DESCRIPTION OF THE PROJECT FOR THE GENERAL PUBLIC

The detection of hazardous gases for security and environmental purposes has become more and more important in the last years, and a growing demand is observed for gas-sensing systems, creating an emerging market. Current detection systems are based on tunable diode laser absorption spectroscopy (TDLAS). In this system, a diode laser source is used in order to scan a wavelength range of several nanometers to detected absorption spectrum being a spectral fingerprint of specific gas. To be able to measure such a gas with a TDLAS system, a laser source emitting longitudinally as well as transversally in a single mode with short tuning range is needed.

Presently micrometer range of wavelength emission is accessible by intersubband cascade lasers (ICL) and by quantum cascade lasers (QCL) emitting in the spectral ranges 2 – 100 μm. Those lasers are mainly constructed in edge-emitting geometry due to large heat generation (ICL) and due to fundamental quantum-mechanical requirements (QCL). Such geometry is not preferential for single mode emission, precise wavelength tuning that are expected in spectroscopic applications. In shorter wavelength ranges vertical-cavity surface emitting lasers (VCSELs) are used in optical communication applications typically due to their inherent longitudinal single-mode operation, (electro) thermal tunability, as well as small beam divergence and low power consumption. Presently the longest wavelength VCSELs based on IC active regions enable emission up to 4 µm that is definitely not enough for possible infra-red applications. Achieving the abovementioned properties and emission of wavelength up to dozens of micrometers is theoretically possible due to quantum-cascade VCSEL (QC VCSEL), in which stimulated emission occurs due to monolithic high-contrast grating (MHCG).

The great advantage of the project will be first demonstration of possibility of use the quantum-cascade for VCSEL scheme. Besides the main very ambitious goal of the project all the steps toward fabrication of QC VCSEL will be of great scientific value: fabrication and demonstration of Distributed Bragg Reflector (DBR) and MHCG aiming high power reflectance at 4 µm and 9 µm, fabrication of high quality-factor optical cavity composed of MHCG and DBR, fabrication of QC active regions embedded in MHCG. All those goals will be performed and verified by using several spectroscopic techniques realized in mid infrared such as polarized dependent Fourier transformed reflectance measurements and intersubband transition detection within electronic states of QCL scheme.

The project will be realized in intense synergy between theory, technology and experiment. All project challenges will be focuses on efforts, which in future, might lead to maximization of output power and quantum efficiency in respect to minimizing energy consumption and production costs of the efficient QCVCSELs working in mid infrared range.