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Published:

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(54) **Title**: FIBER OPTIC FURCATION MODULE

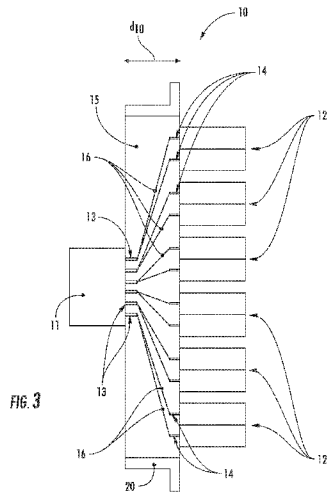


FIG. 3

(57) **Abstract**: The invention relates to a fiber optic furcation module, comprising: at least one planar wave guide card; a first adapter assigned to the or each planar wave guide card, the or each first adapter comprising a plurality of adapter ports for optical fibers terminated in an optical fiber ribbon connector; a plurality of second adapters assigned to the or each planar wave guide card, each of said second adapters comprising one adapter port or two adapter ports, the one or two adapter ports being operative to receive respective single optical fiber connectors terminated with single optical fibers; a plurality of fiber optic transmission channels provided by the or each planar wave guide card, the fiber optic transmission channels providing optical traces being operative to transmit and/or receive optical wavelength signals and connecting each adapter port of a first adapter with an adapter port of one of said second adapters.

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FIBER OPTIC FURCATION MODULE

PRIORITY APPLICATION

[0001] This application claims the benefit of European Patent Application No. 09006500.4 filed on May 14, 2009, the entire contents of which are herein incorporated by reference.

TECHNICAL FIELD

[0002] The invention relates to a fiber optic furcation module.

BACKGROUND

[0003] Corning Cable Systems Plug&Play™ Universal System brand LANscape® Pretium® is a preterminated optical fiber cabling system particularly used in data center applications. Such a system comprises various components, including so-called CCH (Closet Connector Housing) modules. A plurality of such CCH modules can be positioned in housing, whereby a plurality of housings can be mounted to a rack. The LANscape® Pretium® system belongs in principle to the prior art.

[0004] A CCH module of the LANscape® Pretium® system is used to provide a furcation function, namely to break out a 12 fiber ribbon connector being preferably a MTP connector into simplex or duplex style single fiber connectors. Such a CCH module comprises one or two first adapters to which a ribbon fiber connector is connectable. Each first adapter comprises a plurality of adapter ports for optical fibers terminated in a ribbon fiber connector. Such a CCH module comprises further a plurality of second adapters to which single fiber connectors are connectable. Each second adapter comprises one adapter port or two adapter ports for optical fibers terminated in single fiber connectors. A factory-installed and tested optical fiber assembly positioned inside such a CCH module connects each adapter port of the or each first adapter to an adapter port of the second adapters thereby providing the furcation function or break out function.

[0005] The CCH modules known from the prior art have a depth of around 90 mm. For the use of such modules in so-called Next Generation Data Centers ("NGDCs") the depth of the modules needs to be reduced. NGDCs denote data centers, which will be smaller, better integrated, of reduced footprint and with improved ventilation. These factors are needed in order to decrease the total cost of ownership in collocation rooms for the operators, facilitate the installers in their work and finally decrease the power consumption of computer room air conditioners. In view of the above described tendency, the depth of CCH modules known from the prior art has become too big.

[0006] Actions that could be taken with the optical fibers of the optical fiber assembly positioned inside such a CCH module would allow to reduce the depth to around to 40-50 mm. However, a much smaller depth for such a fiber optic furcation module is wanted for the use in NGDCs.

SUMMARY

[0007] Against this background, the present invention is based on the object of providing a novel fiber optic furcation module having a reduced depth. This problem is solved by a fiber optic furcation module according to claim 1.

[0008] The fiber optic furcation module according to the invention comprises at least one planar wave guide card; a first adapter assigned to the or each planar wave guide card, the or each first adapter comprising a plurality of adapter ports for optical fibers terminated in an optical fiber ribbon connector; a plurality of second adapters assigned to the or each planar wave guide card, each of said second adapters comprising one adapter port or two adapter ports, the one or two adapter ports being operative to receive respective single optical fiber connectors terminated with single optical fibers; a plurality of fiber optic transmission channels provided by the or each planar wave guide card, the fiber optic transmission channels providing optical traces being operative to transmit and/or receive optical wavelength signals and connecting each adapter port of a first adapter with an adapter port of one of said second adapters.

[0009] The basic idea of the invention is to replace an optical fiber assembly positioned inside a furcation module by a planar wave guide card.

