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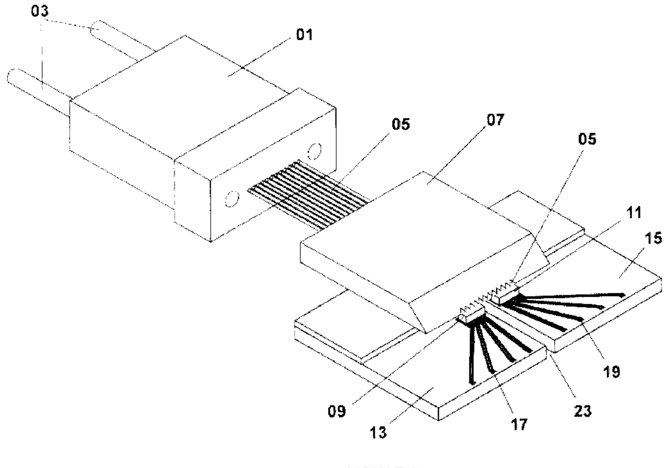

FIGURE 01a

(57) Abstract: There is described an optical assembly comprising: a structure for guiding light having a top surface and a bottom surface, and comprising a plurality of grooves on the bottom surface; a plurality of optical waveguides, each being embedded in a corresponding one of the plurality of grooves, and having a coupling surface at one end; and at least two substrates, each comprising an array of optical components attached thereto, the array of optical components being substantially aligned in a one-to-one manner with the coupling surface for a corresponding group of optical waveguides amongst the plurality of optical waveguides, the at least two substrates being spaced apart to form at least one gap, the at least one gap having a non-constant width along a length thereof in order to allow the array of optical components for each one of the at least two substrates to be aligned with the coupling surface for the corresponding group of optical waveguides.

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A TWO SUBSTRATE PARALLEL OPTICAL SUB-ASSEMBLY

RELATED APPLICATIONS

[0001] The present application claims priority under 35 USC§ 120 of US Patent Application bearing serial number 11/862,594, filed on September 27, 2007, the contents of which are hereby incorporated by reference. This application is related to US patent 7,178,235 granted February 20, 2007 entitled METHOD OF MANUFACTURING AN OPTOELECTRONIC PACKAGE and US patent 7,197,224 granted March 27, 2007 entitled OPTICAL FERRULE, the specifications of which are hereby incorporated by reference.

FIELD OF THE ART

[0002] This description pertains to the field of precision alignment of multiple devices. More precisely, it relates to the field of optical alignment of three or more elements.

BACKGROUND

[0003] There has been much work devoted to the alignment of lasers (or photodetectors) with optical fibers to provide for the maximum amount of coupling and subsequent transmission of light along an optical fiber. Most products are based on a single laser aligned to a single optical fiber - an example is the SFP optical transceiver, with a well aligned transmitter module and a well aligned receiver module; each with a single optical fiber coupling in an LC connector housing.

[0004] However, due to ever growing demands for bandwidth in smaller overall volumes of space (known as a higher bandwidth-density) there has been an increasing trend towards parallel optical modules where multiple lasers are aligned to multiple optical fibers in a single module - an example of this is the SNAP-12 parallel optical transceiver with 12 optical channels in an area roughly 1-cm x 1-cm. Both single and multiple optical channel modules require well positioned and well toleranced sub-components and holders. Furthermore, they are usually aligned while actively monitoring the optical power levels, to or from the optical fiber, to ensure the highest possible coupling (lowest insertion loss). The alignment between the multiple lasers and the optical fibers is time consuming, requires a complicated set of parallel holders and relay optics, such as a patterned microlens array and an MT-style optical ferrule, precision pick-and-place techniques, and also requires the lasers to be powered-on for active alignment.

[0005] Therefore there is a need for an easier and faster alignment method.

SUMMARY

[0006] There is described herein a method and apparatus for the alignment of two or more optical devices with a single structure containing multiple optical waveguides or optical fibers. This relates to the optical coupling of light that requires multiple optical coupling operations to micron (or sub-micron) tolerance levels to produce an optical sub-assembly comprised of both input and output electrical signals and input and output optical signals for bi-directional optical components.

[0007] There is described concepts that are directed towards the manufacturability of volume quantities of bi-directional optical sub-assemblies. This assembly provides for a low-profile, robust sub-component that can be used in a variety of optical modules. Furthermore, the methods described to construct the sub-component allow for low-cost manufacturing.

[0008] There is described a means for bi-directional optical data communications using at least 2 optical channels and comprising at least one light emitting device on a chip that has been mounted on an electrical interconnecting substrate, at least one light detecting device on a chip that has been mounted on an electrical interconnecting substrate, and an optical guiding structure that holds at least two optical channels, where at least one optical channel is for output optical signals and the other is for input optical signals. Structures that contain multiple pathways for light, such as a polymer waveguides or a structure that contains a lens array can also be envisioned.

[0009] Several optical alignment aspects are involved when aligning three (or more) independent objects, especially when each component involves more than 1 optical channel, without the use of expensive pick-and-place equipment.

[0010] Each optoelectronic chip, the emitter chip and the detector chip, is aligned to the optical guiding structure independently from the other. Once all fixed together, the final assembly can then be mounted on a common carrier (typically a printed circuit board) and connected electrically. In this way, the very precise mechanical placement of very small devices, such as the optoelectronic chips, can be eliminated and thus the cost can be reduced as well as the time required. The vertical spacing of the active area of the emitter array to the optical interface of the optical guiding structure can be different from the vertical distance between the active area of the detector array and the optical interface of the same optical guiding structure. The electrical connections (such as wirebonds) between the optoelectronic arrayed devices and their respective substrates can tolerate a large variation in ideal position as does the electrical connection between the completed optical assembly and the common carrier. The type of optical alignments proposed combined with the positional flexibility of the electrical connections to the conductive trace lines eliminate the need for precision pick-and-place equipment and speed up assembly time.

[0011] In accordance with a first broad aspect, there is provided a method for assembling components of an optical assembly, the method comprising: providing a structure for guiding light having a top surface and a bottom surface, and comprising a plurality of grooves on the bottom surface; providing a plurality of optical waveguides, each being embedded in a corresponding one of the plurality of grooves, and having a coupling surface at one end; attaching a first array of first optical components to a first substrate; attaching a second array of second optical components to a second substrate independently of a position of the first array of first optical components on the first substrate; positioning the first substrate such that the first array of first optical components is substantially aligned in a one-to-one manner with the coupling surface for a first group of optical waveguides amongst the plurality of optical waveguides; attaching the first substrate to the structure; positioning the second substrate such that the second array of second optical components is substantially aligned in a one-to-one manner with the coupling surface for a second group of optical waveguides amongst the plurality of optical waveguides, the first substrate and the second substrate being spaced apart to form a gap, the gap allowing a position of the second array of second optical components on the second substrate to be independent of the position of the first array of first optical components on the first substrate; and attaching the second substrate to the structure.

[0012] In accordance with a second broad aspect, there is provided an optical assembly comprising: a structure for guiding light having a top surface and a bottom surface, and comprising a plurality of grooves on the bottom surface; a plurality of optical waveguides, each being embedded in a corresponding one of the plurality of grooves, and having a coupling surface at one end; and at least two substrates, each comprising an array of optical components attached thereto, the array of optical components being substantially aligned in a one-to-one manner with the coupling surface for a corresponding group of optical waveguides amongst the plurality of optical waveguides, the at least two substrates being spaced apart to form at least one gap, the at least one gap having a non-constant width along a length thereof in order to allow the array of optical components for each one of the at least two substrates to be aligned with the coupling surface for the corresponding group of optical waveguides.

[0013] In accordance with a third broad aspect, there is provided an optical assembly comprising: a structure for guiding light having a top surface and a bottom surface and comprising a plurality of V-grooves on the bottom surface, the V-grooves extending from a first structure end to a second structure end, one of the first structure end and the second structure end being a beveled structure end; a plurality of optical fibers, each being embedded in a corresponding one of the plurality of

V-grooves and having a beveled surface at one end and a coupling surface adjacent to the beveled surface, the beveled surface and the beveled structure end being positioned in a flush relationship; a first substrate comprising an array of light emitters attached thereto, the light emitters being substantially aligned with the coupling surface for a first group of optical fibers of the plurality of optical fibers in a one-to-one manner; and a second substrate comprising an array of light detectors attached thereto, the light detectors being substantially aligned with the coupling surface for a second group of optical fibers of the plurality of optical fibers in a one-to-one manner, the first substrate and the second substrate being fixedly attached to the structure, the first substrate and the second substrate being spaced apart to form a gap, the gap having a non-constant width along a length thereof in order to allow the array of light emitters to be aligned with the coupling surface for the first group of optical fibers in a one-to-one manner and the array of light detectors to be aligned with the coupling surface for the second group of optical fibers in a one-to-one manner.

[0014] The term "substrate" is used to define any piece of material on which optical components may be attached. The surface area of the substrate is larger than that of the optical components. While the optical components require precision pick-and-place equipment to be manipulated because of their small dimensions, a substrate can be manipulated by hand. As a result, if an optical component is attached to the substrate, the optical component may be manipulated by hand by manipulating the substrate.

