Silicon Photonics And Photonic Integrated Circuits
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Principles of Photonic Integrated Circuits

High-Speed, Low-Power and Mid-IR Silicon Photonics Applications

Silicon photonic integrated circuits have advanced to the point where thousands of components can now be combined into functioning optical circuits. A variety of quantum technologies are based upon the integrated silicon photonics platform, including pure photonics approaches as well as those based upon emerging silicon spin-photon interfaces. Integrated photonic components, such as grating couplers, photonic crystal cavities, and waveguides, are subject to slight manufacturing variations. For quantum technology applications, such variations often need to be minimized and ideally eliminated through careful post-processing. The laser-assisted "spot oxidation" post-processing technique is able to locally and permanently shift the resonance wavelength of nanophotonic devices using a 532nm continuous wave laser. While global tuning techniques affect entire chips, spot-oxidation is of interest because it can locally correct for specific manufacturing variations among many components within a single chip in an automated way. Yet prior to this work it was unclear if spot oxidation could be made compatible with photonic structures with SiO2 top-cladding, which are more robust and attractive for commercial deployment. Here, we apply laser-assisted tuning to silicon-on-insulator (SOI) devices with SiO2 top-cladding in the telecommunication O-band. In this work, we successfully tune both photonic crystal nanobeam cavities and sub-wavelength grating couplers up to 1.04(5)nm and 9(1)nm, respectively. This will enable higher-yield photonic circuits, as well as allow us to permanently locally tune optical structures into resonance with optically active colour centres in silicon.
Silicon Photonics

Silicon Photonics and Photonic Integrated Circuits

Photonics is an evolving field allowing for optical devices to be made cost effectively using standard semiconductor fabrication techniques, which in turn enables integration with microelectronic chips. Chip scale photonics will play an increasing role in the future of communications as the demand for bandwidth and reduced power consumption per bit continues to grow. Tunable optical circuit components are one of the essential technologies in the development of photonic analogues for classical electronic devices, where tunable photonic resonant structures allow for altering of their electromagnetic spectrum and find applications in optical switching, filtering, buffering, lasers and biosensors. The scope of this work is focused on tunable resonant structures for photonic integrated circuits. Specifically, this work demonstrates active tuning of silicon photonic resonant structures using the properties of dye doped nematic liquid crystals, temperature stabilization of silicon photonics using the passive properties of liquid crystals, and the effects of low density plasma enhanced chemical vapor deposition (PECVD) claddings on ring resonator device performance.

Programmable Integrated Photonics

This book describes the merging of photonics and electronics in silicon and other group IV elements. It presents the challenges, the limitations, and the upcoming possibilities of these developments. It describes the evolution of CMOS integrated electronics, status and development, and the fundamentals of silicon photonics, including the reasons for
its rapid expansion, its possibilities and limitations. Also discussed are the applications of these technologies for such applications as memory, digital logic operations, light sources, including drive electronics, optical modulators, detectors, and post detector circuitry. It will appeal to engineers in the fields of both electronics and photonics who need to learn more about the basics of the other field and the prospects for the integration of the two. --

**Silicon Photonics with Applications to Data Center Networks**

The open access journal Micromachines invites manuscript submissions for the Special Issue “Silicon Photonics Bloom”. The past two decades have witnessed a tremendous growth of silicon photonics. Lab-scale research on simple passive component designs is now being expanded by on-chip hybrid systems architectures. With the recent injection of government and private funding, we are living the 1980s of the electronic industry, when the first merchant foundries were established. Soon, we will see more and more merchant foundries proposing well-established electronic design tools, product development kits, and mature component libraries. The open access journal Micromachines invites the submission of manuscripts in the developing area of silicon photonics. The goal of this Special Issue is to highlight the recent developments in this cutting-edge technology.]

