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PHOTONIC INTEGRATED CIRCUITS

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ABSTRACT :

Photonics is the physical science and application of line generation, detection, and manipulation through emission, transmission, modulation, signal processing, switching, amplification and sensing. Though covering all light's technical applications over the whole spectrum, most photonic applications are in the range of visible and near infrared light. Photonics could potentially be a key technology in the emerging market of fabrication of circuits with its unique performance characteristics. Photonics is expected to play a key role in space applications as optics, integral functional parts of telecommunication, on board signal distribution and remote sensing instrumentation. Photonic Integrated Circuits (PICs) are integrated circuits that use photons instead of electrons to transmit and process information. PICs integrate multiple optical components such as lasers, modulators, waveguides, and detectors onto a single chip, enabling high-speed communication and high-bandwidth signal processing.

I. INTRODUCTION:

Photonic Integrated Circuits (PICs) are integrated circuits that use photons instead of electrons to transmit and process information. PICs integrate multiple optical components such as lasers, modulators, waveguides, and detectors onto a single chip, enabling high-speed communication and high-bandwidth signal processing. PICs promise a range of benefits over traditional electronic circuits, including higher data transfer rates, improved energy efficiency, and increased miniaturization. They find applications in various fields, including telecommunications, data center interconnects, medical imaging, sensing, and quantum computing. The development of PICs has been a major research area for the last few decades, and significant progress has been made in their fabrication, integration, and performance. As the demand for high-speed communication and data processing increases, the use of PICs is expected to grow rapidly, leading to new innovations and advancements in this field. PICs have several advantages over traditional bulk optics systems, including smaller size, lower weight, lower cost, and higher reliability. They also have the potential for higher speeds and greater bandwidth, as well as the ability to integrate with electronic components for more complex and powerful systems. In an electronic chip, electron passes through electrical components such as resistors, inductors, transistors and capacitors where as in photonic chip, photons pass through optical components such as waveguides, lasers, polarizers, and phase shifters.

II. METTHODOLOGY

By Photonic integrated circuits (PICs) offer several advantages over traditional electronic circuits, including faster data transfer rates, lower signal loss, and higher immunity to electromagnetic interference.

The fabrication of PICs involves several key steps:

Substrate selection: The choice of substrate material depends on the desired optical properties and functionalities of the PIC. Common substrate materials include silicon, indium phosphide (InP), and lithium niobate (LiNbO3).

Waveguide formation: Waveguides are tiny channels that confine and guide light propagation within the PIC. They are fabricated using photolithography and etching techniques.

Component integration: Various photonic components such as lasers, modulators, filters, and detectors are integrated onto the chip using thin-film deposition, etching, and other processes.

Packaging: The PIC is packaged to protect it from environmental factors and to facilitate coupling with optical fibers.

III. WORKING PRINCIPLE

The working principle of PICs is based on the manipulation of light using various optical components, such as waveguides, splitters, modulators, detectors, and filters, which are integrated on a single chip. These components are designed to control the propagation of light and its interactions with other components, allowing complex functions to be performed on the chip. Waveguides are the basic building blocks of PICs. They are structures that confine and guide light along a certain path, typically made of materials with a high refractive index contrast, such as silicon and silica. By designing the waveguide dimensions and shape, the propagation of light can be controlled and manipulated. Other components such as splitters and couplers can be used to split the light into multiple paths or combine it from multiple paths, allowing for parallel processing. Modulators can be used to manipulate the amplitude, phase, or polarization of the light to encode information. Detectors can be used to detect the light and convert it back into an electrical signal for further processing.

IV. BLOCK DIAGRAM

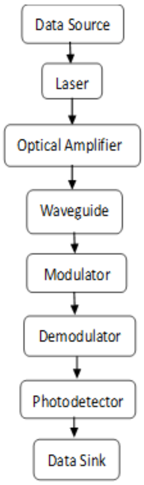

Fig: Operational Block diagram

V. ADVANTAGES

High bandwidth: Photons travel at the speed of light, which means that photonic circuits can transmit data much faster than traditional electronic circuits.
Low power consumption: Since PICs use photons instead of electrons to transmit data, they require much less power than electronic circuits.
Small size: Photonic circuits can be fabricated on a very small scale, allowing for compact and lightweight devices.
High reliability: Photonic circuits are less susceptible to electromagnetic interference and can operate in harsh environments such as high temperatures, radiation, and high vacuum. This makes them ideal for aerospace, defense, and other applications where reliability is essential.
Compact size: Photonic integrated circuits are much smaller than traditional electronic circuits, which makes them ideal for use in compact devices such as smartphones and wearables.
Immunity to electromagnetic interference: Photonic integrated circuits are immune to electromagnetic interference, which can disrupt electronic circuits. This makes them ideal for use in harsh environments where electromagnetic interference is a concern, such as in aerospace and defense .

VI. APPLICATIONS

1. Automotive
2. Lidar
3. Continuum-of-Care
4. Biosensors
5. Data & telecommunications
6. Quantum Computing

CONCLUSION :

Large-scale photonic integrated circuits with performance and capability sufficient for commercial deployment have been demonstrated. These devices represent an order of magnitude or more improvement in number of functions per chip and data capacity per chip compared to previous generation devices, using 50 functions to provide a chip operating at an aggregate data rate of 100 Gb/s. The use of such LS-PICs will enable significant reductions in the cost of optical transport systems, while also enabling new simplified network architectures that make maximum use of the ability to implement low-cost OEO conversions more frequently in the network. Compared to existing DWDM systems, such “Digital Optical Network” architectures offer the promise to enable simplified add/drop, easier optical network engineering, auto mated end-end circuit provisioning, and reduced operational difficulties in such areas as system deployment and turn-up, performance monitoring and trouble-shooting.

FUTURE SCOPE

The development of this technology has not yet reached its high end. Through constant research, people are trying to make this technology a common, low cost, and highly efficient one. But, in future it is sure that almost all electronic IC's will be replaced by PIC. There may also be cases where the integration of both electronics and optics will be possible. Photonic microchips or chips have the ability to perform all the operations with light as the quintessential factor. Photonics has high potential of development, but it needs a thorough scientific research to perform light manipulation for all operations. Because of its limitless potential, the recent data centers are limited by microelectronics for data speed development in numerous connections. It causes excess power consumption. Photonic microchips are capable of very high speed and can efficiently take the place of micro-electronic chips to a certain extent.

Considering the energy constraints and limitations, photonic microchips have high energy efficiency leading to devices work for longer time and notable power saving option. Photonics find its application in healthcare diagnostics, processing industry, mobility, safety and security, and agro-food. This ongoing study and new technical findings are an assurance that Photonics will surely bring important transformations in the new domain. All in all, the potential of integrated photonics market is capable of generating the revenue of more than hundred billion Euros. The dependency of European Union on Photonics as one of the most enabling technologies.

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