decreases gradually and a tip thereof is cut off.

[0024] Another aspect of the present invention provides a polarization rotator characterized in that the polarization rotator comprises: an input-output waveguide into which to input TM-polarized basic mode light; a polarization converter including a silicon rib waveguide and configured to convert the TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral-portion core gradually increases; a ~~core width conversion waveguide~~ a rib-channel conversion waveguide situated between the input-output waveguide and the polarization converter and continuously varying a core width between a waveguide at the input-output waveguide and the center-portion core of the polarization converter; and a mode converter optically connected to the polarization converter and configured to convert the TE-polarized 1st order mode light into TE-polarized basic mode light.

[0025] Also, a polarization rotator according to a still another aspect comprises: a polarization converter including a silicon rib waveguide and configured to convert TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral-portion core gradually increases; and a mode

efficiently causing polarization conversion. There is a possibility that the conversion efficiency might be lowered by an error in core width of about ±0.05 μm caused by a device fabrication error. In contrast, the polarization converter 104 with the structure of the present invention can obtain the same characteristics even if the width of the center-core portion or the peripheral-portion cores changes by about ±0.05 μm. For this reason, the polarization converter 104 and the rib-channel conversion waveguide 102, 103 are preferably provided independently of each other so as to be a structure that has higher tolerance (larger tolerable errors) during device fabrication.

[0050] Thus, the present invention can be implemented as a polarization rotator characterized in that the polarization rotator includes: an input-output waveguide into which to input TM-polarized basic mode light; a polarization converter including a silicon rib waveguide and configured to convert the TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that the core width of the peripheral-portion core gradually increases; a ~~core width conversion waveguide~~ a rib-channel conversion waveguide situated between the input-output waveguide and the polarization converter and continuously varying the core width between a waveguide at the input - output waveguide and the center - portion core of the polarization converter;and a mode converter optically

DESCRIPTION

~~POLARIZATION ROTATION CIRCUIT~~

POLARIZATION ROTATOR

Technical Field

[0001] The present invention relates to a polarization rotator. More specifically, the present invention relates to a planar polarization rotator formed of silicon waveguides.

Background Art

[0002] Optical circuits formed of silicon waveguides have been actively researched and developed since they have an advantage that the circuit size can be significantly smaller than those using conventional materials such as silica. Controlling the polarization of passing light, in particular, polarization splitting and polarization rotation, is one of important functions of an optical circuit. A polarization rotator is a circuit configured to output light of polarization perpendicular to the polarization of polarized light inputted thereto. As optical circuits formed on a planar substrate, generally used is an optical circuit configured to convert TE-polarized light, having its electric-field component horizontal to the substrate, into TM-polarized light, having its electric-field component vertical to the substrate, or an optical circuit configured to convert TM-polarized light into TE-polarized light.

[0003] There have been proposed several methods of

CLAIMS

1. A polarization rotator characterized in that the polarization rotator comprises:

a polarization converter including a silicon rib waveguide and configured to convert TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral-portion core gradually increases along the propagation axis of the TM/TE polarized basic mode lights; and

a mode converter optically connected to the polarization converter and configured to convert the TE-polarized 1st order mode light into TE-polarized basic mode light;

wherein the mode converter includes an optical splitter optically connected to the polarization converter,

a delay circuit including two waveguides, and

an optical coupler.

~~2. The polarization rotator according to claim 1, characterized in that~~

~~the mode converter includes an asymmetric directional coupler including two waveguides differing in width,~~

~~the two waveguides differing in width are silicon rib waveguides with no center portion core, and~~

~~of the two waveguides differing in width, the wider waveguide has one end optically connected to the polarization converter.~~

~~3. The polarization rotator according to claim 2, characterized in that the polarization converter and the mode converter are smoothly connected by a tapered intermediate waveguide, and~~

~~the tapered intermediate waveguide is any one of~~

~~a silicon rib waveguide with no center-portion core,~~

~~a silicon rib waveguide, and~~

~~a silicon rib waveguide with no center portion core and a silicon rib waveguide joined to each other.~~

~~4. The polarization rotator according to claim 1, characterized in that the mode converter includes~~

~~an optical splitter optically connected to the polarization converter,~~

~~a delay circuit including two waveguides, and~~

~~an optical coupler.~~

~~5~~2. The polarization rotator according to claim 1, characterized in that the optical splitter includes

a silicon rib waveguide with no center-portion core, and

a silicon rib waveguide including two thick core portions, and

the silicon rib waveguide with no center-portion core has one end connected to the polarization converter.