**Monolithic Nanoscale Photonics-Electronics Integration in Silicon and Other Group IV Elements**
Silicon Photonics Bloom

Silicon photonics technology, which has the DNA of silicon electronics technology, promises to provide a compact photonic integration platform with high integration density, mass-producibility, and excellent cost performance. This technology has been used to develop and to integrate various photonic functions on silicon substrate. Moreover, photonics-electronics convergence based on silicon substrate is now being pursued. Thanks to these features, silicon photonics will have the potential to be a superior technology used in the construction of energy-efficient cost-effective apparatuses for various applications, such as communications, information processing, and sensing. Considering the material characteristics of silicon and difficulties in microfabrication technology, however, silicon by itself is not necessarily an ideal material. For example, silicon is not suitable for light emitting devices because it is an indirect transition material. The resolution and dynamic range of silicon-based interference devices, such as wavelength filters, are significantly limited by fabrication errors in microfabrication processes. For further performance improvement, therefore, various assisting materials, such as indium-phosphide, silicon-nitride, germanium-tin, are now being imported into silicon photonics by using various heterogeneous integration technologies, such as low-temperature film deposition and wafer/die bonding. These assisting materials and heterogeneous integration technologies would also expand the application field of silicon photonics technology. Fortunately, silicon photonics technology has superior flexibility and robustness for heterogeneous integration. Moreover, along with photonic functions, silicon photonics technology has an ability of integration of electronic functions. In other words, we are on the verge of obtaining an ultimate technology that can integrate all photonic and electronic functions on a single Si chip. This e-Book aims at covering recent developments of the silicon photonic
platform and novel functionalities with heterogeneous material integrations on this platform.

**Silicon Photonics II**

Over the past 15 years, basic photonic crystals operating in optical wavelengths have been theoretically investigated and experimentally realized. New directions must now be set to understand fundamental photon-matter interactions and thus realize active photonic components for integrated and silicon-based photonic applications. This proposal aims at two key areas to study. They are: (1) Thermal emission and silicon photonic crystal lasers—an aspect of photon-phonon interaction. (2) Optical interconnects—an aspect of photonic transport and mutual interaction. Understanding the underlining photon-phonon interaction, blackbody radiation can be altered, and wasted thermal energy recycled. Furthermore, we intend to build SOI based optical components, and study their mutual interaction for achieving complex optical functionality. Two examples are waveguide-cavity and cavity-cavity interaction for channel dropping filter applications. Indeed, the next challenge in photonic crystal research is in material integration, in on-chip integration of photonic components, and lastly the realization of silicon lasers.

**Integrated Optics, Silicon Photonics, and Photonic Integrated Circuits**

This book is volume III of a series of books on silicon photonics. It reports on the development of fully integrated systems where many different photonics component are integrated together to build complex circuits. This is the demonstration of the fully potentiality of silicon photonics. It contains a number of chapters written by engineers.
and scientists of the main companies, research centers and universities active in the field. It can be of use for all those persons interested to know the potentialities and the recent applications of silicon photonics both in microelectronics, telecommunication and consumer electronics market.

**Silicon Photonics**

Silicon Photonics, Volume 99 in the Semiconductors and Semimetals series, highlights new advances in the field, with this updated volume presenting interesting chapters on Transfer printing in Silicon Photonics, Epitaxial integration of antimonide-based semiconductor lasers on Si, Photonic crystal lasers and nanolasers on Si, the Evolution of monolithic quantum-dot light source for silicon photonics, III-V on Si nanocomposites, the Heterogeneous integration of III-V on Si by bonding, the Growth of III-V on Silicon compliant substrates and lasers by MOCVD, Photonic Integrated Circuits on Si, Integrated Photonics for Bio- and Environmental sensing, Membrane Lasers/Photodiodes on Si, and more. Provides the authority and expertise of leading contributors from an international board of authors Represents the latest release in the Semiconductors and Semimetals series Updated release includes the latest information on Silicon Photonics

