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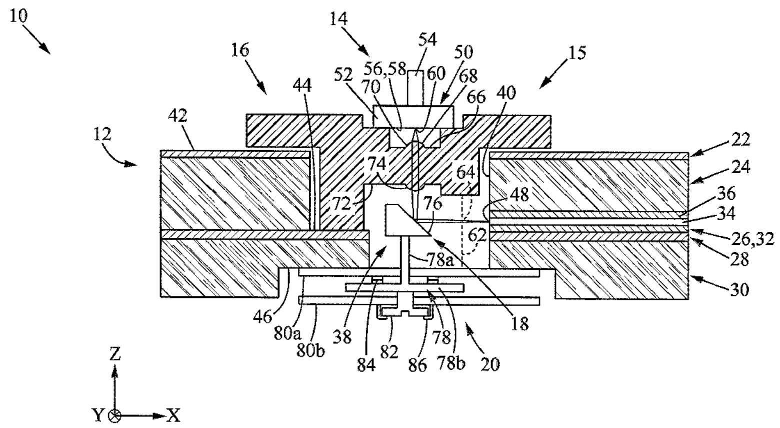

FIG. 1

(57) Abstract: The present invention relates to an optical system (10) comprising: an optical circuit board (12) having a transmission region (48), an optical coupling system (15) comprising a first transmission region (64) optically coupled to the transmission region (48) of the board (12), a second transmission region (68) adapted to be optically coupled to a transmission region (60) of a mating optical device (14), the first and second regions (64, 68) being optically associated only with each other. The optical coupling system (15) further comprises an optical coupling device (16), a reflective arrangement (18), alignment adjusting means (20) adapted to move the reflective arrangement (18) between a position in which the arrangement (18) does not transmit light between the first and second regions (64, 68), and a position in which the arrangement (18) transmits light between the first and second regions (64, 68).

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OPTICAL SYSTEM WITH ALIGNMENT ADJUSTING MEANS

FIELD OF THE INVENTION

The instant invention relates to optical systems.

BACKGROUND OF THE INVENTION

Most communication systems involve a number of system-cards. Such cards are usually manufactured as so-called printed circuit boards (PCBs).

Because of the ever increasing requirements in data rates, due for example to the Internet, the limits of using electrical communications are being reached. It has become difficult to guarantee good signal integrity over the electrical lines.

To respond to this bandwidth demand, high speed systems are now being built with an optical layer (an optical fibre or a planar waveguide) incorporated in replacement of the electrically-conducting metal. Indeed, light does not suffer from the same limitations as electricity.

Optical coupling devices are usually used to interconnect two optical layers of a PCB in an intra-card application or to interconnect an optical layer of a motherboard with an optical device of an outside system-card in an inter-card application.

However, manufacturing tolerances of a PCB are not always well mastered and can reach values of ±10 %, thereby inducing alignment problems leading to an optical coupling which is not efficient or even non-existent.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an optical system with an optimal optical coupling.

To this aim, it is provided an optical system according to claim 1.

With these features, the position of the reflective arrangement can be adjusted to compensate for the misalignment due to the manufacturing tolerances of the optical circuit board, thereby increasing the optical coupling efficiency of the optical system of the present invention.

In some embodiments of the invention, one might also use one or more of the features defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention will readily appear from the following description of several of its embodiments, provided as non-limitative examples, and of the accompanying drawings.

On the drawings:

- Fig. 1 is a cross-sectional view of an optical system according to a first embodiment of the invention;
- Fig. 2 is a cross-sectional view of an optical system according to a second embodiment of the invention;
- Fig. 3 is a cross-sectional view of an optical system according to a third embodiment of the invention;
- Fig. 4 is a cross-sectional view of an optical system according to a fourth embodiment of the invention; and
- Fig. 5 is a cross-sectional view of an optical system according to a fifth embodiment of the invention.

On the different Figures, the same reference signs designate like or similar elements.

DETAILED DESCRIPTION

Fig. 1 shows an optical system 10 according to a first embodiment of the invention.

The optical system 10 comprises an optical circuit board 12, a mating optical device 14 and an optical coupling system 15 comprising an optical coupling device 16, a reflective arrangement 18 and alignment adjusting means 20.

The optical circuit board 12 is a backplane PCB which can be a hybrid or a full optical PCB.

The PCB 12 is a layer stack comprising five superimposed layers: a top reference layer 22, a top insulative layer 24 below the top reference layer 22, an optical waveguide layer 26 below the top insulative layer 24, a bottom reference layer 28 below the optical waveguide layer 26, and a bottom insulative layer 30 below the bottom reference layer 28.

The orientation and position terms used in the present description are given in reference to a vertical direction Z, normal to the different layers of the PCB 12, and pointing toward the mating optical device 14 to be optically coupled to the PCB 12.

Each layer of the PCB 12 extends parallel to an XY plane, X corresponding to the direction of propagation of light in the optical waveguide layer 26 and Y corresponding to the transverse direction.

The top and bottom reference layers 22, 28 are for example made from copper.

The optical waveguide layer 26 comprises a plurality of optical waveguides 32 extending parallel to each other along the direction X.

The optical waveguides 32 are separated one from another by a distance along the direction Y, this distance being either constant or not, depending on the requirements. For example, the distance can be set constant to 250 µm.

Each optical waveguide 32 comprises a core 34 surrounded by a cladding 36 having a lower refractive index than the core 34.

The optical waveguides 32 may be polymer waveguides, glass sheet waveguides or waveguides obtained by embedded fibre technology, or the like.

A cut-out 38 is formed in the PCB 12.

The cut-out 38 is defined by a straight wall 40 on the side of the cut-out 38 where the optical waveguides 32 extend.

The straight wall 40 extends in a plane parallel to the YZ plane, normal to a top surface 42 of the PCB 12 formed by the top surface of the top reference layer 22.

The cut-out 38 is also defined by a first horizontal wall 44 on the side of the cut-out 38 opposite to the straight wall 40.

