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.

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The local density of optical states of a metasurface

While metamaterials are often desirable for near-field functions, such as perfect lensing, or cloaking, they are often quantified by their response to plane waves from the far field. Here, we present a theoretical analysis of the local density of states near lattices of discrete magnetic scatterers, i.e., the response to near field excitation by a point source. Based on a pointdipole theory using Ewald summation and an array scanning method, we can swiftly and semi-analytically evaluate the local density of states (LDOS) for magnetoelectric point sources in front of an infinite two-dimensional (2D) lattice composed of arbitrary magnetoelectric dipole scatterers. The method takes into account radiation damping as well as all retarded electrodynamic interactions in a self-consistent manner. We show that a lattice of magnetic scatterers evidences characteristic Drexhage oscillations. However, the oscillations are phase shifted relative to the electrically scattering lattice consistent with the difference expected for reflection off homogeneous magnetic respectively electric mirrors. Furthermore, we identify in which source-surface separation regimes the metasurface may be treated as a homogeneous interface, and in which homogenization fails. A strong frequency and in-plane position dependence of the LDOS close to the lattice reveals coupling to guided modes supported by the lattice.

General information
State: Published
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**

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*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.  
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**Publication information**

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*Ratings:*  
  BFI (2018): BFI-level 2  
  Web of Science (2018): Indexed yes  
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  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  
  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
Dispersion of guided modes in two-dimensional split ring lattices

We present a semianalytical point-dipole method that uses Ewald lattice summation to find the dispersion relation of guided plasmonic and bianisotropic modes in metasurfaces composed of two-dimensional (2D) periodic lattices of arbitrarily strongly scattering magnetoelectric dipole scatterers. This method takes into account all retarded electrodynamic interactions as well as radiation damping self-consistently. As illustration, we analyze the dispersion of plasmon nanorod lattices, and of 2D split ring resonator lattices. Plasmon nanorod lattices support transverse and longitudinal in-plane electric modes. Scatters that have an in-plane electric and out-of-plane magnetic polarizability, but without intrinsic magnetoelectric coupling, result in two bands that are mixtures of the bands of electric-only and magnetic-only lattices. Thereby, bianisotropy through mutual coupling, in absence of building-block bianisotropy, is evident. Once strong bianisotropy is included in each building block, the Bloch modes become even more strongly magnetoelectric. Our results are important to understand spatial dispersion and bianisotropy of metasurface and metamaterial designs.

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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
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Slow-light-enhanced gain in active photonic crystal waveguides

Passive photonic crystals have been shown to exhibit a multitude of interesting phenomena, including slow-light propagation in line-defect waveguides. It was suggested that by incorporating an active material in the waveguide, slow light could be used to enhance the effective gain of the material, which would have interesting application prospects, for example enabling ultra-compact optical amplifiers for integration in photonic chips. Here we experimentally investigate the gain of a photonic crystal membrane structure with embedded quantum wells. We find that by solely changing the photonic crystal structural parameters, the maximum value of the gain coefficient can be increased compared with a ridge waveguide structure and at the same time the spectral position of the peak gain be controlled. The experimental results are in qualitative agreement with theory and show that gain values similar to those realized in state-of-the-art semiconductor optical amplifiers should be attainable in compact photonic integrated amplifiers.

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
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BFI (2017): BFI-level 2
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 11.8 SJR 6.414 SNIP 2.855
Web of Science (2016): Impact factor 12.124
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 11.23 SJR 6.287 SNIP 2.86
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 10.77 SJR 6.41 SNIP 3.034
Web of Science (2014): Impact factor 11.47
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 9.85 SJR 6.206 SNIP 2.797
Web of Science (2013): Impact factor 10.742
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Scopus rating (2012): CiteScore 8.32 SJR 5.866 SNIP 2.829
Web of Science (2012): Impact factor 10.015
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Scopus rating (2011): CiteScore 4.44 SJR 3.137 SNIP 1.825
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.

Calibrating and Controlling the Quantum Efficiency Distribution of Inhomogeneously Broadened Quantum Rods by Using a Mirror Ball
We demonstrate that a simple silver coated ball lens can be used to accurately measure the entire distribution of radiative transition rates of quantum dot nanocrystals. This simple and cost-effective implementation of Drexhage’s method that uses nanometer-controlled optical mode density variations near a mirror, not only allows an extraction of calibrated ensemble-averaged rates, but for the first time also to quantify the full inhomogeneous dispersion of radiative and non-radiative decay rates across thousands of nanocrystals. We apply the technique to novel ultrastable CdSe/CdS dot-in-rod emitters. The emitters are of large current interest due to their improved stability and reduced blinking. We retrieve a room-temperature ensemble average quantum efficiency of 0.87 ± 0.08 at a mean lifetime around 20 ns. We confirm a log-normal distribution of decay rates as often assumed in literature, and we show that the rate distribution-width, that amounts to about 30% of the mean decay rate, is strongly dependent on the local density of optical states.
Optical properties of two-dimensional magnetolectric point scattering lattices

We explore the electrodynamic coupling between a plane wave and an infinite two-dimensional periodic lattice of magnetolectric point scatterers, deriving a semianalytical theory with consistent treatment of radiation damping, retardation, and energy conservation. We apply the theory to arrays of split ring resonators and provide a quantitative comparison of measured and calculated transmission spectra at normal incidence as a function of lattice density, showing excellent agreement. We further show angle-dependent transmission calculations for circularly polarized light and compare with the angle-dependent response of a single split ring resonator, revealing the importance of cross coupling between electric dipoles and magnetic dipoles for quantifying the pseudochiral response under oblique incidence of split ring lattices.