[0010] The planar waveguide card leverages the quickest possible route from the or each first adapter to the second adapters. The permissible bend diameters of the optical fibers of an optical fiber assembly are no longer critical, since with a planar waveguide card small widths of optic transmission channels within the planar waveguide card and tight bend diameters at the same time can be provided. Moreover, the planar waveguide card reduces the adapter size, which no longer protrudes into the module. All that leads to a fiber optic furcation module having a very compact depth, which never before has been achieved. The invention allows reduction of the depth of a fiber optic furcation module to 5-10 mm.

[0011] According to a preferred embodiment of the invention each adapter port of the or each first adapter and each second adapter comprises a mode conditioning element and a waveguide funnel.

[0012] The mode conditioning element provides the conversion of the size of the light mode to be transmitted within a fiber optic transmission channel of the planar wave guide card.

[0013] The waveguide funnel of each adapter port provides a smooth transition between the fiber optic transmission channel of the planar wave guide card and a fiber core of an optical fiber terminated in a fiber optic connector being connectable to the respective adapter port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Preferred developments of the invention are given in the dependent claims and the description below. Exemplary embodiments will be explained in more detail with reference to the drawing, in which:

[0015] **Figure 1** shows a front view of a fiber optic furcation module according to the present invention;

[0016] **Figure 2** shows a back view of a fiber optic furcation module according to the present invention;

[0017] **Figure 3** shows a schematic cross-sectional view though the fiber optic furcation module according to the present invention along the direction III-III in **Figures 1 and 2**;

[0018] **Figure 4** shows a preferable layout of a planar waveguide card; and

[0019] **Figure 5** shows a detail of an adapter port of the fiber optic furcation module according to the present invention including a mode conditioning element and a waveguide funnel.

DETAILED DESCRIPTION

[0020] **Figure 1** shows a front view and **Figure 2** shows a back view of a preferred embodiment of fiber optic furcation module **10** according to present invention, whereby **Figure 3** shows a cross-sectional view though said fiber optic furcation module **10**.

[0021] The fiber optic furcation module **10** according to **Figures 1 to 3** comprises two first adapters **11** positioned at the back side of the fiber optic furcation module **10** and a plurality of second adapters **12** positioned at the front side of the fiber optic furcation module **10**. Each first adapter **11** comprises a plurality of adapter ports **13** for optical fibers terminated in a ribbon fiber connector. Each second adapter **12** comprises two adapter ports **14** for optical fibers terminated in single fiber connectors.

[0022] In the preferred embodiment shown in **Figures 1 to 3**, the two first adapters **11** are designed as MPO adapters, especially as MTP adapters. Each of the two MPO adapters **11** comprises twelve adapter ports **13** for twelve optical fibers terminated in a ribbon fiber connector.

[0023] In the preferred embodiment shown in **Figures 1 to 3**, the second adapters **12** are designed as duplex adapters each having two adapter ports **14** for two optical fibers each terminated in a single fiber connector.

[0024] Each of the twelve adapter ports **13** of an MPO adapter **11** is optically connected to an adapter port **14** of one duplex adapters **12** being positioned in a row of six duplex adapters **12**.

[0025] The fiber optic furcation module **10** according to **Figures 1 to 3** further comprises two planar wave guide cards **15**. To each planar wave guide card **15** there is assigned one of the first adapters **11** and a plurality of the second adapters **12**. In the preferred embodiment shown in **Figures 1 to 3**, to each planar wave guide card **15** there is assigned one MPO adapters **11** having twelve adapter ports **13** for twelve optical fibers terminated in a ribbon fiber connector and six duplex adapters **12** each having two adapter ports **14** for two optical fibers each terminated in a single fiber connector.

[0026] According to the shown embodiment, the first adapter **11** and said plurality of second adapters **12** are assigned to opposite sides of each planar wave guide card **15**. However, it should be noted that it is also possible that the first adapter **11** and the plurality of second adapters **12** are assigned to the same side of each planar wave guide card **15**.

[0027] In the preferred embodiment shown in **Figures 1 to 3**, the two planar wave guide cards **15** are mechanically cascaded in a way that a first planar wave guide card **15** is mounted to a supporting frame **20** (see **Figures 2, 3**) and that a second planar wave guide card **15** is mounted to the first planar wave guide card **15**. The fiber optic furcation module **10** can be mounted to a housing through said supporting frame **20**, whereby a plurality of such fiber optic furcation modules **10** are typically mounted to a housing.

[0028] The first adapter **11** being preferably a MPO adapter and the plurality of second adapters **12** being preferably duplex adapters which are assigned to each planar wave guide card are halves of standard MPO or standard duplex adapters.

