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Implementation of Mach-Zehander and Sagnac Optical Resonator Using Silicon on Insulator Technology

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***Abstract*—Silicon on insulator is latest fabrication technology. It is easier and cheaper. Due to its characteristics, it is fast becoming a standard in IC fabrication. After giving overview of Mach-zehander resonator and Sagnac resonator design, the focus of this paper is on to develop such optical resonator, gives maximum optical power. Here design both resonators using SOI technology.**

***IndexTerms*—Silicon on insulator, Resonator, Mach-zehander Resonator, Sagnac Resonator.**

I. INTRODUCTION

Now a days, limits in operating speed of electrical IC's. The optimal solution is optical interconnects.A resonator is a device or system that exhibits resonance or resonant behavior, that is, it naturally oscillates at some frequencies, called its resonant frequencies, with greater amplitude than at others and also possible to design in few micrometer size of wafer.The oscillations in a resonator can be either electromagnetic or mechanical (including acoustic). Resonators are used to handle power in optical circuits. Here with this idea given paper is for response of resonators with different parameters.

II. SOI BASIC

The implementation of a full dielectric isolation [silicon on-insulator (SOI)] in smart power technologies is becominga more and more interesting approach to manage very high voltage blocks, to reduce parasitic bipolar effects, and to increase circuit speed [6,7].A primary factor driving the high level of research interest in the silicon photonics platform originates from this system's intrinsic compatibility with CMOS electronics [4].Low power, low-cost, and high-speed photonic links are required in data centers. After significant research and development work over the last few years, silicon photonics has become a promising candidate to provide this technology [5].

Increased demand for High Performance, Low Power and Low Area among microelectronic devices is continuously pushing the fabrication process. Silicon on Insulator fabrication process helps in achieving greater performance and offers less power consumption compared to the Bulk Process[1].

Silicon photonics plays an essential role in optical interconnects because of its compatibility with electronics and its potential for important applications, such as data transport and signal processing [8, 9].A key building block inSilicon photonics is the optical waveguide, which usually consists of a silicon (n =3.5) core and a silicon dioxide (n =1.5) cladding. This waveguide configuration offers several advantages [10].

III. MACH-ZEHANDER AND SAGNAC RESONATOR

Resonators are used to either generate waves of specific frequencies or to select specific frequencies from a signal.The Resonator is a Passive Device whose impedance changes rapidly with frequency over a very narrow frequency range. Resonator is usually the core of the feedback network for oscillator. Resonator is device which contains energy of alternating electromagnetic field; the best keeping is at resonant frequency and depends from losses in resonator. But Resonator is a natural oscillator. A Resonator can be used to filter signals in a specific frequency range. It is not compulsory a Resonator to be Passive. It may be Active as well.

Mach-zehander Resonator(MZI):

Two types of resonators that can be created with MNFs(Micro/ Nano Fibers). The first one is a Mach-Zehander resonator. It consists of an MNF connected to the input and output and a curved MNF segment, which forms two couplers with the first MNF. The input electromagnetic wave splits at the first coupler into two waves propagating along the first and the second MNFs. Fig. 2 shows Mach-zehander Resonator. After passing the second coupler, these waves interfere[2].

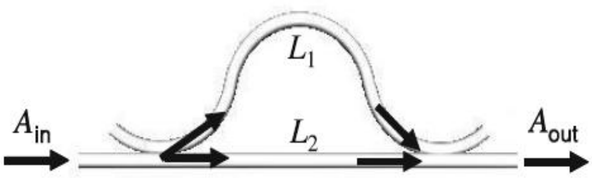

Fig. 1Mach-zehander Resonator [2]

The output wave can be written in the form:

$$A_{out} = A_1 \exp[i\beta_1(\lambda)L_1] + A_2 \exp[i\beta_2(\lambda)L_2] \quad (1)$$

Here β_1 (λ) and β_2 (λ) are the propagation constants of the MNFs and L_1 and L_2 are their lengths. The amplitudes A_1 and A_2 in above Eq. 1 are slow functions of the radiation wavelength compared to the exponents. The interference between terms in above Eq. causes oscillations of the output power $|A_{out}|^2$ as a function of λ. When two micro-couplers are connected in cascade; an MZI is formed [2].