DESCRIPTION OF THE DRAWINGS

[0015] Fig. 01a is a perspective view of a two-substrate parallel optical sub-assembly in accordance with an embodiment described herein;

[0016] Fig. 01b is an enlarged view of the two-substrate parallel optical sub-assembly of Fig. 01a showing the optoelectronic chips and the optical coupling mechanism;

[0017] Fig. 02a is a top view of the alumina substrate of Fig. 01a and Fig. 01b, for a light emitting chip, with the maximum allowable positional tolerance of the chip on the substrate being indicated;

[0018] Fig. 02b is a top view of the alumina substrate of Fig. 01a, and Fig. 01b, for a light detecting chip, with the maximum allowable positional tolerance of the chip on the substrate being indicated;

[0019] Fig. 03 is a top view of an ideal position of the light emitting chip with respect to the light detecting chip of Fig. 05a and Fig. 05b, on their respective alumina substrates;

[0020] Fig. 04a is a top view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, with the substrates and the optical ferrule being perfectly aligned and positioned;

[0021] Fig. 04b is a top view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, with the substrates and the optical ferrule being aligned but not perfectly positioned;

[0022] Fig. 05a is a top view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, with the substrates having an alternative shape;

[0023] Fig. 05b illustrates the coupling of light emitted by a laser into an optical fiber of the guiding structure when the laser is located below the optical fiber, in accordance with an embodiment;

[0024] Fig. 05c illustrates the coupling of light from an optical fiber of the guiding structure into a photodetector when the photodetector is located below the optical fiber, in accordance with an embodiment;

[0025] Fig. 05d illustrates the coupling of light emitted by a laser into an optical fiber of the guiding structure when the laser is aligned with the optical fiber, in accordance with an embodiment;

[0026] Fig. 06 is a front cross-sectional view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, with the vertical height differences between the two substrates and the optical ferrule being shown;

[0027] Fig. 07 is a perspective view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, in an unassembled stage wherein the light emitting apertures are to be aligned with the ends of the optical fibers of the optical ferrule; and

[0028] Fig. 08 is a perspective view of the two-substrate parallel optical sub-assembly of Fig. 01a and Fig. 01b, in an unassembled stage wherein the light detecting apertures are to be aligned with the ends of the optical fibers of the optical ferrule.

DETAILED DESCRIPTION

[0029] In one embodiment, a two substrate parallel optical sub-assembly is described that incorporates a laser array optoelectronic chip, a photodetector array optoelectronic chip and a means for coupling multiple light channels to and from each chip through a coupling side of the structure.

[0030] The two substrate parallel optical sub-assembly uses a single optical guiding structure composed of an arrangement of multiple, fixed, well-aligned or parallel optical guiding channels (or optical fibers) which may be embedded in the structure. The arrangement of the optical fibers in the structure may vary.

[0031] The optical guiding structure typically has a single "external" optical interface - like the multi-terminal (MT) style of parallel optical connector - to maintain a high bandwidth-density ratio.

[0032] Fig. 01a shows an example of a two-substrate parallel optical sub-assembly, herein simply referred to as an optical assembly. The optical assembly has an optical guiding structure having an optical ferrule. The ferrule is composed of an MT-style optical connector [01] with two dowel pins [03] (only shown in Fig. 01a), a short optical fiber ribbon section [05], and silicon v-groove structure [07]. The structure 07 has a coupling side from which light is coupled. The structure also holds the beveled tips (or ends) [21] of the embedded optical fibers in place along the coupling side and such that a coupling surface of each of the optical fibers is substantially adjacent to a beveled side of the structure. Each optoelectronic device, the VCSEL array [09] and the photodetector array [11], are attached to their own respective alumina substrates [13] and [15], and wirebonded to gold trace line electrical conductors [17] and [19].

[0033] Referring to Fig. 01b, in this embodiment, the optical ferrule used has 12 aligned, parallel optical fibers [05] that have 45-degree beveled end tips [21] that are all co-linear and on a pitch of 0.25-mm, a close-up view of the tips of the optical fibers is shown in Fig. 01b.

[0034] Referring to both Fig. 01a and 01b, the other end of the optical ferrule is compatible with a single multi-terminal optical connector [01] called an MT ferrule. In this case, only eight of the twelve optical channels are used - there are four transmitter channels (optical fibers), four unused channels (optical fibers) in the middle, and four receiver channels (optical fibers). The unused set of optical fibers is used as a separation (also referred to as a gap having a gap length) [23] between the transmitter and receiver groups of optical fibers to provide for some alignment clearances for the two alumina substrates. The two groups of optical fibers within the optical guiding structure are fixed in-place, with a fixed separation [23] defining a gap.

[0035] Each alumina substrate has an optoelectronic chip fixed to its surface - a light emitting chip, the VCSEL array [09] and a light detecting chip, namely the photodetecting chip [11]. However, other combinations of emitter-emitter or detector-detector chips, especially for different wavelengths, can also be envisioned. The substrates are to be designed so that they can be individually handled and not obstruct each other during optical alignment. In this particular embodiment, the alumina substrates have been designed to be long and narrow with the optoelectronic chips placed near either edge of each substrate.

[0036] The allowable positional and rotational tolerance of the optoelectronic chip on the substrate depends on the overall sizes and shapes of all the sub-components of the assembly. In this particular embodiment, the substrates are mirror images of each other, as in Fig. 02a and Fig. 02b. The nominal positional and rotational tolerance of each optoelectronic chip on their respective substrate is indicated in Fig. 03 by the dashed ovals [25] and [27] placed around each chip, the VCSEL chip [09] and a photodetecting chip [11], respectively.

[0037] In this particular case, one substrate contains a 1x4 VCSEL laser array that is 1-mm x 0.3-mm in footprint and is placed near one edge of its respective alumina substrate and is wirebonded to the gold traces (wirebonds are not shown). The other substrate contains a 1x4 PD array that is 1-mm x 0.3-mm in area and is placed near one edge of its respective alumina substrate and is wirebonded to the gold traces (wirebonds are not shown). Both optoelectronic chips [9] and [11] are placed on the edges of their respective alumina substrates [13] and [15] such that they are adjacent to one another and form a mirror-image pattern.

[0038] Still as shown in Fig. 03, the centers of the active areas of the VCSEL chip [9] and the photodetector chip [11] lie along the dashed horizontal line [29] - it is noted that aligning the sides of the optoelectronic chips may not in fact align the centers of the active areas. Most dice cuts along semiconductor chips have tolerances of more than +/- 25-microns, so the sides of the chips may not be sufficient to align the active areas properly with respect to one another.

[0039] A second alignment consideration is that of the pitch between the devices. The twelve vertical dashed lines [31] indicate a pitch of 0.25-mm between the centers of adjacent active areas for both chips. The dashed lines [31] continue in the space (also referred to as a gap) section [23] between the two independent substrates, as shown in Fig. 03. The pitch is also referred to as a distance between the centers of the active areas along the dashed horizontal line [29]. Hence, the gap length along the line [29] is greater than the distance between the centers of the active areas along the line [29].

[0040] As an example, given an optical ferrule that is 7-mm x 7-mm in area, where the twelve optical fibers are parallel and vertically centered in the optical ferrule with a pitch of 0.25-mm, the gap between the two outer groups of four optical fibers is 1.125-mm. Given that the length (L) of each alumina substrate is 10-mm, it can be calculated that the positional tolerance of both the VCSEL [9] and PD arrays [11] with respect to their ideal positions is roughly +/- 0.3-mm in both x and y and have a rotational tolerance of +/- 2-degrees.

[0041] Therefore, when the optoelectronic chips are well-aligned to the optical fibers [05] in the v-groove structure [07] of the optical ferrule, and they have also been well aligned to their substrate [13] or [15], the orientation as shown in Fig. 04a is obtained.

[0042] If the optoelectronic chips are placed with low positional and rotational accuracy on their substrate (but within the dashed oval boundaries [25] and [27] shown in Fig.

06), once the active areas of each chip [9] or [11] are aligned to the optical fibers of the optical ferrule, the orientation shown in Fig. 04b is obtained. In this case, the gap [23] between the substrates [13] and [15] has a non-constant width along its length. The gap [23] allows the active areas of each chip [9] or [11] to be aligned with the optical fibers while the substrates [13] and [15] are not parallel.

[0043] In one embodiment, the alumina substrates [13] and [15] will only just touch at one corner [33]. This relatively large placement tolerance therefore allows the optoelectronic devices [9] and [11] to be placed without the use of high-precision pick-and-place equipment and reduces the cost and time of the assembly.

[0044] Other geometries for alumina substrates [13] and [15] exist. There are trade-offs between their manufacturability and their ease of alignment however. A specific example of another geometry would be to use substrates with protruding vertices [35], as shown in Fig. 05a, where the optoelectronic chips would be placed near the vertex of their substrate [13] or [15]. This would lead to a greater tolerance to positional and rotational alignment of the two substrates (since the substrates would be much less likely to interfere with one another). Such substrate geometry could however be more difficult to manufacture. Other examples of substrate shapes and related trade-offs are also possible.

[0045] Figures 05b, 05c and 05d illustrate the coupling of light between an optoelectronic device and an optical waveguide of the structure [07], in accordance with an embodiment. In figure 05b, a laser [52] of the array [09] is located under an optical waveguide [21], such as an optical fiber, embedded into the structure [07]. The laser [52] is positioned under the beveled surface of [54] of the optical fiber [21]. Light emitted by the laser [52] passes though the side of the optical fiber, through the cladding, and reflects off the beveled tip, due to reflection, into the core of the optical fiber. The region [22] of the side surface of the optical fiber [21] which is located below the beveled surface [54] defines a coupling surface by which light enters into the fiber before being reflected by the beveled surface [54]. In one embodiment, the center of the active area of the laser [52] is substantially positioned under the center of the beveled surface [54] of the optical fiber in order to improve the coupling of light into the fiber [21].

[0046] In one embodiment, the beveled surface is at 45-degrees to create a reflective glass-air interface at the fiber tip [54]. This interface can reflect light at 90-degrees by either total internal reflection (TIR) when the glass-air interface is preserved, or by depositing a reflective metal layer on the exposed tips of the fiber. The reflective metal layer may be made of gold, silver, and the like.

[0047] Figure 05c illustrates the coupling of light from the optical fiber [21] into a photodetector [56] of the photodetector array [11]. The photodetector [56] is positioned under the beveled surface [54] of the optical fiber [21]. Light propagating into the optical fiber [21] towards the beveled surface [54] reflects off the beveled surface [54], due to TIR or the metallic surface, and is directed normal to the axis of optical fiber [21]. Light passes through the cladding and out of the side of the optical fiber [21] by the coupling region [22] and is collected by the photodetector [56]. In one embodiment, the center of the active area of the photodetector [56] is substantially positioned under the center of the beveled surface [54] of the optical fiber [21] in order to improve the coupling of light into the photodetector [56].

