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Organisations

Postdoc, Department of Photonics Engineering
18/07/2007 → 03/05/2016 Former
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VIP

Nanophotonics
25/02/2012 → 21/07/2012 Former
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Quantum and Laser Photonics
25/02/2012 → 03/05/2016 Former
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Research outputs:

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 median, Bragg reflection from a periodic stack of layers(3-8), mode coupling in a high contrast grating(9,10) 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(12) has recently been explored in a number of different photonic and plasmonic systems(13,14). 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(15-18). Such a source is of interest for a number of applications within integrated photonics.

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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.

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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, High-Speed Optical Communication, Department of Micro- and Nanotechnology, Centre of Excellence for Silicon Photonics for Optical Communications, Nanophotonic Devices
Contributors: Yu, Y., Xue, W., Hu, H., Oxenløwe, L. K., Yvind, K., Mørk, J.
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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.
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.
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**

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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, High-Speed Optical Communication, Centre of Excellence for Silicon Photonics for Optical Communications, Department of Micro- and Nanotechnology, Nanophotonic Devices
Contributors: Park, G. C., Xue, W., Piels, M., Zibar, D., Mørk, J., Semenova, E., Chung, I.
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  - Scopus rating (2015): CiteScore 5.3 SJR 2.034 SNIP 1.597
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  - Scopus rating (2014): CiteScore 4.75 SJR 2.163 SNIP 1.554
  - Web of Science (2014): Impact factor 5.578
  - Web of Science (2014): Indexed yes
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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.

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/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.
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.
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.
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 \( \mu \text{m} \) with a side-mode suppression-ratio of 27 dB and has a similar threshold as long-wavelength VCSELs.

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.
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BFI (2016): BFI-level 2
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Web of Science (2014): Impact factor 2.965
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ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
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Web of Science (2010): Impact factor 2.259
Web of Science (2010): Indexed yes
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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
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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
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$^{-1}$.

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Web of Science (2015): Impact factor 7.486
Web of Science (2015): Indexed yes
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Slow-light effects in photonic crystal membrane lasers
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
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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, Nanophotonic Devices, Department of Micro- and Nanotechnology
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Source: Findit
Source-ID: 276911118
Research output: Research - peer-review › Article in proceedings – Annual report year: 2015
**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**

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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, Nanophotonic Devices  
Contributors: Xue, W., Ottaviano, L., Chen, Y., Semenova, E., Yu, Y., Lupi, A., Mørk, J., Yvind, K.  
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Scopus rating (2015): CiteScore 3.78 SJR 1.91 SNIP 1.674  
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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  
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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  
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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
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 1 mW.

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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.

Nonplanar nanoselective area growth of InGaAs/InP

In this study, we have investigated metal-organic vapor phase epitaxial nano-patterned selective area growth of InGaAs/InP on non-planar (001) InP surfaces. Due to high etching resistance and the small molecular size of negative tone electron beam HSQ resist, the protection mask formed in HSQ has small feature sizes in ten nanometers scale and allow realization of in-situ etching. As was observed in the SAG regime, in-situ etching of InP by carbon tetrabromide leads to formation of self-limited structures. By altering etching time, the groove shape can be changed from a triangular trench to a trapeze. Another appealing aspect of in situ etching is that the shape of InGaAs can be tuned from a crescent to a triangular or a line by varying growth parameters. Quantum well wires can be fabricated by growing directly in the bottom of V-shaped groove. In addition, changes of mask orientations lead to anistropic or isotropic character of etching. The investigated technique of nano-patterned selective area growth allows obtaining different profiles of structures and different quantum structures such as quantum well or wires in the same growth run. To investigate the shape and crystalline quality of the active material, the cross-sectional geometry was observed by field emission scanning electron microscopy and scanning transmission electron microscopy. The optical properties were carried out at room temperature.
using micro-photoluminescence setup. The results showed different deposition rates for openings oriented along [0-11] and [0-1-1] directions with higher rate along [0-1-1]. The fabricated active material was incorporated into photonic crystal waveguides.

**General information**

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**Organisations:** Department of Photonics Engineering, Nanophotonic Devices, Quantum and Laser Photonics, Center for Electron Nanoscopy, Nanophotonics, St. Petersburg Academic University

**Contributors:** Kuznetsova, N., Colman, P., Semenova, E.; Kadkhodazadeh, S., Kryzhanovskaya, N. V., Ek, S., Xue, W., Schubert, M., Zhukov, A. E., Yvind, K.

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- Web of Science (2017): Indexed yes
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- 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
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- Web of Science (2012): Indexed yes
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- Scopus rating (2011): CiteScore 0.31 SJR 0.217 SNIP 0.286
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- 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
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.
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.
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.

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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.

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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.

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Web of Science (2016): Impact factor 3.671
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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
Tunable true-time delay of a microwave photonic signal realized by cross gain modulation in a semiconductor waveguide

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 ~5 to ~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.

General information
State: Published
Organisations: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Xue, W., Mørk, J.
Pages: 231102
Publication date: 2011
Peer-reviewed: Yes
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.