**Silicon Photonics and Its Applications in Microwave Photonics**

**Photonic Integration and Photonics-Electronics Convergence on Silicon Platform**
Thanks to its compatibility with the current CMOS technology and its potential of seamless integration with electronics, silicon photonics has been attracting an ever-increasing interest in recent years from both the academia and industry. By applying silicon photonic technology in microwave photonics, on-chip integration of microwave photonic systems could be implemented with improved performance including a much smaller size, better stability and lower power consumption. This thesis focuses on developing silicon-based photonic integrated circuits for microwave photonic applications. Two types of silicon-based on-chip devices, waveguide Bragg gratings and optical micro-cavity resonators, are designed, developed, and characterized, and the use of the developed devices in microwave photonic applications is studied. After an introduction to silicon photonics and microwave photonics in Chapter 1 and an overview of microwave photonic signal generation and processing in Chapter 2, in Chapter 3 a silicon-based on-chip phase-shifted waveguide Bragg grating (PS-WBG) is designed, fabricated and characterized, and its use for the implementation of a photonic temporal...
differentiator is experimentally demonstrated. To have a waveguide grating that is wavelength tunable, in Chapter 4 a tunable waveguide grating is proposed by incorporating a PN junction across the waveguide grating, to use the free-carrier plasma dispersion effect in silicon to achieve wavelength tuning. The use of a pair of wavelength-tunable waveguide gratings to form a wavelength-tunable Fabry-Perot resonator for microwave photonic signal processing is studied. Thanks to its electrical tunability, a high-speed electro-optic modulator, a tunable fractional-order photonic temporal differentiator and a tunable optical delay line are experimentally demonstrated. To increase the bandwidth of a waveguide grating, in Chapter 5 a linearly chirped waveguide Bragg grating (LC-WBG) is designed, fabricated and evaluated. By incorporating two LC-WBGs in two arms of a Mach-Zehnder interferometer (MZI) structure, an on-chip optical spectral shaper is produced, which is used in a photonic microwave waveform generation system based on spectral-shaping and wavelength-to-time (SS-WTT) mapping for linearly chirped microwave waveform (LCMW) generation. To enable the LC-WBG to be electrically tuned, in Chapter 6 a lateral PN junction is introduced in the grating and thus an electrically tunable LC-WBG is realized. By incorporating two tunable LC-WBGs in a Michelson interferometer structure, an electrically tunable optical spectral shaper is made. By applying the fabricated spectral shaper in an SS-WTT mapping system, a continuously tunable LCMW is experimentally generated. Compared with a waveguide Bragg grating device, an on-chip optical micro-cavity resonator usually has a much smaller dimension, which is of help to increase the integration density and reduce the power consumption. Different on-chip optical micro-cavity resonators are studied in this thesis. In Chapter 7, an on-chip symmetric MZI incorporating multiple cascaded microring resonators is proposed. By controlling the radii of the rings, the MZI could be designed to have a spectral response with a linearly-varying free spectral range (FSR), which could be used in photonic generation of an LCMW, and to have a multi-channel
spectral response with identical channel spacing, which could be used in the implementation of an independently tunable multi-channel fractional-order temporal differentiator. To further reduce the footprint of an optical micro-cavity resonator, in Chapter 8 an ultra-compact microdisk resonator (MDR) with a single-mode operation and an ultra-high Q-factor is proposed, fabricated and evaluated, and its use for the implementation of a microwave photonic filter and an optical delay line is experimentally demonstrated. To enable the MDR to be electrically tunable, in Chapter 9 an electrically tunable MDR is realized by incorporating a lateral PN junction in the disk. The use of the fabricated MDR in microwave photonic applications such as a high-speed electro-optic modulator, a tunable photonic temporal differentiator and a tunable optical delay line is experimentally demonstrated.

**Optical Interconnects for Data Centers**

This book is volume II of a series of books on silicon photonics. It gives a fascinating picture of the state-of-the-art in silicon photonics from a component perspective. It presents a perspective on what can be expected in the near future. It is formed from a selected number of reviews authored by world leaders in the field, and is written from both academic and industrial viewpoints. An in-depth discussion of the route towards fully integrated silicon photonics is presented. This book will be useful not only to physicists, chemists, materials scientists, and engineers but also to graduate students who are interested in the fields of micro- and nanophotonics and optoelectronics.

