Cavity-waveguide interplay in optical resonators and its role in optimal single-photon sources

Interfacing solid-state emitters with photonic structures is a key strategy for developing highly efficient photonic quantum technologies. Such structures are often organized into two distinct categories: nanocavities and waveguides. However, any realistic nanocavity structure simultaneously has characteristics of both a cavity and waveguide, which is particularly pronounced when the cavity is constructed using low-reflectivity mirrors in a waveguide structure with good transverse light confinement. In this regime, standard cavity quantum optics theory breaks down, as the waveguide character of the underlying dielectric is only weakly suppressed by the cavity mirrors. By consistently treating the photonic density of states of the structure, we provide a microscopic description of an emitter including the effects of phonon scattering over the full transition range from waveguide to cavity. This generalized theory lets us identify an optimal regime of operation for single-photon sources in optical nanostructures, where cavity and waveguide effects are concurrently exploited.
Benchmarking five numerical simulation techniques for computing resonance wavelengths and quality factors in photonic crystal membrane line defect cavities

We present numerical studies of two photonic crystal membrane microcavities, a short line-defect cavity with relatively low quality (Q) factor and a longer cavity with high Q. We use five state-of-the-art numerical simulation techniques to compute the cavity Q factor and the resonance wavelength (\lambda) for the fundamental cavity mode in both structures. For each method, the relevant computational parameters are systematically varied to estimate the computational uncertainty. We show that some methods are more suitable than others for treating these challenging geometries.
Benchmarking state-of-the-art optical simulation methods for analyzing large nanophotonic structures

Five computational methods are benchmarked by computing quality factors and resonance wavelengths in photonic crystal membrane L5 and L9 line defect cavities. Careful convergence studies reveal that some methods are more suitable than others for analyzing these cavities.

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Driving-induced population trapping and linewidth narrowing via the quantum Zeno effect

We investigate the suppression of spontaneous emission from a driven three-level system embedded in an optical cavity via a manifestation of the quantum Zeno effect. Strong resonant coupling of the lower two levels to an external optical field results in a decrease of the decay rate of the third upper level. We show that this effect has observable consequences in the form of emission spectra with subnatural linewidths, which should be measurable using, for example, quantum dot-cavity systems in currently obtainable parameter regimes, and may find use in applications requiring the control of single-photon arrival times and wave-packet extent. These results suggest an underappreciated link between the Zeno effect, dressed states, and Purcell enhancement.
Fano Resonances for Realizing Compact and Low Energy Consumption Photonic Switches

We present our recent experimental work involving nanocavities which enable efficient light-matter interaction in small optical mode volumes. To achieve this, we investigated photonic crystal membrane platforms for designing high-quality (Q) factor nanocavities and efficient planar waveguides. Particularly, we discuss waveguide-nanocavity coupled systems for realization of asymmetric Fano resonances which are characterized by having transmission maximum and minimum in close spectral separation (~1nm) suitable for optical switching applications.

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Fundamental cavity-waveguide interplay in cavity QED

Interfacing solid-state emitters with photonic structures is a key strategy for developing highly efficient photonic quantum technologies [1]. Such structures are often organised into two distinct categories: nanocavities and waveguides. However, any realistic nanocavity structure simultaneously has characteristics of both a cavity and waveguide, which is particularly pronounced when the cavity is constructed using low-reflectivity mirrors in a waveguide structure with good transverse light confinement. In this regime, standard cavity quantum optics theory breaks down, as the waveguide character of the underlying dielectric is only weakly suppressed by the cavity mirrors. In this work [2], we present a quantum optical model that captures the transition between a high-Q cavity and a waveguide, allowing consistent treatment of waveguides, lossy resonators, and high quality cavities. Our model constitutes a bridge between highly accurate optical simulations of nanostructures [3] and microscopic quantum dynamical calculations. This way, the quantum properties of generated light can be calculated, while fully accounting for the electromagnetic properties of the nanostructure. The generality of this
Intrinsic and environmental effects on the interference properties of a high-performance quantum dot single-photon source

We report a joint experimental and theoretical study of the interference properties of a single-photon source based on an In(Ga)As quantum dot embedded in a quasiplanar GaAs microcavity. Using resonant laser excitation with a pulse separation of 2 ns, we find near-perfect interference of the emitted photons, and a corresponding indistinguishability of $I = (99.6 \pm 0.4 \pm 1.4)\%$. For larger pulse separations, quasiresonant excitation conditions, increasing pump power, or with increasing temperature, the interference contrast is progressively and notably reduced. We present a systematic study of the relevant dephasing mechanisms and explain our results in the framework of a microscopic model of our system. For strictly resonant excitation, we show that photon indistinguishability is independent of pump power, but strongly influenced by virtual phonon-assisted processes which are not evident in excitonic Rabi oscillations.
Learning of Laser Dynamics using Bayesian Inference

Techniques from Bayesian machine learning and digital coherent detection are applied to perform frequency noise characterization. Significant advantages of the presented techniques are high-sensitivity and direct access to the uncertainty of the frequency noise measurement.

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Modes, stability, and small-signal response of photonic crystal Fano lasers

Photonic crystal Fano lasers have recently been realised experimentally, showing useful properties such as pinned single-mode lasing and passive pulse generation. Here the fundamental properties of the modes of the Fano laser are analysed, showing how the laser functionality depends sensitively on the system configuration. Furthermore the laser stability is investigated and linked to the small-signal response, which shows additional dynamics that cannot be explained with a conventional rate equation model, including a damping of relaxation oscillations and a frequency modulation bandwidth that is only limited by the nanocavity response.
Pulse carving using nanocavity-enhanced nonlinear effects in photonic crystal Fano structures

We experimentally demonstrate the use of a photonic crystal Fano resonance for carving-out short pulses from long-duration input pulses. This is achieved by exploiting an asymmetric Fano resonance combined with carrier-induced nonlinear effects in a photonic crystal membrane structure. The use of a nanocavity concentrates the input field to a very small volume leading to an efficient nonlinear resonance shift that carves a short pulse out of the input pulse. Here, we demonstrate shortening of ~500 ps and ~100 ps long pulses to ~30 ps and ~20 ps pulses, respectively. Furthermore, we demonstrate error-free low duty cycle return-to-zero signal generation at 2 Gbit/s with energy consumption down to ~1
pJ/bit and power penalty of ~2 dB. The device physics and limitations are analyzed using nonlinear coupled-mode theory.

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Web of Science (2010): Impact factor 3.318
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Rate equation description of quantum noise in nanolasers with few emitters

Rate equations for micro- and nanocavity lasers are formulated which take account of the finite number of emitters, Purcell effects as well as stochastic effects of spontaneous emission quantum noise. Analytical results are derived for the intensity noise and intensity correlation properties, g(2), using a Langevin approach and are compared with simulations using a stochastic approach avoiding the mean-field approximation of the rate equations. Good agreement between the two approaches is found even for large values of the spontaneous emission beta-factor, i.e., for threshold-less lasers, as long as more than about ten emitters contribute to lasing. A large value of the beta-factor improves the noise properties.

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Scopus rating (2000): SJR 4.178 SNIP 2.017
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signal reshaping and noise suppression using photonic crystal Fano structures

We experimentally demonstrate the use of photonic crystal Fano resonances for reshaping optical data signals. We show that the combination of an asymmetric Fano resonance and carrier-induced nonlinear effects in a nanocavity can be used to realize a nonlinear power transfer function, which is a key functionality for optical signal regeneration, particularly for suppression of amplitude fluctuations of data signals. The experimental results are explained using simulations based on coupled-mode theory and also compared to the case of using conventional Lorentzian-shaped resonances. Using indium phosphide photonic crystal membrane structures, we demonstrate reshaping of 2 Gbit/s and 10 Gbit/s return-to-zero on-off keying (RZ-OOK) data signals at telecom wavelengths around 1550 nm. Eye diagrams of the reshaped signals show that amplitude noise fluctuations can be significantly suppressed. The reshaped signals are quantitatively analyzed using bit-error ratio (BER) measurements, which show up to 2 dB receiver sensitivity improvement at a BER of 10−9 compared to a degraded input noisy signal. Due to efficient light-matter interaction in the high-quality factor and small mode-volume photonic crystal nanocavity, low energy consumption, down to 104 fJ/bit and 41 fJ/bit for 2 Gbit/s and 10 Gbit/s, respectively, has been achieved. Device perspectives and limitations are discussed.
Small and Large Signal Analysis of Photonic Crystal Fano Laser
We analyze the small- and large-signal response of a photonic crystal Fano laser (PhC-FL). Conventional current modulation, as well as modulation of the laser via the mirror, is investigated using a numerical approach as well as linear small-signal analysis. The results show that the amplitude modulation bandwidth of one of the laser ports (the through-port) and the frequency modulation (FM) bandwidth of another port (the cross-port) extend to the THz region. Large-signal simulations of the laser response to a 500 Gbit/s pseudo-random bit sequence modulation of the nanocavity are in good agreement with the predictions of the small-signal analysis. Finally, it is investigated how the design of the Fano mirror, in particular, the quality factor (Q) of the nanocavity, affects the modulation properties.
Which Computational Methods Are Good for Analyzing Large Photonic Crystal Membrane Cavities?

By introducing defects into an otherwise periodic photonic crystal lattice, high quality (Q) factor cavities may be formed. However, the size and the lack of simplifying symmetries in the photonic crystal membrane make these types of cavities exceptionally hard to analyze using numerical simulation methods. In this work, we consider two different line defect cavities and we compute their Q factors using state-of-the-art optical simulation tools. We show that certain simulation methods perform much better than others in the analysis of these challenging structures.

Strain tuning of optical properties in Bi$_2$Se$_3$

Based on symmetry principles we determine the most general Hamiltonian for the low energy physics of Bi$_2$Se$_3$, including contributions due to a static electric field and strain. The full three-dimensional model is projected into the surface states at k= 0, giving an effective two-dimensional Hamiltonian for the surface states. Contributions from the strain tensor breaks the anisotropy of the surface state spectrum, giving an elliptical Dirac cone. Within this model we calculate the absorption spectrum for an ultra-thin film. We show that the fundamental absorption edge can be effectively tuned by application of uniaxial strain.
**Benchmarking five computational methods for analyzing large photonic crystal membrane cavities**

We benchmark five state-of-the-art computational methods by computing quality factors and resonance wavelengths in photonic crystal membrane L5 and L9 line defect cavities. The convergence of the methods with respect to resolution, degrees of freedom and number of modes is investigated. Convergence is not obtained for some of the methods, indicating that some are more suitable than others for analyzing line defect cavities.

**Collective effects in nanolasers: Steady-state characteristics and photon statistics**

In the traditional rate equation-approach to nanolasers, the active material is modelled as a collection of independent emitters [1], but in recent years it has become increasingly clear that radiative coupling of the emitters in the cavity can significantly change the characteristics of a (nano)laser under certain conditions [2-5]. The collective effects arising as an emitter-emitter coupling are known to cause a reduction in the steady-state intensity for small values of the pump rate [2, 3], which means the effective jump at threshold becomes larger. As a result, the fraction \( \beta \) of spontaneous emission going into the lasing mode, usually associated with the inverse of the height of this intensity jump, is potentially underestimated in a model neglecting collective effects. Additionally, recent experiments and numerical models [3, 5] show that the inclusion of collective effects leads to super-thermal values of the photon auto-correlation function \( g^2(0) \), i.e. values larger than \( g^2(0) = 2 \) associated with thermal radiation.
Comparison of Five Computational Methods for Computing Q Factors in Photonic Crystal Membrane Cavities

Five state-of-the-art computational methods are benchmarked by computing quality factors and resonance wavelengths in photonic crystal membrane L5 and L9 line defect cavities. The convergence of the methods with respect to resolution, degrees of freedom and number of modes is investigated. Special attention is paid to the influence of the size of the computational domain. Convergence is not obtained for some of the methods, indicating that some are more suitable than others for analysing line defect cavities.

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Comparison of Five Numerical Methods for Computing Quality Factors and Resonance Wavelengths in Photonic Crystal Membrane Cavities

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Comparison of Five Computational Methods for Computing Q Factors in Photonic Crystal Membrane Cavities

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Control of exceptional points in photonic crystal slabs
Various ways of controlling the extent of the ring of exceptional points in photonic crystal slabs are investigated. The extent of the ring in photonic crystal slabs is found to vary with the thickness of the slab. This enables recovery of Dirac cones in open, non-Hermitian systems, such as a photonic crystal slab. In this case, all three bands exhibit a bound state in the continuum in close proximity of the Γ point. These results may lead to new designs of small photonic-crystal-based lasers exhibiting high-quality factors.

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Control of the rings of exceptional points in photonic crystal slabs

Accidental Dirac cones of linear dispersion can occur in photonic crystal (PhC) structures [1]. These configurations can be easily manufactured providing an accessible platform for studying topological properties of Dirac cones and their influence on light-matter interactions. Recently, it has been shown that when the system becomes non-Hermitian, e.g. it is an open system exhibiting radiation losses, Dirac cones can be deformed spawning rings of exceptional points [2]. Within the ring, the dispersion follows the two-dimensional flat band which provides a high density of states and therefore high Purcell factors. Moreover, strong dispersion of loss in the center of the Brillouin zone allows to significantly improve the performance of large-area single mode PhC lasers [3]. These lasers exploit bound states in the continuum [4], and we discuss their relation to Dirac cones.

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Demonstration of a self-pulsing photonic crystal Fano laser

The semiconductor lasers in use today rely on various types of cavity, making use of Fresnel reflection at a cleaved facet, total internal reflection between two different mediums, Bragg reflection from a periodic stack of layers, mode coupling in a high contrast grating or random scattering in a disordered medium. Here, we demonstrate an ultrasmall laser with a mirror, which is based on Fano interference between a continuum of waveguide modes and the discrete resonance of a nanocavity. The rich physics of Fano resonances has recently been explored in a number of different photonic and plasmonic systems. The Fano resonance leads to unique laser characteristics. In particular, because the Fano mirror is very narrowband compared to conventional laser mirrors, the laser is single mode and can be modulated via the mirror. We show, experimentally and theoretically, that nonlinearities in the mirror may even promote the generation of a self-sustained train of pulses at gigahertz frequencies, an effect that has previously been observed only in macroscopic lasers. Such a source is of interest for a number of applications within integrated photonics.

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Efficient quality-eactor estimation of a vertical cavity employing a high-contrast grating
Hybrid vertical cavity lasers employing high-contrast grating reflectors are attractive for Si-integrated light source applications. Here, a method for reducing a three-dimensional (3D) optical simulation of this laser structure to lower-dimensional simulations is suggested, which allows for very fast and approximate analysis of the quality-factor of the 3D cavity. This approach enables us to efficiently optimize the laser cavity design without performing cumbersome 3D simulations.

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Experimental demonstration of a Fano laser based on photonic crystals

Conventional semiconductor laser mirrors are based on Fresnel reflection [1], Bragg reflection [2, 3] or total internal reflection [4]. Here we demonstrate a new laser concept using photonic crystals (PhC), with a mirror based on Fano interference between a waveguide continuum and a discrete resonance of a nanocavity [5]. We show that the very narrowband feature of the Fano resonance [6] can lead to single mode lasing. In addition, when combined with optical nonlinearity, the highly dispersive feature of the Fano resonance can promote self-pulsations at gigahertz frequencies [7], which was previously observed only in macroscopic lasers [8].

Fabrication and experimental demonstration of photonic crystal laser with buried heterostructure

Development of ultra-small and efficient laser sources for photonic integrated circuits is one of the main cornerstones in achieving the requirements imposed for on-chip optical interconnects [1]. The InP photonic crystal (PhC) platform with selectively embedded gain medium [2] is a promising way of separating active light amplification regions from passive regions for light propagation without induced absorption losses and surface recombination. The main focus of this work is the fabrication and experimental demonstration of a buried heterostructure (BH) photonic crystal laser bonded to a silicon wafer, illustrating the effective single-platform active-passive material integration method.
Hybrid Si-on-chip Lasers with Nano Structures

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Large signal simulation of photonic crystal Fano laser
We numerically investigate small and large signal modulation of a photonic crystal laser with a mirror based on Fano interference between continuum modes of a waveguide and a discrete mode of a nanocavity. Our simulation shows that the instantaneous optical frequency of the laser signal can be modulated at frequencies exceeding 1 THz which is much higher than its corresponding relaxation oscillation frequency. Large signal simulation of the Fano laser is also investigated based on pseudorandom bit sequence at 0.5 Tbit/s. It shows eye patterns are open at such high modulation frequency, verifying the large bandwidth of the laser.

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State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Tarbiat Modarres University
Contributors: Zali, A. R., Yu, Y., Moravvej-Farshi, M. K., Mørk, J.
Number of pages: 2
Pages: 75-6
Publication date: 2017

Host publication information
Title of host publication: Proceedings of the 17th International Conference on Numerical Simulation of Optoelectronic Devices
Publisher: IEEE
ISBN (Print): 9781509053230
DOI: 10.1109/NUSOD.2017.8009998
Source: FindIt
Source-ID: 2373491809
Research output: Research - peer-review › Article in proceedings – Annual report year: 2017

Lasers, switches and non-reciprocal elements based on photonic crystal Fano resonances
We discuss the realization of active photonic devices exploiting Fano resonances in photonic crystal membranes.

General information
Limitations of two-level emitters as nonlinearities in two-photon controlled-PHASE gates

We investigate the origin of imperfections in the fidelity of a two-photon controlled-PHASE gate based on two-level-emitter nonlinearities. We focus on a passive system that operates without external modulations to enhance its performance. We demonstrate that the fidelity of the gate is limited by opposing requirements on the input pulse width for one- and two-photon-scattering events. For one-photon scattering, the spectral pulse width must be narrow compared with the emitter linewidth, while two-photon-scattering processes require the pulse width and emitter linewidth to be comparable. We find that these opposing requirements limit the maximum fidelity of the two-photon controlled-PHASE gate to 84% for photons with Gaussian spectral profiles.
On the Theory of Coupled Modes in Optical Cavity-Waveguide Structures

Light propagation in systems of optical cavities coupled to waveguides can be conveniently described by a general rate equation model known as (temporal) coupled mode theory (CMT). We present an alternative derivation of the CMT for optical cavity-waveguide structures, which explicitly relies on the treatment of the cavity modes as quasi-normal modes with properties that are distinctly different from those of the modes in the waveguides. The two families of modes are coupled via the field equivalence principle to provide a physically appealing yet surprisingly accurate description of light propagation in the coupled systems. Practical application of the theory is illustrated using example calculations in one and two dimensions.
Optical Time Domain Demultiplexing using Fano Resonance in InP Photonic Crystals

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices
Contributors: Bekele, D. A., Yu, Y., Bony, P., Ottaviano, L., Oxenløwe, L. K., Yvind, K., Mørk, J.
Number of pages: 1
Publication date: 2017
Peer-reviewed: Yes
Event: Abstract from The European Conference on Lasers and Electro-Optics, CLEO_Europe 2017, Munich, Germany.
Electronic versions:
CLEO_Europe_dagmawi.pdf
Source: PublicationPreSubmission
Source-ID: 138515202
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2017

Parity control of Fano resonances and its application for signal regeneration and pulse carving
Parity control of Fano resonances in a photonic crystal waveguide coupled to a nanocavity is implemented by controlling the position of a partially transmitting element (PTE) in the waveguide. We experimentally demonstrate regeneration and pulse carving of optical signals by exploiting nonlinearities in the nanocavity in combination with the asymmetrical Fano shape.

General information
State: Published
Organisations: Department of Photonics Engineering, High-Speed Optical Communication, Centre of Excellence for Silicon Photonics for Optical Communications, Nanophotonic Devices
Number of pages: 2
Publication date: 2017

Host publication information
Title of host publication: Proceedings of the 8th International Conference on Metamaterials, Photonic Crystals and Plasmonics
Source: PublicationPreSubmission
Source-ID: 142515172
Research output: Research - peer-review › Article in proceedings – Annual report year: 2018

Phonon limit to simultaneous near-unity efficiency and indistinguishability in semiconductor single photon sources
We investigate the role of phonons on the emission properties of solid-state single photon sources. We demonstrate a fundamental trade-off between indistinguishability and efficiency of sources based on both cavity and waveguide
architectures.

**General information**
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Bristol, University of Manchester
Contributors: Iles-Smith, J., McCutcheon, D. P., Nazir, A., Mørk, J.
Number of pages: 2
Pages: 1-2
Publication date: 2017

**Host publication information**
Title of host publication: Proceedings of 2017 Conference on Lasers and Electro-Optics, CLEO 2017
Publisher: Optical Society of America
DOI:
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**Bibliographical note**
From the session: Quantum Optics of Single Emitters (FTu3E)
Source: FindIt
Source-ID: 2397682789
Research output: Research - peer-review › Article in proceedings – Annual report year: 2018

**Phonon scattering inhibits simultaneous near-unity efficiency and indistinguishability in semiconductor single-photon sources**
Semiconductor quantum dots (QDs) have recently emerged as a leading platform to generate highly indistinguishable photons efficiently, and this work addresses the timely question of how good these solid-state sources can ultimately be. We establish the crucial role of lattice relaxation in these systems in giving rise to trade-offs between indistinguishability and efficiency. We analyse the two source architectures most commonly employed: a QD embedded in a waveguide and a QD coupled to an optical cavity. For waveguides, we demonstrate that the broadband Purcell effect results in a simple inverse relationship, in which indistinguishability and efficiency cannot be simultaneously increased. For cavities, the frequency selectivity of the Purcell enhancement results in a more subtle trade-off, in which indistinguishability and efficiency can be increased simultaneously, although not arbitrarily, which limits a source with near-unity indistinguishability (> 99%) to an efficiency of approximately 96% for realistic parameters.
Photonic crystal Fano lasers and Fano switches

We show that Fano resonances can be realized in photonic crystal membrane structures by coupling line-defect waveguides and point-defect nanocavities. The Fano resonance can be exploited to realize optical switches with very small switching energy, as well as Fano lasers, that can generate short optical pulses.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonic Devices
Pages: 88-89
Publication date: 2017
Photonic crystal Fano resonances for realizing optical switches, lasers and non-reciprocal elements

We present our work on photonic crystal membrane devices exploiting Fano resonance between a line-defect waveguide and a side coupled nanocavity. Experimental demonstration of fast and compact all-optical switches for wavelength-conversion is reported. It is shown how the use of an asymmetric structure in combination with cavity-enhanced nonlinearity can be used to realize non-reciprocal transmission at ultra-low power and with large bandwidth. A novel type of laser structure, denoted a Fano laser, is discussed in which one of the mirrors is based on a Fano resonance. Finally, the design, fabrication and characterization of grating couplers for efficient light coupling in and out of the indium phosphide photonic crystal platform is discussed.
Protocol for generating multiphoton entangled states from quantum dots in the presence of nuclear spin fluctuations

Multiphoton entangled states are a crucial resource for many applications in quantum information science. Semiconductor quantum dots offer a promising route to generate such states by mediating photon-photon correlations via a confined electron spin, but dephasing caused by the host nuclear spin environment typically limits coherence (and hence entanglement) between photons to the spin $T_2^*$ time of a few nanoseconds. We propose a protocol for the deterministic generation of multiphoton entangled states that is inherently robust against the dominating slow nuclear spin environment fluctuations, meaning that coherence and entanglement is instead limited only by the much longer spin $T_2$ time of microseconds. Unlike previous protocols, the present scheme allows for the generation of very low error probability polarisation encoded three-photon GHZ states and larger entangled states, without the need for spin echo or nuclear spin calming techniques.

General information
State: Published
Organisations: Department of Photonics Engineering, University of Bristol
Contributors: Denning, E. V., Iles-Smith, J., McCutcheon, D. P. S., Mørk, J.
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Physical Review A (Atomic, Molecular and Optical Physics)
Volume: 96
Issue number: 6
Article number: 062329
ISSN (Print): 2469-9926
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.46 SJR 1.288 SNIP 0.886
Web of Science (2017): Impact factor 2.909
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 2.25 SJR 1.482 SNIP 0.985
Web of Science (2016): Impact factor 2.925
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 2.06 SJR 1.747 SNIP 1.008
Web of Science (2015): Impact factor 2.765
Web of Science (2015): Indexed yes
Scopus rating (2014): CiteScore 2.46 SJR 2.201 SNIP 1.163
Web of Science (2014): Indexed yes
Scopus rating (2013): CiteScore 2.86 SJR 2.305 SNIP 1.166
ISI indexed (2013): ISI indexed yes
Quality factor enhancement in photonic crystal slabs by manipulation of the ring of exceptional points

Presently, we investigate the influence of the extent of a ring of exceptional points on the Q-factor of three-dimensional photonic crystal slabs. By changing the thickness of the slab, the extent of the ring of exceptional points is varied, allowing us to recover the Dirac cones in open, non-Hermitian systems. In this case, three bound states in the continuum are exhibited close to the Gamma-point. For an optimized thickness of the slab, the associated Q-factors are found to grow rapidly with the size of the slab. The present results may lead to novel, small area and high Q-factor photonic crystal surface-emitting lasers.
Regimes of self-pulsing in photonic crystal Fano lasers

Laser self-pulsing was a property exclusive to macroscopic laser systems until recently, where self-pulsing laser operation was demonstrated experimentally and theoretically in a microscopic photonic crystal Fano laser [1]. We now provide a detailed theoretical analysis of the self-pulsing mechanism and laser characteristics with numerical simulations to demonstrate the parameter dependence of the self-pulsing regime and its limitations, indicating how the design may be optimised for applications in e.g. integrated on-chip communication systems.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Rasmussen, T. S., Yu, Y., Mørk, J.
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ISBN (Print): 9781509067367
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Source: FindIt
Source-ID: 2392694759
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Self-consistent Maxwell-Bloch model of quantum-dot photonic-crystal-cavity lasers

We present a powerful computational approach to simulate the threshold behavior of photonic-crystal quantum-dot (QD) lasers. Using a finite-difference time-domain (FDTD) technique, Maxwell-Bloch equations representing a system of thousands of statistically independent and randomly positioned two-level emitters are solved numerically. Phenomenological pure dephasing and incoherent pumping is added to the optical Bloch equations to allow for a dynamical lasing regime, but the cavity-mediated radiative dynamics and gain coupling of each QD dipole (artificial atom) is contained self-consistently within the model. These Maxwell-Bloch equations are implemented by using Lumerical's flexible material plug-in tool, which allows a user to define additional equations of motion for the nonlinear polarization. We implement the gain ensemble within triangular-lattice photonic-crystal cavities of various length N (where N refers to the number of missing holes), and investigate the cavity mode characteristics and the threshold regime as a function of cavity length. We develop effective two-dimensional model simulations which are derived after studying the full three-dimensional passive material structures by matching the cavity quality factors and resonance properties. We also demonstrate how to obtain the correct point-dipole radiative decay rate from Fermi's golden rule, which is captured naturally by the FDTD method. Our numerical simulations predict that the pump threshold plateaus around cavity lengths greater than N = 9, which we identify as a consequence of the complex spatial dynamics and gain coupling from the inhomogeneous QD ensemble. This behavior is not expected from simple rate-equation analysis commonly adopted in the literature, but is in qualitative agreement with recent experiments. Single-mode to multimode lasing is also observed, depending on the spectral peak frequency of the QD ensemble. Using a statistical modal analysis of the average decay rates, we also show how the average radiative decay rate decreases as a function of cavity size. In addition, we investigate the role of structural disorder on both the passive cavity and active lasers, where the latter show a general increase in the pump threshold for cavity lengths greater than N = 7, and a reduction in the nominal cavity mode volume for increasing amounts of disorder.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Queen's University Kingston
Contributors: Cartar, W., Mørk, J., Hughes, S.
Number of pages: 16
Single-photon sources for quantum technologies - Results of the joint research project SIQUTE

In this presentation, the results of the joint research project “Single-Photon Sources for Quantum Technologies” (SIQUTE) [1] will be presented. The focus will be on the development of absolutely characterized single-photon sources, on the realization of an efficient waveguide-based single-photon source at the telecom wavelengths of 1.3 µm and 1.55 µm, on the implementation of the quantum-enhanced resolution in confocal fluorescence microscopy and on the development of a detector for very low photon fluxes.

General information
State: Published
Number of pages: 2
Publication date: 2017

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Title of host publication: Proceedings of 13th International Conference on New Developments and Applications in Optical Radiometry
Electronic versions:
NewRad_2017_SIQUETE_final.pdf
Source: PublicationPreSubmission
Source-ID: 133170866
Research output: Research - peer-review › Article in proceedings – Annual report year: 2017

Theory and simulations of self-pulsing in photonic crystal Fano lasers

A detailed theoretical and numerical investigation of the dynamics of photonic crystal Fano lasers is presented. It is shown how the dynamical model supports self-pulsing, as was recently observed experimentally, and an in-depth analysis of the physics of the self-pulsing mechanism is given. Furthermore, it is demonstrated how different dynamical regimes exist, and these are mapped out numerically, showing how self-pulsing or continuous-wave output may be controlled through the strength of the pump and the detuning of the nanocavity. Finally, laser phase transitions through dynamical perturbations are demonstrated.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Rasmussen, T. S., Yu, Y., Merk, J.
Pages: 83-84
Publication date: 2017

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ISBN (Print): 978-1-5090-5323-0/
Electronic versions:
nusod17paper42.pdf
DOIs:
10.1109/NUSOD.2017.8010002

Bibliographical note
Theory of Self-pulsing in Photonic Crystal Fano Lasers

Laser self-pulsing was a phenomenon exclusive to macroscopic lasers until recently, where self-starting laser pulsation in a microscopic photonic crystal Fano laser was reported. In this paper a theoretical model is developed to describe the Fano laser, including descriptions of the highly-dispersive Fano mirror, the laser frequency and the threshold gain. The model is based upon a combination of conventional laser rate equations and coupled-mode theory. The dynamical model is used to demonstrate how the laser has two regimes of operation, continuous-wave output and self-pulsing, and these regimes are characterised using phase diagrams, establishing the regime of self-pulsing numerically. Furthermore, the physics behind the self-pulsing mechanism are explained in detail and it is demonstrated how cavity absorption makes the Fano mirror function as a saturable absorber, leading to Q-switched pulse generation. A stability analysis is used to demonstrate how the dominant mechanism of instability is relaxation oscillations becoming un-damped. Finally the effect of varying key self-pulsing parameters is investigated by characterisation of the change in self-pulsing regions.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Rasmussen, T. S., Yu, Y., Mørk, J.
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Publication information
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Issue number: 5
Article number: 1700089
ISSN (Print): 1863-8880
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 9.02 SJR 4.228 SNIP 2.988
Web of Science (2017): Impact factor 8.529
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 8.71 SJR 4.013 SNIP 3.351
Web of Science (2016): Impact factor 8.434
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 8.54 SJR 4.205 SNIP 3.479
Web of Science (2015): Impact factor 7.486
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 8.62 SJR 4.958 SNIP 4.446
Web of Science (2014): Impact factor 8.008
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 9.26 SJR 5.132 SNIP 4.796
Web of Science (2013): Impact factor 9.313
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 7.59 SJR 5.144 SNIP 3.617
Web of Science (2012): Impact factor 7.976
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
We present a numerical investigation of the exciton energy and oscillator strength in type-II nanowire quantum dots. For a single quantum dot, the poor overlap of the electron part and the weakly confined hole part of the excitonic wave function leads to a low oscillator strength compared to type-I systems. To increase the oscillator strength, we propose a double quantum dot structure featuring a strongly localized exciton wave function and a corresponding fourfold relative enhancement of the oscillator strength, paving the way towards efficient optically controlled quantum gate applications in the type-II nanowire system. The simulations are performed using a computationally efficient configuration-interaction method suitable for handling the relatively large nanowire structures.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Bristol
Contributors: Taherkhani, M., Willatzen, M., Mørk, J., Gregersen, N., McCutcheon, D. P. S.
Number of pages: 9
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Physical Review B
Volume: 96
Issue number: 12
Article number: 125408
ISSN (Print): 2469-9950
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Impact factor 3.813
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Impact factor 3.836
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 2.8 SJR 2.377 SNIP 1.13
Web of Science (2015): Impact factor 3.718
Web of Science (2015): Indexed yes
Scopus rating (2014): CiteScore 3.3 SJR 2.762 SNIP 1.316
Type-II Quantum Dot Nanowire Structures with Large Oscillator Strengths for Optical Quantum Gating Applications

The exciton oscillator strength (OS) in type-II quantum dot (QD) nanowires is calculated by using a fast and efficient method. We propose a new structure in Double-Well QD (DWQD) nanowire that considerably increases OS of type-II QDs which is a key parameter in optical quantum gating in the stimulated Raman adiabatic passage (STIRAP) process [1] for implementing quantum gates.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
A broadband tapered nanocavity for efficient nonclassical light emission

We present the design of a tapered nanocavity, obtained by sandwiching a photonic wire section between a planar gold reflector and a few-period Bragg mirror integrated into the tapered wire. Thanks to its ultrasmall mode volume ($0.71 \lambda^3/n^3$), this hybrid nanocavity largely enhances the spontaneous emission rate of an embedded quantum dot (Purcell factor: 6), while offering a wide operation bandwidth (full-width half-maximum: 20 nm). In addition, the top tapered section shapes the cavity far-field emission into a very directive output beam, with a Gaussian spatial profile. For realistic taper dimensions, a total outcoupling efficiency to a Gaussian beam of 0.8 is predicted. Envisioned applications include bright sources of non-classical states of light, such as widely tunable sources of indistinguishable single photons and polarization-entangled photon pairs.
All-Optical Switching Improvement Using Photonic-Crystal Fano Structures

We investigate the intensity and phase response of optical switches based on a photonic crystal waveguide coupled to a nanocavity. In particular, we compare the performances of switches with traditional Lorentzian transmission spectrum to switches displaying an asymmetric Fano shape, as obtained by incorporating a partially transmitting element in the waveguide. Compared to traditional Lorentzian structures, the Fano structure shows improved switching contrast and speed without adding any extra phase modulation, corresponding to a much lower chirp parameter. Using a simple and ultracompact InP photonic-crystal Fano structure with broken mirror symmetry, we experimentally demonstrate 20-Gb/s all-optical switching with low-energy consumption.

General information
A modal approach to light emission and propagation in coupled cavity waveguide systems

We theoretically investigate systems of optical cavities coupled to waveguides, which necessitates the introduction of non-trivial radiation conditions and normalization procedures. In return, the approach provides simple and accurate modeling of Green functions, Purcell factors and perturbation corrections, as well as an alternative approach to the so-called coupled mode theory. In combination, these results may form part of the foundations for highly efficient, yet physically transparent models of light emission and propagation in both classical and quantum integrated photonic circuits.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Humboldt University of Berlin
Contributors: Gregersen, N., Kristensen, P. T., de Lasson, J. R., Gregersen, N., Mørk, J.
Number of pages: 2
Publication date: 2016

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Title of host publication: Proceedings of the 7th International Conference on Metamaterials, Photonic Crystals and Plasmonics
Source: PublicationPreSubmission
Source-ID: 125482284
Research output: Research - peer-review › Article in proceedings – Annual report year: 2016

Broadband Purcell enhancement in highly efficient photonic nanowire-based single-photon sources

The photonic nanowire single-photon source design approach allows for efficient broadband coupling between a quantum dot and a 1D photonic environment. In this work, we introduce weak cavity effects to the design by implementing a distributed Bragg reflector in the inverted taper. This leads to broadband enhancement of the photon emission rate with a Purcell factor of 6 over a full-width half-maximum range of 20 nm while maintaining a total outcoupling efficiency of 0.8 to a Gaussian profile.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, CNRS
Contributors: Gregersen, N., McCutcheon, D., Mørk, J., Claudon, J., Gerard, J.
Number of pages: 2
Publication date: 2016

Host publication information
Title of host publication: Proceedings of the 7th International Conference on Metamaterials, Photonic Crystals and Plasmonics
Source: PublicationPreSubmission
Source-ID: 125482241
Research output: Research - peer-review › Article in proceedings – Annual report year: 2016

Comparison of four computational methods for computing Q factors and resonance wavelengths in photonic crystal membrane cavities

We benchmark four state-of-the-art computational methods by computing quality factors and resonance wavelengths in photonic crystal membrane L5 and L9 line defect cavities. The convergence of the methods with respect to resolution, degrees of freedom and number of modes is investigated. Special attention is paid to the influence of the size of the computational domain. Convergence is not obtained for some of the methods, indicating that some are more suitable than others for analyzing line defect cavities.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices, Centre of Excellence for Silicon Photonics for Optical Communications, Department of Electrical Engineering, Electromagnetic Systems, Department of Mechanical Engineering, Solid Mechanics, Zuse Institute Berlin
Contributors: de Lasson, J. R., Frandsen, L. H., Burger, S., Gutsche, P., Kim, O. S., Breinbjerg, O., Sigmund, O., Mørk, J., Gregersen, N.
Number of pages: 2
Publication date: 2016

Host publication information
Title of host publication: Proceedings of the 7th International Conference on Metamaterials, Photonic Crystals and Plasmonics
Efficient Modeling of Coulomb Interaction Effect on Exciton in Crystal-Phase Nanowire Quantum Dot

The binding energy and oscillation strength of the ground-state exciton in type-II quantum dot (QD) is calculated by using a post Hartree-Fock method known as the configuration interaction (CI) method which is significantly more efficient than conventional methods like ab initio method. We show that the Coulomb interaction between electron and holes in these structures considerably affects the transition dipole moment which is the key parameter of optical quantum gating in STIRAP (stimulated Raman adiabatic passage) process for implementing quantum gates [1], [2].

Fundamental Limits to Coherent Scattering and Photon Coalescence from Solid-State Quantum Emitters [arXiv]

The desire to produce high-quality single photons for applications in quantum information science has lead to renewed interest in exploring solid-state emitters in the weak excitation regime. Under these conditions it is expected that photons are coherently scattered, and so benefit from a substantial suppression of detrimental interactions between the source and its phonon environment. Nevertheless, we demonstrate here that this reasoning is incomplete, and phonon interactions continue to play a crucial role in determining solid-state emission characteristics even for very weak excitation. We find that the sideband resulting from non-Markovian relaxation of the phonon environment leads to a fundamental limit to the fraction of coherently scattered light and to the visibility of two-photon coalescence at weak driving, both of which are absent for atomic systems or within simpler Markovian treatments.
Numerical Investigation of Vertical Cavity Lasers With High-Contrast Gratings Using the Fourier Modal Method

We explore the use of a modal expansion technique, Fourier modal method (FMM), for investigating the optical properties of vertical cavities employing high-contrast gratings (HCGs). Three techniques for determining the resonance frequency...
and quality factor (Q-factor) of a cavity mode are compared, and the computational uncertainties in the resonance frequency and Q-factor calculations are analyzed. Moreover, a method for reducing a three-dimensional (3D) simulation to lower-dimensional simulations is suggested, which allows for very fast and approximate analysis of a 3D structure. By using the implemented FMM, the scattering losses of several HCG-based vertical cavities with inplane heterostructures which have promising prospects for fundamental physics studies and on-chip laser applications, are investigated. This type of parametric study of 3D structures would be numerically very demanding using spatial discretization techniques.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Mørk, J., Chung, I.
Pages: 4240-4251
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Journal of Lightwave Technology
Volume: 34
Issue number: 18
ISSN (Print): 0733-8724
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.42 SJR 1.166 SNIP 1.791
Web of Science (2017): Impact factor 3.652
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.87 SJR 1.23 SNIP 1.819
Web of Science (2016): Impact factor 3.671
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.15 SJR 1.598 SNIP 1.901
Web of Science (2015): Impact factor 2.567
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.23 SJR 1.737 SNIP 2.411
Web of Science (2014): Impact factor 2.965
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.03 SJR 1.622 SNIP 2.439
Web of Science (2013): Impact factor 2.862
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.21 SJR 1.888 SNIP 2.491
Web of Science (2012): Impact factor 2.555
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.2 SJR 1.733 SNIP 2.957
Web of Science (2011): Impact factor 2.784
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.737 SNIP 2.401
Phonon limit to simultaneous near-unity efficiency and indistinguishability in semiconductor single photon sources

Semiconductor quantum dots have recently emerged as a leading platform to efficiently generate highly indistinguishable photons, and this work addresses the timely question of how good these solid-state sources can ultimately be. We establish the crucial role of lattice relaxation in these systems in giving rise to trade-offs between indistinguishability and efficiency. We analyse the two source architectures most commonly employed: a quantum dot embedded in a waveguide and a quantum dot coupled to an optical cavity. For waveguides, we demonstrate that the broadband Purcell effect results in a simple inverse relationship, where indistinguishability and efficiency cannot be simultaneously increased. For cavities, the frequency selectivity of the Purcell enhancement results in a more subtle trade-off, where indistinguishability and efficiency can be simultaneously increased, though by the same mechanism not arbitrarily, limiting a source with near-unity indistinguishability (> 99%) to an efficiency of approximately 96% for realistic parameters.

General information

State: Published
Organisations: Department of Photonics Engineering, University of Manchester, University of Bristol
Contributors: McCutcheon, D. P. S., Iles-Smith, J., Nazir, A., Mørk, J.
Number of pages: 2
Publication date: 2016

Host publication information
Title of host publication: 2017 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference
Publisher: IEEE
ISBN (Print): 9781509067367
Photonic crystal Fano structures and their application to ultrafast switching and lasers
We present investigations on photonic-crystal Fano structures based on a cavity-waveguide configuration. We show that the use of Fano resonance can enable great improvements in high-speed low-energy all-optical switching and realizing ultra-fast nanolasers.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices, Department of Micro- and Nanotechnology
Number of pages: 3
Publication date: 2016

Site-controlled quantum dots coupled to photonic crystal waveguides
We demonstrate selective optical coupling of multiple, site controlled semiconductor quantum dots (QDs) to photonic crystal waveguide structures. The impact of the exact position and emission spectrum of the QDs on the coupling efficiency is elucidated. The influence of optical disorder and end-reflections on photon transport in these systems are discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Swiss Federal Institute of Technology Lausanne
Number of pages: 2
Publication date: 2016

Spectrally and temporally resolved resonance shifts of a photonic crystal cavity switch
We present experimental results of temporally and spectrally resolved transmission measurements of a photonic crystal cavity using two-color pump-probe technique. With a gated spectral measurement, we measure the resonance shift's dependence on pump power.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Hansen, P. L., Yu, Y., Mørk, J.
Number of pages: 2
Publication date: 2016
Spectral symmetry of Fano resonances in a waveguide coupled to a microcavity

We investigate the symmetry of transmission spectra in a photonic crystal (PhC) waveguide with a side-coupled cavity and a partially transmitting element (PTE). We demonstrate, through numerical calculations, that by varying the cavity-PTE distance the spectra vary from being asymmetric with the minimum blueshifted relative to the maximum, to being symmetric (Lorentzian), to being asymmetric with the minimum redshifted relative to the maximum. For cavity-PTE distances larger than five PhC lattice constants, we show that the transmission spectrum is accurately described as the transmission spectrum of a Fabry–Perot etalon with a single propagating Bloch mode and that the symmetry of the transmission spectrum correlates with the Fabry–Perot round-trip phase.
Switching dynamics in InP photonic-crystal nanocavity

In this paper, we presented switching dynamic investigations on an InP photonic-crystal (PhC) nanocavity structure using homodyne pump-probe measurements. The measurements were compared with simulations based on temporal nonlinear coupled mode theory and carrier rate equations for the dynamics of the carrier density governing the cavity properties. The results provide insight into the nonlinear optical processes that govern the dynamics of nanocavities.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Risø National Laboratory for Sustainable Energy, Centre of Excellence for Silicon Photonics for Optical
This thesis deals with theoretical investigations of a newly proposed grating structure, referred to as hybrid grating (HG) as well as vertical cavity lasers based on the grating reflectors. The HG consists of a near-subwavelength grating layer and an unpatterned high-refractive-index cap layer. Though both sides of the grating layer are not surrounded by low refractive-index materials as in high-index-contrast gratings (HCGs), the HG can provide a near-unity reflectivity over a broader wavelength range than HCGs, or work as a resonator with a quality (Q) factor as high as 10^9. The physics behind these reflector and resonator properties are studied thoroughly. A HG structure comprising a III-V cap layer with a gain material and a Si grating layer enables the realization of a compact vertical cavity laser integrated on Si platform, which has a superior thermal property and fabrication feasibility than the HCG-based ones. Furthermore, the concept of cavity dispersion in vertical cavities is introduced and its importance in the modal properties is numerically investigated. The dispersion curvature of a cavity mode is interpreted as the effective photon mass of the cavity mode. In a vertical cavity based on a HCG or HG reflector, this effective photon mass can be engineered by changing the grating parameters, which is not the case in a vertical cavity based on distributed Bragg reflectors (DBRs). This engineering capability enables us to form various photonic heterostructures in lateral directions, which is analogous to electronic quantum wells in conduction or valence bands. Several interesting configurations of heterostructures have been investigated and their potential in fundamental physics study and applications are discussed. For numerical and theoretical studies, a three-dimensional (3D) optical simulator has been implemented, based on the Fourier modal method (FMM). A method to simplify 3D simulations to lower dimensional simulations is suggested, which enables us to perform fast simulations before doing a thorough 3D simulation. Moreover, three different techniques for determining the resonance frequency and Q-factor of a cavity mode are compared. Based on that, the quasi-normal mode approach with real frequency has been chosen due to its numerical efficiency. In this comparison, the associated computational uncertainty for the resonance frequency and Q-factor is investigated, which shows that the uncertainty in the Q-factor can be several orders of magnitude larger than the uncertainty in the resonance frequency. Next, the HG is shown to possess a near-unity reflectivity in a broad wavelength range, which can be broader than the HCG, since the cap layer introduces more guided mode resonances (GMRs) in the reflectivity spectrum. The fabrication tolerance of the HG is investigated numerically, which shows that the broadband near-unity reflectivity characteristic is prone to common fabrication errors. An experimental demonstration of...
the HG reflector confirms its broadband reflection characteristics. Furthermore, the physics study of HG as high Q-factor resonator illustrates that the resonance mechanism is similar to the resonances appearing in HCG resonators, and it is quite different from the conventional GMR filters. The effect of fabrication errors and finite size of the structure is investigated to understand the feasibility of fabricating the proposed resonator. Finally, the significance of the cavity dispersion in vertical cavity structure is illustrated. An analytic expression is derived for the dispersion, which shows that the cavity dispersion has contributions from both top and bottom mirrors through their reflectivity phase response as well as the nominal cavity through its thickness. For conventional DBRs, the mirror contribution in dispersion curvature is always positive and negligible, compared to the nominal cavity contribution. However, the HCG or HG contributions can be a specific positive or negative value in different transverse directions, significantly modifying the entire dispersion curvature. The influences of the photon effective mass on the mode confinement, mode spacing and transverse modes are investigated. Particularly, it is shown that the anisotropic dispersion curvature in in-plane heterostructure is responsible for the phenomenon of mode grouping, which is also confirmed by experimental results. Furthermore, in Si-integrated photonics, a laser source that can output light into a Si waveguide is essential, and it is shown that in HGG-based vertical cavity laser the light can be coupled to an in-plane output waveguide. The design rules for achieving a high out-coupling efficiency into the in-plane waveguide are discussed and the in-plane out-coupling efficiency as high as 68% is achieved in design. Based on this platform, a system of two laterally coupled cavities is proposed and investigated, which exhibits the breaking of parity-time (PT) symmetry in vertical cavity structures. Compared to other types of platform for studying this phenomenon such as ring/disk resonators and photonic crystal cavities, the HCG/HG-based vertical cavities appear to be more feasible for realizing an electrically pumped device, which may pave the way for finding device applications for PT-symmetry breaking phenomenon.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Chung, I., Mørk, J.
Number of pages: 149
Publication date: 2016

Publication information
Publisher: DTU Fotonik
Original language: English
Electronic versions:
thesis_1_.pdf
Source: PublicationPreSubmission
Source-ID: 123769347

Threshold Characteristics of Slow-Light Photonic Crystal Lasers
The threshold properties of photonic crystal quantum dot lasers operating in the slow-light regime are investigated experimentally and theoretically. Measurements show that, in contrast to conventional lasers, the threshold gain attains a minimum value for a specific cavity length. The experimental results are explained by an analytical theory for the laser threshold that takes into account the effects of slow light and random disorder due to unavoidable fabrication imperfections. Longer lasers are found to operate deeper into the slow-light region, leading to a trade-off between slow-light induced reduction of the mirror loss and slow-light enhancement of disorder-induced losses.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices, Centre of Excellence for Silicon Photonics for Optical Communications
Contributors: Xue, W., Yu, Y., Ottaviano, L., Chen, Y., Semenova, E., Yvind, K., Mørk, J.
Number of pages: 5
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Physical Review Letters
Volume: 116
Issue number: 6
Article number: 063901
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Ultrafast coherent dynamics of a photonic crystal all-optical switch

We present pump-probe measurements of an all-optical photonic crystal switch based on a nanocavity, resolving fast coherent temporal dynamics. The measurements demonstrate the importance of coherent effects typically neglected when considering nanocavity dynamics. In particular, we report the observation of an idler pulse. The measurements are in good agreement with a theoretical model that allows us to ascribe the observation to oscillations of the free carrier population in the nanocavity. The effect opens perspectives for the realization of new all-optical photonic crystal switches with unprecedented switching contrast.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology
Contributors: Colman, P., Hansen, P. L., Yu, Y., Mørk, J.
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Physical Review Letters
Volume: 117
Issue number: 23
Article number: 233901
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464
Web of Science (2017): Impact factor 8.839
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.33 SJR 4.196 SNIP 2.61
Web of Science (2016): Impact factor 8.462
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.76 SJR 4.656 SNIP 2.538
Web of Science (2015): Impact factor 7.645
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.62 SJR 5.232 SNIP 2.71
Web of Science (2014): Impact factor 7.512
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 7.46 SJR 5.675 SNIP 2.781
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 7.19 SJR 6.292 SNIP 2.867
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Ultrahigh-speed Si-integrated on-chip laser with tailored dynamic characteristics

For on-chip interconnects, an ideal light source should have an ultralow energy consumption per bandwidth (operating energy) as well as sufficient output power for error-free detection. Nanocavity lasers have been considered the most ideal for smaller operating energy. However, they have a challenge in obtaining a sufficient output power. Here, as an alternative, we propose an ultrahigh-speed microcavity laser structure, based on a vertical cavity with a high-contrast grating (HCG) mirror for transverse magnetic (TM) polarisation. By using the TM HCG, a very small mode volume and an un-pumped compact optical feedback structure can be realised, which together tailor the frequency response function for achieving a very high speed at low injection currents. Furthermore, light can be emitted laterally into a Si waveguide. From an 1.54-μm optically-pumped laser, a 3-dB frequency of 27 GHz was obtained at a pumping level corresponding to sub-mA. Using measured 3-dB frequencies and calculated equivalent currents, the modulation current efficiency factor (MCEF) is estimated to be 42.1 GHz/mA(1/2), which is superior among microcavity lasers. This shows a high potential for a very high speed at low injection currents or very small heat generation at high bitrates, which are highly desirable for both on-chip and off-chip applications.

General information
A Hybrid Photonic Nanowire-Cavity Design for a Single-Indistinguishable-Photon Source
**A New Compact Broadband Reflector: The Hybrid Grating**

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Mørk, J., Chung, I.
Number of pages: 1
Publication date: 2015

Host publication information
Title of host publication: European Quantum Electronics Conference 2015
Publisher: Optical Society of America
ISBN (Print): 978-1-4673-7475-0
Source: PublicationPreSubmission
Source-ID: 124321014
Research output: Research - peer-review › Article in proceedings – Annual report year: 2016

**Design and simulations of highly efficient single-photon sources**

The realization of the highly-efficient single-photon source represents not only an experimental, but also a numerical challenge. We will present the theory of the waveguide QED approach, the design challenges and the current limitations. Additionally, the important numerical challenges in the simulations of sources with in-plane emission will be discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Gregersen, N., de Lasson, J. R., Mørk, J.
Number of pages: 2
Publication date: 2015
Peer-reviewed: Yes
Source: PublicationPreSubmission
Source-ID: 112568909
Research output: Research - peer-review › Paper – Annual report year: 2015

**Design of Slow and Fast Light Photonic Crystal Waveguides for Single-photon Emission Using a Bloch Mode Expansion Technique**

We design slow and fast light photonic crystal waveguides for single-photon emission using a Bloch mode expansion and scattering matrix technique. We propose slow light designs that increase the group index-waveguide mode volume ratio for larger Purcell enhancement, and address efficient slow-to-fast-light waveguide coupling.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Swiss Federal Institute of Technology Lausanne
Contributors: de Lasson, J. R., Rigal, B., Kapon, E., Mørk, J., Gregersen, N.
Number of pages: 1
Publication date: 2015
Peer-reviewed: Yes
Event: Abstract from 2015 Progress In Electromagnetics Research Symposium , Prag, Czech Republic.
Effect of In-plane Mirror Dispersion on Vertical Cavities Based on High-Contrast Grating Mirrors

We report how the in-plane dispersion of a high-index-contrast grating reflector influences the transverse mode properties such as shorter wavelengths for lower-order transverse modes and different transverse-mode wavelength spacings for modes with the same size.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Mørk, J., Chung, I.
Number of pages: 2
Publication date: 2015

Host publication information
Title of host publication: Proceedings of 2015 Conference on Lasers and Electro-Optics (CLEO)
Publisher: Optical Society of America
Article number: SW1F.4
ISBN (Print): 978-1-55752-968-8
Electronic versions:
CLEO2015.pdf
DOIs:
10.1364/CLEO_SI.2015.SW1F.4

Bibliographical note
From the session: Surface Emitting Semiconductors Lasers (SW1F)

Experimental demonstration of non-reciprocal transmission in a nonlinear photonic-crystal Fano structure

We suggest and experimentally demonstrate a photonic-crystal structure with more than 30 dB difference between forward and backward transmission levels. The non-reciprocity relies on the combination of ultrafast carrier nonlinearities and spatial symmetry breaking in a Fano structure employing a single nanocavity.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices, Department of Micro- and Nanotechnology
Contributors: Yu, Y., Chen, Y., Hu, H., Xue, W., Yvind, K., Mørk, J.
Number of pages: 2
Publication date: 2015

Host publication information
Title of host publication: Proceedings of 2015 Conference on Lasers and Electro-Optics (CLEO)
Publisher: IEEE
Article number: SF2H.5
ISBN (Print): 978-1-55752-968-8
Keywords: high-speed optical techniques, nanophotonics, nonlinear optics, photoemission, photonic crystals, General Topics for Engineers, Photonics and Electrooptics, backward transmission levels, Cavity resonators, Couplings, forward transmission levels, Nonlinear optics, nonlinear photonic-crystal Fano structure, nonreciprocal transmission, Optical bistability, Optical waveguides, Photonics, single nanocavity, spatial symmetry breaking, ultrafast carrier nonlinearities, Ultrafast optics
DOIs:
10.1364/CLEO_SI.2015.SF2H.5

Bibliographical note
From the session: Photonic Crystals (SF2H)

Source: FindIt
Source-ID: 275757923
Research output: Research - peer-review › Article in proceedings – Annual report year: 2015

**Few-photon Non-linearities in Nanophotonic Devices for Quantum Information Technology**

In this thesis we investigate few-photon non-linearities in all-optical, on-chip circuits, and we discuss their possible applications in devices of interest for quantum information technology, such as conditional two-photon gates and single-photon sources. In order to propose efficient devices, it is crucial to fully understand the non-equilibrium dynamics of strongly interacting photons. Employing both numerical and analytical approaches we map out the full scattering dynamics for two photons scattering on a two-level emitter in a one-dimensional waveguide. The strongest non-linear interaction arise when the emitter is excited the most, which occurs for incoming photon pulses with a spectral bandwidth comparable to the emitter linewidth. For two identical, counter-propagating photons, the emitter works as a non-linear beam splitter, as the emitter induces strong directional correlations between the scattered photons. Even though the non-linearity also alters the pulse spectrum due to a four-wave mixing process, we demonstrate that input pulses with a Gaussian spectrum can be mapped to the output with up to 80% fidelity. Using two identical two-level emitters, we propose a setup for a deterministic controlled-phase gate, which preserves the properties of the two incoming photons with almost 80%, limited by spectral changes induced by the non-linearity and phase modulations upon scattering. Another setup for a controlled-phase operation is suggested with two coupled ring resonators exploiting a strong second-order material non-linearity. By dynamically trapping the first of two temporally separated photons in the non-linear resonator, the scattering of the second photon is altered. Due to the trapping, the undesired aforementioned non-linear effects are avoided, but the gate performance is now limited by the capturing process. Semiconductor quantum dots (QDs) are promising for realizing few-photon non-linearities in solid-state implementations, although coupling to phonon modes in the surrounding lattice have significant influence on the dynamics. By accounting for the commonly neglected asymmetry between the electron and hole wavefunction in the QD, we show how the phonon-assisted transition rate to a slightly detuned optical mode may be suppressed. This is achieved by properly matching the electrical carrier confinement with the deformation potential interaction, where the suppression only occurs in materials where the deformation potential interaction shifts the electron and hole bands in the same direction. We demonstrate also how the phonon-induced effects may be altered by placing the QD inside an infinite slab, where the confinement of the phonons is modified instead. For a slab thickness below ~70 nm, the bulk description of the phonon modes may be insufficient. The QD decay rate may be strongly increased or decreased, depending on how the detuning between the QD and the optical mode matches the phonon modes in the slab.

**General information**

State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nysteen, A., Mørk, J., Kristensen, P. T., McCutcheon, D., Nielsen, P. K.
Number of pages: 172
Publication date: 2015

**Publication information**

Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions:
Nysteen_PhDthesis_march15.pdf

Research output: Research › Ph.D. thesis – Annual report year: 2015

**Highly directive and Gaussian far-field emission from "giant" photonic trumpets**

Photonic trumpets are broadband dielectric antennas that efficiently funnel the emission of a pointlike quantum emitter—such as a semiconductor quantum dot—into a Gaussian free-space beam. After describing guidelines for the taper design, we present a “giant” photonic trumpet. The device features a bottom diameter of 210 nm and a 5 lm wide top facet. Using Fourier microscopy, we show that 95% of the emitted beam is intercepted by a modest numerical aperture of 0.35. Furthermore, far-field measurements reveal a highly Gaussian angular profile, in agreement with the predicted overlap to a Gaussian beam Mg ≈ 0.98. Future application prospects include the direct coupling of these devices to a cleaved single-mode optical fiber. The calculated transmission from the taper base to the fiber already reaches 0.59, and we discuss strategies to further improve this figure of merit.

**General information**

State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Grenoble, Universite Grenoble Alpes, University of Basel, CNRS
Number of pages: 4
Publication date: 2015
Peer-reviewed: Yes

**Publication information**

Highly indistinguishable photons from a QD-microcavity with a large Purcell-factor

We demonstrate the emission of highly indistinguishable photons from a quasi-resonantly pumped coupled quantum dot-microcavity system operating in the weak coupling regime. Furthermore we model the degree of indistinguishability with our novel microscopic theory.

Highly Sensitive Photonic Crystal Cavity Laser Noise Measurements using Bayesian Filtering

We measure for the first time the frequency noise spectrum of a photonic crystal cavity laser with less than 20 nW of fiber-coupled output power using a coherent receiver and Bayesian filtering.
Hybrid III-V-on-Si Laser with Ultra-low Energy Consumption

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Mørk, J., Chung, I.
Publication date: 2015
Peer-reviewed: Yes
Event: Poster session presented at Danish Opening Ceremony of the International Year of Light, Lyngby, Denmark.

Electronic versions:
IYL_2015.pdf
Source: PublicationPreSubmission
Source-ID: 105416218
Research output: Research - peer-review › Poster – Annual report year: 2015

Hybrid III-V/SOI single-mode vertical-cavity laser with in-plane emission into a silicon waveguide
We report a III-V-on-SOI vertical-cavity laser emitting into an in-plane Si waveguide fabricated by using CMOS-compatible processes. The fabricated laser operates at 1.54 µm with a SMSR of 33 dB and a low threshold.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Park, G. C., Xue, W., Semenova, E., Mørk, J., Chung, I.
Number of pages: 2
Publication date: 2015

Host publication information
Title of host publication: Proceedings of 2015 Conference on Lasers and Electro-Optics (CLEO)
Publisher: IEEE
ISBN (Print): 978-1-55752-968-8
Electronic versions:
1._CLEO_Hybrid_III_V_SOI_single_mode_vertical_cavity_laser_with_in_plane_emission_into_a_silicon_waveguide.pdf
DOIs:
10.1364/CLEO_SI.2015.SW3F.2

Bibliographical note
From the session: III-V Lasers on Silicon (SW3F)
Source: PublicationPreSubmission
Source-ID: 110306317
Research output: Research - peer-review › Article in proceedings – Annual report year: 2015

Hybrid vertical-cavity laser with lateral emission into a silicon waveguide
We experimentally demonstrate an optically-pumped III-V/Si vertical-cavity laser with lateral emission into a silicon waveguide. This on-chip hybrid laser comprises a distributed Bragg reflector, a III-V active layer, and a high-contrast grating reflector, which simultaneously funnels light into the waveguide integrated with the laser. This laser has the
advantages of long-wavelength vertical-cavity surface-emitting lasers, such as low threshold and high side-mode suppression ratio, while allowing integration with silicon photonic circuits, and is fabricated using CMOS compatible processes. It has the potential for ultrahigh-speed operation beyond 100 Gbit/s and features a novel mechanism for transverse mode control.

