HL 26: Lasers and LEDs II

Time: Monday 16:45–18:30 Location: H16

HL 26.1 Mon 16:45 H16

Beam steering in mid-IR external cavity quantum cascade lasers — •Verena Blattmann, Frank Fuchs, Stefan Hugger, Jan Jarvis, Michel Kinzer, Quankui Yang, Ralf Ostendorf, Wolfgang Bronner, Rachid Driad, Rolf Aidam, and Joachim Wagner — Fraunhofer-Institut für Angewandte Festkörperphysik IAF, Tullastr. 72, D-79108 Freiburg, Germany

Quantum cascade (QC) lasers have been established as Watt-level coherent light sources in the mid-infrared of the electromagnetic spectrum. Applying band structure engineering, the gain spectrum of a QC laser can be designed according to the specific needs of the given application. Control over the emission wavelength over the entire gain spectrum can be obtained by an external cavity (EC) setup, making QC lasers interesting for broad-band spectroscopy. Such sensing applications require a stable far-field intensity distribution in order to realize a high signal-to-noise ratio during the measurement. However, it has been shown that QC lasers are likely to show lateral multi-mode emission. In particular when operated at higher output power, they show far-field beam instabilities and beam steering effects due to coherent coupling of different lateral modes. In order to understand these effects, we investigate the dependence of far-field characteristics of EC-QC lasers on parameters such as laser current, temperature, emission wavelength as well as the precise alignment of the components of the external cavity. In addition, the influence of lateral optical confinement is evaluated by using laser chips differing in ridge width and processing technology (double trench, buried heterostructure).

HL 26.2 Mon 17:00 H16

Power scaling of 2-μm GaSb-based semiconductor disk laser emitting in TEM_{00} mode — •Steffen Adler, Sebastian Kaspar, Marcel Rattunde, Tino Töpper, Christian Manz, Klaus Köhler, and Joachim Wagner — Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastrasse 72, D-79108 Freiburg, Germany

Semiconductor disk lasers, also known as vertical-external-cavity surface-emitting laser (VECSEL), combine the wavelength versatility of semiconductor laser with the capability of a nearly diffraction-limited high-power output. VECSEL in the 2-3-μm wavelength range are of interest for a broad range of applications in materials processing, medicine, trace gas sensing and optical pumping. In this presentation we will report on power scaling of TEM_{00}-emitting GaSb-based VECSELs, which are excellently suited for applications requiring Watt-level output powers emitted from a single-mode fiber.

Investigating different cavity designs in order to scale the output power in TEM_{00} mode we prove the existence of a thermal lens in GaSb-based VECSEL. This finding was unlikely to be expected since the up-to-date scientific consensus has been that the influence of thermal lensing in GaSb-based VECSEL is negligible.

The thermal lens in the VECSEL chip is due to pump-power induced heating inducing a valid refractive index variation. Since thermal lensing hampers TEM_{00} emission at high output power we have investigated different cavity designs minimizing this unwanted effect. Using an optimized setup, we realized a 2.1-μm emitting VECSEL with an output power above 1.5 W at $M^2 < 1.2$ at 20°C heat-sink temperature.

HL 26.3 Mon 17:15 H16

Design, simulation and characterization of RCLEDs — •Paul Börner[1], Michael Kunzer[1], Thorsten Passow[1], Klaus Köhler[1], Wilfried Pletschen[1], Tarik Moudakir[2], Abdallah Ougazzaden[2], Frédéric Genty[3], and Joachim Wagner[1] — [1]Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastrasse 72, D-79108 Freiburg, Germany — [2]UMI 2958, Georgia Tech CNRS, Georgia Inst Technol, 2-3 Rue Marconi, F-57070 Metz, France — [3]Supelec, 2 Rue Edouard Belin, F-57070 Metz, France

Resonant-cavity light emitting diodes (RCLEDs) can be regarded as a hybrid between vertical-cavity surface-emitting lasers (VCSELs) and conventional LEDs. In contrast to VCSELs, the operating principle is based on spontaneous emission. Putting a light source into a cavity enhances the probability of spontaneous emission (Purcell effect). Therefore, emission perpendicular to the surface is increased. On the one hand, RCLEDs are still incoherent light sources with larger line widths and no speckling compared to lasers since the mirror reflectivity and optical gain is too low for stimulated emission. On the other hand the resonant cavity improves emission directionality compared to conventional LEDs. In combination with circular facets fitting to the fibre core diameter, RCLEDs are suited for efficient fibre coupling.

We report on the realization of RCLEDs emitting in the 400 nm range. The vertical cavity consists of a top dielectric SiO_2/ZrO_2 mirror and a bottom AlInN/GaN or AlGaN/GaN distributed Bragg reflector (DBR) enclosing an InGaN/GaN multiple quantum well active layer.

