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RESEARCH ARTICLE

All optical switching and associated technologies: a review

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Abstract Optical computation is the most desirable technology that enhances the speed, data transmission rate and processing power by replacing the electronics with the optical switches. Optical switching is efficiently performed in high speed signal processing by all optical gates. This paper reviews the progressive development of the optical switching technology, highlights the different technologies of all optical gates and other switching circuits in all optical processing. Basic gates and other logic circuits in optical computing based on nonlinear regimes using semiconductor optical amplifier (SOA), fiber and photonic crystals are discussed, compared and the challenges along with future direction is outlined.

Keywords Optical computing · Optical gates · SOA non linearity · Optical switching

Introduction

The technology advancement has accomplished a new dimension in optical effects and in all optical computing. The classical non- linear optical process involve the coherent motion of electrons; without electrons there would be no interaction between the photons. There are two clear qualitative differences between optics and electronics. One is classical and the other is quantum mechanical. In classical, the wavelength is shorter in optics which has two consequences

1. The waveguide structures using in optical communication and computing are larger than the wavelength so that we can use dielectrics to confine or guide the waves.
2. We can use free space optics to handle many waves at once.

The other difference in optical and electrical interconnection is based on quantum mechanical where the electrical system performs the classical detection by means of electrical voltage and optical system use quantum detection by counting the photons [1].

All optical computing

Improvement of electronics in conventional computing machines is limited by speed, bandwidth and interconnection issues. Scientists were looking for an alternate technology and the researchers opened a new possibility in optical computing by making algorithm for high speed parallel processing. In all optical computing, photon is the information carrier and hence there will be no propagation delay in different parts of the optical system. Optical signals of different frequency can propagate simultaneously which provide a remarkable advantage for parallel processing in optical computing. One feature of optical logic devices is that there is no distinction between the logic energy and communication energy; no line drivers are needed in optics. Switching operation in optical computing is the key role for making flexible and high speed photonic networks. There are many benefits of optical computing which fulfills the expectation of real time demands are shown in Fig. 1.

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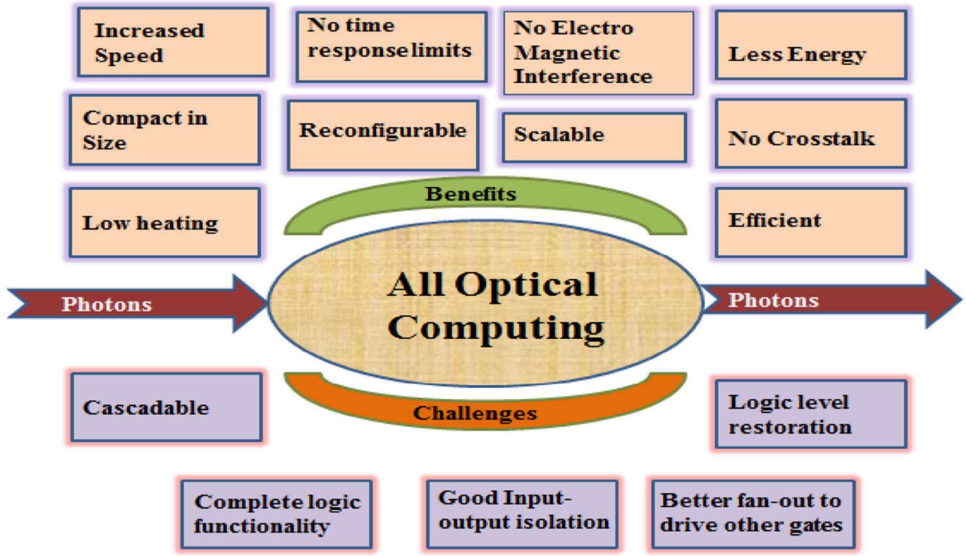

Fig. 1 Benefits and challenges in all optical computing

Linear and non-linear designs for all optical switching

The rapidly growing development of all optical processing systems requires ultra-compact and high speed all optical switches. All optical switching operations can be implemented by linear and nonlinear designs. The linear designs are based on the self-collimation effect, multimode interference effect and light beam interference effect. Non-linear switching effects in optical are classified into two sets of effects, one resulting from the light propagation in a single channel and the other caused due to interactions between numbers of channels in dense wavelength division multiplexing DWDM system. Single-channel nonlinear effects are evidenced mainly through self-phase modulation (SPM), whereby each signal propagates in a channel modulates its own phase. DWDM nonlinear effects are classified into cross phase modulation (XPM) and four wave mixing (FWM). In XPM, the power of the co-propagating channels modifies the phase of the each channel. Three channels interacted together to transfer a fraction of their energy to a fourth one is called FWM [2].