**General information**

State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Park, G. C., Xue, W., Taghizadeh, A., Semenova, E., Yvind, K., Mørk, J., Chung, I.
Pages: L11–L15
Publication date: 2015
Peer-reviewed: Yes

**Publication information**

Journal: Laser & Photonics Reviews
Volume: 9
Issue number: 3
ISSN (Print): 1863-8880
Ratings:
- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 9.02 SJR 4.228 SNIP 2.988
- Web of Science (2017): Impact factor 8.529
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 8.71 SJR 4.013 SNIP 3.351
- Web of Science (2016): Impact factor 8.434
- BFI (2015): BFI-level 1
- Scopus rating (2015): CiteScore 8.54 SJR 4.205 SNIP 3.479
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): CiteScore 8.62 SJR 4.958 SNIP 4.446
- Web of Science (2014): Impact factor 8.008
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): CiteScore 9.26 SJR 5.132 SNIP 4.796
- Web of Science (2013): Impact factor 9.313
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): CiteScore 7.59 SJR 5.144 SNIP 3.617
- Web of Science (2012): Impact factor 7.976
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): CiteScore 7.98 SJR 5.844 SNIP 4.857
- Web of Science (2011): Impact factor 7.388
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 5.851 SNIP 4.009
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
III-V/SOI vertical cavity laser structure for 120 Gbit/s speed

Ultrashort-cavity structure for III-V/SOI vertical cavity laser with light output into a Si waveguide is proposed, enabling 17 fJ/bit efficiency or 120 Gbit/s speed. Experimentally, 27-GHz bandwidth is demonstrated at 3.5 times of threshold. © 2015 OSA.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology, Nanophotonic Devices
Contributors: Park, G. C., Xue, W., Mørk, J., Semenova, E., Chung, I.
Publication date: 2015

Host publication information
Title of host publication: Integrated Photonics Research, Silicon and Nanophotonics 2015
Publisher: Optical Society of America
Article number: JT5A.2
ISBN (Print): 978-1-55752-000-5
Keywords: Electronic, Optical and Magnetic Materials, Magnetic materials, Light output, Si-waveguide, Ultra-short cavity, Vertical cavity lasers, Optical materials, Electrical and Electronic Engineering, Hardware and Architecture, Optical sensors

III-V/SOI vertical cavity laser with in-plane output into a Si waveguide

We experimentally demonstrate an optically-pumped III-V-on-SOI hybrid vertical-cavity laser that outputs light into an in-plane Si waveguide, using CMOS-compatible processes. The laser operates at 1.49 $\mu$m with a side-mode suppression-ratio of 27 dB and has a similar threshold as long-wavelength VCSELs.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Park, G. C., Xue, W., Semenova, E., Yvind, K., Mørk, J., Chung, I.
Number of pages: 3
Publication date: 2015

Host publication information
Title of host publication: Proceedings of the Optical Fiber Communications Conference and Exhibition 2015
Publisher: IEEE
Article number: W2A.17
ISBN (Electronic): 978-1-55752-937-4
Impact of slow-light enhancement on optical propagation in active semiconductor photonic crystal waveguides

We derive and validate a set of coupled Bloch wave equations for analyzing the reflection and transmission properties of active semiconductor photonic crystal waveguides. In such devices, slow-light propagation can be used to enhance the material gain per unit length, enabling, for example, the realization of short optical amplifiers compatible with photonic integration. The coupled wave analysis is compared to numerical approaches based on the Fourier modal method and a frequency domain finite element technique. The presence of material gain leads to the build-up of a backscattered field, which is interpreted as distributed feedback effects or reflection at passive-active interfaces, depending on the approach taken. For very large material gain values, the band structure of the waveguide is perturbed, and deviations from the simple coupled Bloch wave model are found.
Investigations on the parity of Fano resonances in photonic crystals
We investigate the relation between the parity of Fano resonances and field distribution in a photonic crystal structure using Fourier modal method, establishing a correlation between Fano parity and field profile.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Østerkryger, A. D., de Lasson, J. R., Yu, Y., Mørk, J., Gregersen, N.
Number of pages: 1
Publication date: 2015
Peer-reviewed: Yes
Event: Poster session presented at CLEO/Europe - EQEC 2015, Munich, Germany.
Electronic versions:
Poster_FanoParity_CLEO.pdf
Source: PublicationPreSubmission
Source-ID: 111442577
Research output: Research - peer-review › Poster – Annual report year: 2015

Laser Rate Equation Based Filtering for Carrier Recovery in Characterization and Communication
We formulate a semiconductor laser rate equation based approach to carrier recovery in a Bayesian filtering framework. Filter stability and the effect of model inaccuracies (unknown or un-useable rate equation coefficients) are discussed. Two potential application areas are explored: laser characterization and carrier recovery in coherent communication. Two rate equation based Bayesian filters, the particle filter and extended Kalman filter, are used in conjunction with a coherent receiver to measure frequency noise spectrum of a photonic crystal cavity laser with less than 20 nW of fiber-coupled output power. The extended Kalman filter is also used to recover a 28 GBd DP- 16 QAM signal where a decision-directed phase-locked loop fails.

General information
State: Published
Modeling and simulations of light emission and propagation in open nanophotonic systems

Light emission and propagation in photonic crystal membranes are studied theoretically, with an emphasis on waveguides, slow light effects, and coupled cavity-waveguide systems. A Bloch mode expansion formalism for optical modeling of photonic crystal membranes is presented, and perfectly matched layer boundary conditions are introduced to emulate the inherent openness of the photonic crystal membrane. The impact of the computational domain size and perfectly matched layer parameters on dipole emission in a photonic crystal membrane waveguide is investigated, and we find the associated computational uncertainty to be of larger magnitude than typical estimates found in literature. A photonic crystal waveguide with one or two side-coupled cavities is considered, and the local density of states is described using a semi-analytical quasi-normal mode theory. We propose original techniques for computing and normalizing quasi-normal modes in extended systems, and comparing to numerically exact calculations, the theory correctly predicts a slight asymmetry (one cavity) and a peak and a dip (two cavities) in the local density of states spectra. Next, the photonic crystal waveguide is interfaced with a side-coupled cavity and a scattering site in the waveguide, and we demonstrate that the shape of the transmission spectrum can be controlled by the cavity-scattering site distance, for example to exhibit a symmetric Fano shapes. Subsequently, we investigate an active photonic crystal waveguide in the slow light region and present an original coupled Bloch mode model, with material gain treated as a perturbation, that includes back-coupling between the counter propagating passive Bloch modes. We show that this gives rise to distributed feedback, which puts fundamental limitations on the maximum achievable gain of the slow light amplifier. Finally, dipole emission in photonic crystal membrane waveguides is analyzed, where we design slow and fast light waveguides for enhanced single-photon emission into a guided mode. We investigate spectra and spatial maps of dipole emission and find that the relative coupling into the guided mode, β, remains in excess of 50%, even in non-optimum situations, and quickly approaches unity towards the band edge. Preliminary experimental results that build on the theoretical designs demonstrate emission from position-controlled quantum dots into the waveguide mode. In a disjoint chapter, we study the localized surface plasmon modes of plasmonic nanodimers, and both theoretically and experimentally, we find an almost-inverse scaling of the relative shift of the plasmon wavelength with particle distance in the sub-radius range.
Nonreciprocal transmission in a nonlinear photonic-crystal Fano structure with broken symmetry

Nanostructures that feature nonreciprocal light transmission are highly desirable building blocks for realizing photonic integrated circuits. Here, a simple and ultracompact photonic-crystal structure, where a waveguide is coupled to a single nanocavity, is proposed and experimentally demonstrated, showing very efficient optical diode functionality. The key novelty of the structure is the use of cavity-enhanced material nonlinearities in combination with spatial symmetry breaking and a Fano resonance to realize nonreciprocal propagation effects at ultralow power and with good wavelength tunability. The nonlinearity of the device relies on ultrafast carrier dynamics, rather than the thermal effects usually considered, allowing the demonstration of nonreciprocal operation at a bit-rate of 10 Gbit s$^{-1}$ with a low energy consumption of 4.5 fJ bit$^{-1}$. 
Observation of resonance fluorescence and the Mollow triplet from a coherently driven site-controlled quantum dot

Resonant excitation of solid state quantum emitters has the potential to deterministically excite a localized exciton while ensuring a maximally coherent emission. In this work, we demonstrate the coherent coupling of an exciton localized in a lithographically positioned, site-controlled semiconductor quantum dot to an external resonant laser field. For strong continuous-wave driving we observe the characteristic Mollow triplet and analyze the Rabi splitting and sideband widths as a function of driving strength and temperature. The sideband widths increase linearly with temperature and the square of the driving strength, which we explain via coupling of the exciton to longitudinal acoustic phonons. We also find an increase of the Rabi splitting with temperature, which indicates a temperature induced delocalization of the excitonic wave function resulting in an increase of the oscillator strength. Finally, we demonstrate coherent control of the exciton excited state population via pulsed resonant excitation and observe a damping of the Rabi oscillations with increasing pulse area, which is consistent with our exciton-photon coupling model. We believe that our work outlines the possibility to implement fully scalable platforms of solid state quantum emitters. The latter is one of the key prerequisites for more advanced, integrated nanophotonic quantum circuits.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology, Universität Würzburg, Technische Universität Berlin
Contributors: Unsleber, S., Maier, S., McCutcheon, D., He, Y., Dambach, M., Gschrey, M., Gregersen, N., Mørk, J., Reitzenstein, S., Höfling, S., Schneider, C., Kamp, M.
Pages: 1072-1077
Publication date: 2015
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Publication information
Journal: Optica
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Issue number: 12
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Scopus rating (2017): CiteScore 9.05
Web of Science (2017): Impact factor 7.536
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 8.05
Scattering of two photons on a quantum emitter in a one-dimensional waveguide: exact dynamics and induced correlations

We develop a wavefunction approach to describe the scattering of two photons on a quantum emitter embedded in a one-dimensional waveguide. Our method allows us to calculate the exact dynamics of the complete system at all times, as well as the transmission properties of the emitter. We show that the nonlinearity of the emitter with respect to incoming photons depends strongly on the emitter excitation and the spectral shape of the incoming pulses, resulting in transmission of the photons which depends crucially on their separation and width. In addition, for counter-propagating pulses, we analyze the induced level of quantum correlations in the scattered state, and we show that the emitter behaves as a nonlinear beamsplitter when the spectral width of the photon pulses is similar to the emitter decay rate.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nysteen, A., Kristensen, P. T., McCutcheon, D., Nielsen, P. K., Mørk, J.
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: New Journal of Physics
Volume: 17
Issue number: 2
Article number: 023030
ISSN (Print): 1367-2630
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.28 SJR 1.653 SNIP 1.102
Web of Science (2017): Impact factor 3.579
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.97 SJR 2.183 SNIP 1.173
Web of Science (2016): Impact factor 3.786
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.8 SJR 2.33 SNIP 1.157
Web of Science (2015): Impact factor 3.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.89 SJR 2.917 SNIP 1.335
Web of Science (2014): Impact factor 3.558
Web of Science (2014): Indexed yes
Semi-analytical quasi-normal mode theory for the local density of states in coupled photonic crystal cavity-waveguide structures
We present and validate a semi-analytical quasi-normal mode (QNM) theory for the local density of states (LDOS) in coupled photonic crystal (PhC) cavity-waveguide structures. By means of an expansion of the Green's function on one or a few QNMs, a closed-form expression for the LDOS is obtained, and for two types of two-dimensional PhCs, with one and two cavities side-coupled to an extended waveguide, the theory is validated against numerically exact computations. For the single cavity, a slightly asymmetric spectrum is found, which the QNM theory reproduces, and for two cavities a non-trivial spectrum with a peak and a dip is found, which is reproduced only when including both the two relevant QNMs in the theory. In both cases, we find relative errors below 1% in the bandwidth of interest.

**General information**

State: Published
Organisations: Office for Research and Relations, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology, Humboldt University of Berlin
Contributors: de Lasson, J. R., Kristensen, P. T., Mørk, J., Gregersen, N.
Pages: 5790-5793
Publication date: 2015
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**Publication information**

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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.95 SJR 2.441 SNIP 2.058
Web of Science (2013): Impact factor 3.179
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.52 SJR 2.577 SNIP 1.92
Web of Science (2012): Impact factor 3.385
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.69 SJR 2.519 SNIP 2.453
Web of Science (2011): Impact factor 3.399
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.637 SNIP 2.263
In this paper, we present a systematic investigation of photonic crystal cavity laser operating in the slow-light regime. The dependence of lasing threshold on the effect of slow-light will be particularly highlighted.

**General information**

State: Published  
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices, Department of Micro- and Nanotechnology  
Contributors: Xue, W., Yu, Y., Ottaviano, L., Semenova, E., Yvind, K., Mørk, J.  
Number of pages: 3  
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Publication date: 2015

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Publisher: IEEE  
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DOIs: 10.1109/OECC.2015.7340132  
Source: FindIt  
Source-ID: 276911118  
Research output: Research - peer-review › Article in proceedings – Annual report year: 2015
Strong nonlinearity-induced correlations for counterpropagating photons scattering on a two-level emitter

We analytically treat the scattering of two counterpropagating photons on a two-level emitter embedded in an optical waveguide. We find that the nonlinearity of the emitter can give rise to significant pulse-dependent directional correlations in the scattered photonic state, which could be quantified via a reduction in coincidence clicks in a Hong–Ou–Mandel measurement setup, analogous to a linear beam splitter. Changes to the spectra and phase of the scattered photons, however, would lead to reduced interference with other photons when implemented in a larger optical circuit. We introduce suitable fidelity measures which account for these changes and find that high values can still be achieved even when accounting for all properties of the scattered photonic state.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nysteen, A., McCutcheon, D., Mørk, J.
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ISSN (Print): 2469-9926
Ratings:
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.46 SJR 1.288 SNIP 0.886
Web of Science (2017): Impact factor 2.909
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 2.25 SJR 1.482 SNIP 0.985
Web of Science (2016): Impact factor 2.925
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 2.06 SJR 1.747 SNIP 1.008
Web of Science (2015): Impact factor 2.765
Web of Science (2015): Indexed yes
Scopus rating (2014): CiteScore 2.46 SJR 2.201 SNIP 1.163
Web of Science (2014): Indexed yes
Scopus rating (2013): CiteScore 2.86 SJR 2.305 SNIP 1.166
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): CiteScore 2.81 SJR 2.519 SNIP 1.231
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): CiteScore 2.79 SJR 2.316 SNIP 1.252
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 2.4 SJR 2.111
Web of Science (2010): Indexed yes
Scopus rating (2009): SJR 2.469 SNIP 1.346
Web of Science (2009): Indexed yes
Scopus rating (2008): SJR 2.536 SNIP 1.231
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.524 SNIP 1.203
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.834 SNIP 0.968
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.394 SNIP 0.806
Web of Science (2005): Indexed yes
Thermal analysis of line-defect photonic crystal lasers

We report a systematic study of thermal effects in photonic crystal membrane lasers based on line-defect cavities. Two material platforms, InGaAsP and InP, are investigated experimentally and numerically. Lasers with quantum dot layers embedded in an InP membrane exhibit lasing at room temperature under CW optical pumping, whereas InGaAsP membranes only lase under pulsed conditions. By varying the duty cycle of the pump beam, we quantify the heating induced by optical pumping in the two material platforms and compare their thermal properties. Full 3D finite element simulations show the spatial temperature profile and are in good agreement with the experimental results concerning the thermal tolerance of the two platforms.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Xue, W., Ottaviano, L., Chen, Y., Semenova, E., Yu, Y., Lupi, A., Mørk, J., Yvind, K.
Pages: 18277-18287
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 23
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ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
Two-photon interference from a quantum dot-microcavity: Persistent pure-dephasing and suppression of time-jitter

We demonstrate the emission of highly indistinguishable photons from a quasi-resonantly pumped coupled quantum dot–microcavity system operating in the regime of cavity quantum electrodynamics. Changing the sample temperature allows us to vary the quantum dot–cavity detuning and, on spectral resonance, we observe a threefold improvement in the Hong-Ou-Mandel interference visibility, reaching values in excess of 80%. Our measurements off-resonance allow us to investigate varying Purcell enhancements, and to probe the dephasing environment at different temperatures and energy scales. By comparison with our microscopic model, we are able to identify pure dephasing and not time jitter as the dominating source of imperfections in our system.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Würzburg
Contributors: Unsleber, S., McCutcheon, D., Dambach, M., Lermer, M., Gregersen, N., Hofling, S., Mørk, J., Schneider, C., Kamp, M.
Number of pages: 8
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Journal: Physical Review B Condensed Matter
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ISSN (Print): 0163-1829
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Impact factor 3.813
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Impact factor 3.836
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 2.8 SJR 2.377 SNIP 1.13
Web of Science (2015): Impact factor 3.718
Web of Science (2015): Indexed yes
Scopus rating (2014): CiteScore 3.3 SJR 2.762 SNIP 1.316
Web of Science (2014): Impact factor 3.736
Web of Science (2014): Indexed yes
Scopus rating (2013): CiteScore 3.55 SJR 2.813 SNIP 1.326
Web of Science (2013): Impact factor 3.664
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): CiteScore 3.57 SJR 3.173 SNIP 1.378
Web of Science (2012): Impact factor 3.767
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): CiteScore 3.61 SJR 3.326 SNIP 1.423
Web of Science (2011): Impact factor 3.691
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 3.318 SNIP 1.447
Web of Science (2010): Impact factor 3.774
Web of Science (2010): Indexed yes
We numerically investigate the properties of a hybrid grating structure acting as a resonator with ultrahigh quality factor. This reveals that the physical mechanism responsible for the resonance is quite different from the conventional guided mode resonance (GMR). The hybrid grating consists of a subwavelength grating layer and an un-patterned high-refractive-index cap layer, being surrounded by low index materials. Since the cap layer may include a gain region, an ultracompact laser can be realized based on the hybrid grating resonator, featuring many advantages over high-contrast-grating resonator lasers. The effect of fabrication errors and finite size of the structure is investigated to understand the feasibility of fabricating the proposed resonator.

**General information**

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Taghizadeh, A., Merk, J., Chung, I.
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ISSN (Print): 1094-4087
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
Ultrafast all-optical modulation using a photonic-crystal Fano structure with broken symmetry

We experimentally demonstrate ultrafast all-optical modulation using an ultracompact InP photonic-crystal Fano structure. In contrast to symmetric configurations previously considered, the use of a structure with broken symmetry in combination with a well-engineered Fano resonance is shown to suppress patterning effects as well as lower the energy consumption. These properties enable the achievement of error-free 10 Gbit/s modulation with low pump energy using realistic pseudorandom binary sequence patterns. At 20 Gbit/s, the bit error ratio remains well below the limit for forward error correction.
Ultrafast low-energy all-optical switching using a photonic-crystal asymmetric Fano structure
We experimentally demonstrate 20 Gbit/s all-optical switching with low-energy consumption using a simple and ultra-compact InP photonic-crystal structure by employing a well-engineered Fano resonance in combination with broken mirror symmetry.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Department of Micro- and Nanotechnology, Nanophotonic Devices
Contributors: Yu, Y., Hu, H., Oxenløwe, L. K., Yvind, K., Mørk, J.
Pages: 94-96
Publication date: 2015

Host publication information
Title of host publication: Proceedings of 2015 International Conference on Photonics in Switching
Vertical-Cavity In-plane Heterostructures: Physics and Applications

We show that the in-plane heterostructures realized in vertical cavities with high contrast grating (HCG) reflector enables exotic configurations of heterostructure and photonic wells. In photonic crystal heterostructures forming a photonic well, the property of a confined mode is determined by the well width and barrier height. We show that in vertical-cavity in-plane heterostructures, anisotropic dispersion curvatures plays a key role as well, leading to exotic effects such as a photonic well with conduction band like well and a valence band like barrier. We investigate three examples to discuss the rich potential of this heterostructure as a platform for various physics studies and propose a system of two laterally coupled cavities which shows the breaking of parity-time symmetry as an example.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology
Contributors: Taghizadeh, A., Mørk, J., Chung, I.
Number of pages: 5
Publication date: 2015
Peer-reviewed: Yes

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Volume: 107
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Article number: 181107
ISSN (Print): 0003-6951
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
We have reported that a combination of the high-index-contrast grating (HCG) mirror as movable mirror and the extended cavity configuration with an antireflection layer can provide a tuning wavelength range of 100 nm for tunable VCSELs. Here, we report that using the air-coupled cavity configuration instead of the extended cavity configuration can bring 130-nm tuning range around 1330-nm wavelength. The air-coupled cavity is known to reduce the quantum confinement factor in VCSELs, increasing threshold. In our air-coupled cavity HCG VCSEL case, the very short power penetration length in the HCG minimizes this reduction of the quantum confinement factor, not as significant as in the air-coupled cavity DBR VCSEL.
A Bloch modal approach for engineering waveguide and cavity modes in two-dimensional photonic crystals

In open nanophotonic structures, the natural modes are so-called quasi-normal modes satisfying an outgoing wave boundary condition. We present a new scheme based on a modal expansion technique, a scattering matrix approach and Bloch modes of periodic structures for determining these quasi-normal modes. As opposed to spatial discretization methods like the finite-difference time-domain method and the finite element method, the present approach satisfies automatically the outgoing wave boundary condition in the propagation direction which represents a significant advantage of our new method. The scheme uses no external excitation and determines the quasi-normal modes as unity eigenvalues of the cavity roundtrip matrix. We demonstrate the method and the quasi-normal modes for two types of two-dimensional photonic crystal structures, and discuss the quasi-normal mode field distributions and Q-factors in relation to the transmission spectra of these structures.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: de Lasson, J. R., Kristensen, P. T., Mørk, J., Gregersen, N.
Number of pages: 6
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DOIs: doi:10.1117/12.2051885
Research output: Research - peer-review › Article in proceedings – Annual report year: 2014

A Bloch mode expansion approach for analyzing quasi-normal modes in open nanophotonic structures

We present a new method for determining quasi-normal modes in open nanophotonic structures using a modal expansion technique. The outgoing wave boundary condition of the quasi-normal modes is satisfied automatically without absorbing boundaries, representing a significant advantage compared to conventional techniques. The quasi-normal modes are determined by constructing a cavity roundtrip matrix and iterating the complex mode wavelength towards a unity eigenvalue. We demonstrate the method by determining quasi-normal modes of cavities in two-dimensional photonic crystals side-coupled to W1 waveguides.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: de Lasson, J. R., Kristensen, P. T., Mørk, J., Gregersen, N.
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Publication date: 2014

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Title of host publication: Proceedings of META 2014
Source: PublicationPreSubmission
Source-ID: 98594714
Research output: Research - peer-review › Article in proceedings – Annual report year: 2014

All-optical signal processing using InP photonic-crystal nanocavity switches

In this paper, we present recent progress in experimental characterization of InP photonic-crystal nanocavity switches. Pump-probe measurements on an InP PhC H0 cavity show large-contrast ultrafast switching at low pulse energy. At large pulse energies, a large resonance shift passing across the probe leads to pulse broadening. In addition, high-frequency carrier density oscillations can be induced, leading to pulse splitting. Excellent agreements between simulations and experiments are obtained when employing a carrier rate equation model containing three relaxation times, accounting for the joint effects of fast carrier diffusion, slow surface and bulk recombination. Utilizing the simple InP PhC nanocavity structure, we successfully demonstrate 10-Gb/s RZ-OOK all-optical modulation with low energy consumption.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices
Contributors: Yu, Y., Vukovic, D., Heuck, M., Peucheret, C., Oxenløwe, L. K., Yvind, K., Mørk, J.
Number of pages: 4
Publication date: 2014
Application of Nanophotonic Devices in High Speed Optical Communications

All-optical signal processing has attracted a significant research interest in the past decade as it might become competitive with electronics in terms of compactness, energy consumption, and reliability. Furthermore it might solve the current bandwidth mismatch between optical transmission and electronic components in the physical layer and maintain high data rates, transparency and efficiency in optical networks. The remarkable advance, maturity, and cost reduction of optical components has therefore intensified research for the realization and exploitation of all-optical signal processing techniques and their applications.

In this thesis, a number of different all-optical signal processing functionalities have been experimentally investigated taking the advantage of silicon and III-V semiconductor photonic devices. Wavelength converters may find a variety of applications in future highcapacity fiber-optic transmission systems including switching nodes, crossconnectors and add-drop multiplexers. One of the expected key advantages of wavelength converters based on four-wave mixing in nonlinear media exhibiting third-order nonlinearities is the possibility for modulation format and bit-rate independent operation, enabling transparent networking. To confirm this, wavelength conversion of high speed WDM polarizationmultiplexed QPSK signals has been demonstrated using a polarization diversity circuit fully integrated on a silicon platform.

Data signals in a transmission system are suffering from linear and nonlinear impairments, which accumulate along the link and limit the reach of the system. These impairments need to be compensated. Since four-wave mixing provides phase conjugation of the converted signal, dispersion and nonlinearity distortion accumulated during transmission can be compensated using wavelength converters often placed in the middle of the link. This has been confirmed by demonstrating distortion mitigation using a silicon waveguide as optical phase conjugator.

The availability of a fast, compact and low energy all-optical switch should help the development of on-chip photonic networks. In this thesis, the use of a indium phosphide (InP) photonic crystal nanocavity to perform optical switching that is compatible with telecommunication signals has been demonstrated. Cavity switching induced by free carrier generation was achieved in the GHz range with very low energy consumption.

Bright single photon source based on self-aligned quantum dot–cavity systems

We report on a quasi-planar quantum-dot-based single-photon source that shows an unprecedented high extraction efficiency of 42% without complex photonic resonator geometries or post-growth nanofabrication. This very high efficiency originates from the coupling of the photons emitted by a quantum dot to a Gaussian shaped nanohill defect that naturally arises during epitaxial growth in a self-aligned manner. We investigate the morphology of these defects and characterize the photonic operation mechanism. Our results show that these naturally arising coupled quantum dot-defects provide a new avenue for efficient (up to 42% demonstrated) and pure (g^2(0) value of 0.023) single-photon emission.
Comparison of Different Numerical Methods for Quality Factor Calculation of Nano and Micro Photonic Cavities

Four different numerical methods for calculating the quality factor and resonance wavelength of a nano or micro photonic cavity are compared. Good agreement was found for a wide range of quality factors. Advantages and limitations of the different methods are discussed.

Decoherence in semiconductor cavity QED systems due to phonon couplings

We investigate the effect of electron-phonon interactions on the coherence properties of single photons emitted from a semiconductor cavity QED (quantum electrodynamics) system, i.e., a quantum dot embedded in an optical cavity. The degree of indistinguishability, governing the quantum mechanical interference between two single photons, is calculated as a function of important parameters describing the cavity QED system and the phonon reservoir, e.g., cavity quality factor, light-matter coupling strength, temperature, and phonon lifetime. We show that non-Markovian effects play an important role in determining the coherence properties for typical parameter values and establish the conditions under which a Markovian approximation may be applied. The calculations are performed using a recently developed second-order perturbation theory, and the limits of validity are established by comparing to an exact diagonalization approach. We
find that for large cavity decay rates the perturbation theory may break down.
Dual resonance approach to optical signal processing beyond the carrier relaxation rate

We propose using two optical cavities in a differential control scheme to increase the bandwidth of cavity-based semiconductor optical signal processing devices beyond the limit given by the slowest carrier relaxation rate of the medium.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Heuck, M., Kristensen, P. T., Mørk, J.
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Source: FindIt
Source-ID: 269618076
Research output: Research - peer-review ➤ Journal article – Annual report year: 2014

Dual-resonances approach to broadband cavity-assisted optical signal processing beyond the carrier relaxation rate

We propose and analyze a differential control scheme for cavity-enhanced optical signal processing devices based on carrier nonlinearities. The scheme relies on two optical cavities to increase the bandwidth beyond the limit given by the slowest carrier relaxation rate of the medium. Practical implementations are envisioned using photonic crystal cavities, and the controls may be electrical or optical in nature. (C) 2014 Optical Society of America

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Heuck, M., Kristensen, P. T., Mørk, J.
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Publication date: 2014
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Publication information
Journal: Optics Letters
Fano resonance control in a photonic crystal structure and its application to ultrafast switching

We experimentally demonstrate a photonic crystal structure that allows easy and robust control of the Fano spectrum. Its operation relies on controlling the amplitude of light propagating along one of the light paths in the structure from which the Fano resonance is obtained. Short-pulse dynamic measurements show that besides drastically increasing the switching contrast, the transmission dynamics itself is strongly affected by the nature of the resonance. The influence of slow-recovery tails implied by a long carrier lifetime can thus be reduced using a Fano resonance due to a hitherto unrecognized reshaping effect of the nonlinear Fano transfer function. As an example, we present a system application of a Fano structure, demonstrating its advantages by the experimental realization of 10 Gbit/s all-optical modulation with optical control power less than 1mW.

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Far-off-resonant coupling between a semiconductor quantum dot and an optical cavity
We present an investigation of the far-off-resonant coupling between a semiconductor quantum dot and a cavity. We show that the enhanced coupling observed in experiments is explained by Coulomb interactions with wetting layer carriers. © 2014 Optical Society of America.

Hybrid grating reflector with high reflectivity and broad bandwidth
We suggest a new type of grating reflector denoted hybrid grating (HG) which shows large reflectivity in a broad wavelength range and has a structure suitable for realizing a vertical cavity laser with ultra-small modal volume. The properties of the grating reflector are investigated numerically and explained. The HG consists of an un-patterned III-V layer and a Si grating. The III-V layer has a thickness comparable to the grating layer, introduces more guided mode resonances and significantly increases the bandwidth of the reflector compared to the well-known high-index-contrast grating (HCG). By using an active III-V layer, a laser can be realized where the gain region is integrated into the mirror itself.
Indistinguishable photons from a quantum dot–cavity system: competing roles of timing-jitter and pure-dephasing

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Würzburg
Contributors: McCutcheon, D., Gregersen, N., Mørk, J., Unsleben, S., Dambach, M., Lermer, M., Höfling, S., Schneider, C., Kamp, M.
Publication date: 2014
Peer-reviewed: Yes
Event: Poster session presented at International Conference on Nonlinear Optics and Excitation Kinetics in Semiconductors, Bremen, Germany.
Source: PublicationPreSubmission
Source-ID: 100889514
Research output: Research - peer-review › Poster – Annual report year: 2014

Indistinguishable single photons generated by quantum dots in adiabatic micropillar cavities

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Würzburg
Contributors: Unsleber, S., McCutcheon, D., Dambach, M., Lermer, M., Gregersen, N., Höfling, S., Mørk, J., Schneider, C., Kamp, M.
Publication date: 2014
Peer-reviewed: Yes
Event: Poster session presented at International Conference on Nonlinear Optics and Excitation Kinetics in Semiconductors, Bremen, Germany.
Source: PublicationPreSubmission
Source-ID: 100889504
Research output: Research - peer-review › Poster – Annual report year: 2014

Low-power 10 Gbit/s RZ-OOK all-optical modulation using a novel photonic-crystal Fano switch
We demonstrate a novel photonic-crystal nanocavity switch based on a Fano resonance. Compared to conventional structures with Lorentzian lineshape, the Fano resonance reduces the switching energy and suppresses patterning effects, allowing experimental demonstration of 10 Gbit/s RZ-OOK all-optical modulation with input powers less than 1 mW.

General information
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DOIs: 10.1109/ECOC.2014.6963997
Source: FindIt
Source-ID: 272843829
Research output: Research - peer-review › Article in proceedings – Annual report year: 2014

Noise Spectrum of a Semiconductor Optical Amplifier Excited by a Modulated Signal
A detailed analysis of the noise spectrum of a semiconductor optical amplifier excited by an amplitude-modulated input signal is presented. This extends the well-established theory for the case of continuous-wave input signals and is relevant
for various applications within optical signal processing. One important example is the analysis of noise in microwave photonic elements based on slow-light propagation in semiconductor optical amplifiers. Expressions for the noise spectra are derived and the dependence on important operation parameters, such as input power, modulation depth, and modulation frequency, is investigated and explained. We find several interesting modifications to the spectra compared with the continuous-wave case. In particular, the side-bands present in the input-signal lead via four-wave mixing effects to additional structure in the spectra as well as additional noise components.

**General information**

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Norsk Elektro Optikk
Contributors: Blaaberg, S., Mørk, J.
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.19 SJR 1.37 SNIP 1.57
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.372 SNIP 1.687
Web of Science (2010): Impact factor 2.48
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.801 SNIP 1.979
Web of Science (2009): Indexed yes
Nonlinear switching dynamics in a photonic-crystal nanocavity

We report the experimental observation of nonlinear switching dynamics in an InP photonic crystal nanocavity. Usually, the regime of relatively small cavity perturbations is explored, where the signal transmitted through the cavity follows the temporal variation of the cavity resonance. When the cavity is perturbed by strong pulses, we observe several nonlinear effects, i.e., saturation of the switching contrast, broadening of the switching window, and even initial reduction of the transmission. The effects are analyzed by comparison with nonlinear coupled mode theory and explained in terms of large dynamical variations of the cavity resonance in combination with nonlinear losses. The results provide insight into the nonlinear optical processes that govern the dynamics of nanocavities and are important for applications in optical signal processing, where one wants to optimize the switching contrast.

General information

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, High-Speed Optical Communication, Nanophotonic Devices
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Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.018 SNIP 2.414
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 4.281 SNIP 2.22
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 4.178 SNIP 2.017
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 4.173 SNIP 2.066
Original language: English
Photonic Crystal Fano Laser: Terahertz Modulation and Ultrashort Pulse Generation
We suggest and analyze a laser with a mirror realized by Fano interference between a waveguide and a nanocavity. For small-amplitude modulation of the nanocavity resonance, the laser can be modulated at frequencies exceeding 1 THz, not being limited by carrier dynamics as for conventional lasers. For larger modulation, a transition from pure frequency modulation to the generation of ultrashort pulses is observed. The laser dynamics is analyzed by generalizing the field equation for conventional lasers to account for a dynamical mirror, described by coupled mode theory.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Mørk, J., Chen, Y., Heuck, M.
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Journal: Physical Review Letters
Volume: 113
Issue number: 16
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464
Web of Science (2017): Impact factor 8.839
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.33 SJR 4.196 SNIP 2.61
Web of Science (2016): Impact factor 8.462
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.76 SJR 4.656 SNIP 2.538
Web of Science (2015): Impact factor 7.645
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.62 SJR 5.232 SNIP 2.71
Web of Science (2014): Impact factor 7.512
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 7.46 SJR 5.675 SNIP 2.781
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 7.19 SJR 6.292 SNIP 2.867
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 7.02 SJR 6.314 SNIP 2.905
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Photonic Crystal Nanocavity Devices for Nonlinear Signal Processing

This thesis deals with the investigation of InP material based photonic crystal cavity membrane structures, both experimentally and theoretically. The work emphasizes on the understanding of the physics underlying the structures’ nonlinear properties and their applications for all-optical signal processing.

Based on the previous fabrication recipe developed in our III-V platform, several processing techniques are developed and optimized for the fabrication of InP photonic crystal membrane structures. Several key issues are identified to ensure a good device quality such as air hole size control, membranization of InP/InGaAs structure and wet etching.

Experimental investigation of the switching dynamics of InP photonic crystal nanocavity structures are carried out using short-pulse homodyne pump-probe techniques, both in the linear and nonlinear region where the cavity is perturbed by a relatively small and large pump power. The experimental results are compared with coupled mode equations developed based on the first order perturbation theory, and carrier rate equations we established for the dynamics of the carrier density governing the cavity properties. The experimental observations show a good consistency with the numerical simulations. The results provide insight into the nonlinear optical processes that govern the dynamics of nanocavities and are important for applications in optical signal processing. As a step forward, the components are further applied for system characterizations, demonstrating their ability for fast all-optical modulation with low energy consumption.

Another effort of this thesis is the theoretical design of the photonic crystal structures, such as mode adaptors for efficient in/out coupling, a four-port photonic crystal structure which allows two signals to excite different, yet spatially overlapping, resonances and are spatially separated at the output. This structure reduces the complexity of the system that usually includes band pass filters in order to distinguish the signals at the output. Finally, we may need to mention an important design: a simple and ultracompact photonic crystal structure consisting of a single cavity coupled with a waveguide, which allows very robust control of the transmission line shape. Lorentzian and Fano line shapes can be realized by varying the size of a single air-hole. Additional control of the parity of the Fano shape can be obtained by breaking the mirror symmetry of the structure. The turningpoint characteristic of Fano structures is experimentally demonstrated to allow the suppression of slow transmission dynamics, enabling us to achieve fast (20 Gbit/s) all-optical modulation with low energy consumption. Relying on spatial symmetry breaking and carrier nonlinearity, the Fano structure allows the demonstration...
of an enhanced nonreciprocal transmission with ultra-low power consumption and good wavelength tunability.

**Random nanolasering in the Anderson localized regime**

The development of nanoscale optical devices for classical and quantum photonics is affected by unavoidable fabrication imperfections that often impose performance limitations. However, disorder may also enable new functionalities, for example in random lasers, where lasing relies on random multiple scattering. The applicability of random lasers has been limited due to multidirectional emission, lack of tunability, and strong mode competition with chaotic fluctuations due to a weak mode confinement. The regime of Anderson localization of light has been proposed for obtaining stable multimode random lasing, and initial work concerned macroscopic one-dimensional layered media. Here, we demonstrate on-chip random nanolasers where the cavity feedback is provided by the intrinsic disorder. The strong confinement achieved by Anderson localization reduces the spatial overlap between lasing modes, thus preventing mode competition and improving stability. This enables highly efficient, stable and broadband wavelength-controlled lasers with very small mode volumes. Furthermore, the complex interplay between gain, dispersion-controlled slow light, and disorder is demonstrated experimentally for a non-conservative random medium. The statistical analysis shows a way towards optimizing random-lasing performance by reducing the localization length, a universal parameter.
Roundtrip matrix method for calculating the leaky resonant modes of open nanophotonic structures

We present a numerical method for calculating quasi-normal modes of open nanophotonic structures. The method is based on scattering matrices and a unity eigenvalue of the roundtrip matrix of an internal cavity, and we develop it in detail with electromagnetic fields expanded on Bloch modes of periodic structures. This procedure is simpler to implement numerically and more intuitive than previous scattering matrix methods, and any routine based on scattering matrices can benefit from the method. We demonstrate the calculation of quasi-normal modes for two-dimensional photonic crystals where cavities are side-coupled and in-line-coupled to an infinite W1 waveguide and show that the scattering spectrum of these types of cavities can be reconstructed from the complex quasi-normal mode frequency.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: de Lasson, J. R., Kristensen, P. T., Mørk, J., Gregersen, N.
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Journal: Journal of the Optical Society of America A
Volume: 31
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ISSN (Print): 0740-3232
Ratings:
Saturation broadening effect in an InP photonic-crystal nanocavity switch

Pump-probe measurements on InP photonic-crystal nanocavities show large-contrast fast switching at low pulse energy. For large pulse energies, large resonance shifts passing across the probe lead to switching contrast saturation and switching time-window broadening. © 2014 OSA.
Temporal dynamics of all-optical switching in Photonic Crystal Cavity
The temporal dynamics of all-optical switching has been investigated in a Photonic Crystal Cavity with a 150fs-40aJ/pulse resolution. This allowed observing for the first time effects like pulse reshaping, pulse delay and intra-cavity Four-Wave-Mixing.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Colman, P., Heuck, M., Yu, Y., Yvind, K., Hansen, P. L., Mørk, J.
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Publisher: IEEE
Source: PublicationPreSubmission
Source-ID: 96698224
Research output: Research - peer-review » Article in proceedings – Annual report year: 2014

The photonic nanowire: An emerging platform for a highly efficient quantum light source
The single-photon source capable of emitting single indistinguishable photons on demand represents a key component in quantum information applications. The photonic nanowire represents an attractive platform to construct a source with near-unity efficiency

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, French Alternative Energies and Atomic Energy Commission
Contributors: Gregersen, N., Claudon, J., Munsch, M., Bleuse, J., Delga, A., Mørk, J., Gerard, J. M.
Publication date: 2014
Peer-reviewed: Yes
Event: Abstract from 35th Progress In Electromagnetics Research Symposium , Guangzhou (Canton), China.
Two-photon interference from a quantum dot-microcavity: Persistent pure-dephasing and suppression of time-jitter

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, University of Würzburg
Contributors: Unsleber, S., McCutcheon, D., Dambach, M., Lermer, M., Gregersen, N., Hofling, S., Mørk, J., Schneider, C., Kamp, M.
Publication date: 2014
Peer-reviewed: Yes
Event: Abstract from 2nd international workshop on engineering of quantum emitter properties, Innsbruck, Austria.
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Source-ID: 103224168
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2014

Wavelength Conversion of a 9.35-Gb/s RZ OOK Signal in an InP Photonic Crystal Nanocavity

Wavelength conversion of a 10-Gb/s (9.35 Gb/s net rate) return-to-zero ON-OFF keying signal is demonstrated using a simple InP photonic crystal H0 nanocavity with Lorentzian line shape. The shifting of the resonance induced by the generation of free-carriers enables the pump intensity modulation to be transferred to a continuous-wave probe with a sufficiently high quality so that the converted signal can be detected with a conventional telecommunication receiver. A clear eye diagram is observed for the converted signal showing a pre-forward error correction bit-error-ratio down to $10^{-3}$.

General information
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Organisations: Department of Photonics Engineering, High-Speed Optical Communication, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
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Journal: IEEE Photonics Technology Letters
Volume: 26
Issue number: 3
ISSN (Print): 1041-1135
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.457 SNIP 1.678
Web of Science (2010): Impact factor 1.989
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.721 SNIP 1.913
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.975 SNIP 1.864
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.224 SNIP 1.678
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.012 SNIP 1.869
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.882 SNIP 2.411
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.092 SNIP 2.689
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.17 SNIP 2.436
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.97 SNIP 2.1
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.43 SNIP 1.656
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.636 SNIP 1.199
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.564 SNIP 1.279
Original language: English
Keywords: Cavity resonators, Nanophotonics, Optical switches, Photonic crystals
DOIs:
10.1109/LPT.2013.2291965
Source: dtu
Source-ID: u::9716
Research output: Research - peer-review › Journal article – Annual report year: 2014
All-Optical Switching in Photonic Crystal Cavities
All-optical switching in photonic crystal waveguide-cavity structures is studied predominantly theoretically and numerically, but also from an experimental point of view.

We have calculated the first order perturbations to the resonance frequency and decay rate of cavity modes, using a mathematical framework that correctly takes into account the leaky nature of these modes. This represents the foundation for including nonlinearities into the temporal coupled mode theory, which is widely used to model the cavity-waveguide dynamics.

In the experimental part of the thesis, we have considered both homodyne and heterodyne measurements of the cavity dynamics, as well as a comparison with the model developed from the perturbation theory mentioned above. The model was seen to provide a qualitative agreement with the experiments indicating that the relevant physical mechanisms are accounted for by the model.

A considerable effort has been put into designing advanced structures with increased flexibility and the ability to avoid some of the difficulties in terms of experimental investigations mentioned above. This has resulted in e.g. the four port device, where the signal and pump are spatially separated. This device was fabricated and characterized by colleagues within the group, and it was shown to perform very well in terms of cross-talk between the signal and pump.

Theoretical investigations as well as practical design proposals have resulted from a study of waveguide-cavity structures exhibiting Fano resonances. These devices were predicted to be superior to structures with the more well-known Lorentzian line shape in terms of energy consumption and switching contrast.

Finally, the mathematical framework of optimal control theory was employed as a general setting, in which the optical properties of the input fields may be tailored to optimize various objectives, such as the cavity energy. A particular example showed how to adjust the amplitude and phase of the pump field to maximize the cavity energy in a given time interval. The results also revealed how to extract the cavity energy faster than the photon lifetime by utilizing interference effects.

A comparison between experiment and theory on few-quantum-dot nanolasing in a photonic-crystal cavity
We present an experimental and theoretical study on the gain mechanism in a photonic-crystal-cavity nanolaser with embedded quantum dots. From time-resolved measurements at low excitation power we find that four excitons are coupled to the cavity. At high excitation power we observe a smooth low-threshold transition from spontaneous emission to lasing. Before lasing emission sets in, however, the excitons are observed to saturate, and the gain required for lasing originates rather from multi-excitonic transitions, which give rise to a broad emission background. We compare the experiment to a model of quantum-dot microcavity lasers and find that the number of excitons that must be included to fit the data largely exceeds the measured number, which shows that transitions involving the wetting layer can provide a surprisingly large contribution to the gain.
Active Photonic Crystal Switches: Modeling, Design and Experimental Characterization

In this paper, we present recent progress in modeling, design, fabrication and experimental characterization of InP photonic crystal all-optical switches. Novel designs with increased flexibility and performance are presented, and their operation using high speed data signals is analyzed numerically.

All-Optical 9.35 Gb/s Wavelength Conversion in an InP Photonic Crystal Nanocavity

Wavelength conversion of a 9.35 Gb/s RZ signal is demonstrated using an InP photonic crystal H0 nanocavity. A clear eye is observed for the converted signal showing a pre-FEC bit error ratio down to 10-3.
A photonic nanowire trumpet for interfacing a quantum dot and a Gaussian free-space mode

Efficient coupling between a localized quantum emitter and a well defined optical channel represents a powerful route to realize single-photon sources and spin-photon interfaces. The tailored fiber-like photonic nanowire embedding a single quantum dot has recently demonstrated an appealing potential. However, the device requires a delicate, sharp needle-like taper with performance sensitive to minute geometrical details. To overcome this limitation we demonstrate the photonic trumpet, exploiting an opposite tapering strategy. The trumpet features a strongly Gaussian far-field emission. A first implementation of this strategy has lead to an ultra-bright single-photon source with a first-lens external efficiency of 0.75 ± 0.1 and a predicted coupling to a Gaussian beam of 0.61 ± 0.08.
Auger Processes Mediating the Nonresonant Optical Emission from a Semiconductor Quantum Dot Embedded Inside an Optical Cavity

We show that Auger processes involving wetting layer transitions mediate emission from a cavity that is detuned from a quantum dot by even tens of meV. The wetting layer thus acts as a reservoir, which by Coulomb scattering can supply or absorb the energy difference between emitter and cavity. We perform microscopic calculations of the effect treating the wetting layer as a non-Markovian reservoir interacting with the coupled quantum dot-cavity system through Coulomb interactions. Experimentally, cavity feeding has been observed in the asymmetric detuning range of -10 to +45 meV. We show that this asymmetry arises naturally from the quasiequilibrium properties of the wetting layer reservoir. Furthermore, we present numerical calculations of both photoluminescence spectra and photon correlations, demonstrating good qualitative agreement with experiments.

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**Bloch-wave engineered submicron-diameter quantum-dot micropillars for cavity QED experiments**

The semiconductor micropillar is attractive for cavity QED experiments. For strong coupling, the figure of merit is proportional to $Q/\sqrt{V}$, and a design combining a high $Q$ and a low mode volume $V$ is thus desired. However, for the standard submicron diameter design, poor mode matching between the cavity and the DBR Bloch mode limits the $Q$. We present a novel adiabatic design where Bloch-wave engineering is employed to improve the mode matching, allowing the demonstration of a record-high vacuum Rabi splitting of 85 μeV and a $Q$ of 13600 for a 850 nm diameter micropillar.

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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
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Web of Science (2008): Indexed yes
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Web of Science (2007): Indexed yes
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Scopus rating (2005): SJR 0.162 SNIP 0.372
Web of Science (2004): Indexed yes
Coherent Dynamics of Quantum Dots in Photonic-Crystal Cavities

In this thesis we have performed quantum-electrodynamics experiments on quantum dots embedded in photonic-crystal cavities. We perform a quantitative comparison of the decay dynamics and emission spectra of quantum dots embedded in a micropillar cavity and a photonic-crystal cavity. The light-matter interaction in the micropillar cavity is so strong that we measure non-Markovian dynamics of the quantum dot, and we compare to the Jaynes-Cummings model with all parameters independently determined. We find an excellent agreement when comparing the dynamics, but the emission spectra show significant deviations. Similar measurements on a quantum dot in a photonic-crystal cavity saw a Rabi splitting on resonance, while time-resolved measurements prove that the system is in the weak coupling regime.

While tuning the quantum dot through resonance of the high-Q mode we observe a strong and surprisingly broadband Purcell enhancement of the decay rate, which cannot be described by the Jaynes-Cummings model. The broadband Purcell enhancement occurs because the quantum dot emits or absorbs a longitudinal acoustic phonon with the energy corresponding to the detuning between the quantum dot and cavity. We successfully model the decay rates with a microscopic model that allows us to for the first time extract the effective phonon density of states, which we can model with bulk phonons.

Studies on a quantum dot detuned from a low-Q mode of a photonic-crystal cavity show a high collection efficiency at the first lens of (44.3±2.1)%, while emission exhibits a very strong anti-bunching. We demonstrate how the quantum dot can be efficiently and selectively excited through longitudinal optical and acoustic phonon-mediated excitation. Indistinguishability measurements of the emitted photons under these two excitation schemes reveal low dephasing rates of 0.82±0.41µeV and 0.42±0.18µeV respectively.

Dielectric GaAs Antenna Ensuring an Efficient Broadband Coupling between an InAs Quantum Dot and a Gaussian Optical Beam

We introduce the photonic trumpet, a dielectric structure which ensures a nearly perfect coupling between an embedded quantum light source and a Gaussian free-space beam. A photonic trumpet exploits both the broadband spontaneous emission control provided by a single-mode photonic wire and the expansion of this mode within a conical taper. Numerical simulations highlight the performance and robustness of this concept. As a first application in the field of quantum optics, we report the realization of an ultrabright single-photon source. The device, a high aspect ratio GaAs photonic trumpet containing a few InAs quantum dots, demonstrates a first-lens external efficiency of 0.75±0.1 and an external coupling efficiency to a Gaussian beam as high as 0.58±0.08.
Dynamical Properties of Nanolasers Based on Few Discrete Emitters

We investigate the dynamical properties of nanolasers comprising a few two-level emitters coupled to an optical cavity. A set of rate equations is derived, and is shown to agree very well with a solution of the full master equation model. Using a linearized version of these rate equations, we can analytically express the response of the nanolaser to a modulation of the pumping rate. These results are compared with the modulation response obtained directly from the master equation using a novel method. We show that contrary to conventional semiconductor lasers, the nanolaser is typically over-damped and displays a dip in the modulation bandwidth as the two-level systems become inverted. Both these features can be traced back to the use of discrete emitters that are incoherently pumped.
Effect of External Optical Feedback for Nano-laser Structures

We theoretically investigated the effect of optical feedback on a photonic crystal nanolaser, comparing with conventional in-plane and vertical-cavity lasers.

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Contributors: Taghizadeh, A., Mørk, J., Chung, I.
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Contributors: Munsch, M., Malik, N. S., Dupuy, E., Delga, A., Bleuse, J., Gerard, J., Claudon, J., Gregersen, N., Mørk, J.
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Global optimization of silicon nanowires for efficient parametric processes

We present a global optimization of silicon nanowires for parametric single-pump mixing. For the first time, the effect of surface roughness-induced loss is included in the analysis, significantly influencing the optimum waveguide dimensions.

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Contributors: Vukovic, D., Xu, J., Mørk, J., Oxenløwe, L. K., Peucheret, C.
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Heterodyne pump probe measurements of nonlinear dynamics in an indium phosphide photonic crystal cavity

Using a sensitive two-color heterodyne pump-probe technique, we investigate the carrier dynamics of an InP photonic crystal nanocavity. The heterodyne technique provides unambiguous results for all wavelength configurations, including the degenerate case, which cannot be investigated with the widely used homodyne technique. A model based on coupled mode theory including two carrier distributions is introduced to account for the relaxation dynamics, which is assumed to be governed by both diffusion and recombination.

General information
We report on lasing in optically pumped adiabatic micropillar cavities, based on the AlAs/GaAs material system. A detailed study of the threshold pump power and the spontaneous emission $\beta$ factor in the lasing regime for different diameters $d_c$ is presented. We demonstrate a reduction of the threshold pump power by over 2 orders of magnitude from $d_c = 2.25 \, \mu m$ down to 0.95 $\mu m$. Lasing with $\beta$ factors exceeding 0.5 shows that adiabatic micropillars are operating deeply in the cavity quantum electrodynamics regime.

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Highly efficient photonic nanowire single-photon sources for quantum information applications

Within the emerging field of optical quantum information processing, the current challenge is to construct the basic building blocks for the quantum computing and communication systems. A key component is the singlephoton source (SPS) capable of emitting single photons on demand. Ideally, the SPS must feature near-unity efficiency, where the efficiency is defined as the number of detected photons per trigger, the probability $g(2)(\tau=0)$ of multi-photon emission events should be 0 and the emitted photons are required to be indistinguishable.

An optically or electrically triggered quantum light emitter, e.g. a nitrogen-vacancy center or a semiconductor quantum dot (QD), embedded in a solid-state semiconductor host material appears as an attractive platform for generating such single photons. However, for a QD in bulk material, the large index contrast at the semiconductor-air interface leads to a collection efficiency of only 1-2 %, and efficient light extraction thus poses a major challenge in SPS engineering.

Initial efforts to improve the efficiency have exploited cavity quantum electrodynamics (cQED) to efficiently couple the emitted photons to the optical cavity mode. An alternative approach based on QDs in a photonic nanowire (Fig. 1a) was recently proposed, and the first experimental demonstration featured an efficiency of 0.72. [1] This geometry does not employ a cavity but instead relies on a geometrical screening effect to efficiently couple the emitted photons to the optical mode of interest. [2] The photonic nanowire "trumpet" design based on an inverted taper and compatible with metal contacts, shown in Fig. 1(b), very recently resulted in an efficiency of 0.75 under optical pumping. [3]

These designs do not employ a cavity and do not rely on resonant cQED effects to ensure a high factor, meaning that efficient coupling from the QD to the guided mode is obtained over a broad spectral range of ~ 50-100 nm. [4] This means that spectral alignment between the emitter line and a narrow cavity line is not required, which represents a huge practical advantage in the fabrication. Furthermore, for a given dot density, the smaller area of the nanowire QD layer compared to that of e.g. micropillars means that fewer dots are present, and very pure photon emission with a measured $g(2)(\tau=0)$ as low as 0.008 [1] has been obtained.

Improved switching using Fano resonances in photonic crystal structures

We present a simple and robust structure for realizing asymmetric Fano transmission characteristics in photonic crystal waveguide-cavity structures. The use of Fano resonances for optical switching is analyzed using temporal coupled mode theory in combination with three-dimensional finite difference time domain simulations taking into account the signal bandwidth. The results suggest a significant energy reduction by employing Fano resonances compared to more well established Lorentzian resonance structures. A specific example of a Kerr nonlinearity shows an order of magnitude energy reduction.

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Contributors: Gregersen, N., Claudon, J., Munsch, M., Bleuse, J., Dalga, A., Mørk, J., Gérard, J. M.
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Improved switching using Fano resonances in photonic crystal structures

We present a simple and robust structure for realizing asymmetric Fano transmission characteristics in photonic crystal waveguide-cavity structures. The use of Fano resonances for optical switching is analyzed using temporal coupled mode theory in combination with three-dimensional finite difference time domain simulations taking into account the signal bandwidth. The results suggest a significant energy reduction by employing Fano resonances compared to more well established Lorentzian resonance structures. A specific example of a Kerr nonlinearity shows an order of magnitude energy reduction.

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Web of Science (2003): Indexed yes
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Research output: Research - peer-review | Journal article – Annual report year: 2013

Improving nanocavity switching using Fano resonances in photonic crystal structures
We present a simple design for achieving Fano resonances in photonic crystal coupled waveguide-cavity structures. A coupled mode theory analysis shows an order of magnitude reduction in switching energy compared to conventional Lorentz resonances.

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Measuring the effective phonon density of states of a quantum dot in cavity quantum electrodynamics
We employ detuning-dependent decay-rate measurements of a quantum dot in a photonic-crystal cavity to study the influence of phonon dephasing in a solid-state quantum-electrodynamics experiment. The experimental data agree with a microscopic non-Markovian model accounting for dephasing from longitudinal acoustic phonons, and the analysis explains
the difference between nonresonant cavity feeding in different nanocavities. From the comparison between experiment and theory we extract the effective phonon density of states experienced by the quantum dot in the nanocavity. This quantity determines all phonon dephasing properties of the system and is found to be described well by a theory of bulk phonons.

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Scopus rating (2010): SJR 3.318 SNIP 1.447
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Scopus rating (2006): SJR 2.62 SNIP 1.468
Microscopic theory of indistinguishable single-photon emission from a quantum dot coupled to a cavity: The role of non-Markovian phonon-induced decoherence

We study the fundamental limit on single-photon indistinguishability imposed by decoherence due to phonon interactions in semiconductor quantum dot-cavity quantum electrodynamics systems. Employing an exact diagonalization approach we find large differences compared to standard methods. An important finding is that short-time non-Markovian effects limit the maximal attainable indistinguishability. The results are explained using a polariton picture that yields valuable insight into the phonon-induced dephasing dynamics.
Modeling and Design of High-Efficiency Single-Photon Sources

Solid-state sources capable of emitting single photons on demand are of great interest in quantum information applications. Ideally, such a source should emit exactly one photon into the collection optics per trigger, the emitted photons should be indistinguishable, and the source should be electrically driven. Several design strategies addressing
these requirements have been proposed. In the cavity-based source, light emission is controlled using resonant cavity quantum electrodynamics effects, whereas in the waveguide-based source, broadband electric field screening effects are employed to direct the light emission into the optical mode of interest. For all the strategies, accurate modeling and careful optical engineering is required to achieve high performance. In this study, we discuss the models and numerical techniques used to analyze such structures. The physical effects governing the light emission profile and the possibilities of tailoring it as well as the mechanisms governing the coherence are elucidated. The major design strategies pursued to optimize the single-photon source performance and the remaining challenges are reviewed.

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Web of Science (2016): Impact factor 3.971
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BFI (2012): BFI-level 2
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Scopus rating (2011): CiteScore 3.87 SJR 2.368 SNIP 2.78
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Nonlinear Gain Saturation in Active Slow Light Photonic Crystal Waveguides

We present a quantitative three-dimensional analysis of slow-light enhanced traveling wave amplification in an active semiconductor photonic crystal waveguides. The impact of slow-light propagation on the nonlinear gain saturation of the device is investigated.

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http://www.opticsinfobase.org/abstract.cfm?URI=NLO-2013-NTh1A.5. Systematic or multiple reproduction or distribution to multiple locations via electronic or other means is prohibited and is subject to penalties under law.

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Optimal switching using coherent control
We introduce a general framework for the analysis of coherent control in coupled optical cavity-waveguide systems. Within this framework, we use an analytically solvable model, which is validated by independent numerical calculations, to
investigate switching in a micro cavity and demonstrate that the switching time, in general, is not limited by the cavity lifetime. Therefore, the total energy required for switching is a more relevant figure of merit than the switching speed, and for a particular two-pulse switching scheme we use calculus of variations to optimize the switching in terms of input energy.

**General information**

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Photonic wires and trumpets for ultrabright single photon sources

Photonic wires have recently demonstrated very attractive assets in the field of high-efficiency single photon sources. After presenting the basics of spontaneous emission control in photonic wires, we compare the two possible tapering strategies that can be applied to their output end so as to tailor their radiation diagram in the far-field. We highlight the novel "photonic trumpet" geometry, which provides a clean Gaussian beam, and is much less sensitive to fabrication imperfections than the more common needle-like taper geometry. S4Ps based on a single QD in a PW with integrated bottom mirror and tapered tip display jointly a record-high efficiency (0.75±0.1 photon per pulse) and excellent single photon purity. Beyond single photon sources, photonic wires and trumpets appear as a very attractive resource for solid-state quantum optics experiments.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, French Alternative Energies and Atomic Energy Commission
Contributors: Gérard, J., Claudon, J., Bleuse, J., Munsch, M., Malik, N. S., Gregersen, N., Mørk, J.
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Polarization-independent high-index contrast grating and its fabrication tolerances

A polarization-independent, high-index contrast grating (HCG) with a single layer of cross stripes allowing simple fabrication is proposed. Since the cross stripes structure can be suspended in air by selectively wet-etching the layer below, all the layers can be grown at once when implemented for vertical-cavity surface-emitting lasers. We optimized the structure to have a broad and high reflectivity band centered at around 1.3 μm using a finite difference time domain method, and obtained an 80 x 10 nm high reflectivity band centered at 0.97 μm with a reflectivity exceeding 99.5%. We also investigated the fabrication tolerances of the structure and found that, assuming careful optimizations of electron beam lithography for the precise grating width and dry-etching for the vertical sidewall, the suggested polarization-independent HCG can be fabricated using standard technologies.
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Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.186 SNIP 1.709
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.054 SNIP 1.852
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.205 SNIP 1.656
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.025 SNIP 1.906
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.398 SNIP 1.741
Web of Science (2001): Indexed yes
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Source: Bibtex
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Probing plasmon resonance's dependence on gap size in silver dimers by EELS

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Organisations: Center for Electron Nanoscopy, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Structured Electromagnetic Materials, Department of Physics, Biophysics and Fluids
Contributors: Kadkhodazadeh, S., de Lasson, J. R., Raza, S., Kristensen, P. T., Mørk, J., Wagner, J. B., Kneipp, K.
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Probing plasmon resonance's dependence on gap size in silver dimers by EELS

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Proposed Quenching of Phonon-Induced Processes in Photoexcited Quantum Dots due to Electron-Hole Asymmetries

Differences in the confinement of electrons and holes in quantum dots are shown to profoundly impact the magnitude of scattering with acoustic phonons. Using an extensive model that includes the non-Markovian nature of the phonon reservoir, we show how the effect may be addressed by photoluminescence excitation spectroscopy of a single quantum dot. We also investigate the implications for cavity QED, i.e., a coupled quantum dot-cavity system, and demonstrate that the phonon scattering may be strongly quenched. The quenching is explained by a balancing between the deformation potential interaction strengths and the carrier confinement and depends on the quantum dot shape. Numerical examples suggest a route towards engineering the phonon scattering.

