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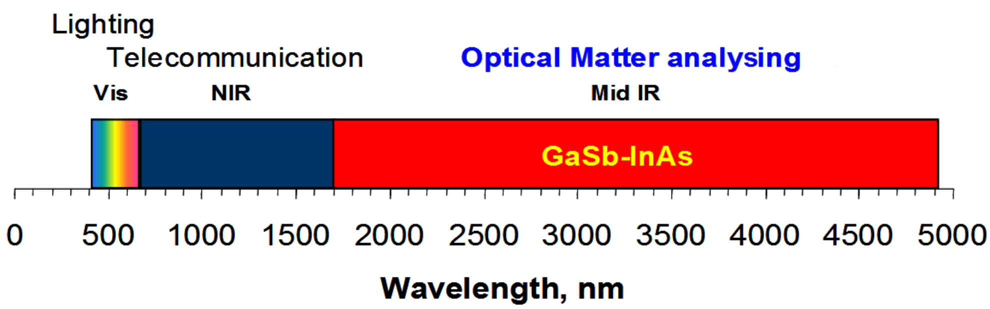
LED Microsensor NT

INTRODUCTION

Technology

Light emitting diodes (LEDs) and Photodiodes (PDs) are semiconductor devices. The LED or PD heterostructure is formed by sequential epitaxy of semiconductor layers on the surface of a crystal substrate. LED radiation is generated in the active layer and the emission wavelength of the LED and the spectral response of the PD are determined by the energy gap of the material in the active layer.

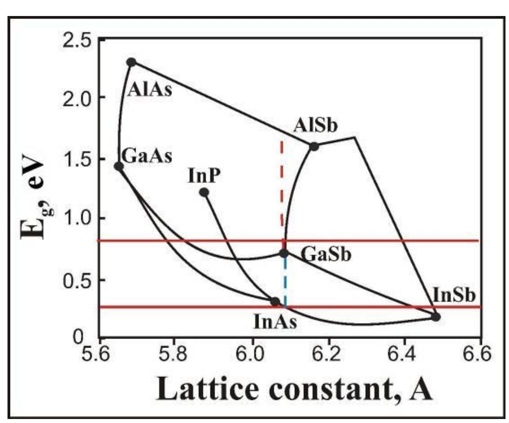
The first laser heterostructures in the world were grown at the end of the 1960s in the Ioffe Physical Technical Institute by Nobel Prize laureate Zhores Alferov.



Nowadays, semiconductor optoelectronic devices for near-infrared and the visible spectral range are widely used in telecommunications and lighting. Additionally, LEDs and PDs possess great potential for use in optical analysing systems. In the middle Infrared spectral range, 1600–5000 nm, there are strong absorption bands for the most important gases and liquids, such as: CH_4 , H_2O, CO_2, CO, C_2H_2, C_2H_4, C_2H_6, CH_3Cl, HCl, HOCl, HBr, H_2S, HCN, NH_3, NO_2, SO_2 , glucose and many others.

Using a GaInAsSb/AlGaAsSb-based heterostructure lattice matched to a GaSb substrate allowed us to create LEDs and PDs for the 1.6–2.4 μm spectral range and by using an InAsSb/InAsSbP-based lattice matched to an InAs substrate we created LEDs and PDs for the 2.8–5.0 μm spectral range. There is a gap from about 2.4 to 2.8 μm due to the existence of a region of immiscibility for GaInAsSb based solid solutions which depends on the epitaxy temperature and the compound composition.

Semiconductor wafer (LED and PD chips with ring top contacts)



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Standard Product Line Overview

We propose:

- A line of standard LEDs (LED chip with circular or ring top contact) with peak wavelengths (μm):

1.80-1.89	1.90-1.99	2.00-2.09	2.10-2.19	2.20-2.29	2.30-2.39	3.30-3.49	3.70-3.84	3.85-3.94	3.95-4.09	4.10-4.30	4.40-4.60
Lms18LED	**Lms19LED**	**Lms20LED**	**Lms21LED**	**Lms22LED**	**Lms23LED**	**Lms34LED**	**Lms38LED**	**Lms39LED**	**Lms41LED**	**Lms43LED**	**Lms46LED**

- A line of flip-chip bonded LEDs (LED chip top surface is free of contacts) with peak wavelengths (μm):