General information
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, FOM Institute for Atomic and Molecular Physics - AMOLF
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 verified 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 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.

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 an 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.
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.
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.
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
State: Published
Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing, Nanophotonic Devices
Contributors: Ek, S., Chen, Y., Schubert, M., Semenova, E., Hansen, P. L., Yvind, K., Mørk, J.
Pages: We.D2.5
Publication date: 2011

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.

General information
State: Published
Organisations: Nanophotonics Theory and Signal Processing, Department of Photonics Engineering, Nanophotonic Devices
Contributors: Ek, S., Hansen, P. L., Semenova, E., Yvind, K., Mørk, J.
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Publication date: 2011

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.

**General information**
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**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.

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
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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
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.2 SJR 1.522 SNIP 1.28
Web of Science (2012): Impact factor 2.21
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.33 SJR 1.526 SNIP 1.499
Web of Science (2011): Impact factor 2.185
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.456 SNIP 1.352
Web of Science (2010): Impact factor 2.097
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.715 SNIP 1.595
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.62 SNIP 1.334
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.721 SNIP 1.326
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.65 SNIP 1.415
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.098 SNIP 1.676
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.018 SNIP 1.682
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.801 SNIP 1.494
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.528 SNIP 1.46
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.938 SNIP 1.451
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.003 SNIP 1.189
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.89 SNIP 1.164

Original language: English
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.

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Journal: IEEE Photonics Technology Letters
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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
Slow and fast light in semiconductor waveguides

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
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.

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.
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, and Λ, 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 Λ-schemes. The physical mechanisms that make the V-scheme less vulnerable to inhomogeneous broadening are analyzed and discussed.

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Contributors: Hansen, P. L., Mørk, J.
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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
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

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Contributors: Mørk, J., Öhman, F., Poel, M. V. D., Chen, Y., Hansen, P. L., Yvind, K.
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Slow and fast light in semiconductor structures: physics and applications: [invited]

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.

Carrier dynamics and slow light in semiconductor nanostructures

General information
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Organisations: Department of Photonics Engineering, Nanophotonics Theory and Signal Processing
Contributors: Merk, J., Öhman, F., Poel, M. V. D., Chen, Y., Xue, W., Hansen, P. L., Yvind, K.
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Title of host publication: CLEO/QELS 2008
Place of publication: San Jose, CA, USA
Publisher: Optical Society of America OSA
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.

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.
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Publication date: 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

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.
Nanoteknologi i masseproduktion

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Yvind, K., Larsson, D., Hansen, P. L.
Number of pages: 259
Pages: 51-62
Publication date: 2007

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Title of host publication: Optiske Horisonter : en rejse på kommunikationsteknologiogens vinger
Place of publication: Odense
Publisher: COM.DTU
Edition: 1
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Source: orbit
Source-ID: 202152
Research output: Research - peer-review › Book chapter – Annual report year: 2007

Slow light in selfassembled quantum dots

General information
State: Published
Organisations: Nanophotonics, Department of Photonics Engineering, Theoretical Nanotechnology, Department of Micro- and Nanotechnology
Contributors: Hansen, P. L., Houmark-Nielsen, J.
Peer-reviewed: Yes
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Source-ID: 202150
Research output: Research - peer-review › Poster – Annual report year: 2007

Slow light in semiconductor quantum dots

General information
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Organisations: Nanophotonics, Department of Photonics Engineering
Contributors: Hansen, P. L., Poel, M. V. D., Yvind, K., Mørk, J.
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Event: Abstract from 3rd Annual meeting Danish Physical Society, Nyborg, Denmark.
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Slow light in semiconductor quantum dots
Slow light in semiconductor waveguides: theory and experiment

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Publication date: 2007
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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

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Source: orbit
Source-ID: 209806
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Projects:

Characterization of pulse propagation in photonic crystal structures and ultrafast dynamics in quantum dots
Ek, S., PhD Student, Department of Photonics Engineering
Mørk, 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
Albrechtsen, O., Examiner
Dorren, H. J. S., Examiner
Eksternt finansieret virksomhed
Processing and Characterization of Quantum dot Devices
Hansen, P. L., PhD Student, Department of Photonics Engineering
Poel, M. V. D., Supervisor, Department of Photonics Engineering
Yvind, K., Supervisor, Department of Photonics Engineering
Vvam, 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

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.

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.
Activities:

International Nano-Optoelectronics Workshop (iNOW)
Per Lunnemann Hansen (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
International Nano-Optoelectronics Workshop (iNOW): Slow light in semiconductor structures - physics and applications
10/08/2009 → 14/08/2009
Berlin, Germany
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.