The first horizontal wall 44 extends in a plane parallel to the XY plane and is formed by a portion of the top surface of the bottom reference layer 28.

The cut-out 38 is further defined by a second horizontal wall 46 on both sides of the cut-out 38.

The second horizontal wall 46 extends in a plane parallel to the XY plane and is formed in the bottom insulative layer 30.

The straight wall 40 forms an optical interface of the PCB 12.

More precisely, all the cores 34 of the optical waveguides 32 mouth into the cut-out 38 to define the optical interface 40 of the PCB 12.

The optical interface 40 comprises a plurality of light transmission regions 48 formed by the openings of the cores 34.

The optical interface 40 thus comprises a row of light transmission regions 48.

The mating optical device 14 can be an optical device, an optoelectrical device or another PCB.

In the present example, the mating optical device 14 comprises a mechanical-transfer ferrule 50 ("MT-ferrule") having a high precision sleeve 52 in which ends of optical fibres 54 extend in precisely defined relative locations.

The mating optical device 14 thus has an optical interface 56 formed by a bottom surface 58 of the MT ferrule 50 and having a plurality of light transmission regions 60 defined by the ends of the optical fibres 54 directed toward the PCB 12.

The optical interface 56 of the mating optical device 14 extends in a plane parallel to the XY plane.

The optical interface 56 of the mating optical device 14 has the same number of light transmission regions 60 as the optical interface 40 of the PCB 12, the light transmission regions 60 being also arranged in a row.

Each transmission region 60 of the optical interface 56 of the mating optical device 14 corresponds to a respective transmission region 48 of the optical interface 40 of the PCB 12.

This means that transmission regions 48 and 60 are associated two by two and that light normally exited through a transmission region of one of the optical interfaces is to be transmitted to the corresponding transmission region of the other optical interface.

The transmission regions 60 of the optical interface 56 of the mating optical device 14 are separated one from another by a fixed distance along the direction Y, this distance corresponding to that of the optical interface 40 of the PCB 12. Thus, for example, the distance can be set constant to 250 µm.

The optical coupling system 15 comprises a virtual first face defining a virtual first optical interface 62 which is to be put in optical coupling with the optical interface 40 of the PCB 12.

The virtual first optical interface 62 has a plurality of virtual first transmission regions 64 arranged in a first row, and which are to be placed opposite to a corresponding transmission region 48 of the optical interface 40 of the PCB 12 such as to be optically coupled with each other.

Hence, the arrangement of the virtual first optical interface 62 directly derives from that of the optical interface 40 of the PCB 12, and it will not be described in further details here.

The optical coupling device 16 is, for example, a unitary piece manufactured by moulding a translucent suitable material, such as a plastic material.

The optical coupling device 16 is mounted on and fixed to the PCB 12, in particular on the first horizontal wall 44 of the cut-out 38, the top surface of the first horizontal wall 44 serving as a reference surface for the positioning of the optical coupling device 16 relative to the PCB 12.

In a variant, the optical coupling device 16 is mounted on the top surface 42 of the PCB 12, this top surface 42 thus serving as a reference surface for the positioning of the optical coupling device 16 relative to the PCB 12.

In another variant, any surface of the PCB 12 can serve as a reference surface for the positioning and the mounting of the optical coupling device 16 relative to the PCB 12.

The optical coupling device 16 comprises a face 66 forming a second face of the optical coupling system 15.

The second face extends in a plane parallel to the XY plane and defines a second optical interface 66 to be put in optical coupling with the optical interface 56 of the mating optical device 14.

The second optical interface 66 has a plurality of second transmission regions 68 arranged in a second row, and which are to be placed opposite to a corresponding transmission region 60 of the optical interface 56 of the mating optical device 14 such as to be optically coupled with each other.

Hence, the arrangement of the second optical interface 66 directly derives from that of the optical interface 56 of the mating optical device 14, and it will not be described in further details here.

Each first transmission region 64 is thus optically associated only with a respective second transmission region 68.

As illustrated on Fig. 1, an optical path is defined between the first and second optical interfaces 62, 66 of the optical coupling system 15.

More precisely, diverging light entering the optical coupling system 15 at its virtual first optical interface 62, coming from the optical interface 40 of the PCB 12, will propagate through the optical coupling system 15 to the second optical interface 66 and will be focussed on the optical interface 56 of the mating optical device 14. It should be noted that light may also propagate in the opposite direction in a similar way.

In particular, the face 66 of the optical coupling device 16 is provided with a first light beam forming structure 70 such as a lens at each second transmission region 68 of the second optical interface 66 of the optical coupling system 15.

On a face 72 of the optical coupling device 16, opposite to the face forming the second optical interface 66, second light beam forming structures 74 (such as lenses) are provided in correspondence with a respective first lens 70.

The first lenses 70 optimize the optical coupling of optical signals between the mating optical device 14 and the optical coupling device 16, whereas the second lenses 74 optimize the optical coupling of optical signals between the optical coupling device 16 and the PCB 12.

Since the first and second lenses 70, 74 focus the optical signals at the entry of each optical fibre end and respectively at the entry of each core 34, the manufacture tolerances of the PCB 12, the mating optical device 14 and the optical coupling device 16 are at least partially compensated in comparison with an optical coupling system without lenses.

The first and second lenses 70, 74 may form an integral part of the optical coupling device 16.

They could be for example of the Fresnel-type or of the aspheric type.

The reflective arrangement 18 is adapted to transmit light between the first optical interface 62 and the second optical interface 66 of the optical coupling system 15 by achieving a deflection of optical signals between the first transmission regions 64 and the associated second transmission regions 68.

In the example of Fig. 1, the reflective arrangement 18 comprises a plane mirror 76 secured on a support base 78.

The support base 78 has a T-shape cross-section comprising a foot 78a extending in a plane parallel to the YZ plane, and a head 78b extending in a plane parallel to the XY plane.

The plane mirror 76 is angled substantially at 45° with respect to the XY plane and extends continuously along the direction Y.

