Design of Optical Triplexer with Cascaded Multi-Mode Interference Couplers

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***Abstract*— An optical triplexer with cascaded multi-mode interference (MMI) couplers is proposed in an optical access system. The optical triplexer is constructed on a silicon-on-insulator (SOI) substrate. The optical triplexer was designed by use of beam propagation method.**

I. INTRODUCTION

In a fiber-to-the-home (FTTH) system, optical triplexer transceivers with good performance are key elements. An optical triplexer is used to demultiplex two downstream waves (1490nm, 1550nm) and multiplex one upstream wave (1310 nm) simultaneously. Several types of optical triplexers were proposed such as a Mach-Zehnder interferometer [1], an arrayed waveduide grating [2], and a directional coupler [3].

Recently, optical devices based on silicon photonics have been actively studied. In this paper, we report on an optical triplexer with cascaded multi-mode interference (MMI) couplers. The optical triplexer is constructed on a silicon-on-insulator (SOI) substrate. The optical triplexer was designed by use of BeamPROP (Rsoft Design Group Inc.).

II. DEVICE STRUCTURE

Fig. 1 shows an optical triplexer fabricated on a SOI substrate. The optical triplexer comprised of two MMI couplers. The waveguide has a Si guiding layer and a SiO_2 lower cladding layer. The refractive indices of Si and SiO_2 are 3.50 and 1.45, respectively, at a wavelength of 1.55 μm. High index contrast waveguides are realized so that a very compact device is expected.

In the optical triplexer, lightwaves incident on an input port are divided to two output ports at a first MMI coupler. The lightwaves (1310 nm) is coupled to an output port 1 and the other lightwaves (1490 nm, 1550 nm) are coupled to the other port. Then, by the second MMI coupler, the lightwaves, whose wavelengths are 1490 nm and 1550 nm, respectively, are divided to two output ports, that is, an output port 2 and an output port 3. Therefore, this device can separate optical signals with three wavelengths to three output ports.

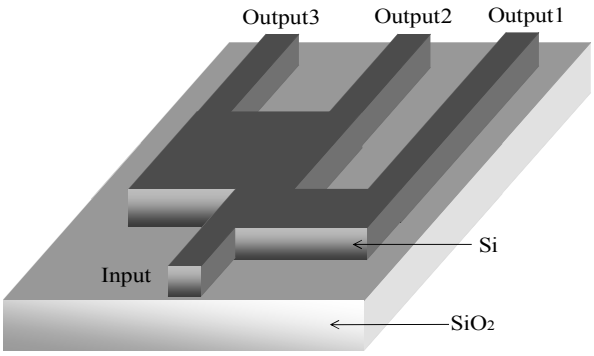

Fig. 1. Schematic diagram of optical triplexer with cascaded MMI couplers.

III. DESIGN

The optical triplexer was designed by use of BeamPROP (Rsoft Design Group Inc.). At first, the first MMI coupler which separates lightwave, whose wavelength is 1310 nm, with the other lightwaves was designed. Fig. 2 shows waveguide parameters of the first MMI coupler and TABLE I shows the optimized parameters.

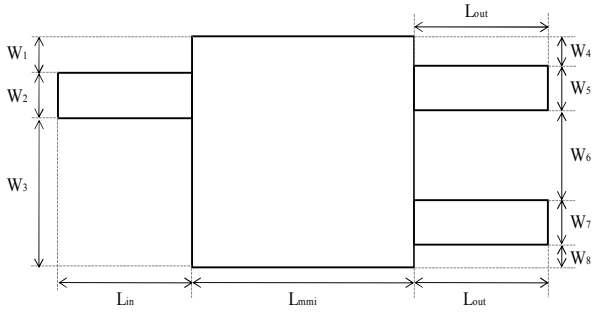

Fig. 2. Waveguide parameters of first MMI coupler.

TABLE I
OPTIMIZED WAVEGUIDE PALAMETERS OF FIRST MMI COUPLER.

Parameters	Values of First MMI[μm]
W_1	0
W_2	0.35
W_3	0.95
W_4	0
W_5	0.35
W_6	0.6
W_7	0.35
W_8	0
L_{in}	15
L_{mmi}	16
L_{out}	15

TABLE II
OPTIMIZED WAVEGUIDE PARAMETER OF SECOND MMI COUPLER

Parameters	Values of Second MMI[μm]
W_1	0.95
W_2	0.35
W_3	0
W_4	0
W_5	0.35
W_6	0.6
W_7	0.35
W_8	0
L_{in}	15
L_{mmi}	79.4
L_{out}	15

The second MMI coupler which separates the lightwave (1490 nm) with the lightwaves (1550 nm) was designed. TABLE II shows the optimized parameters.

By employing the waveguide paremteres listed in TABLE I and TABLE II, the total device length of approximately 140 μm was achieved by utilizing cascaded MMI couplers. Figure 4 shows the field propagation in the whole triplexer simulated by BeamPROP.

Fig. 3 shows BPM simulations of the electric field distribution. Table III shows the coupling loss of each wavelength.

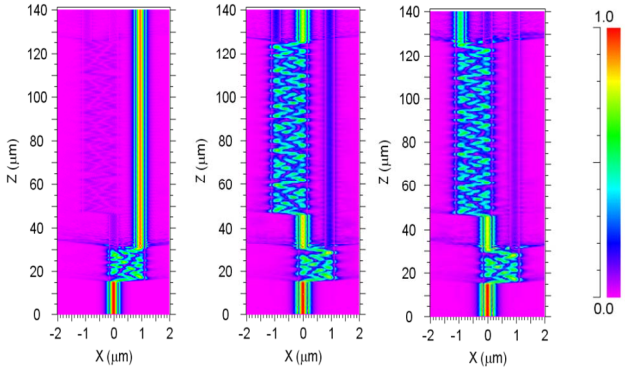

Fig. 4. BPM simulations of the electric field distribution pattern (a) when the wavelength is 1310nm, (b) 1490nm, and (c) 1550nm

TABLE III
COUPLING LOSS OF EACH WAVELENGTH

Wavelength[nm]	Output1[dB]	Output2[dB]	Output3[dB]
1310	0.6	> 60	> 60
1490	15.4	1.5	14.5
1550	21.3	18.3	3.0

IV. CONCLUSION

An optical triplexer constructed on a SOI substrate was proposed. The optical triplexer utilized cascaded MMI couplers to demultiplex two downstream waves and multiplex one upstream wave simultaneously. The optical triplexer was designed by beam propagation method. The total device length of the optical triplexer of approximately 140 μm was achieved owing to cascaded MMI couplers and the high index contrast waveguides.

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