TUT 5: Frontiers of Semiconductor Lasers (joint session HL/TUT)

The development of semiconductor lasers has been an unprecedented success story and enabled multiple applications which influence many aspects of our modern society. Most important is world-wide optical data communication which relies crucially on semiconductor lasers. Additionally, medical diagnostics and many optical sensing applications are enabled by such optoelectronic devices. In this tutorial, we will highlight the state-of-the-art of semiconductor laser in high-speed data communication and terrestrial and extraterrestrial gas sensing applications. Moreover, we will present recent progress towards the realization and in-depth understanding of thresholdless nanolasers and topological nanolasers as well as cavity-enhanced lasers based on novel quantum materials as active medium.

Organiser: Stephan Reitzenstein (TU Berlin)

Time: Sunday 16:00–18:40 Location: HSZ 403

Tutorial TUT 5.1 Sun 16:00 HSZ 403

Interbandkaskaden und weit abstimmbare Laser las Lichtquellen für Sensorik — •Johannes Koeth, Robert Weih, Nicolas Koslowski und Tim Koslowski — nanoplus GmbH, Gerbrunn, Germany

ICLs zeichnen sich unter anderem dadurch aus, dass die Emissionswellenlänge in einem weiten Bereich des mittleren Infrarot durch die Variation der Quantenfilmdicke weitestgehend unabhängig von der Bandlücke des Halbleiters eingestellt werden kann. Da eine Vielzahl von Gasen ihre stärksten Absorptionslinien im Wellenlängenbereich zwischen 3 und 6 μm zeigen, eignen sich ICL basierte DFB-Laser hervorragend für die hochsensitive Absorptionsspektroskopie. Infolge kontinuierlicher Optimierungen des Schichtaufbaus können mittlerweile selbst Laser mit einer Wellenlänge $\lambda > 5\,\mu m$ im Dauerstrichbetrieb bei Raumtemperatur betrieben werden. Sie benötigen dabei kaum mehr als $200\,mW$ Eingangsleistung und erreichen Ausgangsleistungen von bis zu $10\,mW$. DFB Laser sind sehr gut dazu geeignet Absorptionslinien in einem engen Spektralbereicheben auszumessen. Daneben können auch weit abstimmbare, nach dem Vernier-Prinzip betriebene, Laser für Spektroskopie im nahen und mittleren Infrarot verwendet werden.

Tutorial TUT 5.2 Sun 16:40 HSZ 403

Advanced semiconductor lasers for high-speed data communication — •Johann Peter Reithmaier — Institute for Nanostructure Technologies and Analytics (INA), CINSaT, University of Kassel, Germany

An overview will be given on advanced semiconductor lasers and related optoelectronic devices, which are mainly utilizing specific properties of low-dimensional electronic systems, such as quantum dots (QDs) or mixed multi-dimensional systems. The special focus will be on laser properties, which are of highly interest for high-speed optical data communication. In particular, examples will be discussed for high-speed direct modulation, ultra-narrow linewidth lasers for coherent communication and high-speed high-temperature operation of semiconductor optical amplifiers. The tutorial will also give some background for the understanding of the more recent obtained record values of QD lasers in temperature stability, nearly-zero linewidth-enhancement factors and emission linewidths below 30 kHz at room temperature.

Tutorial TUT 5.3 Sun 17:20 HSZ 403

Theory of Nanolasers — •Christopher Gies — Institut für Theoretische Physik, Universität Bremen, Otto-Hahn-Allee 1, 28334 Bremen

The tutorial will give an introduction to the colorful physics and the modeling of nanolasers. The origin of rate equation will be discussed, focussing on their merits and shortcomings when describing nanolasers. Especially in the high-β regime, spontaneous emission plays an important role even above the laser threshold, emphasizing the impact of fluctuations on the emission characteristics.

The lecture will cover the quantized light field, open-systems approaches for including dissipation, and photon statistics and its relation to photon-correlation fuctions. A strong emphasis will be on how to relate the theoretical approaches to modeling real experiments.

Tutorial TUT 5.4 Sun 18:00 HSZ 403

Lasers for emulating topological and spin systems — •Mercedeh Khajavikhan — University of Southern California, Los Angeles, United States of America

In recent years, there has been a growing interest in using micro- and nano-scale lasers for implementing topological and spin systems. Spin models arise in the microscopic description of magnetic materials, where the macroscopic characteristics are governed by exchange interactions among the constituent magnetic moments. On the other hand, topological features are characterized as properties that remain invariant during continuous deformations of the system. The additional degrees of freedom afforded by gain and loss in active elements provide excellent opportunities to emulate these systems in a versatile photonic platform. In this tutorial, we describe some of the activities by our group and others in utilizing nanolasers and microcavities for implementing topological and spin systems. These studies could pave the way towards a new scalable nanophotonic platform to study spin exchange interactions or topological insulators, that can in turn be potentially exploited to design high power laser arrays, investigate more large-scale networks, emulate some magnetic materials, or to address a variety of optimization problems.