In a variant, the reflective arrangement 18 comprises a concave mirror secured on the support base 78 and extending continuously along the direction Y.

In this case, the second lenses 74 could be suppressed, the concave mirror being adapted to focus the optical signals coming to/from the optical waveguides 32.

In another variant, the reflective arrangement 18 comprises a mirror 76 for each first transmission region 64 and the associated second transmission region 68.

The alignment adjusting means 20 are connected to the reflective arrangement 18 and adapted to move the reflective arrangement 18 with respect to the PCB 12 between a misaligned position in which the reflective arrangement 18 does not efficiently transmit light between the first transmission regions 64 and the associated second transmission regions 68 of the optical coupling system 15, and an aligned position in which the reflective arrangement 18 transmits light between the first transmission regions 64 and the associated second transmission regions 68 of the optical coupling system 15.

In the first embodiment shown on Fig. 1, the alignment adjusting means 20 are adapted to move the reflective arrangement 18 linearly along the vertical direction Z.

The alignment adjusting means 20 comprise two frame plates 80a, 80b fixed to each other and extending in a plane parallel to the XY plane.

The alignment adjusting means 20 are mounted on the PCB 12, in particular on the second horizontal wall 46 of the cut-out 38, the bottom surface of the second horizontal wall 46 serving as a reference surface for the positioning of the upper frame plate 80a relative to the PCB 12.

The head 78b of the support base 78 extends between the two frame plates 80a, 80b, the foot 78a of the support base 78 extending through an opening provided in the upper frame plate 80a.

The alignment adjusting means 20 comprise a screw 82 and at least a compression spring 84, for example two compression springs 84 on Fig. 1.

The screw 82 cooperates with a threaded hole provided in the lower frame plate 80b.

The screw 82 is connected to the support base 78 such that it is able to rotate freely relative to the support base 78 while transferring its linear movement along the vertical direction Z to the support base 78 and thus to the mirror 76.

The compression springs 84 are located between the upper frame plate 80a and the head 78b of the support base 78, on either side of the foot 78a.

The compression springs 84 are adapted to maintain the reflective arrangement 18 in position with respect to the frame plates 80a, 80b while allowing the sliding of the reflective arrangement 18 along the vertical direction Z.

The screw 82 is accessible from the exterior of the optical system 10 to be manually actuated.

Hence, when the optical coupling between the PCB 12 and the mating optical device 14 is not efficient, that is to say when the reflective arrangement 18 is in a misaligned position, the screw 82 can be rotated by a user to move the mirror 76 linearly along the vertical direction Z until an optimal coupling is reached, that is to say when the reflective arrangement 18 is in an aligned position.

Locking means connected to the alignment adjusting means 20 can be provided to lock the reflective arrangement 18 in the aligned position.

Such locking means can be for example clamps 86 adapted to fasten the screw 82 to the lower frame plate 80b in the aligned position of the mirror 76.

The optical system 10 has been described with the optical waveguides 32 positioned on the right side of the PCB 12 (on the right on Fig. 1), but the optical waveguides 32 could be positioned on the left side of the PCB 12 (on the left on Fig. 1), the configuration of the optical system 10 being thus symmetrical to the configuration presented on Fig. 1 relative to a median plane parallel to the YZ plane.

Fig. 2 illustrates an optical system 110 according to a second embodiment of the invention.

The second embodiment differs from the first embodiment of Fig. 1 in that the alignment adjusting means 120 are adapted to move the reflective arrangement 118 linearly along the direction X.

The support base 178 of the reflective arrangement 118 has an L-shape cross-section comprising a first wing 178a extending in a plane parallel to the YZ plane, and a second wing 178b extending in a plane parallel to the XY plane.

The second wing 178b extends between the two frame plates 180a, 180b, the first wing 178a extending through an opening provided in the upper frame plate 180a.

The lower frame plate 180b of the alignment adjusting means 120 is extended by a vertical wall 181 provided with a threaded hole cooperating with the screw 182.

The screw 182 is connected to the second wing 178b of the support base 178 by means of a plunger 183 such that it is able to rotate freely relative to the plunger 183 while transferring its linear movement along the horizontal direction X to the plunger 183 and thus to the support base 178 and to the mirror 176.

Clamps 186 are provided to fasten the screw 182 to the vertical wall 181 of the lower frame plate 180b in the aligned position of the mirror 176.

Fig. 3 shows an optical system 210 according to a third embodiment of the invention.

The third embodiment differs from the first embodiment of Fig. 1 in that the PCB 212 comprises a plurality of superimposed optical waveguide layers 226, for example two optical waveguide layers 226a, 226b, each being identical to the optical waveguide layer 26 of the first embodiment.

Hence, the light transmission regions 248 are arranged as an array of rows and columns.

Rows are spaced apart from one another along the vertical direction Z by a first pitch P1. For example, the first pitch P1 of the optical interface 240 of the PCB 212 can be set to 125 µm.

Columns are spaced apart from one another along the direction Y as described with reference to Fig. 1.

In the present example, each optical waveguide layer 226a, 226b has a similar arrangement.

However, alternatively, the two rows might not have the same spacing between neighbour light transmission regions 248, and/or could be laterally shifted with respect to one another along the direction Y.

The optical interface 256 of the optical mating device 214 comprises the same number of transmission regions 260 as the optical interface 248 of the PCB 212.

In addition, the optical interface 256 has the same number of rows as the optical interface 248, here two rows 260a, 260b.

Each row of the optical interface 256 of the mating optical device 214 corresponds to a respective given row of the optical interface 248 of the PCB 212.

Each transmission region 260 of the optical interface 256 of the mating optical device 214 corresponds to a respective transmission region 248 of the optical interface 240 of the PCB 212.

Rows of the optical interface 256 are spaced apart from one another along the direction X by a second pitch P2.

In particular, the second pitch P2 between the rows of the optical interface 256 is different from, advantageously greater than, the first pitch P1 between the rows of the optical interface 240 of the PCB 212. For example, the second pitch P2 can be set to 250 µm, in particular an integral multiple number of the first pitch P1.