HL 26.4 Mon 17:30 H16

Low Threshold Interband Cascade Lasers — •Robert Weih, Sven Höfling, and Martin Kamp — Technische Physik and Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

Several applications like medical diagnostics, free space communication and high sensitivity tunable laser absorption spectroscopy (TLAS) demand compact and robust laser sources in the mid infrared region. Particularly the window from 3 to 6 μm is of great interest for TLAS, since many organic molecules have strong rotational-vibrational absorption lines in this so called fingerprint region. A very promising source for this spectral region is the interband cascade laser (ICL). This device relies on the special band alignment in the InAs/GaSb/AlSb material system that allows the combination of (spatially indirect) interband transitions with tunnel junctions for carrier conversion, enabling cascaded active regions. Within the last years, the performance of ICLs has improved significantly, and continuous wave operation over a wide wavelength range has been demonstrated even at elevated temperatures. We'll present several design optimizations of the layer sequence and the doping scheme that were made to reduce the photon losses and increase the external efficiency. As a result, the threshold current densities for broad area lasers could be reduced below $200A/cm^2$. Narrow ridge waveguide laser operate up to 60°C in continuous wave mode and emit more than 20 mW of optical power at 20°C.

HL 26.5 Mon 17:45 H16

Interband Cascade Lasers for Tunable Laser Spectroscopy — •Michael von Edlinger[1], Julian Scheuermann[1], Lars Nähle[1], Robert Weih[2], Adam Bauer[2], Marc Fischer[1], Sven Höfling[2], Johannes Koeth[1], and Martin Kamp[2] — [1]nanoplus GmbH, Oberer Kirschberg 4, 97218 Gerbrunn, Germany — [2]Technische Physik University of Würzburg, Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Am Hubland, 97074 Würzburg, Germany

Tunable laser sources have proven themselves as a very successful tool for high performance gas sensing and are used in a variety of challenging applications. Especially the mid infrared (MIR) region between 3 and 4 microns is technologically and industrially relevant, since many gas species have their strongest absorption features in this range, including e. g. important hydrocarbons like methane or acetylene as well as formaldehyde.

In this contribution, a promising approach to MIR distributed feedback (DFB) laser devices based on interband cascade laser material is presented. Continuous wave laser operation above room temperature has already been demonstrated in the wavelength range from 3 to 6 microns based on this concept. A crucial requirement for tunable laser spectroscopy (TLS) is the availability of spectrally monomode emitters such as DFB lasers. In this work distributed feedback is achieved by etched sidewall gratings defined by electron-beam lithography. With this method devices with SMSR around 30 dB have been fabricated in the 3.5 micron wavelength range, well suited for formaldehyde detection.

HL 26.6 Mon 18:00 H16

InAs-based Interband-Cascade-Lasers for emission around 6 um — •Matthias Dallner, Martin Kamp, and Sven Höfling — Technische Physik and Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

Interband-cascade-lasers (ICLs) based on the GaSb material system are currently able to provide room-temperature continuous wave operation at wavelengths up to 5.6μm. One limitation of the performance at longer wavelengths is the requirement of thick cladding layers, which have a large thermal resistance if realized as superlattices. An alternative solution is the combination of established active region designs with plasmon enhanced waveguides on InAs substrates. The cladding layers of these devices are made out of highly doped InAs whose refractive index is significantly reduced due to the proximity of the emission wavelength to the plasmon resonance. This allows a combination of strong optical confinement and high thermal conductivity.

We'll present data from InAs-based ICLs emitting around 6 um at room temperature that have been grown using molecular beam epitaxy. Various optimization concepts known from GaSb-based ICLs, like shortend injectors, split hole extractors or carrier rebalancing have been applied to our structures, yielding a considerable improvement in device performance. The latest devices show threshold current densities as low as $1.4kA/cm^2$ at 20°C under pulsed operation and a maximum operation temperature of 40°C.

HL 26.7 Mon 18:15 H16

Evanescently coupled semiconductor laser arrays fabricated in the InGaAs/GaAs material system — •Alexander Reinhold[1], Christian Zimmermann[1], Julian Scheuermann[1], Michael von Edlinger[1], Andreas Heger[1], Wolfgang Zeller[1], Johannes Koeth[1], and Martin Kamp[2] — [1]nanoplus GmbH, Oberer Krischberg 4, D-97218, Gerbrunn, Germany — [2]Technische Physik, Universität Würzburg, Am Hubland,D-97074, Würzburg, Germany

Semiconductor laser diodes are nowadays well established as highly efficient, compact and low cost coherent light sources in various fields of applications. However, the combination of high output power with a good beam quality and narrow spectral linewidth is still challenging. A possible device geometry that can meet these demands is an array of ridge waveguides with lateral gratings in between the ridges. The ridge array leads to a large mode size for the still strongly index guided mode, whereas the grating provides wavelength selection. We have fabricated such devices based on an AlGaAs/GaAs laser structures with a double InGaAs quantum well as active material, emitting in the wavelength range around 890 nm. We achieved spectrally narrow operation around a wavelength of 887 nm with side mode suppression ratios (SMSR) of 33 dB and optical output powers up to 100 mW. The devices operate on a higher order lateral supermode with a multi-lobed farfield. We have also investigated phase matching segments and vertically etched sidewall gratings in order to achieve discrimination of high order lateral supermodes and diffraction limited emission.