Carrier dynamics of type-II quantum wells emitting in mid-infrared

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Interband cascade lasers (ICLs) are a type of semiconductor lasers that operate in the mid-infrared region of the electromagnetic spectrum. They have unique properties that make them essential for a variety of applications, such as gas sensing, spectroscopy, medical diagnostics, and communication [1]. ICLs have a cascade structure of multiple quantum wells, which allows them to achieve high efficiency, low threshold current, and continuous-wave operation at room temperature [2,3]. Nevertheless, further optimization of the active region can be achieved. In this approach we will examine influence of tensile and compressive strain on the electronic structure [4] and carrier dynamics.

This study presents transient absorption (TA) pump-probe measurements of type-II WQW InAs/GaInSb/InAs and InAsSb/GaAsSb/InAsSb structures designed for mid-infrared interband cascade lasers emitting close to 3.5 μm. The aim of this study is to investigate the fundamental carrier dynamics in this material systems, which is essential for their further possible applications in e.g. mode-lock lasers. TA measurements were performed in order to determine influence of the compressive or tensile strain application in quantum wells on carrier lifetimes regarding fundamental transitions and other interface-related ones.

Additionally, photoreflectance (PR) and photoluminescence (PL) measurements were used to investigate the band structure and optical properties of the samples. Both the PR and PL spectra showed strong signals near 3.3 μm, which corresponds to the fundamental type-II transition of the QW and additional signals (observed in PL) related to possible interface-atom intermixing processes. The temperature-dependent PL measurements revealed a strong temperature dependence of the PL intensity, with a significant reduction in the intensity at higher temperatures. The energy shift of the transitions were also studied through temperature-dependent PR. Observed optical transitions and their energies were in good agreement with theoretical calculations realized within 8kp formalism.

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