Columns of the optical interface 256 are spaced apart from one another along the direction Y as described with reference to Fig. 1.

The spacing between the transmission regions 260 along the direction Y corresponds to that of the optical interface 240 of the PCB 212. For example, the spacing can be set to 250 µm, and the rows are identical.

The first optical interface 262 of the optical coupling system 215 has first transmission regions 264 arranged as an array of rows and columns corresponding to the arrangement of the transmission regions 248 of the optical interface 240 of the PCB 212.

The second optical interface 266 of the optical coupling system 215 has second transmission regions 268 arranged as an array of rows and columns corresponding to the arrangement of the transmission regions 260 of the optical interface 256 of the mating optical device 214.

The reflective arrangement 218 comprises a plurality of mirrors 276 independent from each other, here two plane mirrors 276a, 276b each identical to the plane mirror 76 of the first embodiment.

Each mirror 276a, 276b is associated with a respective row 226a, 226b of the PCB 212 and with a respective row 260a, 260b of the optical mating device 214.

The mirrors 276a, 276b are positioned so as to cope with the pitch difference between the two optical interfaces 262, 266 of the optical coupling system 215.

In other words, the reflective arrangement 218 is used to offset light transmitted between the first layer 226a of the PCB 212 and the corresponding row 260a of the optical mating device 214 with respect to light transmitted between the second layer 226b of the PCB 212 and the corresponding row 260b of the optical mating device 214.

To this end, the mirrors 276 are staggered relative to each other along the directions X and Z.

For a given second pitch P2 of the mating optical device 214, the optical coupling system 215 enables to provide a PCB 212 which is thinner than if a single continuous mirror was used in the reflective arrangement

218.

The alignment adjusting means 220 are individually coupled to each mirror 276a, 276, of the reflective arrangement 218.

Hence, a screw 282a, 282b, two compression springs 284a, 284b and clamps 286a, 286b are provided for each mirror 276a, 276b, the two frame plates 280a, 280b being common to the plurality of mirrors 276.

Thus, in case of inefficient optical coupling between the PCB 212 and the mating optical device 214, a user can adjust the position of the mirrors 276 independently from each other to reach an optimal optical coupling.

Fig. 4 shows an optical system 310 according to a fourth embodiment of the invention.

The fourth embodiment differs from the third embodiment of Fig. 3 in that the optical system 310 is used in an intra-card application.

The PCB 312 comprises an additional reference layer 323, whose top surface serves as a reference surface for the positioning of the optical coupling device 316, and an additional insulative layer 325.

The optical mating device 314 comprises a light source/detector array 349 having two rows of light source/detector elements 351.

The light source/detector array 349 is secured on a heat spreader 353 via a substrate 355, the heat spreader 353 being mounted on the lower surface of the additional insulative layer 325.

The reflective arrangement 318 and the alignment adjusting means 320 are mounted on a top surface of the top insulative layer 324.

Fig. 5 illustrates an optical system 410 according to a fifth embodiment of the invention.

The fifth embodiment differs from the fourth embodiment of Fig. 4 in that the PCB 412 comprises four optical waveguide layers 426a, 426b, 426c, and 426d.

The mating optical device 414 thus comprises four rows of light source/detector elements 451 each corresponding to a respective optical waveguide layer 426.

Similarly, the optical coupling system 415 comprises four rows of transmission regions 464, 468 on each of its optical interfaces 462, 466.

The reflective arrangement and the alignment adjusting means are formed by a micro-opto-electromechanical system (MOEMS) 417.

The MOEMS 417 comprises an array of micro-mirrors 419 forming the reflective arrangement and having at least a number of micro-mirrors 419 corresponding to the number of the transmission regions 464, 468 of the optical coupling system 415.

Each micro-mirror 419 is connected to a micro-actuator forming the alignment adjusting means and adapted to move the respective micro-mirror 419.

The micro-actuators can be adapted to move the micro-mirrors 419 linearly along the direction X, and/or along the direction Y and/or along the direction Z.

The micro-actuators can also be adapted to move the micro-mirrors 419 angularly about the direction X, and/or about the direction Y and/or about the direction Z.

The micro-actuators are electrically controlled and the actuation of the micro-mirrors 419 can be carried out by a piezoelectric, electrostatic, thermal or magnetic solicitation or the like.

The operation of the MOEMS 417 is automatic and does not require the intervention of a user. When a deficiency in the optical coupling of the optical system 410 is detected, the micro-actuators are automatically controlled to adjust the alignment of the micro-mirrors 419.

The MOEMS 417 is mounted on the top surface 442 of the PCB 412 as a flip chip and secured by flip chip bumps 421.

The invention thus provides different optical systems offering an optical coupling that can be adjusted to be optimal in order to compensate for the manufacturing tolerances of the different elements of the optical system.

Besides, the optical coupling device and the reflective arrangement being independent from each other enables to have a manufacturing process which is less complex and less expensive than if the reflective arrangement was integrated to the optical coupling device.

CLAIMS

1. An optical system (10) comprising:

- an optical circuit board (12) comprising an optical interface (40) having at least a transmission region (48),

- an optical coupling system (15) comprising:

• a first optical interface (62) having at least a first transmission region (64) optically coupled to a corresponding transmission region (48) of the optical interface (40) of the optical circuit board (12),

• a second optical interface (66) having at least a second transmission region (68) adapted to be optically coupled to a corresponding transmission region (60) of an optical interface (56) of a mating optical device (14),

the first transmission region (64) and the second transmission region (68) being optically associated only with each other,

wherein the optical coupling system (15) comprises:

- an optical coupling device (16) fixed to the optical circuit board (12) and having a light beam forming structure (70, 74),

- a reflective arrangement (18) mounted on the optical circuit board (12) and adapted to transmit light between the first transmission region (64) of the first optical interface (62) and the associated second transmission region (68) of the second optical interface (66) of the optical coupling system (15) through the light beam forming structure (70, 74),

- alignment adjusting means (20) connected to the reflective arrangement (18) and adapted to move the reflective arrangement (18) with respect to the optical circuit board (12) between a misaligned position in which the reflective arrangement (18) does not transmit light between the first transmission region (64) and the associated second transmission region (68) of the optical coupling system (15), and an aligned position in which the reflective arrangement (18) transmits light between the first transmission region (64) and the associated second transmission region (68) of the optical coupling system (15).

