HL 92: VCSELs, optical interconnects and Si photonics

Time: Thursday 15:45–17:45 Location: EW 202

HL 92.1 Thu 15:45 EW 202

Towards an all-Silicon Nanolaser — Sebastian Schmitt[1,2], •George Sarau[1], and Silke Christiansen[1,2] — [1]Max Planck Institut für die Physik des Lichts Erlangen — [2]Helmholtz Zentrum für Materialien und Energie, Berlin

While optical circuit elements based on silicon (Si) photonics are already well established and almost have reached market maturity, fully integrated Si based optoelectronic devices for optical data processing and sensing would require a small near-infrared (NIR) light source, because at lower wavelength the Si host medium is absorbing. So far, Si bonded III-V hybrid or semiconductor nanostructure lasers have generated the most remarkable results, nevertheless the hybrid integration of III-V semiconductors is unlikely to become technologically relevant.Highly integrated and low cost devices would require a CMOS compatible fabrication and therefore a small Si monolithic laser operating at room temperature remains a desirable goal. By applying a novel type of optical cavity, we show that Purcell enhancement of spontaneous emission in Si can generate NIR light beyond the lasing threshold at room temperature.

HL 92.2 Thu 16:00 EW 202

Record-large 23 GHz modulation bandwidth at 85°C of energy-efficient 980 nm VCSELs for optical interconnects — •Philip Moser[1], Gunter Larisch[1], Maya Volwahsen[1], James Lott[1], and Dieter Bimberg[1,2] — [1]Institut für Festkörperphysik und Zentrum für Nanophotonik, Technische Universität Berlin, Berlin, Deutschland — [2]King Abdulaziz University, Jeddah, Saudi Arabia

Energy-efficient oxide-confined vertical-cavity surface-emitting lasers (VCSELs) emitting at 980 nm, particularly well suited for very short reach (< 2m) and ultra short-reach (< 2 mm) optical interconnects, are presented. At 85°C a record-large 23 GHz modulation bandwidth f3dB is achieved with a 5 *m oxide-aperture diameter VCSEL. At 25°C the maximum f3dB is 24.7 GHz. At lower currents before the saturation of f3dB our VCSELs are faster and more energy-efficient at 85°C than at 25°C, making them especially well suited for future optical interconnect technologies with terabit performance, high bandwidth density and low power dissipation.

HL 92.3 Thu 16:15 EW 202

Quantum well-pumped red AlGaInP VECSEL — Fabian Sauter[1], •Stefan Baumgärtner[1], Hermann Kahle[1], Cherry May Mateo[2], Roman Bek[1], Uwe Brauch[2], Michael Jetter[1], and Peter Michler[1] — [1]Universität Stuttgart, Institut für Halbleiteroptik und Funktionelle Grenzflächen und Research Center SCoPE, Allmandring 3, 70569 Stuttgart — [2]Universität Stuttgart, Institut für Strahlwerkezuge, Pfaffenwaldring 43, 70569 Stuttgart

Optically pumped semiconductor vertical-external-cavity surface-emitting lasers (OPS-VECSELs) provide the possibility of bandgap engineering in combination with the benefit of a near-diffraction-limited beam. By the use of AlGaInP material system, the emission wavelength in the red spectral range can easily adjusted around 640 nm to 680 nm depending on the material composition. Furthermore, the external cavity enables intra-cavity wavelength tuning, frequency doubling or mode locking. Previous AlGaInP OPS-VECSELs were pumped usually with green lasers at 532 nm to excite carriers in the barrier layers of the gain structure. The high quantum defect between the pump and the emission wavelength result in an elevated thermal input. In order to avoid degradation of the semiconductor structure and thermal rollover with increased pump power, we lower the quantum defect by carrier excitation in the quantum wells directly via pumping in the red spectral range. This causes challenges like low absorption efficiency and the lack of suitable pump sources. The present work is focusing on these challenges to achieve the quantum well-pumped VECSEL to a vest-pocket prototype.

HL 92.4 Thu 16:30 EW 202

Self-mode-locking vertical-external-cavity surface-emitting laser — Mahmoud Gaafar[1], •Philipp Richter[1], Hakan Keskin[2], Christoph Möller[1], Matthias Wichmann[1], Wolfgang Stolz[1,3], Arash Rahimi-Iman[1], and Martin Koch[1] — [1]Department of Physics and Materials Sciences Center, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany — [2]Department of Physics, Middle East Technical University, Ankara, 06800, Turkey — [3]NAsP III/V GmbH, Am Knechtacker 19, 35041 Marburg, Germany

Self-mode-locked (SML) optically-pumped semiconductor disk lasers emerged in recent years to become a promising alternative to their saturable-absorber-based pendants. Self-mode-locking has yet not only been shown for quantum-well systems, but also for quantum-dot ones. In this work, we present an SML quantum-well semiconductor disk laser at an emission wavelength of 1 micron. Green light originating from second-harmonic generation using the out-coupled laser beam is demonstrated using a BBO crystal outside the cavity. In addition, a long-time-span pulse train as well as an autocorrelation trace is presented for our sub-ps pulses at 500 MHz repetition rate. A beam-profile measurement reveals the excellent beam quality of our device with an M-square factor of less than 1.1 for both axes.