[0048] It should be noted that when the optical waveguide is an optical fiber [21], the curvature of the optical fiber [21] creates a lensing effect which aids in the coupling of light. However, a lensing system may be added between the optical waveguides and the optoelectronic devices in order to improve the coupling of light.

[0049] Figure 05d illustrates the coupling of light emitted by the laser [52] when the laser [52] is aligned with the end [58] of the optical fiber [21]. In this embodiment, the end [58] is cut at a substantially right angle and corresponds to the coupling surface of the optical fiber [21] by which light emitted by the laser [52] is coupled into the optical fiber [21].

[0050] Referring to Fig. 06, in addition to the positional and rotational placement of the optoelectronic chips [09] and [11] on their respective alumina substrates [13] and [15], the vertical height above the optoelectronic chip can be calibrated using a precision spacer (also referred to as a spacing device) [39] or [41] fixed to any of the substrates [13] or [15]. It should be understood that the spacer [39] and [41] may be part of the substrates [13] and [15], respectively.

[0051] Different heights of emitter and detector optoelectronic chips can be accommodated by using different thicknesses for the spacers. A spacer can be made of glass or any other low-expansion precision cut material. The spacer can also accommodate differing optimal divergence conditions or lensing system requirements.

[0052] For example, Fig. 06 shows a front side view of the two substrate optical sub-assembly of Fig. 04a and Fig. 04b in a highly magnified but proportional view of the space (or gap) [23] and the two adjacent wirebonded [37] optoelectronic chips [9] and [11]. Assuming a 1x4 VCSEL array chip [09] which is 200-microns thick and requires a distance [44] of 132.5-microns between the laser aperture (or the active area of the lasing element on the chip [9]) and the centre of the optical fiber, a precision spacer of 280-microns [39] is used.

[0053] With a 1x4 photodetector array [11] which is 150-microns thick and requires a distance [46] of 102.5-microns between the active area of the detector element and the centre of the optical fiber, a precision spacer of 190-microns [41] is used.

[0054] Although a small vertical height difference [43] between the two substrates [13] and [15] may occur, these small differences can be handled in a variety of ways to maintain electrical and mechanical connections, such as different substrate thicknesses or the use of different amounts of epoxy and/or longer or shorter wirebonds or electrical connections between the chips and their substrates [37].

<u>Alignment procedure:</u>

[0055] Where the optical guiding structure has the optical ferrule as described hereinabove, and when the useful channels of the optical ferrule are the four left-most optical fibers and the four right-most optical fibers, with the four middle optical fibers being left unused, the alignment of the three parts (the optical ferrule with the two packages each comprising an optoelectronic device, a substrate and an optional spacer) are as follows:

[0056] A wirebonded 1x4 VCSEL array chip [9] is attached to a first substrate [13] and a wirebonded 1x4 Photodetector array chip [11] is attached to a second alumina substrate [15]. The position of the array chip [11] on the second substrate [15] is independent of the position of the array chip [9] on the first substrate [13].

[0057] The first alumina substrate [13] carrying the wirebonded 1x4 VCSEL array chip [9] is aligned using a vision system so that the centers of each active area of each VCSEL are substantially centered with the centers of the four optical fiber cores on one side of the body of the optical ferrule, as shown in Fig. 07.

[0058] The optical fibers embedded in the ferrule [07] are divided into three groups. A first group of four optical fibers is associated with the four VCSELs, a second group is associated with the gap, and a third group is associated with the four photodetectors.

[0059] In one embodiment, the above alignment is done by holding the first alumina substrate [13] fixed in place while manipulating the body of the optical ferrule [07]. By moving the ferrule [07] along the x and y axis and rotating the ferrule [07] around the z axis, it is possible to align the four optical fibers with the four VCSELs as indicated by the dashed arrows [45]. As a result, each VCSEL is positioned under the beveled surface [21] of a corresponding optical fiber of the first group. The alignment of the beveled surface [21] of the optical fibers with the VCSELs is performed visually by a user of the alignment method while the VCSELs are un-powered. In one embodiment, the active area of each VCSEL is substantially positioned under the center of its corresponding optical fiber.

[0060] While the present description refers to holding the first alumina substrate [13] fixed in place while manipulating the body of the optical ferrule [07], a person skilled in the art understands that the reverse is also possible. In this case, the body of the optical ferrule [07] is held in place while manipulating the first alumina substrate [13].

[0061] In one embodiment, a vision system such as a microscope, for example, may be used to perform the alignment. The vision system can be any system permitting a visual, un-powered alignment. Hence, there is no need to use passive mechanical stops or location borders. Such a system also avoids using a "blind" search for a maximal optical power to perform the alignment.

[0062] Once the VCSELs have been positioned to face the beveled surface [21] of their corresponding optical fiber [21], the structure [07] is attached to the substrate [13]. Any mechanical means known to a person skilled in the art may be used to fixedly attached the substrate [13] and the structure [07] together.

[0063] In one embodiment of the method, a spacer [39] is provided and positioned between the substrate [13] and the structure [07]. During the alignment procedure of the VCSELs with corresponding optical fibers, abutting the spacer [39] on the structure [07] and resting on the spacer [39] restricts the overall movement of the optical ferrule to only about 3 degrees of motion during an alignment which is performed by manipulating the optical ferrule using, for example, a vacuum chuck. The first substrate [13] is then epoxy cured in place to the optical ferrule, as indicated by the black material [47] in Fig. 11.

[0064] Still referring to Fig. 11, the second alumina substrate [15] carrying the wirebonded 1x4 Photodetector array chip [11] is then held fixedly in place while the assembly of the optical ferrule with the first substrate [13] is manipulated as indicated by the dashed arrows [49]. By moving the ferrule [07] with the first substrate [13] along the x and y axis and rotating the ferrule [07] around the z axis, it is possible to align the four optical fibers with the four photodetectors. As result, each photodetector of the array [11] is positioned under the beveled surface [21] of a corresponding optical fiber of the third group. The alignment of the beveled surface [21] of the optical fibers with the VCSELs is performed visually by a user of the alignment method while the VCSELs are un-powered. In one embodiment, the active area of each photodetector is substantially positioned under the center of its corresponding optical fiber.

[0065] It should be understood that the optical ferrule with the first substrate [13] may be held in place instead of the alumina substrate [15]. In this case, the alumina substrate [15] is manipulated in order to align the photodetectors with their corresponding optical fibers.

[0066] Once the photodetectors have been positioned to face the beveled surface [54] of their corresponding optical fiber [21], the structure [07] is attached to the substrate [15]. Any mechanical means known to a person skilled in the art may be used to fixedly attach the substrate [15] and the structure [07] together.

[0067] In one embodiment of the method, a spacer [41] is provided and positioned between the second substrate [15] and the structure [07]. During the alignment procedure of the photodetectors with the corresponding optical fibers, resting on the spacer [41] restricts the overall movement of the optical ferrule [07] to only about 3 degrees of motion during an alignment which is performed by manipulating the optical ferrule using, for example, a vacuum chuck. Once positioned and aligned over the second substrate [15], the optical ferrule can be held in place using a vacuum suction holder, for example, to allow the positioning of the centers of each of the fibers (also referred to as the centers of the coupling surfaces of the fibers) in the second group of four optical fibers over each one of the active areas of the elements in the array of elements of the photodetector chip [15].

[0068] The second substrate [15] is then attached or epoxy cured in place to the body of the optical ferrule along side the first substrate [13] resulting in the assembly as illustrated in Fig. 04a (without the epoxy being shown). Other types or combinations of attaching devices can be chosen depending on the attachment reliability level needed for a particular assembly. For example, such attaching devices can also be ultrasonic bonding, thermal bonding, or a mechanical clamp.

[0069] It should be noted that any means for attaching the substrates [13] and [15] to the structure [07] may be used. Furthermore, any mechanical means for holding in place the structure [07] and/or the substrates [13] and [15] during the alignment procedure may be used.

[0070] Once the second substrate [15] is attached to the body of the optical ferrule alongside the first substrate [13], a defined gap [23] between the two substrates exists but its exact shape is determined by the initial positioning of the VCSEL and Photodetector chips on their respective substrates. The gap allows the position of the array chip [11] on the second substrate [15] to be independent of the position of the array chip [9] on the first substrate [13] while having the arrays [9] and [11] aligned with the coupling surface of their corresponding optical fiber [21].

[0071] Other optical guiding structures can be envisioned for this geometry, including lens arrays and parts made from polymer waveguiding materials. The basic premise is to align two very small parts to the same optical guiding structure - given that each part is on its own, larger, sub-mount and there is a provisioned amount of positional tolerance in the assembly to accommodate the independent movement of each sub-mount. This is in contrast to aligning the very small parts to each other and then aligning to an optical guiding structure.

[0072] The skilled person in the art will appreciate that in the above description, the optoelectronic chips [9] and [11], together with their respective substrate [13] and [15], represent packages having an array of elements. The optical components can be any type of semiconductor devices having light emitting, light detecting or light guiding (such as microlenses) capabilities. Each of the elements is further characterized as having an active area to be aligned with the beveled ends of the optical fibers in the structure when abutting the packages on the structure.

[0073] The above description refers to an optical assembly having two substrates, or two packages each comprising a substrate with elements being on the substrate. It is understood that an assembly having more than two packages can be assembled without departing from the scope of the description. The substrates can also be of any material other than alumina which is suitable for the placement of the elements desired, such as Silicon or Germanium alloys for example.

[0074] Moreover, the packages may be abutted against the structure in other manners as described, with or without the use of a spacing device to provide for a space between the elements of the packages and the optical fibers in the structure.

[0075] While the present description refers to a structure 07 having a beveled end, the structure end may have any shape. In this case, the structure is made of a transparent material so that a user may see the beveled surface 21 through the structure 07 in order to position the arrays of optoelectronic devices. Furthermore, when the structure 07 is transparent, the beveled end 21 can be located at any position along the groove.