The Mach-Zehander Resonator is one of the most widely used structures in optical components and devices ranging from telecom to medical diagnostics to spectroscopy. It is used as Optical sensors and modulators.

Mach-Zehander modulators are incorporated in monolithic integrated circuits and offer well-behaved, high-bandwidth electro-optic amplitude and phase responses over a multiple GHz frequency range.

Sagnac Resonator:

Another type of resonator, which can be made of MNF, is a Sagnac resonator. This Resonator can be created from a single MNF, which couples itself as illustrated in this Fig. 2[2].

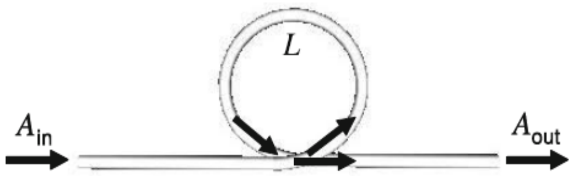

Fig.2 SagnacResonator[2]

The output wave of this Resonator is,

$$A_{out} = A_1 + A_2 \exp[i\beta(\lambda)L] \quad (2)$$

Here Lis the MNF loop length and β (λ) is the propagation constant of the MNF. Similar to Eq. (1), the amplitudes A_1 and A_2 in above Eq. (2) are slow functions of the radiation wavelength λcompared to the exponent and the output power $|A_{out}|^2$ is an oscillating function of the radiation wavelength λ [2].

IV. Simulation Results and Disscution

Mach-zehander Resonator(MZI):

MZI resonators are flexible building blocks in photonic integrated circuits for realizing various optical functionalities such as filters, sensors, modulators, and switches [3].

TABLE 1: SPECIALISATION USED FORMODELINGTHE MACH-ZEHANDER RESONATOR

Parameters	**Value**
Power of the input light	1mw (0 dbm)
Polarization and wavelength of the incident light	TM MODE, 1.5μm
Width and height of the core	0.45 μm,0.21 μm
Refractive index of the core	3.45
Refractive index of the cladding	1.48
Radius of curvature for s-shaped waveguide	2.161873 μm
Length and Width of Wafer	10 μm, 8 μm

The starting coordinates of the s bend waveguide 1 are (4.98, 2.2875) while the end coordinates are (1.62, 0.685). The s-bend waveguide 1 have fixed radius 2.161873 μm. Similarly the starting coordinates of the s bend waveguide 2 are (8.19,2.275) while the ending coordinates are (4.976,0.66). The s-bend waveguide 2 have fixed radius 2.00875 μm.

Linear waveguide has starting and end coordinates as (10, 0.225) and (0, 0.225) respectively. The starting coordinates of the Arc waveguide 1 are (1.605, 1.395) while the end coordinates are (0.405, 0.69) .Similarly the starting coordinates of the Arc waveguide 2 are (9.61, 1.49) while the ending coordinates are (8.2, 0.67). The Arc waveguide have positive radius (μm).

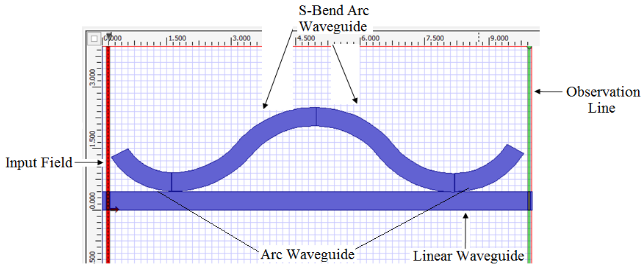

Fig. 3Layout of Mach-zehander Resonator

On simulation we observe the refractive index and Hy component of the light of the Mach-zehander in the analyzer window and with the help of observation lines marked on linear waveguide we observe the output power for different wavelength.