HL 92.5 Thu 16:45 EW 202

Spontaneous and stimulated emission dynamics of quantum dot high-Q micropillar structures — •Sören Kreinberg[1], Elisabeth Schlottmann[1], Steffen Holzinger[1], Janik Wolters[1], Sven Höfling[2,3], Martin Kamp[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Lehrstuhl für Technische Physik, Universität Würzburg, 97074 Würzburg, Germany — [3]School of Physics & Astronomy, University of St Andrews, St Andrews, United Kingdom

Semiconductor microcavites are an ideal environment to study the fundamentals of light matter interaction down to the single emitter-single photon limit. Here, various effects like strong coupling or ultralow threshold lasing can be observed.

We present a comprehensive experimental study on the spontaneous and stimulated emission dynamics of InGaAs quantum dots embedded in high-Q micropillar cavities. While at low excitation powers the Purcell-enhanced spontaneous emission dominates the dynamics, a significant reduction of the emission lifetime indicates the onset of lasing at higher excitation powers.

Our results promise a better understanding of high-beta few-quantum-dot laser.

HL 92.6 Thu 17:00 EW 202

Finite-size high-contrast gratings for VCSELs — •Anjin Liu and Dieter Bimberg — Institut für Festkörperphysik und Zentrum für Nanophotonik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany

Vertical-cavity surface-emitting lasers (VCSELs) are attractive low-cost light sources e.g. for optical interconnects in computer networks or optical sensors, providing high modulation bandwidth, lower power consumption, and symmetric beam properties. High-speed, energy-efficient, and temperature-stable VCSELs for data transmission with increasing link lengths have been demonstrated in the last few years. Nanoscale photonic structures like high-contrast gratings (HCGs) provide novel opportunities for VCSEL design and are expected to exhibit improved device performance like modulation speed, mode selectivity, and polarization control. Previous HCGs were designed with periodic boundary conditions using infinite-size plane incident waves. However, in a real device both the HCG and the incident wave are finite. Such modelling is presented here. The higher-order angular components of the finite-size incident wave are found to excite eigenmodes of the HCG causing reduced reflection and reduced reflection bandwidth. The in-plane and unidirectional transmission by the mode conversion in finite-size HCGs provide opportunities for novel applications like integrated VCSEL-based optical sensors and VCSEL-based on-chip optical interconnects.

HL 92.7 Thu 17:15 EW 202

Large frequency mode-locking of InP/InAs quantum-dot lasers — •Tagir Sadeev, Dejan Arsenijević, and Dieter Bimberg — Technische Universität Berlin Institut für Festkörperphysik

Passively mode-locked semiconductor lasers (MLL) are able to emit fs-short optical pulses at frequencies up to tens of GHz without any external frequency source. MLLs are of largest importance e.g. for ultra-high data rate optical transmission, clock sources and biomedicine. Significant improvements of the performance of MLL as well as continuous-wave lasers have been achieved in last decades, thanks to

implementing zero-dimensional (quantum dot) structures into the active layer. Most advantages of QD MLL have been demonstrated for GaAs-based ones, operating at 1310 nm wavelength, targeting short-range telecom applications, where optical fiber exhibits zero dispersion. Long-haul optical transmission systems operate in the 1550 nm range, where fiber losses are minimal. At this wavelength InP based growth technology is common, but the brake-through results of QD MLLs are much scarcer as compared to their 1310 nm counterparts. In this work we investigate passive mode-locking of two-section QD MLL grown by metalorganic vapor phase epitaxy on InP substrate. We demonstrate monolithic two-section true QD MLLs at 1550 nm with better performance than yet reported: lowest optical pulse FWHM is 3.7 ps without any compression at 33.5 GHz repetition rate, which is noise-free and 300 MHz tuneable.

HL 92.8 Thu 17:30 EW 202

Gain compression induced polarization mode competition in quantum-dot micropillar lasers:A comparison of theoretical modeling via multi-mode rate equations and experimental measurements — •Christoph Redlich, Benjamin Lingnau, and Kathy Lüdge — Institut f. Theo. Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623Berlin, Germany

We present a comparison of experimental results and theoretical modeling of the two-mode light emission of quantum-dot semiconductor micropillar lasers (QD micropillar VCSEL) subjected to optical feedback from a distant mirror. Using stochastic multi-mode rate equations with phenomenological gain compression parameters and spontaneous emission noise we show very good agreement in terms of intensity profiles and stochastic properties of the examined QD lasers. We further investigate intensity correlation functions and correlation times which can nicely be described by the semi-classical rate equation system. Even effects like superthermal bunching are reproduced, showing that this effect also finds its origin in spontaneous emission noise induced mode switching.