2. An optical system (10) comprising:

- an optical circuit board (12) comprising an optical interface (40) having at least one row comprising a plurality of transmission regions (48),

- an optical coupling system (15) comprising:

• a first optical interface (62) having a first row associated to the at least one row of the optical interface (40) of the optical circuit board (12), the first row comprising a plurality of first transmission regions (64) each optically coupled respectively to a corresponding transmission region (48) of the optical interface (40) of the optical circuit board (12),

• a second optical interface (66) having a second row associated to a corresponding row of an optical interface (56) of a mating optical device (14), the second row comprising a plurality of second transmission regions (68) each adapted to be optically coupled respectively to a corresponding transmission region (60) of the optical interface (56) of the mating optical device (14),

each first transmission region (64) being optically associated only with a respective second transmission region (68),

wherein the optical coupling system (15) comprises:

- an optical coupling device (16) fixed to the optical circuit board (12) and having a light beam forming structure (70, 74),

- a reflective arrangement (18) mounted on the optical circuit board (12) and adapted to transmit light between the first transmission regions (64) of the first optical interface (62) and the associated second transmission regions (68) of the second optical interface (66) of the optical coupling system (15) through the light beam forming structure (70, 74),

- alignment adjusting means (20) connected to the reflective arrangement (18) and adapted to move the reflective arrangement (18) with respect to the optical circuit board (12) between a misaligned position in which the reflective arrangement (18) does not transmit light between the first transmission regions (64) and the associated second transmission regions (68) of the optical coupling system (15), and an aligned position in which the reflective arrangement (18) transmits light between the first transmission regions (64) and the associated second transmission regions (68) of the optical coupling system (15).

3. An optical system (210) comprising:

- an optical circuit board (212) comprising an optical interface (240) having a set of rows, each row comprising a plurality of transmission regions (248),

- an optical coupling system (215) comprising:

• a first optical interface (262) having a first set of rows each associated to a corresponding row of the optical interface (240) of the optical circuit board (212), each row of the first set comprising a plurality of first transmission regions (264) each optically coupled respectively to a corresponding transmission region (248) of the optical interface (240) of the optical circuit board (212),

• a second optical interface (266) having a second set of rows each associated to a corresponding row of an optical interface (256) of a mating optical device (214), each row of the second set comprising a plurality of second transmission regions (268) each adapted to be optically coupled respectively to a corresponding transmission region (260) of the optical interface (56) of the mating optical device (214),

each first transmission region (264) being optically associated only with a respective second transmission region (268),

wherein the optical coupling system (215) comprises:

- an optical coupling device (216) fixed to the optical circuit board (212) and having a light beam forming structure (270, 274),

- a reflective arrangement (218) mounted on the optical circuit board (212) and adapted to transmit light between the first transmission regions (264) of the first optical interface (262) and the associated second transmission regions (268) of the second optical interface (266) of the optical coupling system (215) through the light beam forming structure (270, 274),

- alignment adjusting means (220) connected to the reflective arrangement (218) and adapted to move the reflective arrangement (218) with respect to the optical circuit board (212) between a misaligned position in which the reflective arrangement (218) does not transmit light between the first transmission regions (264) and the associated second transmission regions (268) of the optical coupling system (215), and an aligned position in which the reflective arrangement (218) transmits light between the first transmission regions (264) and the associated second transmission regions (268) of the optical coupling system (215).

4. An optical system (210) according to claim 3, wherein the rows of the first set of the first optical interface (262) of the optical coupling system (215) are spaced apart from one another by a first pitch (P1), the rows of the second set of the second optical interface

(266) of the optical coupling system (215) are spaced apart from one another by a second pitch (P2), the reflective arrangement (218) being adapted to offset light transmitted between a first row of the first set and a corresponding first row of the second set with respect to light transmitted between a second row of the first set and a corresponding second row of the second set.

5. An optical system (210) according to claim 4, wherein the second pitch (P2) is greater than the first pitch (P1).

6. An optical system (210) according to claim 4 or 5, wherein the reflective arrangement (218) comprises a plurality of staggered mirrors (276) independent from each other and each associated to both a respective row of the first set and a corresponding row of the second set.

7. An optical system (10) according to any of claims 1 to 6, wherein the reflective arrangement (18) comprises a mirror (76) for each first transmission region (64) and the associated second transmission region (68).

8. An optical system (10) according to any of claims 1 to 7, wherein the reflective arrangement (18) comprises at least a plane mirror (76).

9. An optical system (10) according to any of claims 1 to 8, wherein the reflective arrangement (18) comprises at least a concave mirror.

10. An optical system (10) according to any of claims 6 to 9, wherein the alignment adjusting means (20) are individually coupled to each mirror (76) of the reflective arrangement (18).

11. An optical system (10) according to any of claims 1 to 10, wherein the alignment adjusting means (20) are adapted to move the reflective arrangement (18) linearly along at least one axis.

12. An optical system (10) according to any of claims 1 to 11, wherein the alignment adjusting means (20)

are adapted to move the reflective arrangement (18) angularly about at least one axis.

13. An optical system (10) according to any of claims 1 to 12, wherein the alignment adjusting means (20) are adapted to be manually actuated.

14. An optical system (10) according to any of claims 1 to 13, wherein the alignment adjusting means (20° are adapted to be electrically controlled.

15. An optical system (10) according to any of claims 1 to 14, wherein the light beam forming structure (70, 74) comprises at least an aspheric lens or a Fresnel lens.

16. An optical system (10) according to any of claims 1 to 15, further comprising locking means (86) connected to the alignment adjusting means (20) and adapted to lock the reflective arrangement (18) in the aligned position.

