (quasi-continuous mode). This mode provides maximum average optical power from the LED. Signal data (such as amplitude, repetition rate and pulse duration) remains steady while the input voltage may vary from 5 to 6 voltage.



The driver mD-1p generates sequence of pulses (pulse mode). This mode provides maximum peak optical power from the LED. Signal data (such as amplitude, repetition rate and pulse duration), remains steady while the input voltage may vary from 5 to 6 voltage.



Driver D-31M provides two modes of operation:

1. Quasi Continuous Wave (qCW)(quasi steady-state) mode:This mode provides maximum average optical power from the LED. Current can be changed in the range 25-250 mA. One of four frequences (0.5 kHz, 2 kHz, 8 kHz and 16 kHz) can be selected.

2. Pulse mode: This mode provides maximum peak optical power from the LED. In this mode in addition to adjusting of frequency, pulse duration can be also selected in the range 0.6-20 µs. Peak current can be changed in the range 0-2 A.

Please, don't use combination of frequency and pulse duration that gives duty cycle >10%. We recommend using 2 A pulse current only at pulse duration <1 µs.

ELECTRONICS

LED Drivers (descriptions)

Driver DLT-27M is designed for power supply of all models Mid-IR LED's with built-in thermocoolers. Driver provides two modes of operation:

1. Quasi Continuous Wave (quasi steady-state) mode. Such mode provides maximum average optical power from the LED. Current in this mode can be changed in the range 20-250 mA. Frequence of modulation is 16 kHz.

2. Pulse mode. Such mode provides maximum peak optical power from the LED. Peak current in pulse mode can be changed in the range 0-2 A. Pulse duration is 1 µs. Temperature controller that is built in DLT-27M provides selecting and stabilizing of the temperature on LED's chip in wide range. That gives possibility to tune wavelength or optical power.

Driver DLT-37M is designed for power supply of all models Mid-IR LED's with built-in thermocoolers. Driver provides two modes of operation:

1. Quasi Continuous Wave (quasi steady-state) mode. Such mode provides maximum average optical power from the LED. Current in this mode can be changed in the range 20-250 mA. One of four frequences (2 kHz, 4 kHz, 8 kHz and 16 kHz) can be selected.

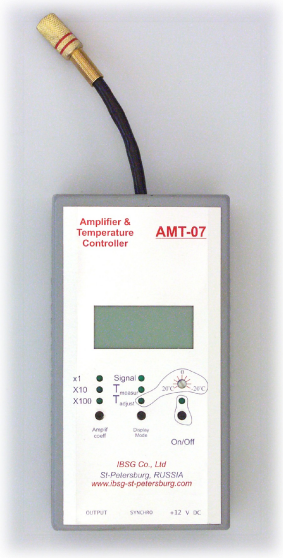
2. Pulse mode. Such mode provides maximum peak optical power from the LED. In this mode besides changing of frequency, pulse duration can be also selected in the range 0.6-20 µs. Peak current in pulse mode can be changed in the range 0-2 A.

Please, don't use combination of frequency and pulse duration that gives duty cycle >10%. We recommend using of 2 A pulse current only at pulse duration <1 µs. Pulse duration is 1 µs. Temperature controller that is built in DLT-37M provides selecting and stabilizing of the temperature on LED's chip in wide range. That gives possibility to tune wavelength or optical power.

ELECTRONICS

Photodiode Amplifiers (descriptions)

Amplifier AM-07M converts the current output of a signal source such as for example Mid-Infrared photodiode, into a voltage output with amplification of the voltage for subsequent use with various electronic systems, like lock-inamplifiers, oscilloscopes or A/D converters. In the same package is included also Sinchrodetector that gives direct current proportional to the signal at selected frequency. Customer can see the signal on LC Display.



Amplifier AMT-07M converts the current output of a signal source such as for example Mid-Infrared photodiode, into a voltage output with amplification of the voltage for subsequent use with various electronic systems, like lock-inamplifiers, oscilloscopes or A/D converters. In the same package is included also Sinchrodetector that gives direct current proportional to the signal at selected frequency. Customer can see the signal on LC Display. Amplifier AMT-07M is designed for operation with photodiodes with built-in termocooler and thermistor (Models PDXX-XX-TEC). Customer can select and set the temperature of PD operation. Circuit with feedback will set the necessary thermocooler current for maintaning the selected temperature.

