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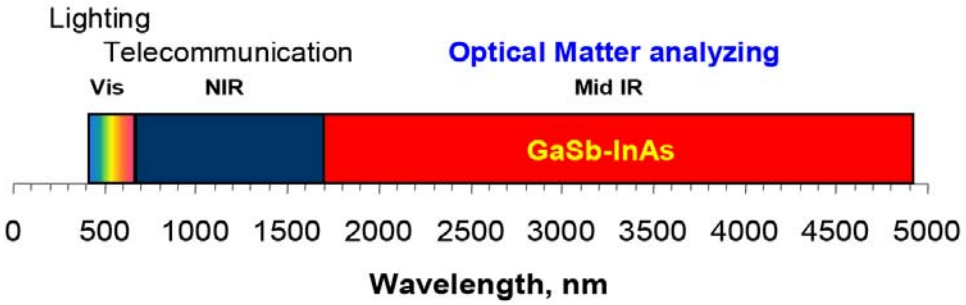
Mid-IR Products

Introduction

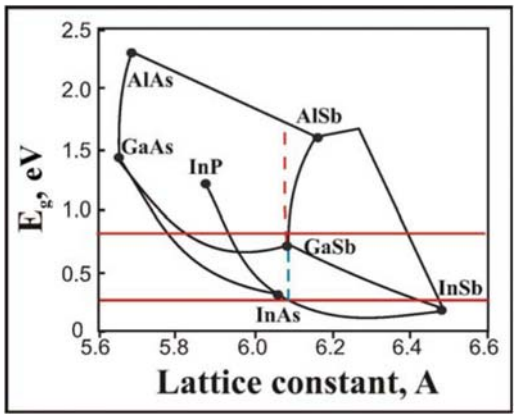
Mid-Infrared Light Emitting Diodes and Photodiodes

Light emitting diodes (LEDs) and Photodiodes (PDs) are semiconductor devices. 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 LED as well as spectral response of PD is determined by the energy gap of the material in the active layer.



At the moment semiconductor optoelectronic devices for near-infrared and visible spectral range are widely used in telecommunications and lighting. In addition to these applications, LEDs and PDs posses great potential for using in optical analyzing systems.
In the Middle Infrared spectral range 1600 - 5000 nm there are strong absorption bands of 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, OCS, HCl, HOCl, HBr, H_2S, HCN, NH_3, NO_2, SO_2, glucose and many others.

Using GaInAsSb/AlGaAsSb heterostructures lattice matched to GaSb substrate allowed to create LEDs and PDs for 1.6-2.4 µm spectral range, InAsSb/InAsSbP lattice matched to InAs substrate is used for 2.8-5.0 µm spectral range.
There is a gap from about 2.4 - 2.8 µm due to existence of incompatibility region for GaInAsSb based solid solutions that depends on the epitaxy temperature and the compound composition.



This technology is 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, fibers, 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 alike chemically or have very similar physical properties.

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

Applications:

- Water Sensors
  water in paper, water in grain, water in oil products, etc.
- Methane Sensors
  for methane leakage in houses, along gas communications, in mines, etc.
- Carbon Dioxide Sensors
  high concentration of CO_2 indorrs, etc.
- Medical Diagnostics
  Glucose and other substances in blood, on tissue
- Medical Diagnostics
  Carbon Dioxide, Acethone and other gases in breath
- Ecological monitoring
  Monitoring of different industrial polutants in air and water

Examples of portable sensors based on LED-PD optopairs

- Carbon Dioxide Sensor

- Water in Cut-Oil Sensor

Benefits of using LEDs:

New optoelectronic devices for the Middle Infrared spectral range open completely new possibilities for portable sensors creation. Using Mid-infrared LED-PD optopairs allow developing an instrument that is smaller, less expensive, and versatile in functionality.
It is worthwhile to focus on some features of gas sensor market since gases are the most significant type of analytes. Today a number of companies produce Mid Infrared optical gas sensors based on dispersive emission sources. These sensors have become popular and often replace chemical and adsorption ones. The main features of different types of gas sensors for on-line monitoring are presented here:

	Gas Sensors	
	Absorption and other chemical Gas Sensors	**Optical Gas Sensors based on heating IR sources**
How it works	There are many different types. For example MOSFET with a sensitive paladium or tin oxide gate: Adsorption of measured gas on the surface of the gate changes current through the metal- oxide-silicon field effect transistor.	Charactreistic absorption bands of the most important gases are located in the middle IR spectral range. In dispersive emission source a wire is heated up by a current flow and emits in a very wide range according to Planck`s law. The required spectral range is cut off by special optical filters.
Advantages	Low cost Acceptable sensitivity Small size of the chip	High selectivity High reliability Simple to use
Disadvantages	**Low selectivity:** Sensitive to high humidity, to presence of such reagents as ammonia, chlorine, fluorine, sulfur, phosphorus, nitrogen and carbon oxides in the environment **Short lifetime:** Often calibration or replacement of a sensitive element is necessary	**Restricted possibilities for miniaturization** due to additional filters and high heat dissipation **High electric power consumption:** only a small part of radiation cut is used by filter **Low response speed** **High cost**

But at present market is strongly restricted due to substantial disadvantages of proposed sensors. Either they have poor selectivity, so that quite complicated and frequent calibrations are required, or they are very expensive. The best way to eliminate disadvantages of the present optical sensors is to apply high-powered fast light emitting diodes for Mid-infrared spectral range.

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LEDs and other sources of infrared radiation

In thermal (heating) emission source of infrared radiation a wire is heated up by a current flow and emits in a very wide range according to Planck`s law. The required spectral range is obtained by using special optical filters. Sensors employing this type of radiation source have some certain drawbacks:

- High electrical power consumption and low efficiency. Filter cuts only small part of wide emitted spectral range.
- Low speed of response.
- Heating infrared source practically can not be modulated by current.
- Short lifetime. Frequent catastrophic degradation takes place.
- Restricted possibilities for miniaturization due to high heat dissipation and necessity for using filters.

Mid-Infrared LEDs posses certain advantages comparing to heating infrared radiation sources:

- compactness (size of the standard LED chip is 0.3x0.3 mm)
- low electrical power consumption (down to 1 mW in pulse mode)
- high speed response (tens per nanoseconds)
- long lifetime (up to 100 000 hours)
- low cost in mass production