HL 94: Poster IV A (Laser; Devices; Heterostructures; Surfaces, interfaces and defects)

Presenters are kindly requested to be near their poster for at least one hour in the time between 16:00-18:00 or to leave a note about their availability for discussions.

Time: Thursday 14:00–20:00 Location: Poster B

HL 94.1 Thu 14:00 Poster B

Towards AlGaInP-based electrically-pumped VECSELs emitting in the red spectral range — •Mona Stadler, Hermann Kahle, Roman Bek, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, Allmandring 3, 70569 Stuttgart, Germany

Electrically-pumped vertical external-cavity surface-emitting lasers (EP-VECSELs) combine the advantages of optically-pumped semiconductor disk lasers with an external cavity and vertical cavity surface emitting lasers (VCSELs). Comparable to optically-pumped VECSELs, they exhibit for example scalable output powers and good beam qualities. The external cavity offers the use of elements within the cavity, which is helpful for further applications. In electrically-pumped devices there is no need of special and often expensive laser pump sources. Electrical pumping facilitates higher integration and further miniaturization and is an important step towards compact laser devices. The development of EP-VECSEL is challenging because of several reasons. The design should be as easy as possible, optical losses and Joule heating in doped layers is unavoidable but should be reduced. Therefore, a good thermal management, a suitable carrier distribution and a balance between the optical and electrical requirements is necessary. We present the first steps towards an electrically-pumped AlGaInP-based VECSEL emitting in the red spectral range.

HL 94.2 Thu 14:00 Poster B

Untersuchungen der Abstrahlcharakteristik von mehrmodigen Strahlquellen — •Inga-Maria Eichentopf, Sebastian Mammitzsch und Martin Reufer — Institut Naturwissenschaften, Hochschule Ruhr West, Mülheim an der Ruhr, Deutschland

Zur Analyse der Strahlqualität von Laserquellen hat sich die Wellenfrontmessung mittels Shack-Hartmann Sensoren etabliert. Abweichungen in der Resonatorgeometrie und im Modenverhalten der Laserquellen können mit hoher Auflösung anhand der Deformation der Wellenfront analysiert werden. Breitstreifenlaserbarren im nahen Infrarot basieren auf dem Materialsystems GaAs. Sie emittieren aufgrund ihrer Resonatorgeometrie eine Vielzahl optischer Moden. Die Anzahl und Ausprägung der Moden wird dabei von thermischen und elektrischen Effekten im aktiven Medium beeinflusst. Aus diesem Grund kann die Emission dieser Bauteile stark mit den Betriebsbedingungen variieren. Von besonderer Bedeutung für die Anwendungen, bei denen das Laserlicht in Glasfasern eingekoppelt wird ist es, die räumlichen Abstrahlbedingungen für einen weiten Leistungsbereich konstant zu halten, um Effizienzeinbußen durch Koppelverluste zu minimieren. In unserer Arbeit untersuchen wir den Einfluss der Betriebsbedingung auf die Emission von Halbleiterdioden. Neben der Intensitätsverteilung der Laseremission im Nahfeld wird die Winkelverteilung im Fernfeld untersucht. Weiterhin liegt ein besonderer Fokus auf der Analyse der Veränderung der Phasenfronten des Lasers. Um Rückschlüsse auf die Modenstruktur zu ziehen zu können, werden die experimentellen Messergebnisse mit den Ergebnissen einer optischen Simulationssoftware korreliert.

HL 94.3 Thu 14:00 Poster B

Sub-Monolayer-Control in Epitaxial Growth of Quantum Cascade Lasers — •Michael Kwiatek[1], Negar Hekmat[1,2], Arne Ludwig[1], Nathan Jukam[2], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum — [2]AG Terahertz-Spektroskopie und Technologie, Ruhr-Universität Bochum

A quantum cascade laser (QCL) consists of multiple vertically stacked semiconductor modules including several well-dimensioned quantum wells. In QCLs intersubband transitions in the conduction band generate the laser light. Due to QCL's cascading structure, one electron generates multiple photons. The production of good QCLs sets high demands on the fabricating process, especially on the layer quality of the quantum wells and barriers, why QCL fabrication is often performed with Molecular Beam Epitaxy (MBE). A known problem in MBE is the shutter transient of the effusion cells (EC). When the EC-shutter is closed, the heat of the EC is reflected back in itself. If the shutter is opened, more power is needed to stabilize the temperature and hence the material flux of the EC. For QCLs, very thin material layers of only a few monolayers with high precision are crucial. The time the EC needs to stabilize leads to a change in the growth rate for those thin layers. Our goal is the reduction of the shutter transient effect and other growth related errors on the QCL's layer structure.