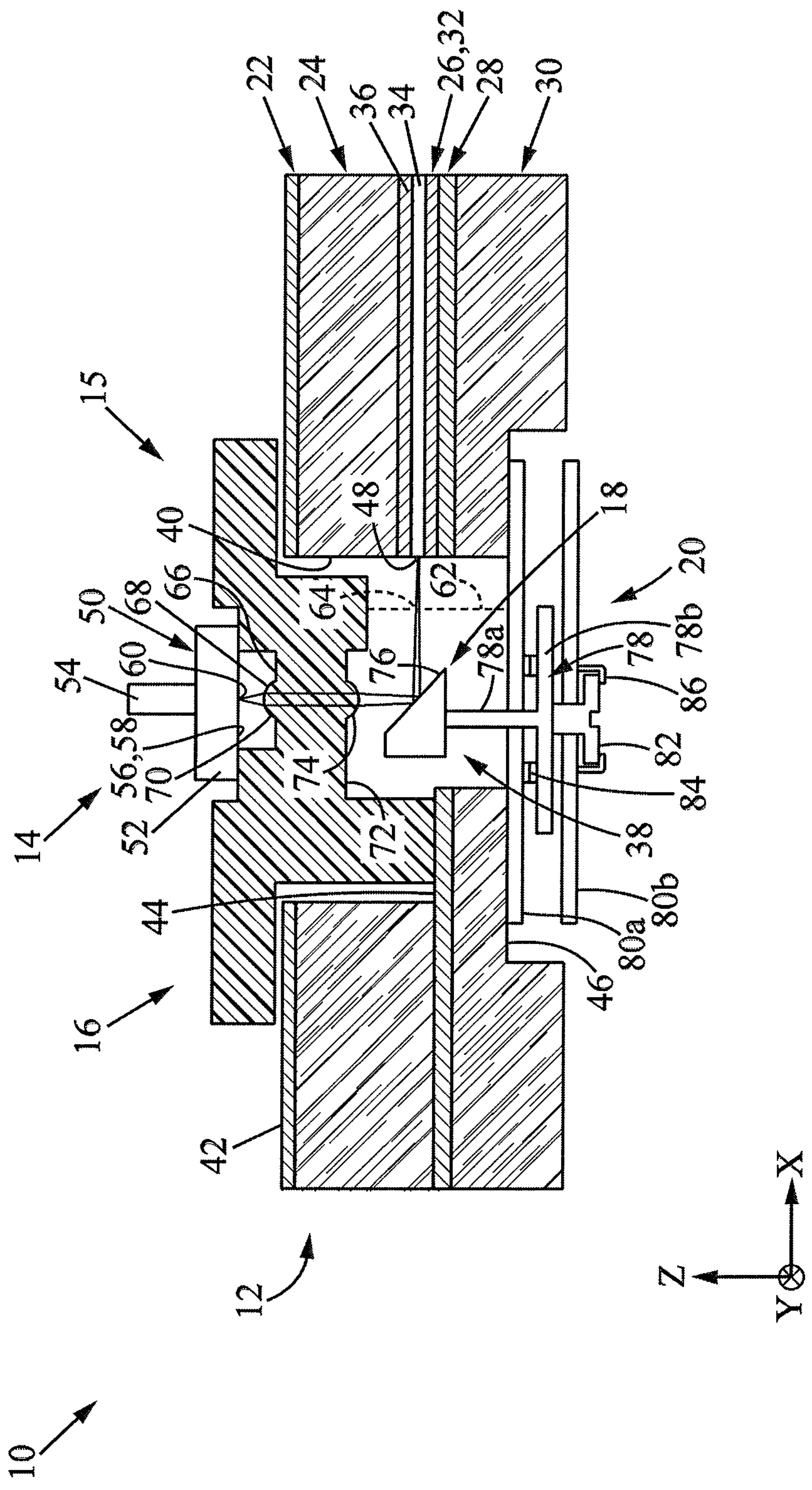
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FIG. 1

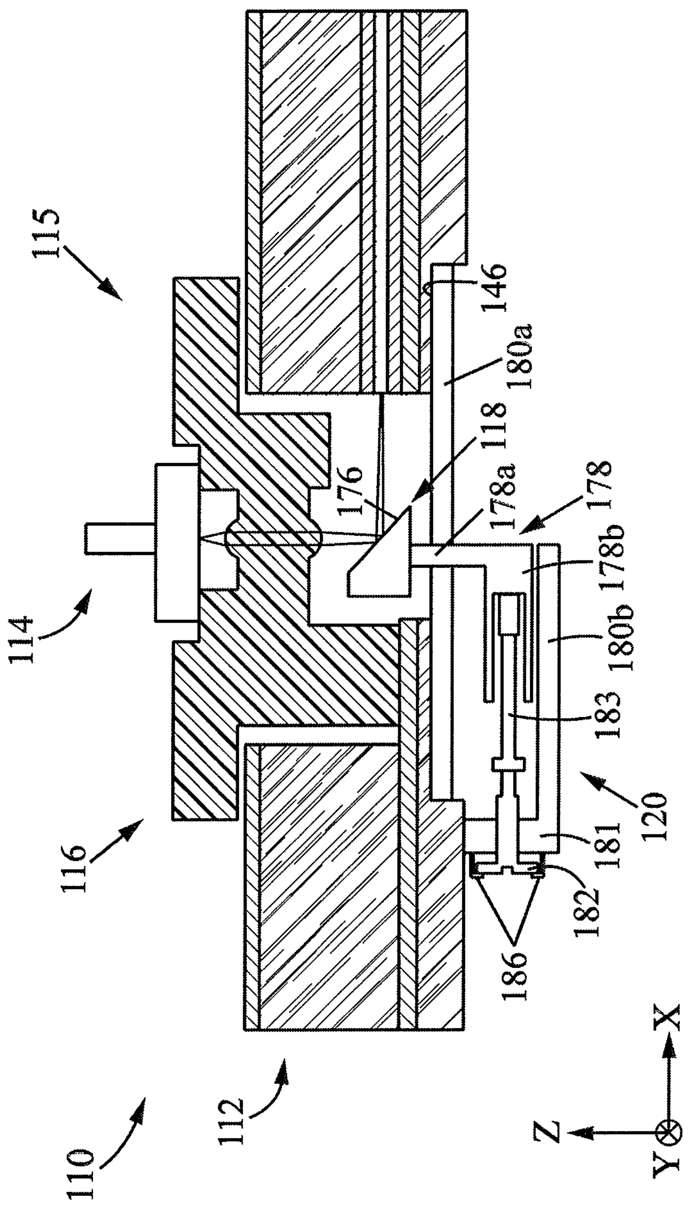
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FIG. 2

