HL 22 Semiconductor laser II

Time: Tuesday 15:15–17:15 Room: BEY 154

HL 22.1 Tue 15:15 BEY 154

Low powerconsumption of blue-violet laser diodes — •C. Rumbolz, C. Eichler, M. Schillgalies, A. Avramescu, M. Furitsch, G. Brüderl, A. Lell, U. Strauss, and V. Härle — OSRAM Opto Semiconductors GmbH, Leibnizstr. 4, 93055Regensburg

Commercial applications like post DVD data storage systems or high resolution printing require blue-violet laser diodes with low power consumption. Mobile devices with limited battery capacities and small sizes need diodes with low heat dissipation to avoid extensive cooling systems. Low heat dissipation also guarantees longer lifetimes of the diodes. We achieve electrical power dissipation values as low as 400mW at 30mW optical cw-output by improving threshold current, slope efficiency and voltage. One step of optimization is the adjustment the n-cladding layer. Layers with strong wave guidance are good for low threshold current but increase the voltage. We found a n-cladding layer optimum for low power dissipation. Next step of improvement is the reduction of the operation current by lowering the internal losses. One main loss mechanism is the absorption at Mg-dopants in the p-GaN- and p-AlGaN layers. A compromise between hole injection and minimization of absorption has been found. With these optimizations we show cw-threshold currents smaller 35mA for 1,5μm wide ridgewaveguide lasers and slope efficiencies up to 1,2W/A.

HL 22.2 Tue 15:30 BEY 154

2.5 Gbit/s data transmission and 800 mW single mode filamentation free operation of InAs/InGaAs quantum dot lasers emitting at 1.5 μm — •T. Kettler[1], L.Ya. Karachinsky[2], G. Fiol[1], M. Kuntz[1], K. Posilovic[1], A. Lochmann[1], O. Schulz[1], L. Reissmann[1], N.Yu. Gordeev[2], I.I. Novikov[2], M.V. Maximov[2], Yu.M. Shernyakov[2], N.V. Kryzhanovskaya[2], A.E. Zhukov[2], A.P. Vasilev[2], E.S. Semenova[2], V.M. Ustinov[2], N.N. Ledentsov[3], A.R. Kovsh[3], V.A. Shchukin[3], S.S. Mikhrin[3], and D. Bimberg[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin — [2]Ioffe Physico-Technical Institute, St. Petersburg — [3]NL Nanosemiconductor GmbH, Dortmund

In recent years semiconductor lasers with self organised quantum dots as an active media grown on GaAs demonstrated theoretically predicted superior characteristics. Until now special emphasis was placed on GaAs-based QD lasers emitting at the datacom and telecom wavelength of 1.3 μm. Here we report on QDs emitting at 1.5 μm using the novel concept of metamorphic growth. The active region consists of InAs/InGaAs QDs, grown on top of a metamorphic InGaAs layer deposited on GaAs. Such devices demonstrate 220 mW single transverse mode cw operation as well as 800 mW single transverse mode pulsed operation, limited only by power supply and showing no sign of filamentation. Small signal modulation and eye pattern back-to-back measurements have been performed at room temperature and show the feasibility to use these devices for 2.5 Gbit/s data transmission. Aging tests showed more than 800 h of operation at 50 mW with less than 10% decrease in output power.

HL 22.3 Tue 15:45 BEY 154

Recombination dynamics in InAs-quantum dots coupled to the tilted cavity waveguide mode — •P. Zimmer[1], N.V. Kryzhanovskaya[2], N.N. Ledentsov[3], A. Hoffmann[1], D. Bimberg[1], A.R. Kovsh[3], S.S. Mikhrin[3], V.A. Shchukin[1], L.Ya. Karachinsky[2], and M.V. Maximov[2] — [1]Institut für Festkörperphysik, Technische Universität, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Abraham Ioffe Physical Technical Institute, Politekhnicheskaya 26, 194021 St.Petersburg, Russia — [3]NL Nanosemiconductor GmbH, Konrad-Adenauer-Allee 11, 44263 Dortmund, Germany

In this report we present recombination dynamics of nonequilibrium carriers in InAs-quantum dots embedded in a "tilted-mode" cavity. All epitaxial structure is based on a resonantly coupled planar waveguide and a multilayer interference reflector. In accordance with the theoretical prediction, the radiative recombination rate increases when the emission wavelenght corresponds to the tilted cavity waveguide mode whereas the off-resonance emission is suppressed. This effect has similar nature as the Purcell effect. Time-resolved photoluminescence studies indeed pointed out that the recombination dynamics is affected by the coupling of photons to the tilted-mode cavity. We found out that the radiative lifetime of carriers whose transition energy is in resonance to a tilted cavity waveguide mode is reduced by a factor of 1,5. The resonant wavelenght can be tuned by the design of the multilayer waveguide structure and it shows only a weak temperature dependence compared to the band gap temperature shift. This approach is promising for the realisation of highly-efficient wavelenght-stabilised LED's and lasers.

HL 22.4 Tue 16:00 BEY 154

Influence of electrostatic confinement on optical gain in GaInNAs quantum well lasers — •Sorcha Healy and Eoin OReilly — Tyndall National Institute, Lee Maltings, Cork, Ireland

There remains controversy surrounding the cause of the magnitude and temperature sensitivity of the threshold current density of 1.3 μm GaInNAs quantum well (QW) lasers, with several authors attributing the strong temperature sensitivity to hole leakage, due to the relatively low valence band offset in GaInNAs/GaAs QW structures. We use a Poisson solver along with a 10-band **k.p** Hamiltonian to calculate self-consistently the influence of electrostatic confinement on the optical gain in such lasers. We find that the proper inclusion of such effects significantly reduces the hole leakage effect, with the electrostatic attraction of the electrons significantly increasing the binding of heavy holes in the QW region. We conclude by comparison with previous theoretical and experimental studies that the room temperature threshold current is generally dominated by monomolecular recombination, while the temperature sensitivity is due predominantly to Auger recombination.