**Silicon Photonics and Photonic Integrated Circuits III**

Silicon photonics uses chip-making techniques to fabricate photonic circuits. The
emerging technology is coming to market at a time of momentous change. The need of the Internet content providers to keep scaling their data centers is becoming increasingly challenging, the chip industry is facing a future without Moore’s law, while telcos must contend with a looming capacity crunch due to continual traffic growth. Each of these developments is significant in its own right. Collectively, they require new thinking in the design of chips, optical components, and systems. Such change also signals new business opportunities and disruption. Notwithstanding challenges, silicon photonics’ emergence is timely because it is the future of several industries. For the optical industry, the technology will allow designs to be tackled in new ways. For the chip industry, silicon photonics will become the way of scaling post-Moore’s law. New system architectures enabled by silicon photonics will improve large-scale computing and optical communications. Silicon Photonics: Fueling the Next Information Revolution outlines the history and status of silicon photonics. The book discusses the trends driving the datacom and telecom industries, the main but not the only markets for silicon photonics. In particular, developments in optical transport and the data center are discussed as are the challenges. The book details the many roles silicon photonics will play, from wide area networks down to the chip level. Silicon photonics is set to change the optical components and chip industries; this book explains how. Captures the latest research assessing silicon photonics development and prospects Demonstrates how silicon photonics addresses the challenges of managing bandwidth over distance and within systems Explores potential applications of SiP, including servers, datacenters, and Internet of Things

Silicon Photonics IV
Silicon Photonics Design

This hands-on introduction to silicon photonics engineering equips students with everything they need to begin creating foundry-ready designs.

Silicon Photonics and Photonic Integrated Circuits II

Simulation of Building Blocks for Silicon Photonic Integrated Circuits

Silicon Photonics

Current data centre networks, based on electronic packet switches, are experiencing an exponential increase in network traffic due to developments such as cloud computing. Optical interconnects have emerged as a promising alternative offering high throughput and reduced power consumption. Optical Interconnects for Data Centers reviews key developments in the use of optical interconnects in data centres and the current state of the art in transforming this technology into a reality. The book discusses developments in optical materials and components (such as single and multi-mode waveguides), circuit boards and ways the technology can be deployed in data centres. Optical Interconnects for Data Centers is a key reference text for electronics designers, optical engineers, communications engineers and R&D managers working in the communications and electronics industries as well as postgraduate researchers. Summarizes the state-of-the-art in this emerging field Presents a comprehensive review of all the key aspects of
deploying optical interconnects in data centers, from materials and components, to circuit boards and methods for integration. Contains contributions that are drawn from leading international experts on the topic.

**Handbook of Silicon Photonics**

This book gives a fascinating picture of the state-of-the-art in silicon photonics and a perspective on what can be expected in the near future. It is composed of a selected number of reviews authored by world leaders in the field and is written from both academic and industrial viewpoints. An in-depth discussion of the route towards fully integrated silicon photonics is presented. This book will be useful not only to physicists, chemists, materials scientists, and engineers but also to graduate students who are interested in the fields of microphotonics and optoelectronics.

**Laser-assisted Selective Tuning of Silicon Nanophotonic Structures**

From the beginning, Integrated Photonics introduces numerical techniques for studying non-analytic structures. Most chapters have numerical problems designed for solution using a computational program such as Matlab or Mathematica. An entire chapter is devoted to one of the numeric simulation techniques being used in optoelectronic design (the Beam Propagation Method), and provides opportunity for students to explore some novel optical structures without too much effort. Small pieces of code are supplied where appropriate to get the reader started on the numeric work. Integrated Photonics is designed for the senior/first year graduate student, and requires a basic familiarity with electromagnetic waves, and the ability to solve differential equations with boundary conditions.
CMOS Integration of High Performance Quantum Dot Lasers for Silicon Photonics

