HL 12: Semiconductor lasers I

Time: Monday 15:00–17:15 Location: POT 112

HL 12.1 Mon 15:00 POT 112

Adjustment of the active region on an InGaAsP VECSEL around 760nm for red pumping — •Rebecca Rühle, Marius Grossmann, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart, Allmandring3, 70569 Stuttgart, Germany

The quantum defect between the emission and the pump wavelength of vertical external-cavity surface-emitting lasers (VECSEL) has a huge impact on the performance of the structure. Especially to improve the thermal behavior, a longer wavelength pump laser is favorable. For the InGaAsP quantum well (QW) VECSEL with an emission wavelength at around 760nm, a pump laser at 675nm is preferable to one at 532nm. But the QWs are embedded in GaInP-barriers, thus are transparent for the pump light and the pump efficiency is rather small. To overcome this the composition of the GaInP can be changed so that the barrier again can absorb the pump light. The effects of adjusting the barrier in the active region and the performance of the VECSELs have now been investigated in detail. Photoluminescence and laser output power measurements were performed to compare the behavior of the different structures. A further study was carried out to evaluate the effect of the different gallium to indium ratio in the crystal structure on the surface roughness of the device.

HL 12.2 Mon 15:15 POT 112

Cavity effects in hybrid resonators embedding InGaAs quantum dots — •Kartik Gaur, Sarthak Tripathi, Imad Limame, Ching-Wen Shih, Chirag Palekar, Sven Rodt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Germany

InGaAs quantum dots (QDs) embedded in microcavities based on highly reflective distributed Bragg reflectors (DBRs) allow for the development of high Q-factor, low mode volume micropillar cavities which feature high light-matter interaction. This makes them almost ideal candidates for quantum light sources and high-β microlasers. However, epitaxially grown GaAs/AlAs DBRs suffer from relatively low refractive index contrast, and often high absorption of the optical pumping laser. Here, we propose replacing the upper III-V DBR with dielectric DBR based on $\lambda/4$-thick layers of SiO_2 and Si_3N_4 deposited using plasma-enhanced chemical vapor deposition. Numerical simulations are carried out to optimize the fabrication parameters and subsequently validate the optical properties. The MOCVD-grown InGaAs QD active region is integrated in the central one-λ GaAs cavity on top of the bottom DBR with 33 $Al_{0.2}Ga_{0.8}As/Al_{0.9}Ga_{0.1}As$ mirror pairs, followed by electron beam lithography processing step to define photonic defects for lateral mode confinement. Such defects in the form of microlenses are created using a SiO_2 hard mask and wet chemical etching. We then deposit dielectric top DBR consisting of 15 $\lambda/4$-thick SiO_2 and Si_3N_4 mirror pairs. The final structure is investigated via low-temperature micro-photoluminescence.

HL 12.3 Mon 15:30 POT 112

Latest developments on membrane external-cavity surface-emitting lasers (MECSELs) — •Hermann Kahle[1,2], Patrik Rajala[2], Philipp Tatar-Mathes[2], and Mircea Guina[2] — [1]Institute for Photonic Quantum Systems (PhoQS), Department of Physics, Paderborn University, Warburger Straße 100, 33098 Paderborn, Germany — [2]Optoelectronics Research Centre (ORC), Physics Unit / Photonics, Tampere University, Korkeakoulunkatu 3, 33720 Tampere, Finland

MECSELs have experienced a rapid progress in recent years. Based on the membrane geometry of MECSELs, an intrinsically excellent beam quality is one important benefit of this new vertically emitting kind of lasers. The most important recent progress, like continuous wave broadband tuning ($\Delta\lambda_{\mathrm{FWHM}} \approx 70\,\mathrm{nm}$ around $\lambda_0 = 985\,\mathrm{nm}$) and anti-resonant gain membrane design will be discussed.

HL 12.4 Mon 15:45 POT 112

Membrane saturable absorber mirror (MESAM) in a red-emitting VECSEL for the generation of stable ultrashort pulses — •Ana Ćutuk, Marius Grossmann, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart

Optically-pumped semiconductor disk lasers, also known as vertical external-cavity surface-emitting lasers (VECSELs), provide several advantageous properties like near-diffraction-limited beam profile and the flexibility to add optical components inside the laser cavity and thereby modify the laser characteristics. One example is the semiconductor saturable absorber mirror (SESAM), a monolithic semiconductor structure consisting of a saturable absorber region on top of a distributed Bragg reflector (DBR). However, the epitaxial growth of SESAMs can be limited by the DBR design, making it difficult to fabricate pulsed lasers with wavelengths within spectral gaps. We demonstrate a membrane saturable absorber mirror (MESAM) which overcomes the growth restrictions of the DBR. A membrane containing the active region only is combined with a dielectric mirror and thus simulates a SESAM with an increased flexibility in design. We compare the dynamic properties of a SESAM- and MESAM-mode-locked VECSEL. With both devices we obtain fundamental mode locking with pulse durations in the ps-range.

