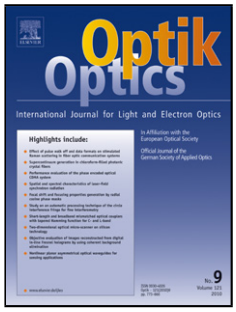

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FAST AND SLOW LIGHT ENHANCEMENT USING CASCADED MICRORING RESONATORS WITH THE SAGNAC REFLECTOR

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Abstract

A cascaded microring resonator based on silicon waveguides with an MMI (Multimode Interference) based Sagnac reflector is proposed in this study. By controlling the coupling coefficients with the used of the MMI based Sagnac reflector, the double of both pulse delay and advancement for the slow and fast light can be achieved. The new structure can produce the fast and slow light phenomenon on one chip with a double of the time delay and pulse advancement. By using the Sagnac reflector, the device is very compact. Transfer matrix method and FDTD (Finite Difference Time Domain) simulation are used to obtain the characteristics of the device. The transmission, phase, group delay and pulse propagation are analyzed in detail. Our FDTD simulations show a good agreement with the analytical theory.

Keywords: *Microring resonator, fast light, slow light, silicon waveguides, FDTD, transfer matrix method, multimode interference (MMI), microresonators*

1. Introduction

In recent years, optical microring resonators have been of great interest for applications in optical communications such as optical delay lines, optical switches, modulators, filters, dispersion compensators etc. [1, 2]. Micro-ring resonator structures consists of a number of single micro-ring resonators cascaded in series or in parallel can be used for higher order filters with extended free spectral ratios [3] or switching [4], modulating applications [5], fast and slow light [6].

Analysis of the group delay and transmission characteristics of cascaded microring resonators used for optical filters and dispersion compensators have been studied [7-9]. However, these structures have positive group delay and mainly designed for pulse delay applications. Slow and fast light generation are emerging as a very attractive research topic. Various techniques have been developed to realize fast light and slow light in atomic vapors and solid-state materials [10]. One application among these techniques is to control the group velocity v_g of light pulses to make them propagate either very slow ($v_g < c$) or very fast ($v_g > c$ or v_g is negative), where c is the velocity of light.

In this study, we propose a new cascaded microring structure based on silicon waveguides with a Sagnac loop reflector. The Sagnac loop reflector has been applied to many application structures such as filtering and fast light structures [11, 12]. By controlling the coupling coefficients of the coupler used in microring resonators in the proposed structure, negative and positive group delay can be obtained. This means that the light velocity can be controlled and therefore the fast and slow light can be induced by the structure [13-15]. Here, we use a Sagnac loop reflector based on an 1x2 MMI (Multimode Interference coupler) at the end of the structure to enhance the fast and slow light. The use of an MMI based reflector for the reflection to double the pulse delay and pulse advancement. It is shown that the group delay, time delay and advancement are doubled compared to the case without using the MMI Sagnac loop reflector. We use silicon microring resonators because of high quality of fabrication by using CMOS compatible process and device compactness with a high index contrast system.

2. Design

The structure consisting of N-single microring resonators cascaded in series with a Sagnac loop reflector is proposed in Figure 1(a).