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Procedia Engineering 8 (2011) 432–435

Engineering Procedia

2nd International Science, Social Science, Engineering and Energy Conference 2010: Engineering Science and Management

ASK-to-PSK Generation based on Nonlinear Microring Resonators Coupled to One MZI Arm

C. Tanaram[a,*], C. Teeka[b,c], R. Jomtarak[c], P. P. Yupapin[c], M. A. Jalil[d], I. S. Amiri[d], and J. Ali[d]

[a] *Faculty of Science and Technology, Kasem Bundit University, Bangkok 10250, Thailand*
[b] *Scientific Equipment center, Faculty of Science and Technology, Suan Dusit Rajabhat University, Bangkok 10700, Thailand*
[c] *Advanced Research Center for Photonics, Faculty of Science King Mongkut's Institute of Technology Ladkrabang Bangkok 10520, Thailand*
[d] *Institute of Advanced Photonics Science, ESciNano Research Alliance, Universiti Teknologi Malaysia (UTM), 81300 Johor Bahru,*

Elsevier use only: Received 15 November 2010; revised 15 December 2010; accepted 20 December 2010

Abstract

We present a new concept of ASK-to-PSK generation based on nonlinear microring resonators coupled to one MZI arm by using OptiWave FDTD method. By microring resonator increase from one to three microring (SR to TR), we found that the amplitude shift keying (ASK) are increase exactly and the phase shift keying (PSK) is equal to π.

Keywords: ASK, PSK, Nonlinear microring resonators

1. Introduction

Recent innovations and breakthroughs in silicon photonics are paving the way for the realization of high speed on-chip optical interconnects [1]-[2]. Transfer of information between components requires that data be superimposed on the optical carrier signal by electro-optic modulation. Numerous high performance silicon electro-optic modulators have been demonstrated which generate non-return-to-zero (NRZ) encoding at bit-rates as high as 40 Gbps [3]-[4]. However, there are numerous other optical modulation formats which could yield improved performance of the optical links such as better Signal/Noise ratio, reduced nonlinearity or even higher bit-rates [5]. Some recent examples of alternate encodings on a silicon photonic platform are the use of ring resonators to convert non-return-to-zero (NRZ) to pseudo-return-to-zero (PRZ) in order to aid clock recovery and the generation of return-to-zero-differential-phase-shift-keying (RZ-DPSK) signals with improved chirp [6]-[7]. Here, we propose a scheme for generating amplitude-shift-keying (ASK) format in order to significantly increase the bit-rate of on-chip optical links by using FDTD method [8].

* Corresponding author Tel.: +6-689-445-2224; fax: +6-627-227-262.
E-mail address: *tchanapk@gmail.com.*

1877–7058
doi:10.1016/j.proeng.2011.03.079

2. Principle of Operation

In Fig. 1, all-optical microring resonators and MZI width 0.3µm, depth 0.5µm, the radii of microring 0.775µm, n0=3.34 (GaInAsP/InP waveguide). Numerical results are generated at input power of 3mW Gaussian modulated CW at wavelength center λ0=1.55µm with time offset 4 × 10-14s, half width 1.5 × 10-14s. As for the numerical simulation of all-optical ASK-to-PSK, all our numerical work has been carried out by using commercially available simulation software-the OptiFDTD simulation package [8].

3. Results and Discussion

Here, we generate three amplitude level signals using a triple of symmetric microring resonators arranged in series in a Mach-Zehnder configuration as seen in Fig. 1. The device works by splitting the input light into two separate paths with a 3-dB coupler. When the light is on resonance with the rings, it is coupled to the out_1 ports where it constructively interferes at the output port. If one ring resonator is shifted off-resonance, the output of the system is halved because only half of the light transfers to the out_2 port as illustrated in Fig. 1.

Fig. 2 shows the compared output result of amplitude generate using single nonlinear microring resonator (SR), double nonlinear microring resonator (DR), and triple nonlinear microring resonator (TR) coupled to one arm of MZI. We found that the enhanced amplitude is increased when three nonlinear microring resonators are placed into the system. In Fig. 3, we found that the ASK generation using SR single peak is seen as shown in Fig. 3(a), where the upper output (out_1) and lower output (out_2) amplitude shift keying (ASK) occurred, and phase shift keying (PSK) enhancement is equal to π [9]. When the number of nonlinear microring resonator is increased, for instance, MZI arm is coupled by DR and TR as shown in Fig. 3(b) and 3(c), respectively, which is found that the ASK enhanced peak is increased, and PSK enhanced peak is equal to π. In Fig. 4, we shown that the ASK output results are generated based on SR, DR and TR, which is coupled into one arm MZI, and we found that the number of ASK enhanced peak is increased more than number of nonlinear microring resonator. In order to generate three amplitude levels, in which all nonlinear microring resonators are modulated simultaneously. As seen in Figs. 3 and 4, when TR is in resonance, a “1” is generated, when one is off-resonance, a “0” is generated. Therefore, it is observed that with TR, it is possible to generate up to three different amplitude levels by an optical device. In conclusion, this scheme can simply be scaled up to more logic levels by adding additional nonlinear microring resonators and splitters to the system.