SETs FOR THE ANALYSIS OF GASES AND LIQUIDS

The Principle of the Analysis

Development of portable gas sensors for the detection of volatile organic compounds, natural and industrial gases such as methane, ammonia, acetylene, acetone, carbon dioxide, oxides of nitrogen and sulfur, and many others, is an important task due to the high demand for these sensors in industrial processes , for the protection of the environment, for medical diagnosis, for quality control and other applications.

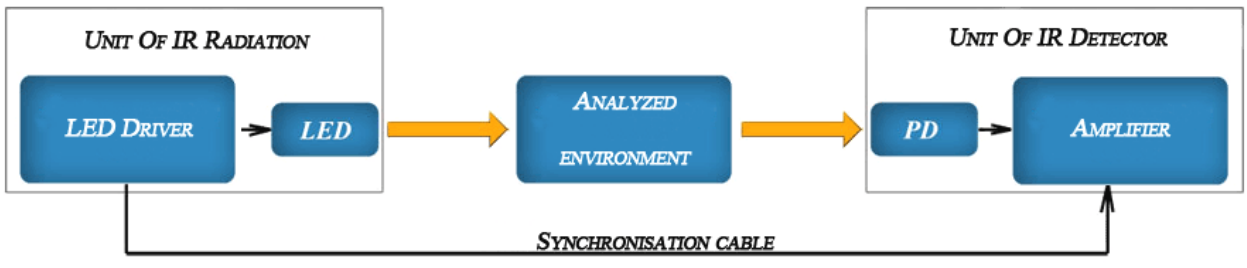
The strong absorption lines of many important chemical compounds such as CO_2, N_2O, NO_2, NH_3, water vapor and others) lie in the Mid-Infrared spectral range (1.5-5.0 μm). The characteristic absorption lines of a number of chemical compounds of interest are presented below:

The characteristic absorption lines of a number of chemical compounds

CH_4 1.65 μm; 2.30 μm; 3.2 - 3.45 μm;	CO_2 2.00 μm; 2.65 μm; 4.2 - 4.3 μm;	H_2O 2.6 - 2.85 μm; 1.86 - 1.94 μm;	N_2 4.0 - 4.54 μm;
C_2H_2 2.99 - 3.09 μm;	HOCl 2.6 - 2.9 μm;	HCl 3.33 - 3.7 μm;	NH_3 2.27 μm; 2.94 μm;
C_2H_4 3.1 - 3.4 μm;	HBr 3.7 - 4.0 μm;	OH 2.38 - 2.63 μm;	NO+ 4.08 - 4.44 μm;
C_2H_6 3.3 μm;	HI 2.27 - 2.3 μm;	H_2CO 3.38 - 3.7 μm;	HNO_3 5.74 - 5.98 μm;
CH_3Cl 3.22 - 3.38 μm;	H_2S 3.7 - 4.4 μm; 2.5 - 2.8 μm	CO 2.24 μm; 4.4 - 4.8 μm;	NO_2 3.4 μm;
OCS 3.45; 4.87 μm;	HCN 2.94 - 3.1 μm;	HO 2.73 - 3.1 μm;$_2$	SO_2 4.0 μm;
C_6H_6 2.44 -2.47 μm 3.17 - 3.33 μm	$CHBr_3$ 2.39 μm 3.29 μm	$C_2H_4Cl_2$ 3.23 - 3.51 μm	$C_2H_2Cl_2$ 2.50 - 2.86 μm
C_2HCl_3 3.22 - 3.25 μm 4.20 - 4.35 μm	H_2O_2 3.70 - 3.85 μm 4.17 - 4.35 μm	HF 2.33 - 2.78 μm 4.17 - 4.43 μm	C_3H_8 3.28 - 3.57 μm

The principle of optical IR spectroscopy analysis is based on the ability the substances to absorb infrared radiation selectively. The degree of absorption of IR radiation depends on the concentration of the substance in the test medium.

The figure shows a schematic diagram of an optical IR analyzer consisting of an optically marched system - the light source and the photodetector.