HL 94.4 Thu 14:00 Poster B

Selection of longitudinal modes in quantum cascade laser via narrow-band injection seeding — Hanond Nong[1], Shovon Pal[1,2], Sergej Markmann[1], •Negar Hekmat[1], Reshma A. Mohandas[3], Paul Dean[3], Lianhe Li[3], Edmund H. Linfield[3], Giles A. Davies[3], Andreas D. Wieck[2], and Nathan Jukam[1] — [1]Arbeitsgruppe THz Spektroskopie und Technologie, Ruhr-Universität Bochum, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany — [3]School of Electronic and Electrical Engineering, University of Leeds, U.K.

Phase seeding is a technique to lock the phase of a quantum cascade laser (QCL) to the repetition rate of a fs laser, enabling access to the time-resolved THz-field of the QCL. In typical phase seeding all longitudinal modes in the gain region of a QCL are simultaneously seeded. We injection seed a THz QCL with narrow-band THz pulses which are generated in a periodically poled lithium niobate (PPLN) crystal. A THz seed pulse with a different frequency can be generated for each of the PPLN crystal's multiple poling periods. The seed pulses' FWHM are comparable to the longitudinal mode spacing of the QCL. When the longitudinal modes overlap the narrow-band seed spectrum they are selectively enhanced while other longitudinal modes are suppressed. When the narrow-band THz seed is shifted the QCL spectral emission also shifts to a higher longitudinal mode overlapping the seed. We study the dynamics of the QCL emission as a function of a round-trip time and a seed frequency. If the seed frequency is outside the gain maxima, a shifting to the preferential mode of a QCL is observed.

HL 94.5 Thu 14:00 Poster B

DFB-Master-Oscillator-Power-Amplifier system for high precision optical sensors — •Anja Kohfeldt[1], Mandy Krüger[1], Max Schiemangk[1,2], Andreas Wicht[1,2], Götz Erbert[1], Achim Peters[1,2], and Günther Tränkle[1] — [1]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin, Germany

We have developed hybrid integrated DFB-Master-Oscillator-Power-Amplifier modules (MOPA) for portable quantum optical sensors. This application typically requires the optical frequency of the laser to be stabilized to $\delta\nu/\nu = 10^{-10}$, in some cases even down to 10^{-15}. Frequency stabilization is commonly realized by controlling (modulating) the injection current of the laser diodes. In order to enable high servo bandwidths as mentioned above, the module hosts an electrical interface for a close-to-chip RF modulation.

We will present a MOPA module designed for rubidium spectroscopy at 780 nm achieving an optical output power > 1 W (cw) and an intrinsic linewidth of < 50 kHz. Furthermore, we discuss the transfer functions of the system for modulation of the injection current of both the master oscillator and the power amplifier.

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HL 94.6 Thu 14:00 Poster B

Quantum dot microlaser under external optical feedback. — •Leon Messner[1], Elisabeth Schlottmann[1], Sören Kreinberg[1], Steffen Holzinger[1], Christian Schneider[2], Sven Höfling[2,3], Martin Kamp[2], Janik Wolters[1], and Stephan Reitzenstein[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany — [2]Technische Physik, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Würzburg, Germany — [3]Present address: SUPA, School of Physics and Astronomy, University of St Andrews, United Kingdom.

To study the transition form linear to non-linear and chaotic behavior, semiconductor lasers under self feedback are an excellent and widely

investigated model system. Similar, quantum dots embedded in photonic nanocavities provide an excellent platform for investigating the border between classical laser emission and quantum optical single photon emitters. In our experiments on feedback coupled micropillar lasers with only a few quantum dots in the active layer we combine both research fields, trying to reach the transition between the classical and the quantum regime of the involved nonlinear dynamics. We setup strong feedback-coupling of quantum dot micropillars while leaving options to explore changes in feedback strength and polarization. Our observations include changes in the second order autocorrelation function and intensity of the emitted light. Our studies promise not only novel insights into the underlying physics, but depending on emitter and feedback types a multitude of applications exist e.g. in quantum information science or cryptography.

HL 94.7 Thu 14:00 Poster B

Junction FETs based on *n*-ZnO/*p*-NiO heterojunctions — •Robert Karsthof, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

In this work we present junction field-effect transistors (JFETs) based on an *n*-ZnO channel with *p*-NiO as gate material. The band gaps of both semiconductors lie in the UV spectral range, thus enabling the realization of visibly-transparent devices and subsequent application in electronic circuits, e.g. for transparent displays.

