HL 49: Semiconductor Lasers II

Time: Thursday 15:00–16:45 Location: EW 561

Invited Talk HL 49.1 Thu 15:00 EW 561
Dynamical laser properties of tunnel-injection devices. — •Michael Lorke[1], Frank Jahnke[1], Gadi Eisenstein[2], and Johann-Peter Reithmeier[3] — [1]Institute for Theoretical Physics, University of Bremen, Germany — [2]Electrical Engineering Department and Russel Berrie Nanotechnology Institute, Technion, Haifa, Israel — [3]Technische Physik, Institute of Nanostructure Technologies and Analytics, Kassel

Tunnel injection lasers are an appealing concept for the next generation of semiconductor lasers, as they promise improved modulation rates and better temperature stability. Moreover, they eliminate a major detrimental effect of quantum dot lasers, which is the gain nonlinearity caused by hot carriers. The introduction of a tunnel barrier for controlling the coupling of quantum dots (QDs) to an injector quantum well (QW) introduces significant design changes in comparison to conventional QD or QW lasers. As a result, nanoscale physics and quantum mechanical interaction processes take a more important role in the device properties. This poses new challenges to our theoretical understanding and increases the need for applying microscopic models. We present a theoretical study of dynamical laser properties inclusing the transport within the device and show the impact of alignment between the injector quantum well and the QDs on the laser switch-on process and modulation properties. These are important for the use of these laser systems in novel telecommunication applications.

HL 49.2 Thu 15:30 EW 561
High-speed low-noise wafer-fused MBE-grown 1550 nm VCSELs — •Sicong Tian[1,2], Georgiy Sapunov[1], Sergei Blokhin[3], Andrey Babichev[4], Innokenty Novikov[4], Anton Egorov[5], Leonid Karachinsky[4], and Dieter Bimberg[1,2] — [1]imberg Chinese-German Center for Green Photonics, Changchun Institute of Optics, Fine Mechanics, and Physics, Chinese Academy of Sciences, Changchun 130033, PR China — [2]Center of Nanophotonics, Institute of Solid State Physics, Technische Universität Berlin, Berlin D-10632, Federal Republic of Germany — [3]Saint Petersburg, Russia — [4]Saint Petersburg, Russia — [5]Saint Petersburg, Russia

High-power low-noise wafer-fused MBE-grown 1550 nm VCSELs with an InP-based optical cavity with InGaAs QWs and a composite InAlGaAs 6 μm BTJ and AlGaAs/GaAs distributed Bragg reflectors are fabricated. The VCSELs demonstrate 5 mW single-mode continuous-wave output optical power at 20 °C and 1 mW at 70 °C. Over 13 GHz 3dB modulation bandwidth is obtained at 20 °C. NRZ data rate of 37 Gbps under BTB condition is shown. A preliminary study shows RIN $<$ -156 dB/Hz and a data rate $>$ 50 Gbit/s at a 500 m distance under PAM4 modulation.

HL 49.3 Thu 15:45 EW 561
High-beta quantum dot micropillar lasers operating at room temperature — •Sarthak Tripathi, Floriana Laudani, Kartik Gaur, Imad Limame, Ching-Wen Shih, Sven Rodt, and Stephan Reitzenstein — Inst. for Solid State Phys., Technical Univ. of Berlin, Germany

Room temperature micropillar lasing has attracted significant attention due to its potential applications in integrated photonics, optoelectronics, and neuromorphic computing. In this study, we present the fabrication and characterization of micropillar lasers showing a room-temperature emission wavelength around 960 nm. The epitaxially grown structure consists of a central one-lambda GaAs cavity with integrated InGaAs quantum dots (QDs), which is sandwiched between bottom and top distributed Bragg reflector (DBR) pair. Based on such planar microcavity structures high-Q micropillar cavities are fabricated using electron beam lithography and dry etching techniques, resulting in uniform pillar dimensions. Multiple layers of high-density InGaAs QDs are stacked in the active region in order to maximize the modal gain of the micropillar resonators for room-temperature operation. The density of dislocations and point defects in QDs heterostructures is strongly reduced by post-growth annealing which enables us to blue shift in wavelength without forfeiting their crystalline quality. Numerical simulations are carried out to optimize the fabrication parameters and subsequently validate the optical properties. Moreover, photoluminescence studies are conducted to evaluate the optical and laser properties of micropillar cavities.