General information
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Organisations: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Xue, W.
Number of pages: 147
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Publisher: Technical University of Denmark (DTU)
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Original language: English
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PhD Thesis_DTU Fotonik_Weiqi Xue.pdf
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Research output: Research - peer-review › Journal article – Annual report year: 2011

360° tunable microwave phase shifter based on silicon-on-insulator dual-microring resonator

We demonstrate tunable microwave phase shifters based on electrically tunable silicon-on-insulator dual-microring resonators. A quasi-linear phase shift of 360° with ~2dB radio frequency power variation at a microwave frequency of 40GHz is obtained.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Quantum and Laser Photonics
Contributors: Pu, M., Xue, W., Liu, L., Ou, H., Yvind, K., Hvam, J. M.
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, Quantum and Laser Photonics
Contributors: Xu, J., Ding, Y., Xue, W., Peucheret, C., Seoane, J., Zsigri, B., Jeppesen, P., Mørk, J.
Pages: P2.22
Publication date: 2010

Microwave photonic phase shifter based on tunable silicon-on-insulator microring resonator
We demonstrate a microwave photonic phase shifter based on an electrically tunable silicon-on-insulator microring resonator. A continuously tunable phase shift of up to 315° at a microwave frequency of 15GHz is obtained.

General information
State: Published
Organisations: Nanophotonic Devices, Department of Photonics Engineering, Quantum and Laser Photonics
Contributors: Pu, M., Liu, L., Xue, W., Frandsen, L. H., Ou, H., Yvind, K., Hvam, J. M.
Pages: 1-2
Publication date: 2010
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, ~10.5 ps tunable true time delay over a microwave bandwidth of several tens of GHz is obtained.

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

Recent advances in slow and fast light for applications in microwave photonics: [invited]

General information
State: Published
Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, Polytechnic University of Valencia
Contributors: Mørk, J., Xue, W., Chen, Y., Blaaberg, S., Sales, S., Capmany, J.
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Proceedings of SPIE, the International Society for Optical Engineering
ISSN (Print): 0277-786X
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Web of Science (2019): Indexed yes
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
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 photonic applications such as filtering, arbitrary waveform generation and optoelectronic oscillators (OEOs) are reviewed, and other directions for future research in the field are discussed.

General information
State: Published
Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, Polytechnic University of Valencia
Contributors: Sales, S., Xue, W., Mørk, J., Gasulla, I.
Pages: 3022-3038
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Microwave Theory and Techniques
Volume: 58
Issue number: 11
ISSN (Print): 0018-9480
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Web of Science (2019): Indexed yes
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
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: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Mørk, J., Hansen, P. L., Xue, W., Chen, Y., Nielsen, P. K., Nielsen, T. R.
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Journal: Semiconductor Science and Technology
Volume: 25
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Ratings:
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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
We demonstrate microwave phase shifters based on electrically tunable silicon-on-insulator microring resonators (MRRs). MRRs with different quality factors are fabricated and tested. A continuously tunable phase shift of up to 336° at a microwave frequency of 40 GHz is obtained using a high-quality-factor (28000) MRR with only 1.6 mW power consumption. A quasi-linear phase shift in the range of 0–204° at 40 GHz with a radio-frequency power variation less than 1.3 dB is also achieved by using a lower-quality-factor MRR.

General information
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Organisations: Nanophotonic Devices, Department of Photonics Engineering, Quantum and Laser Photonics
Contributors: Pu, M., Liu, L., Xue, W., Ding, Y., Frandsen, L. H., Ou, H., Yvind, K., Hvam, J. M.
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BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
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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Copyright: 2010 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE
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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
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Contributors: Xue, W., Sales, S., Capmany, J., Mørk, J.
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Peer-reviewed: Yes

Publication information
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Issue number: 6
ISSN (Print): 1094-4087
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
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
We propose and demonstrate tunable microwave phase shifters based on electrically tunable silicon-on-insulator microring resonators. The phase-shifting range and the RF-power variation are analyzed. A maximum phase-shifting range of 0–600° is achieved by utilizing a dual-microring resonator. A quasi-linear phase shift of 360° with RF-power variation lower than 2dB and a continuous 270° phase shift without RF-power variation at a microwave frequency of 40GHz are also demonstrated.
Compact optically-fed microwave true-time delay using liquid crystal photonic bandgap fiber device

Electrically tunable liquid crystal photonic bandgap fiber device based optically-fed microwave true-time delay is demonstrated. A maximum ~60° phase shift and an averaged ~7.2ps true time delay are obtained over the modulation frequency range 1GHz-19GHz.

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.
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.