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nysteen, A., Nielsen, P. K., Mørk, J.
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Web of Science (2017): Impact factor 8.839
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.33 SJR 4.196 SNIP 2.61
Web of Science (2016): Impact factor 8.462
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.76 SJR 4.656 SNIP 2.538
Web of Science (2015): Impact factor 7.645
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.62 SJR 5.232 SNIP 2.71
Web of Science (2014): Impact factor 7.512
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 7.46 SJR 5.675 SNIP 2.781
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 7.19 SJR 6.292 SNIP 2.867
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 7.02 SJR 6.314 SNIP 2.905
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Quantum Optics with Photonic Nanowires and Photonic Trumpets: Basics and Applications

Optimizing the coupling between a localized quantum emitter and a single-mode optical channel represents a powerful route to realize bright sources of non-classical light states. Reversibly, the efficient absorption of a photon impinging on the emitter is key to realise a spin-photon interface, the node of future quantum networks. Besides optical microcavities [1], photonic wires have recently demonstrated in this context an appealing potential [2, 3]. For instance, single photon sources (SPS) based on a single quantum dot in a vertical photonic wire with integrated bottom mirror and tapered tip have enabled for the first time to achieve simultaneously a very high efficiency (0.72 photon per pulse) and a very pure single photon emission ($g(2)(0) < 0.01$). Furthermore, photonic wires with an elongated cross-section provide polarization control of the spontaneous emission of embedded emitters [4]. However, the performance of photonic wire SPS with tapered tips is sensitive to minute geometrical details and optimum behaviour is only obtained for ultra-sharp tips. Photonic trumpets [5], which exploit the opposite tapering strategy, overcome this important limitation. Moreover, they feature a Gaussian far-field emission, a strong asset for most applications. We report on the first implementation of this strategy and demonstrate an ultra-bright SPS (first-lens external efficiency: 0.75 ± 0.1) [5]. More generally, photonic trumpets appear as a very promising template to explore and exploit in a solid-state system the unique optical properties of 'one-dimensional atoms'.

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Speed enhancement in VCSELs employing grating mirrors

In recent years, various approaches to improve the speed of directly modulated vertical-cavity surface-emitting lasers (VCSELs) have been reported and demonstrated good improvement. In this paper, we propose and numerically investigate a new possibility of using high-index-contrast grating (HCG) as mirror for VCSELs. By changing the grating design, one can control the reflection delay of the grating mirror, enabling the control of cavity photon lifetime. On the other hand, short energy penetration depth of the HCG results in smaller modal volume, compared to DBR VCSELs. An example structure shows that the HCG VCSEL has a 30-% higher 3-dB bandwidth than the DBR VCSEL.

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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SJR 0.226 SNIP 0.258
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.3 SJR 0.212 SNIP 0.239
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.3 SJR 0.217 SNIP 0.249
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.26 SJR 0.234 SNIP 0.273
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.27 SJR 0.219 SNIP 0.275
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.31 SJR 0.217 SNIP 0.286
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.233 SNIP 0.277
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.236 SNIP 0.312
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.245 SNIP 0.3
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.247 SNIP 0.376
Switching characteristics of an InP photonic crystal nanocavity: Experiment and theory

The dynamical properties of an InP photonic crystal nanocavity are experimentally investigated using pump-probe techniques and compared to simulations based on coupled-mode theory. Excellent agreement between experimental results and simulations is obtained when employing a rate equation model containing three time constants, that we interpret as the effects of fast carrier diffusion from an initially localized carrier distribution and the slower effects of surface recombination and bulk recombination. The variation of the time constants with parameters characterizing the nanocavity structure is investigated. The model is further extended to evaluate the importance of the fast and slow carrier relaxation processes in relation to patterning effects in the device, as exemplified by the case of all-optical wavelength conversion.

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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Web of Science (2009): Indexed yes
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Scopus rating (2007): SJR 3.284 SNIP 2.11
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.313 SNIP 2.336
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.819 SNIP 2.472
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.669 SNIP 2.217
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.745 SNIP 1.748
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.496 SNIP 1.42
Web of Science (2001): Indexed yes
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Theory of carrier depletion and light amplification in active slow light photonic crystal waveguides

Using a perturbative approach, we perform a quantitative three-dimensional analysis of slow-light enhanced traveling wave amplification in an active semiconductor photonic crystal waveguide. The impact of slow-light propagation on the carrier-depletion-induced nonlinear gain saturation of the device is investigated. An effective rate-equation-based model is presented. It is shown that it well accounts for the three-dimensional simulation results. Simulations indicate that a slow-light-enhanced photonic crystal traveling-wave amplifier has a high small-signal modal gain and low saturation power.

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Web of Science (2016): Impact factor 3.307
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BFI (2015): BFI-level 2
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ISI indexed (2013): ISI indexed yes
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ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
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Theory of nanolaser devices: Rate equation analysis versus microscopic theory

A rate equation theory for quantum-dot-based nanolaser devices is developed. We show that these rate equations are capable of reproducing results of a microscopic semiconductor theory, making them an appropriate starting point for complex device simulations of nanolasers. The input-output characteristics and the modulation response are investigated and the limits of the rate equation approach are discussed.
The photonic nanowire: an emerging platform for highly efficient single-photon sources for quantum information applications

Efficient coupling between a localized quantum emitter and a well defined optical channel represents a powerful route to realize single-photon sources and spin-photon interfaces. The tailored fiber-like photonic nanowire embedding a single quantum dot has recently demonstrated an appealing potential. However, the device requires a delicate, sharp needle-like taper with performance sensitive to minute geometrical details. To overcome this limitation we demonstrate the photonic trumpet, exploiting an opposite tapering strategy. The trumpet features a strongly Gaussian far-field emission. A first implementation of this strategy has lead to an ultra-bright single-photon source with a first-lens external efficiency of 0.75 ± 0.1 and a predicted coupling to a Gaussian beam of 0.61 ± 0.08.

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Scopus rating (2015): CiteScore 0.3 SJR 0.212 SNIP 0.239
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.3 SJR 0.217 SNIP 0.249
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.26 SJR 0.234 SNIP 0.273
ISI indexed (2013): ISI indexed no
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.27 SJR 0.219 SNIP 0.275
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.31 SJR 0.217 SNIP 0.286
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.233 SNIP 0.277
Web of Science (2010): Indexed yes
The role of phonon scattering in the indistinguishability of photons emitted from semiconductor cavity QED systems

A solid-state single-photon source emitting indistinguishable photons on-demand is an essential component of linear optics quantum computing schemes. However, the emitter will inevitably interact with the solid-state environment causing decoherence and loss of indistinguishability. In this paper, we present a comprehensive theoretical treatment of the influence of phonon scattering on the coherence properties of single photons emitted from semiconductor quantum dots. We model decoherence using a full microscopic theory and compare with standard Markovian approximations employing Lindblad-type relaxation terms. Significant differences between the two approaches are found.

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Scopus rating (2017): CiteScore 3.28 SJR 1.653 SNIP 1.102
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.97 SJR 2.183 SNIP 1.173
Web of Science (2016): Impact factor 3.786
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.8 SJR 2.33 SNIP 1.157
Web of Science (2015): Impact factor 3.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.89 SJR 2.917 SNIP 1.335
Web of Science (2014): Impact factor 3.558
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.77 SJR 2.87 SNIP 1.352
Web of Science (2013): Impact factor 3.671
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.4 SJR 3.368 SNIP 1.517
Web of Science (2012): Impact factor 4.063
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.99 SJR 3.489 SNIP 1.626
Web of Science (2011): Impact factor 4.177
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 3.405 SNIP 1.415
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.194 SNIP 1.508
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.892 SNIP 1.374
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.832 SNIP 1.363
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.259 SNIP 1.316
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.729 SNIP 1.104
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.158 SNIP 0.991
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.929 SNIP 0.696
Scopus rating (2002): SJR 0.962 SNIP 0.647
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.081 SNIP 0.772
Web of Science (2001): Indexed yes
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Three-dimensional integral equation approach to light scattering, extinction cross sections, local density of states, and quasi-normal modes

We present a numerical formalism for solving the Lippmann–Schwinger equation for the electric field in three dimensions. The formalism may be applied to scatterers of different shapes and embedded in different background media, and we develop it in detail for the specific case of spherical scatterers in a homogeneous background medium. In addition, we show how several physically important quantities may readily be calculated with the formalism. These quantities include the extinction cross section, the total Green's tensor, the projected local density of states, and the Purcell factor as well as the quasi-normal modes of leaky resonators with the associated resonance frequencies and quality factors. We demonstrate the calculations for the well-known plasmonic dimer consisting of two silver nanoparticles and thus illustrate the versatility of the formalism for use in modeling of advanced nanophotonic devices.
Ultra-Fast Low Energy Switching Using an InP Photonic Crystal H0 Nanocavity

Pump-probe measurements on InP photonic crystal H0 nanocavities show large-contrast ultrafast switching at low pulse energy. For large pulse energies, high-frequency carrier density oscillations are induced, leading to pulsesplitting.

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Ultrahigh-speed hybrid laser for silicon photonic integrated chips

Increasing power consumption for electrical interconnects between and inside chips is posing a real challenge to continue the performance scaling of processors/computers as predicted by D. Moore. In recent processors, energy consumption for electrical interconnects is half of power supplied and will be 80% in near future. This challenge strongly has motivated replacing electrical interconnects with optical ones even in chip level communications [1]. This chip-level optical interconnects need quite different performance of optoelectronic devices than required for conventional optical communications. For a light source, the energy consumption per sending a bit is required to be <10 fJ/bit for on-chip interconnects and <100 fJ/bit for off-chip interconnects; this is two or three orders of magnitude smaller than the conventional devices. To meet the energy/bit requirement, many innovative laser diode and light-emitting diode (LED) structures have been proposed so far. Our hybrid laser is one of these efforts [2].

The hybrid laser consists of a dielectric reflector, a III-V semiconductor active material, and a high-index-contrast grating (HCG) reflector formed in the silicon layer of a silicon-on-insulator (SOI) wafer. 'Hybrid' indicates that a III-V active material is wafer-bonded to a silicon SOI wafer. In the hybrid laser, light is vertically amplified between the dielectric and the HCG reflectors, while the light output is laterally emitted to a normal Si ridge waveguide that is connected to the HCG reflector. The HCG works as a vertical mirror as well as a vertical-to-lateral coupler. Very small field penetration into the HCG allows for 3-4 times smaller modal volume than typical vertical-cavity surface-emitting lasers (VCSELs). This leads to high direct modulation speed. Details on device operating mechanism will be explained in the lecture.

Recently, a nano light-emitting diode (LED) with energy/bit < 1fJ/bit [3] and a nano laser diode with a buried heterostructure (BH) active material [4] have been recently reported in the literature. Additionally, device physics, engineering issue, and error-free light detection issue in quantum limit will be discussed in relation to these two structures.

VCSELs with a high-index-contrast grating for mode-division multiplexing

A novel vertical-cavity surface-emitting laser (VCSEL) structure for space division multiplexing (SDM) is proposed and numerically investigated. This laser structure employs a high-index-contrast grating (HCG) as a light-emitting mirror. The reflectivity of the HCG mirror is spatially modulated to excite a specific transverse mode, while its transmission phase is kept spatially constant. This laser can provide the selective excitation of a specific transverse mode, leading to a high coupling efficiency to a few mode fiber. Compared to the phase plate approach in current SDM systems, the HCG-integrated VCSEL approach can be a much more compact and cheaper alternative.
Semiconductor Nanomembranes for Quantum Photonics: Quantum Light Sources and Optomechanics

This thesis describes the fabrication and characterizations of semiconductor nanomembranes, i.e., gallium arsenide (GaAs) photonic crystal (PC) and optomechanical nanomembranes.
Processing techniques are developed and optimized in order to fabricate PC membranes for quantum light sources and optomechanical nanomembranes for cavity cooling experiments. For PC cavities, several important processes have been extensively optimized such as the inductively coupled plasma (ICP) dry etch, the release of the membranes and the post-cleaning of the samples. GaAs optomechanical nanomembranes with a world-record mechanical Q-factor up to 1 million have been fabricated with two step selective wet etches. These optomechanical nanomembranes exhibit superb performances in cavity optomechanical cooling experiments in which a mechanical mode has been cooled from room temperature to 4 K.

The interaction between single quantum dots (QDs) and PC cavities has been modeled in the framework of Jaynes-Cummins model (JCM) with the focus on single artificial atom lasers. In the experiments, a highly efficient single photon source with a collection efficiency up to 38% has been achieved and detailed measurements suggest that such a high efficiency could be attributed to the coupling to one of the higher-order cavity modes. Lasing oscillation has also been observed in the same systems. The comparison between the experimental lasing data to an advanced theory reveals that QDs lasing is fundamentally different from single atoms lasing due to the mesoscopic features of QDs.

Random lasers in Anderson-localization regime have been achieved in PC waveguides where the laser output can be controlled with the underlying dispersion relation. The random lasers can be well fitted with a modified semiconductor laser rate equation, showing high-β factors and low mode volumes. The statistical measurements provide a complete and coherent picture of the mechanism and physical properties of a random laser in the Anderson-localization regime which paves the way to control and optimize random lasing in low dimensional optical nanostructures commonly used for tailoring the light-matter interaction.
Active Photonic Crystal Waveguides
This thesis deals with the fabrication and characterization of active photonic crystal waveguides, realized in III-V semiconductor material with embedded active layers. The platform offering active photonic crystal waveguides has many potential applications. One of these is a compact photonic crystal semiconductor optical amplifier. As a step towards such a component, photonic crystal waveguides with a single quantum well, 10 quantum wells and three layers of quantum dots are fabricated and characterized. An experimental study of the amplified spontaneous emission and a implied transmission are presented in this thesis. A variation of photonic crystal design parameters are used leading to a spectral shift of the dispersion, it is veried that the observed effects shift accordingly. An enhancement of the amplified spontaneous emission was observed close to the band edge, where light is slowed down due to photonic crystal dispersion. The observations are explained by the enhancement of net gain by light slow down. Another application based on active photonic crystal waveguides is micro lasers. Measurements on quantum dot micro laser cavities with different mirror configurations and photonic crystal designs are shown. Laser emission is observed at wavelengths corresponding to the slow light regions of the cavity mode, where the enhanced gain lead to lower lasing threshold. Gain dynamics of the quantum dot gain material, used in both amplifier er and laser structures, are investigated. The measurements are based on degenerate pump-probe transmission spectroscopy using 180fs pulses. The characteristic gain recovery times are measured to be 2ps and 0.2ps, with little variation over a wavelength span of 260nm. Sub-assemblies of quantum dots which vary in height by one monolayer are observed. No noticeable changes in carrier dynamics can be associated with dots of different number of monolayers.

A bright single-photon source based on a photonic trumpet
Fiber-like photonic nanowires, which are optical waveguides made of a high refractive index material n, have recently emerged as non-resonant systems providing an efficient spontaneous emission (SE) control. When they embed a quantum emitter like a quantum dot (QD), they find application to the realization of bright sources of quantum light and, reversibly, provide an efficient interface between propagating photons and the QD. For a wire diameter ∼ λ/n (λ is the operation wavelength), the fraction of QD SE coupled to the fundamental guided mode exceeds 90%. The collection of the photons can be brought close to unity with a proper engineering of the wire ends. In particular, a tapering of the top wire end is necessary to achieve a directive far-field emission pattern [1]. Recently, we have realized a single-photon source featuring a needle-like taper. The source efficiency, though record-high, was found to be limited by the geometry of the taper [2]. Here, we propose an alternative, high performance, trumpet-like tapering of the wire and demonstrate its implementation in a bright single-photon source. Specifically, we consider a GaAs structure, for which the wire diameter is progressively increased from 220 nm to 1.5 µm, for a total height of 12 µm. Such trumpet-like tapers present a number of key assets: i) a nearly perfect adiabatic expansion (less than 5% losses) of the fundamental mode is achieved for tapering angle as large as 7o. ii) the emitted mode features a Gaussian profile with a divergence controlled by the top-facet diameter: for a top diameter of 1.5 µm, less than 5% of the light is scattered outside the collection cone of a lens with a 0.75 NA. iii) the large top facet also simplifies the implementation of a top electrode, to achieve an electrical driving of the device [3].

Using top-down fabrication techniques, we have fabricated a single photon source based on this geometry. The trumpet lies on an integrated mirror and embeds a single layer of InAs QDs, located 110 nm above the mirror. We obtain collection efficiencies higher than 40% for a bunch of QDs spread over 35 nm in a single wire, with a maximum of 65%. This result, which approaches the state of the art (70%), is also close to the predicted value of 80%, obtained for a perfect emitter [4]. Eventually, we map the field profile at the top facet and evidence its Gaussian profile. This is desirable to achieve a good coupling to a monomode fiber, in view of the long range distribution of single photons. This is also crucial to increase the mode matching when addressing a single QD with an optical Gaussian beam.
A bright single-photon source based on a photonic trumpet.pdf

Bibliographical note
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A Non-Hermitian Approach to Non-Linear Switching Dynamics in Coupled Cavity-Waveguide Systems

We present a non-Hermitian perturbation theory employing quasi-normal modes to investigate non-linear all-optical switching dynamics in a photonic crystal coupled cavity-waveguide system and compare with finite-difference-time-domain simulations.

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Bloch-wave engineering of quantum dot-micropillars for cavity quantum electrodynamics experiments

We have employed Bloch-wave engineering to realize submicron diameter ultra-high quality factor GaAs/AlAs micropillars (MPs). The design features a tapered cavity in which the fundamental Bloch mode is subject to an adiabatic transition to match the Bragg mirror Bloch mode. The resulting reduced scattering loss leads to record-high visibility of the strong coupling in MPs with modest oscillator strength quantum dots. A quality factor of 13,600 and a Rabi splitting of 85 \mu eV with an estimated visibility v of 0.38 are observed for a small mode volume MP with a diameter dc of 850 nm.

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Coherent single-photon absorption by single emitters coupled to 1D nanophotonic waveguides
We have derived an efficient model that allows calculating the dynamical single-photon absorption of an emitter coupled to a waveguide. We suggest a novel and simple structure that leads to strong single-photon absorption.

Controlling light emission from single-photon sources using photonic nanowires
The photonic nanowire has recently emerged as an promising alternative to microcavity-based single-photon source designs. In this simple structure, a geometrical effect ensures a strong coupling between an embedded emitter and the optical mode of interest and a combination of tapers and mirrors are used to tailor the far-field emission pattern. This non-resonant approach relaxes the demands to fabrication perfection, allowing for record-high measured efficiency of fabricated nanowire single-photon sources. We review recent progress in photonic nanowire technology and present next generation designs allowing for electrical contacting, polarization control, improved efficiency and simplified fabrication.
**Demonstration of Optically Controlled re-Routing in a Photonic Crystal Three-Port Switch**

We present an experimental demonstration of optically controlled re-routing of a signal in a photonic crystal cavity-waveguide structure with 3 ports. This represents a key functionality of integrated all-optical signal processing circuits.

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**Distributed Feedback Effects in Active Semiconductor Photonic Crystal Waveguides**

We present a rigorous coupled-wave analysis of slow-light effects in active photonic crystal waveguides. The presence of active material leads to coherent distributed feedback effects that significantly alter the magnitude and phase of output fields.

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Chen, Y., Mørk, J.
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Electromagnetic Scattering in Micro- and Nanostructured Materials.

The research fields of optical microstructures and plasmonic nanostructures are particularly active these years, and interesting applications in, e.g., quantum information technology in the former and novel types of solar cells in the latter, drive the investigations. Central in both fields is the interaction of light with matter, in the forms of semiconductors and metals in the two cases, and fundamental understanding of the interactions is important to optimize technological designs.

To address this, we in the present thesis develop a formalism for determining the electric field in a homogeneous three dimensional space with spherical inhomogeneities embedded. The formalism accounts fully for the multiple reflections the field undergoes in such structures, and likewise the vectorial nature of the field is treated rigorously. The formalism is based on the Lippmann-Schwinger equation and the electromagnetic Green’s tensor and uses an expansion of the field into the 3D continuum of non-guided modes is strongly inhibited, thanks to a pronounced dielectric screening effect. Additionally, we study dimers and chains of metallic nanoparticles and analyze their spectra, when exposed to fields of different polarizations. The spectral response is highly dependent on the polarization, and we demonstrate for the dimer, under polarization along the dimer axis, a $d^{-1/2}$-dependence of the relative shift of the resonance wavelength, $d$ being the distance between the particles. This dependence on $d$ is softer than reported earlier, and thus constitutes the foundation for a more systematic approach to the study of near-fields, and the breakdown of the simpler approach reveals a need for the present formalism.

Efficient and broadband spontaneous emission control in fiber-like photonic nanowires

Funnelling a large fraction of the spontaneous emission (SE) of a quantum emitter into a single optical mode is a powerful strategy for improving the brightness of quantum light sources or developing an efficient spin-photon interface. In the solid state, preferential emission into a single localized mode has been first achieved taking advantage of the Purcell effect that arises in semiconductor optical microcavities. In the last years, the need to overcome the limited operation bandwidth inherent to a resonant approach has triggered intense research on SE control in waveguide structures. Among the investigated platforms, fiber-like photonic nanowires are particularly appealing, as shown by the recent development of a very bright single-photon source based on a wire with carefully engineered ends [1,2].

Here we focus on the mechanisms governing the SE dynamics of the embedded emitter and consider a photonic nanowire made of GaAs (refractive index $n=3.5$) and surrounded by air ($n=1$). It features a circular section (diameter $d$), and contains spectrally isolated single InAs quantum dots (QD) with a free space emission wavelength around 920 nm. The large refractive index contrast between the wire and the air cladding has two important consequences: i) The coupling to the 3D continuum of non-guided modes is strongly inhibited, thanks to a pronounced dielectric screening effect. Experimentally, the coupling to these modes can be probed by studying the luminescence decay of QDs embedded in 'small' wires ($d=120$ nm), for which the coupling to the guided mode is vanishingly small. In that case, we measure a slow-down of the SE rate by a factor 16, a value which is comparable to the one obtained in state-of-the-art photonic crystal structures. ii) For larger structures ($d=220$ nm), the fundamental guided mode is tightly confined in the wire. The emitter is well coupled to this mode, and the SE rate becomes comparable to the one measured on a QD embedded in bulk GaAs. These experimental results demonstrate the ability of these simple structures to funnel a large fraction ($>90\%$) of the SE into the guided mode [3]. For some applications (e.g. polarization encoded quantum key distribution, generation of indistinguishable photons), it is desirable to control the polarization of the emitted photon. This control can be efficiently implemented in a wire featuring an elliptical section with a moderate aspect ratio ($\sim 2$). In that case, calculations show that the local density of optical modes is largely dominated by a single guided mode, with a linear polarization oriented along the major axis of the ellipse. Polarization-resolved measurements conducted on elliptical GaAs photonic nanowires embedding spectrally isolated InAs QDs fully confirm the predicted performances: the fraction of collected photons with the desired polarization can be as high as 95% [4].

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Electromagnetic Scattering in Micro- and Nanostructured Materials.

The research fields of optical microstructures and plasmonic nanostructures are particularly active these years, and interesting applications in, e.g., quantum information technology in the former and novel types of solar cells in the latter, drive the investigations. Central in both fields is the interaction of light with matter, in the forms of semiconductors and metals in the two cases, and fundamental understanding of the interactions is important to optimize technological designs.

To address this, we in the present thesis develop a formalism for determining the electric field in a homogeneous three dimensional space with spherical inhomogeneities embedded. The formalism accounts fully for the multiple reflections the field undergoes in such structures, and likewise the vectorial nature of the field is treated rigorously. The formalism is based on the Lippmann-Schwinger equation and the electromagnetic Green’s tensor and uses an expansion of the field on spherical wavefunctions. Addition theorems for these are extensively used, and all parts of the formalism are expressed analytically. With the formalism, we show that the simpler approach of modeling the spherical scatterers as polarizable dipoles, which is often alluded to in the literature, breaks down in the limit of closely spaced scattering objects.

The study of metallic nanoparticles is particularly intriguing when these are in close proximity, due to the coupling of their near-fields, and the breakdown of the simpler approach reveals a need for the present formalism. Additionally, we study dimers and chains of metallic nanoparticles and analyze their spectra, when exposed to fields of different polarizations.

The spectral response is highly dependent on the polarization, and we demonstrate for the dimer, under polarization along the dimer axis, a $d^{-1/2}$-dependence of the relative shift of the resonance wavelength, $d$ being the distance between the particles. This dependence on $d$ is softer than reported earlier, and thus constitutes the foundation for a more systematic approach to the study of near-fields, and the breakdown of the simpler approach reveals a need for the present formalism.
study. The correlation of distance and spectral properties may have applications within biosensing and imaging on the nanoscale. For the chain, we demonstrate a next-nearest neighbor interaction between the nanoparticles through the study of its spectral properties. Finally, we present a calculation of the Green’s tensor for the dimer, illustrating that the formalism may likewise be used for modeling optical microstructures, e.g. three dimensional photonic crystals.

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Emission dynamics in QD systems: from single QD resonance fluorescence to many-emitter laser switching
Semiconductor quantum dots (QDs) have emerged in recent years as new active materials for optoelectronic devices, already used in LED’s, lasers, or optical amplifiers. A unique opportunity lies in the combination of QDs with optical microcavities, thus combining three-dimensional electronic and photonic confinement. This combination opens the possibility to exploit the Purcell effect to enhance and direct the photon emission. In this contribution, we investigate multiple facets of the emission dynamics in semiconductor QDs, ranging from the resonance fluorescence of QDs under pulsed excitation to the switch-on behavior of QD based nanolasers.

Recently the resonance fluorescence from semiconductor QDs has received considerable attention [1]. We show that for the case of pulsed excitation the resonance fluorescence spectrum of a quantum dot contains multiple side peaks beyond those of the Mollow triplet, due to interference effects [2]. An analytical model has been derived, which quantitatively accounts for the appearance and position of the peaks. By considering the time-dependent spectrum we demonstrate a time-ordering of the side-peaks, as shown in the left panel of Fig. 1, which is further evidence for the suggested physical explanation.

Additionally, we investigate the dynamical properties of InGaAs QD based nanolasers, combining a microscopic treatment of carrier scattering with a quantum-kinetic description of the carrier-photon interaction that also allows to study the coherence properties of the emitted light [3]. This allows for a detailed analysis of the switch-on process of nanocavity lasers showing strongly damped relaxation oscillations [4]. This behavior is driven by an ultra-fast carrier dynamics, that is shown in detail in Fig. 2. Remarkably, the timescales between the relaxation dynamics in the WL and the dynamics of the QD populations are not decoupled as it is often assumed. This is caused by the fact that the capture into the QD states is most efficient for the WL states with low quasi-momenta. Therefore, these states are constantly depleted during the first stage of the kinetics, which slows down the relaxation of the WL towards a quasi-equilibrium.

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Enhanced Gain in Photonic Crystal Amplifiers
We experimentally demonstrate enhanced gain in the slow-light regime of quantum well photonic crystal amplifiers. A strong gain enhancement is observed with the increase of the group refractive index, due to light slow-down. The slow light enhancement is shown in a amplified spontaneous emission study of a 1 QW photonic crystal amplifier. Net gain is achieved which enables laser oscillation in photonic crystal micro cavities. The ability to freely tailor the dispersion in a semiconductor optical amplifier makes it possible to raise the optical gain considerably over a certain bandwidth. These results are promising for short and efficient semiconductor optical amplifiers. This effect will also benefit other devices, such as mode locked lasers.

General information
Experimental demonstration of a four-port photonic crystal cross-waveguide structure

We report the design and fabrication of a four-port InP photonic crystal cavity-waveguide structure in which two crossing waveguides intersect in a cavity. Transmission measurements show that by exploiting mode-gap effects, high cross-talk suppression between the two waveguides can be obtained. In addition, the waveguides couple to two distinct cavity resonances with different quality-factors as well as small mode volumes. This structure is promising for realizing ultra-fast, low-energy optical switches or memories.
Fundamental Limitations to Gain Enhancement in Periodic Media and Waveguides

A common strategy to compensate for losses in optical nanostructures is to add gain material in the system. By exploiting slow-light effects it is expected that the gain may be enhanced beyond its bulk value. Here we show that this route cannot be followed uncritically: inclusion of gain inevitably modifies the underlying dispersion law, and thereby may degrade the slow-light properties underlying the device operation and the anticipated gain enhancement itself. This degradation is generic; we demonstrate it for three different systems of current interest (coupled-resonator optical waveguides, Bragg stacks, and photonic crystal waveguides). Nevertheless, a small amount of added gain may be beneficial.

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Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 6.62 SJR 5.232 SNIP 2.71
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 7.19 SJR 6.292 SNIP 2.867
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 7.02 SJR 6.314 SNIP 2.905
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 6.45 SNIP 2.757
We present a non-perturbative analysis of light-matter interaction in active photonic crystal waveguides in the slow-light regime. Inclusion of gain is shown to modify the underlying dispersion law, thereby degrading the slow-light enhancement.
High-Q AlAs/GaAs adiabatic micropillar cavities with submicron diameters for cQED experiments

Quantum dot (QD) micropillar cavities represent an interesting class of microresonator systems aiming at the observation and application of cavity quantum electrodynamics (cQED) on a semiconductor platform. They combine valuable properties i.e. a highly directional and approximately Gaussian shaped emission pattern, efficient electrical operation, high quality (Q) factors up to 165,000 at large diameters [1].

In order to observe cQED effects such as weak or strong QD-cavity coupling it is necessary to realize micropillars providing not only high Q factors but also small mode volumes $V_{\text{mode}}$. This puts stringent requirements to the design and the processing of the micropillars which show a drastic decrease of the Q factor in the low diameter limit due to sidewall scattering losses and mode mismatch. Indeed, these effects limit the Q factor to ~2,000 in the submicron diameter range for a standard microcavity design [1, 2].

To overcome the trade-off between high Q and low $V_{\text{mode}}$, we designed and implemented a novel adiabatic AlAs/GaAs cavity design (MC1) with 3 taper segments (Fig. 1 (a)) as it was suggested by Zhang et al. for SiO2/TiO2 micropillar cavities [3]. Comparative measurements of the Q factor were performed between a standard one-λ microcavity structure (MC2) and MC1 for pillars with diameters ranging from 0.70 μm to 1.50 μm (Fig. 1 (b; bottom)). As can be seen in Fig. 1(b) MC1 shows significantly higher Q-factors exceeding 10,000 in the submicron diameter range due to the adiabatic cavity design. Purcell factors FP between 225 and 325 can be expected in the diameter range between 0.70 μm and 1.00 μm as it is indicated by the shaded box in Fig. 1 (b; top). Moreover, strong coupling between a standard InGaAs QD and an 850 nm diameter adiabatic micropillar with quality factor of 13,600 has been achieved.

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Contributors: Lermer, M., Gregersen, N., Dunzer, F., Mark, J., Reitzenstein, S., Höfling, S., Kamp, M., Forchel, A.
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High-Q submicron-diameter quantum-dot microcavity pillars for cavity QED experiments

The semiconductor quantum dot - microcavity pillar system represents an attractive platform for studying fundamental light-matter interaction as well as for demonstrating novel quantum devices, ultra-low threshold lasers and sub-ps optical switching. In this work we present a novel tapered GaAs/AlAs micropillar design where Bloch-wave engineering is employed to significantly enhance the cavity mode confinement in the submicron diameter regime. We demonstrate a record-high vacuum Rabi splitting of 85 μeV of the strong coupling for pillars incorporating quantum dots with modest oscillator strength $f \approx 10$. It is well-known that light-matter interaction depends on the photonic environment, and thus proper engineering of the optical mode in microcavity systems is central to obtaining the desired functionality. In the strong coupling regime, the visibility of the Rabi splitting is described by the light-matter coupling constant $g$ proportional to $Q/\sqrt{\lambda}$, where $Q$ is the quality factor and $\lambda$ is the mode volume. A high $Q$ and a low $\lambda$ are thus desirable.

The mode volume $\lambda$ can be minimized by reducing the pillar diameter. However, for the standard micropillar design, the poor mode matching between the cavity mode and the DBR Bloch mode limits the $Q$ to about 2000. [1] In our optimized design we have replaced the standard λ-spacer with a 3 segment tapered region. The layer thicknesses of these GaAs/AlAs segments are gradually reduced towards the center, effectively detuning the bandgap relative to that of the DBRs and allowing for a single localized mode inside the cavity. The fundamental Bloch mode experiences an adiabatic transition, leading to an improved mode matching and a reduced coupling to propagating Bloch modes in the DBRs. The central GaAs layer incorporating quantum dots is only 60 nm thick corresponding to $\approx \lambda/5$, and regular cavity concepts are thus insufficient to explain the localization of the cavity mode, demonstrating the necessity of Bloch-wave formalism in the analysis of the design.

We compare our adiabatic design to a reference incorporating a λ-spacer. A theoretical improvement of $Q$ of two orders of magnitude and an experimentally measured improvement of $\approx 5$, limited by fabrication imperfections, are obtained. Thus our novel approach allows us to demonstrate remarkably high quality factors exceeding 10,000 for MP cavities with diameters below 1 μm. [2]

Whereas previous studies of strong coupling in micropillars relied on quantum dots with high oscillator strengths $f > 50$, our advanced design allows for the observation of strong coupling for submicron diameter quantum dot-pillars with standard $f \approx 10$ oscillator strength. A quality factor of 13600 and a vacuum Rabi splitting of 85 μeV are observed for a small mode volume micropillar with a diameter of 850 nm.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Universität Würzburg
InGaAsP photonic crystal nanocavities with a Fano line shape resonant at 1.55 μm
We fabricated and characterized InGaAsP photonic crystal nanocavities. By carefully tailoring the structural parameters, both an efficient coupling and a suitable Q-factor can be achieved. Depending on the design of the coupling region, sharp Fano lines may be observed.

Integrated Photonics Enabled by Slow Light
In this talk we will discuss the physics of slow light in semiconductor materials and in particular the possibilities offered for integrated photonics. This includes ultra-compact slow light enabled optical amplifiers, lasers and pulse sources.

Linearly Polarized, Single-Mode Spontaneous Emission in a Photonic Nanowire
We introduce dielectric elliptical photonic nanowires to funnel efficiently the spontaneous emission of an embedded emitter into a single optical mode. Inside a wire with a moderate lateral aspect ratio, the electromagnetic environment is largely dominated by a single guided mode, with a linear polarization oriented along the ellipse major axis. The resulting
monomode spontaneous emission is maintained over a broad wavelength range, a key asset of this 1D photonic structure. Our theoretical analysis is completed by an experimental study of GaAs elliptical photonic wires with embedded InAs quantum dots. In particular, the fraction of collected photons with the desired linear polarization can exceed 95%.

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonics, CNRS
Contributors: Munsch, M., Claudon, J., Bleuse, J., Malik, N. S., Dupuy, E., Gerard, J., Chen, Y., Gregersen, N., Mørk, J.
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BFI (2014): BFI-level 2
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ISI indexed (2012): ISI indexed yes
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Scopus rating (2008): SJR 6.194 SNIP 2.837
Low-energy-consumption hybrid lasers for silicon photonics

Physics and characteristics of a hybrid vertical-cavity laser that can be an on-chip Si light source with high speed and low energy consumption are discussed.

Microscopic theory of phonon-induced effects on semiconductor quantum dot decay dynamics in cavity QED

We investigate the influence of the electron-phonon interaction on the decay dynamics of a quantum dot coupled to an optical microcavity. We show that the electron-phonon interaction has important consequences on the dynamics, especially when the quantum dot and cavity are tuned out of resonance, in which case the phonons may add or remove energy leading to an effective nonresonant coupling between quantum dot and cavity. The system is investigated using two different theoretical approaches: (i) a second-order expansion in the bare phonon coupling constant, and (ii) an expansion in a polaron-photon coupling constant, arising from the polaron transformation which allows an accurate
description at high temperatures. In the low-temperature regime, we find excellent agreement between the two approaches. An extensive study of the quantum dot decay dynamics is performed, where important parameter dependencies are covered. We find that in general the electron-phonon interaction gives rise to a greatly increased bandwidth of the coupling between quantum dot and cavity. At low temperature, an asymmetry in the quantum dot decay rate is observed, leading to a faster decay when the quantum dot has a larger energy than to the cavity. We explain this as due to the absence of phonon absorption processes. Furthermore, we derive approximate analytical expressions for the quantum dot decay rate, applicable when the cavity can be adiabatically eliminated. The expressions lead to a clear interpretation of the physics and emphasize the important role played by the effective phonon density, describing the availability of phonons for scattering, in quantum dot decay dynamics. Based on the analytical expressions, we present the parameter regimes where phonon effects are expected to be important. Also, we include all technical developments in appendices.

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Modeling of cavities using the analytic modal method and an open geometry formalism

We present an eigenmode expansion technique for calculating the properties of a dipole emitter inside a micropillar. We consider a solution domain of infinite extent, implying no outer boundary conditions for the electric field, and expand the field on analytic eigenmodes. In contrast to finite-sized simulation domains, this avoids the issue of parasitic reflections from artificial boundaries. We compute the Purcell factor in a two-dimensional micropillar and explore two discretization techniques for the continuous radiation modes. Specifically, an equidistant and a nonequidistant discretization are employed, and while both converge, only the nonequidistant discretization exhibits uniform convergence. These results demonstrate that the method leads to more accurate results than existing simulation techniques and constitutes a promising basis for further work.
Modeling of Coupled Nano-Cavity Lasers

Modeling of nanocavity light emitting semiconductor devices is done using the semiconductor laser rate equations with spontaneous and stimulated emission terms modified for Purcell enhanced recombination. The modified terms include details about the optical and electronic density-of-states and it is argued that Purcell enhancement should also be included in stimulated recombination term, contrary to the common practice in the literature. It is shown that for quantum well devices, the Purcell enhancement is effectively independent of the cavity quality factor due to the broad electronic density-of-states relative to the optical density-of-states. The low effective Purcell eect for quantum well devices limits the highest possible modulation bandwidth to a few tens of gigahertz, which is comparable to the performance of conventional diode lasers.

Compared to quantum well devices, quantum dot devices have narrower electronic density-of-states and are not affected by the reduction of the Purcell enhancement to the same degree. The highest modulation bandwidth is found for below threshold operation, where the bandwidth is not cavity-limited.

Using finite-difference time-domain methods, systems of passive, coupled photonic crystal nanocavity structures are simulated. The resonance frequencies of in-phase and out-of-phase coupled quadrupole modes in rectangular photonic crystal H1 cavities are extracted and are found to vary non-trivially with the intercavity separation. A qualitative explanation...
is given in terms of the in-plane mode profiles. Fareld emission patterns for the structures are calculated based on the finite-difference time-domain simulations. It is found that only systems with an even number of holes separating the cavities show clear signs of being coupled. This non-trivial coupling behavior is useful for design of coupled systems. A tight-binding description for coupled nanocavity lasers is developed and employed to investigate the phase-locking behavior for the system of two coupled cavities. Phase-locking is found to be critically dependent on exact parameter values and to be dicult to achieve for systems with large linewidth enhancement factors and low Purcell enhancement such as quantum well based lasers. Realistic numbers for the coupling strength are extracted from finite-difference time-domain simulations.

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Modeling of gain saturation effects in active semiconductor photonic crystal waveguides
In this paper, we present a theoretical analysis of slow-light enhanced light amplification in an active semiconductor photonic crystal line defect waveguide. The impact of enhanced light-matter interactions on carrier-depletion-induced modal gain saturation is investigated.

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Multiple-scattering formalism beyond the quasistatic approximation: Analyzing resonances in plasmonic chains
We present a multiple-scattering formalism for simulating scattering of electromagnetic waves on spherical inhomogeneities in 3D. The formalism is based on the Lippmann-Schwinger equation and the electromagnetic Green's tensor and applies an expansion of the electric field on spherical wavefunctions. As an example, we analyze localized surface plasmons in chains of Ag spheres, and show how the resonances of such systems depend sensitively on the polarization of the incoming field, the spacing between the particles and the number of particles in the chain.

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Contributors: de Lasson, J. R., Kristensen, P. T., Mørk, J.
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Near-unity efficiency, single-photon sources based on tapered photonic nanowires

Single-photon emission from excitons in InAs Quantum Dots (QD) embedded in GaAs Tapered Photonic Wires (TPW) already demonstrated a 0.72 collection efficiency, with TPWs were the apex is the sharp end of the cone. Going to alternate designs, still based on the idea of the adiabatic deconfinement of the quasi-Gaussian emission mode, but with inverted TPW where the apex is the cone's base, leads to even larger efficiencies. In addition, these inverted TPWs make the electric pumping of the emitters compatible with these large efficiencies.

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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, CEA
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Nonlinear carrier dynamics in a quantum dash optical amplifier

Results of experimental pump-probe spectroscopy of a quantum dash optical amplifier biased at transparency are presented. Using strong pump pulses we observe a competition between free carrier absorption and two-photon induced stimulated emission that can have drastic effects on the transmission dynamics. Thus, both enhancement as well as suppression of the transmission can be observed even when the amplifier is biased at transparency. A simple theoretical model taking into account two-photon absorption and free carrier absorption is presented that shows good agreement with the measurements.

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Web of Science (2006): Indexed yes
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Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.081 SNIP 0.772
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.063 SNIP 0.999
Scopus rating (1999): SJR 0.714 SNIP 0.255
Non-Markovian phonon dephasing of a quantum dot in a photonic-crystal nanocavity

Single quantum dots (QDs) can be embedded in nanocavities in order to enhance the interaction with a single mode of the electromagnetic field, thereby making them candidates for applications in quantum information systems. In this work [1], we investigate the coupling between single QDs and localized modes in photonic crystal (PC) cavities. From measurements of the detuning-dependent decay rate of a QD embedded in an L3 PC cavity we find a surprisingly broadband enhancement of the decay rate, cf. Fig. 1, which cannot be explained using the standard approach of a dissipative Jaynes-Cummings (JC) model. Similar measurements on a single QD tuned through an Anderson localized (AL) mode [2] in a PC waveguide show that in this system the decay rates closely follow the JC model. We introduce a novel microscopic model taking the interaction with longitudinal-acoustic (LA) phonons into account. Using this model, we are able to explain the broadband enhancement in an L3 cavity, and the quantitative difference compared to the AL-cavity arises from a larger background decay rate in the AL-cavity due to the presence of leaky radiation modes. The concept of the effective phonon density of states (DOS) is introduced, which determines the rate of phonon-assisted spontaneous emission. If, e.g., the QD is blue-detuned from the cavity mode, the QD can emit a photon into the cavity mode by emitting the residual energy as a phonon [3]. Our microscopic model allows us to extract the effective phonon DOS, that turns out to agree with a model for bulk phonons.

Optimal on/off scheme for all-optical switching

We present a two-pulsed on/off scheme based on coherent control for fast switching of the optical energy in a micro cavity and use calculus of variations to optimize the switching in terms of energy.
Photonic nanowires for quantum optics

Photonic nanowires (PWs) are simple dielectric structures for which a very efficient and broadband spontaneous emission (SE) control has been predicted [1]. Recently, a single photon source featuring a record high efficiency was demonstrated using this geometry [2]. Using time-resolved micro-photoluminescence, we investigate directly the SE of single InAs quantum dots (QDs) embedded in GaAs PWs and demonstrate performances that fully confirm the theoretical predictions [3]. In addition, we discuss recent results obtained on elliptical wires that ensure an efficient control of the photon polarization [4].

We first consider cylindrical PWs, defined within a top-down fabrication process. For diameters leading to the optimal confinement of the fundamental guided mode HE11 (d/lambda~0.25, lambda~950nm), the coupling to HE11 (2-time polarization degenerated) dominates the SE process and a maximum enhancement of the SE rate by a factor of 1.5 is reached. When the diameter is decreased by 100nm, the guided mode is completely deconfined. The coupling to this mode vanishes, thus allowing the coupling to the other radiation modes to be probed [3]. In these conditions, a SE inhibition factor of 16, equivalent to the one obtained in state-of-the-art 2D photonic crystals, is measured. Moreover, a PW featuring an elliptical section provides a very efficient control over the polarization of the emitted photon. In that case, only one guided mode, with a linear polarization oriented along the major axis, is confined in the semiconductor. Polarization-resolved experiments show that the coupling to this single mode can exceed 95% for optimum structures [4]. These results confirm the high potential of PWs for the realization of efficient sources of quantum light.

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Physics and applications of slow and fast light in semiconductor optical waveguides

We review the physics of slow and fast light based on coherent population oscillations in active semiconductor waveguides. Exploiting these effects, microwave phase shifters realizing 360 degree phase shift and operating at tens of GHz have been realized.

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**Properties of nanolasers based on few discrete emitters**

The laser has evolved from table size apparatuses to truly nano sized devices, in much the same way that computer chips have been continuously minimized. The few-emitter nanolaser represents an extreme in terms of size. The emitters can be either atoms or quantum dots, and they are coupled to a high-Q optical cavity. This system has previously been studied for the one and two emitters case, see e.g. [1, 2]. The emitters and cavity are modelled as two-level systems and a harmonic oscillator, respectively. The coupled system is modelled using the Jaynes-Cummings Hamiltonian and the two-level systems are pumped incoherently by a rate $P$. Solutions are found using the corresponding master equation. However, with cavity populations exceeding 100 and several emitters, the dimension of the Hilbert space of the system becomes too large to handle efficiently on a conventional computer. E.g. for four emitters and 100 photon states the density matrix has more than $2.5 \times 10^6$ elements.

We have been able to simplify the problem significantly by adiabatically eliminating the photon-assisted polarizations and the correlations between emitters and cavity [3]. This results in a set of rate equations for the population of the cavity, $n_a$, and the occupation of the emitters. Fig. 1a) shows $n_a$ for up to 4 emitters coupled to a cavity, as a function of the pumping rate $P$. The figure also shows results from a full master equation solution, and the correspondence is very good for large values of $P$. In Fig. 1b) the second order correlation functions $g(2)(0)$ are shown, as obtained using the full model. The second order correlation functions become 1 for sufficiently large values of $P$ signifying the onset of lasing. However, for larger values of $P$ the laser quenches and the emission becomes chaotic ($g(2)(0) = 2$). This quenching effect is well-known in two-level models [3], but might not be realistic for semiconductor quantum dots.

A proposed application for these nanolasers is in on-chip optical interconnects. In this application the modulation bandwidth is important. We have calculated the modulation bandwidth using a small-signal analysis of the rate equations, which has the advantage compared the full model of yielding a semianalytical result. The results are shown in Fig. 1c). The nanolaser has a high bandwidth, which is mostly limited by the cavity lifetime ($\Gamma_1$), but shows a prominent drop during the lasing regime. The modulation bandwidth again becomes limited by as the output becomes chaotic.

**Quantum-dot nano-cavity lasers with Purcell-enhanced stimulated emission**

We present a rate equation model for quantum-dot light-emitting devices that take into account Purcell enhancement of both spontaneous emission and stimulated emission as well as the spectral profile of the optical and electronic density-of-states. We find that below threshold the $b$-factor in a quantum-dot nanolaser depends strongly on the pump. For quantum dots with linewidth comparable to that of the cavity, we then show that an otherwise non-lasing device can lase due to Purcell enhancement of the stimulated emission. Finally, we compare the rate equation model to a microscopic model and obtain good agreement.
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BFI (2016): BFI-level 2
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Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
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ISI indexed (2012): ISI indexed yes
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Scopus rating (2005): SJR 3.755 SNIP 2.353
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Scopus rating (2003): SJR 3.897 SNIP 2.275
Reducing dephasing in coupled quantum dot-cavity systems by engineering the carrier wavefunctions

We demonstrate theoretically how photon-assisted dephasing by the electron-phonon interaction in a coupled cavity-quantum dot system can be significantly reduced for specific QD-cavity detunings. Our starting point is a recently published theory,1 which considers longitudinal acoustic phonons, described by a non-Markovian model, interacting with a coupled quantum dot-cavity system. The reduction of phonon-induced dephasing is obtained by placing the cavity-quantum dot system inside an infinite slab, assuming spherical electronic wavefunctions. Based on our calculations, we expect this to have important implications in single-photon sources, allowing the indistinguishability of the photons to be improved.
Resonance Fluorescence from Semiconductor Quantum Dots: Beyond the Mollow Triplet

We show that the resonance fluorescence spectrum of a quantum dot excited by a strong optical pulse contains multiple peaks beyond those of the Mollow triplet. We show that as the area of the optical pulse is increased, new side peaks split off the central peak and shift in frequency. A simple analytical theory has been derived, which quantitatively accounts for the appearance and position of the peaks. This theory explains the physics responsible for the multiple peaks. By considering the time-dependent spectrum we demonstrate a time ordering of the side peaks, which is further evidence for the suggested physical explanation. © 2012 American Physical Society.
Simulation of Nonlinear Gain Saturation in Active Photonic Crystal Waveguides
In this paper we present a theoretical analysis of slowlight enhanced traveling wave amplification in an active semiconductor Photonic crystal waveguides. The impact of group index on nonlinear modal gain saturation is investigated.

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Single-photon indistinguishability: influence of phonons
Recent years have demonstrated that the interaction with phonons plays an important role in semiconductor based cavity QED systems [2], consisting of a quantum dot (QD) coupled to a single cavity mode [Fig. 1(a)], where the phonon interaction is the main decoherence mechanism. Avoiding decoherence effects is important in linear optical quantum computing [1], where a device emitting fully coherent indistinguishable single photons on demand, is the essential ingredient.

In this contribution we present a numerically exact simulation of the effect of phonons on the degree of indistinguishability of photons emitted from a solid-state cavity QED system. Our model rigorously describes non-Markovian effects to all orders in the phonon coupling constant, being based on an exact diagonalization procedure accounting for the time evolution of one-time and two-time photon correlation functions. We compare to standard approaches for treating the phonon interaction, namely the Markovian Lindblad formalism and the long-time limit of the non-Markovian time-convolution-less (TCL) approach, and find large quantitative and qualitative differences [3].

Figures 1(b) and (c) show the calculated indistinguishability as a function of the QD-cavity coupling strength for light emitted from the QD and the cavity, respectively, for all the employed methods. Both the Lindblad and TCL theories deviate significantly from our exact results, where, importantly, the exact results predict a pronounced maximum in the degree of indistinguishability, absent in the approximate theories. The maximum arises due to virtual processes in the highly non-Markovian short-time regime, which dominate the decoherence for small QD-cavity coupling, and phonon-mediated real transitions between the upper and lower polariton branches in the long-time regime, dominating the decoherence for large QD-cavity coupling. Our method captures the physics of the regime of small and as well as large QD-cavity coupling, both corresponding to experimentally relevant situations. Importantly, the commonly used Lindblad formalism fails completely in describing the variations of the indistinguishability predicted by the two other models.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology, Theoretical Nanotechnology, University of Copenhagen
Contributors: Nielsen, P. K., Lodahl, P., Jauho, A., Mørk, J.
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URLs:

Bibliographical note
Poster presentation P1.
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012
Slow light enhancement and limitations in periodic media

Properties of periodic dielectric media have attracted a big interest in the last two decades due to numerous exciting physical phenomena that cannot occur in homogeneous media. Due to their strong dispersive properties, the speed of light can be significantly slowed down in periodic structures. When light velocity is much smaller than the speed of light in a vacuum, we describe this phenomena as slow light. In this thesis, we analyze important properties of slow light enhancement and limitations in periodic structures. We analyze quantitatively and qualitatively different technologies and significant structures with numerical and analytical methods. By analyzing different structures, we show very general properties for limitation and enhancement in the slow light regime.

Inherent imperfections of fabricated structures such as a material loss and structural disorder have a strong influence on slowly propagating light. By means of perturbative analysis, we address the effect of small imperfections in periodic structures. From our analysis, we find very universal behavior in a slow light regime for all periodic structures. Even if losses are very small the dispersion is severely affected in the vicinity of the band edge. The minimum attainable group velocity will depend on the amount of imperfections. Since imperfections are inherited as part of any periodic structure it is necessary to take them into account when we are interested in slow light applications. Slowly propagating light gives rise to longer interaction time in the periodic media. Due to this reason, weak light-matter interaction is enhanced. The enhancement due to slow light has been studied for loss and gain. By introducing gain/loss, dispersive properties, in the slow light region, are severely influenced. The minimum attainable group velocity is strongly dependent on the amount of introduced loss/gain that will result in limitation of enhancement. Therefore, small amounts of gain/loss will provide great enhancement. While for a large amount of gain/loss slow, light is heavily jeopardized, hence no enhancement will occur.

General information
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Organisations: Department of Photonics Engineering, Structured Electromagnetic Materials, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology
Contributors: Grgic, J., Mørk, J., Jauho, A.
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Slow-light enhancement of gain

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Contributors: Mørk, J.
Publication date: 2012
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BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.3 SJR 0.217 SNIP 0.249
BFI (2013): BFI-level 1
Slow-light enhancement of spontaneous emission in active photonic crystal waveguides

Photonic crystal defect waveguides with embedded active layers containing single or multiple quantum wells or quantum dots have been fabricated. Spontaneous emission spectra are enhanced close to the bandedge, consistently with the enhancement of gain by slow light effects. These are promising results for future compact devices for terabit/s communication, such as miniaturised semiconductor optical amplifiers and mode-locked lasers.

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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Ek, S., Chen, Y., Semenova, E., Hansen, P. L., Yvind, K., Mørk, J.
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SJR 0.226 SNIP 0.258
Spontaneous emission from large quantum dots in nanostructures: Exciton-photon interaction beyond the dipole approximation

We derive a rigorous theory of the interaction between photons and spatially extended excitons confined in quantum dots in inhomogeneous photonic materials. We show that beyond the dipole approximation, the radiative decay rate is proportional to a nonlocal interaction function, which describes the interaction between light and spatially extended excitons. In this regime, light and matter degrees of freedom cannot be separated and a complex interplay between the nanostructured optical environment and the exciton envelope function emerges. We illustrate this by specific examples and derive a series of important analytical relations, which are useful for applying the formalism to practical problems. In the dipole limit, the decay rate is proportional to the projected local density of optical states, and we obtain the strong and weak confinement regimes as special cases.
Suppressing electron-phonon interactions in semiconductor quantum dot systems by engineering the electronic wavefunctions

It is well-known that decoherence deteriorates the efficiency of cavity QED systems containing quantum dots (QDs), and that a major contribution stems from the coupling between the electrical carriers in the QD and acoustic phonons [1]. Employing a recently published model [2], we demonstrate how a proper matching between the electronic wavefunction and the phonon-induced energy shift of valence and conduction band may be exploited to change the decoherence and decay properties of the QD by suppressing the phonon-induced processes.

This effect may be addressed in a photoluminescence experiment, where a CW laser excites a two-level QD which interacts with a non-Markovian reservoir of acoustical phonons, see Fig. 1a. We assume a simple harmonic confinement of the electronic carriers, resulting in Gaussian wavefunctions, \( \psi(r) = \exp\left[-r^2/(2W^2)\right] \), with \( W_e \) (\( W_h \)) being the width of the electron (hole) wavefunction. In Fig. 1b we plot the stationary QD population vs. the laser frequency. We observe that for non-equal electron and hole wavefunction, the phonon-induced effect on the population surprisingly is fully suppressed at specific detunings. In a coupled QD–cavity system [2, 3], see Fig. 2a, this effect causes the QD lifetime to be unaffected by phonon processes at specific QD-cavity detunings. Furthermore, as shown in Fig. 2b, a proper choice of the QD wavefunction minimizes the phonon-induced pure dephasing rate, both in terms of the short-time magnitude and the long-time constant value. Furthermore we show, that even for realistic QDs, where \( W_e \) and \( W_h \) are determined by the QD shape and material composition, a significant suppression of phonon-induced processes is possible. Thus, more efficient quantum systems may be obtained if the QD wavefunctions are properly matched with the phononic properties of the surroundings.

Systematic design of loss-engineered slow-light waveguides

This paper employs topology optimization to systematically design free-topology loss-engineered slow-light waveguides with enlarged group index bandwidth product (GBP). The propagation losses of guided modes are evaluated by the imaginary part of eigenvalues in complex band structure calculations, where the scattering losses due to manufacturing imperfections are represented by an edge-related effective dissipation. The loss engineering of slow-light waveguides is realized by minimizing the propagation losses of design modes. Numerical examples illustrate that the propagation losses of free-topology dispersion-engineered waveguides can be significantly suppressed by loss engineering. Comparisons between fixed- and free-topology loss-engineered waveguides demonstrate that the GBP can be enhanced significantly by the free-topology loss-engineered waveguides with a small increase of the propagation losses.
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  Scopus rating (2015): CiteScore 1.61
  Web of Science (2015): Impact factor 1.457
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  Web of Science (2012): Impact factor 1.665
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  Web of Science (2011): Indexed yes
  BFI (2010): BFI-level 1
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Research output: Research - peer-review | Journal article – Annual report year: 2012
Systematic Design of Slow Light Waveguides

Light can propagate much slower in photonic crystal waveguides and plasmonic waveguides than in vacuum. Slow light propagation in waveguides shows broad prospects in the terabit communication systems. However, it causes severe signal distortions and displays large propagation loss. Moreover it is vulnerable to manufacturing disorders. This thesis aims to design novel waveguides to alleviate signal distortions and propagation loss using optimization methodologies, and to explore the design robustness with respect to manufacturing imperfections.

To alleviate the signal distortions in waveguides, an optimization formulation is presented to tailor the slope of the dispersion curve. The design robustness is enforced by considering different manufacturing realizations in the optimization procedure. Both free- and fixed-topology (circular-hole based) slow light photonic crystal waveguides are obtained using two different parameterizations. Detailed comparisons show that the bandwidth of slow light propagation can be significantly enhanced by allowing irregular geometries in the waveguides.

To mitigate the propagation loss due to scattering in the photonic crystal waveguides, an optimization problem is formulated to minimize the average propagation loss of the designed modes. The presented approach is employed to design a free-topology slow light waveguide. Numerical result illustrates that slow light propagation in the optimized waveguide displays significantly suppressed propagation loss while keeping the same bandwidth.

The first optimization formulation is further employed to design slow light metal-dielectric-metal plasmonic waveguides. It is shown that dispersionless slow light propagation is achieved in the optimized plasmonic waveguide. Further study reveals that the loss in metal can be compensated by integrating gain media in the optimized waveguide, while keeping negligible signal distortions.

VCSELs and silicon light sources exploiting SOI grating mirrors

In this talk, novel vertical-cavity laser structure consisting of a dielectric Bragg reflector, a III-V active region, and a high-index-contrast grating made in the Si layer of a silicon-on-insulator (SOI) wafer will be presented. In the Si light source version of this laser structure, the SOI grating works as a highly-reflective mirror as well as routes light into a Si in-plane output waveguide connected to the grating. In the vertical-cavity surface-emitting laser (VCSEL) version, there is no in-plane output waveguide connected to the grating. In the vertical-cavity surface-emitting laser (VCSEL) version, there is no in-plane output waveguide connected to the grating. Thus, light is vertically emitted through the Bragg reflector. Numerical simulations show that both the silicon light source and the VCSEL exploiting SOI grating mirrors have superior performances, compared to existing silicon light sources and long wavelength VCSELs. These devices are highly adequate for chip-level optical interconnects as well as conventional short-distance optical connections. In the talk, device physics will be discussed in detail.
Wave-front-engineered grating mirrors for VCSELs

High-index-contrast grating mirrors featuring beam steering abilities for the transmitted beam as well as high reflectivity over a broad bandwidth are suggested. Gratings designed to provide control over the wave front of the transmitted beam are numerically investigated. The proposed structures are then fabricated for experimental characterization. The measurements performed show the beam steering ability of the suggested HCG designs and are also in good agreement with the theoretical predictions. General design rules to engineer these HCG structures for different applications are derived. These grating mirrors would have a significant impact on low cost laser sources fabrication, since a more efficient integration of optoelectronic modules can be achieved by avoiding expensive external lens systems.
**Active III-V Semiconductor Photonic Crystal Waveguides**

We experimentally demonstrate enhanced amplified spontaneous emission in a quantum well III-V semiconductor photonic crystal waveguide slab. The effect is described by enhanced light matter interaction with the decrease of the group velocity. These are promising results for future compact devices for terabit/s communication, such as miniaturised semiconductor optical amplifiers and mode-locked lasers.

**General information**

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(International Conference on Transparent Optical Networks).
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URLs: http://www.ict.kth.se/MAP/FMI/Negonet/icton2011/
Source: orbit
Source-ID: 280152
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

**A High-Efficiency Photonic Nanowire Single-Photon Source Featuring An Inverted Conical Taper**

A photonic nanowire single-photon source design incorporating an inverted conical tapering is proposed. The inverted taper allows for easy electrical contacting and a high photon extraction efficiency of 89%. Unlike cavity-based approaches, the photonic nanowire features broadband spontaneous emission control and an improved tolerance towards fabrication imperfections.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, CNRS
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J., Claudon, J., Gérard, J.
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URLs: http://www.nusod.org/2011/
Source: orbit
Source-ID: 283022
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

**Bloch-Wave Engineered Submicron Diameter Micropillars with Quality Factors Exceeding 10,000**

Adiabatic design submicron diameter quantum-dot micropillars have been designed and implemented for cavity quantum electrodynamics experiments. Ultra-high experimental quality factors (>10,000) are obtained for submicron diameters and strong light-matter interaction is observed.