The nonlinear designs are based on fiber gratings, SOAs, semiconductor micro resonators, periodically poled lithium niobate (PPLN) waveguides, and so on. A promising candidate among such nonlinear elements is the SOA having the practical advantages of high nonlinearity, low power consumption, short latency, high stability, and strong compactness. In case of weak optical nonlinearities, it requires intense control (switching) fields, which greatly increase the losses and decreases the switching speed. Additionally, the existing all-optical devices are not uniform across a signal pulse because the switching mechanism itself depends on the signal intensity. This can lead to signal degradation and limit the bandwidth of a device. Multi coding technique enhances the efficiency of optical switching by reducing the switching activities and hence the dynamic power consumption [3].

Recent attractions in all optical computing

The progressive development of all optical computing brings new researches in the fields like silicon photonics, organic photonics, Nano photonics, Plasmonic structures and more. In silicon photonics, silicon is used as an optical medium and the propagation of light is governed by non-linear optical effects such as Kerr effect, two photon absorption and Raman effect. It is majorly used in all optical routing and wavelength conversion. Photonic neural networks leverage the silicon photonic platforms and open new regimes of ultrafast information processing for radio, control, and scientific computing. It uses mathematical isomorphism between the silicon photonic circuit and a continuous neural network model [4].

Organic semiconductors are the recent attraction in all optical switching. Organic polymers are a kind of non-linear material having rapid response time which makes them suitable for high speed switching applications. Organic semiconductors are able to transmit modulate and detect light in a light weight, low cost and flexible architecture. There are some applications such as large active area, colour tunability, mechanical flexibility for which inorganic are ideally not suited. Organics provide promising approach for such applications by combine the plastic with high optical cross sections, ultrafast non-linear response and broad spectral tunability. The drawback of organic semiconductors is high repetition rate which requires efficient energy dissipation technique [5, 6].

Recently, Nano scale all-optical logic gate devices in photonic crystals also play important applications in fields of optical switching and ultrahigh speed information processing. The third order optical nonlinearity introduces the phase difference between the two light signals. The photonic band gap in a photonic microstructure is formed by constructive/destructive interference between two light signals in a photonic crystal. Plasmonics are electric charge oscillations at optical frequencies on a metal surface. Plasmonic micro structure confines the light into sub wavelength scale and scale down the photonic devices to realize direct integration with solid-state chips [7].

This paper reports the review of all-optical and its associated technologies. Introduction of optical computing along with linear and non-linear techniques and recent attractions are presented in Sect. 1. The Sect. 2 discusses the development of basic all optical logic gates using various technologies and comparison of all the gates with its operating speed and ER. Section 3 discusses progressive development in optical computing and highlights the various technologies used in advanced switching circuits. Section 4 discusses the challenges along with the future direction and finally the conclusion based on the review is made in Sect. 5.

Review of basic all optical logic gates

Design of basic logic gates needs a nonlinear element to perform a switching operation. Different switching operations can be performed by the non-linearity present in the SOA and optical fiber which includes FWM, XPM, CPM, XGM or the combination of all these. A promising candidate among such nonlinear elements is the SOA because of its high nonlinearity, low power consumption, short latency, high stability, and strong compactness. The basic element for all optical signal processing is the optical decision gate and that can be used as the signal generator.

Gates based on SOA

The nonlinear gates design based on SOA is classified into two categories. In the first category the nonlinear properties of SOA such as cross-phase modulation, cross-polarization modulation (CPM), cross-gain modulation (XGM), and four-wave mixing is used in the design. The second category the gates consist of SOA-assisted fiber Sagnac interferometer, ultra-fast nonlinear interferometer (UNI), SOA-assisted Mach–Zehnder interferometers (SOA-MZIs), and an SOA-assisted Michelson interferometer (SOA-MI). The limitation of conventional bulk SOA is the operation speed due to the slow temporal response of gain and phase recovery. On the other hand, the gain and phase recovery response is significantly faster in Quantum dot SOA (QD-SOA) compared to Quantum well (QW) SOA, which provide high-speed performance for QD-SOA based logic system with high extinction ratio [8] and is shown in Table 1.