[0029] Each planar wave guide card **15** provides a plurality of fiber optic transmission channels **16** running within the respective planar wave guide card **15** and connecting each adapter port **13** of each first adapter **11** to an adapter port **14** of one of said second adapters **12** assigned to the same planar wave guide card **15** thereby providing the furcation function or break out function.

[0030] The fiber optic transmission channels **16** of the planar waveguide cards **15** provide optical traces being operative to transmit and/or receive optical wavelength signals. The planar waveguide cards **15** leverage the quickest possible route from the first adapter **11** to the second adapters **12** and allow reduction of the depth $\mathbf{d_{10}}$ of the fiber optic furcation module **10** to 5 mm-10 mm.

[0031] The permissible bend diameters of optical fibers of an optical fiber assembly are no longer critical (up to 1,6 mm), since with the described, preferred configuration of planar waveguide card **15** small widths of optic transmission channels within the planar waveguide card **15** and tight bend diameters at the same time can be provided.

[0032] A planar waveguide card **15** is a member of the waveguide family, to which optical fibers also belong. A planar waveguide card is formed on a plate of substrate. This produces a firm and rigid parallelepiped, which can be very precisely tailored to the needs. The choice of materials, their refractive indexes and other properties are much bigger than in case of optical fibers.

[0033] The cladding and core of a planar waveguide card are grown or deposited on the substrate. High refractive index difference can be reached, which leads to an ele-

vated numerical aperture (NA), which in turn allows for low widths of channels and tight bends at the same time.

[0034] **Figure 4** illustrates a preferable layout of the planar waveguide card **15** used in the fiber optic furcation module **10** according to the present invention. In general, a core of the planar waveguide card **15** is buried under the Silicon Glass **BPSG** and is made of silicone oxynitride **SiON**.

[0035] The refractive index difference is 5%, which together with the thick cladding yields very good transmission capabilities. A substrate of the planar waveguide card **15** is made of pure silicon **Si** on which the lower cladding layer made from $\mathbf{SiO_2}$ is grown via oxidation.

[0036] The exact dimensions that are given guarantee for the 1550 nm wavelength the desired bend diameters and transmission properties for the single mode operation of the waveguide channels **16**. However, the dimensions can be amended within the scope of this invention, e.g. to adapt the device to different wavelengths to be transmitted. The distance between fiber optic transmission channels **16** is approximately 6 μm.

[0037] The materials and manufacturing of the planar waveguide card **15** can be changed. Is possible to manufacture the core of the planar waveguide card **15** using a sol-gel process, e.g. a metal alkoxide (fluid) is subject to hydrolysis and polymeration, which consequently forms a solid. This is applied to the buried core formation. Further on, it is possible to interchange the materials only by making use of gallium arsenide or indium phosphide.

[0038] It should be noted that other layouts of the planar waveguide card **15** can be used. The so-called rib waveguide layout shown in **Fig. 4** is preferred, but the invention is not limited to this layout. Other layouts of the planar waveguide card **15** can be a so-called ridge waveguide layout, or a so-called embedded waveguide layout, or a so-

called immersed waveguide layout, or a so-called bulge waveguide layout, or a so-called strip-loaded waveguide lay, or a so-called metal or buffered metal waveguide layout.

[0039] Each adapter port **13**, **14** provides a fiber optic interface between a fiber optic transmission channel **16** of the respective planar wave guide card **15** and an optical fiber terminated in a fiber optic connector **11**, **12** and being connectable to said adapter port **13**, **14** by the respective fiber optic connector **11**, **12**. Each adapter port **13**, **14** (see **Figure 5**) comprises a mode conditioning element **17** and a waveguide funnel **18** in order to provide the desired modes for a low loss coupling.

[0040] The mode conditioning element **17** of each adapter port **13**, **14** provides the right size of a mode to be transmitted within the fiber optic transmission channel **16** of the respective planar wave guide card **15**, as well as on the other hand the right size of the mode to be transmitted within the optical fiber core **19**. The mode conditioning element **17** of each adapter port **13**, **14** is positioned between a fiber optic transmission channel **16** of the respective planar wave guide card **15** running to the adapter port **13**, **14** and the waveguide funnel **18** of said adapter port **13**, **14**.

[0041] The mode conditioning element **17** comprises waveguide stripes **21** that are deposited perpendicularly to the main transmission channel and are specially sized and separated to produce a wave broadening antenna. In such a way, the initial mode field diameter in a transmission channel is elevated which is needed to feed the wave properly into a fiber core **19**. On the other hand, the mode conditioning element **17** acts as a wave thinning antenna. In such a way, the initial mode field diameter in an optical fiber core **19** is decreased in order to be fed into the transmission channel **16**.