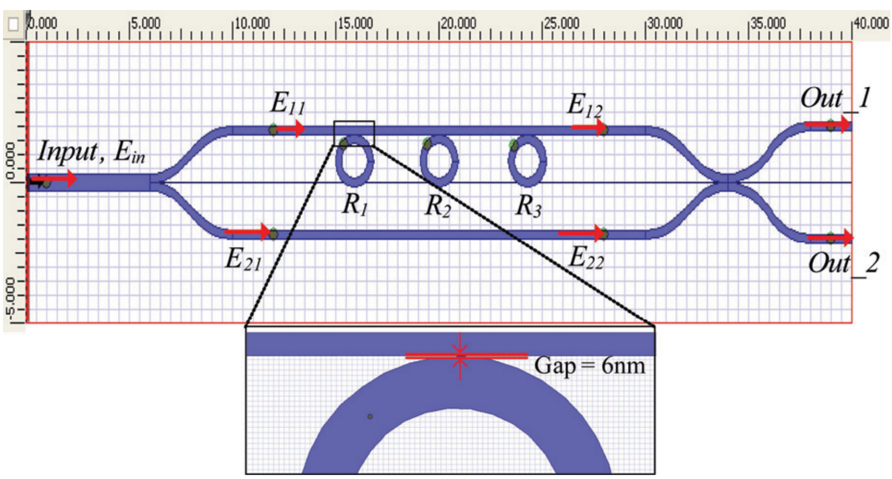

Fig. 1 Scheme of ASK-to-PSK in InGaAsP/InP waveguide size 10 × 40µm^2

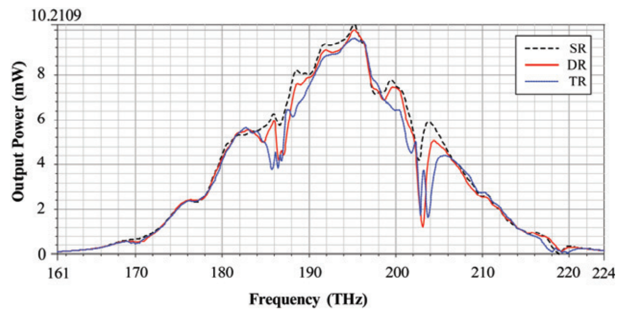

Fig. 2 Output results of nonlinear microring generation.

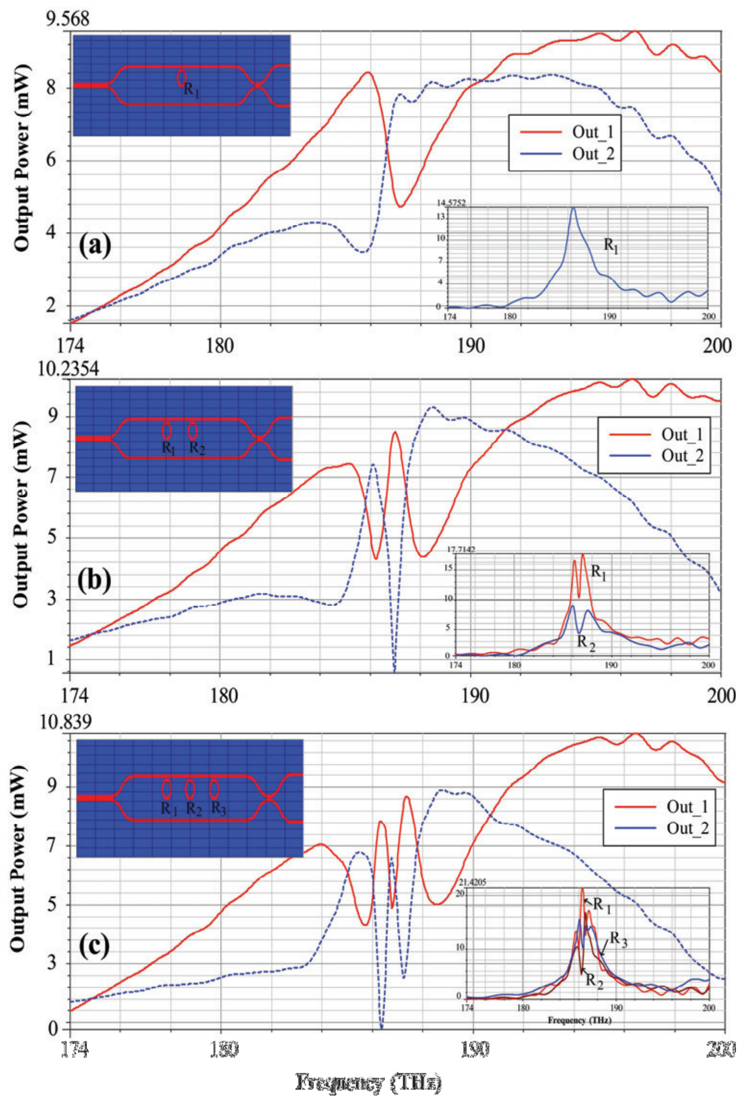

Fig. 3 Output results of ASK-to-PSK generation, when the nonlinear microring (a) SR, (b) DR and (c) TR coupled to one arm MZI.

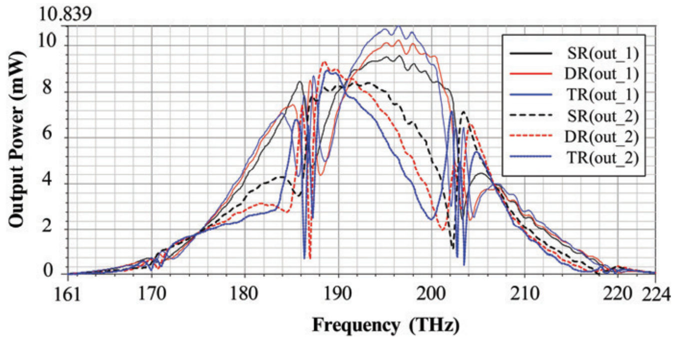

Fig. 4 Output results of ASK.

4. Conclusion

In conclusion, we present a new concept of ASK-to-PSK generation based on nonlinear microring resonators coupled to one MZI arm by using OptiWave FDTD method. By microring resonator increase from one to three microring (SR to TR), we found that the amplitude shift keying (ASK) are increase exactly and the phase shift keying (PSK) is equal to π.

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