DS 7: Semiconductor Nanophotonics: Materials, Models, Devices - Surface Emitters

Time: Monday 11:15–13:00 Location: H 2032

Invited Talk DS 7.1 Mon 11:15 H 2032
Recent advances of VCSEL photonics — •Fumio Koyama — Tokyo Institute of Technology, Yokohama 226-8503, Japan

A vertical cavity surface emitting laser (VCSEL) was invented 30 years ago. A lot of unique features have been proven, such as low power consumption, wafer-level testing, small packaging capability and so on. The market of VCSELs has been growing up rapidly in recent years and they are now key devices in local area networks using multi-mode optical fibers. Also, long wavelength VCSELs are currently attracting much interest for use in single-mode fiber metropolitan area and wide area network applications. In addition, a VCSEL-based disruptive technology enables various consumer applications such as a laser mouse and laser printers.

In this talk, the recent advance of VCSEL photonics will be reviewed, which include the wavelength engineering and integration of single-mode VCSEL arrays. The athermal operation of micromachined VCSELs is demonstrated. Also, this presentation explores the potential and challenges for new functions of VCSELs, including high-speed nonlinear phase-shifters, slow light modulators/switches and so on.

DS 7.2 Mon 12:00 H 2032
12.5 Gbit/s 1250 nm VCSELs Based on Low-Temperature Grown Highly Strained InGaAs — •F. Hopfer[1], A. Mutig[1], G. Fiol[1], M. Kuntz[1], V.A. Shchukin[1], N. N. Ledentsov[1], C. Bornholdt[3], S. S. Mikhrin[2], I. L. Krestnikov[2], D. A. Livshits[2], A. R. Kovsh[2], and D. Bimberg[1] — [1]Institut fuer Festkoerperphysik, Technische Universitaet Berlin, PN 5-2, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Innolume GmbH, Konrad-Adenauer-Allee 11, 44263 Dortmund, Germany — [3]Fraunhofer Institut für Nachrichtentechnik, Heinrich-Hertz-Institut Berlin, Einsteinufer 37, 10587 Berlin, Germany

As frequencies increase, power consumption, signal attenuation, electromagnetic interference and crosstalk are limiting the performance of electrical interconnects. Optical solutions are thus increasingly considered for intrachip clock distribution and short distance chip-to-chip communication. For intra-chip applications the absorption of Si forces the emitters to operate above 1200 nm. Here we realized 12.5 Gb/s GaAs based VCSELs emitting at 1250 nm.

Multimode devices demonstrate at 25 °C a maximum modulation bandwidth of 8.5 GHz, their peak differential efficiency is 0.4 W/A. At the respective bias point the optical output power in a 65.5 muem multi mode fiber is 3 mW. Open eyes for a 12.5 Gb/s non-return-to-zero 2ˆ31-1 pseudo random bit sequence at 25° C are achieved with a signal to noise ratio of 5.6. For single mode devices with a SMSR > 40 dB, the maximum modulation bandwidth at 25 °C is 9 GHz with a multimode fiber coupled optical output power of 1.5 mW.

DS 7.3 Mon 12:15 H 2032
First VECSELs based on quantum dots — •Johannes Pohl[1], Tim David Germann[1], André Strittmatter[1], Udo W. Pohl[1], Dieter Bimberg[1], Jussi Rautiainen[2], Mircea Guina[2], and Oleg G. Okhotnikov[2] — [1]Institute of Solid State Physics, TU Berlin, Germany — [2]ORC, Tampere University of Technology, Finland

Optically Pumped Vertical External Cavity Surface Emitting Lasers (OP-VECSELs) provide excellent beam quality as well as high power continuous-wave (cw) operation and the possibilty of intra-cavity second harmonic generation. Quantum Dots (QDs) are an attractive alternative to quantum wells due to their broad and flat gain spectrum and high temperature stability. However, no QD-based VECSEL devices are reported so far possibly due to the low modal gain of QD ensembles. The first QD-VECSELs are grown by metalorganic vaporphase epitaxy with alternative precursors. Two completely different QD growth techniques are used for the VECSELs aiming at high modal gain. Sub-Monolayer (SML) deposition of InAs/GaAs layers provides ensembles with very high QD areal densities yielding high modal gain at ground state transition energy. These QDs were used to demonstrate the first SML-QD VECSEL with an output power of 1.4 W cw at 1034 nm. Growth in the Stranski-Krastanow (SK) regime provides a QD ensemble with a broad gain spectrum expanding the operational temperature range of the VECSEL. High modal gain values are obtained by matching the cavity resonance to excited state transitions of the QDs. The VECSEL based on InGaAs SK-QDs operates at 1040 nm with an output power of 280 mW cw.

Invited Talk DS 7.4 Mon 12:30 H 2032
Recent Advances on Long Wavelength VCSELs (> 1300 nm) — •Markus C. Amann — Walter Schottky Institut, Technische Universität München, D-85748 Garching, Germany

Recently, InP-based long-wavelength vertical-cavity surface-emitting lasers (VCSELs) based on buried tunnel junctions (BTJ VCSEL) achieved excellent performance for the entire 1300-2300nm wavelength range. With this device concept, a low-resistive tunnel junction enables the replacement of the major part of the p-doped layers by n-doped ones yielding ultra-low electrical resistances and reduced optical losses as well as a self-adjusted transverse photon and carrier confinement. This concept also allows the application of hybrid Au-dielectric Bragg mirrors with high index contrast and reflectivity. BTJ-VCSEL show sub-mA threshold currents, 0.9V threshold voltage (at 1550 nm), operation voltages below 1.2V, 30-70 ohm series resistance, differential efficiencies >25%, up to 3mW single-mode optical output power, >110°C cw operation, stable polarization and single-mode operation with SMSR of the order 50 dB. Electro-thermal wavelength-tuning over 4nm and micromechanical tuning over more than 40nm both in the continuous tuning-mode and with SMSR >30dB can be accomplished. Besides the device design and technology, we will discuss recent achievements on high-speed VCSELs and BTJ-VCSEL arrays and demonstrate experiments on broadband communications and spectroscopic trace-gas sensing.