XOR gates

All-optical exclusive-OR (XOR) is considered to be fundamental logic gate as it is receiving a lot of attention due

Table 1 Comparison between various technologies to implement XOR gate

S. no.	Technology	Operating speed	Extinction ratio	References
Interferometry structure				
1.	Sagnac	40–100 Gb/s	15 dB	[23–25]
2.	Mach–Zehnder Interferometer	10–80 Gb/s	11–15.5 dB	[11]
3.	Delay interferometer	80 Gb/s	13.9 dB	[26]
4.	UNI	5–40 Gb/s	6.5–11 dB	[27]
5.	Michelson	10 Gb/s	11 dB	[27]
Fiber non linearity				
6.	TOAD	10 Gb/s	11 dB	[8]
7.	HNLF	10–40 Gb/s	14–25 dB	[18, 28]
8.	Non linear loop mirror	10 Gb/s	13 dB	[29]
9.	Polarization maintaining loop mirror (PML)	80 Gb/s	13.581 dB	[26]
Waveguide and photonic structure				
10.	NRZ PolshK	40 Gb/s	15 dB	[29]
11.	PPLN	20 Gb/s	14 dB	[30]
12.	Silicon nano wire	40 Gb/s	20 dB	[31]
13.	InGaAs ring resonator	20 Gb/s	11 dB	[32, 33]
SOA				
14.	QDSOA	250 Gb/s–1 Tb/s	> 26 dB	[34]

to its great potential as an optical switch in comparator and decision circuit. It can also perform a set of critical functionalities, such as label or packet switching, decision making, regenerating, basic or complex computing, pseudorandom number generating, parity checking, and so on [9]. So far, many kinds of all optical XOR gates have been demonstrated, with operation speeds ranging from 10 to 1 Tb/s and output contrast ratios from 6.5 dB to approximately 26 dB. The design of XOR using non linearity in SOA include a 10 Gb/s XOR using CPM in SOA [9, 10], a 10–40 Gb/s XOR using FWM [11–19], and a 10/40 Gb/s XOR using XGM [20]. Comparison between various technologies used to implement XOR gate is given in Table 1.

Fiber-based XOR gates have been proven to be faster and pattern-insensitive but bulky in size, while compact SOA based ones suffer from the speed limitation induced by slow SOA gain recovery time. The speed can be improved by fast phase change of a probe signal using two-photon absorption (TPA) of a pump beam and it delivers high speed switching at the rate of 250 Gb/s [21]. Counter-propagating continuous-wave (CW) light also reduces the SOA response times and increasing the maximum bit rate of the signals [22].

Other basic gates

The gates mainly need a simple configuration, high extinction ration, photonic integration, higher bit rate without patterning effect, short response time and re-configurability. An OR gate logic can be performed in single SOA using XGM effect. It has a simple configuration but low extinction ratio and relatively large chirp. It can be overcome by XPM effect which has advantages of high extinction ratio at the cost of complex interferometer configurations. A novel all-optical logic OR gate based on Nonlinear polarization Rotation NPR in SOA with red-shifted filtering also provide simple configuration and allows photonic integration with ultrafast signals [35]. XNOR function can be optically implemented by exploiting FWM and XGM in an SOA. Implementation based on a parallel SOA uses tricky interferometry configurations. Single SOA avoids this issue by adjusting the probe signal to ON and OFF, so that it achieves different gates and re-configurability.

Logic gates based on FWM in SOAs using the Polarization Shift Keying (PolSK) modulation format is free of pattern effect, achieves simple logic gates and also complex logic functions including half adder, half subtractor, decoder and comparator [15]. A wavelength tunable all optical decision schemes using SOA-DBR laser provides steep optical decision curves with improved ER [36]. The ultra-fast optical logic gate using single QD-SOA with FWM, XGM and ring resonators realize many logic functions and demonstrate the potential of ultra-fast operation at 160 Gb/s [32]. The introduction of QD-SOAs continues to develop ultra-high speed optical switching to the rate of 1 Tb/s due to very fast gain and phase recovery response than QW-SOAs [7, 34].

