HL 12: Semiconductor Lasers I

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

HL 12.1 Mon 15:00 EW 561

Multi-Hole-Aperture VCSELs to remove the saturation current barrier — •Sicong Tian[1,2], Mansoor Ahamed[1,3], Georgiy Sapunov[1], 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]The University of Chinese Academy of Sciences, Beijing 100049, People's Republic of China

Novel design of Vertical-Cavity Surface-Emitting Lasers is presented leading to a strong reduction of thermally induced band gap shift as a function of current. The aperture is realized through dry etching geometrically variable arrangements of deep holes and subsequent oxidation. The blind holes are then filled with gold resulting in an effective heat drain technology. The shape and size of the aperture depend on the arrangement of holes [1]. Larger output power, rollover current, single-mode emission, and reduced series resistance are demonstrated. In addition, pseudo-single-mode multi-aperture VCSELs are enabled [2]. Refferences [1] G. Larisch, S.C. Tian, and D. Bimberg, Radiation Emitter, EP2020192355. [2] G. Larisch, S.C. Tian, and D. Bimberg, Radiation Emitter, EP2021168265.

HL 12.2 Mon 15:15 EW 561

Tuning nanowire lasers via hybridization with tailored dye molecules — •Edwin Eobaldt, Leon Kross, Jakob Wurschi, Aurelia Eberhard, Marco Grünewald, Daniel Costabel, Kalina Peneva, and Carsten Ronning — Friedrich-Schiller-Universität, Jena, Deutschland

Among the myriad nanomaterials, semiconductor nanowires have garnered considerable scientific attention as promising candidates for realizing nano-scaled coherent light sources and all-optical circuits. This interest stems from their notable waveguiding properties and intrinsic ability to lase under high excitation. Nevertheless, achieving a precise control over their lasing properties, such as emission wavelength and lasing threshold, is crucial for a diverse range of applications. In this context, the hybridization of nanowires with tailored molecules emerges as a potential avenue, offering new control mechanisms through efficient charge and energy transfer processes at the heterointerface. To illustrate this concept, we chose to hybridize ZnO nanowires with perylene-based dye molecules, leveraging their exceptional chemical and optical stability. Notably, these molecules provide the advantage of easily tuning their optical gap across a broad spectral range through chemical functionalization. This study employs comparative micro-photoluminescence measurements to explore the impact of these molecules on the nanowire lasing properties. Specifically, we demonstrate how different chemical functionalizations and varying amounts of dyes enable nanowire wavelength tuning.

HL 12.3 Mon 15:30 EW 561

Growth, fabrication, and characterization of site-controlled quantum dots microcavity arrays based on buried-stressor approach — •Kartik Gaur, Sam Baraz, Lukas Dworaczek, Sarthak Tripathi, Imad Limame, Ching-Wen Shih, Martin Podhorsky, Aris Koulas-Simos, Sven Rodt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, D-10623 Berlin

The buried-stressor approach is one of the pivotal methods for the growth of site-controlled quantum dots (SCQDs). This growth technique makes use of the strain from a partially oxidized AlAs layer to induce site-selective nucleation of InGaAs quantum dots. Here, we report on the growth, fabrication, and characterizations of SCQD microcavity arrays consisting of spectrally homogeneous single photon sources. Various optimizations in the growth process are explored through simulations, with subsequent samples grown using metal-organic chemical vapor deposition (MOCVD) to achieve position, number, and emission energy-controlled QDs. A systematic investigation of the effects of variation of SCQD growth parameters on QDs density, surface morphology, and optical properties is done using atomic force microscopy (AFM), cathodoluminescence (CL), and microphotoluminescence (μPL) spectroscopy. Furthermore, quantum optical characterizations such as second-order autocorrelation, visibility measurements, etc. are also performed on these SCQD arrays. The comprehensive understanding of the intricacies involved in the growth and characterization of SCQDs offers a roadmap for advancing quantum information technology.

HL 12.4 Mon 15:45 EW 561

Investigation of different QW arrangements in the deep red laser emission range for VECSELs in a V-shaped resonator — •Rebecca Rühle, 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, Germany

In this work we investigate the influence of the quantum well (QW) distribution of a VECSEL (Vertical external-cavity surface emitting laser) on its optical output power. One parameter is the layer thickness, since a thicker laser structure is associated with higher temperatures in the active region. In order to vary the thickness, three different QW distributions are examined. The VECSEL chip consists of a Al(0.3)GaAs/Al(0.95)GaAs DBR and an active region with InGaAsP QWs, grown with a MOVPE (metal-organic vapor-phase epitaxy). For the investigated VECSELs, the total number of QWs is kept approximately at the same to optain a better comparability. The exact structure of the investigated VECSELs consists of 11x1, 6x2 and 4x3 InGaAsP QWs embedded in a GaInP barrier for laser emission at 770nm. Power measurements were used to investigate and analyze the performance of the v-shaped resonator and VECSEL structures.