[0076] It should be understood that any optical waveguide may be embedded in the structure [07]. The optical waveguide may have any dimensions and cross-sectional shape.

[0077] It should be understood that any packages adapted to receive the optical components arrays [09] and [11] thereon may be used to replace the substrates [13] and [15]. The packages may be made of any material and may have any shape. In one embodiment, the dimensions of the packages or the substrates [13] and [15] are greater than those of the arrays [09] and [11].

[0078] While the present description refers to V-grooves, it should be understood that grooves having any shape and dimensions adapted to receive an optical waveguide may be used. The grooves may be positioned in a parallel or non-parallel manner.

I/WE CLAIM:

1. An optical assembly comprising:

a structure for guiding light having a top surface and a bottom surface, and comprising a plurality of grooves on said bottom surface;

a plurality of optical waveguides, each being embedded in a corresponding one of said plurality of grooves, and having a coupling surface at one end; and

at least two substrates, each comprising an array of optical components attached thereto, said array of optical components being substantially aligned in a one-to-one manner with said coupling surface for a corresponding group of optical waveguides amongst said plurality of optical waveguides, said at least two substrates being spaced apart to form at least one gap, said at least one gap having a non-constant width along a length thereof in order to allow said array of optical components for each one of said at least two substrates to be aligned with said coupling surface for said corresponding group of optical waveguides.

2. The optical assembly as claimed in claim 1, wherein said plurality of optical waveguides each comprise a beveled end at said one end, said coupling surface being adjacent to said beveled end.

3. The optical assembly as claimed in claim 1 or 2, wherein the plurality of optical waveguides comprises a plurality of optical fibers.

4. The optical assembly as claimed in any one of claims 1 to 3, wherein said plurality of grooves are arranged in a parallel manner.

5. The optical assembly as claimed in any one of claims 1 to 4, wherein each one of said at least two substrates comprises an array of optoelectronic components.

6. The optical assembly as claimed in claim 5, wherein a first one of said at least two substrates comprises light emitters and a second one of said at least two substrates comprises light detectors.

7. The optical assembly as claimed in claim 1, wherein the optical components comprise active areas having centers which are co-linear and equally spaced, and the width of the gap is greater than a distance between two subsequent centers.

8. The optical assembly as claimed in claim 1, further comprising a spacing device located between the structure and at least one of the at least two substrates, the spacing device providing a space between one of the optical components and one of the optical waveguides.

9. The optical assembly as claimed in claim 1, wherein said array of optical components comprises an array of lenses.

10. The optical assembly as claimed one claim 1, wherein said at least two substrates comprises two substrates, said two substrates being patterned to form a mirror image.

11. The optical assembly as claimed in claim 10, wherein said array of optical components is placed at an edge of a corresponding one of the two substrates.

12. The optical assembly as claimed in claim 11, wherein each one of the two substrates comprises an array of optoelectronic components, said array of optoelectronic components being connected to a corresponding one of said two substrates via electrical connections.

13. The optical assembly as claimed in claim 12, wherein the electrical connections comprise electrical connections for accommodating a tolerance in a position of the optoelectronic components with respect to said corresponding one of said two substrates.

14. The optical assembly as claimed in claim 2, wherein said structure has a beveled end in a flush relationship with said beveled surface for said plurality of said optical waveguides.

15. The optical assembly as claimed in claim 14, further comprising a precision end-couple ferrule member provided at a connector end opposite from the beveled end of the structure, for guiding a complementary ferrule member to end-couple fiber-to-fiber the plurality of fibers at the connector end, wherein the coupling side is also adjacent to the connector end.

16. A method for assembling components of an optical assembly, the method comprising:

providing a structure for guiding light having a top surface and a bottom surface, and comprising a plurality of grooves on said bottom surface;

providing a plurality of optical waveguides, each being embedded in a corresponding one of said plurality of grooves, and having a coupling surface at one end;

attaching a first array of first optical components to a first substrate;

attaching a second array of second optical components to a second substrate independently of a position of said first array of first optical components on said first substrate;

positioning said first substrate such that said first array of first optical components is substantially aligned in a one-to-one manner with said coupling surface for a first group of optical waveguides amongst said plurality of optical waveguides;

attaching said first substrate to said structure;

positioning said second substrate such that said second array of second optical components is substantially aligned in a one-to-one manner with said coupling surface for a second group of optical waveguides amongst said plurality of optical waveguides, said first substrate and said second substrate being spaced apart to form a gap, said gap allowing a position of said second array of second optical components on said second substrate to be independent of said position of said first array of first optical components on said first substrate; and attaching said second substrate to said structure.

17. The method as in claim 16, wherein at least one of said positioning a first substrate and said positioning a second substrate comprises using a vision system.

18. The method as claimed in claim 16, wherein said positioning a first substrate comprises substantially aligning a center of an active area of at least one of said first components with a center of said coupling surface for a corresponding optical waveguide amongst said first group.

19. The method as claimed in claim 18, wherein said positioning a second substrate comprises substantially aligning a center of an active area of at least one of said second components with a center of said coupling surface for a corresponding optical waveguide amongst said second group.

20. The method as claimed in claim 16, wherein at least one of said positioning a first substrate and said positioning a second substrate comprises providing at least one spacing device between said structure and at least one of said first substrate and said second substrate.

21. The method as in claim 20, wherein said positioning said first substrate comprises:

holding the first substrate and a first spacing device in a fixed position;

moving the structure until the optical components of the first array are aligned with the coupling surface of the optical waveguides of the first group in a one-to-one manner, the moving and the holding being performed simultaneously; and

resting on the first spacing device while performing the moving.

22. The method as claimed in claim 21, wherein the moving of the structure comprises using a vacuuming device.

23. The method as claimed in claim 20, wherein said positioning a second substrate comprises:

holding the second substrate and a second spacing device in a fixed position;

moving the structure until the optical components of the second array are aligned with the coupling surface of the optical waveguides in the second group in a one-to-one manner, the moving and the holding being performed simultaneously; and

resting on the second spacing device while performing the moving.

24. The method as claimed in claim 16, wherein said providing a plurality of optical waveguides comprises providing a plurality of optical fibers.

25. The method as claimed in claim 16, wherein said providing a plurality of optical waveguides comprises providing a plurality of optical waveguides, each comprising a beveled end at said one end, said beveled end being adjacent to said coupling surface.

26. The method as claimed in claim 16, wherein said providing a structure comprises providing a beveled structure having a beveled end.

27. The method as claimed in claim 26, wherein said beveled end of said beveled structure and said beveled surface for said plurality of optical waveguides are positioned in a flush relationship.

28. An optical assembly comprising:

a structure for guiding light having a top surface and a bottom surface and comprising a plurality of V-grooves on said bottom surface, said V-grooves extending from a first structure end to a second structure end, one of said first structure end and said second structure end being a beveled structure end;

a plurality of optical fibers, each being embedded in a corresponding one of said plurality of V-grooves and having a beveled surface at one end and a coupling surface adjacent to said beveled surface, said beveled surface and said beveled structure end being positioned in a flush relationship;

a first substrate comprising an array of light emitters attached thereto, said light emitters being substantially aligned with said coupling surface for a first group of optical fibers of said plurality of optical fibers in a one-to-one manner; and

a second substrate comprising an array of light detectors attached thereto, said light detectors being substantially aligned with said coupling surface for a second group of optical fibers of said plurality of optical fibers in a one-to-one manner, said first substrate and said second substrate being fixedly attached to said structure, said first substrate and said second substrate being spaced apart to form a gap, said gap having a non-constant width along a length thereof in order to allow said array of light emitters to be aligned with said coupling surface for said first group of optical fibers in a one-to-one manner and said array of light detectors to be aligned with said coupling surface for said second group of optical fibers in a one-to-one manner.