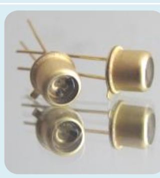
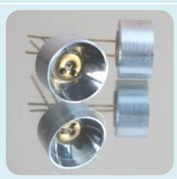
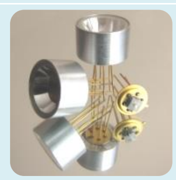
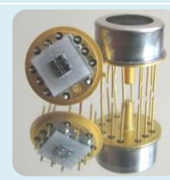
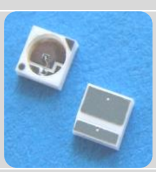
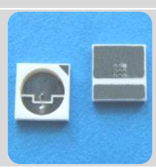
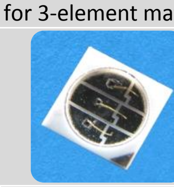
1.60-1.69	1.70-1.79	1.80-1.89	1.90-1.99	2.00-2.09	2.10-2.19	2.20-2.29	2.30-2.39
Lms16LED-FC	**Lms17LED-FC**	**Lms18LED-FC**	**Lms19LED-FC**	**Lms20LED-FC**	**Lms21LED-FC**	**Lms22LED-FC**	**Lms23LED-FC**

- A line of wide band PDs with sensitive area of 0.3 and 0.5 mm and cut-off at wavelengths (μm):

2.4		3.6		4.6	4.3
Lms24PD-03	**Lms24PD-05**	**Lms36PD-03**	**Lms36PD-05**	**Lms43PD-03**	**PR43**
Photodiodes					**Photoresistor (under special request)**

- Multi-element LED matrix – a number of similar or different LED-chips mounted in a single compact package and driven together or independently.

We offer a range of standard and customized packages for these devices:

TO Packages	TO-18	TO-18 with PR	TO-5	TO-5 with PR	TO-8
	with/without window		with/without thermoelectric module		
					
applied to	**LED, PD**		**LED, PD, LED-matrix**		**LED-matrix**
SMD Packages	3×3 mm	5×5 mm	5×5 mm with microreflector	5×5 mm for 3-element matrix	
					
applied to	**LED**			**LED-matrix**	

- Electronics oriented for operating with LEDs, LED-matrix and PDs:

✓ LED drivers D-41, D-51 – unpackaged drivers that provide LED operation in different pulse modes;

D-51M additionally enables the LED p-n junction temperature to be obtained using current-voltage dependence.

✓ LED driver DLT-27* – provides operation and temperature stabilisation of an LED with a built-in thermocooler in QCW and pulse modes at fixed frequency and pulse duration and variable currents

✓ LED driver DLT-37* – provides operation and temperature stabilisation of an LED with a built-in thermocooler in QCW and pulse modes at several frequencies, variable pulse durations and currents;

✓ **NEW** PD preamplifier PAb – converts the output current signal of a photodiode into a voltage pulse output signal with amplification, is available together with a PD in a metal tube – LmsXXPD-XX(w)-PA series;

✓ PD Amplifier AMT-07* – converts the output current signal of a PD with built-in thermocooler into a voltage output with amplification; provides temperature stabilization of a PD.

✓ **NEW** SDM synchronous detector – measures the voltage signal from the output of photodiode preamplifier and converts it to the DC voltage signal proportional to amplitude of voltage from input.

***These models will be replaced with newer unpackaged device versions soon.**

We propose our optoelectronic devices for the mid-infrared spectral range as a new powerful base for optical absorption analysis. One of the great advantages of this method is that virtually any sample in virtually any state may be studied; liquids, solutions, pastes, powders, films, fibres, gases and surfaces can all be examined with a proper choice of sampling technique. This approach may be used for the analysis of one component in a mixture, especially when the compounds in the mixture are chemically alike, or have very similar physical properties.

RANGE OF APPLICATIONS

Control of technological processes, examples:

- Paper industry (water in paper control, paper thickness control)
- Oil and petroleum industry (detection of water concentration in oil and oil products)
- Thickness testing (thickness of plastic, glass bottles)
- Pharmaceutical industry

Medical diagnostics, examples:

- Out-breath control (measurement of carbone dioxide, acetone concentration)
- Non-invasive control of glucose in blood

Ecological monitoring, examples:

- Control of carbon dioxide, carbon monoxide, exhaust gases in the atmosphere
- Control of methane, propane leakage
- Control of hydrocarbons in water
- Water turbidity measurement

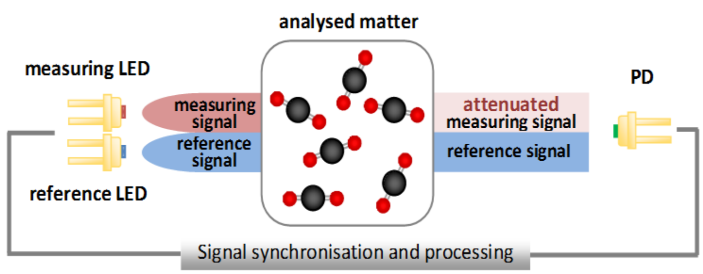
Food industry and agriculture, examples:

