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(54) **OPTOELECTRONIC MODULE AND METHOD OF PRODUCING SAME**

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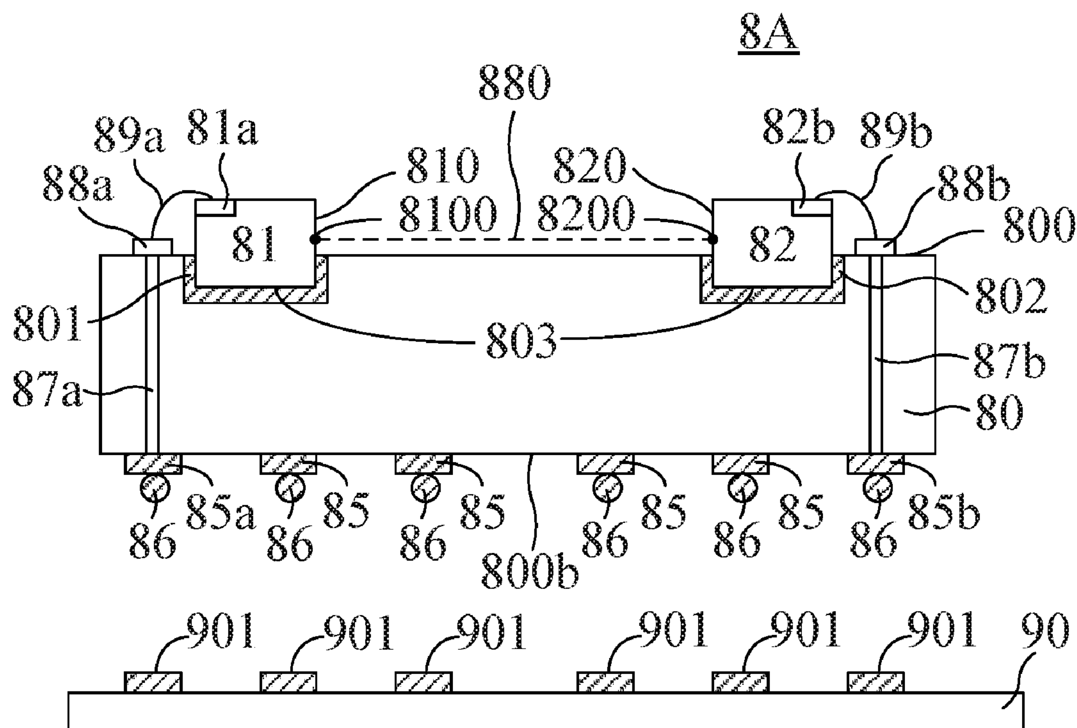
(57) **ABSTRACT**

An optoelectronic module includes an interposer base having first and second recesses formed on a specified surface thereof; a joint material layer filled in the first and second recesses; a first optoelectronic element placed in the first recess and coupled to the interposer base via the joint material layer, wherein an optical signal is emitted from or passes through a lateral surface of the first optoelectronic element; and a second optoelectronic element placed in the second recess and coupled to the interposer base via the joint material layer, wherein a lateral surface of the second optoelectronic element faces the lateral surface of the first optoelectronic element for coupling to and receiving the optical signal emitted from or passing through the lateral surface of the first optoelectronic element. A fixture is used to place the first and second optoelectronic elements into the first and second recesses while controlling some critical distances.



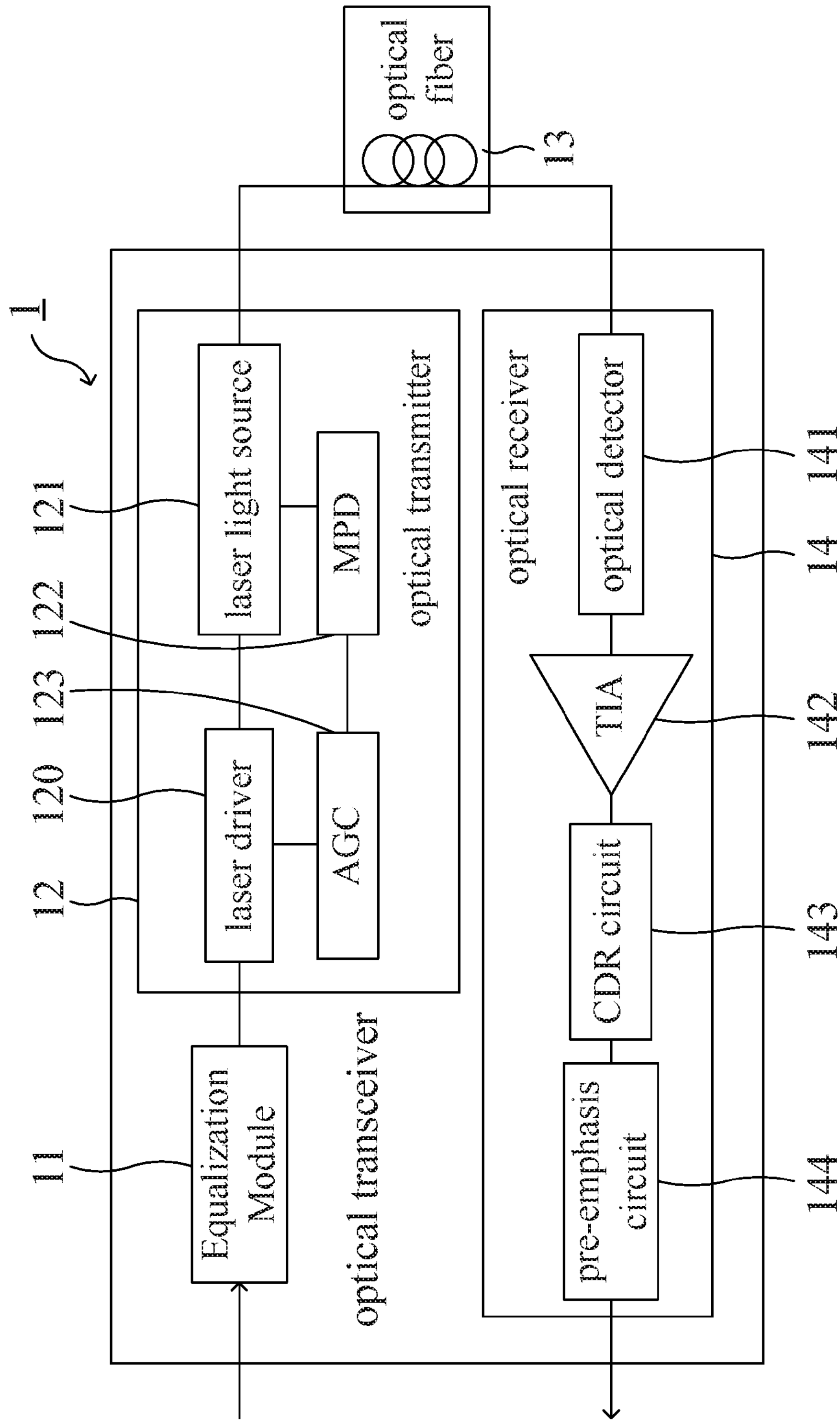


FIG. 1 (Prior Art)

