DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

(State the objective of the project, describe the research to be carried out, and present reasons for choosing the research topics)

The aim of this Project is to investigate physical properties of low dimensional semiconductor systems considered for the active region of e.g. *quantum cascade lasers, heterojunction lasers, and diodes operating in the spectral range of mid infrared*. Engineering of semiconductor materials, by means of growing layers of proper width and composition, allows to design lasers emitting light from 2 to 5 µm. Within the project, necessary numerical calculations will be performed to optimize different material concepts such as semiconductor alloys, heterojunctions and quantum wells, which can be later applied as active parts of the emitters e.g. *interband cascade lasers and further mode-lock lasers.*

Nowadays, the demand for mid-infrared-emitting laser fabrication is one of the driving forces of nanotechnological progress, caused mostly by constantly growing optical gas sensing market. Optical gas sensing is important in many aspects of *medical diagnostics, environment protection, and military*. Medical diagnostics utilizes the analysis of the exhaled breath while in environmental protection, the emission of air pollutants is minimized by optimization of the hydrocarbons mixture being burned in refineries. In defense-related purposes, on the other hand, hazardous materials are detected. *All of these can be achieved by using optical sensors with properly designed lasing devices*.

An important step before fabrication is a deep understanding of physical processes and electronic requirements of the active regions consisting of many multilayers forming the nanostructures, such as quantum wells*. One of the project goals is to obtain the necessary knowledge and discover proper designs, altogether with their experimental verification using optical spectroscopy on prepared testing samples*. Mid infrared spectroscopy is quite challenging due to such reasons as absorption lines of the molecules in air, low detectors sensitivity etc. Because of this, the fundamental characterization (focused on the emission wavelength determination) will be realized by using an unusual approach – Fourier transformed spectrometers. Additionally, in this project, the measurements will be expanded by advanced time domain experiments. They will be realized with newly established experimental setup for mid infrared pump - probe measurements and photoluminescence decay technique. *This will make it possible to determine charge carriers lifetimes in investigated samples, which is highly important for the pulsed operation and final requirements of a ready optoelectronic sensing device*.

Summarizing, in this project, the advanced optical spectroscopy will be carried out (supported by numerical calculations) on the active parts of different type of the lasing devices, predicted for emission in mid infrared spectral range which is important for the optical gas sensing market. *Necessary samples are already obtained by the applicants due to longstanding collaboration with e.g. Wurzburg University (Germany), IOFFE Institute (Russia) and newly established with Tampere University in Finland.*

The topics planned within this project are of fundamental nature, focused on the physical phenomena investigations (e.g. carrier lifetimes and tunneling processes determination). Nevertheless, as a consequence of their realization, we *might gain an important source of knowledge in the future to make further (necessary) steps in fabrication devices which do not exist yet*. They could be crucial for the technological improvement and, in consequence, would improve the quality of life in different and numerous fields.