DS 6: Semiconductor Nanophotonics: Materials, Models, Devices - High Speed Photonics

Time: Monday 9:30–11:00 Location: H 2032

Invited Talk DS 6.1 Mon 9:30 H 2032

High Speed Nano-Photonics — •Gadi Eisenstein — Electrical Engineering Dept. Technion Haifa, Israel

Active optoelectronic devices based on nano structure gain media have the potential to completely revolutionize broad band communication applications.

In particular, quantum dot optical amplifiers and mode locked lasers make use of the extremely broad gain bandwidth of quantum dot material and enable numerous possibilities not possible with previous, lower dimensionality gain media.

This talk will survey the basic concepts governing those broad band properties and will present an overview of the state of art and predicted future performance.

DS 6.2 Mon 10:15 H 2032

Small-signal cross-gain modulation of quantum dot semiconductor optical amplifiers — •Sven Liebich, Christian Meuer, Matthias Laemmlin, Jungho Kim, and Dieter Bimberg — Institut fuer Festkoerperphysik, Technische Universitaet Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Wavelength conversion based on cross-gain modulation (XGM) of semiconductor optical amplifiers (SOA) is of largest importance for future all optical networks. Using the non-linear gain characteristics of quantum dot (QD) based SOAs this technique will be used for optical signal processing. QD SOAs have shown ultra-fast gain recovery which is superior to quantum well or bulk SOAs [1]. Furthermore in QD SOAs no crosstalk is expected for wavelengths having a difference larger than the homogeneous broadening. To measure the small-signal XGM of QD SOAs a sinusoidally modulated optical pump which saturates the QD SOA is amplified. This results in a modulation of the gain of the amplifier and subsequently superimposes an inverted modulation on a second cw-probe signal. The XGM is measured in the frequency range 50 MHz to 40 GHz with a variation of the operating parameters like SOA current and wavelength detuning. The 3dB-bandwidth of the XGM for optimum operating parameters is observed to exceed 40 GHz. In conclusion, by increasing the drive current the SOA can be modified from low to high cross talk enabling efficient wavelength conversion at high bit rates.

[1] S. Dommers, V. V. Temnov, U. Woggon, J. Gomis, J. Martinez-Pastor, M. Laemmlin and D. Bimberg, APL 90 (2007)

DS 6.3 Mon 10:30 H 2032

1500 nm MOVPE-Grown InP-Based Quantum Dot (QD) Emitters — •Harald Künzel, Dieter Franke, Peter Harde, Jochen Kreissl, and Martin Möhrle — Fraunhofer Institut für Nachrichtentechnik HHI, Einsteinufer 37, D-10587 Berlin

A present R&D task is to transfer the QD technology to InP-based GaInAsP materials for applications in the 1550 nm regime and beyond. Real QDs as successfully presently only achieved by conventional MOVPE have become one of the key techniques recently for emitter applications. The Stranski-Krastanow growth mode allows for the realisation of high densities of quite homogeneous QDs which in combination with stacking of uncoupled QD layers is a prerequisite to form the gain region in photonic devices. Furthermore, during implementation of such structures as active layers in laser structures thermal stability of the QDs during growth of the upper claddings was found to be severe problem most probably due to movement of In towards the QDs resulting in a marked blue-shift of the emission. This shift was systematically investigated using thermal treatment to simulate cladding growth. The strong dependence of the blue-shift of the QD emission on growth temperature is attributed to defects being incorporated during QD deposition. A careful adjustment of deposition conditions for stable emission and high QD density forms the basis for the fabrication of lasers with characteristics which as a whole are among the best achieved so far. Recent advances in lasers and epitaxial regrowth for BH-type optical amplifiers will be presented.

DS 6.4 Mon 10:45 H 2032

Relaxation oscillations in quantum dot lasers — •Ermin Malic[1], Kathy Lüdge[1], Moritz Bormann[1], Philipp Hövel[1], Matthias Kuntz[2], Dieter Bimberg[2], Andreas Knorr[1], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Institut für Festkörperphysik, TU Berlin

We present a theoretical simulation of the turn-on dynamics of electrically pumped InAs/GaAs quantum dot lasers. Our approach combines laser rate equations with microscopically calculated Coulomb scattering rates describing Auger transitions between localized quantum dot and continuous wetting layer states. The scattering rates are determined within the Boltzmann equation and within the orthogonalized plane wave approach. We go beyond the Hartree-Fock approximation and consider the Coulomb interaction up to the second order in the screened Coulomb potential.

Our simulations show the generation of relaxation oscillations in both the photon and charge carrier density dynamics. They start after a delay time of approximately 1ns that is due to the charge carrier filling of initially empty quantum dot states. The complex interplay between strongly nonlinear Coulomb scattering rates and radiative processes gives rise to the relaxation oscillations and determines their frequency and damping rate. In agreement with experiments, we obtain a strong damping of relaxation oscillations. Our results indicate the crucial importance of the Coulomb scattering processes for the understanding of the turn-on dynamics of quantum dot lasers.