Both ZnO and NiO were deposited by the pulsed laser deposition (PLD) method. We investigated the influence of the channel layer thickness on the on-voltage, current on-off ratio, and sub-threshold slope of the transfer characteristics of our devices, and we show that by decreasing the ZnO thickness from 80 to 9.2 nm, the switching behavior of the transistors can be shifted from 'normally on' to 'normally off'. The best room-temperature values for current on-off ratio and sub-threshold slope were 3×10^7 and 67 mV/dec, respectively. We also investigated the influence of temperature on the device characteristics in the range between -20°C and 150°C.

HL 94.8 Thu 14:00 Poster B

pnCCD response for hard X-ray pulses — Mohammad Shokr[1], Alaa El Ghashi[1], Ali Abboud[1], Sebastian Send[1], Robert Hartmann[2], •Lothar Strüde[2], and Ullrich Pietsch[1] — [1]) University of Siegen, Solid State Physics, Siegen, Germany — [2]PNSensor GmbH, München, Germany

Differing from other CCD concepts, pnCCD can be used as a four-dimensional detector with two spatial coordinates,one energy coordinate, and a time coordinate running with fast frame rates (1000 images/sec), high quantum efficiency, high energy resolution and low electronic noise. Because the attenuation coefficient of photoelectric absorption is high enough at low energy (below 20keV),the interaction of X-ray photons takes place entirely within the silicon bulk material. This is not the case for hard X-ray radiation where the photoelectric attenuation coefficient become very low while the contribution of Compton scattering increases and starts to be the dominant interaction process. Due to inelastic scattering an incoming photon creates a bunch of scattered electrons which themselves may initiate additional multi scattering events leading to additional features in the detector response function. In this paper we show simulations of the detector response for high energy X-ray photons. The simulated data will be compared to data taken by means of a commercial high energy x-ray source using the pnCCD detector.

HL 94.9 Thu 14:00 Poster B

Electrical characteristics of semiconductor/electrolyte junctions — •Jairo Cesar Nolasco, Oliya Sadrillaevna Abdullaeva, Manuela Schiek, and Jürgen Parisi — Energy and Semiconductor Research Laboratory, Department of Physics, Carl von Ossietzky University of Oldenburg, D-26111, Germany

Recently, organic semiconductor/electrolyte junctions have been investigated in diverse fields, such as artificial photoreceptors for retinal implants, biological sensors, and hydrogen production by organic photo electrochemical cells. The further developing of these technologies require a fundamental understanding of the electrostatic and the current-transport mechanism occurring at such junctions. Towards such understanding, here we present the electrical characteristics of the P3HT (poly-3-hexylthiophene)/electrolyte and the Squarine dye (2,4-Bis[4-(N,N-diisobutylamino)-2,6-dihydroxyphenyl)]squaraine/electrolyte system, specifically the illuminated current voltage characteristics and the illuminated capacitance voltage characteristics are studied.

HL 94.10 Thu 14:00 Poster B

Local Droplet Etching on GaAs (111)A substrates — •Julian Ritzmann[1], Rüdiger Schott[1], Nandlal Sharma[2], Dirk Reuter[1,2], Arne Ludwig[1], and Andreas D. Wieck[1] — [1]Ruhr-Universität Bochum, Universitätstraße 150, D-44780 — [2]Universität Paderborn, Warburger Straße 100, D-33098

The generation of entangled photon pairs is a key to practical quantum communications. In the case of biexcitons in Stranski-Krastanov-grown quantum dots, the fine structure splitting (FSS) of the energy levels causes the transition paths of biexciton and exciton transitions to be distinguishable. Therefore we need quantum dots with strongly reduced FSS. This was theoretically proposed and experimentally shown for GaAs quantum dots on (111)A-oriented AlGaAs by droplet epitaxy (DE)[1]. However, these quantum dots exhibit a strong distribution in size, resulting in rather broad photoluminescence spectra. Nearly uniform quantum dots were achieved by filling up nanoholes on (001)-oriented Al(Ga)As with GaAs, achieving a PL linewidth of less than 10 meV[2]. These nanoholes were generated via local droplet etching (LDE) of gallium droplets on an Al(Ga)As surface. Our approach is to use LDE for the growth of uniform, triangular QDs on (111)A-oriented substrates with low density and reduced FSS. Here, we present first results for different parameters on the LDE and LDE QD process on GaAs (111)A surfaces using atomic force microscopy and photoluminescence measurements.