SETs FOR THE ANALYSIS OF GASES AND LIQUIDS

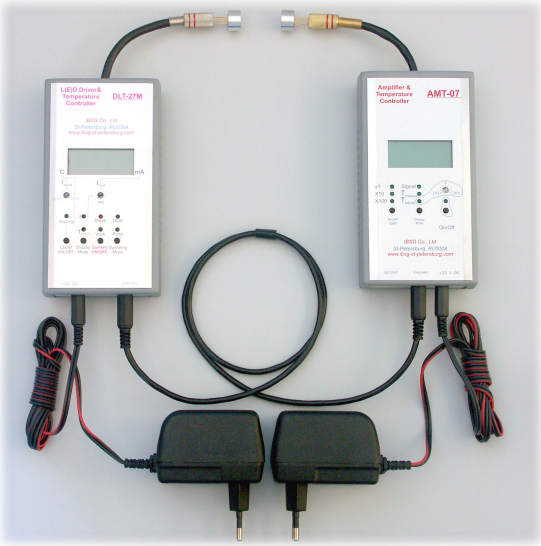
IBSG Company, Ltd. offers sets of the devices for start analysis of gases and liquids. The sets consist of such IBSG products as IR LEDs and photodiodes, LED drivers and PD amplifiers.

Set consists of:

- Light Emmiting Diode (LED is a source of modulated IR radiation with the maximum of emission spectra coinciding with one of the absorption line of the detected substance);
- LED Driver (LED Driver provides power to the LEDs and synchronization pulses for the PD Amplifier. It allows a customer to select the operating mode with adjusted pulse duration, pulse repetition rate and current);
- Photodiode (PD is photodetector for IR radiation spectrally marched with LED);
- PD Amplifier (PD Amplifier converts the photocurrent into voltage with subsequent amplification and provides synchronous detection of the received signal. It is supplied with built-in LCD-display);
- Sync Cable (Sync Cable synchronizes operation of LED Driver and PD Amplifier);
- Adapter (power supply unit).

In forming the sets of gases and liquids there is a choice of different modifications of the devices for the specific customer tasks. IBSG company suggests an individual approach to the needs of each customer.

One of the main advantages of the sets is the following: a customer can choose marched system of optoelectronic devices that gives the successful solution of problems in the area of analysis of many chemical compounds.



SETs FOR THE ANALYSIS OF GASES AND LIQUIDS

SETs for the analysis of gases and liquids

Analyzed gas / liquid	SET	LED	LED Driver	Photodiodes	Amplifier
CH_4	**SET-1**	LED-34-PR	D31-M	PD36-03-PR or PD36-05-PR or PD36-10-PR	AM-07M for PD36
	SET-1T	LED34-TEC-PRW	DLT-27 or DLT-37	PD36-03-TEC-PR or PD36-05-TEC-PR or PD36-10-TEC- PR or PD36-20-TEC-PR	AMT-07M for PD36
	SET-1TN	LED-340-NS-TEC	DLT-27 or DLT-37	PD36-03-TEC-PR or PD36-05-TEC-PR or PD36-10-TEC- PR or PD36-20-TEC-PR	AMT-07M for PD36
	SET-2	LED23-PR	D31-M	PD24-03-PR or PD24-05-PR or PD24-10-PR	AM-07M for PD24
	SET-2T	LED23-TEC-PRW	DLT-27 or DLT-37	PD24-03-TEC-PR or PD24-05-TEC-PR or PD24-10-TEC- PR or PD24-20-TEC-PR	AMT-07M for PD24
CO_2	**SET-3**	LED43-PR	D31-M	PD48-03-NS-PR or PD48-05-NS-PR	AM-07M for PD48
	SET-3T	LED43-TEC-PRW	DLT-27 or DLT-37	PD48-03-NS-TEC-PR or PD48-05-NS-TEC-PR	AMT-07M for PD48
	SET-3N	LED-430-NS	D31-M	PD48-03-NS-PR or PD48-05-NS-PR	AM-07M for PD48
CO	**SET-4N**	LED-465-NS	D31-M	PD48-03-NS-PR or PD48-05-NS-PR	AM-07M for PD48
H_2S HBr	**SET-5N**	LED-390-NS	D31-M	PD48-03-NS-PR or PD48-05-NS-PR	AM-07M for PD48
H_2O	**SET-6**	LED19-PR	D31-M	PD24-03-PR or PD24-05-PR or PD24-10-PR	AM-07M for PD24
	SET-6T	LED19-TEC-PRW	DLT-27 or DLT-37	PD24-03-TEC-PR or PD24-05-TEC-PR or PD24-10-TEC-PR	AMT-07M for PD24
	SET-7	LED-270-NS	D31-M	PD36-03-PR or PD36-05-PR or PD36-10-PR	AM-07M for PD36
	SET-7T	LED-270-NS-TEC	DLT-27 or DLT-37	PD36-03-TEC-PR or PD36-05-TEC-PR or PD36-10-TEC-PR	AMT-07M for PD36

Mid infrared IBSG Optoelectronics

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