**General information**

State: Published
Coherent all-optical switching in a bistable waveguide-cavity-waveguide system

All optical switching based on non-linear material effects is a promising technique for use in future optical communication systems. Promising advances in the field has been achieved using optical microcavities in photonic crystals to increase the optical field strength and hence reduce the required power of the input field [1]. In this work we consider an alternative method of switching, in which the input power is kept constant and only the phase of the input field is varied.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Kristensen, P. T., Heuck, M., Mørk, J.
Publication date: 2011

Coherent single-photon absorption by single emitters coupled to one-dimensional nanophotonic waveguides

We study the dynamics of single-photon absorption by a single emitter coupled to a one-dimensional waveguide that simultaneously provides channels for spontaneous emission (SE) decay and a channel for the input photon. We have developed a time-dependent theory that allows us to specify any input single-photon wavepacket guided by the waveguide as the initial condition, and calculate the excitation probability of the emitter, as well as the time evolution of the transmitted and reflected fields. For single-photon wavepackets with a Gaussian spectrum and temporal shape, we obtain analytical solutions for the dynamics of absorption, with maximum atomic excitation . We furthermore propose a terminated waveguide to aid the single-photon absorption. We found that for an emitter placed at an optimal distance from the termination, the maximum atomic excitation due to an incident single-photon wavepacket can exceed 70%. This high value is a direct consequence of the high SE β-factor for emission into the waveguide. Finally, we have also explored whether waveguide dispersion could aid single-photon absorption by pulse shaping. For a Gaussian input wavepacket, we found that the absorption efficiency can be improved by a further 4% by engineering the dispersion. Efficient single-photon absorption by a single emitter has potential applications in quantum communication and quantum computation.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Structured Electromagnetic Materials, FOM Institute for Atomic and Molecular Physics - AMOLF
Contributors: Chen, Y., Wubs, M., Merk, J., Koenderink, A. F.
Decay dynamics of radiatively coupled quantum dots in photonic crystal slabs

We theoretically investigate the influence of radiative coupling on light emission in a photonic crystal slab structure. The calculation method is based on a formalism that combines the photon Green's tensor with a self-consistent Dyson equation approach and is applicable to a wide range of problems in nanophotonics. We apply the method to calculate how resonant interactions of neighboring quantum dots affect the spontaneous emission, and we observe a pronounced nonexponential decay in the intensity at the detector position. We analyze the decay based on detailed calculations of the Green's tensor and show how interference between different light scattering pathways is responsible for this nontrivial detector response.

General information
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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics, Queen's University Kingston
Contributors: Kristensen, P. T., Mørk, J., Lodahl, P., Hughes, S.
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Web of Science (2017): Impact factor 3.813
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Impact factor 3.836
Decay dynamics of radiatively coupled quantum dots in photonic crystal slabs
We model spontaneous emission dynamics of two optically-coupled quantum dots in a photonic crystal slab. Due to the different light scattering pathways from the dots, we observe a pronounced non-exponential decay in the emitted intensity.

Demultiplexing of OTDM-DPSK signals based on a single semiconductor optical amplifier and optical filtering
We propose and demonstrate the use of a single semiconductor optical amplifier (SOA) and optical filtering to time demultiplex tributaries from an optical time division multiplexing-differential phase shift keying (OTDM-DPSK) signal. The scheme takes advantage of the fact that phase variations added to the target channel by cross-phase modulation from the control signal are effectively subtracted in the differential demodulation scheme employed for DPSK signals. Demultiplexing from 80 to 40 Gbit/s is demonstrated with moderate power penalty using an SOA with recovery time twice as long as the bit period at 80 Gbit/s. Large dynamic ranges for the input power and SOA current are experimentally demonstrated. The scheme is expected to be scalable toward higher bit rates. © 2011 Optical Society of America.
Dependence of the modulation response of quantum dot based nanocavity devices on the number of emitters

A microscopic theory is used to study the dynamical properties of semiconductor quantum dot based nanocavity laser systems. The carrier kinetics and photon populations are determined using a fully quantum mechanical treatment of the light-matter coupling. In this work, we investigate the dependency of the modulation response in such devices on the number of emitters coupled to the cavity mode. (© 2011 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim)
Design for an Electrically-Pumped Photonic Nanowire Single-Photon Source with an Efficiency of 89 %

We propose an electrically-pumped singlephoton source design based on a photonic nanowire. For realistic geometrical parameters, a collection efficiency of 89 % is predicted. Initial fabrication results confirming the feasibility of the design are presented.

Dynamical Properties of QD-based Nanolaser Devices

We investigate the switch-on behavior of semiconductor QD-based nanocavity laser devices. From a microscopic treatment of the carrier-carrier and carrier-photon interaction, we find a fast switch-on, that is accompanied by heavily damped relaxation oscillations and caused by an ultrafast carrier dynamics.

Efficient and broadband control of the spontaneous emission in photonic nanowires

General information
Electrically pumped photonic nanowire single-photon source with an efficiency of 89%

We propose a new electrically-pumped single-photon source design based on a quantum dot in a photonic nanowire. For realistic parameters, the design features an efficiency of 89 % predicted by numerical simulations. Unlike cavity-based designs, our approach allows for broadband spontaneous emission control and has high tolerance towards surface roughness. In the nanowire, a geometrical effect ensures good coupling between the quantum dot and the optical mode, and an inverted tapering section is introduced to adiabatically expand the mode waist and control the far field emission profile while minimizing the relative modal overlap with the metal contacts.
Energy-bandwidth trade-off in all-optical photonic crystal microcavity switches

The performance of all-optical switches is a compromise between the achievable bandwidth of the switched signal and the energy requirement of the switching operation. In this work we consider a system consisting of a photonic crystal cavity coupled to two input and two output waveguides. As a specific example of a switching application, we investigate the demultiplexing of an optical time division multiplexed signal. To quantify the energy-bandwidth trade-off, we introduce a figure of merit for the detection of the demultiplexed signal. In such investigations it is crucial to consider patterning effects, which occur on time scales that are longer than the bit period. Our analysis is based on a coupled mode theory, which allows for an extensive investigation of the influence of the system parameters on the switching dynamics. The analysis is shown to provide new insights into the ultrafast dynamics of the switching operation, and the results show optimum parameter ranges that may serve as design guidelines in device fabrication. © 2011 Optical Society of America.

General information
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Contributors: Heuck, M., Kristensen, P. T., Merk, J.
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Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Enhanced Gain in Slow-Light Photonic Crystal Waveguides with Embedded Quantum Dots

We experimentally demonstrate enhanced gain in the slow-light regime of quantum dot photonic crystal waveguide slabs. These are promising results for future compact devices for terabit/s communication, such as compact optical amplifiers and mode-locked lasers.

Enhancement of light-matter interactions in photonic crystal structures with quantum dots

Enhancing light-matter interactions by slow light
Enhancing slow- and fast-light effects in quantum dot semiconductor waveguides through ultrafast dynamics

In this paper we review our theoretical work on slow and fast light effects in quantum dot semiconductor optical amplifiers (QD SOAs), in particular we investigate the carrier dynamical contributions to the dynamic gain grating and cross gain modulation induced by unique ultrafast inter-subband carrier dynamics between discrete QD bound states. Our calculations predict that by increasing the injection current density, additional ultra-fast coherent gain contributions around 100GHz arise in contrast to the slow sub-gigahertz carrier density pulsation (CDP) effects. For potential applications in microwave photonics, especially targeting the millimeter wave range, we propose that quantum dot devices might be used to realize an optically fed microwave phase shifter in the frequency range of 100GHz.

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Contributors: Chen, Y., Mørk, J.
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Scopus rating (2016): CiteScore 0.42 SJR 0.226 SNIP 0.258
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ISI indexed (2011): ISI indexed no
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.236 SNIP 0.312
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Scopus rating (2008): SJR 0.245 SNIP 0.3
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.247 SNIP 0.376
Finite element modeling of plasmon based single-photon sources

A finite element method (FEM) approach of calculating a single emitter coupled to plasmonic waveguides has been developed. The method consists of a 2D model and a 3D model: (I) In the 2D model, we have calculated the spontaneous emission decay rate of a single emitter into guided plasmonic modes by using the translation symmetry of the waveguides; (II) In the 3D model, we have implemented the FEM calculation to include the radiation modes and the nonradiative contributions by solving the wave equation with a harmonic source terms. The FEM approach is rather flexible, and can handle the plasmonic waveguides with different geometries, as long as only one guided plasmonic mode is predominantly excited.

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URLs: http://www.nusod.org/2011/
Source: orbit
Source-ID: 285440
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

High-index-contrast grating reflector with beam steering ability for the transmitted beam

High-index contrast grating mirrors providing wave front control of the transmitted light as well as high reflectivity over a broad bandwidth are suggested and both numerically and experimentally investigated. General design rules to engineer these structures for different applications are derived. Such grating mirrors would have a significant impact on low cost laser fabrication, since a more efficient integration of optoelectronic modules can be achieved by avoiding expensive external lens systems.

General information
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Organisations: Plasmonics and Metamaterials, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Technical University of Denmark
Contributors: Carletti, L., Malureanu, R., Mørk, J., Chung, I.
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Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
Web of Science (2010): Impact factor 3.753
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.204 SNIP 2.423
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.284 SNIP 2.11
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.313 SNIP 2.336
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.819 SNIP 2.472
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.669 SNIP 2.217
Hybrid Si/III-V vertical-cavity laser for silicon photonics

General information
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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chung, I., Mørk, J.
Publication date: 2011

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Keywords: Optical interconnects, High index contrast grating, HCG
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URLs: http://lpn.epfl.ch/eslw2011/
Source: orbit
Source-ID: 286967
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

Modelling of Active Semiconductor Photonic Crystal Waveguides and Robust Designs based on Topology Optimization
In this paper, we present a theoretical analysis of slow-light enhanced light amplification in an active semiconductor photonic crystal line defect waveguide. The impact of enhanced light-matter interactions on propagation effects and local carrier dynamics are investigated in the framework of the Lorentz reciprocity theorem. We highlight topology optimization as a systematic and robust design methodology considering manufacturing imperfections in optimizing active photonic crystal device performances, and compare the performance of standard photonic crystal waveguides with optimized structures.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Mechanical Engineering, Solid Mechanics
Contributors: Chen, Y., Wang, F., Ek, S., Jensen, J. S., Sigmund, O., Mørk, J.
Pages: We.C4.1
Publication date: 2011

Host publication information
Title of host publication: 2011 13th International Conference on Transparent Optical Networks (ICTON)
Publisher: IEEE
ISBN (Print): 978-1-4577-0881-7
Modulation response of quantum dot nano-LEDs and nano-lasers
NanoLEDs and nanolasers are light emitting devices with characteristic length scales comparable to the wavelength of the emitted light. They are expected to operate at significantly lower powers and higher speeds than their conventional counterparts, which makes them interesting candidates for light emitters in ultrahigh speed optical communication. This is mainly due to the Purcell effect, which increases the spontaneous emission into the nanocavity mode. Early investigations of nanoscale light emitters [1,2] suggest modulation speeds in excess of 100 GHz, however, more work is needed to fully understand the limits and possibilities of these devices.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Skovgård, T. S., Gregersen, N., Lorke, M., Mørk, J.
Publication date: 2011

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Title of host publication: 2011 Conference on and 12th European Quantum Electronics Conference Lasers and Electro-Optics Europe (CLEO EUROPE/EQEC)
Publisher: IEEE
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URLs: http://www.cleoeurope.org/
Source: orbit
Source-ID: 278813
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

Modulation response of quantum dot nanolight-emitting-diodes exploiting purcell-enhanced spontaneous emission
The modulation bandwidth for a quantum dot light-emitting device is calculated using a detailed model for the spontaneous emission including the optical and electronic density-of-states. We show that the Purcell enhancement of the spontaneous emission rate depends critically on the degree of inhomogeneous broadening relative to the cavity linewidth and can improve the modulation speed only within certain parameter regimes.

General information
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Contributors: Skovgård, T. S., Gregersen, N., Lorke, M., Mørk, J.
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BFI (2017): BFI-level 2
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Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.018 SNIP 2.414
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 4.281 SNIP 2.22
Web of Science (2001): Indexed yes
Modulation Response of Semiconductor Quantum Dot Nanocavity Lasers
The modulation response of quantum-dot based nanocavity devices is investigated using a semiconductor theory. We show that high modulation bandwidth is achieved even in the presence of inhomogeneous broadening of the quantum dot ensemble.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Lorke, M., Nielsen, T. R., Mørk, J.
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BFI (2017): BFI-level 1
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Scopus rating (2016): CiteScore 0.21 SJR 0.165 SNIP 0.246
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.18 SJR 0.18 SNIP 0.218
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.17 SJR 0.171 SNIP 0.202
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.16 SJR 0.164 SNIP 0.187
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.14 SJR 0.176 SNIP 0.193
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.12 SJR 0.161 SNIP 0.16
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.166 SNIP 0.158
Numerical modeling in photonic crystals integrated technology: the COPERNICUS Project

Photonic crystals will play a fundamental role in the future of optical communications. The relevance of the numerical modeling for the success of this technology is assessed by using some examples concerning the experience of the COPERNICUS Project.

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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices, University of Ferrara, University of Nottingham, University of Rennes, Thales
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URLs: http://www.nusod.org/2011/
Source-ID: 285442
Research output: Research - peer-review › Article in proceedings – Annual report year: 2011

Patterning Effects in Ultrafast All-Optical Photonic Crystal Nanocavity Switches

All-optical switches are expected to play a key role in increasing the bandwidth of future communication networks by replacing slower electronic components for certain signal processing tasks. Previous work has demonstrated the possibility of switching a single pulse [1,2]. However, a more realistic investigation of the switching performance requires longer random pulse sequences, since detrimental effects may accumulate over time scales longer than one pulse duration. This has been investigated for switches based on semiconductor optical amplifiers [3], but in this work the focus is on a photonic crystal material system, which facilitates a high level of integration with other components such as waveguides, light sources, beam splitters, etc.

General information
State: Published
Phase-locking regimes of photonic crystal nanocavity laser arrays

We model and analyze the dynamical properties of coupled photonic crystal nanocavity lasers. The model includes Purcell enhancement of the spontaneous emission and intercavity coupling. The coupling strength between neighboring cavities is an essential parameter, and by performing finite-difference time-domain calculations, the typical coupling strength is extracted for realistic structures. Phase-locking regimes are identified, and their stability with respect to parameter variation is investigated. The results suggest that quantum well devices are not well suited for phase-locked nanocavity laser array devices.

General information
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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Skovgård, T. S., Kristensen, P. T., Mørk, J.
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Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
Resonance fluorescence from quantum dots: beyond the Mollow triplet

We show that the resonance fluorescence spectrum of a quantum dot excited by a strong pulse contains multiple peaks. An analytical model shows how the peak positions depend on pulse width and amplitude.

Role of the lightmatter coupling strength on nonMarkovian phonon effects in semiconductor cavity QED

Semiconductor cavity quantum electrodynamical (CQED) devices are believed to be important components for future quantum information technologies. Being composed of a single quantum dot (QD) embedded in a cavity, semiconductor CQED systems resemble atomic CQED systems. However, recent experiments [1] have demonstrated that the physics of such all-solid-state systems is much richer than their atomic counterparts. In the regime of small detuning between the QD and cavity resonance, interactions with acoustical phonons are considered [2] to be the most important effect of the solid-state environment. Phonons introduce pure dephasing and other renormalization phenomena [3], which are inherently non-Markovian in nature.

Simple and efficient methods for the accurate evaluation of patterning effects in ultrafast photonic switches

Although patterning effects (PEs) are known to be a limiting factor of ultrafast photonic switches based on semiconductor optical amplifiers (SOAs), a simple approach for their evaluation in numerical simulations and experiments is missing. In this work, we experimentally investigate and verify a theoretical prediction of the pseudo random binary sequence (PRBS) length needed to capture the full impact of PEs. A wide range of SOAs and operation conditions are investigated. The very simple form of the PRBS length condition highlights the role of two parameters, i.e. the recovery time of the SOAs as well as the operation bit rate. Furthermore, a simple and effective method for probing the maximum PEs is demonstrated, which may relieve the computational effort or the experimental difficulties associated with the use of long PRBSs for the simulation or characterization of SOA-based switches. Good agreement with conventional PRBS characterization is obtained. The method is suitable for quick and systematic estimation and optimization of the switching performance.
Slow-light enhancement of integrated photonics

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Mørk, J.
Pages: OEDI-13
Publication date: 2011

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Source: orbit
Source-ID: 317612
Research output: Research - peer-review › Article in proceedings – Annual report year: 2012

SOA-based OTDM-DPSK Demultiplexing Assisted by Offset-Filtering
We demonstrated for the first time 80 to 40 Gb/s OTDM-DPSK demultiplexing using a single SOA assisted by offset-filtering. Error free performance is achieved with an average power penalty of 5.5 dB.

General information
State: Published
Organisations: High-Speed Optical Communication, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Xu, J., Ding, Y., Peucheret, C., Seoane, J., Mulvad, H. C. H., Galili, M., Xue, W., Mørk, J., Jeppesen, P.
Pages: OWG8
Switch-on dynamics of nanocavity laser devices

Theoretical investigations of the switch-on behavior of semiconductor quantum dot based nanocavity laser devices are presented. From a microscopic treatment of the carrier-carrier and carrier-photon interaction, we find a fast switch-on of the laser device that is enabled by ultrafast carrier dynamics and heavily damped relaxation oscillations. We show that the timescales of the dynamics within the continuum states and the quantum dot states are strongly coupled and investigate the time dependence of the non-equilibrium scattering rates in detail. (C) 2011 American Institute of Physics.

[doi:10.1063/1.3651765]
The Influence of Optical Filtering on the Noise Performance of Microwave Photonic Phase Shifters Based on SOAs

Different optical filtering scenarios involving microwave photonic phase shifters based on semiconductor optical amplifiers are investigated numerically as well as experimentally with respect to noise performance. Investigations on the role of the modulation depth and number of elements in cascaded shifting stages are also carried out. Suppression of the noise level by more than 5 dB has been achieved in schemes based on band-pass optical filtering when three phase shifting stages are cascaded.
We experimentally demonstrate the realization of a tunable true-time delay for microwave signals by exploiting cross gain modulation among counter-propagating optical beams in a semiconductor optical amplifier. Broadband operation from $\sim 5$ to $\sim 35$ GHz is observed. The physical effect originates from the combination of carrier dynamics and propagation effects, and the experimental results are well accounted for by a numerical model. We find that, in contrast to the case of the co-propagating beams, the bandwidth is not limited by the lifetime of excited carriers. The trade-off between the magnitude of the true-time delay and the microwave bandwidth is discussed. © 2011 American Institute of Physics.
Modeling of plasmon mediated single-photon devices

The thesis describes the theoretical study of optical plasmons mediated light-matter interaction. We develop a finite element method to study spontaneous emission from emitters coupled to plasmonic waveguides. The numerical method is applied to calculate the coupling of an emitter coupled to a cylindrical nanowire, a square metallic nanowire and a metallic slot waveguide with inhomogenous dielectric environment. We also examine a quantum emitter coupled to optical nanoantennas. We mimic the conventional Yagi-Uda to realize its optical analogy for directional emission. We also propose a plasmon-based reconfigurable antenna to controllably distribute emission from a single emitter in spatially separated channels.

General information

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Chen, Y., Mørk, J., Gregersen, N., Nielsen, T. R., Lodahl, P.
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Source: orbit
Source-ID: 268652
Research output: Research › Ph.D. thesis – Annual report year: 2010

Quantum Dot Devices for Optical Signal Processing

This thesis describes the physics and applications of quantum dot semiconductor optical amplifiers through numerical simulations. As nano-structured materials with zero-dimensional quantum confinement, semiconductor quantum dot material provides a number of unique physical properties compared with other semiconductor materials. The understanding of such properties is important in order to improve the performance of existing devices and to trigger the development of new semiconductor devices for different optical signal processing functionalities in the future. We present a detailed quantum dot semiconductor optical amplifier model incorporating a carrier dynamics rate equation model for quantum dots with inhomogeneous broadening as well as equations describing propagation. A phenomenological description has been used to model the intradot electron scattering between discrete quantum dot states and the continuum. Additional to the conventional time-domain modeling scheme, a small-signal perturbation analysis has been used to assist the investigation of harmonic modulation properties. The static properties of quantum dot devices, for example high saturation power, have been quantitatively analyzed. Additional to the static linear amplification properties, we focus on exploring the gain dynamics on the time scale ranging from sub-picosecond to nanosecond. In terms of optical signals that have been investigated, one is the simple sinusoidally modulated optical carrier with a typical modulation frequency range of 1-100 gigahertz. Our simulations reveal the role of ultrafast intradot carrier dynamics in enhancing modulation bandwidth of quantum dot semiconductor optical amplifiers. Moreover, the corresponding coherent gain response also provides rich dispersion contents over a broad bandwidth. One important implementation is recently boosted by the research in slow light. The idea is to migrate such dynamical gain knowledge for the investigation of microwave phase shifter based on semiconductor optical waveguide. Our study reveals that phase shifting based on the conventional semiconductor optical amplifier is fundamentally limited over a narrow bandwidth determined by the slow carrier density pulsation processes. In contrast, we predict that using quantum dots as the active material instead can provide bandwidth enhancement even beyond 100 gigahertz due to its unique extra ultrafast carrier dynamics. We also investigate the gain dynamics in the presence of pulsed signals, in particular the steady gain response to a periodic pulse trains with various time periods. Additional to the analysis of high speed patterning free amplification up to 150-200 Gb/s in quantum dot semiconductor optical amplifiers, we discuss the possibility to realize a compact high-speed all-optical regenerator by incorporating a quantum dot absorption section in an amplifier structure.
Slow and fast light effects in semiconductor optical amplifiers for applications in microwave photonics

This thesis analyzes semiconductor optical amplifiers based slow and fast light effects with particular focus on the applications in microwave photonics. We conceive novel ideas and demonstrate a great enhancement of light slow down. Furthermore, by cascading several slow light stages, >360 degree microwave phase shifts over a bandwidth of several tens of gigahertz are achieved. These also satisfy the basic requirements of microwave photonic systems. As an application demonstration, a tunable microwave notch filter is realized, where slow light based phase shifters provide 100% fractional tuning over the whole free spectral range. Finally, the noise properties of the proposed slow light devices are investigated.

Slow light and pulse propagation in semiconductor waveguides

This thesis concerns the propagation of optical pulses in semiconductor waveguide structures with particular focus on methods for achieving slow light or signal delays. Experimental pulse propagation measurements of pulses with a duration of 180 fs, transmitted through quantum well based waveguide structures, are presented. Simultaneous measurements of the pulse transmission and delay are measured as a function of input pulse energy for various applied electrical potentials. Electrically controlled pulse delay and advancement are demonstrated and compared with a theoretical model. The limits of the model as well as the underlying physical mechanisms are analysed and discussed. A method to achieve slow light by electromagnetically induced transparency (EIT) in an inhomogeneously broadened quantum dot medium is proposed. The basic principles of EIT are assessed and the main dissimilarities between an atomic and a quantum dot medium are discussed. Three generic schemes are compared, showing that only one of the schemes are viable for slow light in an inhomogeneously broadened medium. The principal differences between the schemes are analysed and discussed. Propagation calculations of the three schemes are presented and compared together with estimates of the achievable delay and transmission. Finally, measurements of the ultra fast gain dynamics of a quantum dot semiconductor optical amplifier are presented. The experiment is based on degenerate pump-probe transmission spectroscopy using 180 fs pulses. Both the wavelength dependence as well as the applied current density dependence are investigated. Two characteristic relaxation rates of 0.2 ps and 1 ps are extracted based on a theoretical model. The choice of model and the underlying physical processes of the measurements are discussed.
Light-matter interaction in nanostructured materials

Light-matter interaction in nanostructured materials is studied theoretically with emphasis on spontaneous emission dynamics of quantum dots in photonic crystals. The main topics of the work are electromagnetic scattering calculations, decay dynamics of single quantum dots and multiple quantum dot dynamics. The electromagnetic Green's tensor enters naturally in calculations of light-matter interaction in multiple scattering media such as photonic crystals. We present a novel solution method to the Lippmann-Schwinger equation for use in electric field scattering calculations and Green's tensor calculations. The method is well suited for multiple scattering problems such as photonic crystals and may be applied to problems with scatterers of arbitrary shape and non-homogeneous background materials. By the introduction of a measure for the degree of fractional decay we quantify to which extent the effect is observable in a given material. We focus on the case of inverse opal photonic crystals and locate the position in the crystal where the effect is most pronounced. Furthermore, we quantify the influence of absorptive loss and give example calculations with experimental parameters for PbSe quantum dots in Si inverse opals showing that absorption has a limiting but not prohibitive effect. In addition, we discuss how the resonant nature of the phenomenon puts rather severe restrictions on the stabilization of the system in possible experiments. Last, we examine the influence on the decay dynamics from other quantum dots. Using a self-consistent Dyson equation approach we describe how scattering from other quantum dots can be included in the Green's tensor for a passive material system. We numerically calculate both local and non-local elements of the Green's tensor for a photonic crystallite slab and apply the method for an example calculation with two quantum dots at specific locations in the unit cell. In this way it is explicitly shown how the decay dynamics of one quantum dot is qualitatively changed by the scattering properties of another.

Quantum Kinetics of charge carriers in quantum dots: applications to slow light and light amplification

Quantum Kinetics of charge carriers in quantum dots: applications to slow light and light amplification
80-nm-tunable high-index-contrast subwavelength grating long-wavelength VCSEL: Proposal and numerical simulations

A widely-tunable single-mode long wavelength vertical-cavity surface-emitting laser structure employing a MEMS-tunable high-index-contrast subwavelength grating (HCG) is suggested and numerically investigated. A very large 80-nm linear tuning range was obtained as the HCG was actuated by -220 to 250 nm. The large tuning range results from making the air gap part of the optical cavity, which was achieved by inserting an antireflection layer below the air gap and by the absence of partial top DBR for current spreading. The single mode operation was maintained throughout the tuning range, thanks to the selective pumping of the fundamental mode and the moderate mode selection by the HCG itself. Analytic expressions for tuning range and tuning sensitivity were derived, using the penetration depth of the HCG for the first time.
A high-efficiency electrically-pumped single-photon source based on a photonic nanowire

An electrically-pumped single-photon source design with a predicted efficiency of 89% is proposed. The design is based on a quantum dot embedded in a photonic nanowire with tailored ends and optimized contact electrodes. Unlike cavity-based approaches, the photonic nanowire features broadband spontaneous emission control and an improved tolerance towards fabrication imperfections. The various building blocks of the design are analyzed using an elements-splitting approach.

General information
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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, French Alternative Energies and Atomic Energy Commission
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J., Claudon, J., Gérard, J.
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Event: Paper presented at 3rd International Workshop on Theoretical and Computational Nano-Photonics, Bad Honnef, Germany.
Keywords: photonic wire, nanowire, single-photon source, electrical pumping

A highly efficient single-photon source based on a quantum dot in a photonic nanowire

General information
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A highly efficient single-photon source based on a quantum dot in a photonic nanowire

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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, French Alternative Energies and Atomic Energy Commission, Laboratoire Charles Fabry de l'Institut d'Optique
A highly efficient single-photon source based on a quantum dot in a photonic nanowire

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Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, French Alternative Energies and Atomic Energy Commission, Laboratoire Charles Fabry de l'Institut d'Optique
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Scopus rating (2017): CiteScore 0.43 SJR 0.243 SNIP 0.289
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SJR 0.226 SNIP 0.258
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.3 SJR 0.212 SNIP 0.239
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.3 SJR 0.217 SNIP 0.249
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.26 SJR 0.234 SNIP 0.273
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.27 SJR 0.219 SNIP 0.275
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.31 SJR 0.217 SNIP 0.286
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.233 SNIP 0.277
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.236 SNIP 0.312
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.245 SNIP 0.3
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.247 SNIP 0.376
Analysis of optical properties of strained semiconductor quantum dots for electromagnetically induced transparency

Using multiband k*p theory we study the size and geometry dependence on the slow light properties of conical semiconductor quantum dots. We find the V-type scheme for electromagnetically induced transparency (EIT) to be most favorable, and identify an optimal height and size for efficient EIT operation. In case of the ladder scheme, the existence of additional dipole allowed intraband transitions along with an almost equidistant energy level spacing adds additional decay pathways, which significantly impairs the EIT effect. We further study the influence of strain and band mixing comparing four different k*p band structure models. In addition to the separation of the heavy and light holes due to the biaxial strain component, we observe a general reduction in the transition strengths due to energy crossings in the valence bands caused by strain and band mixing effects. We furthermore find a non-trivial quantum dot size dependence of the dipole moments directly related to the biaxial strain component. Due to the separation of the heavy and light holes the optical transition strengths between the lower conduction and upper most valence-band states computed using one-band model and eight-band model show general qualitative agreement, with exceptions relevant for EIT operation.

General information

State: Published
Organisations: Department of Micro- and Nanotechnology, Nanophotonics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Theoretical Nanotechnology, University of Southern Denmark
Number of pages: 22
Publication date: 2010
Peer-reviewed: Yes

Publication information

Journal: ArXiv Astrophysics e-prints
Issue number: arXiv:1002.2102
Original language: English
URLs:
http://arxiv.org/abs/1002.2102
Source: dtu
Source-ID: n:oai:DTIC-ART:arxiv/372450170::30770
Research output: Research - peer-review; Journal article – Annual report year: 2010

A scheme comparison of Autler-Townes based slow light in inhomogeneously broadened quantum dot media

We propose a method to achieve significant optical signal delays exploiting the effect of Autler–Townes splitting (ATS) in an inhomogeneously broadened quantum dot medium. The absorption and slowdown effects are compared for three schemes i.e., Ξ, V, and Λ, corresponding to different excitation configurations. Qualitative differences of the V scheme compared to the Ξ and Λ schemes are found, which show that features of (ATS) are only revealed in the V scheme. The underlying physical mechanisms causing this discrepancy are analyzed and discussed. Finally we compare field propagation calculations of the schemes showing significantly larger achievable signal delays for the V scheme despite finite absorption of the coupling field. This opens the possibility for using waveguide structures for both coupling and probe fields, thus significantly increasing the achievable signal delays.

General information

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Hansen, P. L., Merk, J.
Pages: 2654-2664
Publication date: 2010
Peer-reviewed: Yes

Publication information

Journal: Optical Society of America. Journal B: Optical Physics
Volume: 27
Broadband MEMS-tunable high-index-contrast subwavelength grating long-wavelength VCSEL

A widely-tunable single-mode 1.3 μm vertical-cavity surface-emitting laser structure incorporating a microelectromechanical system-tunable high-index-contrast subwavelength grating (HCG) mirror is suggested and numerically investigated. A linear tuning range of 100 nm and a wavelength tuning efficiency of 0.203 are predicted. The large tuning range and efficiency are attributed to the incorporation of the tuning air gap as part of the optical cavity and to the use of a short cavity structure. The short cavity length can be achieved by employing a HCG design of which the reflection mechanism does not rely on resonant coupling. The absence of resonance coupling leads to a 0.59 λ-thick penetration depth of the HCG and enables to use a 0.25 λ-thick tuning air gap underneath the HCG. This considerably reduces the effective cavity length, leading to larger tuning range and efficiency. The basic properties of this new structure are analyzed, and shown to be explained by analytical expressions that are derived in the paper. In this context, the penetration depth of the HCG is introduced and shown to be an important characteristic length scale. Throughout the tuning wavelength range, strong single mode operation was maintained and uniform output power is expected.
Concept for phase-to-intensity conversion in SOAs by facet reflections

All-optical conversion from phase-modulated signals to intensity-modulated signals is theoretically demonstrated in semiconductor optical amplifiers (SOAs). Large-signal and small-signal calculations show significant conversion responses appearing as a result of even minute reflections at the end mirrors of the SOA. It is discussed how reflected phase-modulated signals can lead to interference resulting in intensity fluctuations that are amplified by the gain in a SOA. The effect can be utilized for deliberate conversion between optical modulation formats.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Blaaberg, S., Mørk, J.
Designs for high-efficiency electrically pumped photonic nanowire single-photon sources

We propose and analyze three electrically-pumped nanowire single-photon source structures, which achieve output efficiencies of more than 80%. These structures are based on a quantum dot embedded in a photonic nanowire with carefully tailored ends and optimized contact electrodes. Contrary to conventional cavity-based sources, this non-resonant approach provides broadband spontaneous emission control and features an improved fabrication tolerance towards surface roughness and imperfections. Using an element-splitting approach, we analyze the various building blocks of the designs with respect to realistic variations of the experimental fabrication parameters.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, CNRS
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J., Claudon, J., Gerard, J.
Pages: 21204-21218
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 18
Issue number: 20
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
Web of Science (2010): Impact factor 3.753
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.204 SNIP 2.423
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.284 SNIP 2.11
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.313 SNIP 2.336
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.819 SNIP 2.472
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.669 SNIP 2.217
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.745 SNIP 1.748
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.496 SNIP 1.42
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.98 SNIP 0.761
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.442 SNIP 0.843
Original language: English
Electronic versions:
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**Enhanced amplified spontaneous emission in III-V semiconductor photonic crystal waveguides**

We experimentally demonstrate enhanced amplified spontaneous emission in the slow light regime of an active photonic crystal waveguide slab. This promises great opportunities for future devices such as miniaturized semiconductor optical amplifiers and mode-locked lasers.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Ek, S., Schubert, M., Yvind, K., Mørk, J.
Publication date: 2010

**Host publication information**

Title of host publication: Proceedings IPR
Source: orbit
Source-ID: 271095
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

**Enhancing slow and fast light effects in quantum dot semiconductor waveguides through ultrafast dynamics**

We show that ultrafast carrier dynamics plays an important role on slow and fast light effects based on coherent population oscillations in quantum dot semiconductor waveguides. Fast light in the gain regime and slow light in the absorption regime are found to be enhanced at frequencies beyond the usual limits of the carrier lifetime. The effects are investigated by a comprehensive model and shown to originate from non-equilibrium dynamics within the quantum dot carrier populations.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Mørk, J.
Pages: 697-699
Publication date: 2010
Peer-reviewed: Yes

**Publication information**

Journal: Optics Letters
Volume: 35
Issue number: 5
ISSN (Print): 0146-9592
Ratings:
  - BFI (2018): BFI-level 2
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 2
  - Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
  - Web of Science (2017): Impact factor 3.589
  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 2
  - Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
  - Web of Science (2016): Impact factor 3.416
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 2
  - Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Experimental validation of efficient methods for the prediction of patterning effects in SOA-based optical switches

General information
State: Published
Organisations: High-Speed Optical Communication, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing

Original language: English
DOIs: 10.1364/OL.35.000697
Source: orbit
Source-ID: 257727
Research output: Research - peer-review \ Journal article – Annual report year: 2010
Finite-element modeling of spontaneous emission of a quantum emitter at nanoscale proximity to plasmonic waveguides

We develop a self-consistent finite-element method to quantitatively study spontaneous emission from emitters in nanoscale proximity of plasmonic waveguides. In the model, it is assumed that only one guided mode is dominantly excited by the quantum emitter, while the cross section of the plasmonic waveguide can be arbitrary. The fraction of the energy coupled to the plasmonic mode can be calculated exactly, which can be used to determine the efficiency with which single optical plasmons are generated. We apply our numerical method to calculate the coupling of a quantum emitter to a cylindrical metallic nanowire and a square metallic waveguide, and compare the cylindrical metallic nanowire with previous work that employs quasistatic approximation. For the cylindrical metallic nanowire we observe good agreement with the quasistatic approximation for radii below 10 nm, but for increasing radius the spontaneous emission β factor and the plasmonic decay rate deviate substantially, by factors of up to 5–10 for a radius of ~100 nm, from the values obtained in the quasistatic approximation. We also show that the quasistatic approximation is typically valid when the radius is less than the skin depth of the metals at optical frequencies. For the square metallic waveguide we estimate an optimized value for the spontaneous emission β factor up to 80%.
In this article, we report our results on 980nm high-index-contrast subwavelength grating (HCG) VCSELs for optical interconnection applications. In our structure, a thin undoped HCG layer replaces a thick p-type Bragg mirror. The HCG mirror can feasibly achieve polarization-selective reflectivities close to 100%. The investigated structure consists of a HCG mirror with an underneath /4-thick oxide gap, four p-type GaAlAs/GaAs pairs for current spreading, three InGaAs/GaAs quantum wells, and an n-type GaAlAs/GaAs Bragg mirror. The HCG structure was defined by e-beam lithography and dry etching. The current oxide aperture and the oxide gap underneath the HCG were simultaneously formed by the selective wet oxidation process. Compared to air-gap high contrast grating mirrors demonstrated elsewhere, our grating mirrors are particular since they are supported by thinner /4 aluminium oxide layer, and thus are mechanically robust and thinner than usual designs. Sub-milliamp threshold currents and single-transverse-mode operation was obtained. A hero device exhibited maximum singlemode output power of more than 4 mW at room temperature and 1 mw at 70°C, which are the highest values ever reported from the HCG structures. These results build a bridge between a standard VCSEL and a hybrid laser on silicon, making them of potential use for the realization of silicon photonics.
Hybrid vertical cavity laser
A new hybrid vertical cavity laser structure for silicon photonics is suggested and numerically investigated. It incorporates a silicon subwavelength grating as a mirror and a lateral output coupler to a silicon ridge waveguide.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chung, I., Mørk, J.
Pages: JTuB11
Publication date: 2010

Host publication information
Title of host publication: Proceedings IPR
Publisher: Optical Society of America
Source: orbit
Source-ID: 266859
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Influence of carrier dynamics on the modulation bandwidth of quantum-dot based nanocavity devices
We theoretically investigate the modulation response of quantum-dot based nanocavity light emitting devices. For high Purcell enhancement factors, our theory predicts the possibility of decreasing the modulation bandwidth with increasing scattering rate into the lasing quantum-dot state. This counterintuitive effect is investigated using a microscopic semiconductor model. The resulting guidelines for possible optimizations of quantum-dot based nanocavity laser devices are given.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Lorke, M., Nielsen, T. R., Mørk, J.
Pages: 211106
Publication date: 2010
Peer-reviewed: Yes

Publication information
Volume: 97
Issue number: 21
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Ultrafast optical switching employing semiconductor optical amplifier (SOA) based optical switches has been demonstrated at bitrates up to 640 Gbit/s. However, patterning effects caused by relatively slow recovery processes in semiconductor structures remain as an important deteriorating factor that limits the ultimate speed at which SOA-based switches can be operated. In this paper, we investigate the patterning effects of SOA-based switches using a systematic approach. A simple condition for the lower bound limit of the bit pattern length that should be adopted in the performance evaluations of the switches is derived. It is shown that the minimum bit pattern length scales linearly with the bitrate and
the recovery time of the SOA. To overcome the excessive computation time needed for numerical analysis at long pseudorandom binary sequence (PRBS) lengths, an effective method, i.e., periodic method, has been proposed based on the idea of driving the SOA at two saturation extremes by two periodic pulse trains. The predictive power of the periodic method is verified by comparing its results with those obtained by using ordinary PRBS patterns. Finally, the effectiveness of the periodic method is exploited by analyzing in detail the performance properties of a specific type of switch over large parameter regions. Besides allowing an investigation of patterning effects, the periodic method also simultaneously provides such figures of merit as output power and pulsewidth.

General information
State: Published
Organisations: High-Speed Optical Communication, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Xu, J., Zhang, X., Mørk, J.
Pages: 87-94
Publication date: 2010
Peer-reviewed: Yes

Publication Information
Journal: IEEE Journal of Quantum Electronics
Volume: 46
Issue number: 1
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.19 SJR 1.37 SNIP 1.57
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.372 SNIP 1.687
Web of Science (2010): Impact factor 2.48
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.801 SNIP 1.979
Light propagation in finite-sized photonic crystals: multiple scattering using an electric field integral equation

We present an accurate, stable, and efficient solution to the Lippmann–Schwinger equation for electromagnetic scattering in two dimensions. The method is well suited for multiple scattering problems and may be applied to problems with scatterers of arbitrary shape or non-homogenous background materials. We illustrate the method by calculating light emission from a line source in a finite-sized photonic crystal waveguide.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Kristensen, P. T., Lodahl, P., Mørk, J.
Pages: 228-237
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optical Society of America. Journal B: Optical Physics
Volume: 27
Issue number: 2
ISSN (Print): 0740-3224
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.97 SJR 0.859 SNIP 0.875
Web of Science (2017): Impact factor 2.048
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.85 SNIP 0.936
Web of Science (2016): Impact factor 1.843
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Microwave photonic true time delay based on cross gain modulation in semiconductor optical amplifiers

We experimentally demonstrate microwave time delays in a semiconductor optical amplifier by cross gain modulation. In the counter-propagation configuration, ~10.5ps tunable true time delay over a microwave bandwidth of several tens of GHz is obtained.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Mørk, J.
Pages: 202-203
Publication date: 2010

Host publication information
Title of host publication: proceedings OECC
Publisher: IEEE
Source-ID: 265408
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Microwave signal processing based on ultrafast dynamics in quantum dot waveguides

In this paper we review theoretical work on slow and fast light effects in quantum dot (QD) semiconductor waveguides and the potential applications in microwave photonics. In particular we emphasize the unique ultrafast carrier dynamics occurring between discrete QD bound states and its influence on the dynamic gain grating and cross gain modulation in QD semiconductor optical amplifiers (SOAs). The exploitation of ultrafast carrier dynamics enables the realization of phase shifters at frequencies in the range of 100 GHz.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Chen, Y., Mørk, J.
Pages: 1-4
Publication date: 2010

Host publication information
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Publisher: IEEE
Keywords: semiconductor optical amplifier, quantum dots, microwave photonics
Electronic versions: Chen.pdf
DOIs: 10.1109/ICTON.2010.5549185

Bibliographical note
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Source: orbit
Source-ID: 267373
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Modeling of mode-locked coupled-resonator optical waveguide lasers

Coupled-resonator optical waveguides made from coupled high-Q photonic crystal nanocavities are investigated for use as cavities in mode-locked lasers. Such devices show great potential in slowing down light and can serve to reduce the cavity length of a mode-locked laser. An explicit expression for the cold-cavity transmission spectrum is derived and used to interpret numerical investigations performed to characterize the parameter regime of active mode-locked operation. It is found that the modulation frequency relative to the centerband nearest supermode (SM) frequency shift determines the quality of the emerging pulse train. A range of tuning around this frequency allows for effective mode locking. Finally, noise is added to the generalized single-cavity eigenfrequencies in order to evaluate the effects of fabrication imperfections on the cold-cavity transmission properties and consequently on the locking of SMs.

General information
State: Published
Modulation response of nanoLEDs and nanolasers exploiting Purcell enhanced spontaneous emission

The modulation bandwidth of quantum well nanoLED and nanolaser devices is calculated from the laser rate equations using a detailed model for the Purcell enhanced spontaneous emission. It is found that the Purcell enhancement saturates when the cavity quality-factor is increased, which limits the maximum achievable spontaneous recombination rate. The modulation bandwidth is thereby limited to a few tens of GHz for realistic devices.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Skovgård, T. S., Gregersen, N., Yvind, K., Mørk, J.
Pages: 11230-11241
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 18
Issue number: 11
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Non-markovian effects in semiconductor cavity QED: Role of phonon-mediated processes

We show theoretically that the non-Markovian nature of the carrier-phonon interaction influences the dynamical properties of a semiconductor cavity QED system considerably, leading to asymmetries with respect to detuning in carrier lifetimes. This pronounced phonon effect originates from the polaritonic quasi-particle nature of the carrier-photon system interacting with the phonon reservoir.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Department of Micro- and Nanotechnology
Publication date: 2010
Peer-reviewed: Yes
Event: Poster session presented at 10th International Workshop on Nonlinear Optics and Excitation Kinetics in Semiconductors, Paderborn, Germany.
Source: orbit
Source-ID: 272249
Research output: Research - peer-review » Poster – Annual report year: 2010

Non-markovian model of photon-assisted dephasing by electron-phonon interactions in a coupled quantum-dot-cavity system

We investigate the influence of electron-phonon interactions on the dynamical properties of a quantum-dot-cavity QED system. We show that non-Markovian effects in the phonon reservoir lead to strong changes in the dynamics, arising from photon-assisted dephasing processes, not present in Markovian treatments. A pronounced consequence is the emergence of a phonon induced spectral asymmetry when detuning the cavity from the quantum-dot resonance. The asymmetry can only be explained when considering the polaritonic quasiparticle nature of the quantum-dot-cavity system. Furthermore, a temperature induced reduction of the light-matter coupling strength is found to be relevant in interpreting experimental data, especially in the strong coupling regime.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics, Department of Micro- and Nanotechnology
Pages: 157401
Publication date: 2010
Peer-reviewed: Yes
Web of Science (2016): Impact factor 8.462
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.76 SJR 4.656 SNIP 2.538
Web of Science (2015): Impact factor 7.645
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.62 SJR 5.232 SNIP 2.71
Web of Science (2014): Impact factor 7.512
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 7.46 SJR 5.675 SNIP 2.781
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 7.19 SJR 6.292 SNIP 2.867
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 7.02 SJR 6.314 SNIP 2.905
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 6.45 SNIP 2.757
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 6.325 SNIP 2.947
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 6.194 SNIP 2.837
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 5.95 SNIP 2.738
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 4.781 SNIP 2.443
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 4.082 SNIP 2.101
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.847 SNIP 2.122
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 4.661 SNIP 2.651
Web of Science (2003): Indexed yes
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 5.884 SNIP 3.375
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 5.618 SNIP 3.135
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 5.771 SNIP 2.941
Original language: English
Keywords: excitons, semiconductor quantum dots, Electron-phonon interactions, markov processes, photons
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Kaar.pdf
DOIs:
10.1103/PhysRevLett.104.157401
Micropillar cavities are potential candidates for high-efficiency single-photon sources and are testbeds for cavity quantum electrodynamics experiments. In both applications a high quality (Q) factor is desired. It was recently shown that the Q of high-Q semiconductor micropillar cavities exhibit pronounced quasi-periodic variations in the regime from 1 to 4 μm, and a detailed understanding of the variational behavior of the Q is required. Here, we study the origin of these variations using a multi-mode Fabry-Perot model appropriate for this regime. We analyze in detail contributions to the effective reflectivity of the fundamental mode arising from coupling to scattering channels involving higher-order cavity modes and propagating Bloch modes in the distributed Bragg reflectors (DBRs). We show how these weak contributions lead to strong variations of the Q factor, and we relate the average periodicity of these variations to the thickness of the DBRs and the derivative of the effective indices of the guided Bloch modes. We also examine the influence of various geometrical parameters, including the number of DBR layers pairs, the amplitude of the corrugation of the pillar sidewalls and the number of etched layer pairs in the bottom DBR on the Q versus diameter relation. Comparisons are made between extensive numerical simulations and experimental measurements, and a good qualitative agreement is found.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Pages: 1470-1483
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Peer-reviewed: Yes

Publication information
Journal: IEEE Journal of Quantum Electronics
Volume: 46
Issue number: 10
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
On the use of slow light for enhancing waveguide properties

On the basis of a general analysis of waveguides containing a dispersive material, we identify conditions under which slow-light propagation may enhance the gain, absorption, or phase change. The enhancement is shown to depend on the slow-light mechanism and the translational symmetry of the waveguide. A combination of material and waveguide dispersion may strongly enhance the control of light speed, e.g., using electromagnetically induced transparency in quantum dots embedded in a photonic crystal waveguide.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Mørk, J., Nielsen, T. R.
Pages: 2834-2836
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Pulse delay measurements in cascaded quantum well gain and absorber media

A tunable delay of ultrashort laser pulses in semiconductor waveguide structures are demonstrated in cascaded amplifying and absorbing semiconductor waveguides and compared with a single sectioned waveguide. The single sectioned waveguide shows a low transmission at the maximum delay. This is effectively avoided with the cascaded waveguide configuration, where it is demonstrated viable achieving a net pulse delay while maintaining a transmission of unity. For both type of devices, a pulse advancement is observed, at large pulse energies, that existing models are unable to account for.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
Pages: 365-367
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: IEEE Photonics Technology Letters
Volume: 22
Issue number: 6
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.457 SNIP 1.678
Web of Science (2010): Impact factor 1.989
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.721 SNIP 1.913
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.975 SNIP 1.864
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.224 SNIP 1.678
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.012 SNIP 1.869
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.882 SNIP 2.411
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.092 SNIP 2.689
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.17 SNIP 2.436
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.97 SNIP 2.1
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.43 SNIP 1.656
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.636 SNIP 1.199
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.564 SNIP 1.279

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Source: orbit
Source-ID: 256408
Research output: Research - peer-review » Journal article – Annual report year: 2010
Short pulse generation in a passively mode-locked photonic crystal semiconductor laser

We present a new type of passively mode-locked laser with quantum wells embedded in photonic crystal waveguides operating in the slow light regime, which is capable of emitting sub picosecond pulses with widely controllable properties.

General information

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Heuck, M., Blaaberg, S., Mørk, J.
Pages: ITuA2
Publication date: 2010

Host publication information

Title of host publication: Proceedings of the Integrated Photonics Research
Publisher: Optical Society of America
URLs:
http://www.osa.org/Meetings/Archives/2010/IPR_2010_Archive.pdf
Source: orbit
Source-ID: 265899
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Silicon-photonics light source realized by III-V/Si grating-mirror laser

A III–V/Si vertical-cavity in-plane-emitting laser structure is suggested and numerically investigated. This hybrid laser consists of a distributed Bragg reflector, a III–V active region, and a high-index-contrast grating HCG connected to an in-plane output waveguide. The HCG and the output waveguide are made in the Si layer of a silicon-on-insulator wafer by using Si-electronics-compatible processing. The HCG works as a highly-reflective mirror for vertical resonance and at the same time routes light to the in-plane output waveguide. Numerical simulations show superior performance compared to existing silicon light sources.

General information

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chung, I., Mørk, J.
Pages: 151113
Publication date: 2010
Peer-reviewed: Yes

Publication information

Volume: 97
Issue number: 15
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Slow and fast light effects and their applications to microwave photonics using semiconductor optical amplifiers

We provide a comprehensive review of the application of slow and fast light (SFL) techniques to the field of microwave photonics. Basic principles leading to the implementation of phase shifting and true time delay operations which are instrumental in this field are first considered. We then focus on the description of the main results obtained by our groups in the implementation of broadband, full 360 phase shifting using coherent population oscillations in semiconductor waveguides. Next, attention is given to the evaluation of the system impairments implied by these devices when included in analog links. Finally, the main results obtained for several microwave photonics applications such as filtering, arbitrary waveform generation and optoelectronic scillators (OEOs) are reviewed, and other directions for future research in the field are discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Polytechnic University of Valencia
Contributors: Sales, S., Xue, W., Mørk, J., Gasulla, I.
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Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Microwave Theory and Techniques
Volume: 58
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.59 SJR 1 SNIP 1.956
Web of Science (2017): Impact factor 3.176
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.39 SJR 0.989 SNIP 1.968
Web of Science (2016): Impact factor 2.897
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.48 SJR 1.01 SNIP 2.018
Web of Science (2015): Impact factor 2.284
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.37 SJR 1.465 SNIP 2.267
Web of Science (2014): Impact factor 2.243
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.64 SJR 1.508 SNIP 2.463
Web of Science (2013): Impact factor 2.943
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.89 SJR 1.225 SNIP 1.955
Web of Science (2012): Impact factor 2.229
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.68 SJR 1.12 SNIP 1.702
Web of Science (2011): Impact factor 1.853
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Investigations of slow and fast light effects in semiconductor waveguides entail interesting physics and point to a number of promising applications. In this review we give an overview of recent progress in the field, in particular focusing on the physical mechanisms of electromagnetically induced transparency and coherent population oscillations. While electromagnetically induced transparency has been the most important effect in realizing slowdown effects in atomic gasses, progress has been comparatively slow in semiconductors due to inherent problems of fast dephasing times and inhomogeneous broadening in quantum dots. The physics of electromagnetically induced transparency in semiconductors is discussed, emphasizing these limitations and recent suggestions for overcoming them. On the other hand, the mechanism of coherent population oscillations relies on wave mixing effects and is well suited for semiconductor waveguides. Recent experimental progress is reviewed, emphasizing new ideas that have significantly enhanced the degree of control that can be exercised and the frequency range that can be achieved. Thus, applications within microwave photonics appear to be within reach.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Mørk, J., Hansen, P. L., Xue, W., Chen, Y., Nielsen, P. K., Nielsen, T. R.
Publication date: 2010
Peer-reviewed: Yes

**Publication information**

Journal: Semiconductor Science and Technology
Volume: 25
Issue number: 8
Article number: 083002
ISSN (Print): 0268-1242
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.22 SJR 0.757 SNIP 1.003
Web of Science (2017): Impact factor 2.28
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.75 SJR 0.793 SNIP 1.02
Web of Science (2016): Impact factor 2.305
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.73 SJR 0.844 SNIP 1.12
Web of Science (2015): Impact factor 2.098
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.72 SJR 1.04 SNIP 1.128
Web of Science (2014): Impact factor 2.19
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.53 SJR 1.228 SNIP 1.168
Web of Science (2013): Impact factor 2.206
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.42 SJR 1.081 SNIP 1.012
Web of Science (2012): Impact factor 1.921
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.66 SJR 1.008 SNIP 1.069
Web of Science (2011): Impact factor 1.723
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.809 SNIP 0.864
Web of Science (2010): Impact factor 1.333
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.865 SNIP 0.89
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.272 SNIP 1.271
Scopus rating (2007): SJR 1.234 SNIP 1.168
Scopus rating (2006): SJR 1.191 SNIP 1.098
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.235 SNIP 1.13
Scopus rating (2004): SJR 1.445 SNIP 1.129
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.254 SNIP 0.992
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.851 SNIP 0.956
Scopus rating (2001): SJR 0.988 SNIP 0.846
Scopus rating (2000): SJR 1.262 SNIP 0.803
Scopus rating (1999): SJR 1.121 SNIP 0.866
Original language: English
DOIs:
10.1088/0268-1242/25/8/083002
Source: orbit
Source-ID: 269727
Research output: Research - peer-review › Journal article – Annual report year: 2010
Slow-light enhanced absorption in a hollow-core fiber

Light traversing a hollow-core photonic band-gap fiber may experience multiple reflections and thereby a slow-down and enhanced optical path length. This offers a technologically interesting way of increasing the optical absorption of an otherwise weakly absorbing material which can infiltrate the fibre. However, in contrast to structures with a refractive index that varies along the propagation direction, like Bragg stacks, the translationally invariant structures studied here feature an intrinsic trade-off between light slow-down and filling fraction that limits the net absorption enhancement. We quantify the degree of absorption enhancement that can be achieved and its dependence on key material parameters. By treating the absorption and index on equal footing, we demonstrate the existence of an absorption-induced saturation of the group index that itself limits the maximum absorption enhancement that can be achieved.

General information
State: Published
Organisations: Structured Electromagnetic Materials, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Department of Micro- and Nanotechnology
Contributors: Grgic, J., Xiao, S., Mørk, J., Jauho, A., Mortensen, A.
Pages: 14270-14279
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 18
Issue number: 13
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
Spontaneous decay of a single quantum dot coupled to a metallic slot waveguide in the presence of leaky plasmonic modes

We numerically investigate the coupling efficiency of a single self-assembled quantum dot to a metallic slot waveguide in the presence of leaky plasmonic modes. Leaky plasmonic modes refer to radiation modes with plasmonic features, resulting from the inhomogeneity of the dielectric environment in which the metallic slot waveguide is embedded. Compared to the ideal case of a homogenous dielectric environment, the coupling efficiency of an emitter to a metallic slot waveguide is significantly reduced. We attribute the reduction to the coupling to leaky plasmonic modes. By increasing the refractive index of the coating layer to minimize the impacts from the leaky plasmonic modes, we find that the coupling efficiency of the quantum dot to the single mode supported by the metallic slot waveguide can be enhanced by more than a factor 2.
We report the first theoretical investigation of passive mode-locking in photonic crystal mode-locked lasers. Related work has investigated coupled-resonator-optical-waveguide structures in the regime of active mode-locking [Opt. Express 13, 4539-4553 (2005)]. An extensive numerical investigation of the influence of key parameters of the active sections and the photonic crystal cavity on the laser performance is presented. The results show the possibility of generating stable and high quality pulses in a large parameter region. For optimized dispersion properties of the photonic crystal waveguide cavity, the pulses have sub picosecond widths and are nearly transform limited.
Transverse-mode-selectable microlens vertical-cavity surface-emitting laser

A new vertical-cavity surface-emitting laser structure employing a thin microlens is suggested and numerically investigated. The laser can be made to emit in either a high-power Gaussian-shaped single-fundamental mode or a high-power doughnut-shaped higher-order mode. The physical origin of the mode selection properties of the new structure is rigorously analyzed and compared to other structures reported in the literature. The possibility of engineering the emission shape while retaining strong single mode operation is highly desirable for low-cost mid-range optical interconnects applications as well as the compact optical trapping of high-refractive-index dielectric particles and low-refractive-index, absorbing, or metallic particles.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Polytechnic University of Turin, Gwangju Institute of Science and Technology
Contributors: Chung, I., Debernardi, P., Lee, Y. T., Mørk, J.
Pages: 4138-4147
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 18
Issue number: 5
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
Ultrahigh-frequency microwave phase shifts mediated by ultrafast dynamics in quantum-dot semiconductor optical amplifiers

We present a novel scheme to achieve tunable microwave phase shifts at frequencies exceeding 100 GHz based on wavelength conversion induced by high-speed cross-gain modulation in quantum-dot semiconductor optical amplifiers.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Mørk, J.
Pages: 935-937
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: IEEE Photonics Technology Letters
Volume: 22
Issue number: 12
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.457 SNIP 1.678
Web of Science (2010): Impact factor 1.989
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Une source de photons uniques efficace basée sur une boîte quantique intégrée dans un fil photonique

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, French Alternative Energies and Atomic Energy Commission, Laboratoire Charles Fabry de l'Institut d'Optique
Publication date: 2010

Event Information
Event: Journées de la Matière Condensée
Location: Troyes, France
Source: orbit
Source-ID: 270523
Research output: Research › Sound/Visual production (digital) – Annual report year: 2010

Wideband 360 degrees microwave photonic phase shifter based on slow light in semiconductor optical amplifiers
In this work we demonstrate for the first time, to the best of our knowledge, a continuously tunable 360° microwave phase shifter spanning a microwave bandwidth of several tens of GHz (up to 40 GHz) by slow light effects. The proposed device exploits the phenomenon of coherent population oscillations, enhanced by optical filtering, in combination with a regeneration stage realized by four-wave mixing effects. This combination provides scalability: three hybrid stages are...
demonstrated but the technology allows an all-integrated device. The microwave operation frequency limitations of the suggested technique, dictated by the underlying physics, are also analyzed.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Polytechnic University of Valencia
Contributors: Xue, W., Sales, S., Capmany, J., Mørk, J.
Pages: 6156-6163
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 18
Issue number: 6
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
Web of Science (2010): Impact factor 3.753
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Optical regeneration using a monolithically integrated chip formed by a cascade of semiconductor optical amplifiers and saturable absorbers is investigated. Static transfer functions, signal reshaping, extinction ratio enhancement, noise dynamics and device dependence on operation conditions are measured. Results show that by cascading two-pairs of SOA–EAs a steep static transfer function is achieved. Dynamical measurements show large improvements in extinction ratio as well as a large improvement in the receiver-sensitivity when used as a regenerator for NRZ signals at 10 Gb/s.

2R-regeneration in a monolithically integrated four-section SOA-EA chip
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.86 SJR 0.614 SNIP 0.95
Web of Science (2017): Impact factor 1.887
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.65 SJR 0.603 SNIP 0.87
Web of Science (2016): Impact factor 1.588
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.62 SJR 0.673 SNIP 0.928
Web of Science (2015): Impact factor 1.48
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.62 SJR 0.7 SNIP 1.03
Web of Science (2014): Impact factor 1.449
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.78 SJR 0.74 SNIP 1.154
Web of Science (2013): Impact factor 1.542
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.63 SJR 0.801 SNIP 1.125
Web of Science (2012): Impact factor 1.438
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.62 SJR 0.811 SNIP 1.2
Web of Science (2011): Impact factor 1.486
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.921 SNIP 1.167
Web of Science (2010): Impact factor 1.517
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.014 SNIP 1.203
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.113 SNIP 1.227
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.059 SNIP 1.063
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.063 SNIP 1.196
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.237 SNIP 1.346
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.289 SNIP 1.408
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.34 SNIP 1.327
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.109 SNIP 1.263
Advanced vectorial simulation of VCSELs with nano structures invited paper
The single-mode properties and design issues of three vertical-cavity surface-emitting laser (VCSEL) structures incorporating nano structures are rigorously investigated. Nano structuring enables to deliver selective pumping or loss to the fundamental mode as well as stabilizing the output polarization state. Comparison of three vectorial simulation methods reveals that the modal expansion method is suitable for treating the nano structured VCSEL designs.

A highly efficient monomode single photon source in the photonic wire geometry

A method to achieve large tunable delays based on EIT in an inhomogeneously broadened quantum dot medium
We propose a scheme for reducing the impact of inhomogeneous broadening on quantum dot based EIT for slow light. Field propagation calculations show superior performance in delay compared to traditionally investigated EIT schemes.
Broadband microwave phase shifter based on high speed cross gain modulation in quantum dot semiconductor optical amplifiers

We present a scheme to achieve tunable ~180 degrees microwave phase shifts at frequencies exceeding 100 GHz based on high speed cross gain modulation in quantum dot semiconductor optical amplifiers.