HL 12.5 Mon 16:00 EW 561

265 nm AlGaN based laser heterostructures using distributed polarization doping — •Lennard Zinsilowski[1], Massimo Grigoletto[1,2], Jakob Höpfner[1], Giulia Cardinali[1], Luca Sulmoni[1], Tim Wernicke[1], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institute of Solid State Physics, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut (FBH), Berlin, Germany

In this study the growth of 265 nm laser diode heterostructures by metalorganic vapor phase epitaxy (MOVPE) implementing distributed polarization doping is investigated. P-type AlGaN layers using distributed polarization doping (DPD) have been recently developed to achieve higher conductivity than p-doped AlGaN:Mg layers, which exhibit increasing resistivities due to increasing ionization energies with higher Al mole fractions. Through a pseudomorphically grown grading of the $Al_xGa_{1-x}N$ layers polarization charges are generated in the layer, inducing free hole carriers even in the absence of Mg dopants. The impact of the active zone growth conditions, structural design and also the DPD design regarding the electrical properties of the laser diodes were studied aiming to achieve high current injection efficiencies. Pulsed on-wafer measurements of 5 μm x 800 μm large devices at a current of 1 A (25 kA/cm^2) show voltages around 30 V and a series resistance of 10 Ω. The DPDs show a high durability sustaining current densities of more than 100 kA/cm^2 for different geometries. This shows a promising approach towards UV-C laser diodes working on sapphire.

HL 12.6 Mon 16:15 EW 561

Polarized-resolved Raman scattering of epitaxially grown (Si)GeSn layers — •Agnieszka Corley-Wiciak[1], Shunda Chen[2], Omar Concepción[3], Marvin H. Zoellner[1], Detlev Grützmacher[3], Dan Buca[3], Tianshu Li[2], Giovanni Capellini[1,4], and Davide Spirito[1] — [1]IHP Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder), Germany — [2]Department of Civil and Environmental Engineering, George Washington University, Washington USA — [3]Peter Grünberg Institute 9 (PGI-9) and JARA-Fundamentals of Future Information Technologies, Juelich, Germany — [4]Dipartimento di Scienze, Università Roma Tre, Roma,

Silicon-Germanium-tin (SiGeSn) alloys are gaining popularity due to their potential applications in photonics, optoelectronics, microelectronics, and thermoelectrics. To accomplish this, it is critical to accurately assess the effect of composition, strain, and deposition method on the crystal quality. Raman spectroscopy as an experimental tool for probing vibrational modes allows a detailed study of these qualitites. Here we investigate the role of Sn incorporation on the vibrational properties of (Si)GeSn epitaxial layers using polarized Raman spectroscopy and numerical simulations. The nature of the disorderedassisted spectral feature can be ascertained through a comparative analysis. It comprises two modes: one associated with the vibration of Ge atoms that Sn neighbors do not impact, and the disorder activating specific mode. This provides a framework for understanding the vibrational properties in SiGeSn alloys, particularly concerning the impact of the local ordering of different atomic species.

HL 12.7 Mon 16:30 EW 561

Free space emission spectra and bandwidths of vertical cavity surface emitting lasers — •Pouria Emtenani[1], Nasibeh Haghighi[1], Martin Zorn[3], Markus R Wagner[1,2], and James A Lott[1] — [1]Technical University of Berlin — [2]Paul-Drude-Institut Berlin — [3]JENOPTIK Optical Systems GmbH, Berlin

We measure and analyze the free space (across air) emission spectra and small-signal modulation bandwidths of top-emitting 980 nm vertical cavity surface emitting lasers (VCSELs) and electrically parallel VCSEL arrays. We design and fabricate the VCSELs at the Technical University of Berlin [1] and test them using on-wafer high-frequency probing. The VCSEL emission is collected into a standard OM2 multiple-mode optical fiber patch cord with a length of 10 meters which in turn directs the optical signal into a triplet-lens fiber collimator. The light exits the fiber collimator as a free space beam. A second triplet-lens fiber collimator collects the light and directs it into a second OM2 fiber patch cord with a length of 3 meters which then directs the optical signal into an optical spectrum analyzer or onto a high bandwidth photodiode connected to a 2-port vector network analyzer. We achieve a free space bandwidth across 0.4 and 4.5 meters of air of 16 GHz for a 19-element array and 25 GHz for a single VCSEL, a crucial first step toward free space data transmission at 25 Gbps or faster for future, sixth generation optical wireless communication systems, Internet of Things connectivity, and next generation light fidelity systems. [1] N. Haghighi, Dissertation. [online] https://depositonce.tu-berlin.de/handle/11303/16321