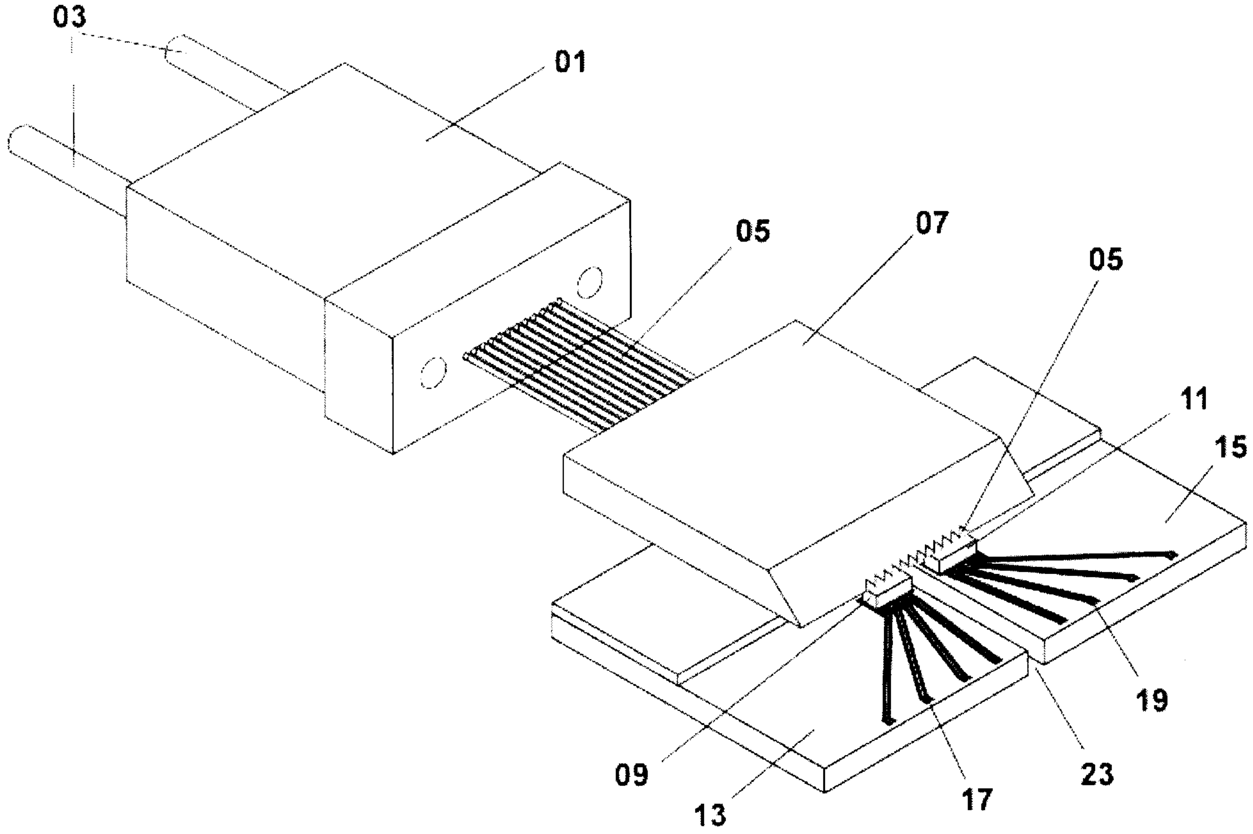

FIGURE 01a

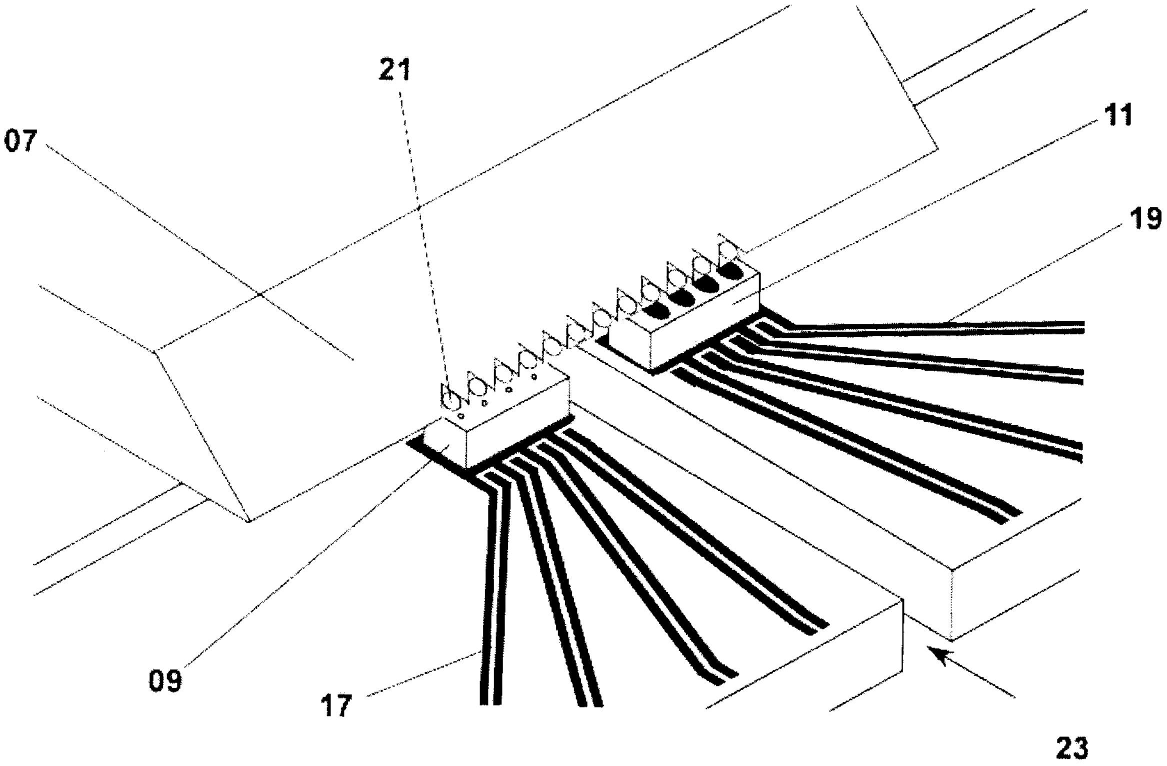

FIGURE 01b

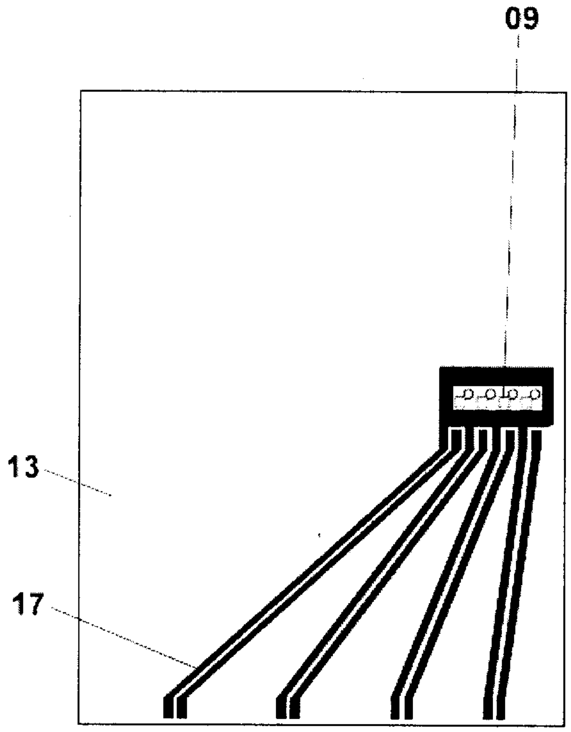

FIGURE 02a

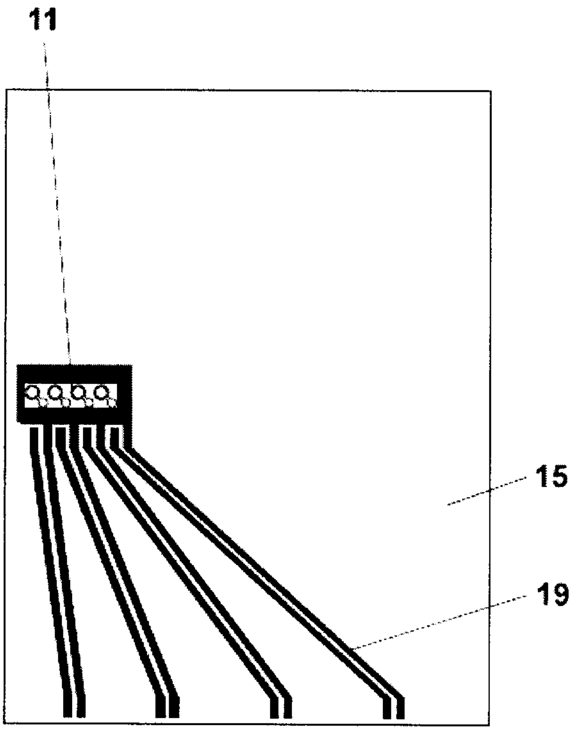

FIGURE 02b

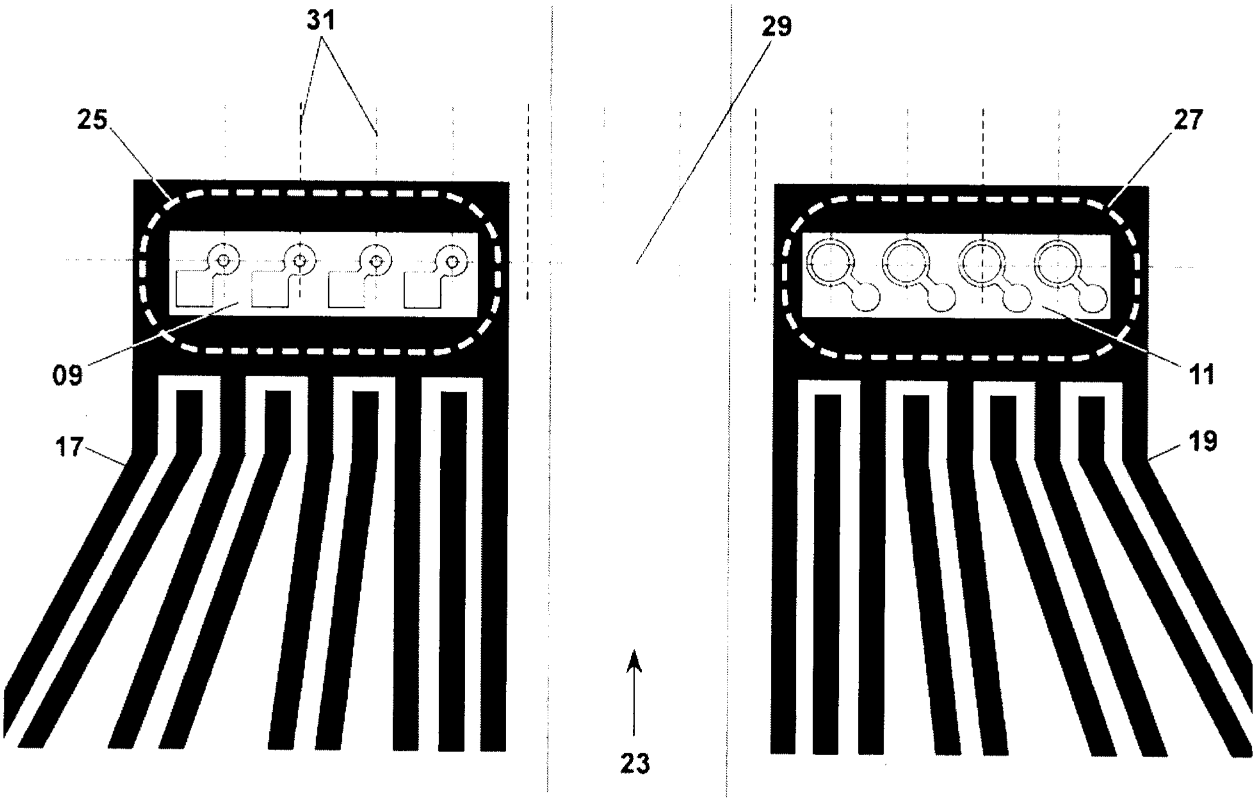

FIGURE 03

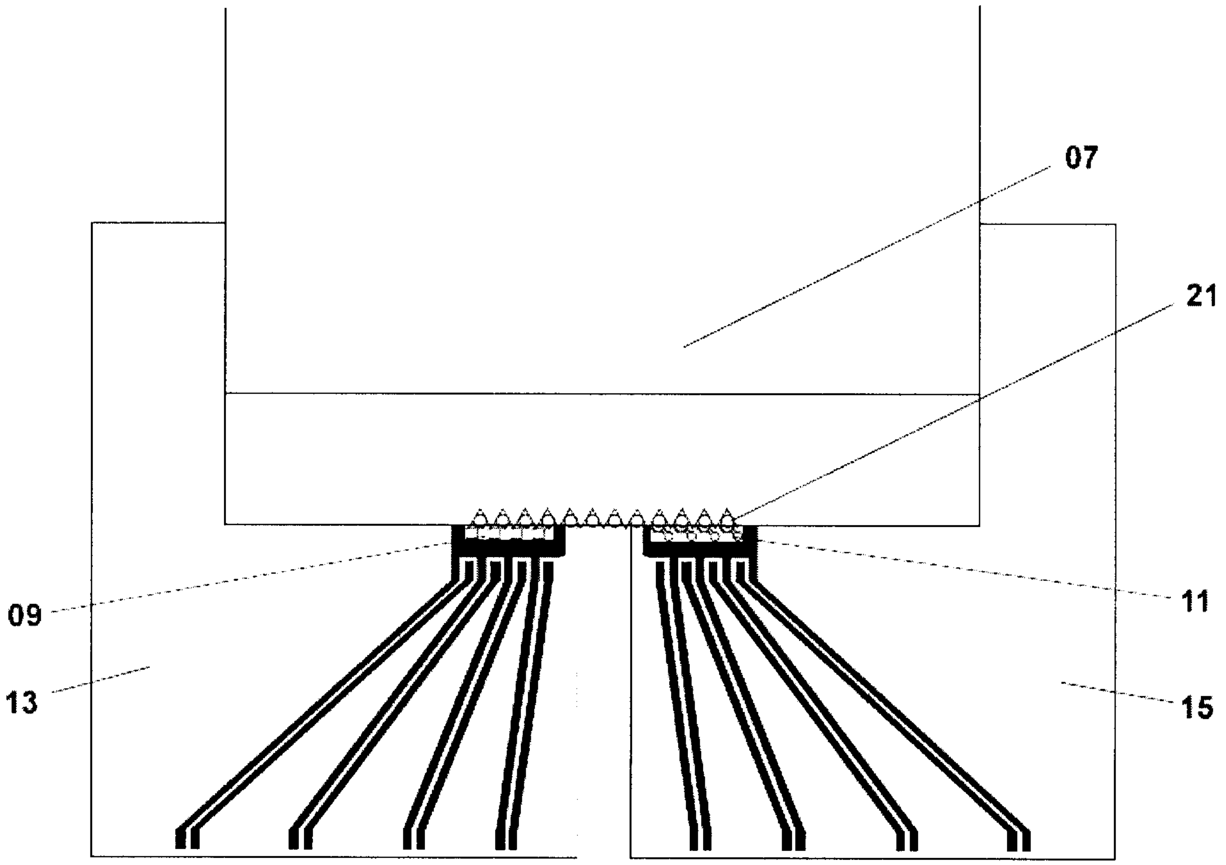

FIGURE 04a

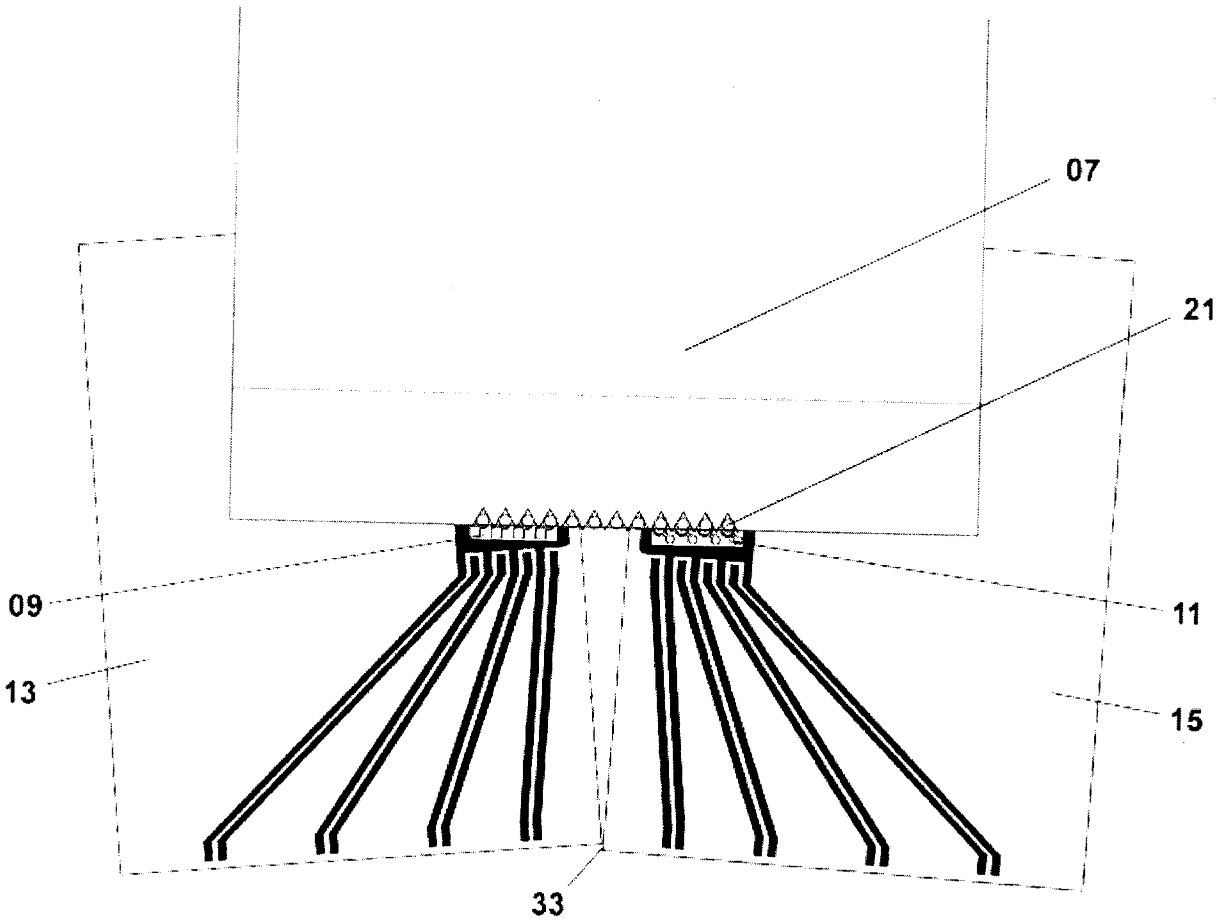

FIGURE 04b

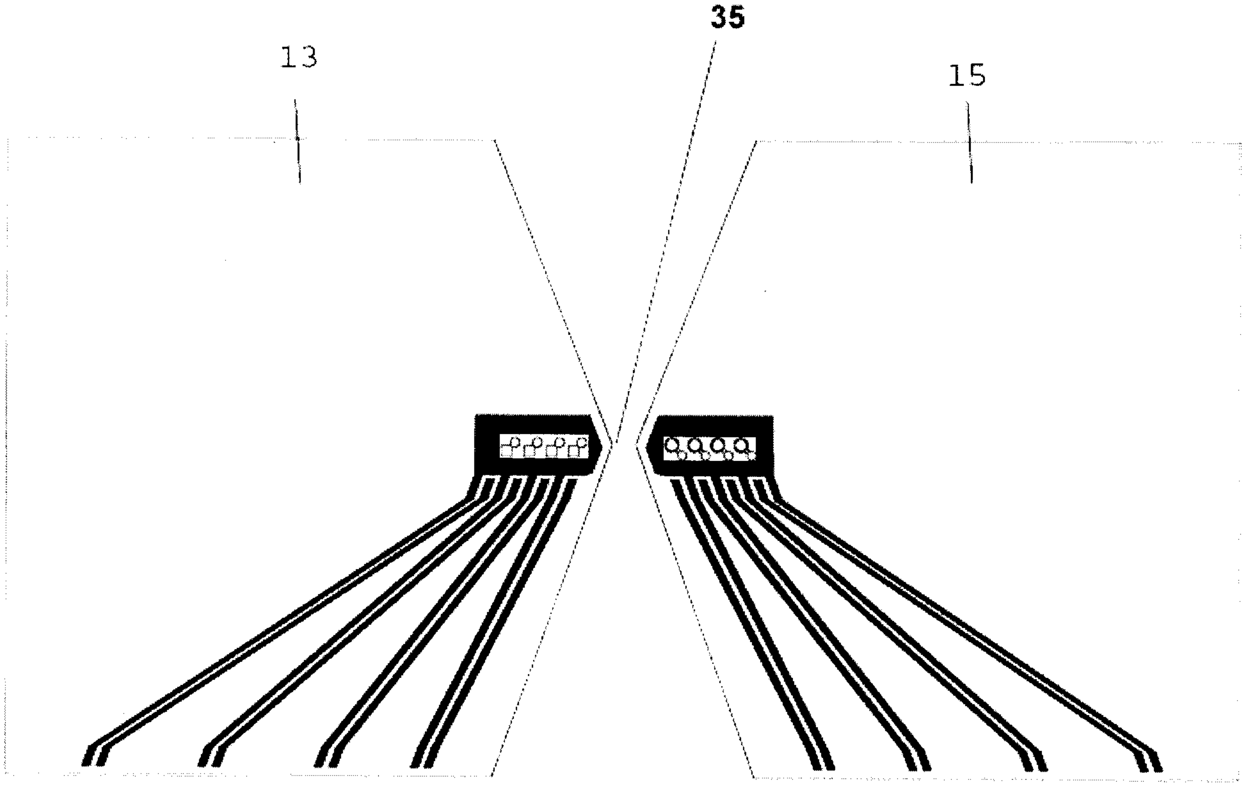

FIGURE 05a

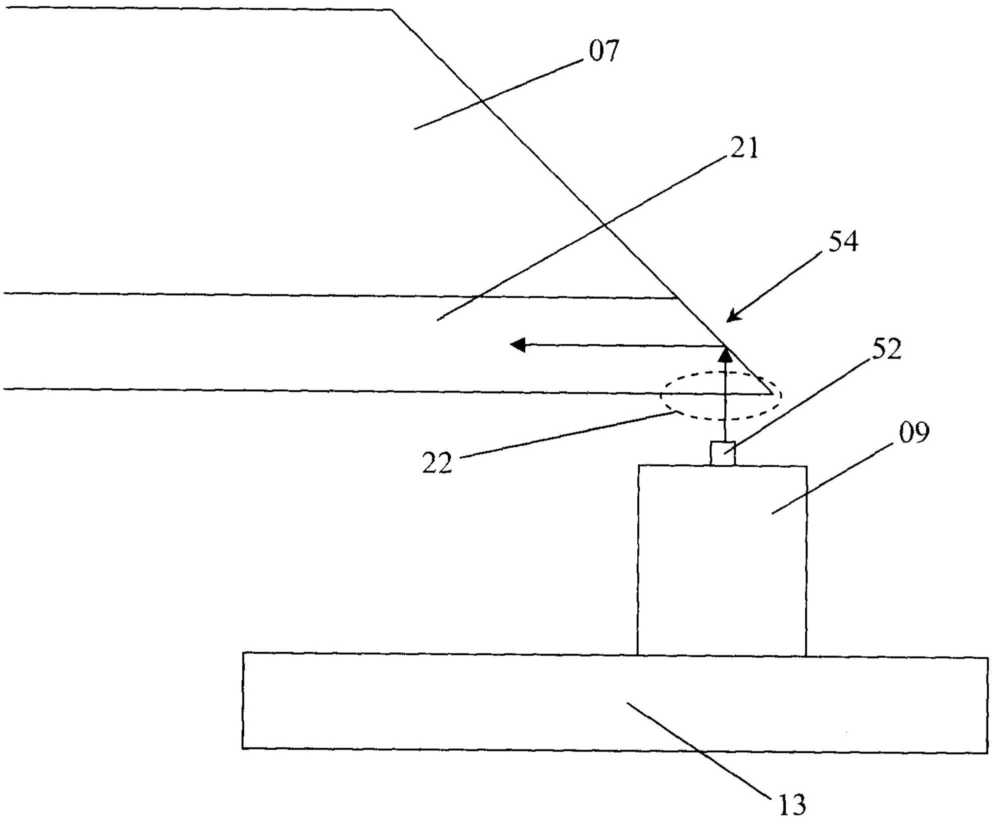

FIGURE 05b

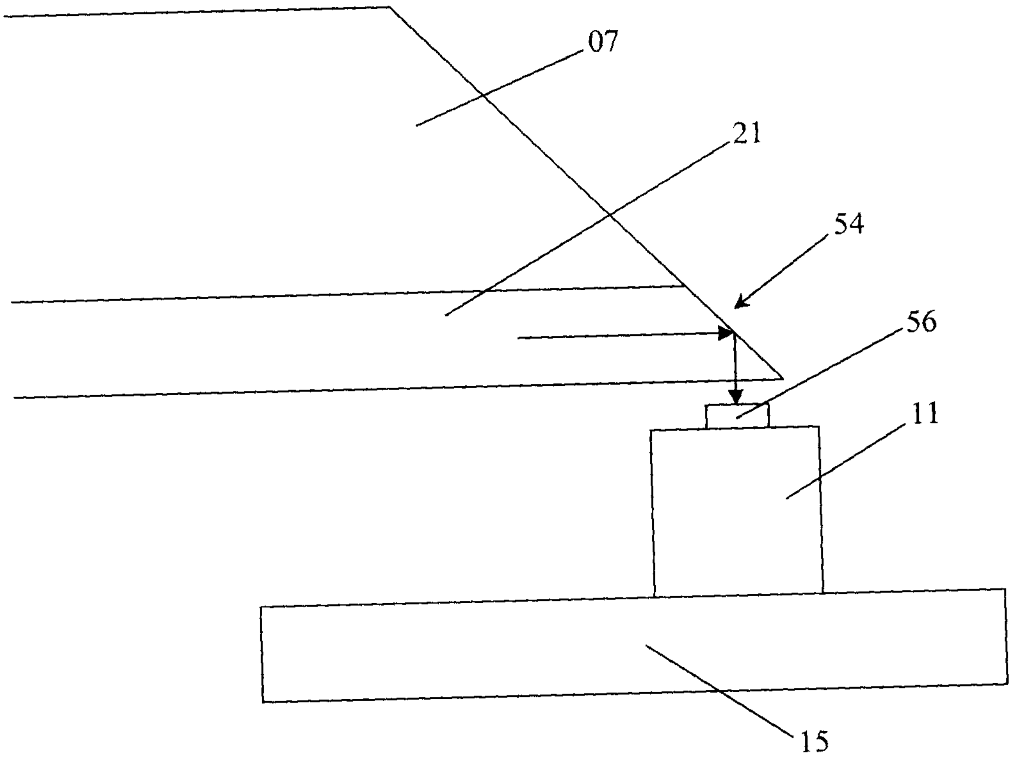

FIGURE 05c

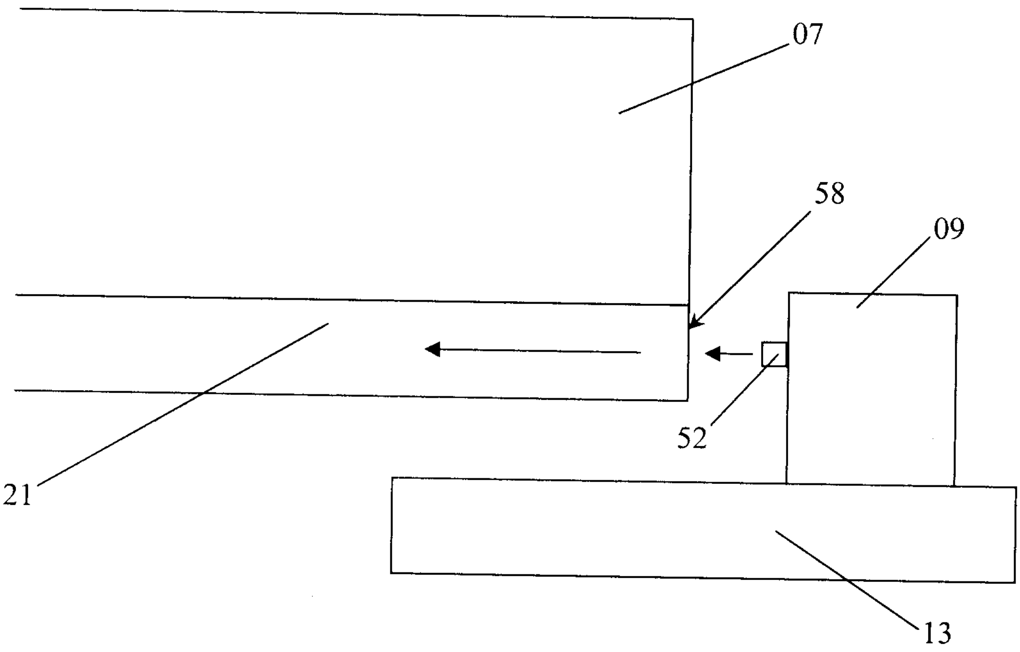

FIGURE 05d

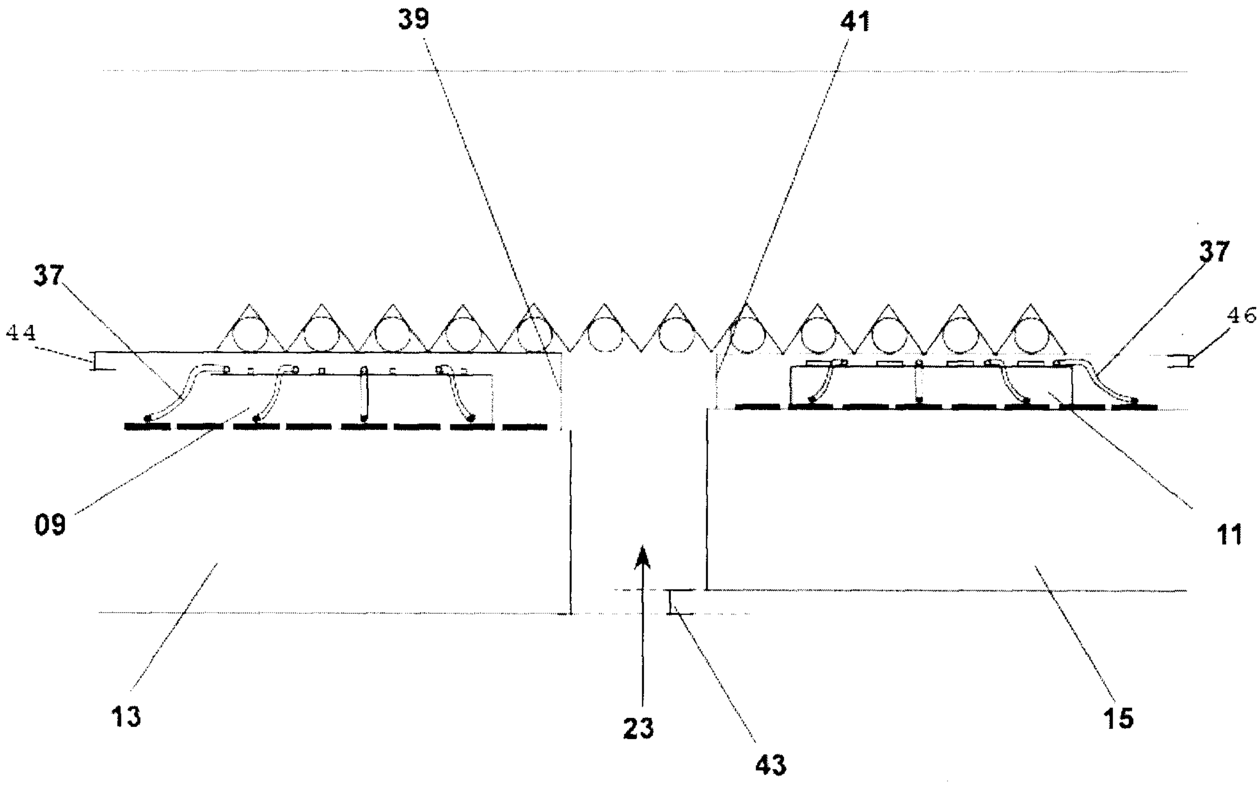

FIGURE 06

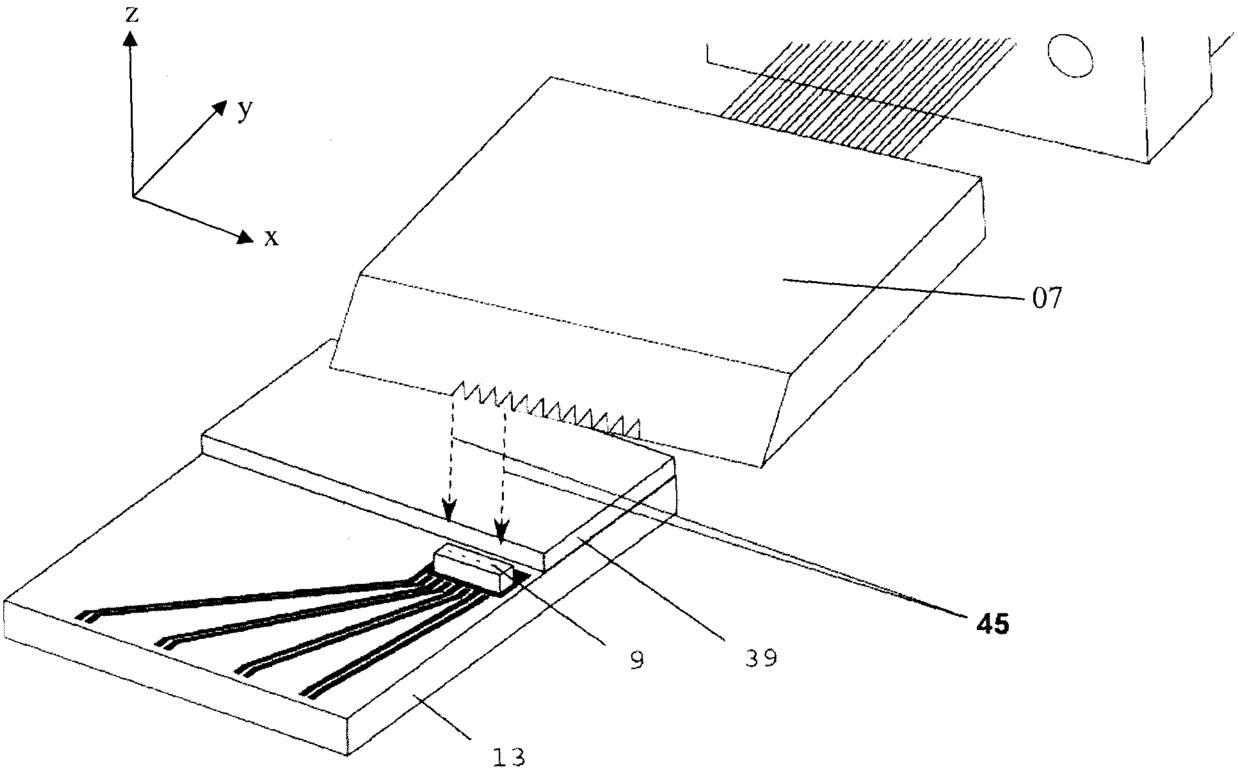

FIGURE 07

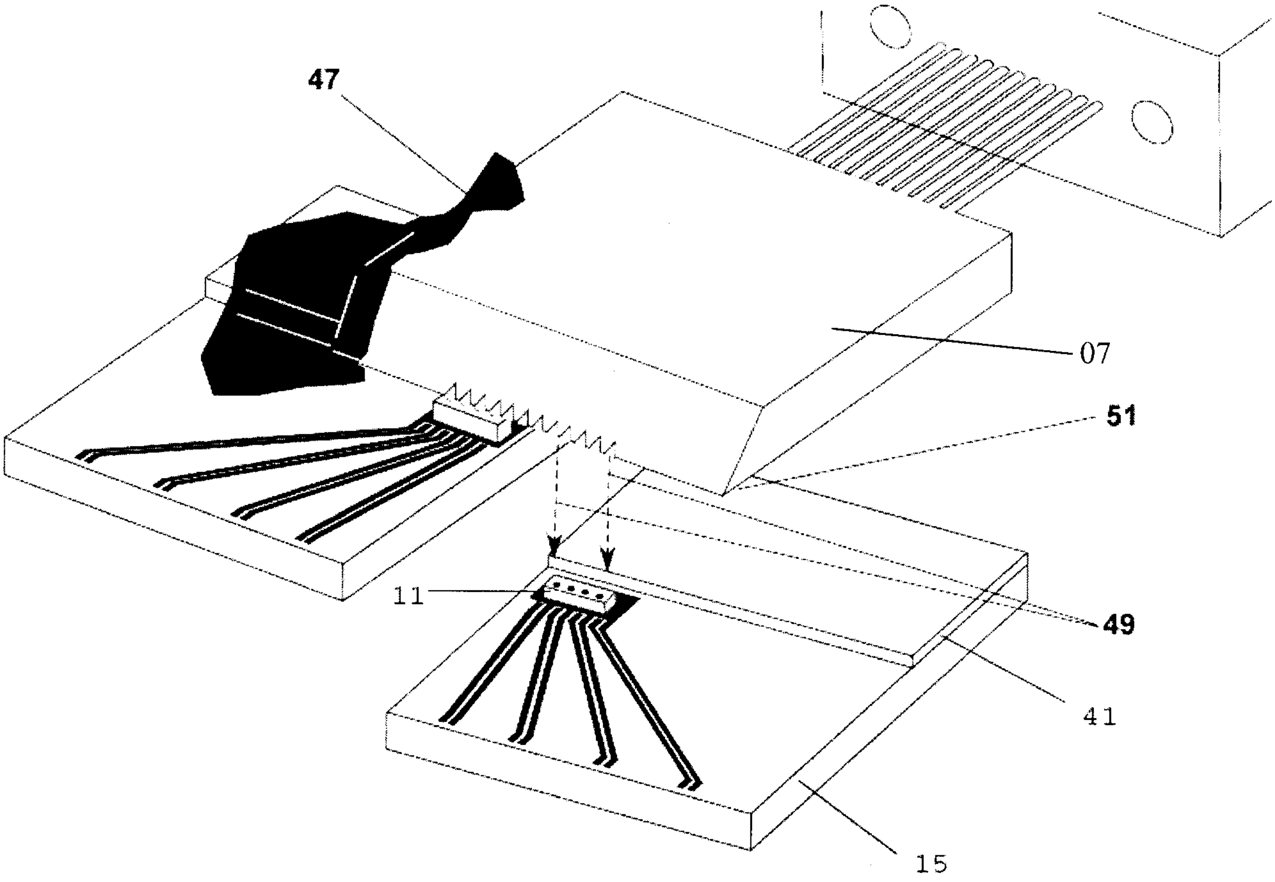

FIGURE 08