[0042] The mode conditioning element **17** provides the conversion of the size of the light mode in the following way: When light propagates from the optical fiber – it reduces the mode field diameter from around 10 μm to around 4 μm to be transmitted within a fiber optic transmission channel of the planar wave guide card.

[0043] When the light propagates from the fiber optic transmission channel of the planar wave guide – it increases the mode field diameter from around 4 μm to around 10 μm to be transmitted within the optical fiber.

[0044] The width w_{16} of each fiber optic transmission channel **16** of the respective planar wave guide card **15** running to an adapter port **13**, **14** is smaller than the width $\mathbf{w_{19}}$ of a fiber core **19** of the optical fiber terminated in a fiber optic connector being connectable to said adapter port **13**, **14**.

[0045] The waveguide funnel **18** of each adapter port **13**, **14** provides a smooth transition between the fiber optic transmission channel **16** of the respective planar wave guide card **15** running to an adapter port **13**, **14** and the fiber core **19** of the optical fiber terminated in a fiber optic connector being connectable to said adapter port **13**, **14**.

[0046] The waveguide funnel **18** is a 3D structure, on which the fiber core's **19** circumference is almost circumscribed. The waveguide funnel **18** can be produced by an etching process.

[0047] In the preferred embodiment, each optic transmission channel **16** provided by a planar wave guide card **15** comprises a width $\mathbf{w_{16}}$ of approximately 3 μm, wherein each fiber core **19** of each optical fiber terminated in a fiber optic connector comprises a width $\mathbf{w_{19}}$ of approximately 8 μm, and wherein the funnel **18** comprising a length $\mathbf{l_{18}}$ of approximately 10 μm providing a smooth transition between the fiber optic transmission channel **16** and the fiber core **19**. The mode conditioning element **17** comprising the waveguide stripes **21** comprising a length $\mathbf{l_{17}}$ of approximately 140 μm, whereby the width $\mathbf{w_{21}}$ of the waveguide stripes **21** is varying between approximately 1 μm and approximately 18 μm and whereby the thickness of the waveguide stripes **21** is approximately 2.7 μm.

[0048] Naturally, the design of the adapter ports **13**, **14** according to **Figure 4** is used on both sides of the module (multifiber and singlefiber), as the light wave can be sent via it in either direction.

What is claimed is:

1. A fiber optic furcation module, comprising

at least one planar wave guide card;

a first adapter assigned to the or each planar wave guide card, the or each first adapter comprising a plurality of adapter ports for optical fibers terminated in an optical fiber ribbon connector;

a plurality of second adapters assigned to the or each planar wave guide card, each of said second adapters comprising one adapter port or two adapter ports, the one or two adapter ports being operative to receive respective single optical fiber connectors terminated with single optical fibers;

a plurality of fiber optic transmission channels provided by the or each planar wave guide card, the fiber optic transmission channels providing optical traces being operative to transmit and/or receive optical wavelength signals and connecting each adapter port of a first adapter with an adapter port of one of said second adapters.

2. The fiber optic furcation module as claimed in claim 1, wherein the first adapter assigned to each planar wave guide card is an MPO adapter, especially an MTP adapter.

3. The fiber optic furcation module as claimed in claim 1 or 2, wherein said second adapters assigned to each planar wave guide card are simplex adapters each having one adapter port for one optical fiber terminated in a single fiber connector.

4. The fiber optic furcation module as claimed in claim 1 or 2, wherein said second adapters assigned to each planar wave guide card are duplex adapters each having two adapter ports for two optical fibers each terminated in a single fiber connector.

5. The fiber optic furcation module as claimed in one of claims 1 to 4, wherein each adapter port provides a fiber optic interface between a fiber optic transmission channel of the respective planar wave guide card and an optical fiber terminated in a fiber optic connector and being connectable to said adapter port by the respective fiber optic connector.

6. The fiber optic furcation module as claimed in one of claims 1 to 5, wherein each adapter port comprises a mode conditioning element and a waveguide funnel.

7. The fiber optic furcation module as claimed in claim 6, wherein said mode conditioning element of each adapter port provides the right size of the light mode to be transmitted within the fiber optic transmission channel of the respective planar wave guide card, as well as the right size of the light mode to be transmitted within the a fiber core of the optical fiber terminated in a fiber optic connector being connectable to said adapter port.

8. The fiber optic furcation module as claimed in claim 6 or 7, wherein the mode conditioning element of each adapter port is positioned between a fiber optic transmission channel of the respective planar wave guide card running to the adapter port and the waveguide funnel of said adapter port.