Gates based on SOA associated interferometry structure

Practically, the gates using interferometer structures are having brighter future due to their potential for integration but are limited by instability and suffer from additional noise and speed limitations. Some of the techniques require more than one SOA to achieve the XOR function. The all-optical logic can be performed by two-cascaded SOA configuration with a high extinction ratio (ER) for a wider range of input and output wavelengths. Optical integrated techniques reduce the interconnection distance between the two-cascaded SOAs [37]. This parallel SOA-MZI structure enables simultaneous operation of various logical functions. Maximum ER can be obtained by adjusting the optical gain and phase differences in SOA-MZI structures.

Conventional techniques using SOA-MZI are limited by the gain and phase response time of SOA, which limits the operating speed. The operation speed using terahertz optical asymmetric de-multiplexer (TOAD) is limited by the carrier recovery time of the SOA. XOR scheme based on UNI, or based on CPM in an SOA needs accurate control of polarization. All these limitations need an alternative platform to allow the integration of these devices into real systems. The major drawbacks we found here are integration capability, high bit rate without patterning effect. Typical gates by using SOA assisted interferometer structures include gates at 10/20 Gb/s with 11 dB of ER ratio using an SOA-Michelson Interferometer [27], 40/100 Gb/s gates and 22 dB of ER using an SOA-assisted fiber Sagnac interferometer [23–25], 80 Gb/s gates with 13.9 dB of ER using SOA-MZI-Delay Interferometer [26] and a 10/40/160 Gb/s gates and 30 dB of ER using SOA-MZIs. Gates implementation based on Sagnac interferometry structure has the advantages of structural simplicity, operation stability, polarization independency, high-speed operation, and integrated potential.

Gates based on fiber non linearity

The change in the refractive index of the material with respect to the applied electric field is called Kerr effect. The Kerr effect is proportional to the fiber nonlinearity and by using highly nonlinear fiber (HNLF) with higher nonlinearity, both the output power and ER can be improved considerably and the required input optical power can be decreased [28]. A simple reconfigurable all-optical logic gate based on XPM in highly non-linear fibers provide basic logic functions such as XOR, OR, NAND, NOR and NOT at higher bit rate. The simple implementation and high-bit-rate operation make the device suitable for ultra-fast applications in the emerging all-optical networks [38].

Non-linear optical loop mirror is a technology provides basic logic gates with improved ER but it requires very high input powers and is greatly dependent on signal polarization and fiber parameters. An all-optical gate using polarization rotation induced by the Kerr effect in a single 2-km (HNLF) is improved to higher bit rate by using return-to-zero differential phase-shift keying (RZ-DPSK) signals. Microring resonator-based logic gates are another technology can able to operate on same input and output wavelength. It allows the cascaded operation and utilized for developing photonic integrated circuits [39].

Gates based on waveguide and photonic structure

All optical logic switches can be realized based on photonic crystals structure and is expected that such designs have the potential to be key components for future photonic integrated circuits due to their simplicity and small size [35]. SOA and PPLN have the integration potential and offer several distinct advantages of ultrafast response, negligible spontaneous emission noise, low intrinsic frequency chirp, and complete transparency to bit rate and data format; however, they are intrinsically comprised: SOAs have free-carriers, leading to patterning effects for data rates of greater than 100 Gb/s; and PPLN has bandwidth limitations and requires precise temperature control [40]. Issues due to SOA are overcome by Nano photonic devices in highly nonlinear materials such as chalcogenide glasses (ChG) which reduces operating power requirements since they can achieve extremely high nonlinear parameters. The experiment establishes ChG waveguides for all-optical logic operations at data rates of up to Tb/s with no patterning effect in [41]. MMI-based waveguide structure supports large bandwidth and data transfer rate and it is a promising method for preventing power loss occurring in idle output ports, and also for compact integration with low power consumption [42].

All-optical logic gates by using multi-branch waveguide structures with localized optical nonlinearity uses the beam propagation method to simulate the all-optical logic switches and find the optimized parameters to perform the logic functions effectively [43]. The three dimensional beam propagation methods use the finite element method for discretizing the fiber cross section and a nonlinear film based on the Crank–Nicholson finite element method to provide the functionality of basic logic gates [44].

