DS 1: Nanophotonics - Devices I (Focused Session together with HL)

Time: Monday 10:15–13:15 Location: H2

Topical Talk DS 1.1 Mon 10:15 H2

Tunable Hollow Waveguides and Their Device Applications — •Fumio Koyama — P&I Laboratory, Tokyo Institute of Technology, 4259-R2-22, Nagatsuta, Midori-ku, Yokohama 226-8503, Japan

We proposed a tunable hollow optical waveguide with a variable air core toward a new class of photonic integrated circuits. We present various unique features in hollow waveguides and the combination with microelectro-mechanical system (MEMS). We describe the design and fabrication of tunable hollow waveguides with a variable air core. We demonstrated low loss and polarization insensitive waveguides. The result shows a possibility of a giant change of over $\sim 10\%$ in propagation constant with a variable air core. We also present a wide variety of device applications based on hollow waveguides, which include tunable Bragg reflectors, tunable lasers, dispersion compensators and so on. In particular, a hybrid-integrated tunable in-plane laser based on HCG-DBR hollow waveguide was demonstrated. A giant tuning range of 52 nm in wavelength has been demonstrated with SMSR of 30 dB. An expected advantage of HWG laser can be its athermal operation resulting from the air-core guiding. A fully monolithic version of the presented device with MEMS tuning can solve alignment issues to offer further large tuning range. Their simplicity and scalability may open up applications in large-scale photonic integration and in realizing other optical functions.

Topical Talk DS 1.2 Mon 10:45 H2

Self-organized quantum dots as single and entangled photon emitters — •Erik Stock[1], Waldemar Unrau[1], Anatol Lochmann[1], Jan Amaru Töfflinger[1], Andrei Schliwa[1], Irina Ostapenko[1], Murat Öztürk[1], Sven Rodt[1], Till Warming[1], Askhat K. Bakarov[2], Aleksandr I. Toropov[2], Ilia A. Derebezov[2], Vladimir Haisler[2], and Dieter Bimberg[1] — [1]Institut für Festkörperphysik, TU-Berlin, 10623 Berlin, Germany — [2]Institute of Semiconductor Physics, 630090 Novosibirsk, Russia

The development of semiconductor based single photon and entangled photon emitters with high efficiency will be a fundamental element for quantum key distribution systems. We have developed InGaAs/GaAs quantum dot (QD) based Resonant-Cavity LEDs (RC-LED). The resonant cavity leads to an increased external quantum efficiency and due to the Purcell effect to an increased spontaneous emission rate allowing us to electrically pump the single QD at 1 GHz repetition rate.

The biexciton-exciton recombination cascade can be used for the generation of entangled photon pairs, if the finestructure splitting (FSS) of the exciton bright states is less than the homogenous line width. Using 8-band k·p theory we predict that symmetric QDs grown on (111) GaAs substrate will demonstrate a vanishing FSS. Mikrophotoluminescence spectroscopy on single QDs grown on (111) GaAs demonstrates a FSS $< 10\ \mu$eV limited by the spectral resolution of our setup. This work was partly funded by the SFB 787 and the SfP 982735.

Topical Talk DS 1.3 Mon 11:15 H2

Nanostructures for Novel Quantum Cascade Structures — •K. Unterrainer, W. Parz, T. Moldaschl, A. Benz, G. Fasching, A.M. Andrews, and G. Strasser — Photonik Institut und Zentrum für Mikro&Nanostrukturen, Technische Universität Wien, A-1040 Wien

In this contribution we will discuss carrier relaxation in quantum wells and quantum dots and its importance for THz quantum cascade lasers (QCLs). THz QCLs have shown rapid improvements of their emission power and wavelength control. However, the operation temperature is still limited to cryogenic temperatures. All attempts to overcome this limitation involve the control of carrier relaxation. Optical phonon relaxation together with other elastic processes determine the non-radiative recombination. We use time-resolved near-infrared pump and THz probe experiments to study carrier dynamics and find that carrier-carrier scattering causes fast relaxation in quantum wells. The subsequent reduction of the doping concentration in QCLs has led to considerably reduced threshold currents. However, the temperature performance has only increased marginal. A further reduction of scattering is only possible by reducing the phase space. As a first step, we have applied a strong magnetic field causing in-plane quantization. The emission intensity of THz QCLs as function of the applied magnetic field shows an increase of the emission power and a decrease of the threshold. Thus, quantum dots should improve the performance of QCLs significantly. We investigate carrier relaxation between sub-levels and study the design requirements for quantum dot cascade structures.

Topical Talk DS 1.4 Mon 11:45 H2

Quantum dot single-photon sources — •Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart, 70569 Stuttgart, Allmandring 3, Germany

Exploiting the quantum properties of the light which is emitted from semiconductor nanostructures has the potential of enabling many new applications in the field of photonics and quantum information technology, such as secure communication, imaging and lithography techniques beyond the diffraction limit, as well as photonic quantum computing. Many of these applications require the generation of triggered single photons or even indistinguishable photons. Single quantum dots in microcavities open this possibility. In my talk, I will discuss the fascinating physic as well as the current status of such light sources.

Topical Talk DS 1.5 Mon 12:15 H2

The Two Conflicting Narratives of Metal-Optics — •Eli Yablonovitch — University of California, Berkeley, CA 94720, USA

There are two conflicting narratives of Electromagnetics in metals:

1. The microwave circuit narrative in which metals, distributed capacitors, and distributed inductors function together in a high frequency circuit, albeit as distributed components. Here there is a rich tradition of various electromagnetic functions, including the antenna function.

2. This is countered by the optical-plasmonic narrative, in which metallic electromagnetics is thought to be dominated by plasmons, electromagnetic normal modes in which the inertia of the electrons plays a major role.

Given that Electromagnetics is generally invariant with frequency, it is not clear why there need to be two separate narratives. Is metal-optics simply the high frequency version of microwave electromagnetics? There is great benefit in unifying our understanding of the two regimes of metallic electromagnetics, and to distinguish the occasional role of electron inertia.

We find that some of the most important metal-optics functions are best understood as extensions of microwave electromagnetics: Antennas, for example, have been thoroughly under-estimated, and are well-poised to change the rules of optical physics.

Topical Talk DS 1.6 Mon 12:45 H2

Fundamental formulation of nanoplasmonic lasers — •Shun Chuang — University of Illinois, Department of Electrical and Computer Engineering, 1406 West Green Street, Urbana, Illinois, 61801, USA

The smallest laser conventionally requires an optical cavity with a size of one half of the effective wavelength in all three directions, which is often referred as the diffraction limit of the cavity. To make a laser with an active volume smaller than the diffraction limit, an idea is to surround the optical waveguide with metals. In this case, the effective volume of the optical mode can be significantly reduced in spite of a higher intrinsic absorption due to the metal loss at optical frequencies. By placing the active materials such as quantum dots or quantum wells near the region of peak optical field, it is possible to enhance the spontaneous and stimulated emissions to overcome the intrinsic loss from metals.

In this talk, we will present a fundamental formulation for nanoplasmonic lasers, which accounts for the negative permittivity and dispersion of metal plasma in a nanocavity. We point out the importance of using the energy (instead of power) confinement factor. We then discuss the ideas of a Fabry-Perot type of plasmonic waveguide laser and a nano-bowtie optical antenna coupled to semiconductor quantum dots, which function as the gain medium.