Ring interband cascade laser arrays

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Introduction

Interband cascade lasers (ICLs) [1,2] combine the concept of conventional photodiodes and quantum cascade lasers (QCLs). Thus, they rely on the long upper-level recombination lifetimes of photodiodes as well as the voltage-efficient in-series connection of multiple active regions as in quantum cascade lasers. Since the carriers are recycled via interband tunneling from the valence to the conduction band when cascading, differential quantum efficiencies greater than one are possible. Hence, a single injected carrier can emit several photons. Electrons and holes are internally generated due to the semimetallic interface between InAs and GaSb and then recombine in the active region. The distinctive low power consumption of ICLs makes them especially attractive for mobile applications in the mid-infrared, such as process control, medical applications and spectroscopy [3].

1. Substrate-emitting ring ICLs

As a first proof of principle we presented interband cascade lasers fabricated into a ring-shaped cavity [4], showing vertical light emission through the GaSb substrate. Our approach [5] for the light outcoupling of our ring interband cascade lasers relies on a distributed feedback (DFB) grating instead of epitaxial grown Bragg mirrors. The DFB grating is etched into the cladding layer on top and subsequently completely covered by a gold metallization layer. We demonstrate ring ICLs with 400µm outer diameter and a waveguide width of 10µm, which emit light at a wavelength ~3.7µm. A pulsed threshold current density <1kA/cm² is measured at 20°C.

2. Polarization measurements and future work

Optical transitions in QCLs favor transverse magnetic (TM) polarized light because of the restriction by the intersubband selection rule. Whereas in ICLs the recombination of electrons in the conduction band with a heavy-hole in the valence band generates transverse electric (TE) polarized light. Consequently, we expected an influence on the polarization of the emitted light. Indeed we found an azimuthal orientation of the emitted light for the ring QCL, whereas the ring ICL shows radial polarization when performing measurements of the projected nearfield.

Subsequently, we want to investigate the applicability of concepts that have been used for ring QCLs to our ring ICLs as a next step of our ongoing research. Two-dimensional DFB laser arrays, for example, have been shown for ring QCLs [6], exhibiting a broad spectral tuning range, which is favourable for applications, such as gas analysis.

References

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