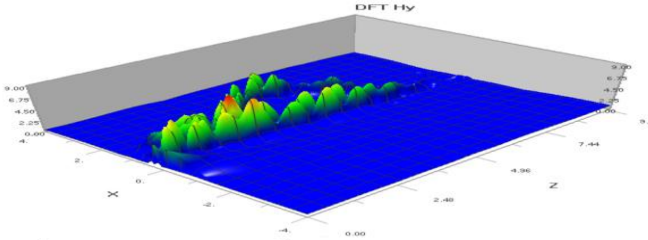

Fig. 4Top view of H_y component of light in Mach-zehander Resonator

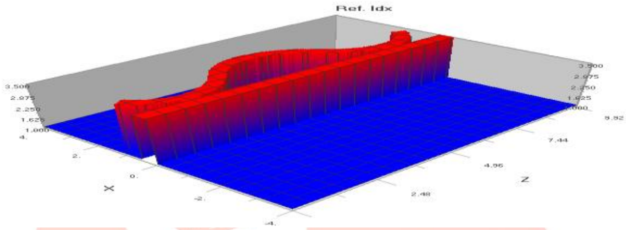

Fig.5Refractive index distribution of Mach-zehander Resonator

TABLE 2: OUTPUT POWER FORDIFFERENT WAVELENGTH

Wavelength(μm)	Output(dbm)
1.5	-310.1
1.51	-313.6
1.52	-317.6
1.53	-321.9
1.54	-327.2
1.55	-333.2
1.56	-340.1
1.57	-347.4
1.58	-355.1
1.59	-361.6
1.6	-365.8

Sagnac Resonator:

There are two main advantages in using a Sagnac resonator over a Mach-Zehander resonator are the stability of the resonator against vibration and the control of the absolute difference in the length of the arms of the resonator.

TABLE 3: SPECIALISATION USED FOR MODELING THE SAGNAC RESONATOR

Parameters	Value
Power of the input light	1mw (0 dbm)
Polarization and wavelength of the incident light	TM MODE, 1.5μm
Width and height of the core	0.45 μm,0.21 μm
Radius of Ring waveguide	2 μm
Length and Width of Wafer	6 μm, 4 μm

Linear waveguide has starting and end coordinates as (10, 0.225) and (0, 0.225) respectively. Similarly the starting coordinates of the circular waveguide are (6, 0.225) while the end coordinates are (0, 0.225).