Comparison of electromagnetically induced transparency schemes in semiconductor quantum dot structures: Impact of many-body interactions

We investigate the impact of many-body interactions on group-velocity slowdown achieved via electromagnetically induced transparency in quantum dots using three different coupling-probe schemes (ladder, V, and Lambda, respectively). We find that for all schemes many-body interactions have an important impact on the slow light properties. In the case of the Lambda and V schemes, the minimum required coupling power to achieve slow light is significantly reduced by many-body interactions. V type schemes are found to be generally preferable due to a favorable redistribution of carriers in energy space.
Controlling the speed of light in semiconductor waveguides: Physics and applications: [invited]

We review the physics of slow and fast light effects in semiconductor optical waveguides. Recent experimental and theoretical results on enhancing the phase shift using optical filtering are presented and applications in microwave photonics are discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Mørk, J., Xue, W., Chen, Y., Blaaberg, S., Sales, S., Capmany, J.
Pages: 1-2
Publication date: 2009

Control of ultrafast pulse propagation in semiconductor components: [invited]

Time shifting of optical pulses with duration in the range from 100 fs to a few ps represents one extreme of slow light, where THz bandwidth for the slow down or speed up is necessary. The physics of the time shifting of such very short pulses involves the gain saturation of the optical medium and is different from the slow-light mechanisms responsible for time shifting of pulses of narrower bandwidth. Experimental and theoretical results with semiconductor components are presented, emphasizing the physics as well as the limitations imposed by the dynamical processes.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Poel, M. V. D., Hansen, P. L., Mørk, J.
Pages: 72140-K-9
Publication date: 2009
Peer-reviewed: Yes
Conversion of phase-modulated signals to amplitude-modulated signals in SOAs due to mirror reflections
We present theoretical results that show conversion of phase modulated signals to amplitude modulated signals in an SOA. Large-signal and small-signal calculations show significant conversion responses caused by even minute reflections at the end mirrors.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Blaaberg, S., Mørk, J.
Pages: IWA5
Publication date: 2009

Demonstration of tunable microwave photonic notch filters using slow and fast light effects in semiconductor optical amplifiers
We introduce a novel scheme based on slow and fast light effects in semiconductor optical amplifiers, to implement a microwave photonic notch filter with ~100% fractional tuning range at a microwave frequency of 30 GHz.

General information
Effect of temperature and phonons on the spectral properties of a multi-level semiconductor quantum dot single-photon source

Since it was realized that efficient quantum computing can be performed using single photons and standard linear optics elements, immense international research activity has been aimed at developing semiconductor quantum dot (QD) single-photon sources (SPS). In order to optimise the design of SPS for high efficiency as well as increase the understanding of the physics, advanced and accurate models are needed that describes the complex solid-state environment the SPS is part of. This paper investigates a many-body model of a SPS based on the non-equilibrium Green's function formalism (NEGF), where the most important many-body interactions occurring in a semiconductor, namely the electron-phonon, electron-photon, and electron-electron interaction are included. The novel part of the model is that both longitudinal optical (LO) and acoustical (LA) phonons in the NEGF model are included, which allows us to study complicated multi-level QDs, not possible within the commonly used independent boson model (IBM).

Enhancing slow and fast light effects in quantum dot optical amplifiers through ultrafast dynamics

We numerically demonstrate potential roles of ultrafast carrier dynamics in Quantum dot amplifiers to achieve tunable microwave phase shifting at frequencies beyond the limits of carrier lifetime in coherent population oscillations mechanism.
Experimental demonstration of 360 tunable RF phase shift using slow and fast light effects

A microwave photonic phase shifter realizing 360º phase shift over a RF bandwidth of more than 10 GHz is demonstrated using optical filtering assisted slow and fast light effects in a cascaded structure of semiconductor optical amplifiers.

Exploring carrier dynamics in semiconductors for slow light: [invited]

We give an overview of recent results on slow and fast light in active semiconductor waveguides. The cases of coherent population oscillations as well as electromagnetically induced transparency are covered, emphasizing the physics and fundamental limitations.

Fast, accurate and stable scattering calculation method with application to finite sized photonic crystal waveguides

We present a multipole solution to the Lippmann-Schwinger equation for electromagnetic scattering in inhomogeneous geometries. The method is illustrated by calculating the Green’s function for a finite sized two-dimensional photonic crystal.
waveguide.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Kristensen, P. T., Lodahl, P., Mørk, J.
Publication date: 2009

**Host publication information**

Title of host publication: Proceedings, Advances in optical sciences
Publisher: Optical Society of America
Source: orbit
Source-ID: 249797
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

**General Method for Calculating the Response and Noise Spectra of Active Fabry-Perot Semiconductor Waveguides With External Optical Injection**

We present a theoretical method for calculating small-signal modulation responses and noise spectra of active Fabry-Perot semiconductor waveguides with external light injection. Small-signal responses due to either a modulation of the pump current or due to an optical amplitude or phase modulation of the input field can be calculated. Both responses and noise spectra are given through semianalytical expressions taking into account the longitudinal extent and finite end-facet reflectivities of the active device. Different examples of responses and spectra are presented for semiconductor optical amplifiers and an injection-locked laser. We also demonstrate the applicability of the method to analyze slow and fast light effects in semiconductor waveguides. Finite reflectivities of the facets are found to influence the phase changes of the injected microwave-modulated light.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Blaaberg, S., Mørk, J.
Pages: 940-953
Publication date: 2009
Peer-reviewed: Yes

**Publication information**

Volume: 45
Issue number: 8
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
High-efficiency single-photon source: The photonic wire geometry

We present a single-photon-source design based on the emission of a quantum dot embedded in a semiconductor (GaAs) nanowire. The nanowire ends are engineered (efficient metallic mirror and tip taper) to reach a predicted record-high collection efficiency of 90% with a realistic design. Preliminary experimental results already show a measured efficiency of 44%.
Investigation of patterning effect in ultrafast SOA-based optical switches

A lower bound of PRBS length is derived considering patterning effects in ultrafast SOA-based switches. An effective method for simulating patterning effects is proposed, validated and applied to characterize the switches in large parameter regions.

Microwave phase shifter with controllable power response based on slow-and fast-light effects in semiconductor optical amplifiers

We suggest and experimentally demonstrate a method for increasing the tunable rf phase shift of semiconductor waveguides while at the same time enabling control of the rf power. This method is based on the use of slow- and fast-light effects in a cascade of semiconductor optical amplifiers combined with the use of spectral filtering to enhance the role of refractive index dynamics. A continuously tunable phase shift of 240° at a microwave frequency of 19 GHz is demonstrated in a cascade of two semiconductor optical amplifiers, while maintaining an rf power change of less than 1.6 dB. The technique is scalable to more amplifiers and should allow realization of an rf phase shift of 360°.
ISSN (Print): 0146-9592
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.95 SJR 2.441 SNIP 2.058
Web of Science (2013): Impact factor 3.179
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.52 SJR 2.577 SNIP 1.92
Web of Science (2012): Impact factor 3.385
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.69 SJR 2.519 SNIP 2.453
Web of Science (2011): Impact factor 3.399
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.637 SNIP 2.263
Web of Science (2010): Impact factor 3.318
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 3.077 SNIP 2.658
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 3.354 SNIP 2.384
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.443 SNIP 2.157
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 3.126 SNIP 2.319
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.245 SNIP 2.451
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.523 SNIP 2.726
Web of Science (2004): Indexed yes
Microwave photonics processing controlling the speed of light in semiconductor waveguides: [Invited]
We review the theory of slow and fast light effect in semiconductor waveguides and potential applications of these effects in microwave photonic systems as RF phase shifters. Recent applications as microwave photonic filters is presented. Also, in the presentation more applications like optoelectronic oscillators and arbitrary waveform generators will be described. Some work related to the noise and distortion will also be discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Polytechnic University of Valencia
Contributors: Xue, W., Chen, Y., Sales, S., Blaaberg, S., Mørk, J., Capmany, J.
Pages: 1-5
Publication date: 2009

Host publication information
Title of host publication: 11th International Conference on Transparent Optical Networks, 2009. ICTON '09
Publisher: IEEE
ISBN (Print): 978-1-4244-4825-8
Keywords: microwave phase shifter, slow/fast light, microwave photonics
Electronic versions:
Xue.pdf
DOIs: 10.1109/ICTON.2009.5185046

Bibliographical note
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Source: orbit
Source-ID: 240841
Research output: Research - peer-review › Journal article – Annual report year: 2009

Nonlinear dynamics in photonic crystal nanocavity lasers
We model coupled nanolasers by adding phase-dependent coupling terms to the Purcell-enhanced laser rate equations. Transitions between phase-locking and complex oscillatory behavior are observed at critical coupling strengths in detuned two-laser systems.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Skovgård, T. S., Kristensen, P. T., Frandsen, L. H., Schubert, M., Gregersen, N., Mørk, J.
Pages: 1-1
Publication date: 2009
Optical properties and optimization of electromagnetically induced transparency in strained InAs/GaAs quantum dot structures

Using multiband k center dot p theory we study the size and geometry dependence on the slow light properties of conical semiconductor quantum dots. We find the V-type scheme for electromagnetically induced transparency (EIT) to be most favorable and identify an optimal height and size for efficient EIT operation. In case of the ladder scheme, the existence of additional dipole allowed intraband transitions along with an almost equidistant energy-level spacing adds additional decay pathways, which significantly impairs the EIT effect. We further study the influence of strain and band mixing comparing four different k center dot p band-structure models. In addition to the separation of the heavy and light holes due to the biaxial-strain component, we observe a general reduction in the transition strengths due to energy crossings in the valence bands caused by strain and band-mixing effects. We furthermore find a nontrivial quantum dot size dependence of the dipole moments directly related to the biaxial-strain component. Due to the separation of the heavy and light holes the optical transition strengths between the lower conduction and upper most valence-band states computed using one-band model and eight-band model show general qualitative agreement, with exceptions relevant for EIT operation.
Optical signal processing using slow and fast light technologies: [invited]

We review the theory of slow and fast light effects due to coherent population oscillations in semiconductor waveguides, which can be potentially applied in microwave photonic systems as a RF phase shifters. In order to satisfy the application requirement of 360 degrees RF phase shift at different microwave or millimeter-wave frequency bands, we present one
scheme to increase the achievable RF phase shift by enhancing light slow-down or speed-up. As a real application in microwave photonics, a widely tunable microwave photonic notch filter with 100% fractional tuning range is also proposed and demonstrated.

**General information**
State: Published
Organisations: Department of Photonics Engineering, Polytechnic University of Valencia
Contributors: Capmany, J., Sales, S., Xue, W., Chen, Y., Blaaberg, S., Mørk, J.
Number of pages: 574
Pages: 351-359
Publication date: 2009

**Host publication information**
Title of host publication: 14th European conference on networks and optical communications
Place of publication: Valladolid, Spain
ISBN (Print): 978-84-692-2943-9
Source: orbit
Source-ID: 249709
Research output: Research › peer-review › Article in proceedings – Annual report year: 2009

**Optimizing the spontaneous-emission ß factor for single optical plasmon generation**
In applications like quantum cryptography and quantum computation, it is desirable to obtain single photon sources which can produce a train of single photons on demand at a high repetition rate, especially at or near room temperature. Such single-photon sources can be realized by tailoring the photonic environment of the quantum emitter. The photonic environment determines the local density of states, into which the photon can be emitted. A number of structures such as interfaces, cavities and waveguides have already been used to modify the spontaneous emission (SE) rate; nevertheless there is still room for improving the overall efficiency of the single-photon sources, e.g., by inventing new ways of enhancing light-matter interaction.

**General information**
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Pages: 1-1
Publication date: 2009

**Host publication information**
Title of host publication: Proceedings, CLEO/Europe - EQEC
Publisher: IEEE
Electronic versions:
Chen.pdf
DOIs:
10.1109/CLEOE-EQEC.2009.5192257

**Bibliographical note**
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Source: orbit
Source-ID: 251708
Research output: Research › Article in proceedings – Annual report year: 2009

**Oscillatory variations in the Q factors of high quality micropillar cavities**
We report on the observation of oscillatory variations in the quality Q factor of quantum dot-micropillar cavities based on planar Bragg reflectors. The oscillatory behavior in the Q versus diameter dependence appears in the diameter range between 1.0 and 4.0 m, has a characteristic period of a few hundred nanometers and increases in amplitude with increasing reflectivity of the planar microcavity structures. The experimental results are well reproduced by numerical calculations which support the interpretation that the Q oscillations are caused by coupling of propagating Bloch modes of different orders at the mirror interfaces.

**General information**
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Reitzenstein, S., Gregersen, N., Kistner, C., Strauss, M., Schneider, C., Pan, L., Nielsen, T. R., Höfling, S., Mørk, J., Forchel, A.
Photonic generation of ultrawideband monocycle and doublet pulses by using a semiconductor-optical-amplifier-based wavelength converter

Photonic generation of ultrawideband (UWB) monocycle and doublet pulses is experimentally demonstrated using a cascaded electroabsorption modulator (EAM) and semiconductor optical amplifier by exploiting a combination of cross-absorption modulation and cross-gain modulation. The polarities and shapes of UWB monocycle and doublet pulses can be simply controlled using an optical time-delay controller and the reverse voltage applied to the EAM. The corresponding measured rf spectra meet the UWB criteria.

General information
State: Published
Organisations: Department of Photonics Engineering, Metro-Access and Short Range Systems, Nanophotonics Theory and Signal Processing
Pages: 1336
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Volume: 34
Issue number: 9
ISSN (Print): 0146-9592
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
Quantitative analysis of oscillatory variations in the quality factor of micropillar cavities

The influence of the pillar radius on the Q factor of a micropillar cavity is investigated numerically. The relation between Q factor and pillar radius shows an advanced oscillatory behavior which cannot be explained in a 1D model. We propose a multi-mode Fabry-Perot model to quantify the oscillation period observed and we show that the governing mechanism behind the oscillation is coupling to higher-order propagating Bloch modes in the distributed Bragg reflectors. We demonstrate that even though the Q factor is an advanced function involving many oscillating contributions, the model still allows for the determination of a characteristic oscillation period.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J.
Pages: 115-117
Publication date: 2009

Quantum dot waveguides: ultrafast dynamics and applications: [invited]

In this paper we analyze, based on numerical simulations, the dynamics of semiconductor devices incorporating quantum dots (QDs). In particular we emphasize the unique ultrafast carrier dynamics occurring between discrete QD bound states, and its influence on QD semiconductor optical amplifiers (SOAs). Also the possibility of realizing an all-optical regenerator by incorporating a QD absorber section in an amplifier structure is discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Chen, Y., Mørk, J.
Pages: 1-4
Publication date: 2009
Reducing the impact of inhomogeneous broadening on quantum dot based electromagnetically induced transparency

Slow light based on electromagnetically induced transparency in an inhomogeneously broadened quantum dot medium is investigated theoretically. Three schemes, \( V \), \( V \), and \( \Lambda \), are compared and it is shown that the \( V \)-scheme gives a group velocity that is more than three orders of magnitude smaller compared to the - and \( \Lambda \)-schemes. The physical mechanisms that make the \( V \)-scheme less vulnerable to inhomogeneous broadening are analyzed and discussed.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Hansen, P. L., Mørk, J.
Pages: 071108
Publication date: 2009
Peer-reviewed: Yes

**Publication information**

Volume: 94
Issue number: 7
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
Slow and fast light: Controlling the speed of light using semiconductor waveguides

We give an overview of slow- and fast-light effects in semiconductor active waveguides. Experimental and theoretical results are presented, emphasizing the physics of these phenomena and the limitations imposed by the carried dynamical processes.
General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Mørk, J., Öhman, F., Poel, M. V. D., Chen, Y., Hansen, P. L., Yvind, K.
Pages: 30-44
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Laser & Photonics Reviews
Volume: 3
Issue number: 1-2
ISSN (Print): 1863-8880
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 9.02 SJR 4.228 SNIP 2.988
Web of Science (2017): Impact factor 8.529
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 8.71 SJR 4.013 SNIP 3.351
Web of Science (2016): Impact factor 8.434
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 8.54 SJR 4.205 SNIP 3.479
Web of Science (2015): Impact factor 7.486
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 8.62 SJR 4.958 SNIP 4.446
Web of Science (2014): Impact factor 8.008
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 9.26 SJR 5.132 SNIP 4.796
Web of Science (2013): Impact factor 9.313
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 7.59 SJR 5.144 SNIP 3.617
Web of Science (2012): Impact factor 7.976
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 7.98 SJR 5.844 SNIP 4.857
Web of Science (2011): Impact factor 7.388
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 5.851 SNIP 4.009
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 4.896 SNIP 4.884
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.573 SNIP 3.117
Slow and fast light effects in semiconductor waveguides for applications in microwave photonics

We review the theory of slow and fast light effects due to coherent population oscillations in semiconductor waveguides, and potential applications of these effects in microwave photonic systems as RF phase shifters. In order to satisfy the application requirement of 360º RF phase shift at different microwave or millimeter-wave frequency bands, we present several schemes to increase the achievable RF phase shift by enhancing light slow-down or speed-up. These schemes include integrating gain and absorption sections, optical filtering and the exploitation of the initial chirp effects. As a real application in microwave photonics, a widely tunable microwave photonic notch filter with 100% fractional tuning range is also proposed and demonstrated.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Xue, W., Chen, Y., Öhman, F., Sales, S., Capmany, J., Yvind, K., Mørk, J.
Pages: 7226-7232
Publication date: 2009

Host publication information
Title of host publication: Proceedings of the International Society for Optical Engineering SPIE. Photonics West
Place of publication: San Jose, CA, USA
Publisher: SPIE - International Society for Optical Engineering
Source: orbit
Source-ID: 237599
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

Slow light based on material and waveguide dispersion

We study slow light pulse propagation in a photonic crystal structure consisting of a dispersive and absorptive dielectric material and compare it with the constant wave case. The group index and the trasmission are investigated for the example of an ensemble of semiconductor quantum dots embedded in a photonic crystal waveguide by FDTD Maxwell-Bloch simulations. The total group index scales linearly with the material based group index while the transmission has a power dependency on the material based absorption coefficient.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials
Contributors: Nielsen, T. R., Lavrinenko, A., Mørk, J.
Pages: 75-77
Slow light in quantum dot photonic crystal waveguides
A theoretical analysis of pulse propagation in a semiconductor quantum dot photonic crystal waveguide in the regime of electromagnetically induced transparency is presented. The slow light mechanism considered here is based on both material and waveguide dispersion. The group index n(g) for the combined system is significantly enhanced relative to slow light based on purely material or waveguide dispersion.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials
Contributors: Nielsen, T. R., Lavrinenko, A., Mørk, J.
Pages: 113111
Publication date: 2009
Peer-reviewed: Yes

Publication information
Volume: 94
Issue number: 11
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Indexed yes
Web of Science (2016): Impact factor 3.411
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Indexed yes
Web of Science (2015): Impact factor 3.142
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Indexed yes
Web of Science (2014): Impact factor 3.302
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Indexed yes
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Indexed yes
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Slow light pulse propagation in dispersive media

We present a theoretical and numerical analysis of pulse propagation in a semiconductor photonic crystal waveguide with embedded quantum dots in a regime where the pulse is subjected to both waveguide and material dispersion. The group index and the transmission are investigated by finite-difference-time-domain Maxwell-Bloch simulations and compared to analytic results. For long pulses the group index (transmission) for the combined system is significantly enhanced (reduced) relative to slow light based on purely material or waveguide dispersion. Shorter pulses are strongly distorted and depending on parameters broadening or break-up of the pulse may be observed. The transition from linear to nonlinear pulse propagation is quantified in terms of the spectral width of the pulse. To cite this article: T.R. Nielsen et al., C. R. Physique 10 (2009). (C) 2009 Academie des sciences. Published by Elsevier Masson SAS. All rights reserved.
The optical chip: high speed and diminutive size

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Gregersen, N., Skovgård, T. S., Ek, S., Xue, W., Chung, I., Mørk, J.
Number of pages: 267
Pages: 235-249
Publication date: 2009

Host publication information
Title of host publication: Beyond optical horizons: today and tomorrow with photonics
Place of publication: Kgs. Lyngby
Publisher: DTU Fotonik
Edition: 1
ISBN (Print): 87-92062-34-2
Source: orbit
Source-ID: 255196
Research output: Communication - Book chapter – Annual report year: 2009

The role of input chirp on phase shifters based on slow and fast light effects in semiconductor optical amplifiers
We experimentally investigate the initial chirp dependence of slow and fast light effects in a semiconductor optical amplifier followed by an optical filter. It is shown that the enhancement of the phase shift due to optical filtering strongly depends on the chirp of the input optical signal. We demonstrate ~120° phase delay as well as ~170° phase advance at a microwave frequency of 19 GHz for different optimum values of the input chirp. The experimental results are shown to be in good agreement with numerical results based on a four-wave mixing model. Finally, a simple physical explanation based on an analytical perturbative approach is presented

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Chen, Y., Öhman, F., Mørk, J.
Pages: 1404-1413
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 17
Issue number: 3
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.56
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Vectorial analysis of dielectric photonic crystal VCSEL

A new vertical-cavity surface-emitting laser structure employing a dielectric photonic crystal mirror has been suggested and been numerically investigated. The new structure has a smaller threshold gain, a moderate strength of single-transverse-mode operation, a high quality of emission beam free from the scattering, and a potential of considerably increasing the single-mode output power.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Chung, I., Mørk, J.
Pages: 1-4
Publication date: 2009

Host publication information
Title of host publication: 11th International Conference on Transparent Optical Networks, 2009. ICTON '09
Place of publication: The Azores, Portugal
Publisher: IEEE
ISBN (Print): 978-1-4244-4825-8
Keywords: high power, single-mode

Bibliographical note
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Widely tunable microwave photonic notch filter based on slow and fast light effects

A continuously tunable microwave photonic notch filter at around 30 GHz is experimentally demonstrated and 100% fractional tuning over 360 range is achieved without changing the shape of the spectral response. The tuning mechanism is based on the use of slow and fast light effects in semiconductor optical amplifiers assisted by optical filtering.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Sales, S., Mørk, J., Capmany, J.
Pages: 167-169
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: IEEE Photonics Technology Letters
Volume: 21
Issue number: 3
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Controlling the emission profile of a nanowire with a conical taper

The influence of a tapering on nanowire light-emission profiles is studied. We show that, for nanowires with divergent output beams, the introduction of a conical tapering with a small opening angle reduces the beam divergence and increases transmission. This results in a dramatic increase in the collection efficiency of the detection optics. For a realistic tapering and a modest NA, the collection efficiency is enhanced by more than a factor of 2. This improvement is ensured by the adiabatic expansion of the guided mode in the tapering.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Pages: 1693-1695
Publication date: 1 Aug 2008
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Volume: 33
Issue number: 15
ISSN (Print): 0146-9592
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Web of Science (2014): Indexed yes
A many-body model of semiconductor single-photon sources

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Nielsen, P. K., Nielsen, T. R., Lodahl, P., Mørk, J.
**Analysis of an effective optical filtering technique to enhance microwave phase shifts based on slow and fast light effects**

We theoretically analyze and interpret an effective mechanism, which employs optical filtering to enhance the microwave phase shift that can be achieved in semiconductor optical amplifiers based on slow and fast light effects.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Ohman, F., Xue, W., Mørk, J.
Pages: CME4
Publication date: 2008

**Host publication information**

Publisher: Optical Society of America
Source: orbit
Source-ID: 220617
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

**Analysis of quantum dot EIT based on 8-band kp theory**

**General information**

State: Published
Organisations: Department of Micro- and Nanotechnology, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at 29th International Conference on the Physics of Semiconductors, Rio de Janeiro, Brazil.
Source: orbit
Source-ID: 228435
Research output: Research - peer-review › Poster – Annual report year: 2008

**An improved perfectly matched layer for the eigenmode expansion technique**

When performing optical simulations for rotationally symmetric geometries using the eigenmode expansion technique, it is necessary to place the geometry under investigation inside a cylinder with perfectly conducting walls. The parasitic reflections at the boundary of the computational domain can be suppressed by introducing a perfectly matched layer (PML) using e.g. complex coordinate stretching of the cylinder radius. However, the traditional PML suffers from an artificial field divergence limiting its usefulness. We show that the choice of a constant cylinder radius leads to mode profiles with exponentially increasing field amplitudes resulting in numerical instability. As a remedy we propose an improved PML based on a mode-dependent cylinder radius and mode profiles with stable field amplitudes. The new PML formulation eliminates the artificial field divergence and ensures numerical stability.

**General information**

State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Gregersen, N., Mørk, J.
Pages: 957-966
Publication date: 2008
Peer-reviewed: Yes

**Publication information**

Journal: Optical and Quantum Electronics
Volume: 40
Issue number: 11-12
An improved perfectly matched layer in the eigenmode expansion technique

When employing the eigenmode expansion technique (EET), parasitic reflections at the boundary of the computational domain can be suppressed by introducing a perfectly matched layer (PML). However, the traditional PML, suffers from an artificial field divergence limiting its usefulness. We propose a remedy.

A novel high-efficiency single-mode quantum dot single photon source

We present a novel single-mode single photon source exploiting the emission of a semiconductor quantum dot (QD) located inside a photonic wire. Besides an excellent coupling (>95%) of QD spontaneous emission to the fundamental guided mode [1], we show that a single photon collection efficiency above 80% within a 0.5 numerical aperture can be achieved using a bottom Bragg mirror and a tapering of the nanowire tip. Because this photon collection strategy does not exploit the Purcell effect, it could also be efficiently applied to broadband single photon emitters such as F-centers in diamond.

Broadband microwave photonic phase shifter based on polarisation rotation

A broadband microwave photonic phase shifter is presented based on the polarisation properties of a Mach-Zehnder intensity modulator and nonlinear polarisation rotation in a semiconductor optical amplifier. The system can realise about 150deg phase shift in the frequency range from 50 MHz to 19 GHz.
Broadband subwavelength grating mirror and its application to vertical-cavity surface-emitting laser

Various high-index-contrast sub-wavelength grating (HCG) mirror designs have been investigated. It reveals that transverse magnetic (TM-) and transverse electric (TE-) HCG reflect the incident fields in quite different ways and that the TM-HCG enables very thin gap below the grating. Based on these results, a new HCG VCSEL design with a thin oxide gap has been suggested. The thin oxide gap structure has a number of advantages including easier fabrication, better mechanical stability, and very strong single-mode properties.

Carrier dynamics and slow light in semiconductor nanostructures

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Chirp Dependence of Filter Assisted Slow and Fast Light Effects in Semiconductor Optical Amplifiers

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Chen, Y., Öhman, F., Sales, S., Mørk, J.
Pages: JMB12
Publication date: 2008

Comparison of EIT schemes in semiconductor quantum dots

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Houmark-Nielsen, J., Nielsen, T. R., Mørk, J., Jauho, A.
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at Slow and Fast Light (SL) 2008, Boston, United States.
Source: orbit
Source-ID: 228439
Research output: Research - peer-review › Poster – Annual report year: 2008

Controlling nanowire emission profile using conical taper
The influence of a conical taper on nanowire light emission is studied. For nanowires with divergent output beams, the introduction of tapers improves the emission profile and increase the collection efficiency of the detection optics.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J., Claudon, J., Gerard, J.
Pages: ITuB2
Publication date: 2008

Host publication information
Title of host publication: Integrated Photonics and Nanophotonics Research and Applications
Place of publication: Boston, Massachusetts, USA
Publisher: Optical Society of America
Source: orbit
Source-ID: 220532
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Controlling the emission profile of a nanowire with a conical taper

General information
Enhanced slow light in quantum dot photonic crystal waveguides

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials
Contributors: Nielsen, T. R., Lavrinenko, A., Mørk, J.
Publication date: 2008

Host publication information
Title of host publication: Slow and Fast Light (SL) 2008
Place of publication: Boston, MA, USA
Source: orbit
Source-ID: 228433
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Enhancing light slow-down in semiconductor optical amplifiers by optical filtering

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Chen, Y., Öhman, F., Sales, S., Mørk, J.
Pages: 1084-1086
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Volume: 33
Issue number: 10
ISSN (Print): 0146-9592
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Experimental demonstration of strongly enhanced light slow-down in semiconductor optical amplifiers by optical filtering

**General information**

*State:* Published

*Organisations:* Nanophotonics Theory and Signal Processing, Department of Photonics Engineering

**Experimental demonstration of strongly enhanced light slow-down in semiconductor optical amplifiers by optical filtering**

**General information**

*State:* Published

*Organisations:* Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Experimental observation of pulse delay and speed-up in cascaded quantum well gain and absorber media

Slow-down and speed-up of 180 fs pulses in semiconductor waveguides beyond the existing models is observed. Cascaded gain and absorbing sections is shown to provide significant temporal pulse shifting at near constant output pulse energy.

Fractional decay of quantum dots in photonic crystals

We define a practical measure for the degree of fractional decay and establish conditions for the effect to be observable for quantum dots in photonic crystals exhibiting absorptive losses.
Fractional decay of quantum dots in real photonic crystals
We show that fractional decay may be observable in experiments using quantum dots and photonic crystals with parameters that are currently achievable. We focus on the case of inverse opal photonic crystals and locate the position in the crystal where the effect is most pronounced. Furthermore, we quantify the influence of absorptive loss and show that it is a limiting but not prohibitive effect.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Kristensen, P. T., Koenderink, A. F., Lodahl, P., Tromborg, B., Mørk, J.
Pages: 1557-1559
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Volume: 33
Issue number: 14
ISSN (Print): 0146-9592
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.95 SJR 2.441 SNIP 2.058
Web of Science (2013): Impact factor 3.179
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.52 SJR 2.577 SNIP 1.92
Web of Science (2012): Impact factor 3.385
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.69 SJR 2.519 SNIP 2.453
Web of Science (2011): Impact factor 3.399
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.637 SNIP 2.263
General and efficient method for calculating modulation responses and noise spectra of active semiconductor waveguides

We present a theoretical method for obtaining small-signal responses in a spatially resolved active semiconductor waveguide including finite end-facet reflectivities and amplified spontaneous emission. RF-modulation responses and output noise spectra of an SOA are shown.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Blaaberg, S., Öhman, F., Mørk, J.
Pages: IWE5
Publication date: 2008

Influence of many-particle interactions on slow light phenomena in quantum dots

We investigate the impact of many-particle interactions on group-velocity slowdown achieved via Electromagnetically Induced Transparency (EIT) in quantum dots. Using a ladder scheme we find in the steady-state an increase in maximum slow-down as compared to the non-interacting case, which can be attributed to Coulomb interaction effects. The necessary pump power at which maximum slow down is obtained EIT remains, however.

General information
Influence of pure dephasing on emission spectra from quantum dot-cavity systems
Influence of pure dephasing on emission spectra from single photon sources
We investigate the light-matter interaction of a quantum dot with the electromagnetic field in a lossy microcavity and calculate emission spectra for nonzero detuning and dephasing. It is found that dephasing shifts the intensity of the emission peaks for nonzero detuning. We investigate the characteristics of this intensity shifting effect and offer it as an explanation for the nonvanishing emission peaks at the cavity frequency found in recent experimental work.
Influence of pure dephasing on emission spectra from single photon sources

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Rasmussen, A. N., Skovgård, T. S., Kristensen, P. T., Mørk, J.
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at Danish Optical Society/Danish Physical Society annual meeting 2008, Nyborg, Denmark.
Source: orbit
Source-ID: 223727
Research output: Research - peer-review › Poster – Annual report year: 2008

Introduction to the Feature Issue on Slow Light and Its Applications

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Pages: 3707-3707
Publication date: 2008
Low-noise monolithic mode-locked semiconductor lasers through low-dimensional structures

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonic Devices, Nanophotonics Theory and Signal Processing
Number of pages: 9
Pages: 69090A
Publication date: 2008

Host publication information
Title of host publication: Proc. SPIE
Volume: 6909
Publisher: SPIE - International Society for Optical Engineering
DOI: 10.1117/12.768641

Bibliographical note
Pagination: 69090A1-9
Source: orbit
Source-ID: 211277
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Microwave phase shifter based on mach-zehnder intensity modulator and polarization rotation in an SOA

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Xue, W., Öhman, F., Blaaberg, S., Chen, Y., Sales, S., Mark, J.
Pages: CMP2
Publication date: 2008

Host publication information
Mitigation of patterning effect in wavelength conversion by cascaded semiconductor optical amplifier and electroabsorption modulator

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Zhou, E., Zhang, X., Öhman, F., Cheng, C., Mørk, J., Huang, D.
Number of pages: 713,607
Publication date: 2008

Host publication information
Title of host publication: APOC
Place of publication: San Francisco, USA
Publisher: SPIE - International Society for Optical Engineering
Source: orbit
Source-ID: 233403
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Nanofotonik: Nanofotonik kaster lys over fremtiden

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
Contributors: Hansen, P. L., Andersen, M. L., Poel, M. V. D., Mørk, J.
Pages: 144-159
Publication date: 2008

Host publication information
Title of host publication: Nanoteknologiske Horisonter
Edition: 1
Source: orbit
Source-ID: 222247
Research output: Research - peer-review › Book chapter – Annual report year: 2008

Nanophotonics: Semiconductor Optical Devices

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Yvind, K., Öhman, F., Larsson, D., Poel, M. V. D., Mørk, J., Hvam, J. M., Chung, I.
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at Joint Nano Workshop, Munich, Germany.
Source: orbit
Source-ID: 220831
Research output: Research - peer-review › Poster – Annual report year: 2008

Optical Characterisation of Nanostructures Embedded in Materials

General information
State: Published
Organisations: Department of Mathematics, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials, Technical University of Denmark
Contributors: Karamehmedovic, M., Sørensen, M. P., Hansen, P., Mørk, J., Lavrinenko, A.
Publication date: 2008
Optical Characterisation of Nanostructures Embedded in Materials

General information
State: Published
Organisations: Department of Mathematics, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials, Technical University of Denmark
Contributors: Karamehmedovic, M., Sørensen, M. P., Hansen, P., Mørk, J., Lavrinenko, A.
Publication date: 2008
Peer-reviewed: No
Source: orbit
Source-ID: 228009
Research output: Research › Poster – Annual report year: 2008

Pulse delay and advancement of ultrafast pulses in semiconductor waveguides

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
Publication date: 2008
Peer-reviewed: Yes
Source: orbit
Source-ID: 222246
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2008

Pulse Delay and Speed-up of Ultra Fast Pulses in an Absorbing Quantum Well Medium

Slow down and speed-up of 180 fs pulses in an absorbing semiconductor beyond the existing models is observed. Cascading gain and absorbing sections give us significant temporal pulse shifting at almost constant output pulse energy.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
Pages: CW11.
Publication date: 2008

Host publication information
Title of host publication: CLEO/QELS 2008
Place of publication: San Jose, CA, USA
Publisher: Optical Society of America
Source: orbit
Source-ID: 220902
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Pulse propagation in dispersive media

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials
Contributors: Nielsen, T. R., Lavrinenko, A., Mørk, J.
Publication date: 2008
Pulse propagation in quantum dot photonic crystal waveguides

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Plasmonics and Metamaterials
Contributors: Nielsen, T. R., Mørk, J., Lavrinenko, A.
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at COST Action 734 Meeting, Bratislava, Slovakia.
Source: orbit
Source-ID: 228446
Research output: Research - peer-review » Poster – Annual report year: 2008

Pulse train amplification and regeneration based on semiconductor quantum dots waveguide
We numerically analyze pulse train amplification up to 200 Gbit/s in quantum dot amplifiers and present regeneration properties with saturable absorber based on semiconductor quantum dot waveguides.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Öhman, F., Mørk, J.
Publication date: 2008

Host publication information
Title of host publication: Semiconductor quantum dot devices and applications workshop
Place of publication: Rennes, France
Source: orbit
Source-ID: 222231
Research output: Research - peer-review » Article in proceedings – Annual report year: 2008

Reduction of patterning effects in SOA-based wavelength converters by combining cross-gain and cross-absorption modulation
A scheme for mitigating patterning effects in wavelength conversion by using a concatenated semiconductor optical amplifier (SOA) and electroabsorption modulator (EAM) is proposed. The optimization of the parameters of the semiconductor devices and receiver electronics is theoretically investigated. The bit error ratio (BER) of the output signals in both the co-propagating and the counter-propagating configurations is quantitatively evaluated. The simulation results indicate that the patterning effect in wavelength conversion due to the slow recovery of the carrier density in the SOA can be well compensated by a concatenated EAM. The simulation results are confirmed by preliminary pump-probe experiment using a 10 Gb/s clock pulse train.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Zhou, E., Öhman, F., Cheng, C., Zhang, X., Hong, W., Mørk, J., Huang, D.
Pages: 21522-21528
Publication date: 2008
Peer-reviewed: Yes
Publication information
Journal: Optics Express
Volume: 16
Issue number: 26
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Semi-analytical model of filtering effects in microwave phase shifters based on semiconductor optical amplifiers

We present a model to interpret enhanced microwave phase shifts based on filter assisted slow and fast light effects in semiconductor optical amplifiers. The model also demonstrates the spectral phase impact of input optical signals.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Xue, W., Öhman, F., Mørk, J.
Pages: JMB14
Publication date: 2008

Host publication information
Title of host publication: Semi-analytical model of filtering effects in microwave phase shifters based on semiconductor optical amplifiers
Place of publication: Boston, MA, USA
Source: orbit
Source-ID: 231913
Research output: Research - peer-review › Journal article – Annual report year: 2008

Slow and fast light effects in semiconductor waveguides for applications in microwave photonics

We review the physics of slow and fast light effects in semiconductor waveguides. Different schemes for achieving optically or electronically controlled phase shifts are introduced and explained.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Mørk, J., Öhman, F., Xue, W., Chen, Y., Blaaberg, S., Sales, S.
Pages: 210-213
Publication date: 2008

Host publication information
Title of host publication: 2008 International Topical Meeting on Microwave Photonics
Publisher: IEEE
ISBN (Print): 978-1-4244-2168-8
Electronic versions: Mørk.pdf
DOIs: 10.1109/MWP.2008.4666699

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Source: orbit
Source-ID: 233431
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Slow and fast light in semiconductor waveguides for applications in microwave photonics
**Strong coupling of a quantum emitter to surface plasmon polaritons**

General information
- State: Published
- Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Quantum Photonics
- Contributors: Chen, Y., Nielsen, T. R., Lodahl, P., Mørk, J.
- Publication date: 2008
- Peer-reviewed: Yes
- Event: Poster session presented at Danish Optical Society/Danish Physical Society annual meeting 2008, Nyborg, Denmark.
- Source: orbit
- Source-ID: 228443
- Research output: Research - peer-review • Poster – Annual report year: 2008

A new vertical-cavity surface-emitting laser (VCSEL) structure based on a subwavelength grating mirror and a thin oxide gap is suggested and numerically investigated. The structure is shown to exhibit similar threshold gain, suppression of higher order transverse modes, and polarization stability as a grating-mirror VCSEL reported in the literature based on a thick air gap. The thin oxide gap structure has a number of advantages including easier fabrication, better mechanical stability, and very strong single-mode properties.

**Subwavelength grating-mirror VCSEL with a thin oxide gap**

General information
- State: Published
- Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
- Contributors: Chung, I., Mørk, J., Gilet, P., Chelnokov, A.
- Pages: 105-107
- Publication date: 2008
- Peer-reviewed: Yes

A new vertical-cavity surface-emitting laser (VCSEL) structure based on a subwavelength grating mirror and a thin oxide gap is suggested and numerically investigated. The structure is shown to exhibit similar threshold gain, suppression of higher order transverse modes, and polarization stability as a grating-mirror VCSEL reported in the literature based on a thick air gap. The thin oxide gap structure has a number of advantages including easier fabrication, better mechanical stability, and very strong single-mode properties.
Theory of Optical-Filtering Enhanced Slow and Fast Light Effects in Semiconductor Optical Waveguides

A theoretical analysis of slow and fast light effects in semiconductor optical amplifiers based on coherent population oscillations and including the influence of optical filtering is presented. Optical filtering is shown to enable a significant increase of the controllable phase shift experienced by an intensity modulated signal traversing the waveguide. The theoretical model accounts for recent experimental results and is used to analyze and interpret the dependence on material and device parameters. Furthermore analytical approximations are derived using a perturbation approach and are used to gain a better physical understanding of the underlying phenomena.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Chen, Y., Xue, W., Öhman, F., Mørk, J.
Pages: 3734-3743
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Journal of Lightwave Technology
Volume: 26
Issue number: 23
ISSN (Print): 0733-8724
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.42 SJR 1.166 SNIP 1.791
Web of Science (2017): Impact factor 3.652
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.87 SJR 1.23 SNIP 1.819
Web of Science (2016): Impact factor 3.671
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.15 SJR 1.598 SNIP 1.901
Web of Science (2015): Impact factor 2.567
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.23 SJR 1.737 SNIP 2.411
Web of Science (2014): Impact factor 2.965
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.03 SJR 1.622 SNIP 2.439
Web of Science (2013): Impact factor 2.862
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.21 SJR 1.888 SNIP 2.491
Web of Science (2012): Impact factor 2.555
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
We discuss calculations of spontaneous emission from quantum dots in photonic crystals and show how the decay depends on the intrinsic properties of the emitter as well as the position. A number of fundamentally different types of spontaneous decay dynamics are shown to be possible, including counter intuitive situations in which the quantum dot decays only partially.
10 Gb/s-NRZ Optical 2R-regeneration in two-section SOA-EA chip

All optical 2R-regeneration based on the integration of semiconductor optical amplifiers and electroabsorbers in a single waveguide is experimentally demonstrated. Static transfer functions of concatenated structures show strong improvements of the nonlinearity. An extinction ratio improvement > 4.5 dB has been obtained under dynamics operation. For optical signal-to-noise ratio values above 17 dB, improvement in BER is observed. A receiver sensitivity improvement > 2 dB at BER of 10^{-9} was found for 10 Gb/s operation.

Analysis of the effects of pulse shape and width on the retiming properties of a 3R regenerator

The jitter (retiming) transfer function of the 3R regenerator in the presence of the recovered clock signal was investigated based on a newly developed numerical model. The effects of data signal jitter and pulse shape, recovered clock signal jitter and FWHM of control signal pulses on the timing jitter of the retimed data signal is investigated. The jitter performance of a 3R regenerator significantly improves for flat-top data signal pulses and decreasing control signal pulse width.
Applications for the slow and fast light effects in SOA-EA structures in the radio over fiber links

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Sales, S., Öhman, F., Capmany, J., Mørk, J.
Pages: 269-272
Publication date: 2007

Host publication information
Title of host publication: International Conference on Transparent Optical Networks
Source: orbit
Source-ID: 202139
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Controlling microwave signals by means of slow and fast light effects in SOA-EA structures

We present a novel scheme for the control of microwave signals in the optical domain. We propose the use of alternating amplifying and absorbing sections to implement phase control by using fast and slow light effects in semiconductors. The potential benefits from the proposed semiconductor optical amplifier and electroabsorber structures are the high tuning speed, the continuous scan of the phase delay that brings antenna angular continuing scanning, the small size, the capability of integration, the low insertion losses, and the low bias voltage. We have obtained phase changes of almost 60deg around 10 GHz using commercially available components that were not optimized for this purpose. These results indicate a potential for several microwave photonic applications including the change of the direction of the radiation pattern of photonic phase-array antennas or the implementation of fast tunable microwave photonic filters.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Sales, S., Öhman, F., Capmany, J., Mørk, J.
Pages: 1589-1591
Publication date: 2007
Peer-reviewed: No

Publication information
Journal: IEEE Photonics Technology Letters
Frequency response of slow and fast light in integrated semiconductor waveguide amplifiers and absorbers

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Öhman, F., Mørk, J.
Number of pages: 1
Pages: ThF1
Publication date: 2007

Host publication information
Title of host publication: Proceedings ECIO
Place of publication: Kgs. Lyngby, Denmark
Publisher: COM.DTU
Source: orbit
Source-ID: 199214
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Influence of Coulomb interactions on quantum coherence in quantum dots

General information
State: Published
Organisations: Theoretical Nanotechnology, Department of Micro- and Nanotechnology, Nanophotonics, Department of Photonics Engineering
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at Physics-basedmathematical models of low-dimensional semiconductor nanostructures: analysis and computation, Banff, Canada,
Source: orbit
Source-ID: 209851
Research output: Research - peer-review › Poster – Annual report year: 2007

Influence of geometry on the quality factor of a micro pillar

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J.
Number of pages: 1
Publication date: 2007

Host publication information
Title of host publication: Proceedings OWTNM : April 27-28
Influence of geometry on the quality factor of a micro-pillar

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Gregersen, N., Nielsen, T. R., Mørk, J.
Publication date: 2007
Peer-reviewed: Yes

Large microwave phase shift and small distortion in an integrated waveguide device
We have obtained a tunable phase shift of 150 degrees in an integrated semiconductor waveguide by optimizing the interplay of fast and slow light effects. Furthermore, the distortions imposed by device nonlinearities have been quantified.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Öhman, F., Sales, S., Chen, Y., Granell, E., Mørk, J.
Publication date: 2007

Host publication information
Title of host publication: Slow and Fast Light, OSA Technical Digest (CD)
Volume: paper STuA6
Publisher: Optical Society of America
Source-ID: 202146

Modelling Q-factors of micro pillars
The influence of fabrication induced imperfections on quality factors for a microcavity pillar is studied numerically. The dependence on side-wall inclination and etch variations is quantified.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Nielsen, T. R., Gregersen, N., Tromborg, B., Mørk, J.
Publication date: 2007

Host publication information
Title of host publication: 9th International Conference on Transparent Optical Networks, 2007. ICTON '07.
Publisher: IEEE
ISBN (Print): 1-4244-1249-8
Electronic versions:
Nielsen.pdf
DOIs:
10.1109/ICTON.2007.4296176

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Source-ID: 209793
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007
Nanomaterials - quantum dots for optoelectronics

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Mørk, J.
Publication date: 2007

Host publication information
Title of host publication: European Conference on Integrated Optics (ECIO)
Place of publication: Lyngby, Denmark
Source: orbit
Source-ID: 211635
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Numerical investigation of electromagnetically induced transparency in a quantum dot structure

General information
State: Published
Organisations: Quantum Photonics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nielsen, P. K., Nielsen, H. T., Mørk, J., Tromborg, B.
Pages: 6396-6408
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 15
Issue number: 10
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
We have developed a second-order small-signal model for describing the nonlinear redistribution of noise in a saturated semiconductor optical amplifier. In this paper, the details of the model are presented. A numerical example is used to compare the model to statistical simulations. We show that the proper inclusion of second-order noise terms is required for describing the change in the skewness (third-order moment) of the noise distributions. The calculated probability density functions are described far out in the tails and can hence describe signals with very low bit error rate (BER). The work is relevant for describing the noise distribution and BER in, for example, optical regeneration.
Phase noise analysis of clock recovery based on an optoelectronic phase-locked loop

A detailed theoretical analysis of a clock-recovery (CR) scheme based on an optoelectronic phase-locked loop is presented. The analysis emphasizes the phase noise performance, taking into account the noise of the input data signal, the local voltage-controlled oscillator (VCO), and the laser employed in the loop. The effects of loop time delay and the laser transfer function are included in the stochastic differential equations describing the system, and a detailed timing jitter analysis of this type of optoelectronic CR for high-speed optical-time-division-multiplexing systems is performed. It is shown that a large loop length results in a higher timing jitter of the recovered clock signal. The impact of the loop length on the clock signal jitter can be reduced by using a low-noise VCO and a low loop filter bandwidth. Using the model, the timing jitter of the recovered optical and electrical clock signal can be evaluated. We numerically investigate the timing jitter requirements for combined electrical/optical local oscillators, in order for the recovered clock signal to have less jitter than that of the input signal. The timing jitter requirements for the free-running laser and the VCO are more relaxed for the extracted optical clock (lasers's output) signal.
Quality factors of nonideal micro pillars

The influence of fabrication-induced imperfections and material absorption on the quality (Q) factor of a microcavity pillar is studied numerically. The dependence on sidewall inclination, selective underetch, and intrinsic loss is quantified. The authors show that imperfections can lead to an improvement in Q and that a sidewall inclination angle of less than 1° causes a dramatic change in the Q factor. The variations in Q can be attributed to a delicate balance between effective index contrasts, mode overlap, and higher-order mode contributions.
Quality factors of nonideal micro pillars

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Contributors: Nielsen, T. R., Gregersen, N., Tromborg, B., Mørk, J.
Publication date: 2007

Host publication information
Title of host publication: Integrated photonics and nanophotonics research and applications
Place of publication: Salt Lake City, USA
Source: orbit
Self-consistent FDTD Maxwell-Bloch solver

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Nielsen, T. R., Ejsing, S., Lavrinenko, A., Mørk, J.
Publication date: 2007
Peer-reviewed: Yes
Source: orbit
Source-ID: 203089
Research output: Research - peer-review › Poster – Annual report year: 2007

Slow light in a semiconductor waveguide for true-time delay applications in microwave photonics
We have investigated the slow and fast light properties of a semiconductor waveguide device employing concatenated gain and absorber sections. This letter presents the experimental results as well as theoretical modeling. A large phase shift of 110° and a true-time delay of more than 150 ps are demonstrated. The combination of amplitude and phase control of the modulated signal shows great promise for applications within microwave photonics.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Öhman, F., Yvind, K., Mørk, J.
Pages: 1145-1147
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: IEEE Photonics Technology Letters
Volume: 19
Issue number: 15
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Slow light in semiconductor quantum dots

General information
Slow light in semiconductor quantum dots

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
Publication date: 2007
Peer-reviewed: Yes
Event: Abstract from 3rd Annual meeting Danish Physical Society, Nyborg, Denmark.
Source: orbit
Source-ID: 202149
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2007

Slow light in semiconductor quantum dots

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at Quantum noise and quantum optics in the solid state. PhD Summer School, 2007, Bad Honnef, Germany,
Source: orbit
Source-ID: 202151
Research output: Research - peer-review › Poster – Annual report year: 2007

Slow light in semiconductor waveguides: theory and experiment

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Publication date: 2007
Peer-reviewed: Yes
Source: orbit
Source-ID: 202148
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2007

Slow light in semiconductor waveguides: Theory and experiment

Slow light in multi-section quantum well waveguide structure is realized using either coherent population oscillations (CPO) and electromagnetically induced transparency (EIT) is studied. The properties of the two schemes are compared and discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Publication date: 2007

Host publication information
Publisher: IEEE
ISBN (Print): 978-1-4244-0931-0
Electronic versions:
Mark.pdf
DOIs:
10.1109/CLEOE-IQEC.2007.4386121

Bibliographical note
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Source: orbit
The effect of timing jitter on a 160-Gb/s demultiplexer

For high-speed optical communication systems, timing jitter is a crucial parameter for switching operations between the data and control signal. This is especially the case for the demultiplexer. The effect of timing jitter becomes very important as the bit rate of the data signal increases beyond 100 Gb/s and it is, therefore, essential to quantify its effect. In this letter, the impact of gating timing jitter on a 160-Gb/s demultiplexer is investigated by using two pulse sources with different timing jitter properties. We also investigate the interplay between the control signal pulsewidth and timing jitter. The experiment shows that it is essential to minimize jitter in the 20-kHz to 10-MHz range. Furthermore, we show that the impact of timing jitter can be reduced if the control signal pulses are broader than data signal pulses.

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Nanophotonics
Contributors: Zibar, D., Oxenløwe, L. K., Mulvad, H. C. H., Mørk, J., Galili, M., Clausen, A., Jeppesen, P.
Pages: 957-959
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: I E E E Photonics Technology Letters
Volume: 19
Issue number: 13
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
Analysis of timing jitter in external-cavity mode-locked semiconductor lasers

We develop a comprehensive theoretical description of passive mode-locking in external-cavity mode-locked semiconductor lasers based on a fully distributed time-domain approach. The model accounts for the dispersion of both gain and refractive index, nonlinear gain saturation from ultrafast processes, self-phase modulation, and spontaneous emission noise. Fluctuations of the mode-locked pulses are characterized from the fully distributed model using direct integration of noise-skirts in the phase-noise spectrum and the soliton perturbations introduced by Haus. We implement the model in order to investigate the performance of a MQW buried heterostructure laser. Results from numerical simulations show that the optimum driving conditions for achieving the shortest pulses with minimum timing jitter occur for large reverse bias in the absorber section at an optimum optical bandwidth limited by Gordon–Haus jitter.
Bandwidth enhancement of SOA-based switches using optical filtering: theory and experimental verification

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Nielsen, M. L., Mørk, J.
Pages: 1260-1265
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Optical Express
Volume: 14
Original language: English
Source: orbit
Source-ID: 186461
Research output: Research - peer-review; Journal article – Annual report year: 2006

Comment on "Dephasing times in quantum dots due to elastic LO phonon-carrier collisions" - Uskov et al. reply

General information
State: Published
Organisations: Theoretical Nanotechnology, Department of Micro- and Nanotechnology, Department of Photonics Engineering, Nanophotonics
Contributors: Uskov, A., Jauho, A., Tromborg, B., Mørk, J., Long, R.
Pages: 019704
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Physical Review Letters
Volume: 96
Issue number: 1
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464

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Source: orbit
Source-ID: 188758
Research output: Research - peer-review; Journal article – Annual report year: 2006
Dynamic Spatio-temporal Speed Control of Ultrashort Pulses in Quantum-Dot SOAs

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Gehrig, E., Poel, M. V. D., Mørk, J., Hvam, J. M.
Pages: 1047-1054
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Journal of Quantum Electronics
Volume: 42
Issue number: 10
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.19 SJR 1.37 SNIP 1.57
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
ISI indexed (2011): ISI indexed yes
Experimental and theoretical investigation of the impact of ultra-fast carrier dynamics on high-speed SOA-based all-optical switches

General information
State: Published
Organisations: Networks, Department of Photonics Engineering, Nanophotonics
Pages: 331-347
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 14
Issue number: 1
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
Influence of wetting-layer wave functions on phonon-mediated carrier capture into self-assembled quantum dots

Models of carrier dynamics in quantum dots rely strongly on adequate descriptions of the carrier wave functions. In this work we numerically solve the one-band effective mass Schrodinger equation to calculate the capture times of phonon-mediated carrier capture into self-assembled quantum dots. Comparing with results obtained using approximate carrier wave functions, we demonstrate that the capture times are strongly influenced by properties of the wetting layer wave functions not accounted for by earlier theoretical analyses.
Large Signal Modulation and Distortion in a Microwave Phase Shifter Based on Slow Light in a Semiconductor Waveguide

We model slow/light propagation in an active semiconductor waveguide in the large modulation depth regime. Distortion from higher harmonics is countered by filtering and the regenerating properties of the device further increase the modulation depth.
Modeling of Bit Error Rate in Cascaded 2R Regenerators
This paper presents a simple and efficient model for estimating the bit error rate in a cascade of optical 2R-regenerators. The model includes the influences of amplifier noise, finite extinction ratio and nonlinear reshaping. The interplay between the different signal impairments and the regenerating nonlinearity is investigated. It is shown that an increase in nonlinearity can compensate for an increase in noise figure or decrease in signal power. Furthermore, the influence of the improvement in signal extinction ratio along the cascade and the importance of choosing the proper threshold of the nonlinearity are investigated.
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.2 SJR 1.733 SNIP 2.957
Web of Science (2011): Impact factor 2.784
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.737 SNIP 2.401
Web of Science (2010): Impact factor 2.259
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.096 SNIP 2.749
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.198 SNIP 2.443
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.313 SNIP 2.212
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.03 SNIP 2.562
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.846 SNIP 2.952
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.332 SNIP 2.688
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.703 SNIP 2.876
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.751 SNIP 2.588
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 2.999 SNIP 2.112
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.379 SNIP 1.821
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.342 SNIP 1.659
Original language: English
Electronic versions:
Mørk.pdf
DOIs:
10.1109/JLT.2005.862446

Bibliographical note
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Source: orbit
Source-ID: 188181
Research output: Research - peer-review › Journal article – Annual report year: 2006

Monolithically integrated reflective SOA-EA carrier re-modulator for broadband access nodes

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Nanophotonics
Contributors: Tafur Monroy, I., Öhman, F., Yvind, K., Christiansen, L., Mørk, J., Peucheret, C., Jeppesen, P.
Pages: 8060-8064
Publication date: 2006
Peer-reviewed: Yes

Publication information

General information
State: Published
Organisations: Metro-Access and Short Range Systems, Department of Photonics Engineering, High-Speed Optical Communication, Nanophotonics Theory and Signal Processing
Contributors: Zibar, D., Oxenløwe, L. K., Mulvad, H. C. H., Mørk, J., Galili, M., Clausen, A. T., Jeppesen, P.
Publication date: 2006

Host publication information
Title of host publication: Optical Fiber Communication Conference, 2006 and the 2006 National Fiber Optic Engineers Conference
Publisher: IEEE
Electronic versions:
Zibar.pdf

Bibliographical note
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Source: orbit
Source-ID: 253189
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Patterning effects in multi-purpose amplification by a quantum dot amplifier
The potential for ultrafast signal processing in a quantum dot amplifier is investigated by observing the gain dynamics during amplification of femtosecond pulses in rapid succession. Significant patterning is seen at picosecond pulse separation.

General information
State: Published
Organisations: Department of Photonics Engineering, Center for Nanoteknologi
Contributors: Poel, M. V. D., Berg, T. W., Mørk, J., Hvam, J. M.
Publication date: 2006

Host publication information
Title of host publication: IWSQDA2006 programme
Volume: session 2: Dynamics properties of QD-lasers-1
Source: orbit
Source-ID: 188697
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Phased-array antennas employing slow and fast light in alternating amplifying and absorbing sections

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Sales, S., Öhman, F., Bermejo, A., Mørk, J., Capmany, J.
Publication date: 2006
Peer-reviewed: Yes
Event: Poster session presented at International Topical Meeting on Microwave Photonics 2006, Grenoble, France.
Source: orbit
Source-ID: 194139
Research output: Research - peer-review › Poster – Annual report year: 2006
Pulse interactions in a quantum dot waveguide in the regime of electromagnetically induced transparency

The interaction of optical pulses in a quantum dot waveguide in the slow-light regime is investigated. Dipole oscillations lead to strong interactions between the two pulses, implying a minimum pulse separation for optical buffer applications.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi, Technical University of Denmark
Contributors: Nielsen, P., Nielsen, H., Mørk, J., Tromborg, B.
Pages: CThW6
Publication date: 2006

Pulse properties of external cavity mode locked semiconductor lasers

The performance of an external-cavity mode-locked semiconductor laser is investigated both theoretically and experimentally. The optimization analysis focuses on the regimes of stable mode locking and the generation of sub-picosecond optical pulses. We demonstrate stable output pulses down to one picosecond duration with more than 30 dB trailing pulse suppression. The limiting factors to the device performance are investigated on the basis of a fully-distributed time-domain model. We find that ultrafast gain dynamics effectively reduce the pulse-shaping strength and inhibit the generation of femtosecond optical pulses.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi, Universitat de les Illes Balears, Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI
Contributors: Mulet, J., Kroh, M., Mørk, J.
Pages: 1119-1124
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 14
Issue number: 3
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
Web of Science (2010): Impact factor 3.753
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 3.039 SNIP 2.679
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 3.204 SNIP 2.423
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.284 SNIP 2.11
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.313 SNIP 2.336
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.819 SNIP 2.472
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.669 SNIP 2.217
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.745 SNIP 1.748
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.496 SNIP 1.42
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.98 SNIP 0.761
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.442 SNIP 0.843
Original language: English
Electronic versions:
9.pdf
DOIs:
10.1364/OE.14.001119
URLs:
http://www.opticsinfobase.org/oe/abstract.cfm?id=87780
Source: orbit
Source-ID: 188273
Recent Advancements in Semiconductor-based Optical Signal Processing
Significant advancements in technology and basic understanding of device physics are bringing optical signal processing closer to a commercial breakthrough. In this paper we describe the main challenges in high-speed SOA-based switching.

Reduction of Timing Jitter by Clock Recovery based on an Optical Phase-Locked Loop
We numerically investigate the phase noise requirements for combined electrical/optical local oscillators in a PLL-based clock recovery. Suggestions for reducing the timing jitter are given.

Semiconductor Quantum Dots Devices: Recent Advances and Application Prospects
Slow and Fast Light in an Electro-Absorber
We demonstrate controllable and large time delay in cascaded semiconductor saturable absorbers and amplifiers. The possibility of further increasing the tuneable phase shift by utilizing field screening effects in the quantum well absorber is demonstrated.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi, Polytechnic University of Valencia
Contributors: Öhman, F., Bermejo Ramirez, A., Sales, S., Mørk, J.
Pages: MC5
Publication date: 2006

Host publication information
Title of host publication: Slow and Fast Light Topical Meeting - Technical Digest CD-Rom
Publisher: Optical Society of America (OSA)
ISBN (Print): 15-57-52816-0
Source: orbit
Source-ID: 190555
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Slow and Fast Light in SOA-EA structures for phased-array antennas
We present an SOA-EA structure for controlling the phase and amplitude of optically fed phased-array antennas. Phase shifts of 40 degrees are obtained through slow and fast light effects by changing only the reverse voltage.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi, Polytechnic University of Valencia
Contributors: Sales, S., Öhman, F., Bermejo, A., Mørk, J., Capmany, J.
Publication date: 2006
Peer-reviewed: Yes
Event: Poster session presented at 32nd European Conference on Optical Communications, Cannes, France.
Source: orbit
Source-ID: 191285
Research output: Research - peer-review › Poster – Annual report year: 2006

Slow Light at High Frequencies in an Amplifying Semiconductor Waveguide
We demonstrate slow-down of a modulated light signal in a semiconductor waveguide. Concatenated amplifying and absorbing sections simultaneously achieve both amplification and a controllable time delay at 15 GHz.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi
Contributors: Öhman, F., Yvind, K., Mørk, J.
Pages: 1-2
Publication date: 2006
Steep and Adjustable Transfer Functions of Monolithic SOA-EA 2R-Regenerators
Measurements and numerical modeling of a reamplification and reshaping (2R) regenerator demonstrate a steep power transfer function with adjustable threshold. The threshold can be adjusted more than 6 dB by simple control of the reverse bias voltage of the absorber section. The device consists of a semiconductor waveguide with alternating amplifier and absorber sections using quantum-well active material. The steep nonlinearity of the transfer function is achieved by concatenating several sections. We identify the saturation properties of the absorbing media, as dictated by the band-filling and field screening, as important for the observed transfer functions. The relation of the saturation powers of the gain and absorption sections is important for design optimization.
The impact of gating timing jitter on a 160 Gb/s demultiplexer
The impact of gating timing jitter on a 160Gb/s demultiplexer is investigated by using two pulse sources with different timing jitter properties. It is found that jitter in the range 20kHz-10MHz is essential to minimize. (C)2005 Optical Society of America.