HL 22.5 Tue 16:15 BEY 154

GaInAsN Quantum Dot Lasers grown by RF MBE — •Bernd Marquardt[1], Dirk Bisping[1], Marc Fischer[2], and Alfred Forchel[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany — [2]nanoplus Nanosystems and Technologies GmbH, Oberer Kirschberg 4, 97218 Gerbrunn, Germany

Two different approaches are currently used to achieve long wavelength emission on GaAs substrate: InGaAs quantum dot (QD) and GaInAsN quantum well (QW) material. Laser emission with promising device properties has been demonstrated in both material systems. Here we report on the successful combination of both approaches: the realization of a GaInAsN QD laser. First, high quality N-free lasers emitting at 1280 nm with an active region consisting of InAs QDs embedded in an InGaAs Quantum Well (QW) were realized by solid source MBE. Based on this active region the incorporation of nitrogen in either the QDs or the embedding QW material or both was studied to extend the emission wavelength. Active nitrogen was supplied by an RF plasma source. A QD density of about 3.5 1010 cm-2 combined with excellent photoluminescence (PL) properties was obtained from PL test structures. Subsequently SCH laser structures with N-containing QD active region were realized. Based on a multi stack active region, a GaInAsN QD laser emitting at 1360 nm has been realized for the first time.

HL 22.6 Tue 16:30 BEY 154

Study of the dark line defects caused by the catastrophic optical mirror damage in broad area red-emitting high-power AlGaInP lasers — •Marwan Bou Sanayeh, Arndt Jaeger, Wolfgang Schmid, Sönke Tautz, and Klaus Streubel — OSRAM Opto Semiconductors GmbH, Leibnizstr. 4, 93055 Regensburg

Red-emitting AlGaInP lasers are being used in many applications such as optical discs, barcode readers, and color printers. Moreover, AlGaInP high-power broad area lasers have found usage in display technology and especially in the medical field, where they are required to show an outstanding performance and long-term reliability of many thousand hours. However, compared to infrared-emitting high-power AlGaInAs lasers, AlGaInP lasers are still lacking behind in showing high output powers, one reason is due to their low catastrophic optical mirror damage (COMD) levels. Therefore, studying the COMD in these lasers is of utmost importance to improve their performance and reliability.

In this work, we present deep analysis of the COMD on broad area red-emitting high power 650 nm AlGaInP lasers by studying the dark line defects (DLDs) caused by the COMD at the mirror facets and their propagation in the active region using micro-photoluminescence mapping and scanning electron microscopy.

HL 22.7 Tue 16:45 BEY 154

Carrier Losses in Semiconductor Laser Structures — •Angela Thränhardt[1], Christoph Schlichenmaier[1], Irina Kuznetsova[1], Stephan W. Koch[1], Jörg Hader[2], and Jerome V. Moloney[2] — [1]Fachbereich Physik, Philipps-Universität Marburg, Renthof 5, 35032 Marburg — [2]Arizona Center for Mathematical Sciences, The University of Arizona, Tucson, AZ 85721, USA

Microscopic modelling of semiconductor heterostructures offers the advantages of a better understanding of laser operation as well as enhanced predictability and possibility of optimisation. A theory on the level of the semiconductor Bloch equations including scattering in second Born and Markov approximation has been shown to quantitatively reproduce and predict optical spectra for, among others, gain, refractive index and linewidth enhancement factor [1,2]. To accurately determine the threshold, losses in laser operation are also important [3]. Simple dependencies as e.g. a quadratic rise of radiative losses with density are often assumed; however, these are valid for a Boltzmann distribution of carriers, i.e. far below lasing threshold, and may not be used for laser operation.

In this talk, we present a microscopic theory to accurately predict optical gain/absorption, refractive index, photoluminescence and laser losses on the same level. Good agreement with experiment is obtained. We investigate the validity of simple rules of thumb commonly used for laser simulations and find strong deviations in the lasing regime.

[1] J. Hader, S. W. Koch, J. V. Moloney, Sol. Stat. El. **47**, 513 (2003).
[2] A. Thränhardt et al., Appl. Phys. Lett. **86**, 201117 (2005).
[3] J. Hader et al., IEEE J. Quant. El. **41**, 1217 (2005).

HL 22.8 Tue 17:00 BEY 154

Multi-spectral infrared imaging of high-power diode lasers — •Mathias Ziegler, Fritz Weik, and Jens W. Tomm — Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Str. 2A, 12489 Berlin, Germany

Below band gap radiation of 808 nm GaAs-based high-power diode laser arrays in several spectral channels, namely the mid (MIR: 2.4-6 μm) and the near infrared (NIR: 1.5-2 μm), is used to reveal potential signs of the driving forces of an enhanced device degradation. By applying a fast infrared camera setup the infrared images of the devices can be analyzed spatially resolved down to the diffraction limit. Thus a localization of these degradation signs is possible on the scale of an emitter of the multi-emitter bar and even of parts of it.

With the multi-spectral approach it is possible to distinguish between the different mechanisms involved. The MIR signal mainly is assigned to the thermal radiation according to Planck's law and the NIR signal to deep-level-related luminescence These assumptions are supported by complementary measurements of the arrays infrared emission and absorption spectra, which indeed show the described spectral features.