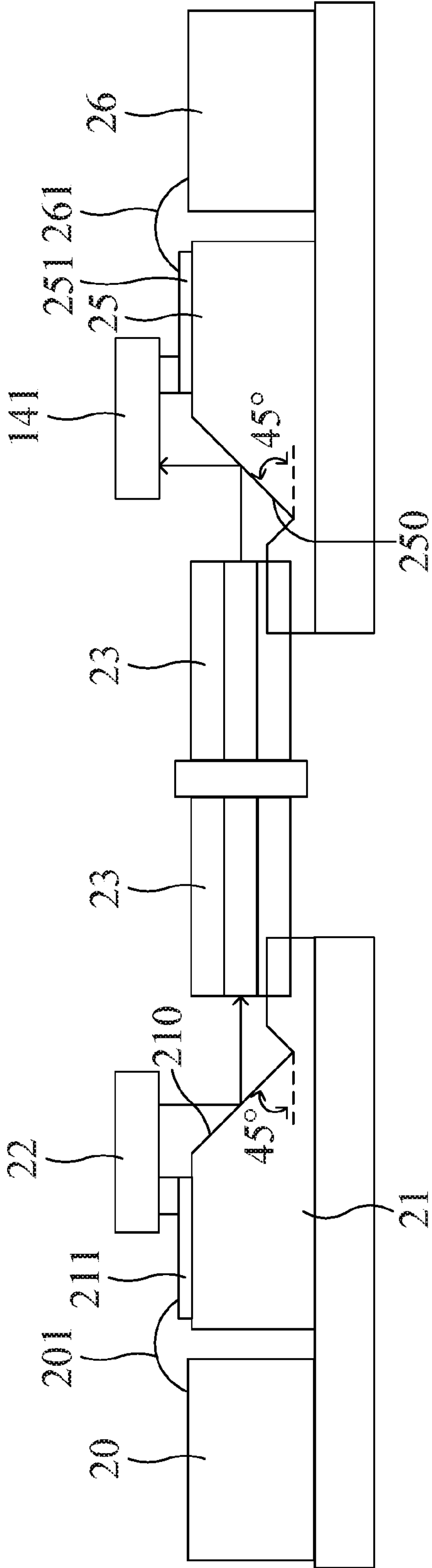


FIG. 2 (Prior Art)

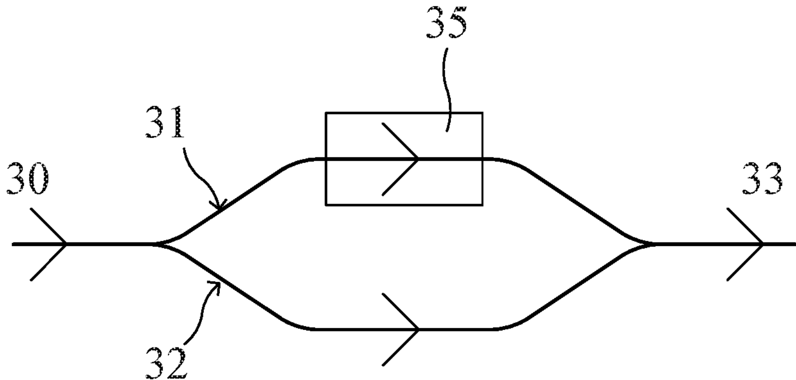


FIG. 3 (Prior Art)

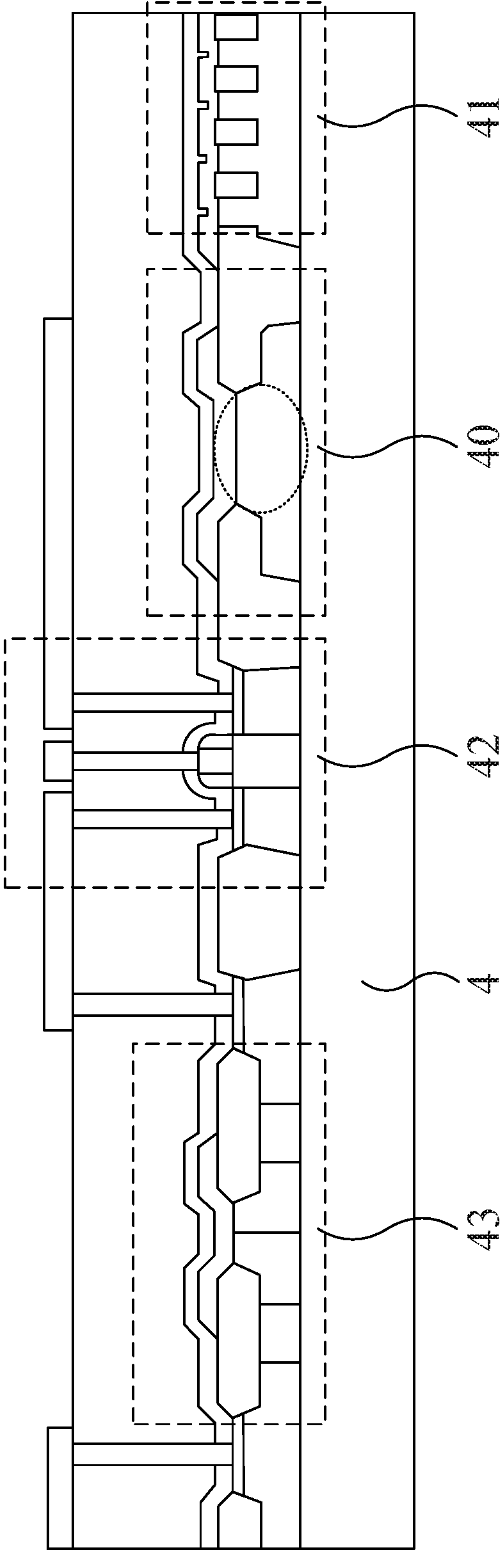


FIG. 4 (Prior Art)