General information
State: Published
Organisations: Metro-Access and Short Range Systems, Department of Photonics Engineering, High-Speed Optical Communication, Nanophotonics Theory and Signal Processing, Optical Transmission and Network Elements, Technical University of Denmark
Contributors: Zibar, D., Oxenlowe, L., Mulvad, H. C. H., Mørk, J., Gallili, M., Clausen, A., Jeppesen, P.
Pages: 28-30
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: 2006 Optical Fiber Communication Conference/national Fiber Optic Engineers Conference, Vols 1-6
Original language: English
Source: orbit
Source-ID: 238074
Research output: Research - peer-review › Conference article – Annual report year: 2006

True-time delay by slow light in a semiconductor waveguide with alternating amplifying and absorbing sections
Modeling of slow light in a semiconductor waveguide with alternating gain and absorption sections demonstrate an increase in time delay by concatenating segments. A true-time delay is predicted over a large bandwidth at high frequency.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi
Contributors: Öhman, F., Mørk, J.
Pages: OME4
Publication date: 2006

Host publication information
Title of host publication: Optical Amplifiers and their Applications - Technical Digest CD.Rom
Publisher: Optical Society of America (OSA)
ISSN (Print): 15-57-52809-6
Source: orbit
Source-ID: 190556
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Ultrafast gain and index dynamics of quantum dash structures emitting at 1.55 μm
The authors systematically characterize the ultrafast gain and index recovery of a quantum dash semiconductor optical amplifier after it has amplified a strong femtosecond pulse. The results show a recovery dominated by a fast time constant of 1.4 ps with an ultimate recovery taking place on a 150 ps time scale. The results are distinctly different from the recovery of quantum dot amplifiers and reflect the special density of states of the quantum-wire-like dashes.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Center for Nanoteknologi, Universität Würzburg, University of Kassel, Technion-Israel Institute of Technology
Pages: 081102
Publication date: 2006
Peer-reviewed: Yes

Publication information
Volume: 89
Issue number: 8
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Voltage-controlled slow light in an integrated semiconductor structure with net gain

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Öhman, F., Yvind, K., Mørk, J.
Pages: 9955-9962
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 14
Issue number: 21
ISSN (Print): 1094-4087
Ratings:
Scopus rating (2022): SJR 4.018 SNIP 2.414
Web of Science (2022): Indexed yes
Scopus rating (2021): SJR 4.281 SNIP 2.22
Web of Science (2021): Indexed yes
Scopus rating (2020): SJR 4.178 SNIP 2.017
Web of Science (2020): Indexed yes
Scopus rating (2019): SJR 4.173 SNIP 2.066
Original language: English
Keywords: DEVICES, LASERS, HETERODYNE PUMP-PROBE, DOT AMPLIFIERS
Electronic versions:
Mark.pdf
DOIs:
10.1063/1.2337881
URLs:
http://link.aip.org/link/APPLAB/v89/i8/p081102/s1

Bibliographical note
Copyright (2006) American Institute of Physics. This article may be downloaded for personal use only. Any other use requires prior permission of the author and the American Institute of Physics.
Source: orbit
Source-ID: 190880
Research output: Research - peer-review ; Journal article – Annual report year: 2006
In this letter, we propose and experimentally demonstrate a new orthogonal labeling scheme based on a 40-Gb/s differential phase-shift keying payload and a 2.5-Gb/s polarization-shift keying label, which entirely eliminates the modulation crosstalk between the payload and label and shows negligible swapping penalty.
A second order model of noise in saturated semiconductor optical amplifiers

We have developed a second order model of spontaneous emission noise in semiconductor optical amplifiers (SOAs). The resulting noise distributions agree well with statistical simulations and explain the measured redistribution of noise in saturated SOAs.

General information

State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Öhman, F., Tromborg, B., Merk, J.
Publication date: 2005

Host publication information
Title of host publication: CLEO/Europe-EQEC 2005 Conference Digest CD : Europhysics Conference Abstracts
Volume: vol. 29B
Publisher: IEEE
ISBN (Print): 0-7803-8974-3
Electronic versions:
Merk.pdf
DOIs:
10.1109/EQEC.2005.1567183

Bibliographical note
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Source: orbit
Source-ID: 196441
Research output: Research - peer-review ; Journal article – Annual report year: 2005
Bandwidth Enhancement of SOA-based Switches Using Optical Filtering: Theory and Experiment

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Nielsen, M. L., Mørk, J.
Publication date: 2005

Host publication information
Title of host publication: Proc. of ECOC 2005
Source: orbit
Source-ID: 183463
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Carrier dynamics in quantum well and quantum dot lasers and optical amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Mørk, J.
Number of pages: 64
Publication date: 2005

Host publication information
Title of host publication: APOC 2005 Technical Summary Digest
Source: orbit
Source-ID: 183001
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2005

Controllable delay of ultrashort pulses in a quantum dot optical amplifier
Optical and electrical tuning of the propagation time of 170 fs pulses in a quantum dot semiconductor amplifier at room temperature is demonstrated. Both pulse slowdown and advancement is possible and we achieve fractional delays (delay divided with pulse duration) of up to 40%. The results are explained by a simple gain saturation model.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Poel, M. V. D., Mørk, J., Hvam, J. M.
Pages: 8032-8037
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Optics Express
Volume: 13
Issue number: 20
ISSN (Print): 1094-4087
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.74 SJR 1.519 SNIP 1.567
Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Design and evaluation of modelocked semiconductor lasers for low noise and high stability

We present work on design of monolithic mode-locked semiconductor lasers with focus on the gain medium. The use of highly inverted quantum wells in a low-loss waveguide enables both low quantum noise, low-chirped pulses and a large stability region. Broadband noise measurements are performed and used to confirm the design principles.

Detailed modelling and experimental characterisation of an ultra-fast optoelectronic clock recovery circuit

Experimental Demonstration and Theoretical Analysis of Slow Light in a Semiconductor Waveguide at GHz Frequencies

Experimental demonstration and theoretical analysis of slow light in a semiconductor waveguide at GHz frequencies slow-down of light by a factor of two in a semiconductor waveguide at room temperature with a bandwidth of 16.7 GHz using the effect of coherent pulsations of the carrier density. The achievable delay is shown to be limited by the short lifetime. The maximum time delay observed reflects an approximately two-fold increase of the group refractive index, corresponding to a time delay of approximately 20 % of the carrier (population) lifetime. The experimental observations are well-explained by a model accounting for the absorption saturation in the waveguide, when using a lifetime that depends on the reverse bias.
Impact of Optical Filtering on Linear and Nonlinear Patterning Effects in SOA-based All-optical Switches

General information
State: Published
Organisations: Department of Photonics Engineering, Networks, Nanophotonics
Contributors: Nielsen, M. L., Mørk, J.
Publication date: 2005

Host publication information
Title of host publication: Proc. of OAA 2005
Volume: SuB6 (on CD ROM)
Source: orbit
Source-ID: 183467
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Influence of wetting layer wave functions on carrier capture in quantum dots
This work numerically solves the effective mass Schrödinger equation and shows that the capture times are strongly influenced by details of the continuum states not accounted for by the approximate wave functions. Results show that calculations of capture time for phonon mediated carrier capture from a wetting layer into a quantum dot depend critically on the approximations used for the wetting layer wave functions.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Theoretical Nanoelectronics Group, Theory Section, Department of Micro- and Nanotechnology
Contributors: Kristensen, P. T., Markussen, T., Tromborg, B., Mørk, J.
Pages: 3-3
Publication date: 2005

Host publication information
Title of host publication: EQEC '05. European Quantum Electronics Conference, 2005.
Volume: 29B
Publisher: IEEE
ISBN (Print): 07-80-38973-5
Electronic versions: Markussen.pdf
DOIs: 10.1109/EQEC.2005.1567176

Influence of wetting layer wave functions on carrier capture in quantum dots

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Markussen, T., Kristensen, P., Tromborg, B., Mørk, J.
Publication date: 2005

Host publication information
InP based lasers and optical amplifiers with wire-/dot-like active regions

Long wavelength lasers and semiconductor optical amplifiers based on InAs quantum wire/dot-like active regions were developed on InP substrates dedicated to cover the extended telecommunication wavelength range between 1.4 - 1.65 mm. In a brief overview different technological approaches will be discussed while in the main part the current status and recent results of quantum-dash lasers are reported. This includes topics like dash formation and material growth, device performance of lasers and optical amplifiers, static and dynamic properties as well as fundamental material and device modeling.
Integrated Pattern Effect Compensator based on Self-Switching

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Publication date: 2005

Host publication information
Title of host publication: Proc. of 12th European Conference on Integrated Optics 2005
Volume: WeA1-6
Source: orbit
Source-ID: 181074
Light slow-down in semiconductor waveguides due to population pulsations
This study theoretically analyzes the prospect of inducing light-slow down in a semiconductor waveguide based on coherent population oscillation. Experimental observations of the effect are also presented.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Mørk, J., Kjær, R., Poel, M. V. D., Yvind, K.
Pages: EA3-5-WED
Publication date: 2005

Host publication information
Title of host publication: CLEO/Europe-EQEC 2005 Conference Digest CD : Europhysics Conference Abstracts
Volume: vol. 29B
Publisher: IEEE
ISBN (Print): 07-80-38974-3
Electronic versions:
Kjaer.pdf
DOIs:
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Source: orbit
Source-ID: 181478
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2005

Measurement and Modeling of the Transfer Function of a Monolithic SOA-EA 2R-Regenerator
We have measured steep power transfer characteristics with tunable threshold for a monolithic 2R-regenerator combining amplifying and absorbing sections. Modeling results explain the basic characteristics.
Measurements and simulations of non-linear noise re-distribution in an SOA

Measurements and numerical simulations of the noise statistics after a semiconductor optical amplifier (SOA) demonstrate non-linear noise re-distribution. The re-distribution, which depends on self-modulation due to gain saturation and carrier dynamics, show a strong power and bandwidth dependence and can be important for SOA based regenerators.
Measurements and Simulations of nonlinear noise redistribution in an SOA

Measurements and numerical simulations of the noise statistics after a semiconductor optical amplifier (SOA) demonstrate nonlinear noise redistribution. The redistribution, which relies on self-modulation due to gain saturation and carrier dynamics, shows a strong power and bandwidth dependence and can be important for SOA-based regenerators.

General information

State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Mode-locking semiconductor lasers with low noise and high stability

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Yvind, K., Larsson, D., Mørk, J., Hvam, J. M.
Publication date: 2005

Nonlinear saturation dynamics and its application to all-optical regeneration and light slow-down

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Mørk, J., Öhman, F., Kjær, R., Yvind, K.
Publication date: 2005
Peer-reviewed: No
Event: Abstract from Workshop on Nonlinear Dynamics in Photonics, Berlin, Germany, .
Source: orbit
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Research output: Research › Conference abstract for conference – Annual report year: 2005

Optical Regeneration and Noise in Semiconductor Devices
In this report all-optical 2R-regeneration in optical communication systems is investigated. A simple regenerator device
based on concatenated semiconductor optical amplifiers (SOAs) and electro absorbers (EAs) is introduced and examined.
Experiments show that the monolithic SOA-EA 2R-regenerator has a sharp step-like transfer function with a threshold that
is easily adjusted by simply changing the bias voltage over the electro absorbers. Measurements on a modulated signal show that the device can improve the extinction ratio of a degraded signal with more than 5 dB, and improve the receiver sensitivity with more than 8 dB compared to the back-to-back case, using a degraded signal. The noise properties and cascadability of the proposed device are examined through modeling. Furthermore, the influence of the saturation properties of the EA on the regeneration performance is investigated. Calculations show that it is possible to increase the nonlinearity of the transfer function and improve the regenerating properties by lowering the saturation power of the EA and concatenating several SOA-EA pairs, although this also adds more noise to the signal. In order to analyze the influence of the regenerator properties on the bit error rate in a cascade of regenerators, a general model for a 2R-regenerator, neglecting timing jitter, is developed. The model conceptually divides the regenerator into a linear amplifying part and a nonlinear reshaping part. The amplifier adds noise in the form of amplified spontaneous emission and the nonlinear transfer function redistributes the noise and improve the extinction ratio of the signal. The model shows that the best choice of decision threshold is made by considering the properties of the cascaded regenerators rather than the signal going into the cascade. Furthermore, the interplay between different regenerator properties like noise figure, nonlinearity and extinction ratio is examined. The results show that an increase in nonlinearity can compensate for a higher amplifier noise figure or increase the reach of a transmission link. These kinds of investigations make it possible to compare different kinds of regenerators and guide the optimization of regenerators. Theoretical modeling and direct measurement of the probability density function (PDF) of a continuous wave (cw) signal after an SOA show the nonlinearity noise redistribution due to gain saturation and carrier dynamics. The redistribution gives both a reduction in the width and change in the overall shape of the PDF, compared to a linear amplification. The redistribution of noise, as described by the changes in the PDF, is central to the understanding of regeneration. The changes of the noise in an SOA is examined closer by use of a small-signal model, including first and second order noise terms, and a large-signal time-domain simulation. The calculations show the noise spectra and the bandwidth dependence of the noise redistribution in the device. Both pass-through amplification and wavelength conversion through cross-gain modulation is investigated and compared.
Pulsewidth and stability properties of external-cavity mode-locked semiconductor lasers: Simulations and experiments

Quantum dot devices for optical communications

Reduction of nonlinear patterning effects in SOA-based All-optical Switches using Optical filtering
Self-slowdown and -advancement of fs pulses in a quantum-dot semiconductor optical amplifier

We demonstrate changes in the propagation time of 180 femtosecond pulses in a quantum-dot semiconductor optical amplifier as function of pulse input power and bias current. The results interpreted as a result of pulse reshaping by gain saturation but are also analogous to coherent population oscillations. Relative pulse delays (i.e., pulse time delay to pulse FWHM ratio) up to 40% and relative advancements up to 15% are observed when the amplifier is biased at zero current and at currents well above transparency, respectively. Under gain conditions, no pulsedistortion is seen while a considerable pulse distortion occurs at zero bias.

Semiconductor laser

Slow light in a semiconductor waveguide at gigahertz frequencies

We experimentally demonstrate slow-down of light by a factor of three in a 100 µm long semiconductor waveguide at room temperature and at a record-high frequency of 16.7 GHz. It is shown that the group velocity can be controlled all-optically as well as through an applied bias voltage. A semi-analytical model based on the effect of coherent population oscillations and taking into account propagation effects is derived and is shown to well account for the experimental results. It is shown that the carrier lifetime limits the maximum achievable delay. Based on the general model we analyze fundamental limitations in the application of light slowdown due to coherent population oscillations.
The Influence of Nonlinearity, Noise and Extinction Ratio on the Cascading Properties of 2R-Regenerators
We have derived an expression for the BER of a cascade of 2R-regenerators including the effects of nonlinearity, noise and extinction-ratio. The best choice of threshold and the interplay between device parameters are investigated.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Öhman, F., Mørk, J.
Publication date: 2005

Theoretical and experimental study of fundamental differences in the noise suppression of high-speed SOA-based all-optical switches
We identify a fundamental difference between the ASE noise filtering properties of different all-optical SOA-based switch configurations, and divide the switches into two classes. An in-band ASE suppression ratio quantifying the difference is derived theoretically and the impact of the ASE filtering on the optical spectrum is verified experimentally using a hybrid DISC setup. ASE power suppression of around 3 dB over the total signal bandwidth is demonstrated.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Pages: 5080-5086
Publication date: 2005
Peer-reviewed: Yes
Timing Jitter Analysis for Clock recovery Circuits Based on an Optoelectronic Phase-Locked Loop (OPLL)

Timing jitter of an OPLL based clock recovery is investigated. We demonstrate how loop gain, input and VCO signal jitter, loop filter bandwidth and a loop time delay influence jitter of the extracted clock signal.

Tunable propagation delay of femtosecond pulse in quantum-dot optical amplifier at room temperature

Optically induced dispersion over a large bandwidth of 2.6 THz is used to slow or speed up a 150 fs pulse in a quantum-dot optical amplifier. A group refractive index change of 4*10^{-3} is observed.
Tunable propagation delay of femtosecond pulses in a quantum-dot optical amplifier at room temperature

Optically induced dispersion over a large bandwidth of 2.6 THz is used to slow or speed up a 150 fs pulse in a quantum-dot optical amplifier. A group refractive index change of $4 \times 10^{-3}$ is observed.

**General information**

State: Published

Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing

Contributors: Poel, M. V. D., Mørk, J., Hvam, J. M.

Publication date: 2005

**Host publication information**

Title of host publication: Quantum Electronics and Laser Science Conference, 2005. QELS ’05

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Source: orbit

Source-ID: 257025

Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

**Electroabsorption modulators used for all-optical signal processing and labelling**

This thesis concerns the applications of semiconductor components, primarily electroabsorption modulators (EAMs), in optical signal processing and labelling for future all optical communication networks. An introduction to electroabsorption modulators is given and several mechanisms that form the basis of electroabsorption are briefly discussed including Franz Keldysh effect, Quantum-Confined Stark Effect (QCSE) and Quantum-Confined Franz-Keldysh effect. QCSE is found to be more effective for absorption modulation than FKE at room temperature due to the quantum confinement of electrons and holes. Experimental investigations on electrical-to optical (e/o) modulation of the EAM are presented. From the measured power transfer curves, static extinction ratios larger than 20 dB were obtained for wavelengths in the C-band. It is also shown that the insertion loss and static extinction ratio decrease with the signal wavelength, indicating that an optimum wavelength can be found as a trade-off between the on-off ratio and the signal-to-noise ratio. The chirp property and the small signal bandwidth for electrical-to-optical modulation of the EAM are investigated. It is found that the measured chirp $\alpha$-parameter ranges from $-0.4$ to $0.8$ depending on the reverse bias; the higher the bias, the smaller the chirp becomes. Negative chirp may be achieved by sacrificing the extinction ratio and the output power. The small signal bandwidth was measured to be as large as 24 GHz. Cross absorption modulation (XAM) in an EAM is discussed including an introduction to the carrier effects and a simple model that simulates the carrier dynamics. Based on this model the static characteristics of an EAM under optical excitation are investigated theoretically; the results demonstrate the capability of an EAM used for wavelength conversion and 2R regeneration. The optical-to optical (o/o) modulation bandwidth and frequency chirp are experimentally investigated. It is found that the o/o modulation bandwidth drastically depends on the quantum well depth while the e/o modulation bandwidth is mainly influenced by the electrical bonding pad size. A device having a small pad and shallow wells shows 24 GHz bandwidth for both e/o and o/o modulation. In the o/o chirp measurements very small chirp $\alpha$-parameters are obtained. Depending on the operating wavelength and the bias the chirp $\alpha$-parameter ranges from $-0.6$ to $0.2$. It is also found that higher bias voltages and shorter wavelengths are preferred to obtain a small or negative chirp $\alpha$-parameter. The principle of EAM-XAM based wavelength conversion is discussed and a wavelength conversion experiment at 40 Gb/s is presented. The influence of some operation parameters, including pump light power, reverse bias of the converter and probe light wavelength, is experimentally investigated for the wavelength-converted light, including its chirp performance. As a result of this investigation, a higher pump power (up to 20 dBm) and a relatively larger reverse bias ($-2.5$ V) are preferred for obtaining both larger extinction ratio and lower chirp of the converted signal. A multi-wavelength conversion scheme ($8 \times 40$ Gb/s) is demonstrated, where the receiver sensitivity for the back-to-back case is $-33$ dBm and the average power penalty for the eight converted channels is 9.2 dB. The best channel at 1555.7 nm has a power penalty of 8 dB. The wavelength dependence of the power penalty is explained by studying the impact of the extinction ratio and the average power of the converted signal on the Q parameter. Physical explanations for the optimum pump power and device length is given by considering impacts on the extinction ratio, average power and pulse width of the wavelength-converted signal. Other wavelength conversion schemes such as fibre-based cross phase modulation (XPM) and optical filtering, fibre-based Kerr switch, fibre based four-wave-mixing (FWM) and semiconductor optical amplifier (SOA)-based cross gain modulation (XGM), are briefly discussed. As a result of the comparison, it is suggested that fibre-based solutions have relatively lower power penalties and have great potential.
Experimental and theoretical investigation of semiconductor optical amplifier (SOA) based all-optical switches

This thesis analyzes semiconductor optical amplifier (SOA) based all-optical switches experimentally and through numerical simulations. These devices are candidates for optical signal processing functionalities such as wavelength conversion, regeneration, and logic processing in future transparent optical networks. The factors governing the modulation bandwidth of SOAs are determined, and schemes for reducing detrimental patterning effects are discussed. Three types of SOA-based switches are investigated numerically: so-called standard-mode and differential-mode switches, and the filtering assisted switch. Differential -mode switches are shown to eliminate one contribution to the patterning effects, referred to as the linear patterning. This enables operation at bitrates far beyond the limit set by the carrier lifetime, but ultimately a saturation-induced patterning effect, nonlinear patterning, is found to limit the performance. Two
implementations of differential-mode switches, the Mach Zehnder interferometer (MZI) and the delayed-interferometer signal converter (DISC), are compared at bitrates up to 160 Gb/s, and fundamental differences in terms of noise filtering are demonstrated. The DISC, consisting of an SOA and an asymmetric MZI filter, is analyzed in the small-signal regime, and the obtainable modulation bandwidth is expressed analytically. A new optical spectrum approach to small signal analysis is introduced, and is used to assess the bandwidth enhancing effect of different optical filters, as well the impact of the filter phase response. Experiments at 40 Gb/s verify the predictions of the small-signal analysis. Wavelength conversion is demonstrated experimentally at 40 Gb/s using a simple filtering-assisted scheme with an ultra-low optical switching energy, and up to 80 Gb/s employing MZIs operated in the standard mode, also assisted by bandwidth enhancing filtering. The impact of 2R regeneration (re-amplification and re shaping) is explained through simulations, and demonstrated using MZIs at 10 Gb/s. In addition, the 2R regenerative capability of a novel all-active 2x2 coupler is verified, also at 10 Gb/s. 3R regeneration (2R + re-timing), based on a cross-gain modulation wavelength converter and a MZI, is demonstrated at 40 Gb/s in a recirculating loop experiment over 4000 km. Moreover, an optical subsystem for NRZ clock recovery, based on self-phase modulation and cross-phase modulation in an SOA, and capable of generating the 40 GHz spectral component from a 40 Gb/s NRZ signal, is presented. All-optical Boolean logic gates and functionalities involving several gates are investigated experimentally and numerically. Boolean AND and XOR gates are realized experimentally with MZIs, at 20 Gb/s and 10 Gb/s, respectively, whereas combinations of Boolean functions in MZIs are used to demonstrate a 3-input XOR gate, a data segment bit comparator, and a compact parity checking scheme, all at 10 Gb/s.

General information
State: Published
Organisations: Department of Photonics Engineering, Networks, Systems, Nanophotonics
Contributors: Nielsen, M. L., Dittmann, L., Clausen, A., Mørk, J.
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Research output: Research › Ph.D. thesis – Annual report year: 2004

106 to 10 Gb/s all-optical demultiplexing using a single electroabsorption modulator

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Xu, L., Chi, N., Christiansen, L. J., Yvind, K., Oxenløwe, L. K., Mørk, J., Jeppesen, P.
Publication date: 2004

Host publication information
Title of host publication: Proceedings of ECOC 2004
Volume: Paper We1.5.3
Place of publication: Sweden
Source: orbit
Source-ID: 155661
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

2R Regeneration in Concatenated Semiconductor Optical Amplifiers and Electroabsorbers
We present a novel 2R regenerator with a large level separation and steep step a sharp, adjustable threshold based on concatenated semiconductor optical amplifiers and electroabsorbers. We demonstrate demonstrate improvements in both extinction-ratio and BER sensitivity atfor a 10 Gb/s NRZ signal.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Christiansen, L. J., Xu, L., Yvind, K., Ohman, F., Oxenløwe, L. K., Mørk, J.
Pages: 30-31
Publication date: 2004

Host publication information
Title of host publication: ECOC 2004 Proceedings
7x40 Gb/s base rate RZ all-optical broadcasting utilizing an electroabsorption modulator

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Xu, L., Chi, N., Yvind, K., Christiansen, L. J., Oxenløwe, L. K., Mørk, J., Jeppesen, P.
Pages: 416-420
Publication date: 2004
Peer-reviewed: Yes

Publication information
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Volume: 12
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
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Web of Science (2017): Impact factor 3.356
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.48 SJR 1.532 SNIP 1.544
Web of Science (2016): Impact factor 3.307
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.18 SJR 2.313 SNIP 2.124
Web of Science (2014): Impact factor 3.488
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.38 SJR 2.337 SNIP 2.196
Web of Science (2013): Impact factor 3.525
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.85 SJR 2.562 SNIP 2.108
Web of Science (2012): Impact factor 3.546
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.58 SNIP 2.572
Web of Science (2011): Impact factor 3.587
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.906 SNIP 2.428
8x40 Gb/s RZ all-optical broadcasting utilizing an electroabsorption modulator

We experimentally demonstrate all-optical broadcasting through simultaneous 8 × 40 Gb/s wavelength conversion in the RZ format based on cross absorption modulation in an electroabsorption modulator. The original intensity-modulated information is successfully duplicated onto eight wavelengths that comply with the ITU-T proposal. The advantages of the proposed wavelength conversion scheme are discussed.

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Pages: MF71
Publication date: 2004

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DOIs:
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Source: orbit
Source-ID: 155659
**Research output: Research - peer-review › Article in proceedings – Annual report year: 2004**

**All-optical Extraction of 40 GHz Component from 40 Gb/s NRZ data using Signal Processing in an SOA combined with optical filtering**

**General information**
State: Published
Organisations: Networks, Department of Photonics Engineering, Optoelectronics
Contributors: Nielsen, M. L., Buron, J. D., Mørk, J.
Publication date: 2004

**Host publication information**
Title of host publication: Proc. of OECC 2004
Source: orbit
Source-ID: 154408

**Analysis of the effects of time delay in clock recovery circuits based on Phase-locked loops**
Influence of time delay in a balanced optical phase-locked loops (OPLL) with a proportional integrator (PI) filter is investigated using a delayed differential equation (DDE) is investigated. The limitations, which a time delay imposes on the PI filter bandwidth, at increasing values of loop gain, are investigated by numerical simulations. Furthermore, simple expressions governing the stability properties of the loop, in the presence of time delay, are derived. For this purpose, three standard loop filters are considered: a PI filter, a low pass (LP) filter and an active lag (AL) filter. The derived expressions are used to perform an optimisation in terms of the selected loop filters.

**General information**
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Zibar, D., Oxenløwe, L. K., Clausen, A., Mørk, J., Jeppesen, P.
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Publication date: 2004

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Publisher: IEEE
ISBN (Print): 0-7803-8557-8
Electronic versions: Zibar.pdf
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Source-ID: 155379

**Comparison of noise redistribution in an SOA in pass-through and wavelength conversion mode**
We use numerical simulations to investigate the redistribution of noise in a saturated SOA. A comparison of cross-gain modulation and self-modulation pass-through mode shows fundamental differences relevant to all-optical wavelength converters and regenerators.

**General information**
State: Published
Organisations: Department of Photonics Engineering
Contributors: Öhman, F., Tromborg, B., Merk, J.
Pages: 394-395
Publication date: 2004

**Host publication information**
Title of host publication: 2004 IEEE LEOS Annual Meeting, Conference Proceedings
Gain dynamics and saturation in semiconductor quantum dot amplifiers

Quantum dot (QD)-based semiconductor optical amplifiers offer unique properties compared with conventional devices based on bulk or quantum well material. Due to the bandfilling properties of QDs and the existence of a nearby reservoir of carriers in the form of a wetting layer, QD semiconductor optical amplifiers may be operated in regimes of high linearity, i.e. with a high saturation power, but can also show strong and fast nonlinearities by breaking the equilibrium between discrete dot states and the continuum of wetting layer states. In this paper, we analyse the interplay of these two carrier populations in terms of a simple rate equation model. Based on the steady-state and small-signal properties of the model, we analyse and discuss the optical modulation response and the four-wave mixing properties of QD semiconductor optical amplifiers, in particular emphasizing the role of ultrafast gain dynamics.
High-performance 10 GHz all-active monolithic mode-locked semiconductor lasers

Using a novel design strategy for the epitaxial structure for monolithic modelocked semiconductor lasers, lasers capable of producing <2 ps pulses at 10 GHz with very low high-frequency jitter have been fabricated in a single growth step.

**General information**

State: Published
Organisations: Department of Photonics Engineering
Pages: 735-736
Publication date: 2004
Peer-reviewed: Yes

**Publication information**

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Volume: 40
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Web of Science (2018): Indexed yes

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Scopus rating (2017): CiteScore 1.55 SJR 0.407 SNIP 0.906
Web of Science (2017): Impact factor 1.232
Web of Science (2017): Indexed yes

BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.35 SJR 0.402 SNIP 0.86
Web of Science (2016): Impact factor 1.155
Web of Science (2016): Indexed yes

BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.31 SJR 0.47 SNIP 0.959
Web of Science (2015): Impact factor 0.854
Web of Science (2015): Indexed yes

BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.31 SJR 0.5 SNIP 1.024
Web of Science (2014): Impact factor 0.93
Web of Science (2014): Indexed yes

BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.45 SJR 0.544 SNIP 1.108
Web of Science (2013): Impact factor 1.068
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes

BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.45 SJR 0.588 SNIP 1.12
Web of Science (2012): Impact factor 1.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes

BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.44 SJR 0.605 SNIP 1.08
Web of Science (2011): Impact factor 0.965
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes

BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.603 SNIP 0.971
Web of Science (2010): Impact factor 1.004
Web of Science (2010): Indexed yes

BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.665 SNIP 1.036
Web of Science (2009): Indexed yes

BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.789 SNIP 0.944
Web of Science (2008): Indexed yes

Scopus rating (2007): SJR 0.887 SNIP 1.173
Web of Science (2007): Indexed yes

Scopus rating (2006): SJR 0.83 SNIP 1.171
Web of Science (2006): Indexed yes

Scopus rating (2005): SJR 1.014 SNIP 1.27
Web of Science (2005): Indexed yes

Scopus rating (2004): SJR 1.103 SNIP 1.31
Identification of amplitude and timing jitter in external-cavity mode-locked semiconductor lasers
We theoretically and experimentally investigate the dynamics of external-cavity mode-locked semiconductor lasers, focusing on stability properties, optimization of pulsewidth and timing jitter. A new numerical approach allows to clearly separate timing and amplitude jitter.

Improving the All-Optical Response of SOAs Using a Modulated Holding Signal
A method for increasing the all-optical modulation bandwidth of semiconductor optical amplifiers (SOAs) by use of a cross-gain-modulated (XGM) holding signal is suggested and analyzed. The bandwidth improvement is numerically demonstrated by studying wavelength conversion in an SOA-based Mach-Zehnder interferometer (MZI) at 160 and 40 Gb/s. The new scheme is predicted to improve the extinction ratio and the minimum mark output power, as well as to reduce the amplitude jitter of the wavelength converted signal.
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Increasing the Modulation Bandwidth of Semiconductor Optical Amplifier based Switches using Optical Filtering

General information
State: Published
Organisations: Networks, Department of Photonics Engineering, Optoelectronics
Contributors: Nielsen, M. L., Mørk, J.
Pages: 1601-1619
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Optical Society of America. Journal B: Optical Physics
Volume: 21
Issue number: 9
ISSN (Print): 0740-3224
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.97 SJR 0.859 SNIP 0.875
Web of Science (2017): Impact factor 2.048
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.85 SNIP 0.936
Web of Science (2016): Impact factor 1.843
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.78 SJR 0.963 SNIP 0.923
Web of Science (2015): Impact factor 1.731
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.09 SJR 1.167 SNIP 1.137
Web of Science (2014): Impact factor 1.97
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.33 SJR 1.348 SNIP 1.286
Web of Science (2013): Impact factor 1.806
ISI indexed (2013): ISI indexed yes
Low-jitter and high-power 40 GHz all-active mode-locked lasers
A novel design strategy for the epitaxial structure of monolithic mode-locked semiconductor lasers is presented. Using an all-active design, we fabricate 40-GHz lasers generating 2.8-ps almost chirp-free pulses with record low high-frequency jitter and more than 7-mW fiber coupled output power.

General information
State: Published
Organisations: Department of Photonics Engineering
Pages: 975-977
Publication date: 2004
Peer-reviewed: Yes
Measurements and simulations of non-linear noise re-distribution in an SOA

Measurements and statistical simulations demonstrate that a semiconductor optical amplifier (SOA) induces non-linear noise re-distribution with a strong power and bandwidth dependence.

© 2004 Optical Society of America

General information
State: Published
Organisations: Department of Photonics Engineering, RISE ICT
Contributors: Öhman, F., Tromborg, B., Merk, J., Aurelius, A., Djupsjöbacka, A., Berntson, A.
Number of pages: 3
Publication date: 2004

Measurements of gain and index dynamics in quantum dash semiconductor optical amplifiers

Ultrafast gain and index recovery of a 1.5μm quantum dash amplifier after short pulse amplification is measured using pump-probe spectroscopy. The major part of the gain reduction is found to recover within a few picoseconds.

General information
State: Published
Organisations: Department of Photonics Engineering, Technion-Israel Institute of Technology, Universität Würzburg, Thales
Publication date: 2004

Host publication information
Title of host publication: Optical Amplifiers and Their Applications (OAA) - Technical Digest CD-Rom
Publisher: Optical Society of America
ISBN (Print): 15-57-52774-1
Source: orbit
Source-ID: 61233
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004
Measurements of non-linear noise re-distribution in an SOA
Measurements of the noise statistics after a semiconductor optical amplifier (SOA) demonstrate non-linear noise re-distribution with a strong power and bandwidth dependence.

General information
State: Published
Organisations: Department of Photonics Engineering, RISE ICT
Contributors: Öhman, F., Tromborg, B., Mørk, J., Aurelius, A., Djupsjöbacka, A., Berntson, A.
Publication date: 2004

Host publication information
Title of host publication: 2004 CLEO/IQEC Technical Digest CD-Rom
Publisher: IEEE
ISBN (Print): 15-57-52770-9
Electronic versions: Tromborg.pdf

Bibliographical note
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Source: orbit
Source-ID: 61278
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Noise and regeneration in semiconductor waveguides with saturable gain and absorption
We have modeled the noise properties of a novel waveguide device with regenerative properties. The device consists of alternating sections of saturable gain and absorption, which give a nonlinear power transfer function. We investigate the relative intensity noise spectra and signal-to-noise ratio after the device by both a small-signal analysis and large-signal simulation, and we show that the gain saturation gives noise redistribution at the mark level. We also examine the influence of the nonlinearity on the noise probability density function and show that the standard approximations of Gaussian and noncentral distributions fail.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Alight Technologies ApS
Contributors: Öhman, F., Bischoff, S., Tromborg, B., Mørk, J.
Pages: 245-255
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal of Quantum Electronics
Volume: 40
Issue number: 3
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Novel design of low-jitter 10 GHz all-active monolithic mode-locked lasers

Using a novel design, we have fabricated 10 GHz all-active monolithic mode-locked semiconductor lasers that generate 1.4 ps pulses with record-low timing jitter. The dynamical properties of lasers with 1 and 2 QWs are compared.

General information
State: Published
Organisations: Department of Photonics Engineering
Publication date: 2004

Host publication information
Title of host publication: 2004 CLEO/IQEC Technical Digest CD-Rom
Publisher: IEEE
ISBN (Print): 15-57-52770-9
Electronic versions: Larsson.pdf
DOI: 10.1109/CLEO.2004.1360941

Bibliographical note
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Source: orbit
Source-ID: 61264
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Numerical investigations on the performance of external-cavity mode-locked semiconductor lasers

The performance of an external-cavity mode-locked semiconductor laser is analyzed theoretically and numerically. Passive mode-locking is described using a fully-distributed time-domain model including fast effects, spectral hole burning and carrier heating. We provide optimization rules in order to improve the mode-locking performance, such as reducing the pulsewidth and time-bandwidth product as much as possible. Timing jitter is determined by means of extensive numerical simulations of the model, demonstrating that an external modulation is required in order to maintain moderate timing-jitter and phase-noise levels at low frequencies. The effect of the driving conditions is investigated in order to achieve short pulses and low timing jitter. Our results are in qualitative agreement with reported experiments and predictions obtained from the master equation for mode-locking.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Mulet, J., Mørk, J.
Pages: 571-582
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Proceedings of SPIE, the International Society for Optical Engineering
Volume: 5452-70
ISSN (Print): 0277-786X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.43 SJR 0.243 SNIP 0.289
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SJR 0.226 SNIP 0.258
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.3 SJR 0.212 SNIP 0.239
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.3 SJR 0.217 SNIP 0.249
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 0.26 SJR 0.234 SNIP 0.273
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.27 SJR 0.219 SNIP 0.275
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.31 SJR 0.217 SNIP 0.286
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.233 SNIP 0.277
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.236 SNIP 0.312
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.245 SNIP 0.3
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.247 SNIP 0.376
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.323 SNIP 0.676
Scopus rating (2005): SJR 0.162 SNIP 0.372
Web of Science (2004): Indexed yes
Web of Science (2002): Indexed yes
Original language: English
DOIs:
10.1117/12.544978
Source: orbit
Source-ID: 61145
Research output: Research - peer-review › Journal article – Annual report year: 2004

On the mechanisms governing the repetition rate of mode-locked semiconductor lasers
We investigate the mechanisms influencing the synchronization locking range of mode-locked lasers. We find that changes in repetition rates can be accommodated through a joint interplay of dispersion and pulse shaping effects.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Mulet, J., Mørk, J.
Publication date: 2004

Host publication information
Publisher: IEEE
ISBN (Print): 15-57-52770-9
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Source: orbit
Source-ID: 61276
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004
Quantum Dot Semiconductor Optical Amplifiers - Physics and Applications

This thesis describes the physics and applications of quantum dot semiconductor optical amplifiers based on numerical simulations. These devices possess a number of unique properties compared with other types of semiconductor amplifiers, which should allow enhanced performance of semiconductor devices in communication systems in the future.

The basic properties of quantum dot devices are investigated, especially regarding the potential of realizing amplification and signal processing without introducing pattern dependence. Also the gain recovery of a single short pulse is modeled and an explanation for the fast gain recovery observed experimentally is given. The properties of quantum dot amplifiers operating in the linear regime are investigated. The devices are predicted to show high device gain, high saturated output power, and low noise figure, resulting in a performance, that in some respects is comparable to those of fiber amplifiers. The possibility of inverting the optically active states to a large degree is essential in order to achieve this performance. Optical signal processing through cross gain modulation and four wave mixing is modeled and described. For both approaches quantum dot amplifiers are found to be able to operate with high efficiency and at high bitrates. Strong spectral hole-burning arising from a relatively slow carrier capture time, is shown to play a dominant role in this context. The results obtained numerically are compared to the properties of bulk and QW devices and to experiments on quantum dot amplifiers. These comparisons outline the qualitative differences between the different types of amplifiers. In all cases focus is put on the physical processes responsible the differences.

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Berg, T. W., Mørk, J.
Number of pages: 202
Publication date: 2004

Saturation and noise properties of quantum-dot optical amplifiers
Based on extensive numerical calculations, quantum-dot (QD) amplifiers are predicted to offer higher output power and lower noise figure compared to bulk as well as quantum well amplifiers. The underlying physical mechanisms are analyzed in detail, leading to the identification of a few key requirements that QD amplifiers should meet in order to achieve such superior linear characteristics. The existence of a highly inverted wetting layer or barrier region, acting as a carrier reservoir, is central to this performance enhancement. It is shown that amplified spontaneous emission acts to decrease the inversion of the wetting layer states, thus helping to quench the gain of these states, which might otherwise dominate.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Berg, T. W., Mørk, J.
Pages: 1527-1539
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal of Quantum Electronics
Volume: 40
Issue number: 11
ISSN (Print): 0018-9197
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.19 SJR 1.37 SNIP 1.57
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.372 SNIP 1.687
Web of Science (2010): Impact factor 2.48
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.801 SNIP 1.979
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.716 SNIP 1.763
Scopus rating (2007): SJR 2.025 SNIP 1.837
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.792 SNIP 1.859
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.806 SNIP 2.269
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.856 SNIP 2.487
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.648 SNIP 2.181
Scopus rating (2002): SJR 1.869 SNIP 1.952
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 2.527 SNIP 1.727
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.167 SNIP 1.334
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.096 SNIP 1.364
Original language: English
Electronic versions:
Mark.pdf
DOIs:
10.1109/JQE.2004.835114

Bibliographical note
Theory of Pulse Train Amplification Without Patterning Effects in Quantum Dot Semiconductor Optical Amplifiers

A theory for pulse amplification and saturation in quantum dot (QD) semiconductor optical amplifiers (SOAs) is developed. In particular, the maximum bit rate at which a data stream of pulses can be amplified without significant patterning effects is investigated. Simple expressions are derived that clearly show the dependence of the maximum bit rate on material and device parameters. A comparative analysis of QD, quantum well (QW), and bulk SOAs shows that QD SOAs may have superior properties; calculations predict patterning-free amplification up to bit rates of 150–200 Gb/s with pulse output energies of 0.2–0.4 pJ. The superiorly of QD SOAs is based on: 1) the faster achievement of the regime of maximum gain in QD SOAs compared to QW and bulk SOAs and 2) the lower effective cross section of photon-carrier interaction in QDs.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics, P. N. Lebedev Physical Institute
Contributors: Uskov, A. V., Berg, T. W., Mørk, J.
Pages: 306-320
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal of Quantum Electronics
Volume: 40
Issue number: 3
ISSN (Print): 0018-9197

Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.79 SJR 0.65 SNIP 0.891
Web of Science (2017): Impact factor 2.069
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.74 SJR 0.723 SNIP 1.071
Web of Science (2016): Impact factor 1.852
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.99 SJR 0.968 SNIP 1.162
Web of Science (2015): Impact factor 1.843
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.95 SJR 1.09 SNIP 1.25
Web of Science (2014): Impact factor 1.887
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.53 SJR 1.384 SNIP 1.649
Web of Science (2013): Impact factor 2.113
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.19 SJR 1.37 SNIP 1.57
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
The Role of Fast Carrier Dynamics in SOA Based Devices: (invited paper)
We describe the characteristics of all-optical switching schemes based on semiconductor optical amplifiers (SOAs), with particular emphasis on the role of the fast carrier dynamics. The SOA response to a single short pulse as well as to a data-modulated pulse train is investigated and the properties of schemes relying on cross-gain as well as cross-phase modulation are discussed. The possible benefits of using SOAs with quantum dot active regions are theoretically analyzed. The bandfilling characteristics and the presence of fast capture processes may allow to reach bitrates in excess of 100 Gb/s even for simple cross-gain modulation schemes.

General information
State: Published
Organisations: Department of Photonics Engineering, P. N. Lebedev Physical Institute
Contributors: Mørk, J., Berg, T. W., Nielsen, M. L., Uskov, A. V.
Pages: 1126-1133
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: IEICE Transactions on Electronics
Volume: E87-C
Issue number: 7
Original language: English
Source: orbit
Source-ID: 61144
Research output: Research - peer-review; Journal article – Annual report year: 2004
Modeling of phonon- and Coulomb-mediated capture processes in quantum dots

This thesis describes modeling of carrier relaxation processes in self-assembled quantum-dot-structures, with particular emphasis on carrier capture processes in quantum dots. Relaxation by emission of longitudinal optical (LO) phonons is very efficient in bulk semiconductors and nanostructures of higher dimensionality. Here, we investigate carrier capture processes into quantum dots, mediated by emission of one and two LO phonons. In these investigations is is assumed that the dot is empty initially. In the Case of single-phonon capture we also investigate the influence of the presence of a charge in the quantum-dot state to which the capture takes place. In general, capture rates are of the same order as capture rates into an empty dot state, but in some cases the dot-size interval for which the capture process is energetically allowed, is considerably reduced. The above calculations are performed by assuming that the incident carrier is a free carrier described by a plane wave. Therefore, the influence of waves are scattered by the quantum dot have been neglected. At certain wavelengths and dot sizes, the quantum dot can act as a Fabry-Perot mirror in which the incident carrier travels back and forth in the dot leading to a quasi-bound state of finite linewidth that resembles the bound states. We investigate the coupling of carriers in quasi-bound states with LO phonons and demonstrate that they can couple strongly with phonons. This leads to the formation of a mixed carrier-phonon mode that is called a polaron. Capture processes mediated by carrier-carrier scattering (Auger processes) are investigated and their dependence on quantum-dot geometry is studied in detail.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics
Contributors: Magnúsdóttir, I., Mørk, J., Bischoff, S., Hvam, J. M.
Number of pages: 159
Publication date: Apr 2003

Publication information
Original language: English
Electronic versions:
im_thesis_corr.pdf
Source: orbit
Source-ID: 42942
Research output: Research › Ph.D. thesis – Annual report year: 2003
Absorption recovery in strongly saturated quantum-well electroabsorption modulators

We observe experimentally that a quantum-well electroabsorption modulator, when strongly saturated by a highly energetic optical pulse, may exhibit an absorption recovery time much longer than for excitation with a low-energy pulse. Using a comprehensive drift-diffusion-type model, we are able to explain this effect theoretically. The prolongation of the absorption recovery is induced by carrier distribution effects, not by field-induced changes in the dynamical transport parameters such as the time carriers take to escape from the wells.
All optical regeneration using semiconductor devices

All-optical regeneration is a key functionality for implementing all-optical networks. We present a simple theory for the bit-error-rate in links employing all-optical regenerators, which elucidates the interplay between the noise and nonlinearity of the regenerator. A novel device structure is analyzed, emphasizing general aspects of active semiconductor waveguides.
Analytical expression for the bit error rate of cascaded all-optical regenerators

We derive an approximate analytical expression for the bit error rate of cascaded fiber links containing all-optical 2R-regenerators. A general analysis of the interplay between noise due to amplification and the degree of reshaping (nonlinearity) of the regenerator is performed.
Geometry dependence of Auger carrier capture rates into cone-shaped self-assembled quantum dots

We calculate carrier capture rates into cone- and truncated-cone-shaped quantum dots mediated by Auger processes. It is demonstrated that the capture rates depend strongly on both dot size and shape. The importance of phonon-mediated versus the Auger-mediated capture processes is discussed.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, P. N. Lebedev Physical Institute
Contributors: Magnúsdóttir, I., Bischoff, S., Uskov, A., Mørk, J.
Pages: 205326
Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Physical Review B Condensed Matter
Volume: 67
Issue number: 20
ISSN (Print): 0163-1829

Ratings:

BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes

BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Impact factor 3.813
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 3.16 SJR 2.339 SNIP 1.151
Web of Science (2016): Impact factor 3.836
Web of Science (2016): Indexed yes
Scopus rating (2015): CiteScore 2.8 SJR 2.377 SNIP 1.13
Web of Science (2015): Impact factor 3.718
Web of Science (2015): Indexed yes
Scopus rating (2014): CiteScore 3.3 SJR 2.762 SNIP 1.316
Web of Science (2014): Impact factor 3.736
Web of Science (2014): Indexed yes
Scopus rating (2013): CiteScore 3.55 SJR 2.813 SNIP 1.326
Web of Science (2013): Impact factor 3.664
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): CiteScore 3.57 SJR 3.173 SNIP 1.378
Web of Science (2012): Impact factor 3.767
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): CiteScore 3.61 SJR 3.326 SNIP 1.423
Web of Science (2011): Impact factor 3.691
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Scopus rating (2010): SJR 3.318 SNIP 1.447
Web of Science (2010): Impact factor 3.774
Web of Science (2010): Indexed yes
Web of Science (2009): Indexed yes
Scopus rating (2008): SJR 2.923 SNIP 1.516
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.892 SNIP 1.588
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.62 SNIP 1.468
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.126 SNIP 1.156
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.012 SNIP 1.103
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.184 SNIP 1.179
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.856 SNIP 1.841
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 3.132 SNIP 1.727
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.84 SNIP 1.603
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.789 SNIP 1.541
Geometry dependence of Auger carrier capture rates into self-assembled quantum dots

We present calculations of Auger carrier capture processes into self-assembled quantum dots. A strong dependence of the Auger capture rate on the size and geometry of the quantum dots is demonstrated.

Low jitter and high power all-active mode-locked lasers

A novel epitaxial design leading to low loss and low gain saturation improves the properties of 40 GHz mode-locked lasers. We obtain 2.8 ps nearly chirp free pulses with 228 fs jitter and fiber-coupled power of 7 mW.
Noise properties of semiconductor waveguides with alternating sections of saturable gain and absorption

We investigate the dynamical noise properties of saturable semiconductor devices for optical signal processing. A trade-off between noise redistribution and extinction ratio improvement has to be made for all-optical regeneration.
Optical label encoding using electroabsorption modulators and investigation of chirp properties

A novel scheme of optical label encoding by wavelength conversion based on electroabsorption modulators (EAMs) is reported. Based on the experimental observations, the chirp properties of the wavelength-converted signal are discussed and a wide dynamic range of the chirp $\alpha$-parameter is found allowed. Compared with cross-gain modulation (XGM) in a semiconductor optical amplifier (SOA), the EAM has several advantages, which make it attractive for optical label encoding or other applications as a wavelength converter.

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Xu, L., Chi, N., Oxenløwe, L. K., Yvind, K., Mørk, J., Jeppesen, P., Hanberg, J.
Pages: 1763-1769
Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Journal of Lightwave Technology
Volume: 21
Issue number: 8
ISSN (Print): 0733-8724
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.42 SJR 1.166 SNIP 1.791
Web of Science (2017): Impact factor 3.652
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.87 SJR 1.23 SNIP 1.819
Web of Science (2016): Impact factor 3.671
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.15 SJR 1.598 SNIP 1.901
Web of Science (2015): Impact factor 2.567
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.23 SJR 1.737 SNIP 2.411
Web of Science (2014): Impact factor 2.965
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.03 SJR 1.622 SNIP 2.439
Web of Science (2013): Impact factor 2.862
Optical signal processing using electro-absorption modulators: (invited)

Reverse-biased semiconductor waveguides are efficient saturable absorbers and have a number of promising all-optical signal processing applications. Results on ultrafast modulator dynamics as well as demonstrations and investigations of
wavelength conversion and regeneration are presented.

**General information**
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Systems, GI GA A/S
Pages: 45-54
Publication date: 2003

**Host publication information**
Title of host publication: ECIO’03 Proceedings
Source: orbit
Source-ID: 23335
Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

**Polarisation independent optical sampling using four-wave mixing: SCOOP**

**General information**
State: Published
Organisations: Systems, Department of Photonics Engineering, Department of Mechanical Engineering, Optoelectronics
Contributors: Tersigni, A., Martin, V., Clausen, A., Oxenløwe, L. K., Mørk, J., Jeppesen, P.
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Source: orbit
Source-ID: 59688
Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

**Quantum dot amplifiers with high output power and low noise**
Quantum dot semiconductor optical amplifiers have been theoretically investigated and are predicted to achieve high saturated output power, large gain, and low noise figure. We discuss the device dynamics and, in particular, show that the presence of highly inverted barrier states does not limit the performance of these devices.

**General information**
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Berg, T. W., Mørk, J.
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
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Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.018 SNIP 2.414
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 4.281 SNIP 2.22
Semiconductor devices for all-optical regeneration: (invited)

We review different implementations of semiconductor devices for all-optical regeneration. A general model will be presented for all-optical regeneration in fiber links, taking into consideration the trade-off between non-linearity and noise. Furthermore we discuss a novel regenerator type, based on saturable gain and absorption in a waveguide structure.

The Dynamics of Semiconductor Optical Amplifiers – Modeling and Applications

The importance of semiconductor optical amplifiers is discussed. A semiconductor optical amplifier (SOA) is a semiconductor laser with anti-reflection coated facets that amplifies an injected light signal by means of stimulated emission. SOAs have a number of unique properties that open up significant opportunities in the area of fast, all-optical signal processing. Integrated SOA-based devices are considered suitable for future all-optical systems because of their compact size, low optical and electrical power consumption, polarization independence and high speed.

Theoretical analysis of four wave mixing in quantum dot optical amplifiers

The four wave mixing properties of semiconductor quantum dot amplifiers have been investigated. The combination of strong non-equilibrium depletion of dot levels and a small linewidth enhancement factor results in efficient and symmetric four wave mixing.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Berg, T. W., Mørk, J.
Publication date: 2003

Host publication information
Title of host publication: Conference on Lasers and Electro-Optics, 2003. CLEO '03.
Theoretical and experimental investigation of a balanced phase-locked loop based clock recovery at a bit rate of 160 Gb/s

This paper describes a mathematical model of a balanced opto-electronic phase-locked loop (OPLL), which is required to be very fast for some network applications. OPLL is investigated in terms of clock pulse width, loop filter gain and residuals of the balancing DC level. Based on the guidelines from the theoretical evaluations, a very simple experimental demonstration including a single electroabsorption modulator as phase comparator is constructed.

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Zibar, D., Oxenløwe, L. K., Clausen, A., Mørk, J.
Pages: TuY5
Publication date: 2003

Two-phonon capture processes into quantum dots: The role of intermediate states

We present a study of carrier capture into quantum dots via emission of longitudinal optical phonons. Two-phonon capture times are found to be of the order of some picoseconds at carrier densities $10^{17}$cm$^{-3}$ in situations where single-phonon capture processes are energetically prohibited. The influence of different intermediate carrier states on the two-phonon capture rate is investigated and found to exhibit effects of interference between the different contributions.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Modeling, P. N. Lebedev Physical Institute
Contributors: Magnúsdóttir, I., Uskov, A. V., Bischoff, S., Tromborg, B., Mørk, J.
Pages: 111-113
Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Physica E: Low-Dimensional Systems and Nanostructures
Volume: 17
Issue number: 1-4
ISSN (Print): 1386-9477
Ultrafast dynamics in semiconductor optical amplifiers and all-optical processing: Bulk versus quantum dot devices: (invited)

We discuss the dynamical properties of semiconductor optical amplifiers and the importance for all-optical signal processing. In particular, the dynamics of quantum dot amplifiers is considered and it is suggested that these may be operated at very high bit-rates without significant patterning effects, as opposed to quantum well or bulk devices.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, P. N. Lebedev Physical Institute
Contributors: Mørk, J., Berg, T. W., Magnúsdóttir, I., Uskov, A. V.
Pages: 46-49
Publication date: 2003

Absorption and refractive index dynamics in waveguide semiconductor electroabsorbers

This thesis describes the optical characterization of waveguide semiconductor electroabsorbers with an INGaAsP multi-quantum well heterostructure. The investigations have focused on applying the electroabsorbers as electroabsorption modulators or as saturable absorbers. The components have been manufactures with the Danish research council sponsored SCOOP-programme (Semiconductor Components for Optical signal Processing) in collaboration with the Danish company GIGA-An Intel Company. The focus of the SCOOP-programme is to develop new semiconductor components for optical signal processing in telecommunication systems. Both the amplitude and phase transfer functions of electroabsorption modulators as function of reverse bias and wavelength, are measured using a heterodyne detection technique. With this information, the bias and wavelength dependent $\alpha$-H-parameter is calculated and so is the electroabsorption modulator response to a 10 Gb/s modulation of the bias. It is concluded that operation close to the absorption edge is advantageous both chirp-wise and with respect to lowering the drive voltage. This however becomes at the expense of a higher insertion loss. A comparison between a component with 10 shallow quantum wells and a component with 5 deep quantum wells shows that the shallow 10 quantum wells component is preferable with respect to chirp, extinction ratio and potentially also the insertion loss. Calculations of the refractive index change confirm the measurements and show, that the fabricated electroabsorption modulators can generate high quality pulses for optical fiber transmission. The all-optical wavelength conversion and demultiplexing capabilities of the electroabsorbers, when operated as saturable absorbers, are investigated using femtosecond laser pulses in an amplitude and phase sensitive heterodyne pump-probe experiment. It is shown that the absorption can be bleached effectively by optical generation of carriers. The absorption recovery is measured as a function of pump pulse energy and reverse bias applied to the component and it is shown that a 10 ps switching window with 9.6 dB of extinction ratio can be realized. The sign of the refractive index change, induced by optical generation of carriers in the active region, is seen to depend both on the optical power and on the reverse bias applied to the saturable absorber. The trends of the observed refractive index dynamics are explained from a combination of band filling and field screening. It is concluded, that for the right bias and wavelength it is possible to wavelength convert into negatively chirped pulses.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics
Contributors: Romstad, F. P., Hvam, J. M., Mørk, J.
Number of pages: 122
Publication date: Jun 2002
Analysis of noise suppression in cascaded all-optical regenerators
We derive an approximate analytical expression for the BER of cascaded links with all-optical regenerators and use it for performing a general analysis of the interplay between noise and the non-linearity of the regenerator characteristic.

Bandwidth and chirp characterisation of wavelength conversion based on electroabsorption modulators
It is demonstrated experimentally that the frequency chirp of a data modulated signal can be reduced and the modulation bandwidth increased through wavelength conversion in an electroabsorption modulator.

BER estimation for all-optical regenerators influenced by pattern effects
An efficient method is presented for the estimation of the bit-error rate (BER) of a system employing all-optical regenerators influenced by pattern effects. We theoretically study noise accumulation and noise redistribution in long distance transmission systems employing a delayed interference signal wavelength converter for all-optical regeneration. The BER is studied for return-to-zero signals at bit rates of 2.5 Gb/s (no patterning) up to 40 Gb/s (strong patterning).
calculation of the BER is based on pattern dependent transfer functions, which may be obtained numerically or measured.
Dispersion-induced nonlinearities in semiconductors

A dispersive and saturable medium is shown, under very general conditions, to possess ultrafast dynamic behaviour due to non-adiabatic polarisation dynamics. Simple analytical expressions relating the effect to the refractive index dispersion of a semiconductor are derived and the magnitude of the equivalent Kerr coefficient is shown to be in qualitative agreement with measurements on active semiconductor waveguides.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Mørk, J., Mecozzi, A.
Pages: 173-177
Publication date: 2002
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Publication information
Journal: Optics Communications
Volume: 210
Issue number: 3-6
ISSN (Print): 0030-4018
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.86 SJR 0.614 SNIP 0.95
Web of Science (2017): Impact factor 1.887
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.65 SJR 0.603 SNIP 0.87
Web of Science (2016): Impact factor 1.588
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.62 SJR 0.673 SNIP 0.928
Web of Science (2015): Impact factor 1.48
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.62 SJR 0.7 SNIP 1.03
Web of Science (2014): Impact factor 1.449
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.78 SJR 0.74 SNIP 1.154
Web of Science (2013): Impact factor 1.542
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.63 SJR 0.801 SNIP 1.125
Web of Science (2012): Impact factor 1.438
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.62 SJR 0.811 SNIP 1.2
Web of Science (2011): Impact factor 1.486
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.921 SNIP 1.167
Web of Science (2010): Impact factor 1.517
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.014 SNIP 1.203
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.113 SNIP 1.227
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.059 SNIP 1.063
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.063 SNIP 1.196
Web of Science (2006): Indexed yes
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Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.289 SNIP 1.408
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.34 SNIP 1.327
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.109 SNIP 1.263
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.305 SNIP 1.258
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.268 SNIP 0.925
Experimental characterisation of wavelength conversion at 40 Gb/s based on electroabsorption modulators
The optimum operation point for high-speed wavelength conversion in electroabsorption modulators is investigated with respect to conversion efficiency and wavelength chirp. In particular, pump power, reverse bias and probe wavelength are found to be important operation parameters.

