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Parameter optimization and characteristic analysis of a polymer microring resonant wavelength multiplexer

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Abstract

Novel formulas of transmission functions are presented, some parameters are optimized, and transmission characteristics are analyzed for a polymer microring resonant wavelength multiplexer around the central wavelength of 1.55 μm with the wavelength spacing of 5.6 nm and with eight vertical output channels. The computed results show that the designed device possesses some excellent features including the 3 dB bandwidth of 0.25 μm, weaker background light of 3.8×10^{-4}, smaller inserted loss of less than 0.6 dB, and lower crosstalk below −20 dB for every vertical output channel.

Keywords: Polymer; Microring resonance; Wavelength multiplexer; Transmission spectrum; Inserted loss; Crosstalk

1. Introduction

The wavelength multiplexer composed of some microring resonator elements is a novel device in optical telecommunication systems. In the last decade, various kinds of microring resonators [1–5] for integrated optics have received considerable attention because of some excellent features, such as lower inserted loss, smaller crosstalk, and easier integration of fabrication. Recently, some researchers have designed and fabricated some microring resonant wavelength multiplexer which exhibited good wavelength demultiplexing in experiments [6,7].

Electro-optic polymers can also be used to fabricate wavelength multiplexers, which possess better thermal stability and temperature dependence, smaller birefringence, and easier control of the refractive index. Therefore, polymers are promising materials for fabricating multiplexers including arrayed waveguide gratings (AWG) and microring resonators (MRR).

In this paper, in order to obtain better wavelength demultiplexing, first we perform the optimization for the parameters of a polymer microring resonant wavelength multiplexer. Then we present novel formulas of transmission functions, and use them to analyze the transmission characteristics of this kind of device around the central wavelength of 1.55 μm with the wavelength spacing of 5.6 nm and with 8 vertical output channels. Finally, we reach some conclusions on the basis of the analysis and discussion.

2. Parameter optimization

In order to obtain the better wavelength demultiplexing, in this section, the values of some parameters of the polymer microring resonant wavelength multiplexer for the E_{00}^{x} mode are optimized.

2.1. Structure of the device

Fig. 1(a) shows the schematic diagram of a polymer microring resonant wavelength multiplexer with eight

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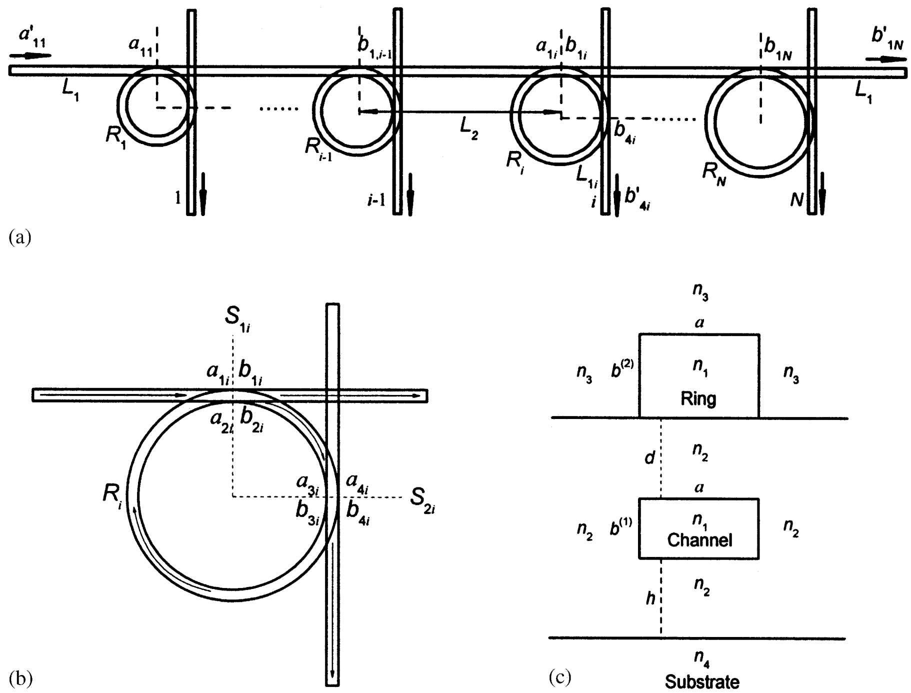

Fig. 1. (a) Schematic diagram of a microring resonant wavelength multiplexer, (b) that of a basic filter element, and (c) cross sections and refractive index profiles of the channel and the microring.

vertical output channels. Every polymer microring is placed on the top of the main polymer channel and the corresponding polymer vertical output channel which are buried in another polymer cladding on the Si substrate. Assume that the total length of the main channel is $2L_1 + (N-1)L_2$, where L_1 is the distance from the input or output port of the main channel to the adjacent coupling point, and L_2 is that of the adjacent coupling points on the main channel, L_{1i} is that from the output port of the ith vertical channel to the adjacent coupling point. Fig. 1(b) shows a basic filter element, and Fig. 1(c) shows the cross sections and the refractive index profiles of the channel and the microring, which have the same core width a and different core thickness $b^{(1)}$ and $b^{(2)}$, and have the same core refractive index n_1 and different cladding indices n_2 and n_3, respectively. Selecting the proper values of the material and structural parameters, we can control the channels and the microrings to have the same mode propagation constant.

In the following analysis, the values of parameters used in the calculation are given in the relative figure captions.

2.2. Size of the vertical channels and rings

Fig. 2 presents the curves of the effective refractive indices n_c versus the core thickness $b^{(1)}$ and $b^{(2)}$ of the channel and the microring, respectively, which are solved from the eigenvalue equations of the E^x_{pq} mode

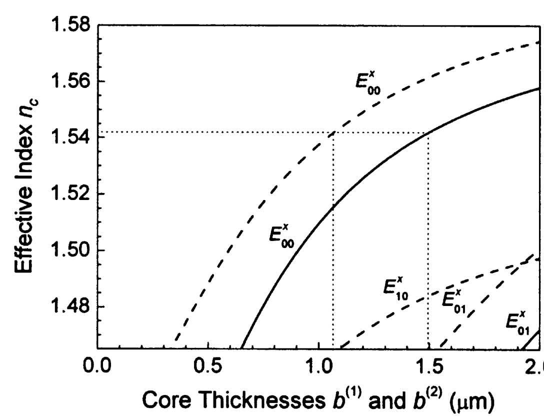

Fig. 2. Curves of n_c versus $b^{(1)}$ (dashed lines) and $b^{(2)}$ (solid lines) for E^x_{pq} mode, where $a = 2$ μm, $\lambda = 1.550918$ μm, $n_1 = 1.6278, n_2 = 1.465, n_3 = 1$.

of the rectangular optical waveguide [8]. We can find that when we select the core width and thicknesses of channels and microrings to be $a = 2.0$ μm, $b^{(1)} = 1.07$ μm and $b^{(2)} = 1.5$ μm, respectively, the single mode propagation is realized in the device, and both the channel and the microring have the same propagation constant.

Fig. 3 presents the curves of the effective refractive indices n_c versus the propagating wavelength λ for the channel and the microring, respectively. We can also find that the device has also realized single mode