Large on-chip bandwidths required for high performance electronic chips will render optical components essential parts of future on-chip interconnects. Silicon photonics enables highly integrated photonic integrated circuit (PIC) using CMOS compatible process. In order to maximize the bandwidth density and design flexibility of PICs, vertical integration of electronic layers and photonics layers is strongly preferred. Comparing deposited silicon, single crystalline silicon offers low material absorption loss and high carrier mobility, which are ideal for multi-layer silicon PIC. Three different methods to build multi-layer silicon PICs based on single crystalline silicon are demonstrated in this dissertation, including double-bonded silicon-on-insulator (SOI) wafers, transfer printed silicon nanomembranes, and adhesively bonded silicon nanomembranes. 1-to-12 waveguide fanouts using multimode interference (MMI) couplers were designed, fabricated and characterized on both double-bonded SOI and transfer printed silicon nanomembrane, and the results show comparable performance to similar devices fabricated on SOI. However, both of these two methods have their limitations in optical interconnects applications. Large and defect-free silicon nanomembrane fabricated using adhesive bonding is identified as a promising solution to build multi-layer silicon PICs. A double-layer structure constituted of vertically integrated silicon nanomembranes was demonstrated. Subwavelength length based fiber-to-chip grating couplers were used to couple light into this new platform. Three basic building blocks of silicon photonics were designed, fabricated and characterized, including 1) inter-layer grating coupler based on subwavelength nanostructure, which has efficiency of 6.0 dB and 3 dB bandwidth of 41 nm, for light coupling between layers, 2) 1-to-32 H-tree optical distribution, which has excess loss of 2.2 dB, output uniformity...
of 0.72 dB and 3 dB bandwidth of 880 GHz, 3) waveguide crossing utilizing index-engineered MMI coupler, which has crossing loss of 0.019 dB, cross talk lower than -40 dB and wide transmission spectrum covering C-band and L-band. The demonstrated integration method and silicon photonic devices can be integrated into the CMOS back-end process for clock distribution and global signaling.

**Integrated Photonics**

This book provides the first comprehensive, up-to-date and self-contained introduction to the emergent field of Programmable Integrated Photonics (PIP). It covers both theoretical and practical aspects, ranging from basic technologies and the building of photonic component blocks, to design alternatives and principles of complex programmable photonic circuits, their limiting factors, techniques for characterization and performance monitoring/control, and their salient applications both in the classical as well as in the quantum information fields. The book concentrates and focuses mainly on the distinctive features of programmable photonics, as compared to more traditional ASPIC approaches. After some years during which the Application Specific Photonic Integrated Circuit (ASPIC) paradigm completely dominated the field of integrated optics, there has been an increasing interest in PIP. The rising interest in PIP is justified by the surge in a number of emerging applications that call for true flexibility and reconfigurability, as well as low-cost, compact, and low-power consuming devices. Programmable Integrated Photonics is a new paradigm that aims at designing common integrated optical hardware configurations, which by suitable programming, can implement a variety of functionalities. These in turn can be exploited as basic operations in many application fields. Programmability enables, by means of external control signals, both chip reconfiguration for multifunction operation, as well as chip
stabilization against non-ideal operations due to fluctuations in environmental conditions and fabrication errors. Programming also allows for the activation of parts of the chip, which are not essential for the implementation of a given functionality, but can be of help in reducing noise levels through the diversion of undesired reflections.

Silicon Photonics and Photonic Integrated Circuits

Silicon Photonics and Photonic Integrated Circuits V

Includes Proceedings Vol. 7821

Principles of Photonic Integrated Circuits

Silicon Photonics III

Silicon Photonics

This graduate-level textbook presents the principles, design methods, simulation, and materials of photonic circuits. It provides state-of-the-art examples of silicon, indium phosphide, and other materials frequently used in these circuits, and includes a thorough discussion of all major types of devices. In addition, the book discusses the integrated photonic circuits (chips) that are currently increasingly employed on the
international technology market in connection with short-range and long-range data communication. Featuring references from the latest research in the field, as well as chapter-end summaries and problem sets, Principles of Photonic Integrated Circuits is ideal for any graduate-level course on integrated photonics, or optical technology and communication.

**Silicon Photonics IV**

This fourth book in the series Silicon Photonics gathers together reviews of recent advances in the field of silicon photonics that go beyond already established and applied concepts in this technology. The field of research and development in silicon photonics has moved beyond improvements of integrated circuits fabricated with complementary metal-oxide-semiconductor (CMOS) technology to applications in engineering, physics, chemistry, materials science, biology, and medicine. The chapters provided in this book by experts in their fields thus cover not only new research into the highly desired goal of light production in Group IV materials, but also new measurement regimes and novel technologies, particularly in information processing and telecommunication. The book is suited for graduate students, established scientists, and research engineers who want to update their knowledge in these new topics.