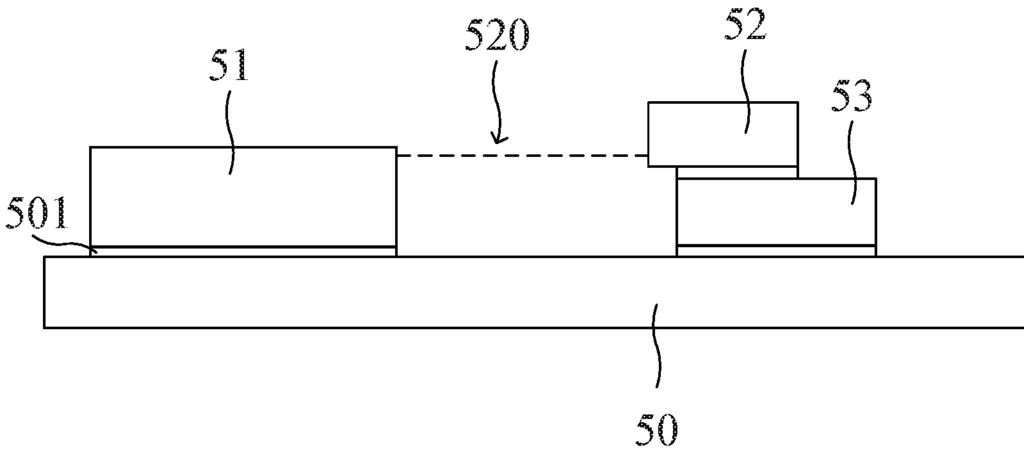


FIG. 5 (Prior Art)