9. The fiber optic furcation module as claimed in one of claims 1 to 8, wherein the width of each fiber optic transmission channel of the respective planar wave guide card running to an adapter port is smaller than the width of a fiber core of the optical fiber terminated in a fiber optic connector being connectable to said adapter port.

10. The fiber optic furcation module as claimed in one of claims 6 to 9, wherein the waveguide funnel of each adapter port provides a smooth transition between the fiber optic transmission channel of the respective planar wave guide card running to an adapter port and the fiber core of the optical fiber terminated in a fiber optic connector being connectable to said adapter port.

11. The fiber optic furcation module as claimed in claim 10, wherein each optic transmission channel provided by a planar wave guide card comprises a width of approximately 3 μm, wherein each fiber core of each optical fiber terminated in a fiber optic connector comprises a width of approximately 8 μm, and wherein the waveguide funnel comprising a length of approximately 10 μm provides a smooth transition between the fiber optic transmission channel and the fiber core.

12. The fiber optic furcation module as claimed in one of claims 1 to 11, wherein said first adapter and said plurality of second adapters are assigned to opposite sides of the planar wave guide card.

13. The fiber optic furcation module as claimed in one of claims 1 to 11, wherein said first adapter and said plurality of second adapters are assigned to the same side of the planar wave guide card.

14. The fiber optic furcation module as claimed in one of claims 1 to 13, comprising two mechanically cascaded planar wave guide cards, each comprising a first adapter, a plurality of second adapters and fiber optic transmission channels, whereby a first planar wave guide card is mounted to a supporting frame and whereby a second planar wave guide card is mounted to the first planar wave guide card.