**Silicon Photonics and Photonic Integrated Circuits III**

Includes Proceedings Vol. 7821

**Reconfigurable Silicon Photonic Devices for Optical Signal Processing**

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Processing of high-speed data using optical signals is a promising approach for tackling the bandwidth and speed challenges of today's electronics. Realization of complex optical signal processing functionalities seems more possible than any time before, thanks to the recent achievements in silicon photonics towards large-scale photonic integration. In this Ph. D. work, a novel thermal reconfiguration technology is proposed and experimentally demonstrated for silicon photonics that is compact, low-loss, low-power, fast, with a large tuning-range. These properties are all required for large-scale optical signal processing and had not been simultaneously achieved in a single device technology prior to this work. This device technology is applied to a new class of resonator-based devices for reconfigurable nonlinear optical signal processing. For the first time, we have demonstrated the possibility of resonance wavelength tuning of individual resonances and their coupling coefficients. Using this new device concept, we have demonstrated tunable wavelength-conversion through four-wave mixing in a resonator-based silicon device for the first time.

**Silicon Photonics and Photonic Integrated Circuits V**

Optical and microwave waveguides have attracted much research interest in both science and industry. The number of potential applications for their use is growing rapidly. This book examines recent advances in the broad field of waveguide technology. It covers current progress and latest breakthroughs in emergent applications in photonics and microwave engineering. The book includes ten contributions on recent developments in waveguide technologies including theory, simulation, and fabrication of novel waveguide concepts as well as reviews on recent advances.
The development of integrated silicon photonic circuits has recently been driven by the Internet and the push for high bandwidth as well as the need to reduce power dissipation induced by high data-rate signal transmission. To reach these goals, efficient passive and active silicon photonic devices, including waveguide, modulators, photodetectors,

**Silicon Photonics**

Silicon photonics is currently a very active and progressive area of research, as silicon optical circuits have emerged as the replacement technology for copper-based circuits in communication and broadband networks. The demand for ever improving communications and computing performance continues, and this in turn means that photonic circuits are finding ever increasing application areas. This text provides an important and timely overview of the ‘hot topics’ in the field, covering the various aspects of the technology that form the research area of silicon photonics. With contributions from some of the world’s leading researchers in silicon photonics, this book collates the latest advances in the technology. Silicon Photonics: the State of the Art opens with a highly informative foreword, and continues to feature: the integrated photonic circuit; silicon photonic waveguides; photonic bandgap waveguides; mechanisms for optical modulation in silicon; silicon based light sources; optical detection technologies for silicon photonics; passive silicon photonic devices; photonic and electronic integration approaches; applications in communications and sensors. Silicon Photonics: the State of the Art covers the essential elements of the entire field that is silicon photonics and is therefore an invaluable text for photonics engineers and professionals working in the fields of optical networks, optical communications, and semiconductor electronics. It is also an informative reference for graduate students studying for PhD in fibre optics, integrated optics, optical networking, microelectronics,
or telecommunications.

**Multi-layer Silicon Photonic Devices for On-chip Optical Interconnects**

In data center applications, fiber-based optical interconnects can be used to provide point-to-point links enabling high-bandwidth, inter-rack, data communications. In order to provide for future network scalability, which must be able to handle ultra-large data flows and bandwidth-intensive requests, optical technologies are increasingly introduced to different levels of the data center architecture to enable a variety of transparent network or all-optical networking schemes. However, the use of bulk optical components, which take up valuable rack-space real estate, can be extremely energy and cost prohibitive, especially when scaled up to the size of industrial warehouse-scale computing and considering that predictions of future data center networks are expected to contain millions of nodes. As such, we study chip-scale, silicon photonic, integrated circuits and their use as the optical hardware in future data center implementations. This work describes aspects of the design and integration of silicon photonic devices, which can be used for high-bandwidth, multi-channel, wavelength division multiplexed, optical communications. Examples of silicon photonic subsystems are discussed, including the realization of an on-chip channelized spectrum monitor and a network-node-on-a-chip. These optical integrated circuits are meant to replace bulk optical components with their functional equivalents on monolithic silicon. This work demonstrates that silicon photonics may be advantageous in meeting the urgent hardware-scaling demands of high-bandwidth, multi-user, communication networks.

