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Ring interband cascade lasers for spectroscopic applications

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The interband cascade laser (ICL) [1,2] is a combination of conventional photodiodes and quantum cascade lasers (QCLs). Hence, it relies both on the long upper-level recombination lifetimes of photodiodes and the voltage-efficient in-series connection of multiple active regions utilized in quantum cascade lasers. Cascading allows achieving differential quantum efficiencies greater than one because the carriers are recycled via interband tunneling from the valence to the conduction band. Thus, a single injected carrier can emit multiple photons. The semimetallic interface between InAs and GaSb allows the internal generation of electrons and holes, which recombine in the active region. ICLs are very attractive for mobile applications in the mid-infrared, such as process control, medical applications and spectroscopy, due to their low power consumption [3].

We present interband cascade lasers fabricated into ring-shaped cavities [4], showing vertical light emission through the GaSb substrate. Instead of epitaxial grown Bragg mirrors for light outcoupling, our approach [5] relies on a distributed feedback (DFB) grating, which is etched into the uppermost cladding layer. In a subsequent fabrication step, the DFB grating is completely covered by a gold metallization layer. We fabricated ring ICLs with 400μm outer diameter and 10μm waveguide width, which emit light at a wavelength ~3.7μm. A pulsed threshold current density <1kA/cm² is measured at 20°C.

Optical transitions in QCLs favor transverse magnetic (TM) polarized light due to 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 leads to transverse electric (TE) polarized light. Hence, 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.

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