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2008/001708

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***G02B 6/12*** (2006.01) , ***G02B 6/13*** (2006.01) , ***G02B 6/24*** (2006.01)
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.: G02B 6/12, G02B 6/13, G02B 6/24, G02B 6/30, G02B 6/36, G02B 6/122, G02B 6/125
US Cl. 385/014; 385/046; 385/049; 385/050; 385/052; 385/053

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
DELPHION (all collections) Google Scholar Japanese Patent Database Korean Patent Database
IEEE Online Database ESPACENET Canadian Patent Database
search terms used: optical, connect*, surface, mount, substrate, array*, fiber, fibre, waveguide, adjacent, parallel, groove, slot, notch, parabit, MAC, flip-chip, assembly, space, gap, width, align*, module, coupl*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Technical Publication - Conf. Proceedings: Electronic Packaging Technology Conference - 2005 (SUZUKI ET AL.) "40 Gb/s parallel optical (9 December 2005) (09-12-2005) interconnection module pgs. 367 to 370 for optical backplane application" (entire document)	1 to 28
Y	Technical Publication - Conf. Proceedings: 1998 IEMT/IMC Symposium "An optical coupling technique (NTT OPTO-ELECTRONIC LABS) for parallel optical interconnection (17 April 1998) (17-04-1998) modules using polymeric optical pgs. 127 to 132	1 to 28

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

*	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
9 December 2008 (09-12-2008)

Date of mailing of the international search report
17 December 2008 (17-12-2008)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
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50 Victoria Street
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Facsimile No.: 001-819-953-2476

Authorized officer

Daniel Weslake 819- 997-2999

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2005/010587 A1 (REFLEX PHOTONICS INC.) (03-02-2005) (03-February-2005) (entire document)	1 to 28

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2008/001708

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO 2005010587A1	03-02-2005	CA 2569263A1 EP 1664871A1 JP 2006528786T US 7197224B2 US 2005018993A1	03-02-2005 07-06-2006 21-12-2006 27-03-2007 27-01-2005