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.
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°.
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.
Optically fed microwave true-time delay based on a compact liquid-crystal hotonic-bandgap-fiber device

An electrically tunable liquid-crystal, photonic-bandgap-fiber-device-based, optically fed microwave true-time delay is demonstrated with the response time in the millisecond range. A maximum electrically controlled phase shift of around 70° at 15GHz and an averaged 12.9ps true time delay over the whole modulation frequency range of 1-15GHz are obtained.
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., Merk, J.
Number of pages: 574
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Place of publication: Valladolid, Spain
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Source: orbit
Source-ID: 249709
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

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
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Organisations: Department of Photonics Engineering, Metro-Access and Short Range Systems, Quantum and Laser Photonics
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Publication date: 2009
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Journal: Optics Letters
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Web of Science (2019): Indexed yes
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
Photonic generation of UWB monocycle using a cascaded semiconductor optical amplifier and electroabsorption modulator
Photonic generation of ultrawideband monocycle pulses is experimentally demonstrated by using a cascaded semiconductor optical amplifier and electroabsorption modulator. The polarity and the shape of the ultrawideband monocycle pulses can be electrically controlled and optimized.

**General information**
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Organisations: Department of Photonics Engineering, Metro-Access and Short Range Systems, Quantum and Laser Photonics
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Title of host publication: Proceedings, OFC
Publisher: IEEE
Source: orbit
Source-ID: 243543
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

**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 requirements of 360° 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.
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Place of publication: San Jose, CA, USA
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Source: orbit
Source-ID: 237599
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

**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.

**General information**
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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics
Contributors: Mørk, J., Nielsen, T. R., Xue, W., Chen, Y., Hansen, P. L.
Publication date: 2009
Peer-reviewed: Yes
Event: Abstract from International Nano-Optoelectronics Workshop (iNOW), Berlin, Germany.
Source: orbit
Source-ID: 250085
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2009

**The optical chip: high speed and diminutive size**

**General information**
State: Published
Organisations: Quantum and Laser Photonics, Department of Photonics Engineering
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.
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.
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.

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.
Carrier dynamics and slow light in semiconductor nanostructures

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Organisations: Department of Photonics Engineering, Quantum and Laser Photonics, Nanophotonic Devices
Contributors: Mørk, J., Öhman, F., Poel, M. V. D., Chen, Y., Xue, W., Hansen, P. L., Yvind, K.
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Host publication information
Title of host publication: CLEO/QELS 2008
Place of publication: San Jose, CA, USA
Publisher: Optical Society of America OSA
Source: orbit
Source-ID: 233419
Research output: Research - peer-review › Journal article – Annual report year: 2008

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

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

Host publication information
Title of host publication: Slow and Fast Light (SL)
Place of publication: Boston, Massachusetts, USA
Publisher: Optical Society of America
Source: orbit
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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: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Xue, W., Chen, Y., Öhman, F., Sales, S., Mørk, J.
Pages: 1084-1086
Publication date: 2008
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Publication information
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   Web of Science (2019): Indexed yes
   BFI (2018): BFI-level 2
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   Web of Science (2017): Impact factor 3.589
   Web of Science (2017): Indexed yes
   BFI (2016): BFI-level 2
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   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
Experimental demonstration of strongly enhanced light slow-down in semiconductor optical amplifiers by optical filtering

General information
State: Published
Organisations: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Xue, W., Öhman, F., Chen, Y., Sales, S., Mørk, J.
Pages: STuA5
Publication date: 2008

Host publication information
Title of host publication: Slow and Fast Light (SL) 2008
Place of publication: Boston, Massachusetts, USA
Source: orbit
Source-ID: 223407
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: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Xue, W., Öhman, F., Blaaberg, S., Chen, Y., Sales, S., Mørk, J.
Pages: CMP2
Publication date: 2008

Host publication information
Title of host publication: CLEO/QELS08
Place of publication: San Jose, CA, USA
Publisher: Optical Society of America
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: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Chen, Y., Xue, W., Öhman, F., Mørk, J.
Pages: JMB14
Publication date: 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, Quantum and Laser Photonics
Contributors: Mørk, J., Öhman, F., Xue, W., Chen, Y., Blaaberg, S., Sales, S.
Pages: 210-213
Publication date: 2008

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: Quantum and Laser Photonics, Department of Photonics Engineering
Contributors: Chen, Y., Xue, W., Öhman, F., Mørk, J.
Pages: 3734-3743
Slow and Fast Light for Applications in Microwave Photonics
Xue, W., PhD Student, Department of Photonics Engineering
Mørk, J., Main Supervisor, Department of Photonics Engineering
Sales, S., Supervisor
Öhman, F., Supervisor, Department of Photonics Engineering
Öxenløwe, L. K., Examiner, Department of Photonics Engineering
Morthier, G. J. I., Examiner
Nielsen, M. L., Examiner, Department of Photonics Engineering
Sales, S., Supervisor

Forskningsrådssfinansiering
01/07/2007 → 29/09/2010
Award relations: Slow and Fast Light for Applications in Microwave Photonics
Project: PhD

PhCLaser: Dynamics and noise of Photonic-crystal based nano and micro lasers
Xue, W., Project Participant, Department of Photonics Engineering, Quantum and Laser Photonics
01/01/2013 → …
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
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Pu, M., Project Participant, Department of Photonics Engineering
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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

Activities:

**International Nano-Optoelectronics Workshop (iNOW)**
Weiqi Xue (Participant)
Department of Photonics Engineering
Quantum and Laser Photonics

**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.