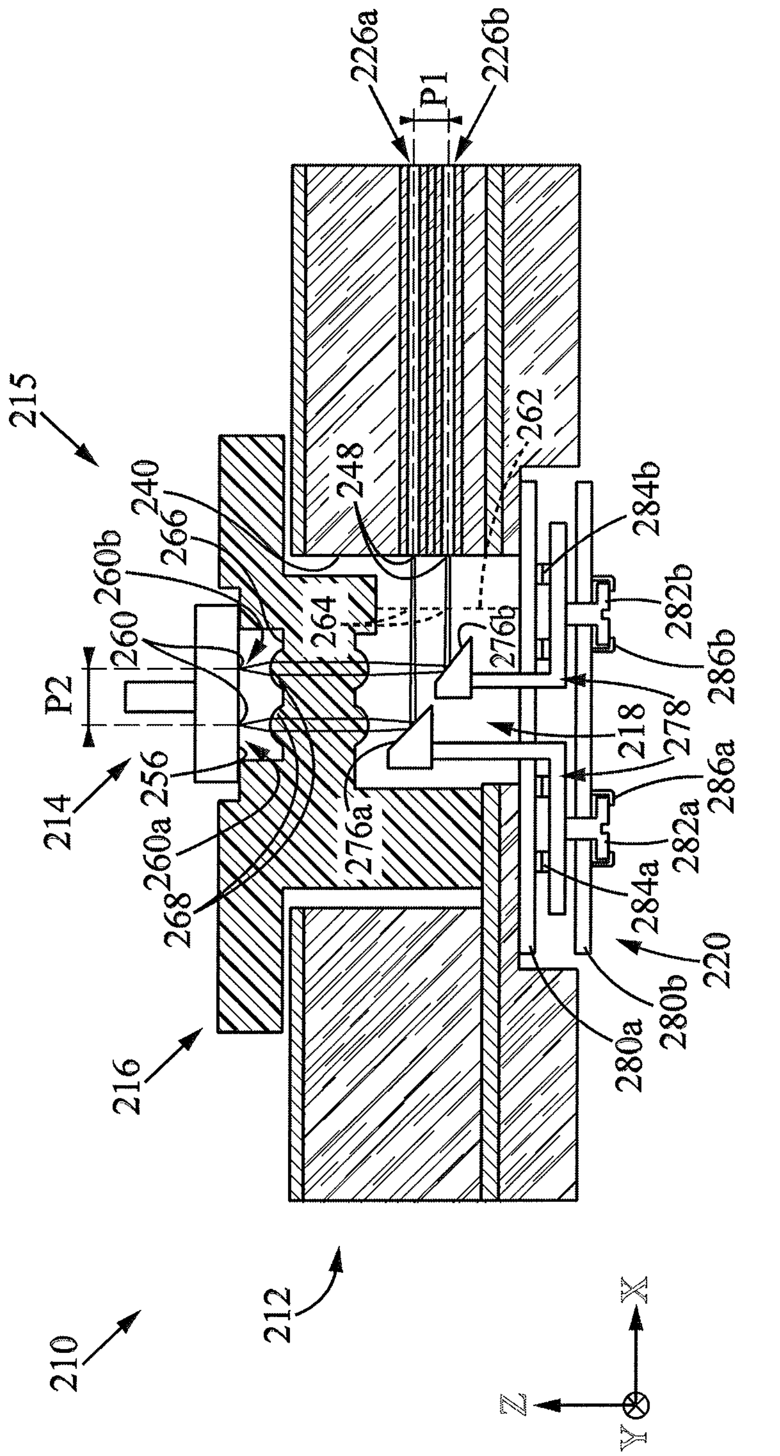
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FIG. 3