~~6~~3. A polarization rotator characterized in that the polarization rotator comprises:

a polarization converter including a silicon rib waveguide and configured to convert TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral-portion core gradually increases; and

a mode converter optically connected to the polarization converter and configured to convert the TE-polarized 1st order mode light into TE-polarized basic mode light;

wherein the mode converter includes an asymmetric directional coupler including two waveguides differing in width,

the two waveguides differing in width are silicon channel waveguides,

of the two waveguides differing in width, the wider waveguide has one end optically connected to the polarization converter by an intermediate waveguide,

the intermediate waveguide includes a silicon rib waveguide including two portions with relatively thick cores and a peripheral portion with a relatively thin core, and

each of the portions with the relatively thick cores has a tapered structure.

~~6. The polarization rotator according to claim 1, characterized in that~~

~~the mode converter includes an asymmetric directional coupler including two waveguides differing in width,~~

~~the two waveguides differing in width are silicon channel waveguides,~~

~~of the two waveguides differing in width, the wider waveguide has one end optically connected to the polarization converter by an intermediate waveguide,~~

~~the intermediate waveguide includes a silicon rib waveguide including two portions with relatively thick cores and a peripheral portion with a relatively thin core, and~~

~~each of the portions with the relatively thick cores has a tapered structure.~~

4. A polarization rotator characterized in that the polarization rotator comprises:

a polarization converter including a silicon rib waveguide and configured to convert TM-polarized basic mode light into TE-polarized 1st order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral-portion core gradually increases; and

a mode converter optically connected to the polarization converter and configured to convert the TE-polarized 1st order mode light into TE-polarized basic mode light;

wherein the mode converter includes a delay circuit including two waveguides optically connected to the polarization converter, and

any one of an optical coupler and an optical combiner.

~~7. The polarization rotator according to claim 2 or 5, characterized in that~~

~~a tapered waveguide is connected to at least one of one end of the widere waveguide of the asymmetric directional coupler and one end of the narrower waveguide of the asymmetric directional coupler, and~~

~~a width of the tapered waveguide decreases gradually and a tip thereof is cut off.~~

~~8. A polarization rotator characterized in that the polarization rotator comprises:~~

~~an input-output waveguide into which to input TM-polarized basic mode light;~~

~~a polarization converter including a silicon rib waveguide and configured to convert the TM-polarized basic mode light into TE-polarized 1st-order mode light, the silicon rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and having such a tapered shape that a core width of the peripheral portion core gradually increases;~~

~~a core-width conversion waveguide situated between the input-output waveguide and the polarization converter and continuously varying a core width between a core at the input-output waveguide and the center-portion core of the polarization converter; and~~

~~a mode converter optically connected to the polarization converter and configured to convert the TE-polarized 1st-order mode light into TE-polarized basic mode light.~~

~~9. The polarization rotator according to claim 1, characterized in that the mode converter includes~~

~~a delay circuit including two waveguides optically connected to the polarization converter, and~~

~~any one of the optical coupler and an optical combiner.~~

~~10~~5. The polarization rotator according to claim ~~9~~4, characterized in that the mode converter includes

a delay circuit configured to cause a delay of ½ of a wavelength and a 2x1 coupler, or

a delay circuit configured to cause a delay of ¼ of a wavelength and a 2x2 combiner.

~~11~~6. The polarization rotator according to claim ~~10~~5, characterized in that

the delay circuit of the mode converter that is configured to cause a delay of ¼ of a wavelength is two silicon rib waveguides each including a relatively thick center-portion core and a relatively thin peripheral-portion core,

one of the two silicon rib waveguides has a structure including such tapers that a width of the center-portion core gradually increases and then gradually decreases toward an output side, and

the 2x2 combiner of the mode converter is a directional coupler.

~~12~~7. The polarization rotator according to any one of claims ~~9~~ 4 to ~~11~~ 6, characterized in that

the polarization converter and the mode converter are optically connected by a tapered intermediate waveguide,

the tapered intermediate waveguide is a rib waveguide including a center-portion core and a peripheral-portion core thinner than the center-portion core, and has such a tapered shape that a width thereof gradually decreases toward an output side,

a portion connecting the tapered intermediate waveguide and the mode converter includes two cores, and

each of the two cores has such a tapered shape that a width of the core gradually increases.

~~13~~8. The polarization rotator according to any one of claims ~~9~~ 4 to ~~12~~ 7, characterized in that

the center-portion core of the polarization converter has such a tapered shape that a width of the center-portion core gradually decreases toward an output side, and

the peripheral-portion core of the polarization converter has such a tapered shape that the width of the peripheral-portion core gradually increases toward the output side.

~~14~~9. The polarization rotator according to any one of claims ~~9~~ 4 to ~~13~~ 8, characterized in that the tapered shape of the peripheral-portion core of the polarization converter is designed such that the width of the peripheral-portion core increases in a curved manner.

~~15~~10. The polarization rotator according to any one of claims ~~9~~ 4 to ~~14~~ 9, characterized in that the polarization rotator operates also as a polarization rotator-splitter.