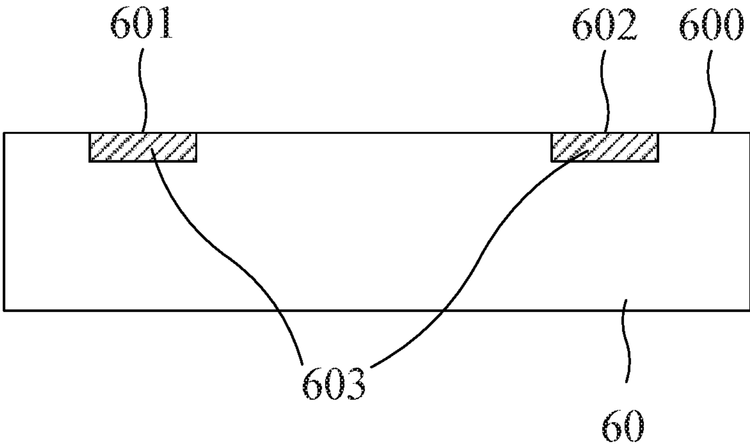


FIG. 6A

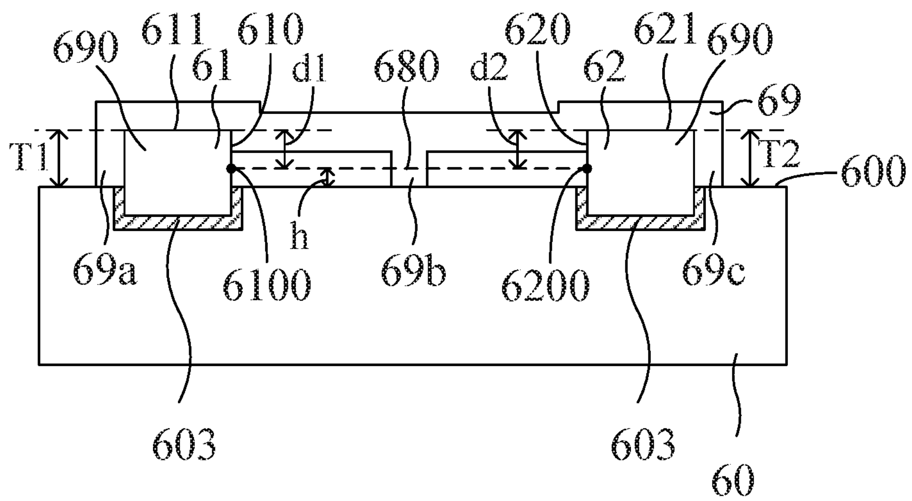


FIG. 6B

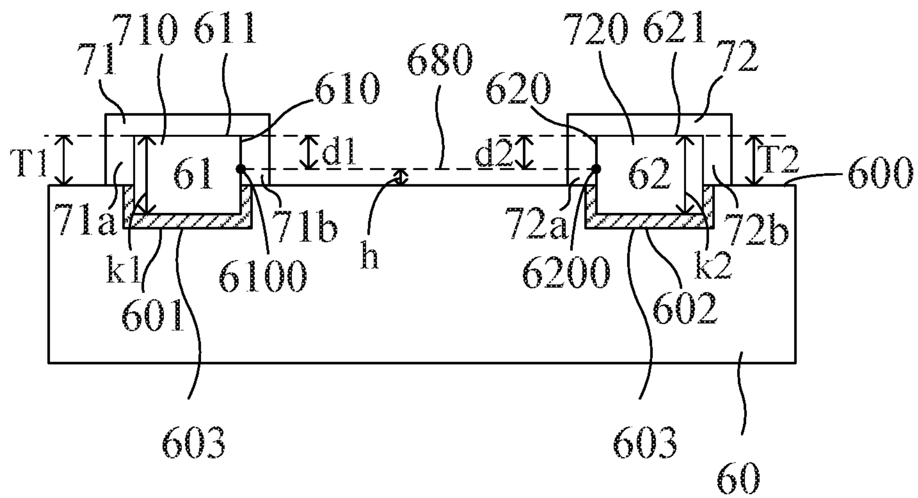


FIG. 6C

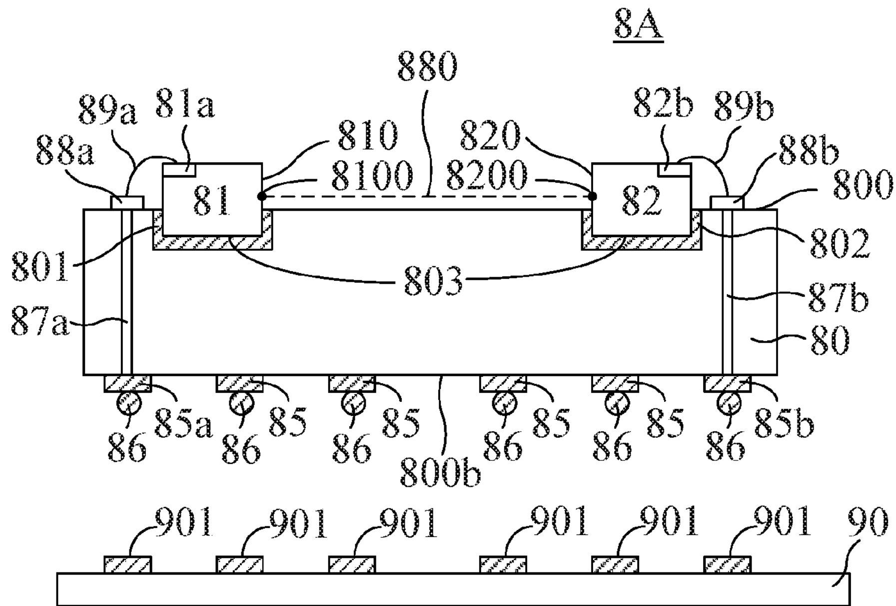


FIG. 7A

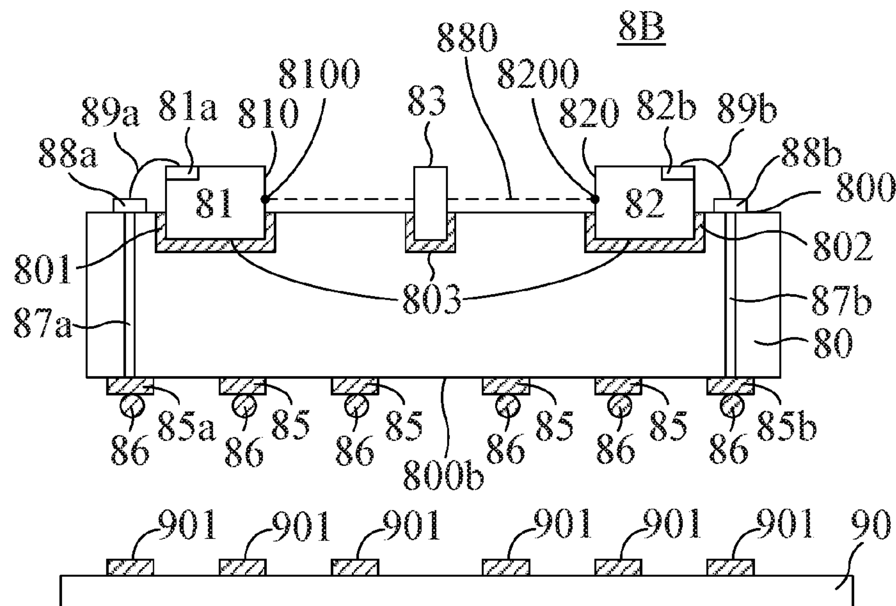


FIG. 7B

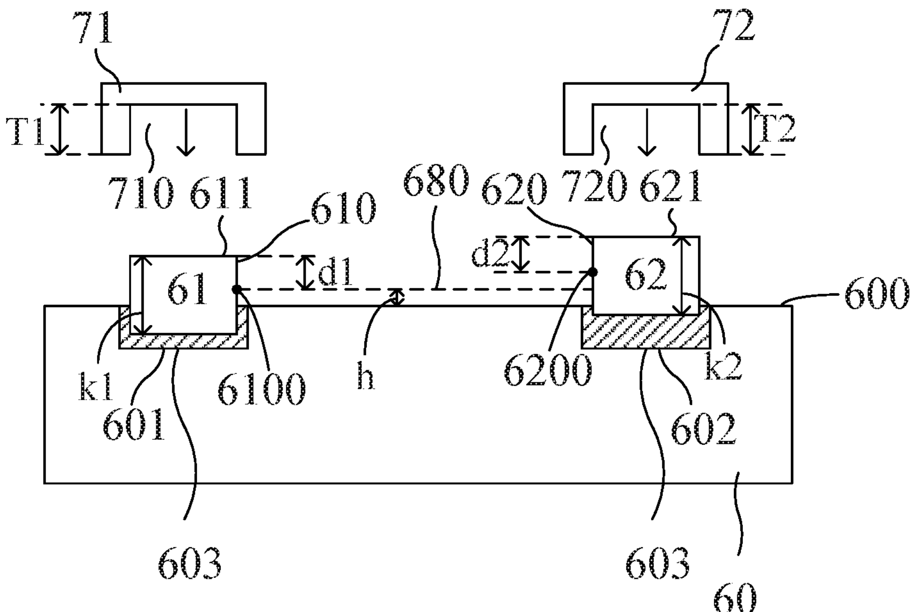


FIG. 8

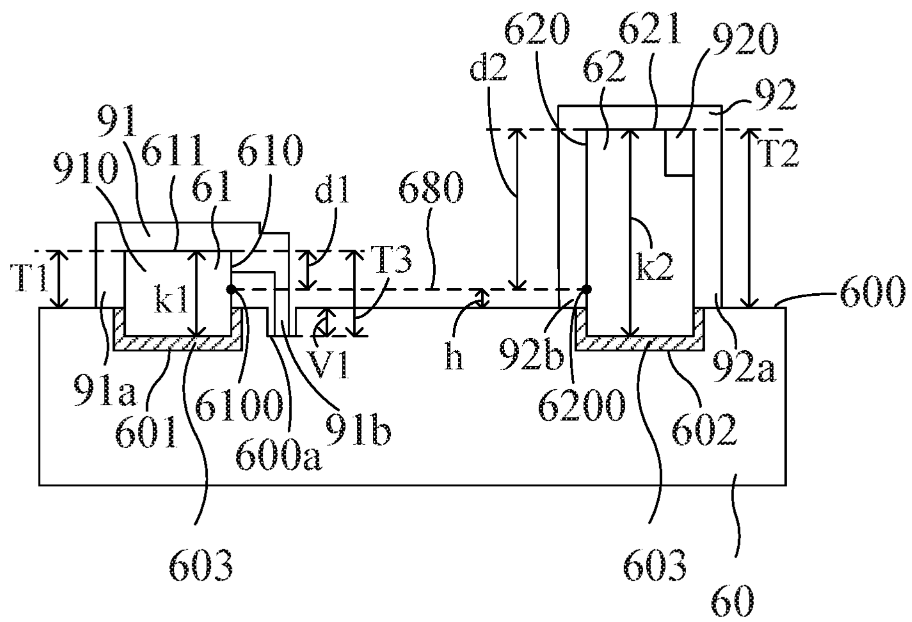


FIG. 9

OPTOELECTRONIC MODULE AND METHOD OF PRODUCING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to a method of producing an optoelectronic module, and more particularly to a method of producing an optoelectronic module involving a optoelectronic alignment process. The present invention also relates to an optoelectronic module, and more particularly to an optoelectronic module produced by a method of producing an optoelectronic module involving an optoelectronic alignment process.

