HL 43: Semiconductor lasers II

Time: Thursday 15:00–16:45 Location: POT 251

Invited Talk HL 43.1 Thu 15:00 POT 251

Superradiance as a witness to multipartite entanglement — •Frederik Lohof[1,2] and Christopher Gies[1,2] — [1]Institute for Theoretical Physics, University of Bremen, Bremen — [2]BCCMS, University of Bremen, Bremen

Generation and detection of entanglement is at the forefront of most quantum information technologies. There is a plethora of techniques that reveal entanglement on the basis of only partial information about the underlying quantum state including, in particular, entanglement witnesses. Superradiance refers to the phenomenon of highly synchronized photon emission from an ensemble of quantum emitters that is caused by correlations among the individual particles and has been connected to the presence of multipartite entangled states. We investigate this connection in a quantitative way and discuss the question, whether or not signatures of superradiance from semiconductor nanolasers, e.g. as revealed by photon-correlation measurements, can be interpreted as a witness to detect entanglement in the underlying state of the emitters.

HL 43.2 Thu 15:30 POT 251

Towards a quantum dot based semiconductor optical amplifier for sensing applications in the telecom O-band — •Philipp Noack, Michael Zimmer, Sergej Vollmer, Michael Jetter, and Peter Michler — Universität Stuttgart, IHFG

Optical methods for gas sensing are of great interest in recent technologies. To facilitate the optical detection of gases, a swept laser source can be realized through a semiconductor optical amplifier (SOA) and a tunable MEMS filter.

MOVPE grown quantum dots (QDs) are a prime candidate for providing gain in such a SOA system because of fast charge carrier recovery times and broad gain spectrum created by the statistical distribution of QD sizes.

To this end, we grow InGaAs QDs on a GaAs substrate. We control the growth parameters, such as material flow and growth time, to produce QDs at high densities. We incorporate a dots-in-well structure to shift the emission into the telecom O-band and to improve charge carrier confinement. To provide sufficient gain in a broad spectrum, we especially investigate the properties of vertically stacked QD layers.

After the optimization of the gain structure we perform optical simulations to find the electric field modes of edge-emitting laser structures. Then we incorporate the investigated QDs into electrically pumped edge-emitting structures and characterize the net modal absorption and net modal gain spectra of the devices as antecedent of the SOA.

HL 43.3 Thu 15:45 POT 251

Optical and quantum optical studies of feedback induced chaotic emission in bimodal VCSELs — •Aris Koulas-Simos, Timo Willburger, Niels Herrmeier, Ching-Wen Shih, Imad Limame, James Lott, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

Vertical Cavity Surface Emitting Lasers (VCSELs) have proven to be a key building block for commercial applications in data communication, automotive systems and sensing as well as for novel complex neuromorphic photonic platforms. Here, we report on signatures of chaotic emission in bimodal GaAs-based quantum well VCSELs subject to delayed optical feedback. In excitation power-dependent microelectroluminescence studies, a clear lasing transition is evident for the strong mode reflected in the strong s-shape form of the I/O-curve accompanied by an abrupt linewidth narrowing, in contrast to the weak mode which exhibits intensity saturation and rollover at high injection currents. In power-dependent photon autocorrelation measurements, super thermal bunching is observed with $g^{(2)}(0)$ reaching values of 3. Revival peaks with a period equal to the round trip time of the external cavity emerge, indicating that the chaotic emission is induced from the optical feedback. This is further validated from signatures of chaotic emission, directly observed in single-shot intensity measurements with a streak camera.

HL 43.4 Thu 16:00 POT 251

Monolithic 850 nm VCSEL Array for QKD via the decoy state protocol — •Michael Zimmer, Moritz Birkhold, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Center for Integrated Quantum Science and Technology (IQST) and SCoPE, University of Stuttgart, Allmandring 3, 70569 Stuttgart.

In recent years, the need for secure data communication has increased. Here, the usage of quantum key distribution (QKD) offers fundamental advantages over classical key distribution. However, despite its high level of security, QKD comes a long with numerous challenges regarding the application of single photons. In this view, the decoy state protocol offers the possibility to implement QKD using classical light sources such as semiconductor lasers. Here, we present an approach for the realization of a monolithic 850 nm eight VCSEL array capable for QKD via the BB84 and decoy state protocol. Growth of the VCSEL structure takes place by metal-organic vapor-phase epitaxy (MOVPE) on a GaAs substrate. In order to obtain defined light polarization states, each VCSEL features an integrated polarization grating in its light emission window. To allow for operation in the GHz-regime and hence a high key rate generation, the VCSEL are arranged in a coplanar contact design. Electro-optical device characteristics regarding light polarization and high frequency operation are presented.

HL 43.5 Thu 16:15 POT 251

In-situ EBL fabrication of highly homogeneous micropillar laser arrays based on InGaAs quantum dots for neuromorphic computing — •Imad Limame[1], Ching-Wen Shih[1], Sven Rodt[1], Daniel Brunner[2], and Stephan Reitzenstein[1] — [1]Technical Univ. of Berlin, Germany — [2]Univ. Bourgogne Franche-Comté, France

As classical computers are reaching their limit, especially in novel fields such as machine learning and artificial intelligence, cost-effective hardware platforms, and new computing architectures are needed. We combine reservoir computing with a nanophotonic platform in an all-optical computing architecture, taking inspiration from neuroscience. Our approach aims to utilize diffractive coupling between 900 micropillars to create a large-scale processing reservoir. Due to the high number of microlasers and the use of a spatial light modulator, laser arrays with low lasing threshold powers and high spectral homogeneity are required. We develop the necessary nanophotonic platform by optimized growth and in-situ electron beam lithography (EBL) fabrication of micropillar laser arrays. The MOCVD growth focuses on increasing the optical gain of the InGaAs quantum dots, used as the gain medium and on the design of the microresonator to decrease the lasing threshold. The realized devices feature thresholds as low as 20 μW. In the second phase, low temperature in-situ EBL is performed. In this process, first a CL map is recorded to determine the local resonance of the planar microcavity before micropillar with suitable diameter to match a target wavelength are patterned by electron beam lithography. Finally, the resulting micropillar array is investigated via photoluminescence.

HL 43.6 Thu 16:30 POT 251

Multimode lasing in a microdisk nanolaser — •M. L. Drechsler[1], F. Nippert[2], L. Sung-Min Choi[2], M. R. Wagner[2], P. Boucaud[3], S. Reitzenstein[2], and Frank Jahnke[1] — [1]Institute for Theoretical Physics, University of Bremen, Bremen, Germany — [2]nstitute of Solid State Physics, Technische Universität Berlin, Berlin, Germany — [3]CRHEA, Université Côte d*Azur, 06560 Valbonne, France

We investigate the quantum emission properties of a GaN-based microdisk nanolasers with a diameter of 2 μm and β-factor close to unity, pushing the device in the regime of strongly reduced laser threshold. A quantum optical semiconductor laser model based on the cluster expansion technique is used to describe the pump-power dependent emission with one consistent set of material parameters, thereby identifying laser action. Photon correlations quantified by $g^{(1)}(\tau)$ and $g^{(2)}(\tau)$ are an essential tool for this research. Information about the energy spectrum and the detection characteristics of photons is encoded in them. In this device we observe multimode lasing. We show that the mode coupling between well-separated resonator modes has a significant influence on the emission characteristics. Furthermore, we analyze what influence the mode couplings have on photon correlations.