Since the first demonstration of the Quantum Cascade Lasers (QCLs) in 1994 by the group of prof. Capasso from Bell Labs, these devices have undergone rapid development and are now a rapidly growing group of semiconductor lasers emitting in the mid-infrared range (3.5–24 μm) and in the terahertz range (1.2–4.9 THz). 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. Cascade lasers are an ideal source of radiation in gas pollutant detection systems, molecular spectroscopy and free-space communications systems in military technology, medicine, and for early detection of contamination and biological substances.

Project is dedicated to the investigation of thermal processes and optimization of QCLs designed for emission in long wavelength infrared (Far–IR) range 10–16 μm for applications in molecular spectroscopy. This range of the wavelengths is very important due to the presence of strong absorption lines of many environmentally, medically and industrially important gases (e.g. hydrocarbons, ammonia, nitrogen oxide, nitrous oxide, ozone, sulfur dioxide). QCLs emitting in this range are still not characterized by high performance and reliability. The main factor limiting the application development of long-wave cascade lasers is their relatively low efficiency. It is a result, as in the case of Mid-IR QCLs, of the generation of significant amounts of heat in the active area of the laser. Relatively high currents and threshold voltages have a significant impact on the performance of the devices, independently of the material system used and the wavelength range covered. The internal over-heating has significant effect on device performance, independently of the material system used and the wavelength range covered.

In case of Far–IR QCLs, an additional thermal problem was observed. **It was observed that in case of uncoated facet, due to surface oxidation, optical absorption occurring at the laser facet is many times greater in Far-IR than in Mid- IR, which results in significantly higher temperatures at the output facet, than those predicted by considering Joule heating only.**

Within the project an appropriate methodology for optimizing the thermal and degradation phenomena occurring in these devices will be developed. The realization of the Project requires realization of two specific research goals.

- The first specific research objective is to study the thermal processes and degradation mechanisms of Far–IR QCLs using thermoreflectance spectroscopy and infrared imaging.
- The second specific research objective concerns the optimization of manufacturing technology by designing, developing and manufacturing the optimal laser waveguide and mirror coatings leading to increased efficiency of long-wave quantum cascade lasers.

The implementation of this project will significantly contribute to knowledge about the phenomena occurring in the far infrared cascade lasers, a better understanding of the heating and degradation mechanisms responsible for the main performance parameters.

The result of the project will be the development of optimized design and technology of long-wave quantum cascade lasers for applications in molecular spectroscopy.