**3D Active Photonic Crystal Devices for Integrated Photonics and Silicon Photonics**
The growing demand for instant and reliable communication means that photonic circuits are increasingly finding applications in optical communications systems. One of the prime candidates to provide satisfactory performance at low cost in the photonic circuit is silicon. Whilst silicon photonics is less well developed as compared to some other material technologies, it is poised to make a serious impact on the telecommunications industry, as well as in many other applications, as other technologies fail to meet the yield/performance/cost trade-offs. Following a sympathetic tutorial approach, this first book on silicon photonics provides a comprehensive overview of the technology. Silicon Photonics explains the concepts of the technology, taking the reader through the introductory principles, on to more complex building blocks of the optical circuit. Starting with the basics of waveguides and the properties peculiar to silicon, the book also features: Key design issues in optical circuits. Experimental methods. Evaluation techniques. Operation of waveguide based devices. Fabrication of silicon waveguide circuits. Evaluation of silicon photonic systems. Numerous worked examples, models and case studies. Silicon Photonics is an essential tool for photonics engineers and young professionals working in the optical network, optical communications and semiconductor industries. This book is also an invaluable reference and a potential main text to senior undergraduates and postgraduate students studying fibre optics, integrated optics, or optical network technology.

**Principles of Photonic Integrated Circuits**

"Integration of III-V components on Si substrates is required for realizing the promise of Silicon Photonic systems. Specifically, the direct bandgap of many III-V materials is required for light sources, efficient modulators and photodetectors. Several different approaches have been taken to integrate III-V lasers into the silicon photonic platform,
such as wafer bonding, direct growth, butt coupling, etc. Here, we have devised a novel laser design that overcomes the above limitations. In our approach, we use InAs quantum dot (QD) lasers monolithically integrated with silicon waveguides and other Si photonic passive components. Due to their unique structures, the QD lasers have been proven by several groups to have the combination of high temperature stability, large modulation bandwidth and low power consumption compared with their quantum well counterparts, which makes it an ideal candidate for Si photonic applications. The first section of this dissertation introduces the theory and novelty of QD lasers, the DC and RF characterization methods of QD lasers are also discussed. The second section is focused on the growth of QD gain chip which a broadband gain chip based on QD inhomogeneous broadening properties was demonstrated. In third section, the lasers devices are built on Si substrate by Pd wafer bonding technology. Firstly, a ridge waveguide QD laser is demonstrated in this section which have better heat dissipation and lower threshold current compared to the unbonded lasers. In section four, a on Si comb laser is also developed. Due to inhomogeneous broadening and ultrafast carrier dynamics, InAs quantum dots have key advantages that make them well suited for Mode-locked lasers (MLLs). In section five, a passively mode-locked InAs quantum dots laser on Si is achieved at a repetition rate of ~7.3 GHz under appropriate bias conditions. In section six, a butt-joint integration configuration based on QD lasers and silicon photonics ring resonator is tested by using to translation stage. In order to achieve the on chip butt-joint integration, an on chip laser facet was created in section seven. A novel facet etching method is developed by using Br-ion beam assist etching (Br-IBAE). In section eight, a Pd-GaAs butt-joint integration platform was proposed, a hybrid tunable QD laser which consist of a QD SOA gain chip butt joint coupled with a passive Si3N4 photonic integrated circuit is proof of concept by using an external booster SOA coupled with a Si3N4 ring reflector feedback circuit. The final section summarized the work discussed
in this thesis and also discussed some future approaches by using QD lasers integrated with silicon photonics integrated circuits based on the Pd-GaAs wafer bonding butt-joint coupled platform."--Abstract.

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