BACKGROUND OF THE INVENTION

[0002] Due to the rapid development of internet and mobile communication technologies, the need for transmitting big data is getting higher and higher. The transmission speed by way of electronic signals seems to have reached a bottle neck. Therefore, the requirement on new transmission means is increasing. For example, the use of optical signals in data transmission paths as an artery would become a trend in the near future. Please refer to FIG. **1**, in which a conventional optical transceiver is schematically shown. In the optical transceiver **1**, an equalization module **11** functions for diminishing attenuation and jitters of an electronic signal. The electronic signal is then converted into optical signals carrying a large amount of data by an optical transmitter **12**, which includes a laser driver **120**, a laser light source **121**, a monitor photodiode (MPD) **122**, and an automatic gain controller (AGC) **123**. The optical signal is transmitted to an optical receiver **14** via an optical fiber **13**. The optical receiver **14** mainly include an optical detector **141**, a trans-impedance amplifier (TIA) **142**, a clock and data recovery (CDR) circuit **143** and a pre-emphasis circuit **144** for converting the received optical signal into a corresponding electronic signal, and then outputting the corresponding electronic signal.

[0003] Please refer to FIG. **2**, in which the structure of an active optical cable (AOC) formed on the basis of a silicon optical bench (SiOB) is schematically shown. An integrated circuit (IC) chip **120** is formed with the equalization module **11** and other associated circuitry, e.g. the laser driver **120**, the monitor photodiode **122** and the automatic gain controller **123**, and functions for outputting the electronic signals carrying the data to a laser light generator **22** via an external metal wire **201** and a transmission line **211** of a silicon optical bench **21**, thereby generating the optical signal. The laser light generator **22** may be implemented with the laser light source **121** as shown in FIG. **1**, e.g a vertical cavity surface emitting laser (VCSEL). The laser light signal generated by the laser light generator **22** implemented with the vertical cavity surface emitting laser is injected onto a 45-degree reflective surface **210** of the silicon optical bench **21**, reflected to an optical fiber **23**, and then transmitted to another silicon optical bench **25**. By way of a 45-degree reflective surface **250** of the silicon optical bench **25**, the optical signal is inputted into the optical detector **141**. In general, the trans-impedance amplifier **142**, the clock and data recovery circuit **143** and the pre-emphasis circuit **144** are formed on an integrated circuit (IC) chip **26**. Through an external metal line **261** and a transmission line **251** of the silicon optical bench **25**, the IC chip **26** is electrically connected to the transmission line **251** of the SiOB **25**.

[0004] When the transmission speed is required to be higher and higher in order to meet commercial needs, for example expected to increase from 10 Gbps to 40-100 Gbps, the vertical cavity surface emitting laser technique would not be a good choice any more due to high cost of elements such as the laser light source **121** and the laser driver **120**, and technical problems. Instead, a complementary metal-oxide-semiconductor (CMOS) photonics platform is used. The CMOS photonics platform allows most of the elements included in the optical transceiver **1** as shown in FIG. **1** to be formed on the same silicon substrate by way of a CMOS manufacturing process. In this technique, the laser driver **120** and the laser light source **121** are replaced with a Mach-Zehnder interferometer (MZI) as shown in FIG. **3**.

[0005] It can be seen from FIG. **3** that in a typical Mach-Zehnder interferometer, an input waveguide **30** is divided into an upper waveguide **31** and a lower waveguide **32**. With no voltage applied, light is coupled to form an output waveguide **33**, and meanwhile, an "ON" signal is generated. Once a proper voltage is applied to a phase retarder **35**, the voltage changes the refraction index of the waveguide so that in the path of the upper waveguide **31**, light is retarded with half a wavelength, or 180-degree phase. Accordingly, the energy of light in the two optical paths become offset so as to generate an "OFF" signal. Therefore, by controlling the operation of the phase retarder **35**, the laser light source which continuously emits laser light can exhibit "ON" and "OFF" effects without directly control the power of the laser light source. Consequently, circuitry complexity can be largely reduced and transmission speed can be significantly enhanced.

[0006] As shown in FIG. **4**, a cross-sectional view of a CMOS photonics platform is schematically shown. A waveguide structure **40**, a grating structure **41**, a transistor structure **42** and a modulator structure **43** are formed on a silicon substrate **4**. The waveguide structure **40** includes a variety of elements, e.g. a light input nanotaper, light splitter, light filter, light coupler, and light output nanotaper, functioning for receiving the external laser light and transmitting the modulated optical signal to the external optical fiber (not shown). The grating structure **41** mainly functions as a Bragg grating. The transistor structure **42** functions as a phase shifter and a waveguide detector. The modulator structure **43** functions as the MZI modulator as shown in FIG. **3**.

[0007] Please refer to FIG. **5**, in which the packaging of a CMOS photonics platform **51** and an edge emitting laser source **52** via an interposer **50** according to prior art is schematically illustrated. The edge emitting laser source **52** is disposed on a submount **53**, and configured in a manner that the light outlet of the edge emitting laser source **52** disposed outside is at a level consistent to the level of the light output end of the optical waveguide structure (not shown in this figure) of the CMOS photonics platform **51**. Since the optical signal **520** emitted from the edge emitting laser source **52** is diffracted by a slit, and then passes a collimator, an isolator and a condenser lens (not shown) to couple to the optical waveguide structure of the CMOS photonics platform **51**, the condenser lens is adjusted by way of active alignment. When aligning and assembling operations are performed, the edge emitting laser source **52** has to keep operating to generate the optical signal **520**. Meanwhile, the coupling effect needs to be detected in real time by way of image processing. Then feedback control is

performed to locate optimal assembling position, where the light coupling effect of the optical signal to the waveguide structure **40** as shown in FIG. **4** is optimized. Acceptable deviation in the active alignment process is about +/−4 μm in each of the three axes. Shift deviation beyond the acceptable range would make the optical signal unable to couple to the waveguide structure **40** with a satisfactory light coupling efficiency. In the prior art, it is relatively easy to control the shift deviation in the X-axis and the Y-axis, but the shift deviation in the Z-axis, i.e. in the height dimension, is hard to be controlled. Therefore, the optoelectronic device needs current transmitting therethrough for operations. In addition, the assembling equipment needs additional power supply and detecting circuit, which renders high cost and complicated assembling. The relatively long assembling time is disadvantageous to batch production. Furthermore, assembling deviation might be even worse due to imprecise thickness of the solder layer **501** between the interposer **50** and the CMOS photonics platform **51**, as well as imprecise thickness of the interposer **50** and the CMOS photonics platform **51** themselves. Moreover, the thickness of the edge emitting laser source **52** and the submount might also be imprecise, and thus the overall deviation might exceed +/−4 μm.

