DS 10: Semiconductor Nanophotonics: Materials, Models, Devices - Novel Concepts

Time: Monday 17:30–19:00 Location: H 2032

Invited Talk DS 10.1 Mon 17:30 H 2032

Nanotechnology based single-mode lasers for telecommunication and sensing — Martin Kamp, Sven Höfling, and •Alfred Forchel — Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg

High-performance single-mode lasers are key devices for optical communication, spectroscopy and sensing applications. For InP laser structures, the fabrication of single-mode devices using distributed feedback (DFB) gratings is a well established technology. However, the transfer of this technology to lasers with gain materials such as quantum dots, dilute nitrides or quantum cascade structures is not straightforward.

In this talk, we present several alternative approaches for the realization of single-mode lasers based on a single epitaxial step and subsequent nano-patterning. Several types of feedback gratings, e.g. lateral metal gratings, deeply etched sidewall gratings, top-surface gratings and distributed Bragg reflectors will be discussed. In all cases, the gratings can be defined without a second epitaxial step, leading to a greatly simplified fabrication process. Tunable single-mode lasers can be realized by the use of multiple segments with different gratings.

Another route towards single-mode devices is the use of photonic crystals, which can be used to tailor the mode structure of a semiconductor laser. Similar to the devices with gratings, tunability can be achieved by dividing the laser resonator in multiple segments. Photonic crystal based devices also allow the integration of additional functional elements, such as wavelength monitors.

DS 10.2 Mon 18:00 H 2032

20 W high brightness beam emission from 850 nm edge emitting lasers based on longitudinal photonic band crystal — •Thorsten Kettler[1], Kristijan Posilovic[1], Jörg Fricke[2], Armin Ginolas[2], Udo W. Pohl[1], Vitaly A. Shchukin[1], Nikolai N. Ledentsov[1], Dieter Bimberg[1], Jan Jönsson[3], Markus Weyers[3], and Götz Erbert[2] — [1]Institut für Festkörperphysik, Technische Universität Berlin — [2]Ferdinand-Braun-Institut für Höchstfrequenztechnik — [3]TESAG, Three-Five Epitaxial Services AG

Conventional edge emitting lasers suffer from large vertical beam divergence and are limited in maximal output power due to a narrow modal spot size of the optical mode leading to catastrophic optical mirror damage. For many applications, e.g. telecommunications, optical storage, display technology, as pump sources or for direct material processing higher brightness than available hitherto is desirable. Improving brightness at low cost is thus a key issue in research and development. We present here results from GaAs based 850 nm lasers with a one dimensional photonic band crystal (PBC) acting as an ultra broad waveguide as well as a mode filter. The structure features 4 QW and 16 periods of the PBC. It exhibits high internal efficiency of 93 % and low losses of 3 cm^{-1}, measured for broad area devices. Vertical single mode operation is observed for various stripe widths with far field divergence below 8°. A 50 μm wide, 1.3 mm long stripe shows a high differential efficiency of 71 % with maximal output power of 19.5 W, leading to a brightness being one of the best values ever reported.

DS 10.3 Mon 18:15 H 2032

High-power wavelength stabilized 970-nm-range Tilted Cavity Laser — •G. Fiol[1], L.Ya. Karachinsky[1,2], I.I. Novikov[2], M. Kuntz[1], Yu.M. Shernyakov[2], N.Yu. Gordeev[2], M.V. Maximov[2], V.A. Shchukin[1,2], N.N. Ledentsov[1,2], and D. Bimberg[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, EW 5-2, Hardenbergstr. 36, D-10623 Berlin, Germany — [2]A.F.Ioffe Physico-Technical Institute, Politekhnicheskaya 26, 194021, St.Petersburg, Russia

Tilted Cavity Lasers (TCL) present an unexpensive all-epitaxial alternative to DFB- or DBR-lasers for wavelength stabilization avoiding lithographie. Broad-area (100 micrometer) devices, based on a GaAs/GaAlAs waveguide and GaInAs quantum wells emitting in the 970 nm spectral range, showed high temperature stability of the lasing wavelength (0.13 nm/K), low threshold current density (300 A/cm^2), a high power operation (> 7 W in pulsed mode and > 1.5 W in continuous wave mode), a high spectral stability at high output power, and a narrow vertical far field beam divergence (FWHM ≈ 20 degrees). 4 mm wide ridge lasers demonstrated spatial and spectral single mode continuous wave (cw) operation with a side mode suppression ratio (SMSR) up to 41.3 dB. Small signal modulation bandwidth of 3 GHz with a resonance peak of 6 dB at the relaxation oscillation frequency was measured for a 870 micrometer long device. TCL modulation efficiency is 0.36 GHz/$(mA)^{1/2}$. S-parameter measurements indicate that much higher frequencies may be expected in case of more advanced processing and/or shorter cavity lengths.

DS 10.4 Mon 18:30 H 2032

Small-Signal Cross-Gain Modulation Dynamics of Quantum-Dot Semiconductor Optical Amplifiers — •Jungho Kim[1], Matthias Laemmlin[1], Christian Meuer[1], Sven Liebich[1], Dieter Bimberg[1], and Gadi Eisenstein[1,2] — [1]Institut fuer Festkoerperphysik, Technische Universitaet Berlin, EW 5-2, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Electrical Engineering Department, Technion, Haifa 32000, Israel

Quantum dot (QD) semiconductor optical amplifiers (SOAs) have been intensively investigated as pattern-effect-free, high-speed wavelength converters based on cross-gain modulation (XGM). Although pattern-effect-free wavelength conversion at 10 Gbit/s was experimentally achieved due to the ultrafast recovery time of spectral hole burning (<1ps) [1] in the gain saturation region, a comprehensive understanding of the gain saturation mechanisms is still required for further performance improvement. In this paper, we investigate the high-speed small-signal XGM response of QD SOAs. We numerically solve multiple coupled rate equations, which describe carrier dynamics and optical interaction among an ensemble of inhomogeneously broadened QDs. The calculated small-signal XGM with various injection currents is well matched with the experimental results and elucidates how the dynamics of QD gain saturation can be affected by the amount of stored carriers at QD excited states.

[1] S. Dommers, V. V. Temnov, U. Woggon, J. Gomis, J. Martinez-Pastor, M. Laemmlin, and D. Bimberg, Appl. Phys. Lett., vol. 90, 033508, 2007.

DS 10.5 Mon 18:45 H 2032

Single Photons for Quantum Information — •Oliver Benson — Institut für Physik , Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Single Photons have been widely discussed as ideal carriers of the fundamental units of quantum information processing (QIP), the quantum bits. In proposals and first experimental realizations the role of photons is two-fold: First, in linear optical quantum computing (LOQC) the photons themselves as used to implement single- and two-qubit gates. Second, in quantum interfaces photons are merely used to transfer quantum information from one place to another or among different physical QIP systems.

In this contribution we introduce experimental components that are required to implement photons for both purposes. We will describe the design of efficient single photon detectors based on superconducting NbN. Additionally, we report on the realization of an interferometric time-bin encoding setup for narrow band single photons.