Optoelectronic pairs (LED’s and Photodiodes) in the MID - IR spectral range (1.8 - 5.0 µm) for the Ecological monitoring

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**BIOGRAPHY**

Yury P.Yakovlev was born on October 17, 1939. He graduated with a M.Sc. degree from the Leningrad Electrical Engineering Institute in 1962 and joined Ioffe Physical-Technical Institute in 1969. He received his Ph.D. degree in 1978 and the Doctor of Science degree in 1995 both in physics and mathematics from Ioffe Institute. His main research interests are technology and researches of narrow band gap III-V solid alloys heterostructures and optoelectronic devices (LED, Lasers and Photodiodes).

In 1992, Yury Yakovlev established and headed an optoelectronic company, IBSG for research and development of MID-IR semiconductor devices (www.ibsg-st-petersburg.com). In 1995, Yury Yakovlev organized and headed the Laboratory of Infraredo Optoelectronics (LIRO) in Ioffe Institute. Prof. Yury P.Yakovlev has authored or co-authored 80 patents, over 200 papers, reviews and book chapters.

**TECHNICAL ABSTRACT**

High power LEDs and photodiodes at the spectral range of 1.8-5.0 µm are very promising devices for the different applications such as medical diagnostics (noninvasive method for measuring glucose in blood and so on) and monitoring of surrounding atmosphere. A number of such relevant gases as H₂O, CO₂, CO, CH₄, N₂O, SO₂, NH₃, HF and others have strong fundamental absorption lines in the mid-infrared spectral range that are 50-500 times stronger in comparison with near- Infrared overtone bands at shorter wavelength. Therefore such mid-Infrared LEDs and PDs can be used for creation of optical low power consumption portable gas analyzers.

The talk will consist of four parts. The first part of the talk will be devoted to narrow band gap solid solution based on III-V compounds (GaSb - InAs, GaSb - AlSb ) which were used for creation of LED’s and Photodiodes. The second part of the talk will be devoted to the creation of LED’s for two spectral ranges: (1.8 – 2.4) µm based on GaSb/GaInAsSb/GaAlSbAs heterostructures (Fig1, Fig2) and (2.8 – 5.0) µm based on InAs/InAsSb/ InAsSbP heterostructures (Fig.3, Fig4). Design and basal optical characteristics LED’s for two spectral ranges will be presented.

![FIG.1. Energy diagrams of 1.8 – 2.4 µm LED structures](image)

![FIG.2. Typical electroluminescence spectra of 1.6 – 2.4 µm LEDs](image)

At room temperature CW output power of (1.6 – 2.4) µm LED’s can reach (2-3) mW and the pulse mode power is up to 100 mW. The main peculiarity of (2.8 – 5.0) µm LED’s is strong decreasing quantum efficiency with increasing wavelength emission due to strong influence non-radiation Auger recombination process. At room temperature CW output power of 3.3 µm LED’s and 4.3 µm LED’s can reach 100 µW and 20 µW, and the pulse mode power is up to 1 mW and 150 µW, respectively. Basically, fundamental limitation for increasing optical power for MID-IR LED’s will be reviewed.
The third part of talk deals with the creation and investigation of Photodiodes for five spectral ranges: 1.2 – 2.5 μm based on GaSb/GaInAsSb/GaAlAsSb heterostructures, 1.5 – 3.6 μm based on InAs/InAsSbP heterostructures, 2.3 - 4.3 μm based on InAs/InAsSb/InAsSbP heterostructures and 2.5 - 5.0 μm based on InAs/InAsSb/InAsSbP heterostructures.

The main peculiarity of MID-Infrared photodiodes is decreasing the detectivity (Fig.5) with decreasing energy band gap in active layer of photodiodes. An analysis of the photodiodes performance through the investigation of current – voltage, capacitance – voltage characteristics and spectral responsively will be presented.

The forth part of the talk will be devoted the Application of Mid-Infrared LED’s and Photodiodes in Gas sensor. Principal schemes for detection of CO₂, CH₄, CO, H₂O and so on with using Mid-Infrared LED’s and Photodiodes will be given.

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