SUMMARY

„Elaboration of the InP-based semiconductor technology for the construction of a quantum cascade laser"

Quantum cascade lasers are currently among the most sophisticated radiation emitters, based on intersubband phenomena, whose core (active region) consists of hundreds or even thousands of layers with sub-nanometer thicknesses. Quantum cascade lasers are the basis of many applications such as: detection of hazardous gases, infrared spectroscopy, medical diagnostics, optical communication in free space, security gates. The presented doctoral dissertation responds to the aforementioned needs of the modern market. It discusses the developed technology of crystallization of QCL laser components, based on the InGaAs/AlInAs/InP material system, using the low-pressure metalorganic vapour phase epitaxy LP-MOVPE technique.

The thesis describes the epitaxial growth of layers that are part of various areas of the cascade laser. Thick *n*-type silicon-doped InP layers of several micrometers formed the cladding of the laser waveguide, ensuring that the base mode was trapped inside the core structure. The influence of the developed InP:Si cladding layers, deposited with the LP-MOVPE technique, on the parameters of the reference laser, made exclusively by the MBE (molecular beam epitaxy) method, was investigated in the team of Prof. Maciej Bugajski (currently the Łukasiewicz Research Network, Institute of Microelectronics and Photonics in Warsaw). The achieved was a 1.5-fold decrease in threshold current and an increase in the emitted optical power by an order of magnitude, from several hundred mW to over 2.5 W. The crystallization parameters of the InGaAs/AlInAs superlattice were investigated and defined. The developed technology of deposition of sub-nanometer layers was used in the crystallization of the cascade laser core. Additionally, the subject of research was the development of iron-compensated high-resistive InP layers (InP:Fe) for the advanced design of a cascade laser with buried heterostructure BH-QCL. The use of the developed technology in device structures of QCL lasers improved the efficiency of heat dissipation from the core area, which made it possible to extend the supply pulse 50 times with a simultaneous increase in the emitted optical power.

The result of the research carried out in this work was the development of a technology for the crystallization of the entire epitaxial structure of a quantum cascade laser using the LP-MOVPE technique. An additional contribution of the author of the dissertation was the development and production of Bragg mirrors at mid-infrared, based on the AlAs/GaAs and InGaAs/InP heterostructures. They will be used in the innovative design of a quantum cascade laser with a vertical resonance cavity QC-VCSEL (Quantum-Cascade Vertical-Cavity Surface-Emitting Laser), which is not possible in a classic design due to fundamental quantum-mechanical requirements.

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