SUMMARY OF THE INVENTION

[0008] Therefore, the present invention provides an optoelectronic module, which exhibits improved assembling precision and promoted yield rate compared with the prior art.

[0009] The present invention provides an optoelectronic module, which comprises an interposer base having a first recess and a second recess, both formed on a specified surface thereof; a joint material layer filled in the first recess and the second recess; a first optoelectronic element placed in the first recess and coupled to the interposer base via the joint material layer, wherein an optical signal is emitted from or passes through a lateral surface of the first optoelectronic element; and a second optoelectronic element placed in the second recess and coupled to the interposer base via the joint material layer, wherein a lateral surface of the second optoelectronic element faces the lateral surface of the first optoelectronic element for coupling to and receiving the optical signal emitted from or passing through the lateral surface of the first optoelectronic element.

[0010] The present invention further provides a method of producing an optoelectronic module, which comprises: providing an interposer base having a first recess and a second recess, both formed on a specified surface thereof; filling a joint material layer in the first recess and the second recess; placing a first optoelectronic element in the first recess to be coupled to the interposer base via the joint material layer, wherein an optical signal is emitted from or passes through a first align point at a lateral surface of the first optoelectronic element, and a distance from the first align point to a top surface of the first optoelectronic element is a first length; and placing a second optoelectronic element in the second recess to be coupled to the interposer base via the joint material layer, wherein a second align point at a lateral surface of the second optoelectronic element faces the lateral surface of the first optoelectronic element, and a distance from the second align point to a top surface of the second optoelectronic element is a second length, wherein a horizontal height of the first align point of the first optoelectronic element is substantially at the same level as a horizontal height of the second align point of the second optoelectronic element for the second optoelectronic element to couple to and receive the optical signal from the first optoelectronic element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above contents of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

[0012] FIG. **1** is a schematic circuit block diagram of a conventional optical transceiver;

[0013] FIG. **2** is a structural diagram schematically illustrating an active optical cable (AOC) formed on the basis of a silicon optical bench (SiOB);

[0014] FIG. **3** is a scheme illustrating the function of a typical Mach-Zehnder interferometer;

[0015] FIG. **4** is a schematic cross-sectional view of a conventional CMOS photonics platform;

[0016] FIG. **5** is a schematic diagram illustrating the packaging of a CMOS photonics platform and an edge emitting laser source via an interposer according to prior art;

[0017] FIGS. **6**A-**6**C are schemes illustrating steps for producing an optoelectronic module according to an embodiment of the present invention;

[0018] FIG. **7**A and FIG. **7**B are schematic cross-sectional views illustrating two examples of the structure of an optoelectronic module according to an embodiment of the present invention;

[0019] FIG. **8** is a schematic diagram illustrating a method of producing an optoelectronic module according to another embodiment of the present invention; and

[0020] FIG. **9** is a schematic diagram illustrating a method of producing an optoelectronic module according to a further embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] The present invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this invention are presented herein for purpose of illustration and description only; it is not intended to be exhaustive or to be limited to the precise form disclosed.

[0022] Please refer to FIGS. **6**A-**6**C, in which a method of producing an optoelectronic module according to an embodiment of the present invention is shown. As shown in FIG. **6**A, an interposer base **60** is provided, and a recess structure is formed thereon. The recess structure includes at least a first recess **601** and a second recess **602** formed on the same surface **600** of the interposer base **60**. A joint material layer **603** is filled in the recess structure. The cross sections of the first recess **601** and the second recess **602** may have a shape independently selected from a rectangle, U-shape or V-shape. The interposer base **60** may be common silicon interposer base or any other suitable interposer base for packaging a chip. The material of the interposer base **60**, for example, may be glass or ceramic. The joint material layer **603** is desirably formed of a suitable material so as to make the thickness of the layer **603** variable with pressure, e.g. the pressure resulting from installation of an optoelectronic

element. In a specific example, a soft joint material such as alloy soldering material, silver glue, epoxy, non-conductive adhesive, or UV-cured adhesive, which is deformable with pressure before curing, may be used. More specifically, the alloy soldering material may be selected from tin/gold alloy, tin/silver/copper alloy, tin/silver alloy, copper/tin alloy, lead/tin alloy, gold/tin alloy, tin/cobalt alloy, tin/bismuth alloy, tin/zinc alloy, tin/nickel alloy, aluminum/tin alloy or any other suitable alloy. It is understood that metallic joint material is advantageous in good heat dissipation effect to keep the temperature of the optoelectronic element low. Since the first recess **601** and the second recess **602** can be created by way of a semiconductor manufacturing process, e.g. defined and etched by way of a microlithographic process, high precision can be achieved so as to enhance the light coupling effect of the final product.