An optical multi-level modulation functions can be realized using electro-absorption modulator (EAM) and intensity dependent frequency shifting self-phase modulation (SPM), by adjusting the center frequency of an optical band-pass filter in the logic gate. It provides an error free, polarization independent operation and longtime stability [45]. Designs based on multimode interference (MMI) provide many benefits such as simple configuration, compactness and suitability for monolithic integration [46]. All -optical logic gate based on ultrahigh—Q microcavities allows the operation at ultra-low input power [47]. The gates can also implemented by Injection based Laser method [48], Saturable absorber etalons [49], NRZ Polarization shift keying and many techniques using photonic structures. The comparison based on few implementations with operating speed and ER is given in Table 2.

Advanced optical circuits: a review

Simple optical switches that are performing the operation of basic logic gates are commonly used in telecommunication networks. All optical switching is very much attractive in high capacity networks where it avoids the opto-electronic conversion. The switching unit is the basic building block for all optical signal processing. The concepts and technologies evolved in all optical switching brings advanced semi-conductor based all optical switching devices and circuits.

Arithmetic and logic processor

The fast non- linear characteristics of SOA are more attractive in the applications of all optical signals processing such as basic logic gates, counter, comparator, adder, subtractor etc. Basic logic gates and SOA are found to be the basic building block to build arithmetic and logic processors. An all-optical arithmetic and logic unit is the integral part of optical switching and data processing. It needs multi-valued logic for the fast processing in optical computing. The major disadvantage in binary based system is the limitation of large information handling capacity. The tri-state mechanism is using frequency encoding principle. It uses co-propagating beams having different frequencies to generate cascaded sum and difference frequency. It performs logical and arithmetic operation by using the frequency encoded input data by properly selecting the frequency of the control signals [62, 63]. Quaternary gate is another type of multi valued logic utilizing polarization encoded quaternary (4-valued) principle with the help of TOAD. For the quaternary information processing in optics, the quaternary number (0, 1, 2, 3) can be represented by four discrete polarized states of light and

Table 2 Comparison between different logic gates

S. no.	Technology	Gate	Operating speed	ER	References
SOA					
1.	SOA-XGM	NOR, XOR	10 Gb/s	11–12 dB	[8, 37]
2.	SOA-FWM	XOR, XNOR, NOR, NOT	10–20 Gb/s	9 dB	[15]
3.	SOA-CPM	AND	2.5 Gb/s	16 dB	[9]
4.	NPR in SOA and red shifted sideband filtering	OR	20 Gb/s	10.1 dB	[50]
5.	SOA associated with blue and red shifted filtering	NOR, OR and AND	100 Gb/s	> 10 dB	[51]
Interferometry structure					
6.	Toad	XOR	10 Gb/s	11 dB	[8]
7.	Sagnac interferometer	XOR	40–100 Gb/s	14.6–15 dB	[23–25]
8.	UNI	Basic gates	10–40 Gb/s	5–40 dB	[27]
9.	SOA-MZI	XOR, NOR, OR, NAND	20, 40 and 80 Gb/s	15.5 dB	[11, 12, 26]
10.	Two parallel SOA-MZI	XOR, NOR, OR, NAND	10, 20, 40 Gb/s	15 dB	[52]
11.	SOA integrated with DBR laser	NAND, NOR	1.25 and 10 Gb/s	28–6 dB and improved to 24–20 dB	[36]
12.	Differential interferometer	AND, NOR	20 Gb/s	10 dB	[53]
13.	Non linear MZI QD-SOA	Wave length conversion, XOR, 3R regeneration	1 Tb/s	50 dB	[54]
Fiber non linearity					
14.	Kerr effect in HNLF	XOR	10 Gb/s	25 dB	[28]
15.	Fiber non linearity in optical loop mirror	XOR, OR, NAND, NOR, NOT	40–160 Gb/s	9.85–14.68 dB	[38]
16.	XPM in HNLF	XOR, AND, OR	10 Gb/s	14.0 dB (XOR), 22.2 dB (AND), and 16.5 dB (OR)	[55]
Waveguide and photonic structure					
17.	Non return to zero polarization shift keying	AND, NOR, XNOR, XOR, half adder, half subtracter, decoder and comparator	40 Gb/s	15 dB	[16]
18.	Electro absorbtion modulator using phase modulation	AND	10 Gb/s	> 10 dB	[56]
19.	Micro ring resonators	XOR, NOR, OR, NAND, XNOR	30, 160 Gb/s	19.5, 20 dB	[57, 58]
20.	FWM In InGaAsp/Inp ring resonator	AND	40 Gb/s	10 dB	[58]
21.	Fiber optical parametrical amplifier	XOR, OR, NOT and AND	10 Gb/s	XOR- 1.6 dB, OR- 2.6 dB, NOT- 1.2 dB, and AND- 1.1 dB	[17]
22.	Photonic chip	XOR	160 Gb/s		[41]
23.	Single mode Fabry Perrot laser diode	NAND, AND	10 Gb/s	14.6 dBm (NAND), 12.5 dBm (AND)	[59]
24.	FWM in silicon nanowire	XOR	40 Gb/s		[31]
25.	MMI based waveguide with beam propagation method	XNOR, NAND, OR, XNOR, NOT	40 Gb/s	XNOR- 26 dB, NAND- 24.7 dB, OR- 25.9 dB, XNOR- 26 dB, NOT- 25 dB	[42]
26.	Nanoscale plasmonic slot waveguides	XNOR	> 10 Gb/s	24 dB	[6]
27.	Photonic crystal structure	OR	0.8 Tb/s	7.27 dB	[60]

