NEMIS – Project Summary

Project full name: New Mid-Infrared Sources for Photonic Sensors (NEMIS)

Funding: 6th EU Research Framework Programme, Information Society Technologies, Specific Targeted Research or Innovation Project (FP6 IST)

Contract No.: FP6-2005-IST-5-031845

Objectives

The objectives of the NEMIS project are the development and realisation of compact and packaged vertical-cavity surface-emitting semiconductor laser diodes (VCSEL) for the 2-3.5 µm wavelength range and the demonstration of a pilot photonic sensing system for trace gas analysis using these new sources. The availability of electrically pumped VCSELs with their low-cost potential, low power consumption, small beam divergency and compactness in this wavelength range that operate continuously at or at least near room-temperature and emit in a single transverse and longitudinal mode (i. e. single-frequency lasers) is considered a basic breakthrough for laser-based optical sensing applications. These devices are also mode-hop-free tuneable over a couple of nanometers via the laser current or the heatsink temperature.

It is the purpose of the project to develop the underlying semiconductor technology based on Gallium Antimonide, the VCSELs as well as pilot applications in sensing systems to demonstrate the potential and performance of these novel lasers for tunable diode laser spectroscopy (TDLS).

Participants

The NEMIS consortium consists of partners from five European countries and comprises one of the world leader manufacturers of photonics systems, two small/medium enterprises and four universities. All participants have expertise in the field of photonics and complement each other for the design, fabrication and characterision of GaSb-based VCSELs as well as for the application of tunable laser diodes in photonic sensors and sensing systems.

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Institute of Physics of the Academy of Sciences of the Czech Republic (Czech Republic)

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VERTILAS GmbH (Germany)

Omnisens SA (Switzerland)

Siemens AG (Germany)

VCSEL design, technology and characterization

The basis of the development of the VCSELs for the NEMIS project is defining the target device specifications suitable for sensing applications. Promising designs are optimized using numerical simulations. Two design concepts pursued in the project are the buried-tunnel-junction (BTJ) concept which has proven very successful on InP-based VCSELs and the oxide-/mesa-confined design similar to GaAs-based short-wavelength lasers.

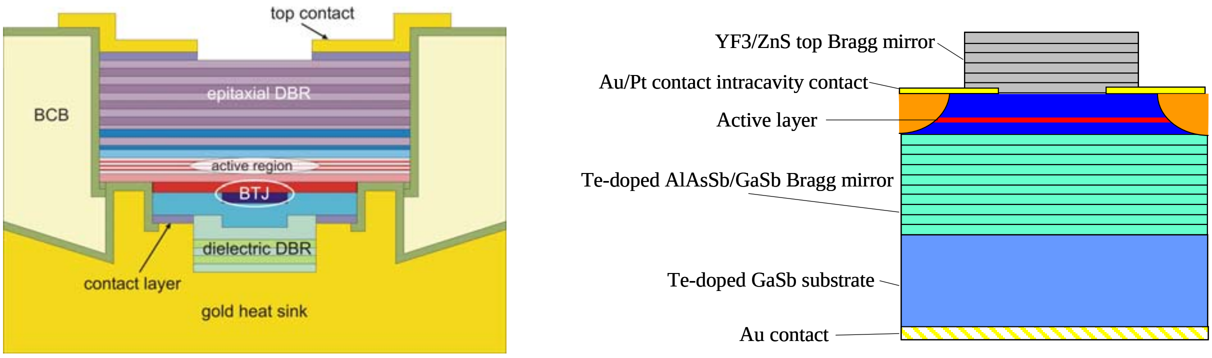

Fig. 1: BTJ-design (left) and oxide-/mesa-confined design (right)

The manufacturing part consists of the growth of the layer systems using molecular beam epitaxy and forming the devices utilizing semiconductor process technology like lithography, wet and dry etching, as well as several deposition techniques. During all steps of the VCSEL development the novel materials system of antimonides poses many challenges.

The characterization of the devices serves to optimize the aspects of laser performance relevant for sensing applications. This includes physical analysis of VCSEL structures and components, laser operation measurements and device lifetime studies.

Applications

The potential range of applications for TDLS is very wide. Today it covers besides industrial process control and emission control, mainly research topics as trace gas detection for atmospheric research or medical diagnostics. With the development of low-cost mid-infrared VCSEL sources new application fields such as monitoring of hazardous gases and process control for mass markets will be made accessible.

Many technologically and environmentally relevant gases including, but not restricted to CO, HF, NH_3, NO, CH_4 or HCN have strong absorption bands in the 2-3.5 µm wavelength range. Compared to other sensing methods presently used for such substances TDLS shows better chemical selectivity, as well as cost and performance advantages and can therefore contribute to improve general health, environment and economy.

Besides sensing applications the high transparency of the atmosphere within certain windows of the mid-infrared spectral region opens a way to ranged laser measurements and optical free-space communication where the superior properties of VCSELs such as spectral quality, low power consumption and cost are of great benefit.