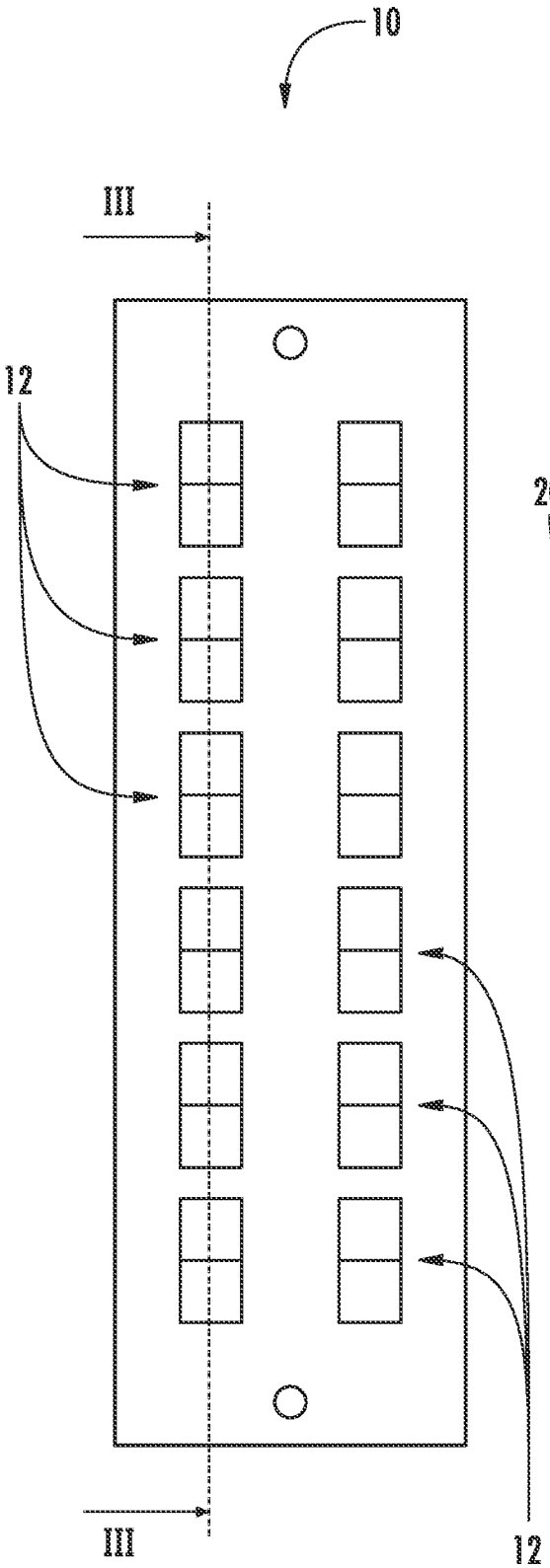


FIG. 1

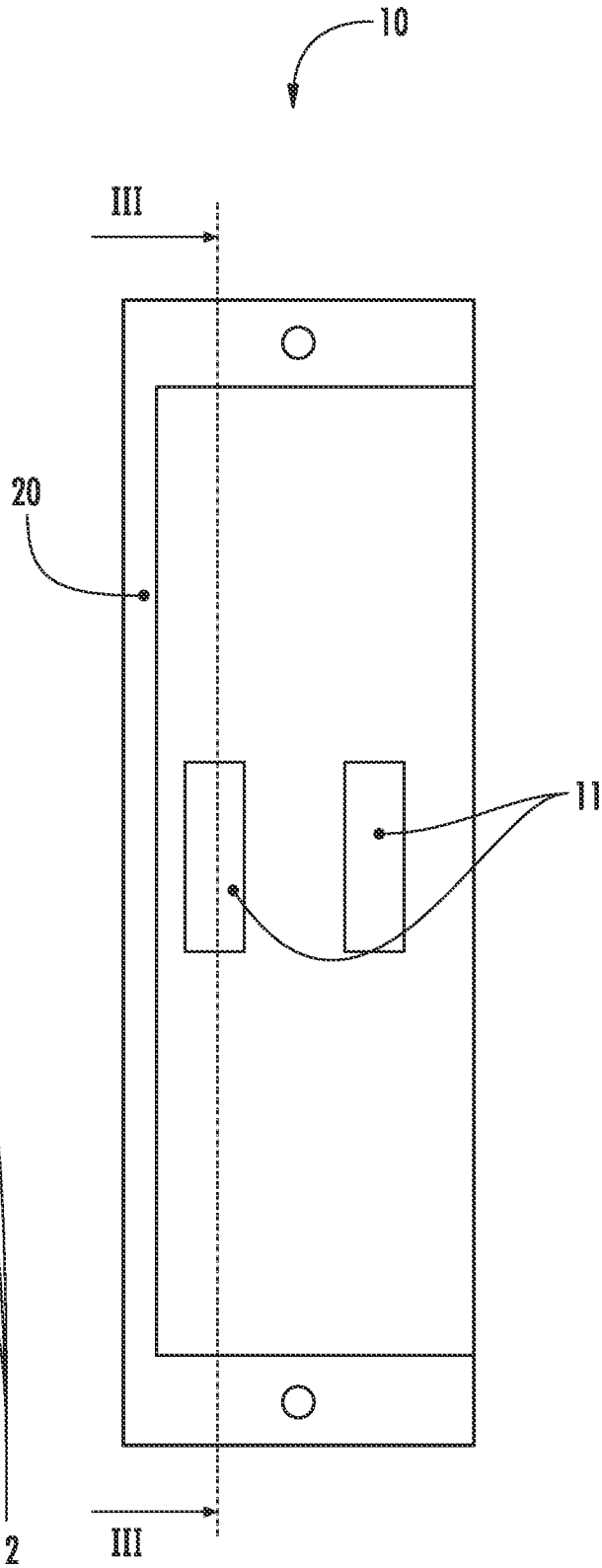


FIG. 2

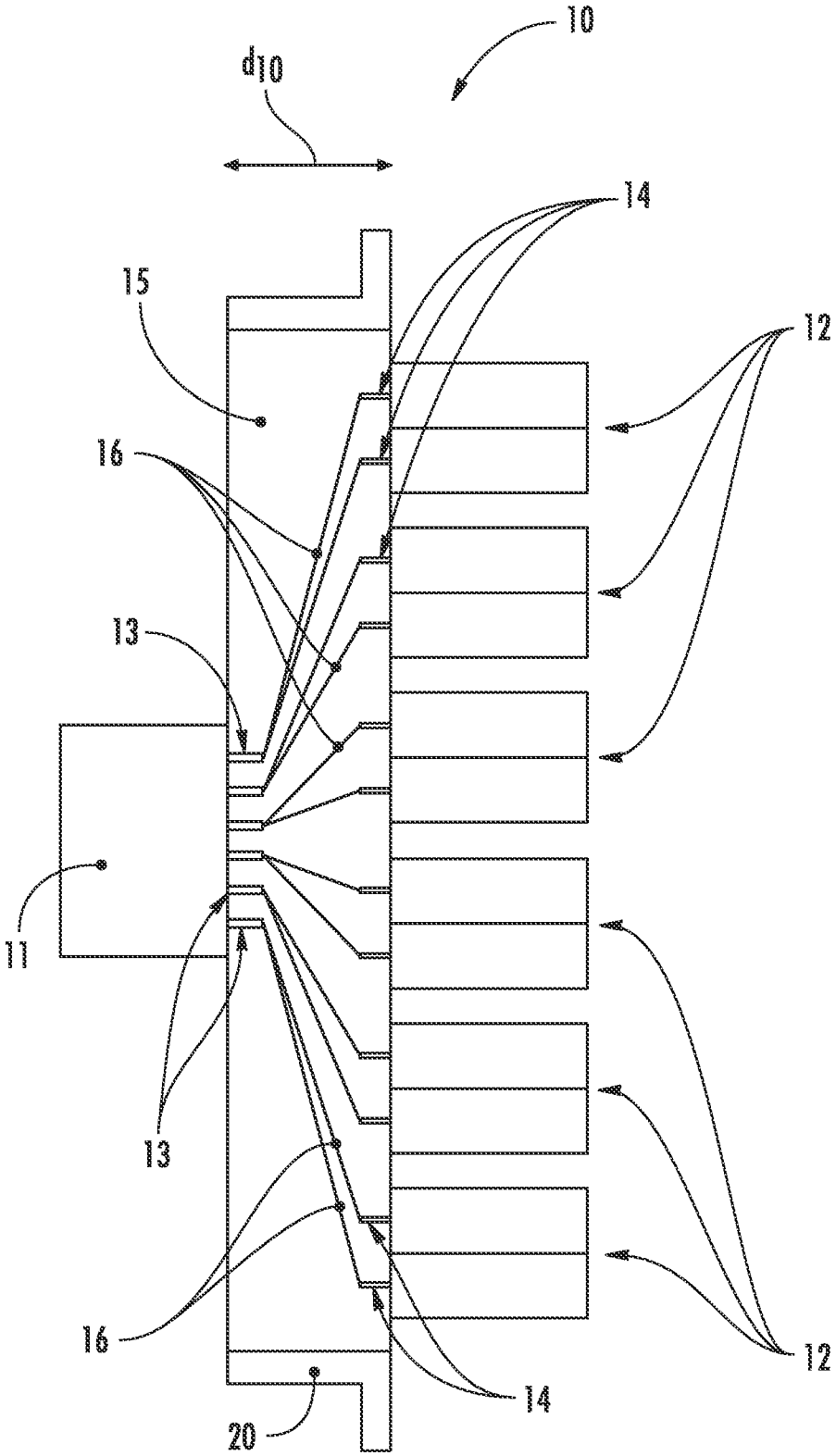


FIG. 3