General information
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Organisations: Systems, Department of Photonics Engineering, Optoelectronics, Department of Micro- and Nanotechnology
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Volume: 1
Publisher: IEEE
ISBN (Print): 0-7803-7500-9
Electronic versions:
Xu.pdf
DOIs:
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Source: orbit
Source-ID: 153969
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

Fast processes in semiconductor optical amplifiers: theory and experiment
We review the physical processes responsible for ultrafast gain and index dynamics in semiconductor optical amplifiers and discuss their impact on optical switching applications

General information
State: Published
Organisations: Department of Photonics Engineering, Optoelectronics
Contributors: Mørk, J.
Publication date: 2002

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ISBN (Print): 07-80-37378-2
Electronic versions:
Mørk.pdf
DOIs:
10.1109/LEOSST.2002.1027582

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Source: orbit
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Research output: Research - peer-review › Article in proceedings – Annual report year: 2002
Heterodyne technique for measuring the amplitude and phase transfer functions of an optical modulator

In this letter, we propose a technique based on heterodyne detection for accurately and simultaneously measuring the amplitude and phase transfer functions of an optical modulator. The technique is used to characterize an InGaAsp multiple quantum-well electroabsorption modulator. From the measurements we derive the small-signal alpha-parameter and the time-dependent chirp for different operation conditions.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Romstad, F. P., Birkedal, D., Mørk, J., Hvam, J. M.
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Peer-reviewed: Yes

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.457 SNIP 1.678
Influence of quasibound states on the carrier capture in quantum dots

The interaction of carriers in quantum-dot quasibound states with longitudinal optical phonons is investigated. For a level separation between the quasibound state and a discrete quantum-dot state in the vicinity of the phonon energy, a strong electron-phonon coupling occurs. A mixed electron-phonon mode-polaron is formed. The finite lifetime of the phonons is shown to give rise to another type of carrier capture into quantum dots.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Modeling, P. N. Lebedev Physical Institute, Laboratoire de Physique de la Matière Condensée
Contributors: Magnúsdóttir, I., Uskov, A., Ferreira, R., Bastard, G., Mørk, J., Tromborg, B.
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BFI (2018): BFI-level 2
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Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Influence of quasi-bound states on the carrier capture into quantum dots
An important characteristic of quantum dot (QD) materials is the timescale on which carriers are captured into the dots and relax to their ground state. The properties of devices based on QDs, such as lasers, thus rely on efficient carrier feeding to the active QD states. These processes are believed to be mediated by carrier-phonon and carrier-carrier interaction (Auger processes). In systems of higher dimensionality, carrier relaxation via emission of LO (Longitudinal Optical) phonons is dominant. However, due to the discrete QD density of states, this process is often considered impossible unless the energy level separation equals the LO phonon energy, leading to a so-called phonon bottleneck. This argument is based on the assumption that the carrier-LO phonon interaction is weak. It was shown that carriers in discrete QD states couple strongly to phonons and that the intersubband transition cannot be treated with Fermi's golden rule. Here, we extend the analysis to the coupling between carriers in quasi-bound continuum states and discrete QD states.

Modeling of Carrier Dynamics in Electroabsorption Modulators
This thesis is concerned with modeling of electroabsorption modulators. Electroabsorption modulators are expected to play an important role both in the coming 40-Gbit/s optical communication systems and in next-generation, all-optical communication systems. Understanding the dynamics in electroabsorption modulators will help to support the
development of high-speed components tailored for specific functionalities. We present modeling of all-optical functionalities realized with electroabsorption modulators. Using a model that includes propagation equations, a detailed gain model and a phenomenological model for the carrier sweep-out dynamics, we investigate all-optical wavelength conversion, all-optical signal regeneration, and all-optical demultiplexing. A detailed drift-diffusion type model for the sweep-out of photo-excited carriers in electroabsorption modulators is presented. We use the model to calculate absorption spectra and steady-state carrier distributions in different modulator structures. This allows us to investigate a number of important properties of electroabsorption modulators, such as the electroabsorption effect and the saturation properties. We also investigate the influence that carrier recapture has on the device properties, and we discuss the recapture process on a more fundamental level. The model is also used to investigate in detail the carrier sweep-out process in electroabsorption modulators. We investigate how the intrinsic-region width, the separate-confinement heterobarrier design, the optical power level, the number of wells and other important design- and external parameters affect the dynamical properties. We characterize the field change across the wells in a multi-quantum-well structure, and we investigate the sweep-out in a structure with shallow wells. Sweep-out upon excitation with highly energetic pulses is investigated, and the influence of carrier recapture on the sweep-out process is modeled and discussed. From our results we draw a number of conclusions concerning the carrier sweep-out dynamics in electroabsorption modulators, and about the influence that the epitaxial structure design has on the intrinsic dynamical properties.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics
Contributors: Højfeldt, S., Mørk, J., Bischoff, S.
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Publication information
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phd_SuneHøjfeldt.pdf
Source: orbit
Source-ID: 197547
Research output: Research › Ph.D. thesis – Annual report year: 2002

Modeling of carrier dynamics in quantum-well electroabsorption modulators
We present a comprehensive drift-diffusion-type electroabsorption modulator (EAM) model. The model allows us to investigate both steady-state properties and to follow the sweep-out of carriers after pulsed optical excitation. Furthermore, it allows for the investigation of the influence that various design parameters have on the device properties, in particular how they affect the carrier dynamics and the corresponding field dynamics. A number of different types of results are presented. We calculate absorption spectra and steady-state field screening due to carrier pile-up at the separate-confinement heterostructures. We then move on to look at carrier sweep-out upon short-pulse optical excitation. For a structure with one well, we analyze how the well position affects the carrier sweep-out and the absorption recovery. We calculate the field dynamics in a multi-quantum-well structure and discuss how the changes in the field near each well affect the escape of carriers from that well. Finally, we look at the influence that the separate-confinement heterostructure barriers have on the carrier sweep-out.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Højfeldt, S., Mørk, J.
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Publication information
Journal: IEEE Journal on Selected Topics in Quantum Electronics
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Issue number: 6
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BFI (2018): BFI-level 2
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.116 SNIP 1.346
Web of Science (2017): Impact factor 3.367
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.99 SJR 1.217 SNIP 1.409
Web of Science (2016): Impact factor 3.971
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.03 SJR 1.475 SNIP 1.437
Web of Science (2015): Impact factor 3.466
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.49 SJR 1.884 SNIP 2.044
Web of Science (2014): Impact factor 2.828
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.55 SJR 2.249 SNIP 2.353
Web of Science (2013): Impact factor 3.465
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.35 SJR 2.736 SNIP 2.598
Web of Science (2012): Impact factor 4.078
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.87 SJR 2.368 SNIP 2.78
Web of Science (2011): Impact factor 3.78
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.17 SNIP 2.552
Web of Science (2010): Impact factor 3.466
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.809 SNIP 2.867
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.403 SNIP 2.495
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.361 SNIP 1.913
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.077 SNIP 2.448
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.901 SNIP 2.584
Scopus rating (2004): SJR 2.781 SNIP 2.592
Scopus rating (2003): SJR 3 SNIP 3.092
Scopus rating (2002): SJR 2.514 SNIP 2.529
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 2.249 SNIP 1.935
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.992 SNIP 1.364
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 3.471 SNIP 1.6
Original language: English
Electronic versions:
Højfeldt.pdf
Modeling of carrier transport in multi-quantum-well p-i-n modulators

The dynamical properties of InGaAsP multi-quantum-well electroabsorption modulators are investigated using a comprehensive numerical device model. We calculate the time-dependent sweep-out of photo-generated carriers and the corresponding time-dependent absorption change. The sweep-out is influenced by carriers being recaptured into subsequent wells as they move towards the contacts. This process drastically increases the sweep-out time in our ten-well structure (similar to 25 ps) compared to the pure drift-time (similar to 1 ps). We also compare the saturation properties of two components with different separate-confinement heterostructures.
Modeling of semiconductor optical amplifiers

We discuss the modeling of semiconductor optical amplifiers with emphasis on their high-speed properties. Applications in linear amplification as well as ultrafast optical signal processing are reviewed. Finally, the possible role of quantum-dot based optical amplifiers is discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Optoelectronics, Networks
Contributors: Mørk, J., Bischoff, S., Berg, T. W., Nielsen, M. L., Öhman, F.
Publication date: 2002
Peer-reviewed: Yes
Event: Abstract from 2002 OSA Annual Meeting, Orlando, USA.
Source: orbit
Source-ID: 37061
Research output: Research - peer-review › Conference article – Annual report year: 2002

Noise and saturation properties of semiconductor quantum dot optical amplifiers

We present a detailed theoretical analysis of quantum dot optical amplifiers. Due to the presence of a reservoir of wetting layer states, the saturation and noise properties differ markedly from bulk or QW amplifiers and may be significantly improved.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Berg, T. W., Mørk, J.
Publication date: 2002

Host publication information
Title of host publication: Technical Digest Optical Amplifiers and Their Applications
Source: orbit
Source-ID: 42915
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2002

Noise properties and cascadability of SOA-EA regenerators

We suggest and analyse a new device containing concatenated pairs of semiconductor optical amplifiers (SOAs) and electroabsorption modulators (EAs). The device has regenerative properties and improves the cascadability of optical fibre links.

General information
State: Published
Numerical Analysis of an All-optical Logic XOR gate based on an active MZ Interferometer

Summary form only given. A vital issue for practical implementation of optical XOR gates is the tolerance of the gate towards imperfect synchronism of the two signals participating in the XOR operation, as well as the tolerance towards variations of the signal pulse widths. These issues are investigated numerically for a Mach-Zehnder interferometer (MZI) based XOR gate. For bit-rates up to 40 Gb/s, the synchronization tolerance of a MZI XOR gate is determined by the pulse width for RZ format. For the NRZ format, the tolerance decreases as the rise/fall-time approaches the timeslot. The gate is found to be very tolerant towards differences in the RZ pulse width.

General information
State: Published
Organisations: Networks, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Nielsen, M. L., Mørk, J., Fjelde, T., Dagens, B.
Publication date: 2002

Host publication information
Volume: 1
Place of publication: USA
Publisher: IEEE
ISBN (Print): 1-55752-706-7
Electronic versions:
Nielsen.pdf
DOIs:
10.1109/CLEO.2002.1034382

Bibliographical note
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Source: orbit
Source-ID: 42925
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

One- and two-phonon capture processes in quantum dots

Multiphonon capture processes are investigated theoretically and found to contribute efficiently to the carrier injection into quantum dots. It is shown that two-phonon capture contributes where single-phonon capture is energetically inhibited and can lead to electron capture times of a few picoseconds at room temperature and carrier densities of $10^{17}$ cm$^{-3}$ in the barrier.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Modeling, Nanophotonics Theory and Signal Processing, Technical University of Denmark
We have experimentally investigated the performance of external cavity mode-locked semiconductor lasers employing reverse biased saturable absorbers. We have measured the magnitude of trailing pulses when varying the chip length and studied the pulse quality when changing the driving conditions. The observed behavior is explained and we conclude on the optimum operating parameters.
Precise measurement of EAM chirp alpha-parameter and theoretical analysis of effective chirp under large signal moduling

General information
State: Published
Organisations: Systems, Department of Photonics Engineering, Optoelectronics
Contributors: Xu, L., Chi, N., Mørk, J., Oxenløwe, L. K., Jeppesen, P.
Pages: 61-63
Publication date: 2002

Host publication information
Title of host publication: Proc. ICT 2002
Publisher: ICT
Source: orbit
Source-ID: 154006
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

Reduction of pattern effects in SOA-based all-optical switches by using cross-gain modulated holding signal
The effective carrier lifetime of SOAs is typically shortened by an intense Continuous Wave (CW) holding signal. However, the SOA gain is reduced by the holding signal resulting in smaller gain and refractive index changes induced by the data signal. Accordingly, an optimum exists for the CW and data signal power. Here, we demonstrate that the modulation bandwidth (amplitude jitter) is significantly improved (reduced) by replacing the CW holding beam with a signal, which is
low-pass filtered and inverted with respect to the data signal. Such a holding beam can be generated by XGM WC in an SOA, and reduces the fluctuations of the total energy injected into the interferometer within a bit-slot. Thus, we demonstrate a technique for reducing pattern effects in SOAs by employing a partially inverted holding beam. The method should be useful for increasing the data rates of all-optical switches.

**General information**

State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Bischoff, S., Mørk, J.
Number of pages: 353
Publication date: 2002

**Host publication information**

Volume: 1
Publisher: IEEE
ISBN (Print): 15-57-52705-9
Electronic versions: Bischoff.pdf
DOIs: 10.1109/CLEO.2002.1034076

**Bibliographical note**

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Source: orbit
Source-ID: 42888
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

**Short pulse absorption dynamics in a p-i-n InGaAsP MQW waveguide saturable absorber**

The saturation properties and absorption dynamics of an InGaAsP MQW waveguide saturable absorber is measured using short 200-fs and 1-ps pulses. The dependence on the pulse energy and reverse bias is characterized.

**General information**

State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Romstad, F. P., Öhman, F., Mørk, J., Yvind, K., Hvam, J. M., Hanberg, J.
Pages: 1-2
Publication date: 2002

**Host publication information**

Volume: 3
Publisher: IEEE
ISBN (Print): 87-90974-63-8
Electronic versions: Romstad.pdf

**Bibliographical note**

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Source: orbit
Source-ID: 42918
Research output: Research - peer-review › Article in proceedings – Annual report year: 2002

**Theoretical analysis of quantum dot amplifiers with high saturation power and low noise figure**

Semiconductor quantum dot amplifiers are predicted to exhibit superior characteristics such as high gain, and output power and low noise. The analysis provides criteria and design guidelines for the realization of high quality amplifiers.

**General information**

State: Published
Two-phonon capture processes into quantum dots: The role of intermediate states

Ultrafast optical signal processing using semiconductor optical devices

Ultrafast optical signal processing using semiconductor quantum dot amplifiers
Ultrafast signal processing in quantum dot amplifiers through effective spectral holeburning

Significant progress has been obtained on quantum dot (QD) lasers, but the possible advantages of QD amplifiers are not yet clear. We show here that a relatively slow coupling between the optically active QD carrier states and the surrounding carrier reservoir can lead to efficient gain modulation suitable for ultrafast signal processing. The basis of this property is that the process of spectral hole burning (SHB) can become very effective. We consider a traveling wave optical amplifier consisting of the dot states, which interact with the optical signal (no inhomogeneous broadening included), and the wetting layer (WL), where current is injected. Time evolution is described by two coupled rate equations. Carrier capture from WL to dots is characterized by the capture time $\tau_0$.

Absorption and refractive index recovery in an InGaAsP MQW electro-absorption modulator

We show the first measurements of gain and refractive index recovery in an electro-absorber. The measurements show strong dependence of the refractive index dynamics on the reverse bias. The results are discussed in relation to field screening following the optical carrier injection.
Comparison of all-optical co- and counter-propagating high-speed signal processing in SOA-based Mach-Zehnder interferometers

The all-optical signal processing performance of a Mach-Zehnder interferometer (MZI) is investigated. Calculated switching windows are used to investigate and understand the physical mechanisms limiting the high speed performance. Especially, the co- and counter-propagating operation of the MZI is discussed and important differences in the performance for the two schemes are addressed. The non-regenerative all-optical clear and drop functionality is investigated for a 2, 4 and 8 x 40 Gbit/s signal, showing good performance in the co-propagating case. Regenerative simultaneous clear and drop functionality in a single MZI is demonstrated experimentally and compared to the large signal model predictions.
Efficient phonon-assisted capture into quantum dots

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Modeling
Contributors: Magnúsdóttir, I., Uskov, A., Bischoff, S., Tromborg, B., Mørk, J.
Publication date: 2001
Peer-reviewed: Yes
Event: Abstract from 19th Nordic Semiconductor Meeting, Gentofte, Denmark.
Source: orbit
Source-ID: 36707
Research output: Research - peer-review › Journal article – Annual report year: 2001

Electrical versus optical pumping of quantum dot amplifiers
The influence of the pumping mechanism for the dynamical properties of quantum dot amplifiers is investigated for 10, 40 and 160 GHz signals. A fast response is predicted in the case of optical pumping in the wetting layer (WL). The combination of fast relaxation and capture times and the presence of a reservoir of carriers in the WL opens up for the possibility of ultrafast gain recovery in QD devices. The strength of optical contra electrical pumping is that it reduces the bottleneck effect of a slow WL. Optical pumping thus allows significant improvement of the dynamical properties of QD devices.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Berg, T. W., Bischoff, S., Mørk, J.
Gain recovery dynamics and limitations in quantum dot amplifiers

Summary form only given. While ultra-low threshold current densities have been achieved in quantum dot (QD) lasers, the predicted potential for high-speed modulation has not yet been realized despite the high differential gain. Furthermore, recent single pulse experiments demonstrated very fast gain recovery in a quantum dot amplifier, and it is thus not yet clear what the limiting processes for the device response are. We present the results of a comprehensive theoretical model, which agrees well with the experimental results, and indicates the importance of slow recovery of higher energy levels. The model used is of the rate-equation type with three energy levels: ground state (GS) and excited state (ES) dot levels and a wetting layer.

Improvement of noise redistribution by employing an SOA-EA cascade

Noise redistribution and pulse reshaping in an optical transmission link, by concatenated pairs of SOAs and electro-absorbers, is investigated theoretically. The results show sharper nonlinear transfer function, better noise redistribution and stronger pulse compression for increasing number of pairs.
Limits to speed of semiconductor devices for all-optical processing

General information
State: Published
Organisations: Department of Photonics Engineering, Optoelectronics
Contributors: Mørk, J., Bischoff, S., Højfeldt, S.
Number of pages: 104
Publication date: 2001

Line broadening caused by Coulomb carrier-carrier correlations and dynamics of carrier capture and emission in quantum dots
Mechanisms of pure dephasing in quantum dots due to Coulomb correlations and the dynamics of carrier capture and emission are suggested, and a phenomenological model for the dephasing is developed. It is shown that, if the rates of these capture and emission processes are sufficiently high, significant homogeneous line broadening of the order of several meV can result.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Modeling, Nanophotonics Theory and Signal Processing, Tokyo University of Agriculture and Technology
Contributors: Uskov, A. V., Magnúsdóttir, I., Tromborg, B., Mørk, J., Lang, R.
Pages: 1679-1681
Publication date: 2001
Peer-reviewed: Yes

Publication information
Volume: 79
Issue number: 11
ISSN (Print): 0003-6951
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.25 SJR 1.382 SNIP 1.167
Web of Science (2017): Impact factor 3.495
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Measurement of the amplitude and phase transfer functions of an optical modulator using a heterodyne technique

We present a new technique that measures the full amplitude and phase transfer curves of the modulator as a function of the applied bias, from which the small signal $\alpha$-parameter can be calculated. The technique measures the amplitude and phase transfer functions simultaneously and directly, compared to techniques where a time-consuming data analysis is necessary to calculate the $\alpha$-parameter and an additional measurement is necessary to estimate the phase. Additionally, the chirp profile for all operation points can be calculated.

General information
State: Published
Organisations: Optoelectronics, Department of Micro- and Nanotechnology, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Romstad, F. P., Birkedal, D., Mørk, J., Hvam, J. M.
Pages: 34-35
Publication date: 2001

Host publication information
Title of host publication: Proceedings on The 14th Annual Meeting of the IEEE Lasers and Electro-Optics Society
Volume: 1
Publisher: IEEE
ISBN (Print): 07-80-37105-4
Electronic versions: romstad.pdf
DOIs: 10.1109/LEOS.2001.969159

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Modeling of carrier transport in multi-quantum-well p-i-n modulators

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Bischoff, S., Højfeldt, S., Mørk, J.
Publication date: 2001
Peer-reviewed: Yes
Event: Abstract from 19th Nordic Semiconductor Meeting, Gentofte, Denmark.
Source: orbit
Source-ID: 42990
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Modeling of semiconductor devices for high-speed all-optical signal processing

The all-optical signal processing performance of devices based on active semiconductor waveguides is investigated. A large signal model is used to analyse the physical mechanisms limiting the high-speed performance of both semiconductor optical amplifiers (SOAs) and electro-absorption modulators (EAMs). Wavelength conversion and signal regeneration in EAMs is discussed at 10 and 40 Gbit/s. The finite carrier sweep-out time is shown to limit the EAM performance. Four-wave mixing (FWM) in SOAs is almost instantaneous. However, with increasing bit rates and advanced processing functionalities some limitations arise. These limitations are elucidated by studying bi-directional simultaneous clear and drop (de-multiplexing) for a 4x40 Gbit/s signal. The simultaneous clearing and de-multiplexing (drop) of an optical time division multiplexing signal channel for an 8x40 Gbit/s signal is investigated in a Mach-Zehnder interferometer. The finite response time of the SOAs is found to limit the base bit rate to 40 Gbit/s. Base bit rates above 40 Gbit/s will require an improved device design with faster material response.

General information
State: Published
Modeling of temperature characteristics of quantum dot amplifiers: rate vs. master equation models

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Berg, T. W., Bischoff, S., Magnúsdóttir, I., Mørk, J.
Publication date: 2001
Peer-reviewed: Yes
Event: Abstract from 19th Nordic Semiconductor Meeting, Gentofte, Denmark.
Source: orbit
Source-ID: 42962
Research output: Research - peer-review › Journal article – Annual report year: 2001

Multiphonon capture processes in self-assembled quantum dots
We investigate capture of carriers from states in the continuous part of the energy spectrum into the discrete states of self-assembled InAs/GaAs QDs via emission of one or two phonons. We are not aware of any other investigations of two-phonon mediated capture processes in QDs, but we show that this may be an efficient capture mechanism. The phonons are assumed to be bulk GaAs LO phonons with zero dispersion. The QD was modelled by a finite confinement potential well in the effective-mass approximation.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Magnúsdóttir, I., Uskov, A., Bischoff, S., Merk, J.
Pages: 206-207
Publication date: 2001

Host publication information
Title of host publication: Summaries of Papers Presented at the Technical Digest Quantum Electronics and Laser Science Conference
Electronic versions:
mork.pdf
Numerical Investigation of Dual-order Mode Wavelength converter

General information
State: Published
Organisations: Networks, Department of Photonics Engineering, Optoelectronics
Contributors: Nielsen, M. L., Mørk, J., Bischoff, S., Wolfson, D., Klock, A.
Pages: 576-577
Publication date: 2001

Host publication information
Title of host publication: Proc. of ECOC 2001
Source: orbit
Source-ID: 156145
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Pattern effects and noise accumulation in concatenated all-optical regenerators

In future high-speed networks, interferometric structures based on semiconductor optical amplifiers (SOAs) are strong candidates for wavelength conversion applications and signal regeneration. One of the latest reported interferometric devices is the semiconductor delayed-interference signal-wavelength converter (DISC), which allows for high-speed switching by exploiting the fast carrier-depletion related refractive index changes in the SOA. Here, we use a numerical model of the DISC configuration, including saturation and dynamical effects in the SOA, to generate pattern dependent transfer functions. These transfer functions are used to evaluate the noise accumulation and the BER of concatenated regenerators.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Modeling, Systems
Contributors: Lading, B., Mørk, J., Bischoff, S., Tromborg, B., Poulsen, H. N.
Pages: 527-528
Publication date: 2001

Host publication information
Title of host publication: Summaries of papers presented at the Conference on Lasers and Electro-Optics
Publisher: Opt. Soc. America
ISBN (Print): 15-57-52662-1
Electronic versions:
landing.pdf
DOIs: 10.1109/CLEO.2001.948128

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Source: orbit
Source-ID: 42979
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

SCOOP - Semiconductor COmponents for Optical signal Processing

Opto-electronic semiconductor devices operating at very high bitrates play a central role in the continued expansion of the transmission capacity of optical communication systems. A number of different devices based on quantum well structures have been manufactured within the framework of the national SCOOP programme. Results for a high-speed modulator, a
short-pulse laser and an all-optical switch are presented.

**General information**

State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Systems, GIGA A/S
Pages: 25-30
Publication date: 2001
Peer-reviewed: Unknown

**Publication information**

Journal: DOPS-Nyt
Volume: 16
Issue number: 2
ISSN (Print): 0901-4632
Ratings:
- ISI indexed (2013): ISI indexed no
- ISI indexed (2012): ISI indexed no
- ISI indexed (2011): ISI indexed no
Original language: English
Source: orbit
Source-ID: 42963
Research output: Communication › Journal article – Annual report year: 2001

**Semiconductor quantum dot amplifiers for optical signal processing**

The dynamics of quantum dot semiconductor amplifiers are investigated theoretically with respect to the potential for ultrafast signal processing. The high-speed signal processing capacity of these devices is found to be limited by the wetting layer dynamics in case of electrical pumping, while optical pumping partly removes this limitation. Also, the possibility of using spectral hole burning for signal processing is discussed.

**General information**

State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, P. N. Lebedev Physical Institute
Contributors: Berg, T. W., Uskov, A. V., Bischoff, S., Magnúsdóttir, I., Mørk, J.
Pages: 76-78
Publication date: 2001

**Host publication information**

Title of host publication: Proc. International Workshop on Optical Signal Processing
Publisher: COM.DTU
Source: orbit
Source-ID: 42968
Research output: Research › Article in proceedings – Annual report year: 2001

**Temperature characteristics of quantum dot devices: Rate vs. Master Equation Models**

The change of transparency current with temperature for quantum dot devices depends strongly on whether a rate or master equation model is used. The master equation model successfully explains experimental observations of negative characteristic temperatures.

**General information**

State: Published
Organisations: Optoelectronics, Department of Photonics Engineering
Contributors: Berg, T. W., Bischoff, S., Magnúsdóttir, I., Mørk, J.
Publication date: 2001

**Host publication information**

Title of host publication: Technical Digest Integrated Photonics Research
Source: orbit
Source-ID: 42965
Research output: Research › peer-review › Article in proceedings – Annual report year: 2001
Ultrafast gain recovery and modulation limitations in self-assembled quantum-dot devices

Measurements of ultrafast gain recovery in self-assembled InAs quantum-dot (QD) amplifiers are explained by a comprehensive numerical model. The on excited state carriers are found to act as a reservoir for the optically active ground state carriers resulting in an ultrafast gain recovery as long as the excited state is well populated. However, when pulses are injected into the device at high-repetition frequencies, the response of a on amplifier is found to be limited by the wetting-layer dynamics.

General information
State: Published
Organisations: Optoelectronics, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Berg, T. W., Bischoff, S., Magnúsdóttir, I., Mørk, J.
Pages: 541-543
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: IEEE Photonics Technology Letters
Volume: 13
Issue number: 6
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.52 SJR 0.989 SNIP 1.224
Web of Science (2016): Impact factor 2.375
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.62 SJR 1.19 SNIP 1.266
Web of Science (2015): Impact factor 1.945
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.78 SJR 1.421 SNIP 1.583
Web of Science (2014): Impact factor 2.11
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.95 SJR 1.495 SNIP 1.548
Web of Science (2013): Impact factor 2.176
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.46 SJR 1.647 SNIP 1.694
Web of Science (2012): Impact factor 2.038
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.48 SJR 1.539 SNIP 2.04
Web of Science (2011): Impact factor 2.191
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.457 SNIP 1.678
Web of Science (2010): Impact factor 1.989
All-optical wavelength conversion and signal regeneration using an electroabsorption modulator

All-optical wavelength conversion and signal regeneration based on cross-absorption modulation in an InGaAsP quantum well electroabsorption modulator (EAM) is studied at different bit rates. We present theoretical results showing wavelength conversion efficiency in agreement with existing experimental results, and the signal regeneration capability of the device is investigated. In particular, we demonstrate the dependence of the extinction ratio of both the converted signal and the control signal on the device length and on the power level of the control signal. We also show how the sweep-out dynamics influences the results.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Højfeldt, S., Bischoff, S., Mørk, J.
Pages: 1121-1127
Publication date: Aug 2000
Peer-reviewed: Yes
Ratings:

BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes

BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.42 SJR 1.166 SNIP 1.791
Web of Science (2017): Impact factor 3.652
Web of Science (2017): Indexed yes

BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.87 SJR 1.23 SNIP 1.819
Web of Science (2016): Impact factor 3.671
Web of Science (2016): Indexed yes

BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.15 SJR 1.598 SNIP 1.901
Web of Science (2015): Impact factor 2.567
Web of Science (2015): Indexed yes

BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.23 SJR 1.737 SNIP 2.411
Web of Science (2014): Impact factor 2.965
Web of Science (2014): Indexed yes

BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.03 SJR 1.622 SNIP 2.439
Web of Science (2013): Impact factor 2.862
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes

BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.21 SJR 1.888 SNIP 2.491
Web of Science (2012): Impact factor 2.555
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes

BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.2 SJR 1.733 SNIP 2.957
Web of Science (2011): Impact factor 2.784
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes

BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.737 SNIP 2.401
Web of Science (2010): Impact factor 2.259
Web of Science (2010): Indexed yes

BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.096 SNIP 2.749
Web of Science (2009): Indexed yes

BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.198 SNIP 2.443
Web of Science (2008): Indexed yes

Scopus rating (2007): SJR 2.313 SNIP 2.212
Web of Science (2007): Indexed yes

Scopus rating (2006): SJR 2.03 SNIP 2.562
Web of Science (2006): Indexed yes

Scopus rating (2005): SJR 2.846 SNIP 2.952
Web of Science (2005): Indexed yes

Scopus rating (2004): SJR 2.332 SNIP 2.688
Web of Science (2004): Indexed yes

Scopus rating (2003): SJR 2.703 SNIP 2.876
All-optical clear/drop optimisation for a 4x40 Gbit/s signal in Mach-Zehnder Interferometers Based on Semiconductor Optical Amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Bischoff, S., Mørk, J.
Publication date: 2000

Host publication information
Title of host publication: ECOC 2000 Proceedings
Source: orbit
Source-ID: 173109
Research output: Research - peer-review; Journal article – Annual report year: 2000

All-optical demultiplexing using an electroabsorption modulator
In the 1990s, the electroabsorption modulator (EAM) has found a wide range of applications. Functionalities such as pulse generation and demultiplexing by electrical modulation have been demonstrated using an EAM. Recently, all-optical wavelength conversion, demultiplexing, and signal regeneration, have also been experimentally demonstrated. In this paper, we investigate all-optical demultiplexing from 80 to 10 Gbit/s.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Højfeldt, S., Bischoff, S., Mørk, J.
Pages: 342-343
Publication date: 2000

Host publication information
Title of host publication: Proceedings of Lasers and Electro-Optics
Place of publication: San Francisco, CA
Publisher: IEEE
ISBN (Print): 1-55752-634-6
Electronic versions:
sune.pdf
DOIs:
10.1109/CLEO.2000.907091
All-optical signal regeneration at 40 Gbit/s using a Mach-Zehnder Interferometer based on semiconductor optical amplifiers

Summary form only given. All-optical signal regeneration and processing are interesting for high bit-rate transmission systems. The Mach-Zehnder interferometer (MZI) is a promising device for functionalities like all-optical add/drop and signal regeneration. Wavelength conversion up to 20 Gbit/s, demultiplexing of a 8×10 Gbit/s signal and all-optical signal regeneration at 40 Gbit/s have been experimentally demonstrated, showing the high speed processing potential. We have theoretically investigated all-optical signal regeneration in a SOA based MZI and identified some of the main limiting factors and optimization issues.

A transfer function approach to the small-signal response of saturated semiconductor optical amplifiers

A theoretical analysis of the small-signal frequency response (SSFR) of a wavelength converter based on cross-gain modulation in a semiconductor optical amplifier with a finite waveguide loss is presented. We use a transfer function formalism to explain the resonant behavior of the frequency response. The limitations to the magnitude of the spectral overshoot are also accounted for. Operating with the data and CW signals in a co-propagating configuration, we find that the resonance only exists for a finite waveguide loss. In a counter-propagating scheme, a resonance can exist regardless of the presence of loss.
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<td>2003</td>
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<td>2002</td>
<td>Indexed yes</td>
<td>Impact factor 2.751</td>
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Interpretation of experiments on quantum dot (QD) lasers presents a challenge: the phonon bottleneck, which should strongly suppress relaxation and dephasing of the discrete energy states, often seems to be inoperative. We suggest and develop a theory for an intrinsic mechanism for dephasing in QDs: second-order elastic interaction between quantum dot charge carriers and LO phonons. The calculated dephasing times are of the order of 200 fs at room temperature, consistent with experiments. The phonon bottleneck thus does not prevent significant room temperature dephasing.
Elastic LO-phonon scattering as an efficient mechanism of dephasing and homogeneous broadening in quantum dots

General information
State: Published
Organisations: Department of Photonics Engineering, P. N. Lebedev Physical Institute, Tokyo University of Agriculture and Technology
Contributors: Uskov, A. V., Tromborg, B., Jauho, A., Mørk, J., Lang, R.
Pages: 31-32
Publication date: 2000

Host publication information
Title of host publication: QELS 2000 Technical Digest
Place of publication: Washington DC
Publisher: Optical Society of America
Source: orbit
Source-ID: 173105
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Measurement of pulse amplitude and phase distortion in a semiconductor optical amplifier: from pulse compression to breakup

We have performed extensive measurements of the propagation of ultrashort pulses in a semiconductor bulk amplifier using an ultrasensitive cross frequency-resolved optical gating technique. Pulses of 175-fs duration with energies from below 1 fJ to above 100 pJ are measured both in amplitude and phase after propagation through the device. While only moderate reshaping effects occur at pulse energies of below 1 pJ, strong amplitude distortion together with nonlinear chirp is found for input energies of 5-100 pJ. This leads to a pulse narrowing by more than a factor of two when the amplifier is biased for material transparency or absorption and to a pronounced pulse breakup in the gain regime.

General information
State: Published
Organisations: Department of Photonics Engineering, Department of Micro- and Nanotechnology, Nanophotonics Theory and Signal Processing
Contributors: Romstad, F. P., Borri, P., Langbein, W. W., Mørk, J., Hvam, J. M.
Pages: 1674-1676
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: I E E E Photonics Technology Letters
Volume: 12
Issue number: 12
ISSN (Print): 1041-1135
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.84 SJR 0.961 SNIP 1.25
Web of Science (2017): Impact factor 2.446
Web of Science (2017): Indexed yes
Non-adiabatic effects in semiconductor waveguide

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Mørk, J., Mecozzi, A.
Pages: 658-672
Publication date: 2000

Host publication information
Title of host publication: SPIE, vol. 3944
Source: orbit
Source-ID: 176286
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Pulse-distortion in a quantum-dot optical amplifier

General information
State: Published
Organisations: Department of Photonics Engineering, Technische Universität Berlin
Contributors: Romstad, F. P., Borri, P., Mørk, J., Hvam, J. M., Heinrichsdorff, F., Mao, M., Bimberg, D.
Number of pages: 471
Publication date: 2000

Host publication information
Title of host publication: CLEO 2000 Technical Digest
Place of publication: Washington DC
Publisher: Optical Society of America
Source: orbit
Source-ID: 173933
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Room-Temperature Dephasing in InAs Quantum Dots

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Dortmund, Technische Universität Berlin
Contributors: Borri, P., Langbein, W., Mørk, J., Hvam, J. M., Heinrichsdorff, F., Mao, M., Bimberg, D.
Pages: 337-340
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: Physica Status Solidi A
Volume: 178
Issue number: 1
Original language: English
Source: orbit
Source-ID: 174850
All-optical Demultiplexing Using an Electroabsorption Modulator

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Højfeldt, S., Bischoff, S., Mørk, J.
Number of pages: 28
Publication date: 1999

Host publication information
Title of host publication: Proceeding, Annual meeting of the Danish Optical Society
Place of publication: Lyngby
Publisher: DOPS
Source: orbit
Source-ID: 173188
Research output: Research - peer-review › Journal article – Annual report year: 2000

All-optical wavelength conversion and signal regeneration using an electroabsorption modulator

All-optical wavelength conversion in an InGaAsP quantum well electroabsorption modulator is studied at different bit-rates. We present theoretical results showing wavelength conversion efficiency in agreement with existing experimental results, and signal regeneration capability is demonstrated.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Højfeldt, S., Bischoff, S., Mørk, J.
Publication date: 1999

Host publication information
Volume: 2
Place of publication: San Francisco
Publisher: IEEE
Bi-directional four wave mixing in semiconductor amplifiers for mid-span spectral inversion: theory and experiment

Summary form only given. We have developed a large signal model to theoretically assess the performance of a mid span spectral inversion (MSSI) transmission system. The large signal model has previously been used to successfully model the fast gain dynamics of semiconductor optical amplifiers.

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Bischoff, S., Buxens, A. A., Poulsen, H. N., Clausen, A., Mørk, J.
Pages: CTuW3
Publication date: 1999

Host publication information
Title of host publication: Proceedings of CLEO'99
Place of publication: Baltimore
Publisher: IEEE
ISBN (Print): 1-55752-595-1
Electronic versions:
Bischoff.pdf
DOIs:
10.1109/CLEO.1999.834101

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Source: orbit
Source-ID: 172573
Research output: Research - peer-review › Article in proceedings – Annual report year: 1999

Bi-directional four-wave mixing in semiconductor optical amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Fondazione Ugo Bordoni
Pages: 1-3
Publication date: 1999

Host publication information
Title of host publication: Proceedings of COST 267 Workshop
Place of publication: Rome
Publisher: European Cooperation in the Field of Scientific and Technical Research
Source: orbit
Source-ID: 172572
Research output: Research › Article in proceedings – Annual report year: 1999

Bidirectional Four-Wave Mixing in Semiconductor Optical Amplifiers: Theory and Experiment
Bit rate and pulse width dependence of four-wave mixing of short optical pulses in semiconductor optical amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHF, Fondazione Ugo Bordoni
Contributors: Diez, S., Mecozzi, A., Mørk, J.
Pages: 1675-1677
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: Optics Letters
Volume: 24
Issue number: 23
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.89 SJR 1.79 SNIP 1.597
Web of Science (2017): Impact factor 3.589
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.54 SJR 1.769 SNIP 1.549
Web of Science (2016): Impact factor 3.416
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.53 SJR 2.013 SNIP 1.53
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.86 SJR 2.429 SNIP 1.997
Web of Science (2014): Impact factor 3.292
Carrier Dynamics in Quantum Dots and Quantum Dot Lasers

General information
State: Published
Organisations: Department of Photonics Engineering, Technische Universität Berlin, Technical University of Dortmund
Contributors: Heitz, R., Bimberg, D., Mao, M., Heinrichsdorff, F., Borri, P., Märk, J., Langbein, W., Hvam, J. M.
Publication date: 1999
Dephasing in InAs/GaAs quantum dots
The room-temperature dephasing in InAs/GaAs self-assembled quantum dots is measured using two independent methods: spectral-hole burning and four-wave mixing. Dephasing times weakly dependent on the excitation density are found, with a low density value of 290+/-80 fs from spectral-hole burning and of 260+/-20 fs from four-wave mixing.
Dispersion-induced non-linearities in semiconductors

We show that index dispersion in connection with the standard (slow) saturation of the medium due to carrier density changes, lead to ultrafast gain and index dynamics. Analytical formulas are derived, and it is shown that these new contributions may dominate experimentally observed results.
Fotonik - et nyt og revolutionerende begreb

General information
State: Published
Organisations: Department of Photonics Engineering
Contributors: Mørk, J., Hvam, J. M.
Pages: 14-19
Publication date: 1999
Peer-reviewed: No

Publication information
Journal: Naturens Verden
Volume: 10
Original language: Danish
Source: orbit
Source-ID: 173387
Research output: Research › Journal article – Annual report year: 1999

Four-wave mixing between short optical pulses in SOAs

General information
State: Published
Organisations: Department of Photonics Engineering, Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, HHI, Fondazione Ugo Bordoni
Contributors: Mørk, J., Diez, S., Mecozzi, A.
Publication date: 1999

Host publication information
Title of host publication: Proceedings of ACTS Workshop on Advanced photonic components and subsystems
Place of publication: Brussels
Source: orbit
Source-ID: 172604
Research output: Research › Article in proceedings – Annual report year: 1999

Heterodyne pump-probe and four-wave mixing in semiconductor optical amplifiers using balanced lock-in detection

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Dortmund
Contributors: Borri, P., Langbein, W., Mørk, J., Hvam, J. M.
Pages: 317-324
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: Optics Communications
Volume: 169
ISSN (Print): 0030-4018
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.86 SJR 0.614 SNIP 0.95
Web of Science (2017): Impact factor 1.887
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.65 SJR 0.603 SNIP 0.87
Web of Science (2016): Impact factor 1.588
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.62 SJR 0.673 SNIP 0.928
Web of Science (2015): Impact factor 1.48
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.62 SJR 0.7 SNIP 1.03
Web of Science (2014): Impact factor 1.449
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.78 SJR 0.74 SNIP 1.154
Web of Science (2013): Impact factor 1.542
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.63 SJR 0.801 SNIP 1.125
Web of Science (2012): Impact factor 1.438
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.62 SJR 0.811 SNIP 1.2
Web of Science (2011): Impact factor 1.486
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.921 SNIP 1.167
Web of Science (2010): Impact factor 1.517
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.014 SNIP 1.203
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.113 SNIP 1.227
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.059 SNIP 1.063
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.063 SNIP 1.196
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.237 SNIP 1.346
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.289 SNIP 1.408
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.34 SNIP 1.327
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.109 SNIP 1.263
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.305 SNIP 1.258
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.268 SNIP 0.925
Web of Science (2000): Indexed yes
Measurements and calculation of the critical pulsewidth for gain saturation in semiconductor optical amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Fondazione Ugo Bordoni, Technical University of Dortmund
Contributors: Borri, P., Scaffetti, S., Merk, J., Langbein, W., Hvam, J. M., Mecozzi, A., Martelli, F.
Pages: 51-55
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: Optics Communications
Volume: 164
Issue number: 1-3
ISSN (Print): 0030-4018
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.86 SJR 0.614 SNIP 0.95
Web of Science (2017): Impact factor 1.887
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.65 SJR 0.603 SNIP 0.87
Web of Science (2016): Impact factor 1.588
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.62 SJR 0.673 SNIP 0.928
Web of Science (2015): Impact factor 1.48
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.62 SJR 0.7 SNIP 1.03
Web of Science (2014): Impact factor 1.449
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 1.78 SJR 0.74 SNIP 1.154
Web of Science (2013): Impact factor 1.542
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 1.63 SJR 0.801 SNIP 1.125
Web of Science (2012): Impact factor 1.438
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 1.62 SJR 0.811 SNIP 1.2
Web of Science (2011): Impact factor 1.486
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Numerical model of frequency converter based on four-wave mixing in semiconductor amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Fondazione Ugo Bordoni
Contributors: Cassioli, D., Scotti, S., Mecozzi, A., Mørk, J., Spano, P. (ed.)
Publication date: 1999

Host publication information
Title of host publication: Proceedings of the first workshop on Semiconductor devices for optical signal processing
Place of publication: Rome
Publisher: COST Action 267
Source: orbit
Source-ID: 172587
Research output: Research › Article in proceedings – Annual report year: 1999

Return-map for low-frequency fluctuations in semiconductor lasers with optical feedback

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Denmark
Contributors: Mørk, J., Sabbatier, H., Sørensen, M. P., Tromborg, B.
Pages: 93-97
Publication date: 1999
Peer-reviewed: Yes

Publication information
Return-map for semiconductor lasers with optical feedback

It is well known that a semiconductor laser exposed to moderate optical feedback and biased near threshold exhibits the phenomenon of low-frequency intensity fluctuations (LFF). While this behavior can be numerically simulated using the so-called Lang-Kobayashi model, the interpretation of the phenomenon has remained a controversy. The LFF consist of a sudden drop in intensity followed by a build-up in steps of the external cavity roundtrip time, $\tau$, before a new drop-out occurs. The phenomenon has been attributed to a kind of chaotic itinerancy and a bifurcation cascade has been identified very recently. These results give insight into the behavior observed on a short time-scale, but do not explain some of the pronounced features of the LFF seen for moderate feedback levels; namely the stepwise build-up and its characteristic time of about 15 steps close to the solitary laser threshold. We present new results related to the slow time-scale behaviour of LFF which give a simple explanation of these general characteristics, as well as providing a new tool for studying the statistics of the LFF.

Room-temperature dephasing in InGaAs quantum dots

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Dortmund, Technische Universität Berlin
Contributors: Borri, P., Langbein, W., Mørk, J., Hvam, J. M., Heinrichsdorff, F., Mao, M., Bimberg, D.
Publication date: 1999
Saturation properties of four-wave mixing between short optical pulses in semiconductor optical amplifiers

Summary form only given. The authors report the first comparison between theory and experiment on the four wave mixing between trains of short pulses in semiconductor optical amplifiers. The theory is able to explain all qualitative features seen in the experiment.

Semiconductor Devices for All Optical Signal Processing: Just How Fast can They Go?

Several different semiconductor device structures for accomplishing all-optical signal processing have been proposed, but they nearly all employ the semiconductor optical amplifier (SOA) as a central element. In this talk we will discuss the physical processes in SOA's that are important in determining the speed of SOA based switches. We shall consider both devices based on incoherent processes, such as optically induced cross-gain and cross-phase modulation as well as devices employing coherent four-wave mixing.
Sub-picosecond pulse break-up in an InGaAsP optical amplifier

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Dortmund
Contributors: Romstad, F. P., Borri, P., Bischoff, S., Mørk, J., Langbein, W., Hvam, J. M.
Publication date: 1999

Host publication information
Title of host publication: Proceedings of Danish Physical Society Annual Meeting
Publisher: Danish Physical Society
Source: orbit
Source-ID: 172616
Research output: Research › Article in proceedings – Annual report year: 1999

Sub-picosecond pulse distortion in an InGaAsP optical amplifier

General information
State: Published
Organisations: Department of Photonics Engineering, Technical University of Dortmund
Contributors: Romstad, F. P., Borri, P., Bischoff, S., Mørk, J., Langbein, W., Hvam, J. M.
Pages: 28-29
Publication date: 1999

Host publication information
Title of host publication: ECOC'99 Technical Digest II
Place of publication: Nice
Source: orbit
Source-ID: 172876
Research output: Research › Article in proceedings – Annual report year: 1999

The Modulation Response of a Semiconductor Laser Amplifier

General information
State: Published
Organisations: Department of Photonics Engineering, Fondazione Ugo Bordoni, Technion-Israel Institute of Technology
Contributors: Mørk, J., Mecozzi, A., Eisenstein, G.
Pages: 851-860
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Topics in Quantum Electronics
Volume: 5
Issue number: 3
ISSN (Print): 1077-260X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.116 SNIP 1.346
Web of Science (2017): Impact factor 3.367
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.99 SJR 1.217 SNIP 1.409
Web of Science (2016): Impact factor 3.971
Ultrafast gain and index dynamics in quantum dot amplifiers

General information
Measurement and calculation of the critical pulsewidth for gain saturation in semiconductor optical amplifiers

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Borri, P., Mørk, J., Hvam, J. M., Merozzi, A.
Number of pages: 100
Publication date: 1998

Host publication information
Publisher: IEEE
ISBN (Print): 0-7803-4233X
Electronic versions: Borri.pdf

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Source: orbit
Source-ID: 171079
Research output: Research - peer-review › Article in proceedings – Annual report year: 1998

Theory of four-wave mixing
Ch.11

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Contributors: Obermann, K., Mecozzi, A., Mørk, J.
Pages: 281-320
Publication date: 1998

Host publication information
Title of host publication: Photonic devices for telecommunications
Publisher: Springer
Source: orbit
Source-ID: 314633
Research output: Research › Book chapter – Annual report year: 1998

Chirp of hybridly modelocked monolithic CPM diode lasers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Contributors: Hofmann, M., Bischoff, S., Franck, T., Prip, L., Fröjdh, K., Brorson, S. D., Mørk, J.
Pages: 2514
Publication date: 1997
Peer-reviewed: Yes
Chirp of monolithic colliding pulse mode-locked diode lasers
Spectrally resolved streak camera measurements of picosecond pulses emitted by hybridly colliding pulse mode-locked (CPM) laser diodes are presented in this letter. Depending on the modulation frequency both blue-chirped (upchirped) and red-chirped (downchirped) pulses can be observed. The two different regimes and the transition between them are characterized experimentally and the behavior is explained on the basis of our model for the CPM laser dynamics. (C) 1997 American Institute of Physics.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Contributors: Hofmann, M., Bischoff, S., Franck, T., Prip, L., Fröjdh, K., Brorson, S. D., Mørk, J.
Pages: 2514-2516
Publication date: 1997
Peer-reviewed: Yes

Publication Information
Volume: 70
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 2.67 SJR 1.673 SNIP 1.249
Web of Science (2016): Impact factor 3.411
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.47 SJR 1.499 SNIP 1.226
Web of Science (2015): Impact factor 3.142
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.25 SJR 1.861 SNIP 1.492
Web of Science (2014): Impact factor 3.302
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.77 SJR 2.146 SNIP 1.633
Web of Science (2013): Impact factor 3.515
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.76 SJR 2.57 SNIP 1.739
Web of Science (2012): Impact factor 3.794
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.04 SJR 2.814 SNIP 1.917
Web of Science (2011): Impact factor 3.844
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.92 SNIP 1.775
Web of Science (2010): Impact factor 3.841
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.826 SNIP 1.834
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.894 SNIP 1.82
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 3.012 SNIP 1.916
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 3.755 SNIP 2.353
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 3.992 SNIP 2.367
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 3.897 SNIP 2.275
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 4.018 SNIP 2.414
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 4.281 SNIP 2.22
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 4.178 SNIP 2.017
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 4.173 SNIP 2.066
Original language: English
DOIs:
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Source: orbit
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Research output: Research - peer-review › Journal article – Annual report year: 1997

Monolithic colliding pulse mode-locked semiconductor lasers

General information
State: Published
Organisations: Department of Micro- and Nanotechnology
Contributors: Bischoff, S., Mørk, J., Franck, T., Brorson, S. D., Hofmann, M., Fröjd, K., Sørensen, M. P.
Pages: 655
Publication date: 1997
Theory of nondegenerate four-wave mixing between pulses in a semiconductor waveguide

We develop a perturbation theory for calculating the effects of saturation on nondegenerate four-wave mixing between short optical pulses in a semiconductor optical amplifier. Saturation due to ultrafast intraband dynamics like carrier heating and spectral hole burning is found to be important for pulses on the order of 10-20 ps or less.
Web of Science (2012): Impact factor 1.83
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 1.301 SNIP 1.567
Web of Science (2011): Impact factor 1.879
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.372 SNIP 1.687
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.801 SNIP 1.979
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.716 SNIP 1.763
Scopus rating (2007): SJR 2.025 SNIP 1.837
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.792 SNIP 1.859
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.806 SNIP 2.269
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Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.648 SNIP 2.181
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Web of Science (2002): Indexed yes
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Web of Science (2001): Indexed yes
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Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.096 SNIP 1.364

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Research output: Research - peer-review › Journal article – Annual report year: 1997

Projects:

**Light-matter interaction and laser dynamics in nanophotonic structures**
Rasmussen, T. S., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Gregersen, N., Supervisor, Department of Photonics Engineering
Yu, Y., Supervisor, Department of Photonics Engineering
Grundforskningsfonden
15/08/2017 → 14/08/2020
Award relations: Light-matter interaction and laser dynamics in nanophotonic structures
Project: PhD
Photonic quantum technologies in structured environments
Denning, E. V., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Iles-Smith, J., Supervisor, Department of Photonics Engineering
Willatzen, M., Supervisor, Department of Photonics Engineering
Grundforskningsfonden
01/02/2017 → 31/01/2020
Award relations: Photonic quantum technologies in structured environments
Project: PhD

An open quantum systems approach to few photon scattering in photonic devices
Joanesarson, K. B., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Gregersen, N., Supervisor, Department of Photonics Engineering
Iles-Smith, J., Supervisor, Department of Photonics Engineering
Grundforskningsfonden
01/02/2017 → 31/01/2020
Award relations: An open quantum systems approach to few photon scattering in photonic devices
Project: PhD

Fabrication and characterization of novel nanophotonic structures with electrical control
Marchevsky, A., PhD Student, Department of Photonics Engineering
Yvind, K., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Ottaviano, L., Supervisor, Department of Photonics Engineering
Samfinansierede - Virksomhed
01/10/2016 → 30/09/2019
Award relations: Fabrication and characterization of novel nanophotonic structures with electrical control
Project: PhD

Meta-materialer i antenne-teknik til trådløs kommunikation
Arslanagic, S., PhD Student, Department of Electrical Engineering
Breinbjerg, O., Main Supervisor, Department of Electrical Engineering
Mark, J., Examiner, Department of Photonics Engineering
Mosig, J. R., Examiner
Nosich, A. I., Examiner
DTU-lønnet stipendie
15/03/2004 → 03/09/2007
Award relations: Meta-materialer i antenne-teknik til trådløs kommunikation
Project: PhD

Ulineær Dynamik i Halvlederlasere
Blaaberg, S., PhD Student, Department of Photonics Engineering
Rottwitt, K., Main Supervisor, Department of Photonics Engineering
Petersen, P. M., Supervisor, Department of Photonics Engineering
Tromborg, B., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Buus, J., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
Risø (Løn)
01/11/2002 → 30/01/2007
Award relations: Ulineær Dynamik i Halvlederlasere
Project: PhD

Ulineære effekter i fotoniske krystalfibre
Hansen, K. P., PhD Student
Bjarklev, A. O., Main Supervisor, Department of Photonics Engineering
Jensen, J. R., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Andrekson, P. A., Examiner
Philipsen, J. L., Examiner, Department of Photonics Engineering
Erhvervsforskerordningen
01/04/2001 → …
Award relations: Ulinære effekter i fotoniske krystalfibre
Project: PhD

Opto-elektroniske komponenter baseret på kvante-strukturer
Berg, T. W., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Birkedal, D., Supervisor, Department of Photonics Engineering
Tromborg, B., Supervisor, Department of Photonics Engineering
Jauho, A., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
DTU-lønnet stipendie
15/10/2000 → 06/09/2004
Award relations: Opto-elektroniske komponenter baseret på kvante-strukturer
Project: PhD

Logiske funktioner til rent-optiske netværk
Nielsen, M. L., PhD Student, Department of Photonics Engineering
Dittmann, L., Main Supervisor, Department of Photonics Engineering
Clausen, A., Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Jeppesen, P., Examiner, Department of Photonics Engineering
Manning, R. J., Examiner
Friis Pedersen, C., Examiner
DTU-lønnet stipendie
15/10/2000 → 09/03/2005
Award relations: Logiske funktioner til rent-optiske netværk
Project: PhD

UV-skrivning af optiske bølgeledere
Færch, K. U., PhD Student, Department of Photonics Engineering
Kristensen, M., Main Supervisor, Department of Photonics Engineering
Svalgaard, M., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Bøttiger, J., Examiner
Douay, M., Examiner
Forskningsrådsfinansiering
01/10/2000 → 24/05/2004
Award relations: UV-skrivning af optiske bølgeledere
Project: PhD

Ikke-lineære pulser i optiske medier
Schjødt-Eriksen, J., PhD Student, Department of Informatics and Mathematical Modeling
Christiansen, P. L., Main Supervisor, Department of Informatics and Mathematical Modeling
Rasmussen, J. J., Supervisor
Serensen, M. P., Supervisor, Department of Informatics and Mathematical Modeling
Mark, J., Examiner
Berge, L., Examiner
Johansen, P. M., Examiner
DTU-lønnet stipendie
01/02/1998 → 29/05/2001
Award relations: Ikke-lineære pulser i optiske medier
Project: PhD

Photonic Crystal Fano Lasers
Mathiesen, K. S., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Samfinansierede - Virksomhed
01/09/2016 → 31/08/2019
Award relations: Photonic Crystal Fano Lasers
Project: PhD

Theory of superradiance and quantum noise in few-emitter lasers
André, E. C., PhD Student, Department of Photonics Engineering
Wubs, M., Main Supervisor, Center for Nanostructured Graphene
Mark, J., Supervisor, Department of Photonics Engineering
Samfinansierede - Virksomhed
01/07/2016 → 30/06/2019
Award relations: Theory of superradiance and quantum noise in few-emitter lasers
Project: PhD

k.p Theory of Two-Dimensional Materials
Brems, M. R., PhD Student, Department of Photonics Engineering
Willatzen, M., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Grundforskningsfonden
01/07/2016 → 29/11/2019
Award relations: k.p Theory of Two-Dimensional Materials
Project: PhD

Active nanophotonic antenna arrays for effective light-matter interactions
Kaminski, P. M., PhD Student, Department of Electrical Engineering
Arslanagic, S., Main Supervisor, Department of Electrical Engineering
Breinbjerg, O., Supervisor, Department of Electrical Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Samfinansierede - Virksomhed
15/08/2015 → 14/03/2019
Award relations: Active nanophotonic antenna arrays for effective light-matter interactions
Project: PhD

Tailored nanoscale optical materials and devices
Sakanas, A., PhD Student, Department of Photonics Engineering
Yvind, K., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Semenova, E., Supervisor, Department of Photonics Engineering
Samfinansierede - Virksomhed
01/08/2015 → 31/01/2019
Award relations: Tailored nanoscale optical materials and devices
Project: PhD

Single-photon quantum information technology
Taherkhani, M., PhD Student, Department of Photonics Engineering
Gregersen, N., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Jauho, A., Examiner, Center for Nanostructured Graphene
Marquardt, O., Examiner
Zinner, N. T., Examiner
McCutchcheon, D., Supervisor, Department of Photonics Engineering
Marquardt, O., Examiner
Zinner, N. T., Examiner
Forskningsrådshvansiering
15/05/2015 → 05/09/2018
Award relations: Single-photon quantum information technology
Project: PhD

Photonic crystal Fano structures
Bekele, D. A., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Ottaviano, L., Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Single photon sources for quantum information applications
Osterkryger, A. D., PhD Student, Department of Photonics Engineering
Gregersen, N., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Lavrinenko, A., Examiner, Department of Photonics Engineering
Burger, S., Examiner
Kristensen, P. T., Examiner, Department of Photonics Engineering
Samfinansieret - Andet
15/03/2015 → 05/09/2018
Award relations: Single photon sources for quantum information applications
Project: PhD

Synthesis and RealTime Implementation of DSP Algorithms for Nonlinearity Mitigation
Gaiarin, S., PhD Student, Department of Photonics Engineering
Zibar, D., Main Supervisor, Department of Photonics Engineering
Tafur Monroy, I., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Turitsyn, S. K., Examiner
Wahls, S., Examiner
Marie Curie (EU-stipendium)
01/11/2014 → 05/04/2018
Award relations: Synthesis and RealTime Implementation of DSP Algorithms for Nonlinearity Mitigation
Project: PhD

Dispersionskompenserende fotoniske krystalfibre
Hansen, T. P., PhD Student, Department of Photonics Engineering
Bjarklev, A. O., Main Supervisor, Rector's office
Broeng, J., Supervisor, Department of Photonics Engineering
Poulsen, M. R., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Henningsen, J., Examiner
ErhvervsPhd-ordningen VTU
01/05/2002 → 04/11/2005
Award relations: Dispersionskompenserende fotoniske krystalfibre
Project: PhD

Technology Platform for digital optical filter sturctures
Philipp, H. T., PhD Student, Department of Photonics Engineering
Rottwitt, K., Main Supervisor, Department of Photonics Engineering
Povlsen, J. H., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Johansen, P. M., Examiner
Margalit, M., Examiner
Samarbejdssaftalefinans
01/02/2001 → 26/10/2004
Award relations: Technology Platform for digital optical filter sturctures
Project: PhD

Optical networking in future aircraft systems
An, Y., PhD Student, Department of Photonics Engineering
Clausen, A., Main Supervisor, Department of Photonics Engineering
Berger, M. S., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
High Channel Density Wavelength Division Multiplexed Systems

Seoane, J., PhD Student, Department of Photonics Engineering
Jeppesen, P., Main Supervisor, Department of Photonics Engineering
Clausen, A., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Eisenstein, G., Examiner
Eksternt EU-finansieret
01/11/2001 → 26/09/2005
Award relations: High Channel Density Wavelength Division Multiplexed Systems
Project: PhD

Optical Methods for Characterization of Surface or Interface Structures on a Nanometer Scale

Grenaa, J., Supervisor, Department of Micro- and Nanotechnology
Hanson, S. G., Supervisor, Department of Photonics Engineering
Laegsgaard, J., Examiner, Department of Photonics Engineering
Bienstman, P., Examiner
Vohnsen, B., Examiner
Offentlig finansiering
01/11/2003 → 30/03/2007
Award relations: Optical Methods for Characterization of Surface or Interface Structures on a Nanometer Scale
Project: PhD

Systems technology and component characterisation

Oxenløwe, L. K., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Electrical Engineering
Mørk, J., Supervisor, Department of Photonics Engineering
Tromborg, B., Examiner, Department of Photonics Engineering
Devaux, F., Examiner
Friis Pedersen, C., Examiner
Ansat eksternt
01/09/1998 → 14/11/2002
Award relations: Systems technology and component characterisation
Project: PhD

Slow light enhancement and limitations in periodic media

Grigic, J., PhD Student, Department of Photonics Engineering
Mortensen, N. A., Main Supervisor, Department of Photonics Engineering
Jauho, A., Supervisor
Mark, J., Supervisor, Department of Photonics Engineering
Lavrinienko, A., Examiner, Department of Photonics Engineering
De Rossi, A., Examiner
Wiisatzen, M., Examiner, Department of Photonics Engineering
Eksternt finansieret virksomhed
01/01/2009 → 19/04/2012
Award relations: Slow light enhancement and limitations in periodic media
Project: PhD

Characterization of pulse propagation in photonic crystal structures and ultrafast dynamics in quantum dots

Ek, S., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Hansen, P. L., Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Oxenløwe, L. K., Examiner, Department of Photonics Engineering
Albrekstsen, O., Examiner
Dorren, H. J. S., Examiner
Eksternt finansieret virksomhed
01/11/2008 → 22/06/2012
Award relations: Characterization of pulse propagation in photonic crystal structures and ultrafast dynamics in quantum dots
Project: PhD

Methods for stability and Noise Analysis of Coupled Oscillating Systems
Djurhuus, T., PhD Student, Department of Electrical Engineering
Krozer, V., Main Supervisor, Department of Electrical Engineering
Vidkjær, J., Supervisor, Department of Electrical Engineering
Mørk, J., Examiner
Leuzzi, G., Examiner
Quéré, R., Examiner
Institut/centerfinansieret
01/07/2004 → 24/06/2008
Award relations: Methods for stability and Noise Analysis of Coupled Oscillating Systems
Project: PhD

Processing and Characterization of optoelectronic components for ultra high-speed signal processing
Romstad, F., PhD Student, IT Service
Hvam, J. M., Main Supervisor, Department of Photonics Engineering
Mørk, J., Supervisor, Department of Photonics Engineering
Thirstrup, C., Examiner
Technical University of Denmark
01/05/1998 → 30/08/2002
Award relations: Processing and Characterization of optoelectronic components for ultra high-speed signal processing
Project: PhD

