Abstract (ENG)

This dissertation presents extensive research on the optical properties of low-dimensional semiconductor structures designed for emission in the mid-infrared range, which plays a key role in optical gas detection, environmental pollution monitoring, and industrial process control.

The research was conducted using a wide range of spectroscopic techniques, including photoluminescence, photoreflectance, time-resolved photoluminescence, and ultrafast pump-probe experiments.

Material systems such as GaSbBi and InSbBi were analyzed. By introducing bismuth atoms into traditional antimonide semiconductors, these systems offer the possibility of increasing the emission wavelength by reducing the bandgap energy. The influence of composition changes, strain, and growth conditions on the band structure, spin-orbit coupling, defect generation, and ultimately charge carrier dynamics was examined.

Research was also carried out on InAsSbP/InAsSb heterojunctions and InAsSb/GaAsSb/InAsSb quantum wells. In the first group, the relationships between radiative and non-radiative processes were investigated. Through analysis of experimentally determined dependencies for the bandgap energy and the spin-orbit split-off level, the spectral applicability range of InAsSb at room temperature was determined, showing a reduction in undesirable Auger processes.

In the case of quantum wells, the focus was on studying the impact of the so-called "antimony soaking time" during the growth process on the quality of the well/barrier interfaces. Here, the increasing characteristic decay times of pump-probe signals (for wells grown with longer soak times) were linked to a reduction in atomic diffusion processes between layers and an improvement in interface quality.

The results obtained in this work provide new insights into the optical properties of the studied material systems, offering guidance for the optimization of existing structures and the design of a new generation of active regions for mid-infrared emitters.