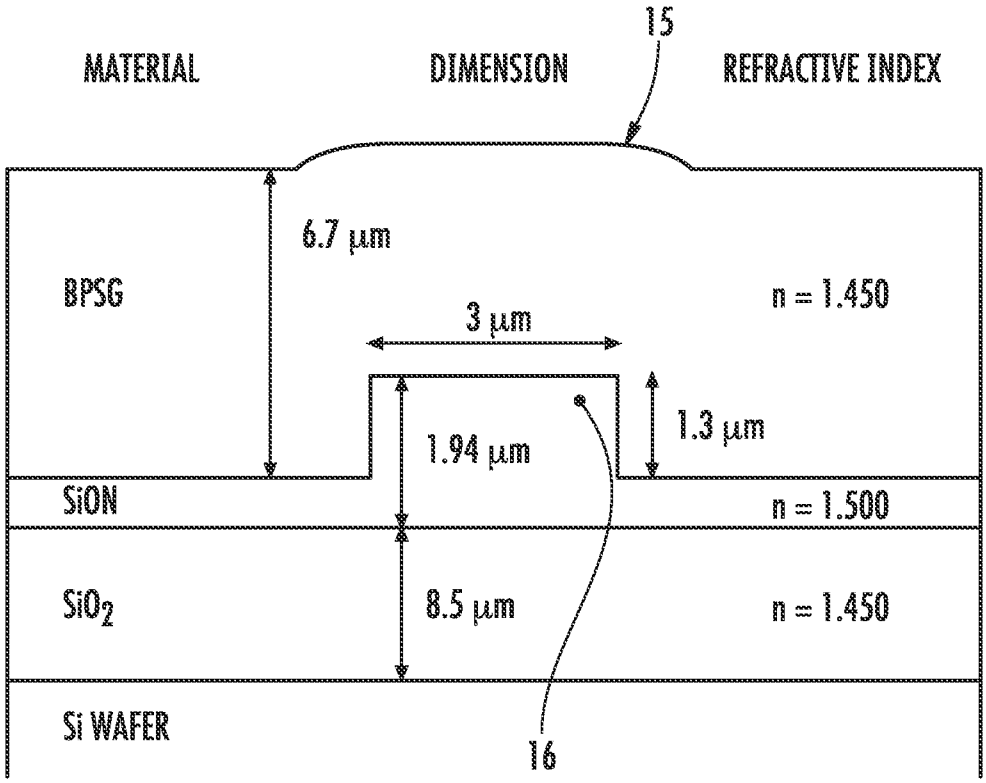

15
MATERIAL
DIMENSION
REFRACTIVE INDEX
6.7 μm
BPSG
n = 1.450
3 μm
1.3 μm
1.94 μm
SiON
n = 1.500
SiO_2
8.5 μm
n = 1.450
Si WAFER
16

