Integrated Optical Mode Converter for Mid Infra-red (MIR) Mode-division Multiplexing System

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An optical mode converter is proposed and designed. It consist of Y-branch splitters, combiners, and phase shifter array. The input fundamental mode can be converted to TE_1, TE_2, TE_3 mode by controlling the phase shifters. Furthermore, the proposed mode converter support high order optical modes conversion by the expansion of the structure. It is designed for the wavelength of mid infra-red (MIR). This device shows potential applications for the mode division multiplexing (MDM) system at MIR.

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In recent years, on-chip mode division multiplexing system has attracted much more attention since its pave a way to increase the capacity in single wavelength. Plenty of building blocks for the MDM system have been reported and show excellent performance, such as the mode-division switch [1-2], mode multiplexer[3], mode converter[4], etc. Among these devices, one of the important device is the optical mode converter, which manage the optical mode in the MDM network. This work is focus on the demonstration of CMOS-compatible integrated silicon optical mode converter, which support high order modes conversion, with scalable structure. We also forward the working wavelength of the device from the NIR to MIR, since MIR photonics provide great potential application in the sensing, communication, thermal imaging [5-7], etc.

The proposed silicon mode converter contains three parts, including splitter, phase shifter array and combiners, as shown in Fig. 1. The input light TE_0 mode divided into four beams. After propagation through the phase shifters array, the light will be modulated with different phase. The four beams will be combined by two stage Y branch. We can choose the proper phase modulation to get the different optical mode. The working manner is listed in Table 1. Taking the conversion from TE_0 mode and TE_2 mode for example, in order to generate the TE_2 order optical mode, two in-phase TE_1 optical mode is required to superposition at the second-stage Y-branch combiner. So, phase shifter A and B works to generate two in-phase optical beam and superposition at the first-stage combiner to generate two in-phase TE_1 order optical mode, as shown in Fig. 2(c). The thermo/electric-optic effect could be employed to generate π shift. The simulation is performed by the FD-BPM method.

In conclusion, the silicon optical mode converter can support the conversion between TE_0 mode and 0-3th mode, which provide much more flexibility for mode management in the optical interconnects. This structure could be updated to higher modes conversion by extension the structures.

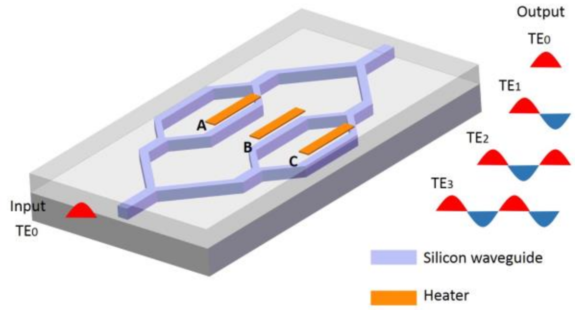

Fig.1 Schematic diagram optical mode converter.

Table. 1 Operation manner of the optical mode converter

Output Mode	Phase shifter
TE_0	-------
TE_1	B and C
TE_2	A and B
TE_3	A and C

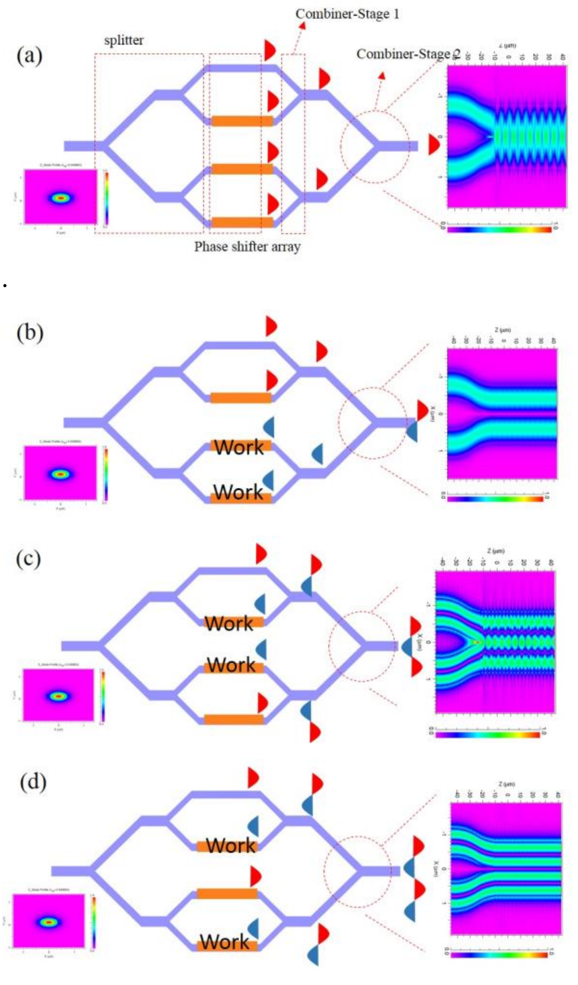

Fig. 2 Simulation result of optical mode converter output mode is (a) TE_0 mode; (b) TE_1 mode; (c) TE_2 mode (d) TE_3 mode

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