Kompakte Fiberbaserede Ultrahurtige Pulskilder
Greibe, T., PhD Student, DTU Danchip
Hvam, J. M., Main Supervisor, Department of Photonics Engineering
Birkedal, D., Supervisor, Department of Micro- and Nanotechnology
Yvind, K., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Hanberg, P. J., Examiner, DTU Danchip
Larsson, A. G., Examiner
Centerfinansieret
01/09/2001 → 01/03/2007
Award relations: Kompakte Fiberbaserede Ultrahurtige Pulskilder
Project: PhD

Systematic design of nano-photonic systems
Wang, F., PhD Student, Department of Mechanical Engineering
Jensen, J. S., Main Supervisor, Department of Mechanical Engineering
Mørk, J., Supervisor, Department of Photonics Engineering
Sigmund, O., Supervisor, Department of Mechanical Engineering
Pedersen, N. L., Examiner, Department of Mechanical Engineering
Qiu, M., Examiner
Tortorelli, D. A., Examiner, Department of Solid Mechanics
Programbevilling
01/09/2009 → 20/12/2012
Award relations: Systematic design of nano-photonic systems
Project: PhD

Pulse Shaping
Palushani, E., PhD Student, Department of Photonics Engineering
Oxenløwe, L. K., Main Supervisor, Department of Photonics Engineering
Clausen, A., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Alic, N., Examiner
Doran, N. J., Examiner
Forskningsrådsmæssige fremstillinger
15/01/2009 → 22/06/2012
Award relations: Pulse Shaping
Project: PhD

**Topology Optimization of Transient Optoelectric Wave-interaction Problems**
Matzen, R., PhD Student, Department of Mechanical Engineering
Sigmund, O., Main Supervisor, Department of Mechanical Engineering
Jensen, J. S., Supervisor, Department of Mechanical Engineering
Mark, J., Examiner
Diaz, A. R., Examiner, Department of Mechanical Engineering
Kawamoto, A., Examiner
Forskningsrådsmæssige fremstillinger
01/04/2008 → 31/08/2011
Award relations: Topology Optimization of Transient Optoelectric Wave-interaction Problems
Project: PhD

**Slow and Fast Light for Applications in Microwave Photonics**
Xue, W., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Sales, S., Supervisor
Ohman, F., Supervisor, Department of Photonics Engineering
Oxelén, L. K., Examiner, Department of Photonics Engineering
Morthier, G. J. I., Examiner
Nielsen, M. L., Examiner, Department of Photonics Engineering
Forskningsrådsmæssige fremstillinger
01/07/2007 → 29/09/2010
Award relations: Slow and Fast Light for Applications in Microwave Photonics
Project: PhD

**Low Power Adaptive Beamforming**
Zibar, D., PhD Student, Department of Photonics Engineering
Jeppesen, P., Main Supervisor, Department of Photonics Engineering
Clausen, A., Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Oxelén, L. K., Supervisor, Department of Photonics Engineering
Christensen, E. L., Examiner, Department of Electromagnetic Systems
Jacobsen, G., Examiner
Petermann, K., Examiner
Forskningsrådsmæssige fremstillinger
01/05/2004 → 28/09/2007
Award relations: Low Power Adaptive Beamforming
Project: PhD

**Polymer Dye Micro-Cavity Lasers**
Balslev, S., PhD Student, Department of Micro- and Nanotechnology
Kristensen, A., Main Supervisor, Department of Micro- and Nanotechnology
Mark, J., Examiner, Department of Micro- and Nanotechnology
Lading, L., Examiner, Department of Micro- and Nanotechnology
Tumbull, G. A., Examiner
Forskningsrådsmæssige fremstillinger
01/02/2003 → 31/05/2006
Award relations: Polymer Dye Micro-Cavity Lasers
Project: PhD

**Modelling of Ultrafast Semiconductor Components**
Nielsen, J. A., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Hvam, J. M., Examiner, Department of Photonics Engineering
Lenstra, D., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
Forskningsrådsfinansiering
01/01/2003 → 29/10/2007
Award relations: Modelling of Ultrafast Semiconductor Components
Project: PhD

High-capacity optical communication systems employing optical signal processing
Xu, L., PhD Student, Department of Photonics Engineering
Jeppesen, P., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Oxenløwe, L. K., Supervisor, Department of Photonics Engineering
Rottwitt, K., Examiner, Department of Photonics Engineering
Koonen, T., Examiner
Poustie, A. J., Examiner
Forskningsrådsfinansiering
01/11/2001 → 17/12/2004
Award relations: High-capacity optical communication systems employing optical signal processing
Project: PhD

Modeling of optoelectronic components for ultra high-speed optical signal processing
Hejfeldt, S., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Bischoff, S., Supervisor, Department of Photonics Engineering
Rottwitt, K., Examiner, Department of Photonics Engineering
Olin, U., Examiner
Tessler, N., Examiner
Forskningsrådsstipendium
01/08/1998 → 14/11/2002
Award relations: Modeling of optoelectronic components for ultra high-speed optical signal processing
Project: PhD

Novel Fibre-ring Laser System Based on Frequency Chirping for Optical Coherence Tomography (OCT)
Agger, S. D., PhD Student, Department of Photonics Engineering
Povlsen, J. H., Main Supervisor, Department of Photonics Engineering
Rottwitt, K., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Pedersen, B., Examiner
Taylor, J. R., Examiner
DTU, Samfinansiering
01/10/2002 → 31/05/2006
Award relations: Novel Fibre-ring Laser System Based on Frequency Chirping for Optical Coherence Tomography (OCT)
Project: PhD

Photonic Bandgap Based Add/Drop Multiplexer
Harpøth, A., PhD Student, Department of Photonics Engineering
Kristensen, M., Main Supervisor, Department of Photonics Engineering
Borel, P. I., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Pedersen, J. E., Examiner
Wehrspohn, R. B., Examiner
DTU, Samfinansiering
01/12/2001 → 12/02/2005
Award relations: Photonic Bandgap Based Add/Drop Multiplexer
Project: PhD

Metamaterial Homogenization and Antenna Miniaturization
Hansen, T. V., PhD Student, Department of Electrical Engineering
Breinbjerg, O., Main Supervisor, Department of Electrical Engineering
Arslanagic, S., Supervisor, Department of Electrical Engineering
Kim, O. S., Supervisor, Department of Electrical Engineering
Traffic analysis and signal processing in optical packet switched networks
Fjelde, T., PhD Student, Department of Photonics Engineering
Dittmann, L., Main Supervisor, Department of Photonics Engineering
Stubbkjær, K., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Koonen, T., Examiner
Poustie, A. J., Examiner
DTU-lønnet stipendie
01/11/1998 → 03/05/2002
Award relations: Traffic analysis and signal processing in optical packet switched networks
Project: PhD

Quantum Photonics in Nanostructured Media
Ivinskaya, A., PhD Student, Department of Photonics Engineering
Lavrinenko, A., Main Supervisor, Department of Photonics Engineering
Lodahl, P., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Laegsgaard, J., Examiner, Department of Photonics Engineering
Busch, K., Examiner
Søndergaard, T., Examiner, Department of Photonics Engineering
DTU-lønnet stipendie
01/04/2006 → 24/08/2011
Award relations: Quantum Photonics in Nanostructured Media
Project: PhD

Quantum-limited measurement in mesoscopic
Flindt, C., PhD Student, Department of Micro- and Nanotechnology
Jauho, A., Main Supervisor, Department of Micro- and Nanotechnology
Flensberg, K., Supervisor
Mørk, J., Examiner, Department of Micro- and Nanotechnology
Brandes, T., Examiner
Loss, D., Examiner
DTU-lønnet stipendie
15/08/2004 → 29/10/2007
Award relations: Quantum-limited measurement in mesoscopic
Project: PhD

Optical switching in nanophotonic structures
Yu, Y., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Morioka, T., Examiner, Department of Photonics Engineering
Krauss, T. F., Examiner
Manning, R. J., Examiner
Krauss, T. F., Examiner
Manning, R. J., Examiner
Institut/centerfinansieret
01/09/2011 → 18/03/2015
Award relations: Optical switching in nanophotonic structures
Project: PhD

Elektroniske og Fotoniske Halvleder Nanostruktur
Johansen, J., PhD Student, Department of Photonics Engineering
Lodahl, P., Main Supervisor, Department of Photonics Engineering
Hvam, J. M., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Jensen, J. R., Examiner, Department of Micro- and Nanotechnology
Gerard, J. M., Examiner
DTU-lønnet stipendie
01/04/2005 → 29/08/2008
Award relations: Elektroniske og Fotoniske Halvleder Nanostruktur
Project: PhD

Electrons And Photons In Periodic Structures
Pedersen, J. G., PhD Student, Department of Photonics Engineering
Mortensen, N. A., Main Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Qiu, M., Examiner
Schomerus, H., Examiner
DTU, Samfinansiering
01/03/2007 → 29/09/2010
Award relations: Electrons And Photons In Periodic Structures
Project: PhD

Semiconductor Quantum Dot Devices for Optical Signal Processing
Chen, Y., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Poe, M. V. D., Supervisor, Department of Photonics Engineering
Ohman, F., Supervisor, Department of Photonics Engineering
Jeppeesen, P., Examiner, Department of Photonics Engineering
Manning, R. J., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
DTU-lønnet stipendie
01/05/2007 → 29/09/2010
Award relations: Semiconductor Quantum Dot Devices for Optical Signal Processing
Project: PhD

Semiconductor Devices for Quantum Information Processing
Anderssen, M. L., PhD Student, Department of Photonics Engineering
Lodahl, P., Main Supervisor, Department of Photonics Engineering
Mark, J., Supervisor, Department of Photonics Engineering
Hvam, J. M., Examiner, Department of Photonics Engineering
Pedersen, T. G., Examiner, Department of Micro- and Nanotechnology
Pedersen, T. G., Examiner
DTU-lønnet stipendie
01/03/2007 → 21/12/2010
Award relations: Semiconductor Devices for Quantum Information Processing
Project: PhD

Metamaterialer til lab-on-a-chip applikationer
Jeppeesen, C., PhD Student, Department of Micro- and Nanotechnology
Kristensen, A., Main Supervisor, Department of Micro- and Nanotechnology
Boltasseva, A., Supervisor
Mortensen, N. A., Main Supervisor, Department of Micro- and Nanotechnology
Mark, J., Examiner, Department of Micro- and Nanotechnology
Bozhevolnyi, S. I., Examiner, Department of Micro- and Nanotechnology
Levy, U., Examiner
DTU-lønnet stipendie
15/12/2007 → 20/04/2011
Award relations: Metamaterialer til lab-on-a-chip applikationer
Project: PhD

Modelling of semiconductor single-photon sources
Chen, Y., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Gregersen, N., Supervisor, Department of Photonics Engineering
Lodahl, P., Supervisor, Department of Photonics Engineering
Nielsen, T. R., Supervisor, Department of Photonics Engineering
Mortensen, N. A., Examiner, Department of Micro- and Nanotechnology
Björk, G., Examiner
Søndergaard, T., Examiner, Department of Electromagnetic Systems
DTU-lønnet stipendie
01/09/2007 → 21/12/2010
Award relations: Modelling of semiconductor single-photon sources
Project: PhD

Light-matter Interaction in Nano-structured Materials
Kristensen, P. T., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Lodahl, P., Supervisor, Department of Photonics Engineering
Breinbjerg, O., Examiner
Busch, K., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
DTU-lønnet stipendie
15/10/2006 → 21/04/2010
Award relations: Light-matter Interaction in Nano-structured Materials
Project: PhD

Transport in nanostructures
Donarini, A., PhD Student, Department of Micro- and Nanotechnology
Jauho, A., Main Supervisor, Department of Micro- and Nanotechnology
Novotny, T., Supervisor
Mark, J., Examiner, Department of Micro- and Nanotechnology
Armour, A. D., Examiner
Platero, G., Examiner
DTU-lønnet stipendie
01/09/2001 → 27/10/2004
Award relations: Transport in nanostructures
Project: PhD

Gain dynamics in quantum dot structures
Magnúsdóttir, I., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Bischoff, S., Supervisor, Department of Informatics and Mathematical Modeling
Hvam, J. M., Supervisor, Department of Photonics Engineering
Bjarklev, A. O., Examiner, Rector’s office
Vinter, B., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
DTU-lønnet stipendie
01/09/1999 → 28/05/2003
Award relations: Gain dynamics in quantum dot structures
Project: PhD

Ultrahurtige Data Signalers Transmission og Databehandling i optiske Fibre
Mulvad, H. C. H., PhD Student, Department of Photonics Engineering
Jeppesen, P., Main Supervisor, Department of Photonics Engineering
Clausen, A., Supervisor, Department of Photonics Engineering
Grüner-Nielsen, L. E., Supervisor, Department of Micro- and Nanotechnology
Oxenløwe, L. K., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Andrekson, P. A., Examiner
Winzer, P. J., Examiner
DTU-lønnet stipendie
01/07/2005 → 27/10/2008
Award relations: Ultrahurtige Data Signalers Transmission og Databehandling i optiske Fibre
Project: PhD
Advanced devices for ultra-high capacity optical communication systems
Ohman, F., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Bischoff, S., Supervisor, Department of Photonics Engineering
Tromborg, B., Supervisor, Department of Photonics Engineering
Bang, O., Examiner, Department of Photonics Engineering
Jacobsen, G., Examiner
Shtaif, M., Examiner
DTU-lønnet stipendie
01/09/2001 → 18/03/2005
Award relations: Advanced devices for ultra-high capacity optical communication systems
Project: PhD

Advanced simulation tools for nanophotonic devices
de Lasson, J. R., PhD Student, Office for Research and Relations
Gregersen, N., Main Supervisor, Department of Photonics Engineering
Kristensen, P. T., Supervisor, Department of Photonics Engineering
Lavrinienko, A., Examiner, Department of Photonics Engineering
Hughes, S., Examiner
Søndergaard, T., Examiner, Department of Electromagnetic Systems
Hughes, S., Examiner
Institut stipendie (DTU) Samf.
01/10/2012 → 20/01/2016
Award relations: Advanced simulation tools for nanophotonic devices
Project: PhD

Processing and Characterization of Quantum dot Devices
Hansen, P. L., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Poel, M. V. D., Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Hvam, J. M., Examiner, Department of Photonics Engineering
Eisenstein, G., Examiner
Marcinkevicius, S., Examiner
Forskningsrådsfinansiering
15/06/2006 → 26/05/2010
Award relations: Processing and Characterization of Quantum dot Devices
Project: PhD

Fundamentale egenskaber af komponenter til kvanteinformationsteknologi
Nielsen, P. K., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Jauho, A., Supervisor
Lodahl, P., Supervisor, Department of Photonics Engineering
Knorr, A., Examiner
Mølmer, K., Examiner
Institut stipendie (DTU) Samf.
01/02/2009 → 20/09/2012
Award relations: Fundamentale egenskaber af komponenter til kvanteinformationsteknologi
Project: PhD

Hybrid III-V-on-Si laser with ultralow energy consumption
Taghizadeh, A., PhD Student, Department of Photonics Engineering
Chung, I., Main Supervisor, Department of Photonics Engineering
Mørk, J., Supervisor, Department of Photonics Engineering
Lavrinienko, A., Examiner, Department of Photonics Engineering
Hammar, M., Examiner
Morthier, G. J. I., Examiner
Forskningsrådsfinansiering
01/02/2013 → 04/05/2016
Award relations: Hybrid III-V-on-Si laser with ultralow energy consumption
Project: PhD
Applications of Nanophotonic Devices for Terabit Optical Communications
Vukovic, D., PhD Student, Department of Photonics Engineering
Oxenløwe, L. K., Main Supervisor, Department of Photonics Engineering
Mørk, J., Supervisor, Department of Photonics Engineering
Peucheret, C., Supervisor, Department of Photonics Engineering
Xu, J., Supervisor, Department of Photonics Engineering
Rottwitt, K., Examiner, Department of Photonics Engineering
Cassan, E., Examiner
Schubert, C., Examiner
Institut, samfinansiering
01/10/2011 → 18/03/2015
Award relations: Applications of Nanophotonic Devices for Terabit Optical Communications
Project: PhD

Probing photonic nanostructures with electron energy loss spectroscopy
Raza, S., PhD Student, Department of Photonics Engineering
Mortensen, N. A., Main Supervisor, Department of Photonics Engineering
Wagner, J. B., Supervisor, Center for Electron Nanoscopy
Wubs, M., Supervisor, Department of Photonics Engineering
Mørk, J., Examiner, Department of Photonics Engineering
Abajo, J. G. D., Examiner
Wegener, M., Examiner
Abajo, J. G. D., Examiner
Wegener, M., Examiner
Institut stipendie (DTU) Samf.
01/09/2011 → 15/11/2014
Award relations: Probing photonic nanostructures with electron energy loss spectroscopy
Project: PhD

Quantum Kinetics of charge carriers in quantum dots: applications to slow light and light amplification
Houmark-Nielsen, J., PhD Student, Department of Micro- and Nanotechnology
Jauho, A., Main Supervisor, Department of Micro- and Nanotechnology
Mørk, J., Supervisor, Department of Micro- and Nanotechnology
Nielsen, T. R., Supervisor
Willatzen, M., Supervisor
Mortensen, N. A., Examiner, Department of Micro- and Nanotechnology
Kuhn, T., Examiner
Pedersen, T. G., Examiner, Department of Micro- and Nanotechnology
Forskningsrådssamfinansiering
15/05/2006 → 20/01/2010
Award relations: Quantum Kinetics of charge carriers in quantum dots: applications to slow light and light amplification
Project: PhD

Threshold less Photonic Crystal Laser
Stobbe, S., PhD Student, Department of Photonics Engineering
Lodahl, P., Main Supervisor, Department of Photonics Engineering
Hvam, J. M., Supervisor, Department of Photonics Engineering
Mark, J., Examiner, Department of Photonics Engineering
Jensen, J. R., Examiner, Department of Micro- and Nanotechnology
Ritchie, D. A., Examiner
Forskningsrådssamfinansiering
01/02/2006 → 23/09/2009
Award relations: Threshold less Photonic Crystal Laser
Project: PhD

Nanophotonic devices for quantum information technology
Nysteen, A., PhD Student, Department of Photonics Engineering
Mark, J., Main Supervisor, Department of Photonics Engineering
Kristensen, P. T., Supervisor, Department of Photonics Engineering
McCUTCHEON, D., Supervisor, Department of Photonics Engineering
Nielsen, P. K., Supervisor, Department of Photonics Engineering
All-optical transistor / Optisk transistor
Heuck, M., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Kristensen, P. T., Supervisor, Department of Photonics Engineering
Willatzen, M., Examiner, Department of Photonics Engineering
Manning, R. J., Examiner
Santagiustina, M., Examiner
Institut stipendie (DTU) Samf.
01/01/2010 → 15/08/2013
Award relations: All-optical transistor / Optisk transistor
Project: PhD

Single-photon emission in disordered photonic crystal waveguides
Liu, J., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Lodahl, P., Supervisor, Department of Photonics Engineering
Stobbe, S., Supervisor, Department of Photonics Engineering
Wubs, M., Examiner, Department of Photonics Engineering
Drewsen, M., Examiner
Fernández, C. L., Examiner
Institut stipendie (DTU) Samf.
15/07/2009 → 27/09/2012
Award relations: Single-photon emission in disordered photonic crystal waveguides
Project: PhD

Modeling of Coupled Nano-Cavity Lasers
Skovgård, T. S., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Gregersen, N., Supervisor, Department of Photonics Engineering
Abram, I., Examiner
Willatzen, M., Examiner, Department of Photonics Engineering
Institut stipendie (DTU) Samf.
01/10/2008 → 19/04/2012
Award relations: Modeling of Coupled Nano-Cavity Lasers
Project: PhD

Properties of single quantum dot lasers
Lund, A. M., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Nielsen, P. K., Supervisor, Department of Photonics Engineering
Jauho, A., Examiner
Björk, G., Examiner
Kapon, E., Examiner
Institut stipendie (DTU)
01/09/2010 → 19/03/2014
Award relations: Properties of single quantum dot lasers
Project: PhD

Coherent Dynamics of Quantum Dots in Photonic Crystals
Madsen, K. H., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Lodahl, P., Supervisor, Risø National Laboratory for Sustainable Energy
Gregersen, N., Examiner, Department of Photonics Engineering
Atatüre, M., Examiner
High-speed Laser with Ultralow Energy Consumption for Silicon Photonics

This project aims to investigate and demonstrate a novel laser structure that appears as a very promising high-speed, ultralow-energy-consumption light source for silicon photonics. The laser structure differs from conventional designs in that the active material (III-V semiconductor) is incorporated into one of the mirrors, a so-called high-index-contrast grating mirror, which provides very strong field confinement within the grating. This allows ultra-small lasers with very efficient energy conversion of electrons to photons simultaneously with a high modulation bandwidth. At the same time, the laser can be integrated onto a silicon chip, allowing the realization of the long-time dream of integrating photons and electronics on the same chip. In this integrated chip, one can exploit the properties of electrons for processing data and the properties of photons for transmitting data. This vision of silicon photonics is being actively pursued by companies like IBM and Intel, but the light source remains the critical component. Considerable interest shown by several companies reflects the potential of this innovative laser structure. The novel structure that we wish to investigate, however, has some fundamental challenges. Thus, a good understanding of the mode properties, the electrical transport and the thermal issues is needed. Also, the technology for integrating the active material (buried heterostructure) within the grating mirror needs to be developed. The project will thus rely on a close interaction between theory, design, fabrication and characterization. The knowledge gained in this project can form the background for research and development of a new class of ultra-small and highly-integrated photonic devices.

Chung, I., Project Manager, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonics
Ran, Q., Project Participant, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering
Mark, J., Project Participant, Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonics
Yvind, K., Project Participant, Department of Photonics Engineering, Nanophotonic Devices, Nanophotonics
01/01/2012 → 31/12/2014
Keywords: Hybrid, Silicon photonics, optical interconnects, low energy consumption
Project: Research

NATEC: Nanophotonics for terabit communications : VKR centre of excellence - NATEC

We propose to establish a Willum Kann Rasmussen Centre of Excellence that explores the fundamental physics and technology of nanophotonic materials and devices in order to reach data rates in the terabit per second regime. Following a brief introduction, the goals of the Centre, its organization, the main research activities, research plans and proposed budget are described.

Mark, J., Project Manager, Department of Photonics Engineering
Hvam, J. M., Project Participant, Department of Photonics Engineering
Yvind, K., Project Participant, Department of Photonics Engineering
Mortensen, N. A., Project Participant, Department of Photonics Engineering
Jeppesen, P., Project Participant, Department of Photonics Engineering
Oxenløwe, L. K., Project Participant, Department of Photonics Engineering
Peucheret, C., Project Participant, Department of Photonics Engineering
Chung, I., Project Participant, Department of Photonics Engineering
Sigmund, O., Project Participant, Department of Photonics Engineering
Jensen, J. S., Project Participant, Department of Photonics Engineering
Jauho, A., Project Participant, Department of Photonics Engineering
Burrows, A., Project Participant, Department of Photonics Engineering
Hübner, J., Project Participant, Department of Photonics Engineering
Ukendt
01/09/2008 → 31/08/2014
Award relations: Nanophotonics for terabit communications : VKR centre of excellence - NATEC
Project: Research

GOSPEL: Governing the speed of light

The GOSPEL project aims at developing new, highly effective technologies for enabling slow and fast light propagation as a tunable feature in photonic devices. In fact, controlling the speed of light offers a solution to a necessary, and often missing, functionality in broadband ICT systems: a time-delay/phase-shift line. The proposed research will address three slow and fast light device platforms: linear and nonlinear semiconductor photonic crystal waveguides with position controlled embedded quantum dots, active semiconductor waveguides based on quantum dots and advanced, specifically engineered optical fibers. These technologies will be harnessed in microwave and millimeter wave applications, such as: true time delay antenna feed systems for radars and ultra wide band wireless communication; complex microwave filters; high spectral purity opto-electronic oscillators and electro optical sampling systems. This project gathers world leading experts in microwave photonics and semiconductor and fiber technologies, under a unified vision of the role that slow and
fast light can play in advanced microwave applications. The project tackles several key challenges of the 7th Framework Work programme in the ICT domain and represents a significant step towards the removal of a major roadblock, i.e. the lack of practical, tunable, broadband, low distortion time-delay/phase-shift lines for microwave signals. This elemental component, besides enabling several applications, can ease the convergence of photonics and electronics and can attribute new functions to photonic devices. The proposed fundamental research will produce new results in multi-disciplinary topics like semiconductor physics, quantum dots, photonic crystal design and fiber technology and it will also represent a significant advancement across many sectors of ICT.

Mørk, J., Project Manager, Department of Photonics Engineering
Gregersen, N., Project Participant, Department of Photonics Engineering
Yvind, K., Project Participant, Department of Photonics Engineering
Kristensen, P. T., Project Participant, Department of Photonics Engineering
Hansen, P. L., Project Participant, Department of Photonics Engineering
Semenova, E., Project Participant, Department of Photonics Engineering
Xue, W., Project Participant, Department of Photonics Engineering
Pu, M., Project Participant, Department of Photonics Engineering
Larsson, D., Project Participant, Department of Photonics Engineering
Project ID: 70445
External Project ID: info:eu-repo/grantAgreement/EC/FP7/219299
Forsk. EU - Rammeprogram: DKK2,380,000.00
01/09/2008 → 31/12/2011
Award relations: Governing the speed of light
Project: Research

**QUEST: Quantum dot structures enabling light slow-down and amplification**

QUEST is a research project exploring the use of semiconductor quantum dot technology for realizing practical slow-light devices and integrated optical amplifiers. Such devices find important applications within information, communication and sensor technology and the project targets practical demonstrations within these areas, leading to possibilities of commercial exploitation. From a wider perspective, the proposed project contributes to the ongoing evolution of the information society. The project brings together three groups from the Technical University of Denmark (DTU) and The University of Southern Denmark (SDU) with strong and complementary research experience.

Mørk, J., Project Manager, Department of Photonics Engineering, Nanophotonic Devices
Hvam, J. M., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Yvind, K., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Poel, M. V. D., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Hansen, P. L., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Willatzen, M., Project Participant, University of Southern Denmark, Mads Clausen Institute,
Kamath, H., Project Manager, University of Southern Denmark, Mads Clausen Institute,
Wang, L., Project Participant, University of Southern Denmark, Mads Clausen Institute,
Jauho, A., Project Participant, Department of Micro- and Nanotechnology
Houmark-Nielsen, J., Project Participant, Department of Micro- and Nanotechnology

Project ID: 70319
Forskningsrådene - STVF: DKK12,269,000.00
01/01/2006 → 30/06/2012
Collaborators: University of Southern Denmark, University of Southern Denmark, Mads Clausen Institute,
Award relations: Quantum dot structures enabling light slow-down and amplification
Project: Research

**Hybrid vertical cavity laser**

In the present invention, a new concept of hybrid laser diodes is suggested. In this laser structure, a lightgenerating active material that is made of compound semiconductor is integrated with a silicon electronics platform including a nano-structured mirror, in a novel way. This hybrid laser is predicted to have superior laser performance such as much higher output power and much lower power consumption, compared to existing laser technologies and known proposals. Thus, this hybrid laser will be a key building block for several important applications such as seen in Table 1: 1) Computers with optical interconnects, 2) optical data cable (e.g., USB 3.0), 3) much faster and cheap internet connections, and 4) portable diagnosis tool for diseases or chemicals. Practically, this hybrid laser has a potential to enable these applications, since it can be produced at low costs, exploiting mature silicon processing technologies.

Nielsen, T., Project Participant, Department of Photonics Engineering
Chung, I., Project Manager, Department of Photonics Engineering
Mark, J., Project Participant, Department of Photonics Engineering

Project ID: 70572
Forskningsprojekter - Andre ministerier og styrelser: DKK750,000.00
01/06/2010 → 31/12/2011
Award relations: Hybrid vertical cavity laser
Project: Research
**Ultrafast dynamics after optical pulse excitation in semiconductor waveguide structures**

The ultrafast carrier dynamics of semiconductor optoelectronic devices set some of the fundamental limits in their practical use. The nonlinear gain and refractive index changes encountered under high-speed modulation of semiconductor optical amplifiers can be investigated using ultrafast optical techniques. We employ in particular two different techniques: single pulse propagation and pump-probe investigations. In the single pulse propagation experiment, an ultrafast optical pulse is launched into the semiconductor amplifier, which is at normal operating conditions. The output pulse is the characterized with respect to pulse energy, temporal profile, chirp, spectrum, and spectral phase. We have used the technique to characterize a commercial InGaAsP-bulk amplifier for long-haul optical communication. We have demonstrated that gain saturation and non-linear gain compression limits the performance of the device for operation above 20 GHz. Strong non-linear effects giving rise to pulse break-up for high input pulse energies are demonstrated. These effects are related to self-phase modulation occurring in the strong saturation regime. The investigations have been extended to multiple-quantum well (MQW) devices from the SCOOP program and British Telecom within a COST program. The non-linear gain compression coefficient and the ultrafast carrier dynamics of the optical amplifier can be measured directly using ultrafast pump-probe techniques with a heterodyne detection scheme. The technique allows for nonlinear experiments in waveguide geometry and has been demonstrated on the commercial devices. We have extended the experiments to MQW and quantum dots (QD) based optical amplifiers. The QD devices show new and interesting results on the ultrafast carrier dynamics such as a substantially decreased carrier relaxation time of the inverted material. We have also been able, for the first time, to measure the optical dephasing time of InAs QDÆEs at room temperature.

**Project: Research**

**Mørk, J., Contact Person, Department of Photonics Engineering**

**Ou, H., Contact Person, Department of Photonics Engineering**

**Chen, Y., Project Manager, Department of Photonics Engineering**

**Birkedal, D., Project Participant, Department of Photonics Engineering**

**Hvam, J. M., Project Participant, Department of Photonics Engineering**

**Mark, J., Project Participant, Department of Photonics Engineering**

**Romstad, F., Project Participant, Department of Photonics Engineering**

**Langbein, W. W., Project Participant, Department of Micro- and Nanotechnology**

**Scaffetti, S., Project Participant, Department of Micro- and Nanotechnology**

**Bimberg, D., Project Participant**

**Martelli, F., Project Participant**

**Kelly, T., Project Participant, British Telecom**

**Award relations:** Ultrafast dynamics after optical pulse excitation in semiconductor waveguide structures, Ultrafast dynamics after optical pulse excitation in semiconductor waveguide structures, Ultrafast dynamics after optical pulse excitation in semiconductor waveguide structures

**Project: Research**

**Plasmon-based Light-Emitting Diodes**

**Chen, Y., Project Manager, Department of Photonics Engineering**

**Ou, H., Contact Person, Department of Photonics Engineering**

**Mark, J., Contact Person, Department of Photonics Engineering**

**Project ID: 70665**

**Forskningsrådene - Andre: DKK2,016,000.00**

**Ukendt: DKK20,000.00, Ukendt: DKK45,000.00, Ukendt: DKK1,000,000.00**

**15/03/2011 → 14/03/2013**

**Award relations:** Plasmon-based Light-Emitting Diodes

**Project: Research**

**QDLaser**: Development of novel quantum dot based materials for compact laser devices for potential

The goal of the project is the development of portable, low-cost, reliable and highly-efficient ultrashort pulse (down to 100 fs) laser sources based on quantum dot (QD) material working in the spectral range 1.0-1.6 microns. This new generation of QD based mode-locked lasers has to become an alternative to the conventionally used ultrafast solid-state lasers, which are very expensive, cumbersome and complex to operate. The proposed research has a very high practical significance because it creates the possibility for evolution in different science and medical areas, in particular, advanced telecommunication, terahertz generation, optical sampling, biophotonics, non-invasive medical diagnosis and therapeutics. By placing a primary emphasis on novel materials, devices and system designs, this project will encompass a range of challenging and cutting-edge research directions that exploit QD-based semiconductor structures. The work in the frame of this project will mainly be focused on epitaxial growth of QD-based laser structures. It will be devoted to the optimisation of the epitaxial growth procedure, testing optical, structural and transport measurements and working on the design of epitaxial structure and design of the final devices. This research is in the area of interest of the host organisation and is interdependent with other projects running at the department. I will closely collaborate with other researchers in the fields of laser device design, laser characterisation and discuss results at every stage of the project. Moving to DTU, I bring all of my knowledge gained during my PhD and postdoctoral research work in Russia and France, which will lead to new scientific achievements at DTU. My connections to international scientists will increase the collaboration of DTU with other European goal of the project is the development of portable, low cost, reliable and highly-efficient ultrashort pulse (down to 100 fs) laser sources based on quantum dot (QD) material working in the spectral range 1.0-1.6 microns. This new
generation of QD based mode locked lasers has become an alternative to the conventionally used ultrafast solid state lasers, which are very expensive, cumbersome and complex to operate. The proposed research has a very high practical significance because it creates the possibility for evolution in different science and medical areas, in particular, advanced telecommunication, terahertz generation, optical sampling, biophotonics, non-invasive medical diagnosis and therapeutics. By placing a primary emphasis on novel materials, devices and system designs, this project will encompass a range of challenging and cutting-edge research directions that exploit QD-based semiconductor structures. The work in the frame of this project will mainly be focused on epitaxial growth of QD-based laser structures. It will be devoted to the optimisation of the epitaxial growth procedure, testing optical, structural and transport measurements and working on the design of epitaxial structure and design of the final devices. This research is in the area of interest of the host organisation and is interdependent with other projects running at the department. I will closely collaborate with other researchers in the fields of laser device design, laser characterisation and discuss results at every stage of the project. Moving to DTU, I bring all of my knowledge gained during my PhD and postdoctoral research work in Russia and France, which will lead to new scientific achievements at DTU. My connections to international scientists will increase the collaboration of DTU with other European and Russian Universities as well.

Mark. J., Project Manager, Department of Photonics Engineering
Semenova, E., Project Participant, Department of Photonics Engineering

Project ID: 70658
External Project ID: info:eu-repo/grantAgreement/EC/FP7/252890
Forsk. EU - Andre EU-midler
01/01/2011 → 31/12/2012
Keywords: Semiconductor lasers, Ultrafast optical pulses, Quantum dots, Epitaxial growth, Biophotonics, Optoelectronics
Telecommunications technology, Nanotechnology
Award relations: QDLaser : Development of novel quantum dot based materials for compact laser devices for potential applications
Project: Research

From classical to quantum all-optical switching
We will model and analyze ultra-fast, all-optical switches operating at record low energy levels as well as few and single-photon switching with applications to quantum information technology (QIT). The analysis will be based on a powerful and versatile model for the description of lightmatter interaction in optical cavities and waveguides in photonic crystals (PCs), and we will test the model using advanced numerical methods as well as by direct comparison with experiments. In this way we will identify design trade-offs and calculate optimum device parameters.

Kristensen, P. T., Project Manager, Department of Photonics Engineering
Mark. J., Contact Person, Department of Photonics Engineering

Project ID: 70660
Forskningsrådene - Andre: DKK3,484,800.00
01/01/2011 → 31/12/2013
Award relations: From classical to quantum all-optical switching
Project: Research

Modelling/SCOOP (Semiconductor COmponents for Optical signal Processing)
The SCOOP project has the goal of developing novel semiconductor devices for ultrafast optical signal processing in broadband optical networks. The modelling activity has to formulate mathematical models for the different device types and develop tools that can be used for analysing measurement results and designing/optimizing the devices. This requires a number of tasks to be considered: Materials dynamics: Models that accurately describe the materials (gain and index) dynamics down to a time scale of at least 1 picosecond need to be developed. Since the solution of microscopic (Semiconductor Bloch) equations are too demanding computationally, simpler models have to be derived. This is particularly challenging in the case of electro-absorption modulators, which are quantum well structures whose absorption can be changed by applying an electrical field. The transport of electrons across the structure and the sweep-out from the quantum well are known to limit the device speed and needs to be carefully modelled. Interferometric devices: By incorporating active semiconductor waveguides into interferometric structures of the Michelson or Mach-Zehnder type, it is possible to switch signals at very high bit rates. Computer simulation tools are needed in order to help interpret measurements on actual devices. In particular it is interesting to understand the mechanisms that limit the bandwidth. The tools need to be detailed enough to allow for optimization of the device designs as well as exploration of new ideas. Subsystem modelling: Device models are combined with models of signal sources, the transmission path and detectors to help understand the behaviour and limitations of the system as a whole. Presently, dispersion compensation of high-bit rate pulse trains using mid-span spectral inversion (phase conjugation) in a semiconductor laser amplifier has been analysed. The calculated results compare well with measurements.

Hvam, J. M., Project Manager, Department of Micro- and Nanotechnology
Mark. J., Project Participant, Department of Micro- and Nanotechnology
Bischoff, S., Project Participant, Department of Micro- and Nanotechnology
Hajfeldt, S., Project Participant, Department of Micro- and Nanotechnology

Ukendt: DKK3,600,000.00
01/01/1998 → 31/12/1999
Collaborators: GIGA A/S
Ultrafast dynamics after optical pulse excitation in semiconductor waveguide structures

Short optical pulse excitation is a direct tool in order to investigate ultrafast non-linear changes in the gain and refractive index in semiconductor optical amplifiers. We use two different techniques: single pulse propagation and pump-probe. In the first case, after injection of a single pulse into the amplifier, we measure the total energy of the pulse at the output of the device, the profile in frequency and real time and the pulse chirp. The technique has been tested on a InGaAsP bulk amplifier operating at 1.53μm. The measurements of the output energy indicate saturation of the gain for intense input pulses, and a non-linear gain compression dominating for pulse duration lower than 10ps. The pulse profile in time and frequency and the pulse chirp reveal strong non-linear effects giving rise to a break-up of the pulse for very high (~100pJ) input energy, related to self-phase modulation occurring in the strong saturation regime. The second technique is a pump-probe experiment in heterodyne detection scheme to directly measure non-linear gain compression coefficients and ultrafast carrier dynamics in the amplifier. The technique has been tested on the bulk device. Pump-probe measurements have been also performed on InAs quantum dot (QD) amplifiers showing new interesting results on the carrier dynamics of these devices, like an ultrafast carrier capture time (Hvam, J. M., Project Manager, Department of Micro- and Nanotechnology.

Borri, P., Project Participant, Department of Micro- and Nanotechnology.

Mark, J., Project Participant, Department of Micro- and Nanotechnology.

Langbein, W. W., Project Participant, Department of Micro- and Nanotechnology.

Scaffetti, S., Project Participant, Department of Micro- and Nanotechnology.

Romstad, F., Project Participant, Department of Micro- and Nanotechnology.

Bimberg, D., Project Participant.

Lidentsof, N., Project Participant.

Martelli, F., Project Participant.

Project: Research.

Photonic devices for multi-wavelength amplification and regeneration (M-WARE)

In an optical communication system information is sent using light signals that travel through a glass fiber. The signals experience difference forms of degradation which decrease signal quality and therefore have to be compensated for by signal regeneration. In order to increase the capability of communication systems several wavelength channels are sent through the same fiber, using a technique called wavelength division multiplexing (WDM). When regenerating a WDM signal the wavelengths have to be separated and regenerated in parallel, which makes the process complex and difficult. The aim of the proposed project is to develop a 2R-regenerator (re-amplification and re-shaping) capable of regenerating several wavelength channel simultaneously in an single device. The means of reaching this goal will be devices using saturable gain and absorption in quantum dot and quantum well semiconductor materials. Quantum dots of different sizes interact with light of different wavelengths and make it possible to regenerate them independently from each other. The project will focus on designing materials and devices for optimising this effect. A fast limiting amplifier is one part of the envisioned 2R device with important applications of its own. A QD limiting amplifier will therefore be a first important milestone. Device processing will be made at the new processing facilities at DANCHIP, DTU and the material growth will be made together with partners in the European network of excellence ePiXnet. The project is based on experience from two Ph.D. projects which have demonstrated and investigated single wavelength regeneration in similar devices.

Öhman, F., Project Manager, Department of Photonics Engineering, Nanophotonic Devices.

Mark, J., Project Participant, Department of Photonics Engineering, Nanophotonic Devices.

Yvind, K., Project Participant, Department of Photonics Engineering, Nanophotonic Devices.

Tromborg, B., Project Participant, Department of Photonics Engineering, Nanophotonic Devices.

Project ID: 70318.

Forskningsrådene - STVF: DKK2,122,800.00.

01/03/2006 → 28/02/2009.

Award relations: Photonic devices for multi-wavelength amplification and regeneration (M-WARE).

Project: Research.

MOSEL: Monomode Surface Emitting Lasers

Vertical cavity surface emitting lasers (VCSELs) have several particular advantages over the edge emitting lasers (EEL) for replacing them in optical communication applications, as the possibility of wafer-level testing during the fabrication process as well as facilitated optical coupling and overall module packaging. Nevertheless, several major improvements should be brought to the existing VCSELs before they become widely used in high speed optical datacom links. Among existing limitations, a limited power delivered by high speed (10 Gbit/s and up) transversely monomode VCSELs. This limitation is a key issue for the introduction of VCSELs in FTTH devices, especially in Passive Optical Networks where the power launched into the fiber must be rather high. Hence, mode size and polarization control are the key issues in design of high performance VCSELs. Introducing elements of photonic crystal is an efficient way to increase the mode size while maintaining or even improving operating characteristics in the present project, we aim to achieve an overall improvement of the VCSELs performances using micro and nanoscale patterning. The novel cavity configurations explored will allow:
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Nielsen, C., Contact Person, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
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Rudra, A., Project Participant, Ecole Polytechnique Federale de Lausanne (EPFL)
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Mark, J., Project Participant, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
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Lavrinenko, A., Project Participant, Department of Photonics Engineering, Plasmonics and Metamaterials

COPERNICUS aims to develop compact demultiplexing receivers for 100 Gb/s optical time division multiplexed (OTDM) and wavelength division multiplexed (WDM) signals, based on photonic crystal technology. There is a pressing need for these devices for ultra-high bandwidth data links in server farms, optical storage networks and on-board internet/entertainment systems, where demand is driving the data bandwidth and technology integration level rapidly upwards. Next generation telecom systems will also benefit from these devices for OTDM and optical packet switching. Their high-speed and bandwidth, together with their ultra-low power consumption and extreme compactness, also make them a very promising technology for seamless cross-chip and off-chip data links for CMOS electronics. This approach has all the hallmarks of a highly disruptive technology with the potential to place Europe at the forefront of photonics. COPERNICUS targets advances in the physics, technology, modelling, and integration of photonic crystal devices. Key devices include high-speed all-optical gates, low-crosstalk wavelength drop filters, and high-speed integrated photodetectors. These devices rely on very strong light-matter interactions arising from the large, ultrafast nonlinear optical response of III-V semiconductors and the strong resonant field enhancement in photonic crystals. This is ideal for filters and all optical gates, enabling a dramatic reduction in size and switching energy. Their switching energy*delay product is two orders of magnitude smaller than that of competing technologies. Modelling will consider carrier plasma (spectral and spatial) contributions to the nonlinear optical response and develop a robust optical, thermal and electronic design tool for photonic crystal devices. New levels of photonic crystal integration will be pursued to combine these devices and achieve complex all-optical functions attractive to both medium- and long-term markets.

COPERNICUS: Compact OtDM/wDM Opitical rEceiveRs based on photoNic crystal Integrated

Forsk. EU - Andre EU-midler: DKK1,678,500.00
01/06/2006 → 31/05/2009

COPERNICUS aims to develop compact demultiplexing receivers for 100 Gb/s optical time division multiplexed (OTDM) and wavelength division multiplexed (WDM) signals, based on photonic crystal technology. There is a pressing need for these devices for ultra-high bandwidth data links in server farms, optical storage networks and on-board internet/entertainment systems, where demand is driving the data bandwidth and technology integration level rapidly upwards. Next generation telecom systems will also benefit from these devices for OTDM and optical packet switching. Their high-speed and bandwidth, together with their ultra-low power consumption and extreme compactness, also make them a very promising technology for seamless cross-chip and off-chip data links for CMOS electronics. This approach has all the hallmarks of a highly disruptive technology with the potential to place Europe at the forefront of photonics. COPERNICUS targets advances in the physics, technology, modelling, and integration of photonic crystal devices. Key devices include high-speed all-optical gates, low-crosstalk wavelength drop filters, and high-speed integrated photodetectors. These devices rely on very strong light-matter interactions arising from the large, ultrafast nonlinear optical response of III-V semiconductors and the strong resonant field enhancement in photonic crystals. This is ideal for filters and all optical gates, enabling a dramatic reduction in size and switching energy. Their switching energy*delay product is two orders of magnitude smaller than that of competing technologies. Modelling will consider carrier plasma (spectral and spatial) contributions to the nonlinear optical response and develop a robust optical, thermal and electronic design tool for photonic crystal devices. New levels of photonic crystal integration will be pursued to combine these devices and achieve complex all-optical functions attractive to both medium- and long-term markets.

Prevotat, O., Contact Person, Thales
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Neumeuer, D., Contact Person, MergeOptics GmbH
A high-efficiency nanowire single-photon source

The project aims at engineering a nanowire-based single photon source (SPS) with efficiency approaching 100 % and takes place in close collaboration with the fabrication and characterization activities of an external partner. A recently discovered screening effect in highindex-contrast low-diameter nanowires will be exploited, an effect promising improved tolerance towards the fabrication-induced geometry imperfections currently limiting the efficiency of existing micropillar SPSs. The new nanowire physics will be analyzed, the established know-how will be used to suggest specific SPS structures for fabrication and several design-fabrication-characterization iterations will be performed.

Gregersen, N., Project Manager, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Mørk, J., Project Participant, Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Lodahl, P., Project Participant, Department of Photonics Engineering, Quantum Photonics
Gerard, J. M., Contact Person, CEA

FLASH: Femtosecond semiconductor LASers Harnessed


Yvind, K., Contact Person, Department of Photonics Engineering, Nanophotonic Devices
Kim, J. M., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Semenova, E., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Hvam, J. M., Project Participant, Department of Photonics Engineering, Nanophotonic Devices
Penty, R., Contact Person, University of Cambridge

Optical coherent control in photonic nanostructures

In the project, photonic nanostructures will be employed for controlling emission of light from semiconductor quantum dots. We propose fabricating ultra compact and high quality optical cavities in photonic crystals. Such nano-cavities will provide a new technology for effective low-threshold lasers and single-photon sources. Furthermore, the project will contribute to fundamental understanding of quantum optical properties of solid-state nanostructures, and their potential for scalable quantum logic.

Lodahl, P., Project Manager, Department of Photonics Engineering, Nanophotonic Devices
Thermo-electro-optical analysis of subwavelength grating-mirror VCSELs

A vertical-cavity laser consists of a top mirror, an optical cavity containing a gain medium, and a bottom mirror. Its typical size is similar as a human hair. Light generated in the gain medium passes through the optical cavity and are reflected back to the cavity by the two mirrors. By repeating this cycle, the light is amplified and laser action starts. Due to this light generation mechanism, the properties of a laser is significantly influenced by the properties of the optical cavity and two mirrors. Gratings are one- or two-dimensional periodic structures mad of semiconductor or dielectrics. A one-dimensional grating looks like a barbecue grill and its typical size is 1/200 times thinner than a human hair. Specially designed gratings have high reflectivity adequate for laser mirrors. One of the important features of the grating mirror is that its reflection properties can be easily controlled by changing the grating design. Thus, using a grating mirror instead of a conventional mirror opens a unique way of designing laser properties through engineering the grating mirror, but also possibilities of many novel applications, which was not feasible with the conventional mirrors. In this project, the physics of the grating mirror and its effects on laser properties will be rigorously investigated. by using this understanding, two novel application devices will be optimized. For this aim, an advanced laser simulator will be developed for the first time.

Optoelectronic integration technologies

The project falls in two stages. First a reliable process has to be set up using the new compound semiconductor processing equipment, such that isolated "standard components" can be fabricated. This will also include grating fabrication using a newly installed e-beam writer. The focus will be components for high-speed optical communication systems in the 1.55mm wavelength range thus employing InGaAsP on InP. Next, when the growth apparatus (Emcore D125) has been installed, integration of mode-locked lasers with signal processing devices will be performed.

Self-configurable optical links

Projekts mål er at studere og implementere optiske dupleks forbindelser til korte afstande, der er i stand til at justere sig selv uden forhånds kendskab til alle parametre. Dette kan gøres ved at anvende modtageren til at karakterisere det modtagne signal og sende denne information tilbage til senderen, hvor det bruges til at justere det sendte signal. Signalets karakteristika sendes via den optiske forbindelse tilbage til senderen på en sub kanal, på en sådan måde at det påvirker den direkte data trafik mindst muligt og uden at ændre på denne. Et sådant system har mange fordele som bl.a. lavere strøm forbrug, lavere produktions omkostninger, automatisk kompensation for temperatur variationer og ældning og mulighed for at advare hvis de optiske komponenter nærmer sig levetiden.

Self-configurable optical links
Modulation response of semiconductor quantum dot nanolasers and nanoLEDs

To meet the continuously increasing need for progressively higher data transmission rates on the internet, faster signal modulation of the underlying semiconductor lasers or LEDs is required. High modulation bandwidth is a key quantity for the realization of high-speed data optical components, as it limits the maximum possible data rate. Recent developments in nanotechnology allow fabrication of new device types for lasers and LEDs with quantum dots embedded in optical microcavities which have the potential to outperform current devices. The nanolasers and nanoLEDs belong to this class of future optical communication devices. Conventional analysis methodology needs to be reassessed based on more realistic models which are appropriate for this type of semiconductor quantum dot based devices. The project will be carried out at DTU Fotonik which is involved in several projects in the field of micro- and nanostructured materials. This gives access to experimental results on devices as well as inside knowledge on technological developments. DTU Nanotech is also a partner and will contribute to this project.

Nielsen, T. R., Contact Person, Department of Photonics Engineering
Lorke, M., Contact Person, Department of Photonics Engineering
Mørk, J., Contact Person, Department of Photonics Engineering
Jauho, A., Project Participant, Department of Micro- and Nanotechnology

Keywords: laser, nanotechnology, information technology, broadband
Award relations: Modulation response of semiconductor quantum dot nanolasers and nanoLEDs
Project: Research

DOTCOM: Quantum DOT laser devices for optoelectronic information COMmunication

The DOTCOM consortium of universities, research institutions and industrial companies aims to realise and investigate innovative optoelectronic quantum dot semiconductor lasers. The project spans the entire spectrum from materials development via device fabrication to systems testing. State-of-the-art methods will be employed for growing quantum dot material fibre 1300 nm and 1550 nm emission wavelength. Calculations of material properties and microscopic device simulation will together with advanced experimental investigation optimise the quantum dot nano-technologies and guide the design of laser devices. Objectives: The central objective of the DOTCOM project is the development of innovative quantum dot lasers based on GaAs quantum dot wafer technology. To fabricate high quality quantum dots for 1300 nm and 1550 nm emission wavelength in a controlled and reproducible manner the MBE and MOCVD materials technologies will be employed. They are to be assessed with respect to reliability, market applicability and environmental friendliness. Calculations of electronic quantum dot properties as well as experimental characterisation will allow an optimisation of the growth process. For highest information system flexibility high-performance lasers will be designed, realised and optimised by comparison with simulation and experiment. Based on this novel 1300 and 1550 nm quantum dot laser technology testbeds for optoelectronic metropolitan and local area information systems will be realised and their characteristics analysed. Work description: The unique combination of expertise of the DOTCOM partners combines exploratory MBE and MOCVD epitaxial quantum dot material development and characterisation, quantum dot laser device fabrication and optimisation as well as opto-electronic information system realisation and testing. New theories and electronic structure calculations as well as state-of-the-art experimental characterisation will provide direct feedback for optimisation of the growth process. To meet the ultra broad-band system requirements of next-generation optoelectronic information networks, innovative quantum dot lasers and amplifiers will be fabricated. The lasers will be optimised in close comparison with microscopic simulations and ultra-short time experimental characterisation. Laser modules will be characterised and integrated into a laboratory testbed with capability for changing module temperature and fibre type and length at speeds of 2.5 Gb/s and 10 Gb/s. 1300 nm lasers will be assessed to verify compliance with datacom standards such as the proposed IEEE 10 Gigabit Ethernet standard. 1550 nm lasers will be assessed in the context of telecommunications networks with the emphasis on extended reach. Quantum dot semiconductor optical amplifiers at both 1300 nm and 1550 nm will be assessed in the systems context with e.g. saturation power, noise performance, linearity. The suitability of the semiconductor optical amplifiers as both line and pre-amplifiers will be evaluated. Amplified systems at both wavelength will be theoretically and experimentally demonstrated and the limits for amplified transmission will be determined.

Hess, O., Project Manager, University of Surrey
Hvam, J. M., Project Participant, Department of Photonics Engineering
Poel, M. V. D., Project Participant, Department of Photonics Engineering
Mørk, J., Contact Person, Department of Photonics Engineering
Marsh, J., Project Participant, Intense Ltd.
**Study of semiconductor devices for ultrafast all-optical signal processing**

The purpose of the project is to develop models for the study of four-wave mixing and propagation effects in semiconductor optical amplifiers and the use of these to investigate topics that are related to the application of four-wave mixing in functional devices. In particular, it is interesting to explore the use of four-wave mixing for large detunings. Under such conditions the FWM process can be used for nearly transparent switching of signals with large bandwidth and may be important for many optical signal processing applications. However, the efficiency may be quite low and it is therefore led to the use of strong optical pulses. These conditions - large detuning and high power - put strong demands on the theoretical models. In particular, it becomes important to include the effects of ultrafast gain and index dynamics; such as carrier heating and spectral holeburning. The work will be based on already existing models, but these will be extended to match the experimental conditions of very short and possibly non-transform limited pulses. In particular it will be of interest to understand in detail the delay-time dependence of short pulses interacting via FWM.

**Modelling/SCOOP (Semiconductor COmponents for Optical signal Processing)**

The SCOOP project has the goal of developing novel semiconductor devices for ultrafast optical signal processing in broadband optical networks. The modelling activity has to formulate mathematical models for the different device types and develop tools that can be used for analysing measurement results and designing/optimizing the devices. These tasks are to be considered: Materials dynamics: Models that describe the materials (gain and index) dynamics down to a time scale of at least 1 picosecond need to be developed. Since the solution of microscopic (Semiconductor Bloch) equations are too demanding computationally, simpler models have to be derived. This is particularly challenging in the case of electro-absorption modulators, which are quantum well structures whose absorption can be changed by applying an electrical field. The transport of electrons across the structure and the sweep-out from the quantum well need to be carefully modelled. Interferometric devices: By incorporating active semiconductor waveguides into interferometric structures of the Michelson or Mach-Zehnder type, it is possible to switch signals at very high bit rates. Computer simulation tools are needed in order to help interpret measurements on actual devices. In particular it is interesting to understand the mechanisms that limit the bandwidth. The tools need to allow for optimization of the device designs as well as exploration of new ideas. Subsystem modelling: Device models are combined with models of signal sources, the transmission path and detectors to help understand the behaviour and limitations of the system. Four-wave mixing in semiconductor optical amplifiers has been investigated with respect to system applications: Dispersion compensation using phase-conjugation and add-drop functionalities. Electro-absorption modulators for optical wavelength conversion and de-multiplexing at high-bit rate pulse trains is another topic.

**Forsk. EU - Rammeprogram: DKK2,897,640.00**

01/09/2001 → 31/05/2005

**Forsker: Huyet, G., Bryce, C., Bimberg, D., Rorison, J., Penty, R.,**

National University of Ireland - University College Cork, The University of Glasgow, Technische Universität Berlin, University of Bristol, University of Cambridge.

**Collaborators: Nanosemiconductor GmbH, University of Surrey, University College Cork, University of Cambridge, Technische Universität Berlin, Finisar Germany, The Centre for Integrated Photonics, University of Glasgow, National University of Ireland - University College Cork, The University of Glasgow, University of Bristol, Intense Ltd.**

**Award relations: Quantum DOT laser devices for optoelectronic information COMmunication**

**Project: Research**

**Forsk. Andre offentlige og private - Udenlandske: DKK96,000.00**

01/01/2002 → 31/12/2003

**Collaborators: University of Cambridge, Yamagata University, Kharkiv National University of Radioelectronics**

**Award relations: Study of semiconductor devices for ultrafast all-optical signal processing**

**Project: Research**

**Ukendt: DKK3,000,000.00**

01/01/1998 → 31/12/2005

**Collaborators: GIGA A/S**

**Award relations: Modelling/SCOOP (Semiconductor COmponents for Optical signal Processing)**
Modelling of quantum dot semiconductor devices

The goal of the project is to develop theoretical models that can be used to understand the properties of semiconductor optical devices based on quantum dot structures. Semiconductor quantum dots can be considered man-made artificial atoms, with a typical length scale of 100 Å, and it has long been speculated that, e.g., optical devices based on such nanostructures should offer superior characteristics in terms of controllability, power consumption and device speed. In recent years, it has been experimentally demonstrated that semiconductor lasers based on quantum dots offer record-low threshold current densities, but many aspects of quantum dot based devices are still not well understood. The project initially consists in formulating models for calculating capture and escape rates in quantum dots; i.e., how fast can electrons be supplied to and removed from the tiny dots? These rates affect important device characteristics, such as the modulation speed of semiconductor lasers. Later stages of the project will involve setting up more macroscopic models for the overall device dynamics and comparison with experimental results obtained at COM.

Mørk, J., Project Manager, Department of Photonics Engineering
Bischoff, S., Project Participant, Department of Photonics Engineering
Magnúsdóttir, I., Project Participant, Department of Photonics Engineering
01/08/1999 → 31/08/2002

Activities:

3rd International Workshop on Theoretical and Computational Nano-Photonics
Period: 3 Nov 2010 → 5 Nov 2010
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

Description
The International Workshop on Theoretical and computational Nanophotonics (TaCoNa-Photonics 2010); 3

An electrically-pumped single-photon source design with a predicted efficiency of 89% is proposed. The design is based on a quantum dot embedded in a photonic nanowire with tailored ends and optimized contact electrodes. Unlike cavity-based approaches, the photonic nanowire features broadband spontaneous emission control and an improved tolerance towards fabrication imperfections. The various building blocks of the design are analyzed using an elements-splitting approach.

Place: Bad Honnef, Germany

Related event
3rd International Workshop on Theoretical and Computational Nano-Photonics
03/11/2010 → 05/11/2010
Bad Honnef, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Journées de lamatière Condensée
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

Related event
Journées de la matière Condensée
23/08/2010 → 27/08/2010
Troyes, France
Activity: Attending an event › Participating in or organising a conference

10th International Workshop on Nonlinear Optics and Excitation Kinetics in Semiconductors
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

**Description**
We will review recent studies performed on InAs quantum dots embedded in GaAs photonic wires, which highlight the strong interest of the photonic wire geometry for quantum optics experiments and quantum optoelectronic devices.

**Related event**
10th International Workshop on Nonlinear Optics and Excitation Kinetics in Semiconductors
16/08/2010 → 19/08/2010
Paderborn, Germany
Activity: Attending an event › Participating in or organising a conference

**Integrated Photonics Research, Silicon and Nano Photonics**
Period: 25 Jul 2010 → 28 Jul 2010
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

**Description**
Integrated Photonics Research, Silicon and Nano Photonics (IPR): Short pulse generation in a passively mode-locked photonic crystal semiconductor laser

We present a new type of passively mode-locked laser with quantum wells embedded in photonic crystal waveguides operating in the slow light regime, which is capable of emitting sub picosecond pulses with widely controllable properties
Place: Monterey, CA, USA

**Related event**
Integrated Photonics Research, Silicon and Nano Photonics
25/07/2010 → 28/07/2010
Monterey, CA, United States
Activity: Attending an event › Participating in or organising a conference

**International Conference on Superlattices, Nanostructures and Nanodevices**
Period: 18 Jul 2010 → 23 Jul 2010
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

**Related event**
International Conference on Superlattices, Nanostructures and Nanodevices 2010
18/07/2010 → 23/07/2010
Beijing, China
Activity: Attending an event › Participating in or organising a conference

**International Conference on Transparent Optical Networks (ICTON); 12**
Period: 27 Jun 2010 → 1 Jul 2010
Jesper Mørk (Other)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

**Description**
In this paper we review theoretical work on slow and fast light effects in quantum dot(QD) semiconductor waveguides and the potential applications in microwave photonics. In particular we emphasize the unique ultrafast carrier dynamics occurring between discrete QD bound states and its influence on the dynamic gain grating and cross gain modulation in
QD semiconductor optical amplifiers (SOAs). The exploitation of ultrafast carrier dynamics enables the realization of phase shifters at frequencies in the range of 100 GHz.

Related event

6th International Conference on Quantum Dots 2010
Period: 26 Apr 2010 → 30 Apr 2010
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

Description
We discuss the physics and applications of slow light in semiconductor waveguides. In particular we introduce methods for enhancing the degree of light speed control considering both electromagnetically induced transparency as well as coherent population oscillations.

Related event

17th International Workshop on Optical Waveguide Theory and Numerical Modelling
Jesper Mørk (Participant)
Department of Photonics Engineering
Nanophotonics Theory and Signal Processing

Description
An improved perfectly matched layer in the eigenmode expansion technique------------- When employing the eigenmode expansion technique (EET), parasitic reflections at the boundary of the computational domain can be suppressed by introducing a perfectly matched layer (PML). However, the traditional PML suffers from an artificial field divergence limiting its usefulness. We propose a remedy.