FIG. 4

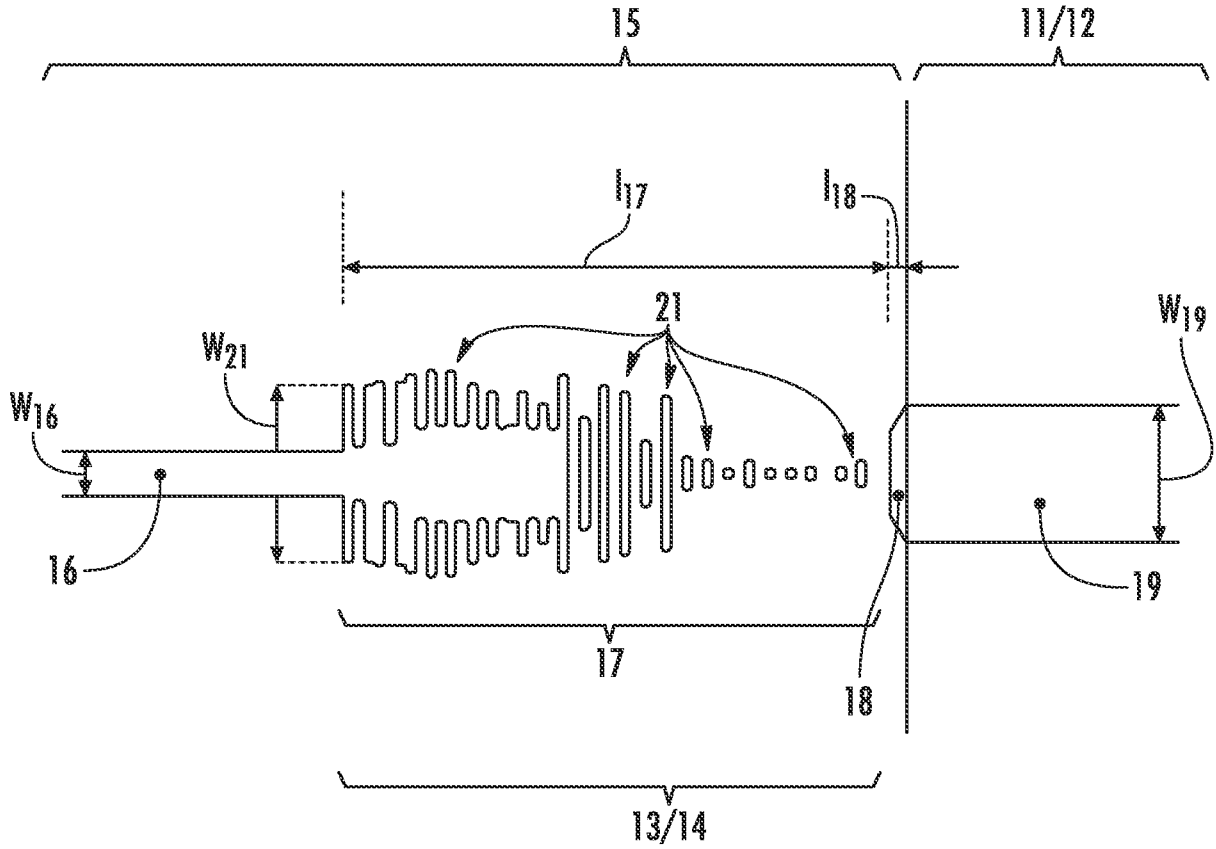


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/034298

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G02B 6/10 (2010.01)
USPC - 385/129
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 6/10, 24, 36 (2010.01)
USPC - 385/53, 89, 129

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent, Google Patents, The ACM Digital Library

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7,300,216 B2 (MORSE et al) 27 November 2007 (27.11.2007) entire document	1-4
A	US 7,220,065 B2 (HAN et al) 22 May 2007 (22.05.2007) entire document	1-4
A	US 6,952,530 B2 (HELVAJIAN et al) 04 October 2005 (04.10.2005) entire document	1-4
A	US 6,385,374 B2 (KROPP) 07 May 2002 (07.05.2002) entire document	1-4

☐ 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
01 July 2010	15 JUL 2010

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	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/US2010/034298

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.: 5-14
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:

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.:

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.