[0023] Referring to FIG. **6**B, a first optoelectronic element **61** is placed into the first recess **601** and coupled to the interposer base **60** via the joint material layer **603**. The second optoelectronic element **62** is placed into the second recess **602** and coupled to the interposer base **60** via the joint material layer **603**. An optical signal **680** is emitted from or passes through a light outlet **6100** at a lateral surface **610** of the first optoelectronic element **61**. The second optoelectronic element **62** has a light inlet **6200** at a lateral surface **620** thereof. The lateral surface **620** of the second optoelectronic element **62** is disposed opposite to the lateral surface **610** of the first optoelectronic element **61** with the light inlet **6200** aligned with the light outlet **6100** so that the optical signal **680** from the first optoelectronic element **61** can be received by the second optoelectronic element **62**. It is preferred that the first optoelectronic element **61** and the second optoelectronic element **62** have the same thickness. Nevertheless, even if the thickness of the first optoelectronic element **61** and the thickness of the second optoelectronic element **62** are not exactly the same, a high-precision optoelectronic module can still be produced according to the present invention as long as the thickness difference between the first optoelectronic element **61** and the second optoelectronic element **62** is less than the depth of the first recess **601** or the second recess **602**, and a first length d1 from the light outlet **6100** to the top surface **611** of the first optoelectronic element **61** is substantially consistent with a second length d2 from the light inlet **6200** to the top surface **621** of the second optoelectronic element **62**. Accordingly, a first distance T**1** from the surface **600** of the interposer base **60** to the top surface **611** of the first optoelectronic element **61** can be equal to a second distance T**2** from the surface **600** of the interposer base **60** to the top surface **621** of the second optoelectronic element **62**, thereby assuring of well horizontal alignment of the light outlet **6100** of the first optoelectronic element **61** with the light inlet **6200** of the second optoelectronic element **62**. In this way, automatic passive alignment can be achieved to accomplish high coupling efficiency of the optical signal **680** between the first optoelectronic element **61** and the second optoelectronic element **62**.

[0024] The first optoelectronic element **61** and the second optoelectronic element **62** exhibit functions of processing optoelectronic signals. For example, they process conversion between an electronic signal and an optical signal, and/or modulation, focusing, splitting, guiding, collimating, filtering and/or coupling of an optical signal. An example of an element for converting an electronic signal into an optical signal is a light-emissive optoelectronic element such as a laser diode or a light emitting diode (LED), which includes surface emitting and edge emitting types. An example of an element for converting an optical signal into an electronic signal is a photodetecting optoelectronic element, i.e. a photodetector, which may be a semiconductor-based photo diode such as a p-n junction diode, a p-i-n diode, or a avalanche photo diode. In addition, a metal-semiconductor-metal (MSM) photodetector or a photoconductor whose resistance is changeable under illumination may also be used as the photodetecting optoelectronic element.

[0025] The functions of modulating, focusing, splitting, guiding, collimating, filtering and/or coupling the optical signal can be performed by, for example, a photonics IC, a condenser lens, an optical splitter, an optical waveguide structure, an optical isolator, an optical collimator, and/or an optical fiber connector, etc. An optoelectronic device or an optoelectronic module commonly exhibits both light transmission and light receiving functions for transmitting and receiving data-carrying optical signals, and generally, the light transmission function is likely to suffer from poor alignment between associated optoelectronic elements. For example, light emitted by a laser diode is transmitted sequentially through a lens-type optical collimator for collimating the scattering light, an optical isolator for filtering light, a condenser lens for focusing light, and then a photonics IC for modulating and splitting light in order to generate multiple optical signals carrying a large quantity of data, i.e. multiple channels. At last, the multiple optical signals carrying the large quantity of data are transmitted and coupled to an optical fiber outside the optoelectronic module via an optical fiber connector. The present invention can be applied to alignment of each of the optoelectronic elements, particularly the photonics IC and the light emissive optoelectronic element. In the following embodiments, the first optoelectronic element **61** is a light emissive optoelectronic element, and the second optoelectronic element **62** is a photonics IC. The resulting optoelectronic module according to the present invention has better optical waveguide efficiency and/or light coupling efficiency.

[0026] For this purpose, in an embodiment of the present invention, a fixture **69** as shown in FIG. **6**B is used. The fixture **69** has a hollow chamber **690** for accommodating therein the first optoelectronic element **61** or the second optoelectronic element **62**. When the fixture **69** is used to place the first optoelectronic element **61** into the first recess **601**, the fixture **69** urges the first optoelectronic element **61** against the joint material layer **603**, and the joint material layer **603** deforms until at least one of the bottom structures **69***a*, **69***b* and **69***c*, e.g. the exterior bottom structure **69***a* and **69***c*, contacts with the surface **600** of the interposer base **60**. In this way, a distance between an inner surface of the fixture **69** in contact with the top surface **611** of the first optoelectronic element **61** disposed inside the hollow chamber **690** and the surface **600** of the interposer base **60**, i.e. the first distance T**1**, can be kept constant. Likewise, a distance between an inner surface of the fixture **69** in contact with the top surface **621** of the second optoelectronic element **62** disposed inside the hollow chamber **690** and the surface **600** of the interposer base **60**, i.e. the first distance T**2**, can also be kept constant, and equal to the first distance T**1**. The fixture **69** engages with or disengages from the first optoelectronic element **61** or the second optoelectronic element **62** by way of a vacuum attraction technique. A vacuum

attraction technique is only an example, and any other suitable technique may be adopted for the engagement and disengagement of elements. An electromagnetic attraction technique is one of the alternative examples. In the above-described embodiment, possible deviation between elements can be offset by the thickness change of the joint material layer **603**. In other words, when the first optoelectronic element **61** is placed into the first recess **601** and the second optoelectronic element **62** is placed into the second recess **602**, a reflow, snap cure or UV cure process can be performed to adjust the thickness of the joint material layer **603** so as to accomplish height adjustment and readily positioning.

[0027] Alternatively, two separate fixtures can be used to conduct the packaging operation, as shown in FIG. **6**C. As shown, a first fixture **71** is used for mounting the first optoelectronic element **61** into the first recess **601** and a second fixture **72** is used for mounting the second optoelectronic element **62** into the second recess **602**. The first fixture **71** has a hollow chamber **710** for accommodating therein the first optoelectronic element **61**. When the fixture **71** is used to place the first optoelectronic element **61** into the first recess **601**, the fixture **71** urges the first optoelectronic element **61** against the joint material layer **603**, and the joint material layer **603** deforms until at least one of the bottom structures **71***a* and **71***b* contacts with the surface **600** of the interposer base **60**. In this way, a distance between an inner surface of the first fixture **71** in contact with the top surface **611** of the first optoelectronic element **61** disposed inside the hollow chamber **710** and the surface **600** of the interposer base **60**, i.e. the first distance T**1**, can be kept constant. Likewise, the second fixture **72** has a hollow chamber **720** for accommodating therein the second optoelectronic element **62**. When the second fixture **72** is used to place the second optoelectronic element **62** into the second recess **602**, the second fixture **72** urges the second optoelectronic element **62** against the joint material layer **603**, and the joint material layer **603** deforms until at least one of the bottom structures **72***a* and **72***b* contacts with the surface **600** of the interposer base **60**. In this way, a distance between an inner surface of the second fixture **72** in contact with the top surface **621** of the second optoelectronic element **62** disposed inside the hollow chamber **720** and the surface **600** of the interposer base **60**, i.e. the second distance T**2**, can be kept constant.

