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[Continued on next page]

(54) **Title**: SYSTEM AND METHOD FOR AN OPTICAL COUPLER

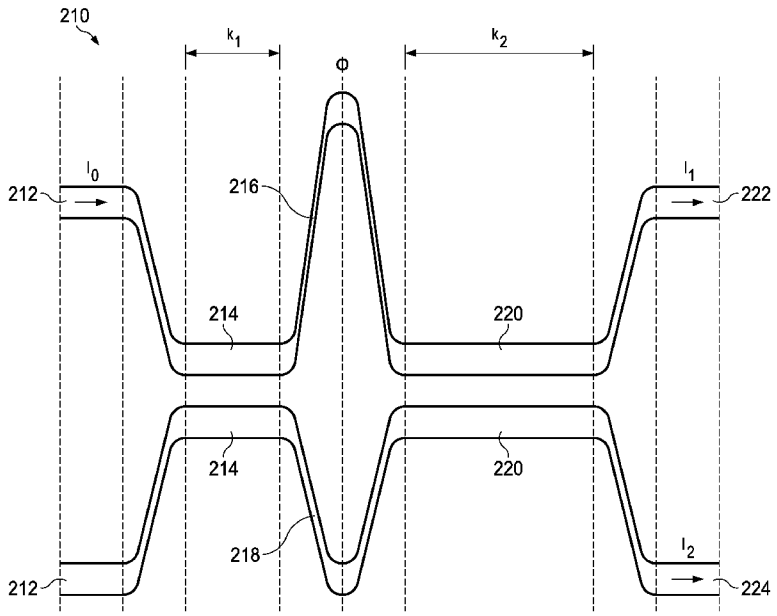

FIG. 8

(57) **Abstract**: In one embodiment, an optical directional coupler is configured to receive an input optical signal and includes a first coupler, where the first coupler has a first coupling length, where the first coupler is configured to couple a first portion to a first optical leg and a second portion to a second optical leg, where the first optical leg produces a phase shift relative to the second optical leg, where the first phase shift signal has a phase difference relative to the second phase shift signal. Additionally, the optical directional coupler includes a second coupler, where the second coupler has a second coupling length, where a crosstalk of the input optical signal to a second output is below -15 dB for both transverse electrical (TE) polarized light and transverse magnetic (TM) polarized over a wavelength range spanning 40 nm.

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23 April 2015

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G02B 6/35 (2014.01)
CPC - G02B 6/3508 (2014.11)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - G02B 6/00, 6/24, 6/26, 6/27, 6/35 (2014.01)
US: 385/4, 9, 11, 14, 15, 16, 17, 25, 27, 31, 39, 42

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - G02B 6/00, 6/24, 6/2726, 6/2935, 6/29353, 6/29352, 6/29355, 6/3506, 6/3508, 6/354 (2014.11) (Keyword Delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google Scholar

Search terms used: Mach-Zehnder first polarization rotator silicon waveguide etched corner

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2002/0025103 A1 (THANIYAVARN) 28 February 2002 (28.02.2002) entire document	1-4, 8, 10-11, 14 --- 5-7, 9, 12-13, 15-18
Y	US 2006/0198572 A1 (YEGNANARAYANAN et al) 07 September 2009 (07.09.2009) entire document	5-7
Y	US 2004/0008965 A1 (BETTY) 15 January 2004 (15.01.2004) entire document	9
Y	US 2010/0111470 A1 (ASSEFA et al) 06 May 2010 (06.05.2010) entire document	12-13
Y	US 2010/0303476 A1 (BARTON et al) 02 December 2010 (02.12.2010) entire document	15-18
A	US 2002/0159684 A1 (SUN et al) 31 October 2002 (31.10.2002) entire document	1-18

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2014	29 JAN 2015
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/040354

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-18

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/040354

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-18, drawn to an optical directional coupler, wherein the first coupler is configured to couple a first portion of the input optical signal to a first optical leg and a second optical portion of the input optical signal to a second optical leg, wherein the first optical leg is configured to phase shift the first portion of the optical signal to produce a first phase shift signal, wherein the second optical leg is configured to phase shift the second portion of the optical signal to produce a second phase shift signal, and wherein the first phase shift signal has a phase difference relative to the second phase shift signal; and a second coupler configured to receive the first phase shift signal and the second phase shift signal and to output a first output optical signal to a first output, wherein the second coupler has a second coupling length, wherein a crosstalk of the input optical signal to a second output is below about -15 dB for both transverse electrical (TE) polarized light and transverse magnetic (TM) polarized over a wavelength range spanning about 40 nm.

Group II, claims 19-20, drawn to discloses a method of designing a directional coupler, the method comprising: calculating a transverse electrical (TE) coupling ratio error function of the directional coupler as a first function of a first coupling length, a second coupling length, and a phase shift; calculating a transverse magnetic (TM) coupling ratio error function of the directional coupler as a second function of the first coupling length, the second coupling length, and the phase shift; minimizing the TE coupling ratio error function and the TM coupling ratio error function over a wavelength range to produce a selected first coupling length, a selected second coupling length, and a selected phase shift; and fabricating the directional coupler having the selected first coupling length, the selected second coupling length, and the selected phase shift.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: the first coupler is configured to couple a first portion of the input optical signal to a first optical leg and a second optical portion of the input optical signal to a second optical leg, wherein the first optical leg is configured to phase shift the first portion of the optical signal to produce a first phase shift signal, wherein the second optical leg is configured to phase shift the second portion of the optical signal to produce a second phase shift signal, and wherein the first phase shift signal has a phase difference relative to the second phase shift signal, nd a second coupler configured to receive the first phase shift signal and the second phase shift signal and to output a first output optical signal to a first output, wherein a crosstalk of the input optical signal to a second output is below about -15 dB for both transverse electrical (TE) polarized light and transverse magnetic (TM) polarized over a wavelength range spanning about 40 nm, as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: a method of designing a directional coupler, the method comprising: calculating a transverse electrical (TE) coupling ratio error function of the directional coupler as a first function of a first coupling length, a second coupling length, and a phase shift; calculating a transverse magnetic (TM) coupling ratio error function of the directional coupler as a second function of the first coupling length, the second coupling length, and the phase shift; minimizing the TE coupling ratio error function and the TM coupling ratio error function over a wavelength range to produce a selected first coupling length, a selected second coupling length, and a selected phase shift; and fabricating the directional couple, as claimed therein is not present in the invention of Groups I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of a first and second optical directional coupler with first and second lengths, optical signals, both transverse electrical (TE) polarized light and transverse magnetic (TM) functions, phase shift the first portion of the optical signal, this technical feature is not a special technical feature as it does not make a contribution over the prior art. Specifically, US 2002/0025103 A1 (THANIYAVARN) 28 February 2002 teaches a first and second optical directional coupler with first and second lengths (342, 346; figure 3a; paragraph 49), optical signals (abstract; paragraph 48), both transverse electrical (TE) polarized light and transverse magnetic (TM) functions (paragraph 52), phase shift the first portion of the optical signal (paragraph 67).

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.