Table 2 continued

S. no.	Technology	Gate	Operating speed	ER	References
28.	Superposition of polarization modulation	25 optical logic gate functions	10 Gb/s	6.01 dB	[61]

is very much applicable in performing logical operation and memory device to store the information [64].

Large scale general purpose photonic signal processors highly need a feature of re-configurability. The photonic integrated signal processors usually have the drawback of limited re-configurability. It can be overcome by controlling the injection currents applied to the active components of the signal processor [65]. A reconfigurable optical logic gate with up to 25 logic functions based on superposition of polarization modulation are successfully experimented with the better extinction ratio. In this the input states are generated by varying amplitude and phase on horizontal and vertical polarizations respectively. Different logic output is detected by direct detection based on polarization modulation [61]. The extension of the research on Ternary optical computer (TOC) make the reconfiguration of the processors more convenient and efficient 81 commands for the reconfiguration are effectively implemented for tri-valued logic [66].

Signal processing

All-optical signal processing can be realized based on various technologies, produces advanced signaling circuits such as all optical sampling, bit error monitoring system, symbolic substitution etc. All optical sampling needs low switching energy with high linearity. The linearity factor directly results in signal distortion. Distortion reduced with the improvement in linearity. The low complexity makes the sampling gate as small size and easy to be integrated [67]. A low-complexity TOAD based all optical sampling gate is experimentally proved by placing a polarization-insensitive multiple-quantum-well semiconductor optical amplifier (PI-MQW-SOA) within a fiber loop mirror. All-optical bit-error monitoring system (BEMS) needs two threshold levels to determine the error bits. The resulting optical indicator signal, known as the “pseudo-error” signal, identifies both the positions and the durations of the error bits and can be used in performance monitoring such as eye monitoring [48]. Symbolic substitution in optical computing is a rule which can be used to replace the input patterns by new patterns associated with the results of the operation. It stores the value and transports it through modulated beams of light and coding is done by optical intensity.

In recent days several new technologies enters into the optical signal processing and attracts the major attention in information encoding. Quantum computing gives the solution for complexity in other technologies by exploring the model includes intermediate, adiabatic and analog quantum computing [68]. Plasmonic devices and circuits are the intermediate form between electronics and optics that integrates the properties of both. Using plasmonics, it is able to manipulate the information with high bandwidth of optics [69]. The neuromorphic optical computing emulates the aspects of neural networks in optical processes and avoids the need for explicit training in hidden nodes of large system with arbitrary interconnection. It processes a set of inter connected optical switches to solve computationally hard problems [70]. Metamorphic computing is the example for optical computing which uses coupled oscillatory dynamical systems and leverage the use of neuromorphic computing process [71]. Photonic processing in analog computer for neuromorphic computing is also processed on network node as fundamental unit of switching and computation in such systems [72]. Nano structure design provides information security using the artifacts of fabrication. This technique can be used to store and retrieve data without processing the data in the information domain which enables more efficient security for optical processing [73]. All-optical digital processing circuits using multiple gates, capable of performing more complex logic operations such as flip-flop, counter, half adder, full-adder, counter, or parity checker and other advanced circuits have been reported are listed in Table 3.