30 min. break

HL 12.5 Mon 16:30 POT 112

AlGaInP-based VECSELs with grating waveguide structures — •Peter Gierss[1], Ana Ćutuk[1], Maxim Leyzner[2], Uwe Brauch[2], Marwan Abdou Ahmed[2], Michael Jetter[1], Thomas Graf[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart — [2]Institut für Strahlwerkzeuge, Universität Stuttgart, Pfaffenwaldring 43, 70569 Stuttgart

Vertical external-cavity surface-emitting lasers (VECSELs) provide several superior properties like a near-diffraction beam profile and the flexibility to add optical components inside the cavity for further tailoring of the laser parameters. However, the heat generated by the pump laser within the active region proves to be a limiting factor for achieving higher output powers. This is mainly due to the poor thermal conductivity of the thick distributed Bragg reflector (DBR), which could be overcome by placing a heatspreader right next to the active region.

In this contribution, we present our recent progress in the development of an AlGaInP-VECSEL based on a grating waveguide structure (GWS). Excluding the DBR and adding a heatspreader instead improves the heat removal from the gain region while the guided-mode resonances from the GWS should provide good coupling of the pump and laser field and a high reflectivity to replace the function of the DBR. Our current research focuses on the fabrication and characterization of the high-contrast grating on top of a gain membrane.

HL 12.6 Mon 16:45 POT 112

Manipulating the emission characteristics of VCSEL in the red spectral range with polymer microlenses and etched surface reliefs — Farnaz Khamseh, •Lena Engel, Michael Zimmer, Sergej Vollmer, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technol- ogy (IQST) and SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart

Vertical-cavity surface-emitting lasers (VCSELs) are promising candidates for various applications like sensing, printing and data transfer due to their low power consumption and the possibility of arranging them in arrays. Especially in the red spectral range around 660nm VCSEL are interesting for example in biomedical applications. However, their implementation is often hampered as light is emitted under an angle of divergence of 10° for single mode operation and higher order transverse modes are emitted especially for higher output power operation, further increasing the divergence and limiting the fiber coupling efficiency. Thus, the aim of this work is to improve the emission characteristics of red emitting VCSELs. Therefore, polymer microlenses for beam collimation are integrated directly on the VCSEL surface. Their ideal geometry and the tolerances for the alignment relative to the oxide aperture are thoroughly investigated utilizing ray-optics simulations. Additionally, etched surface reliefs are used to suppress the emission of higher order modes via a spatial modulation of the top mirror loss.

HL 12.7 Mon 17:00 POT 112

Multifold lasing threshold reduction of optically pumped micropillar lasers with low-absorbing $Al_{0.2}Ga_{0.8}As/Al_{0.9}Ga_{0.1}As$ distributed Bragg reflectors — •Ching-Wen Shih[1], Imad Limame[1], Chirag Palekar[1], Sebastian Krüger[1], Aris Koulas-Simos[1], Daniel Brunner[2], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany — [2]Département d'Optique P. M. Duffieux, Institut FEMTO-ST, Université Bourgogne-Franche-Comté CNRS UMR 6174, Besançon, France

Micropillar photonic devices, where the active layers are in an optical cavity sandwiched between epitaxially grown dielectric Bragg mirrors (DBRs), are one of the fundamental elements to study cavity quantum electrodynamics and to enable devices for quantum technology applications. Here, we report on the experimental realization of multifold lasing threshold reduction of optically pumped micropillar lasers by simply replacing the commonly used $GaAs/Al_{0.9}Ga_{0.1}As$ DBRs with low-absorbing $Al_{0.2}Ga_{0.8}As/Al_{0.9}Ga_{0.1}As$ DBRs, which minimizes the DBRs absorption of the optical pump power. In pump-wavelength-dependent I/O measurements, we demonstrate that the incorporation of 20% Al content in the DBRs opens an optical pumping window from the absorption edge of $Al_{0.2}Ga_{0.8}As$ at 700 nm to the one of GaAs at 820 nm, where the excitation laser light can effectively reach the GaAs cavity above its bandgap while remaining transparent to the DBRs, resulting in high power conversion efficiency, low lasing threshold, and high thermal stability.