MODE CONVERSION OPTICAL ISOLATOR FABRICATED BY WAFER BONDING

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INTRODUCTION

In optical communication systems, an optical isolator is indispensable to protect optical active devices from unwanted reflected light. Magnetic garnet crystals are essential to construct the isolator, which makes it difficult to integrate the isolator with other optical devices. By using wafer bonding technique, a magneto-optic waveguide with a semiconductor guiding layer can be constructed. In this paper, the authors report on the optical isolator with a magnetic garnet / GaInAsP / InP waveguide employing a nonreciprocal TE-TM mode conversion.

DEVICE STRUCTURE

Figure 1 shows an optical isolator employing a TE-TM mode conversion fabricated by wafer bonding. A $\pi/4$ rad nonreciprocal mode converter and a $\pi/4$ rad reciprocal mode converter are cascaded in tandem. In the nonreciprocal mode converter, a magnetic garnet cladding layer is connected with a GaInAsP guiding layer with no materials in between. An external magnetic field is applied to the waveguide along the light propagation direction in order to saturate the magnetization of the magnetic garnet. The reciprocal mode converter can be obtained by eletctro-optic effect (1) or asymmetric periodic loaded rib waveguides (2).

To achieve large mode conversion, phase matching between the two modes is necessary. Waveguide parameters of the magneto-optic waveguide are considered to accomplish the phase matching. A cross section of the magneto-optic waveguide is shown in Fig. 2. A Ce-substituted yttrium iron garnet (Ce:YIG) (3) is employed as a magnetic garnet cladding layer. Figure 3 shows the relationship between strip width and strip height for phase matching at a wavelength of 1.55 µm. An optical confinement factor in Ce:YIG is also shown in Fig. 3. A small cross section of the GaInAsP guiding layer is effective for large optical confinement in the Ce:YIG layer, which gives rise to small propagation distance required for the $\pi/4$ rad mode converter. When the strip height is 0.55 µm, the required propagation distance is estimated to be approximately 7.9 mm.

Wafer bonding between a GaInAsP strip waveguide and a Ce:YIG grown on a garnet substrate was studied. The Ce:YIG was slightly etched by H_3PO_4 and the GaInAsP waveguide was activated by O_2 plasma prior to wafer bonding. Wafer bonding was successfully achieved with heat treatment at 220°C in H_2 ambient. Evaluation of the nonreciprocal TE-TM mode converter with the semiconductor guiding layer is now in progress.

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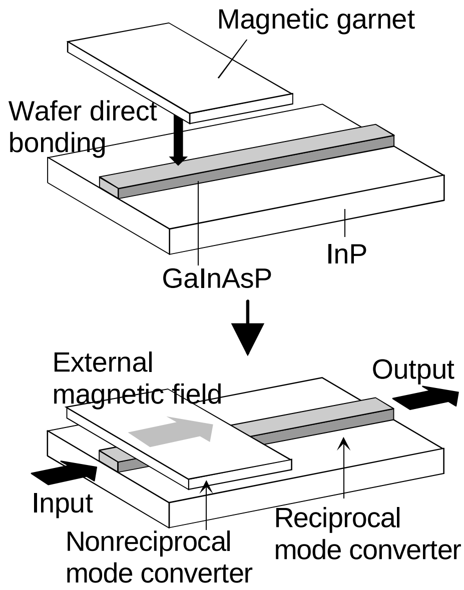

Fig. 1. Optical isolator with semiconductor guiding layer employing nonreciprocal TE-TM mode conversion.

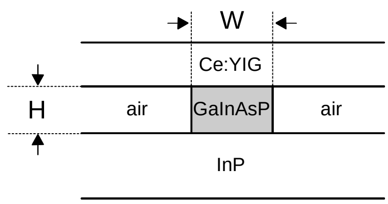

Fig. 2. Cross section of magneto-optic waveguide for nonreciprocal TE-TM mode converter.

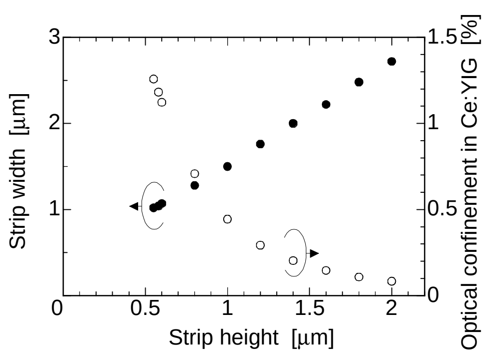

Fig. 3. Relationship between strip width and strip height for phase matching.