Challenges and future direction

In spite of the continuous developments, there are some challenges in optical switching that still we are so long way off from optical computing and communication. Mainly, in communication the parts required to build optical switches are very much expensive and miniaturization of components to build tiny optical computer is not possible beyond a certain limit. Exact manufacturing of these miniaturized components with the given specification is also not yet been achieved. Slight deviation in the light beam can cause major diversion and massive problem in optical stream and also in optical networks. It makes the production process

Table 3 List of advanced optical circuits with associated technologies

S. no.	Circuit	Technology	References
1.	Flipflop	2 × 2 spatial and wavelength preserving switch	[74]
2.	Passive optical limiter and switches, inverters, distributors	Kerr nonlinearities	[75]
3.	Random number generator	Quantum effects in photonic emission	[76]
4.	All-optical signal regenerator	Saturable absorbers, differential phase shift keying encoding with SOA-MZIs	[49, 77]
5.	Inverted wavelength converter	Injection locked laser	[48]
6.	Photonic router	Optical logic gates in network nodes (IST-LASAGNE)	[78]
7.	Pulse frequency division multiplexing	TOAD	[79]
8.	Optical correlator, optical divider, forward error detection, cache memory architectures	SOA-MZI	[80]
9.	Linear superposition, quantum parallelism, quantum entanglement	Quantum mechanics	[81]
10.	Arithmetic and logic unit	Frequency encoding using SOA	[82]
11.	All optical sampling	FWM, parametric amplification, TOAD	[67]
12.	Nano structure optical waveguide	Non linear optical interactions in a waveguide interferometer	[73]

quite expensive as demanding highly accurate components in medical and control applications. Optical switching techniques are having importance in the medical field, because these are the promising techniques to be safe and cheap and also offer a therapeutic potential. Advances in optical technology have made it possible to apply all optical in a wide variety of applications but medical applications are still dominating. In communicating the information all over the world all optically, it needs the optical computer should able to communicate with other optical computer. It requires major cost as they will not be compatible with ordinary mainframes. This is again the major drawback in bringing the all optical computers in high speed network and communication and hence to the real world immediately [83].

The major requirement needed by all optical switching and circuits in optical computing are wide bandwidth, compactness, no cross talk, cascadable, high bit rate without patterning effect and less complexity. The other limitation of all optical gates using various technologies is found that the extinction ratios are still superior in digital gates compared to all optical designs. Optical feedback interferometry (OFI) is currently evolved as an all optical sensor for bio-medical applications and is used to analyze periodic vibration patterns to extract vibrational parameters, such as displacement, frequency etc. All these signals are time dependent and it requires the speed of switching, sampling and information processing at very high rate [84]. Many areas of society, including information and communications, imaging and sensing, health care, energy, manufacturing, and national security demand the above needs and may provide the functional solution as hybrid electronic-photonic systems [85]. The emergence of advanced technologies is based on convergence of some alternatives. There is a need for change in approaching the optical computing in quantum and neural architectures, and changes in mechanisms such as plasmonics, entanglement and wave mixing. The changes in these approaches define a new way for an exciting field where we can expect rich potential in different optical circuits operating at ultra-high speed and high-density integration with improved ER.

Conclusions

All optical switches are efficient in high speed signal processing by performing digital switching using photons. The photons otherwise known as the light particles do not interact. If two photons interact in a vacuum, they simply pass through each other. This property of photon makes an efficient way for the new prospects in classical switching and quantum computing. This paper reviews the optical switches using basic gates to the advanced technologies in computing. The different gates are designed using different non linearity and different modulation techniques. It shows excellent performance for all optical switching and signals processing without deteriorating the quality and power of the signal. The limitation of optical switching is found that the extinction ratios are still superior in digital gates compared to all optical designs. The Tables 1 and 2 represents the various switching technologies based on gates in terms of operating speed and ER and Table 3 lists the other optical switching circuits in all-optical signal processing. All optical computing is an exciting field where we can expect much innovation in different optical circuits operating at ultra-high speed switching with much improved ER.

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