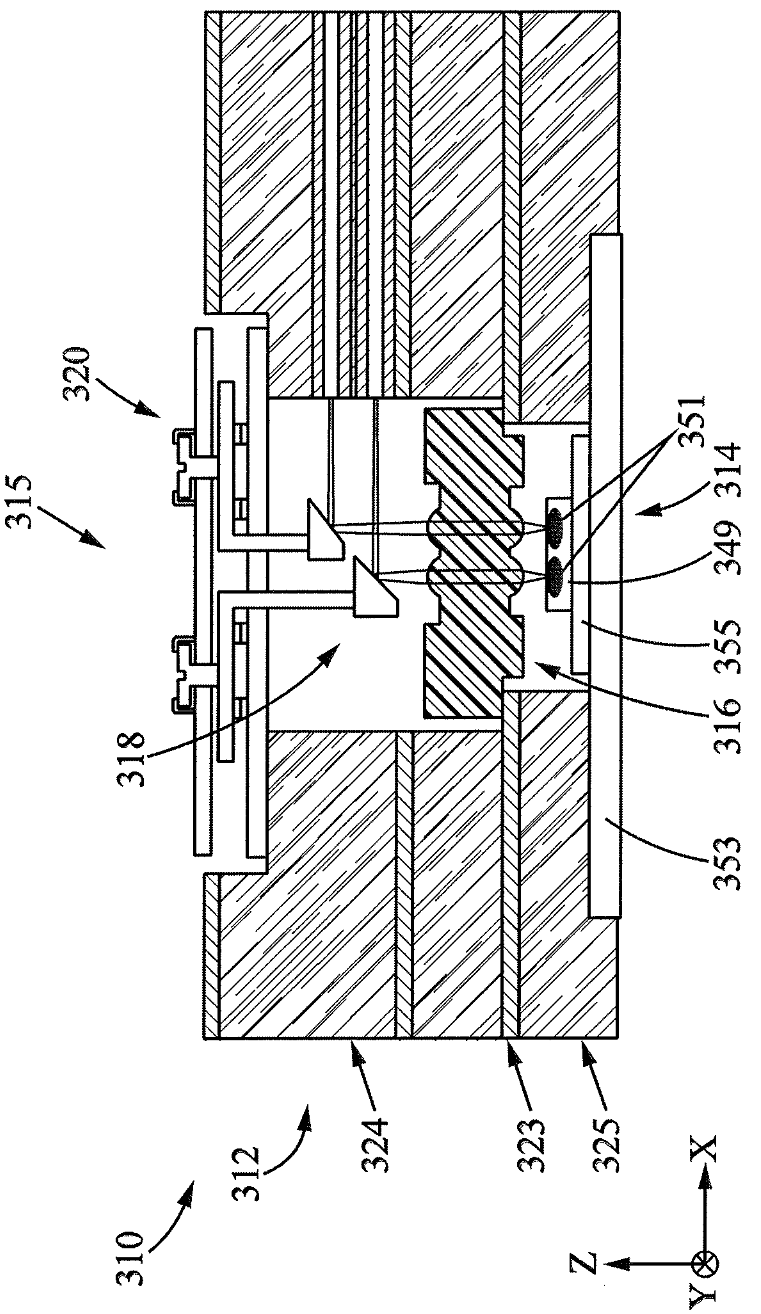
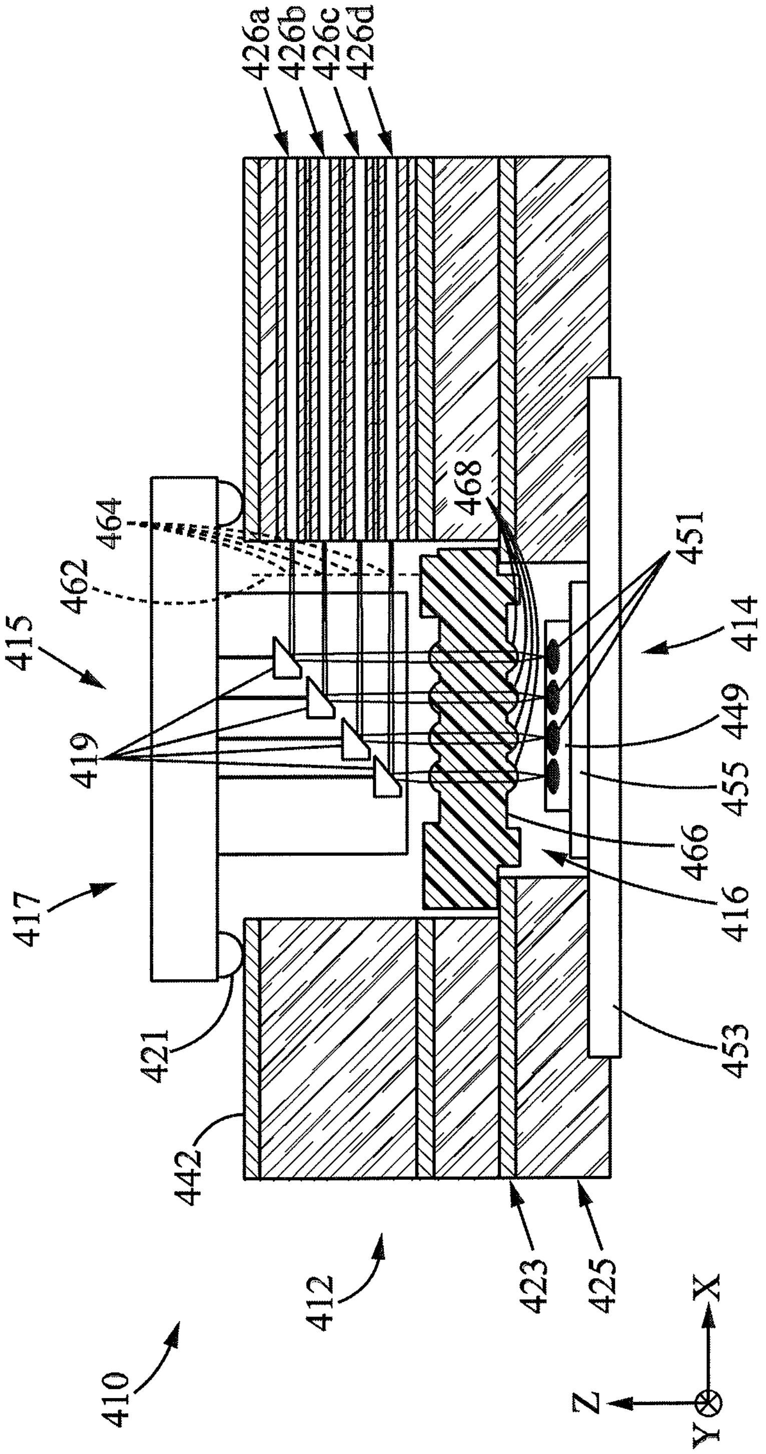


FIG. 4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423
425
410
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FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/068970

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B6/42 G02B6/43
ADD.

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)
G02B

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)

EPO-Internal, WPI Data

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/231831 A1 (YAMAMOTO TSUYOSHI [JP] ET AL) 18 December 2003 (2003-12-18) figures 13-18B paragraph [0102] - paragraph [0111]	1-8,10, 14,15
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Y	figures 1-6 column 4 - column 5	9,11,13
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A	figures 3-7	7,8,10, 14

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2013	18/01/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Beutter, Matthias

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/068970

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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