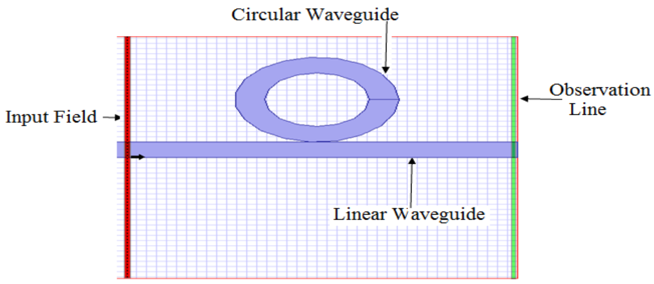

Fig. 6Layoutof Sagnac Resonator

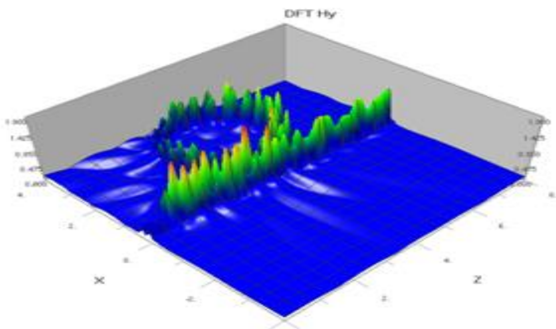

Fig. 7 Top view of H_y component of light in Sagnac Resonator

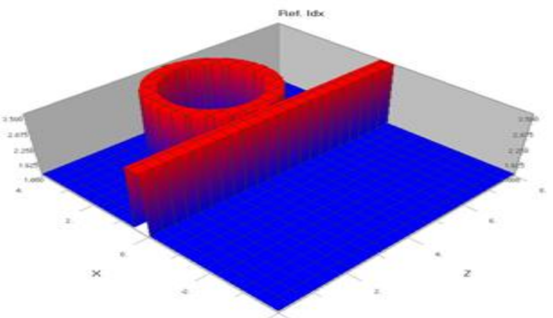

Fig. 8 Refractive index distribution of Sagnac Resonator

TABLE 4: OUTPUT POWER FOR DIFFERENT WAVELENGTH

Wavelength(μm)	**R=1**	**R=2**	**R=3**	**R=4**	**R=5**
1.5	-23.6	-20.8	-22.6	-35.5	-277.2
1.51	-24.6	-21.8	-24.4	-35.8	-276.4
1.52	-25.5	-23.0	-26.4	-36.4	-276.0
1.53	-26.7	-24.1	-28.4	-37.1	-275.47
1.54	-27.6	-25.3	-30.6	-37.9	-275.2
1.55	-28.6	-26.7	-32.9	-38.9	-275.1
1.56	-29.5	-28.1	-35.3	-40.1	-275.5
1.57	-30.4	-29.5	-37.6	-41.4	-275.8
1.58	-31.3	-31.0	-39.9	-42.1	-276.3
1.59	-32.1	-32.4	-42.0	-44.1	-276.9
1.6	-33.0	-33.9	-43.9	-45.6	-277.6

V. Conclusion

I analyzed response of Mach-zehander resonator at various wavelengths, size of wafers, radius of s-bend and radius of arc waveguide.Also I got suitable results forSagnac resonator and analyze at various wavelengths, size of wafers and radius of circular waveguide.In future these designs of Mach-zehander and Sagnac Resonators are using in optical based Flip-Flops.

References

[1] N. M.Kodeti, Infotech Enterprises Ltd. White Paper on “Silicon on Insulator(SOI) Implementation”, *June 2009.*

[2] L. Tong, M. Sumetsky, “Subwavelength and Nanometer diameter optical fiber” (Bookos.org)

[3] S. Darmawan, Y. M. Landobasa, P. Dumon, R. Baets, and M. K. Chin, “Resonance enhancement in silicon-on-insulator-based two ring Mach-zehander interferometer”, *IEEE photonics technology letters, vol. 20, no. 18, September 15, 2008.*

[4] H. Kogelnik and R. V. Schmidt, "Switched directional couplers with alternating Δβ," *IEEE J. Quantum Electron*., vol. QE-12, no. 7, pp. 396–401, Jul. 1976.

[5] D. Feng, W. Qian, H. Liang, B. J. Luff and M.Asghari, "High speed Receiver technology on SOI Platform", *IEEE journal of selected topics in quantum electronics, vol. 19, no. 2, march/april 2013.*

[6] R. vab Dalen, S. Dhar, A. Heringa, M. J. Swanenberg, A. B. van der Wal,P. W. M. Boss, and V. Braspenning-Girault, "Hot carrier degradation of HV-SOI devices under OFF and ON-state current conditions," in *Proc. IEEE ISPSD ICs*, 2011, pp. 348–351.

[7] J.-M. Roux, X. Federspiel, D. Roy, and P. Abramowitz, "HCI lifetime correction based on self-heating characterization for SOI technology," *IEEETrans. Device Mater. Rel.*, vol. 7, no. 2, pp. 217–224, Jun. 2007.

[8] B. Jalali and S. Fathpour, ''Silicon Photonics,'' *IEEE J. Lightwave Technology, Dec. 2006, pp. 4600-4615.*

[9] M. Paniccia, ''Integrating Silicon Photonics,'' *Nature Photonics, vol. 4, 2010, pp. 498-499.*

[10] C. M. Chang, O. Solgaard, "monolithic silicon waveguide in standard silicon", *Stanford university, IEEE computer society, January/February 2013.*

[11] W. Bogaerts,R.Baets, P.Dumon, V.Wiaux, S. Beckx, D.Taillaert, B.Luyssaert, J. V.Campenhout, P.Bienstman, D. V.Thourhout,"NanophotonicWaveguides in Silicon-on-Insulator fabricated With CMOS Technology"*IEEE journal of lightwave technology, vol 23, no. 1, January 2005.*

[12] F. Jiang, A. Keating, M. Martyniuk, R. Pratap, L. Faraone, J. M. Dell, "Process Control of cantilever deflection for sensor application based on optical waveguide" *IEEE journal of microelectromechanical systems, vol. 22, no. 3, june 2013 569.*

[13] L. Zimmermann, T. Tekin, H. Schroeder, P. Dumon and W. Bogaerts, "How to bring nanophotonics to application-silicon photonics packaging", *IEEE publication, December 2008.*

[14] Z. Zalevsky and I. Abdulhalim, "Integrated nanophotonic devices" (Books.org).