Quantum cascade lasers are new class of unipolar semiconductor lasers which operation is based on intersubband transitions. Contrary to classical junction lasers, utilizing interband transitions, the wavelength of their emission is to less extend dependent on the material they are made of but mainly depends on geometry of the quantum wells constituting active region. This allows for covering a broad wavelength range from mid-infrared to far-infrared using structures fabricated on the basis of GaAs and InP, the materials which technology is well developed. The cascading mechanism of generation, allowing photon multiplication increases quantum efficiency of the devices. The unipolarity, i.e., presence of one type of carriers eliminates majority of disadvantageous nonradiative recombination mechanisms. The quantum cascade lasers are also very fast and their output can be modulated to high frequencies, reaching tens of GHz. All these features make them an ideal sources of radiation in gas detection systems, molecular spectroscopy and free space communication systems. They also find application in military techniques and medical diagnosis. The full commercialization of quantum cascade lasers, however, depends heavily on their reliability, which at the moment is hampering their deployment.

The project is aimed on understanding of the complex processes of degradation of inter-subband lasers and extending knowledge about fundamental physical phenomena behind degradation processes. Results of the project will supply experimental and theoretical data considering key problem of QCLs: reliability and lifetime, which affect their further development. The knowledge gained from the research will be applied in development of new devices, as well as optimization of design, processing and technology of devices being already fabricated in ITE. The project is expected to deliver a knowledge about QCLs failure modes, time evolution of key operational parameters: reliability, device lifetime and maximal operation temperature. Control and improvement of abovementioned parameters has invaluable importance from the point of view of potential applications

The research will focus on the following experimental techniques: thermoreflectance spectroscopy, Fourier transform infrared spectroscopy (FTIR), time resolved FTIR, as well as light-current-voltage characterization. These techniques allow analysis of thermal processes occurring at the laser facet (localization of the heat sources and defects on the facets, identifying heat propagation directions) and key electro-optical parameters of devices and their evolution in time, allowing determination of the type of device degradation mechanism. Newly developed experimental setups like micro photoluminescence and thermal imaging, will supplement the experimental data with analysis of the strain induced by thermal load during operation, analysis of defect creation and propagation, recognition of defects leading to degradation of devices, as well as determination of mechanisms, sources and types of laser degradation. To assess the time evolution of the device performance a specialized setup will be developed, allowing performing aging experiments.