[1] T. Mano et al., Appl. Phys. Express 3, 065203 (2010).
[2] Ch. Heyn et al., Appl. Phys. Lett. 94, 183113 (2009).

HL 94.11 Thu 14:00 Poster B

Photoluminescence and microstructure of porous silicon doped by gallium — •Mehrnoosh Naderi[1], Wafaa Al-khayat[2], and Gerhard Wilde[1] — [1]Institute of Materials Physics, University of Münster, Germany — [2]Baghdad,Iraq

Silicon itself has been the most important and widely used variable semiconductor in silicon based optoelectronics. Crystalline silicon has an indirect band gap of 1.1 eV, which limits its application in optoelectronics while porous silicon (PSi), due to its recent discovery of visible light emission at room-temperature may open a new field combining Si integrated technology and optoelectronics. On the other hand, doping is the most widely used method in semiconductor materials to obtain the required properties. For fast optoelectronics applications, blue photoluminescence (PL) is important. However, this specific PL has been less investigated in doped-PSi materials. In this contribution, the results obtained on Ga doped n-type porous silicon is reported. The Ga doping process was carried out by physical vapour deposition. The surface morphology and microstructure was observed by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Photoluminescence measurements illustrate that the luminescence behavior of Ga-doped PSi changes strongly from the red to the blue part of the spectrum by Ga doping.

HL 94.12 Thu 14:00 Poster B

Deep level transient spectroscopy of hydrogen-generated traps in nanoporous titanium dioxide — •Laurin Schnorr[1], Mihai Cerchez[1], Thomas Heinzel[1], and Dieter Ostermann[2] — [1]Solid State Physics Laboratory (IPkM), Heinrich-Heine-Universität Düsseldorf, 40204 Düsseldorf, Germany — [2]ODB-Tec GmbH & Co. KG, Bussardweg 12, 41468 Neuss, Germany

Deep level transient spectroscopy was carried out on Pt / nanoporous TiO_2 Schottky diode hydrogen sensors to investigate whether in addition to a shallow donor level deep traps get formed during hydrogen exposure. Therefore the sensor was exposed to different doses of molecular hydrogen using a H_2 in N_2 gas mixture with hydrogen concentrations in the ppm regime to allow time resolved measurements. A defined initial state of the sensor was achieved by exposing it to dry air at hight temperatures until the current-voltage characteristics became purely diodic. The DLTS measurements revealed two hydrogen-independent deep levels at 0.4eV and 0.6eV below the bottom of the conduction band. A third level at about 0.6eV with a significantly smaller emission rate could only be observed after exposures to high doses of H_2 and was reversible by oxygen exposure, suggesting that this level is related to hydrogen atoms interacting with oxygen vacancies.

HL 94.13 Thu 14:00 Poster B

Continuous composition spread method for amorphous zinc-tin-oxide — •Sofie Bitter, Peter Schlupp, Heiko Frenzel, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Institut für ExperimentellePhysik II, Germany

Amorphous zinc-tin-oxide (ZTO) is a close-to-ideal candidate for low cost transparent devices. It consists of naturally abundant, non-toxic materials only and can be deposited at room temperature. It was shown that electron densities as high as $10^{19}\,\mathrm{cm}^{-3}$ and mobilities as high as $10\,\mathrm{cm}^2/\mathrm{Vs}$ are possible [1]. With that ZTO is a suitable material for transparent transistors and thus for transparent electronic applications.

It is of great interest to acquire knowledge about the optimal Zn/Sn ratio in order to tune electrical and optical properties as desired. Up to now, only a few different Sn/Zn ratios were realized experimentally [2]. We present ZTO thin films deposited by pulsed laser deposition using a method of continuous composition spread (ccs) [3] and a ccs thin film produced by co-sputtering. The films were deposited on $50 \times 50\,\mathrm{mm}^2$ glass substrates. Using energy dispersive X-ray analysis the spatial dependence of the Zn/Sn ratio was mapped. Subsequently the samples were divided along the compositional gradient into stripes and their electrical and optical properties were compared. Both types of properties show a systematic dependence on the Zn/Sn ratio.

[1] Jayaraj et al. J. Vac. Sci. Technol. B, **26(2)** 2008
[2] Görrn et al. Applied Physics Letters, **91** , 193504 (2007)
[3] von Wenckstern et al. , CrystEngComm, **15**, 100 20, 2013