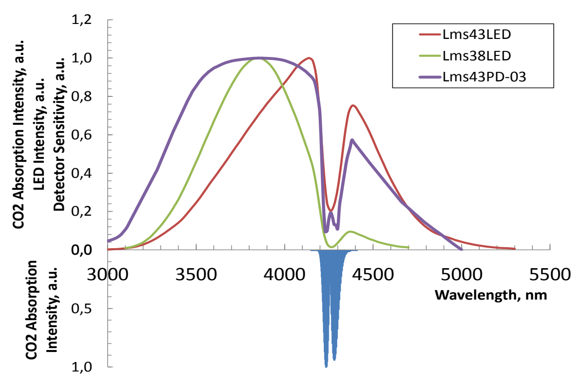
- Control of water, fibre, protein concentration in grains, humidity control of coffee beans, corn
- Control of fat and protein in milk
- Analysis of ethanol content in wine

Most commercially available instruments for this analysis employ quite sophisticated large-sized and expensive spectrometers that provide measurements solely at the laboratory. Using LED-Photodiode optopairs for the mid-infrared spectral range has allowed the development portable sensors with high reliability and adequate accuracy that can be successfully applied in different areas for matter analysis purposes.

PRINCIPLE OF OPTICAL SPECTROSCOPY BASED ON LED – PD OPTOPAIR

Infrared optical analysis is based on the vibrations of the atoms of a molecule. Infrared radiation passes through a sample and the fraction of the incident radiation that is absorbed at a particular energy is determined. The energy at which any change in the absorption occurs corresponds to the frequency of a vibration of a molecule that is analysed.





The principle scheme for sensing chemical agents, based on LED-PD optopairs, is quite simple. The measuring LED emits radiation at a wavelength corresponding to the maximum absorption of the analyte. The reference LED emits radiation at a wavelength that is not absorbed by the analyte. The signal difference between the measuring LED that is partially absorbed in the optical cell and the reference LED is proportional to the concentration of the analyte.

Range of Applications

There are strong absorption bands for many chemical agents at the mid-infrared spectral range that allows their detection with sensor devices based on LED-PD optopairs. Some of these chemical agents and their absorption bands are presented here.

Although the spectra are characteristic of the molecules, in a number of cases they overlap. The frequency of the fundamental vibrations varies with the atomic weight of the constituents. Further spectra exist due to overtones. These are in general much weaker, but there are still possibilities for these to be used for measurement purposes. The absorption strengths also vary with different molecules and therefore, different path lengths should be provided in order to obtain adequate absorption in the required sensitivity range. Small measuring cells can be advantageous, notably when a rapid response is needed (such as in medical applications).

CH_4 (methane) *1.65;2.30 μm;* *3.2÷3.45 μm*	***CO_2 (carbon dioxide)*** *2.00; 2.65 μm;* *4.2÷4.3 μm*	***H_2O (water)*** *2.65÷2.85 μm;* *1.86÷1.94 μm*	***N_2 (nitrogen)*** *2.2÷2.5 μm*
C_2H_2 (acetylene) *2.99÷3.09 μm*	***HOCl (hypochlorous acid)*** *2.6÷2.9 μm*	***HCl (hydrogen chloride)*** *3.33÷3.7 μm*	***NH_3 (ammonia)*** *2.27; 2.94 μm*
C_2H_4 (ethylene) *3.1÷3.4 μm*	***HBr (hydrogen bromide)*** *3.7÷4.0 μm*	***OH (hydroxyl radical)*** *2.7÷3.0 μm*	***NO+ (nitrogen oxide cation)*** *4.08÷4.44 μm*
C_2H_6 (ethane) *3.35 μm*	***HI (hydrogen iodide)*** *2.22÷2.35μm;* *4.2÷4.5μm*	***H_2CO (formaldehyde)*** *3.38÷3.7 μm*	***HNO_3 (nitric acid)*** *2.80÷2.84 μm*
CH_3Cl (methyl chloride) *3.22÷3.38 μm*	***H_2S (hydrogen sulfide)*** *4.2÷4.4 μm;* *3.6÷3.8 μm;* *2.5÷2.75 μm*	***CO (carbon monoxide)*** *4.5÷4.85 μm;* *2.3-2.4 μm*	***HF (hydrogen fluoride)*** *2.33÷2.78 μm*
OCS (carbonyl sulfide) *4.80-4.92 μm;* *3.40-3.47μm*	***HCN (hydrogen cyanide)*** *2.94÷3.1 μm*	***HO_2 (hydroperoxy radical)*** *2.73÷3.1 μm*	***SO_2 (sulfur dioxide)*** *3.96-4.06 μm*
N_2O (nitrous oxide) *2.85-3.01 μm;* *3.85-4.10 μm;* *4.23-4.57 μm*	***NO_2 (nitrogen dioxide)*** *3.4-3.5 μm*	***C_3H_8 (propane)*** *3.28÷3.57 μm*	***$C_6H_{12}O_6$ (glucose)*** *2.12; 2.27; 2.32 μm*