HL 49.4 Thu 16:00 EW 561
Radially doped InGaAs-GaAs(Sb)/AlGaAs multi-quantum well nanowire laser structures on silicon — •Sebastian Werner, Tobias Schreitmüller, Hyowon Jeong, Paul Schmiedeke, Jonathan Finley, and Gregor Koblmüller — Walter Schottky Institute, Technical University of Munich, 85748 Garching, Germany

The ability to integrate III-V semiconductor nanowires (NW) on silicon (Si) platform opens many perspectives for advanced optoelectronic and photonic device applications on-chip. However, for energy-efficient device performance, as in III-V NW-solar cells, light emitting diodes (LEDs) or laser diodes, the design of accurately doped heterostructures and the optically active region is very crucial. In this contribution, we present our developments of radially doped n-i-p core-multishell NW hetero-structures monolithically integrated on the n-Si (111) platform for compact NW laser diode devices in the near-infrared spectral range. The NW structure is designed to host n-type doped GaAs(Sb) cores, while the shell is composed of (In,Al)GaAs(Sb)-based heterojunctions that define intrinsic multi-quantum well (MQW) active and p-type doped regions. Under optical pumping schemes, we show that n-doped (Si-doped) GaAs(Sb) NWs show lasing characteristics, with a doping dependent lasing threshold < 50 μJ/cm^2. Extending these experiments to fully doped radial heterojunctions hosting seven coaxial InGaAs/GaAs MQWs, we further demonstrate low-threshold lasing of < 43 μJ/cm^2 (10K) and even up to ∼150K in an integrated vertical-cavity geometry on Si.

HL 49.5 Thu 16:15 EW 561
Numerical investigation of the far-field behavior of VCSELs with monolithic high contrast gratings — •Lilli Kuen[1,2], Mikołaj Janczak[3], Marcin Gebski[3], Tomasz Czyszanowski[3], Sven Burger[1,2], Stephan Reitzenstein[4], and Martin Hammerschmidt[1,2] — [1]Zuse Institute Berlin, Takustraße 7, 14195 Berlin, Germany. — [2]JCMwave GmbH, Bolivarallee 22, 14050 Berlin, Germany. — [3]Institute of Physics, Lodz University of Technology, 93-005 Łódź, Poland. — [4]Institute of Solid State Physics, Technische Universität Berlin, 10623 Berlin, Germany.

Vertical-cavity surface-emitting lasers (VCSELs) are widely used light sources, and their functional principle is well known. A novel approach to control the resonant wavelength and the polarisation state is to replace the upper DBR mirror with a line grating with finite size and high contrast material, a so-called monolithic high contrast grating (MHCG).

In this contribution, we investigate the far-field behavior of such structures with respect to the oxide aperture width, the size of the grating, and the number of grating periods. This enables a better understanding of the relation between oxide aperture width and the finite grating size on the most important properties of VCSELs with MHCG.

In our numerical study, we compute resonance modes, which are solutions to Maxwell's equations without sources. To this aim, we employ a finite-element method. The far-field pattern is obtained by using a near-field to far-field transformation.

HL 49.6 Thu 16:30 EW 561
Gain characteristics of AlGaN quantum wells for UVC laser diodes application — •Giulia Cardinali[1], Alexander Schulz[1], Sebastian Kölle[2], Friedhard Römer[2], Bernd Witzigmann[2], Norman Susilo[1], Daniel Hauer Vidal[1], Martin Guttmann[1], Tim Wernicke[1], and Michael Kneissl[1,3] — [1]Technische Universität Berlin, Insitute of Solid State Physics, Berlin, Germany — [2]University of Erlangen-Nürnberg (FAU), Department of Electrical Engineering, Erlangen, Germany — [3]Ferdinand-Braun-Institut (FBH), Berlin, Germany

UVC laser diodes have small size, low cost and high output power, providing a viable alternative to 266 nm frequency-quadrupled solid-state lasers. Thick AlGaN single quantum wells (SQW) with large confinement factors are advantageous for UVC devices, and can achieve relatively low thresholds despite the large polarization fields. In this study, AlGaN UVC optically pumped lasers with a SQW active region with thickness between 3 nm and 12 nm were fabricated with m-plane resonators and cavity lengths between 600 μm and 1400 μm.

The threshold power density decreases with increasing QW width, with the lowest value of 1.3 MW/cm^2 for a 9 nm SQW laser. All the samples exhibited positive gain for all QW widths, with the highest differential gain for the 9 nm SQW, in correspondence of the minimum of the threshold. The high gain and low threshold of thick AlGaN QWs are explained by $k{\cdot}p$ simulations, showing a large electron-hole wavefunction overlap at high carrier density in thick wells, where a high contribution to the gain also comes from excited state transitions.