[0028] In this embodiment, if a first length d**1** from the light outlet **6100** of the first optoelectronic element **61**, i.e. a first align point for optical signal, to the top surface **611** of the first optoelectronic element **61** is consistent to a second length d**2** from the light inlet **6200** of the second optoelectronic element **62**, i.e. a second align point for optical signal, to the top surface **621** of the second optoelectronic element **62**, i.e. d**1**=d**2**, the first distance T**1** would be inherently equal to the second distance T**2**. The difference between them is substantially zero. Unfortunately, the thickness K**1** of the first optoelectronic element **61** is sometimes unequal to the thickness K**2** of the second optoelectronic element **62**, so the first length d**1** might be different from the second length d**2**. Nevertheless, by accurately controlling the depth of the first hollow chamber **710** and the depth of the second hollow chamber **720** to have a difference between the first distance T**1** and the second distance T**2** substantially equal to the difference between the first length d**1** and the second length d**2** according to the present invention, the relative positions of the first align point and the second align point for optical signal can still be kept horizontally consistent. Accordingly, the optical signal **680** emitted from or passing through the first optoelectronic element **61** can be coupled to the second optoelectronic element **602** with satisfactory optical wave conducting rate and optical coupling efficiency. The first optoelectronic element **61** may be a common edge emitting laser source, and the light emitted by the edge emitting laser source is diffracted via a slit, and then passes a collimator, an isolator and a condenser lens to tune a light output angle. The second optoelectronic element **62** may be a MOS photonics platform, and the light inlet **6200** is an optical waveguide structure of the MOS photonics platform.

[0029] An optoelectronic module produced by either of the above two embodiments is schematically shown in FIG. **7**A. The optoelectronic module **8**A includes an interposer base **80**, and a recess structure is formed on the interposer base **80**. The recess structure includes at least a first recess **801** and a second recess **802** formed on the same surface **800** of the interposer base **80**. A joint material layer **803** is filled into the first recess **801** and the second recess **802**. The first optoelectronic element **81** is placed into the first recess **601** and coupled to the interposer base **80** via the joint material layer **803**. The second optoelectronic element **82** is placed into the second recess **802** and coupled to the interposer base **80** via the joint material layer **803**. An optical signal **880** is emitted from or passes through a light outlet **8100** at a lateral surface **810** of the first optoelectronic element **81**. The second optoelectronic element **82** has a light inlet **8200** at a lateral surface **820** thereof. The lateral surface **820** of the second optoelectronic element **82** is disposed opposite to the lateral surface **810** of the first optoelectronic element **81** with the light inlet **8200** aligned with the light outlet **8100** so that the optical signal **880** from the first optoelectronic element **81** can be received by the second optoelectronic element **82**. For example, the first optoelectronic element **81** may be an optoelectronic element functioning as an optical signal emitter, e.g. the above-described edge emitting laser source, and the second optoelectronic element **82** may be an optoelectronic element functioning as an optical signal receiver, e.g. the above-described MOS photonics platform. The optical signal **880** emitted from or passing through the first optoelectronic element **81** is parallel to the upper surface **800** of the interposer base **80**. In a specific example, the joint material layer **803** may be made of alloy soldering material, silver glue, epoxy, non-conductive adhesive, or UV-cured adhesive, which is deformable to adjust thickness thereof with the aid of a fixture before being cured by way of a reflow, snap cure or UV cure process. The cured joint material layer **803** in different recesses may have different thickness as long as the light outlet **8100** is well aligned with the light inlet **8200** in the packaged final product for effective optical wave conduction and efficient light coupling.

[0030] In this embodiment, the optoelectronic module **8**A further includes a plurality of module pins **85***a*, **85***b* and **85**, pads **88***a* and **88***b*, metal lines **89***a* and **89***b*, and solder balls **86**. The interposer base **80** has interlayer structures **87***a* and **87***b* with through silicon vias (TSV). The interlayer structures **87***a* and **87***b* are electrically connected between the module pins **85**, **85***a* and **85***b* on the lower surface **800***b* and the pads **88***a* and **88***b* on the upper surface **800**. The solder balls **86** may be soldering material such as tin, tin/silver or tin/coper alloy. A ball placement process may be performed after an aligning and compressing process to attach the

solder balls **86** onto the lower surface of each module pins **85**. Furthermore, a wire bonding process may be performed to have the metal wires **89***a* and **89***b* electrically connected between the pads **88***a* and **88***b* of the interposer base **80** and the pins **81***a* and **82***b* of the optoelectronic elements **81** and **82**. The electronic signals of the optoelectronic elements **81** and **82** can thus be transmitted to the interposer base **80**, elements disposed on the interposer base **80** (not shown) and/or the module pins **85***a*, **85***b* and **85** through the metal lines **89***a* and **89***b*. When the optoelectronic module **8**A is welded to a system PCB board **90**, the module pins **85** on the lower surface of the optoelectronic module would be electrically coupled to a corresponding pad **901** of the system PCB board **90**.

[0031] FIG. **7**B schematically illustrates another example of optoelectronic module similar to that shown in FIG. **7**A. In this example, an optoelectronic module **8**B is similar to the optoelectronic module **8**A except further comprising a third optoelectronic element **83**, e.g. a collimator, wherein the optical signals through the optoelectronic element **81** and the optoelectronic element **82** will pass the third optoelectronic element **83**. The disposition and alignment of the third optoelectronic element **83** is similar to the optoelectronic elements **81** and **82**.

[0032] Please refer to FIG. **8**, which schematically illustrates a method of producing an optoelectronic module according to another embodiment of the present invention. In this embodiment, which is different from the embodiment shown in FIG. **6**C, the first optoelectronic element **61** and the second optoelectronic element **62** are first placed into the first recess **601** and the second recess **602**. Then the first fixture **71** is used to press the first optoelectronic element **61** against the joint material layer **603**. Likewise, the second fixture **72** is used to press the second optoelectronic element **62** against the joint material layer **603**. The joint material layer **603** in the first recess **601** and the joint material layer **603** in the second recess **602** deform to respectively required levels to well align the light outlet **6100** and the light inlet **6200**.

[0033] FIG. **9** schematically illustrates a method of producing an optoelectronic module according to a further embodiment of the present invention. If the thickness K**1** of the first optoelectronic element **61** is different from the thickness K**2** of the second optoelectronic element **62**, the first length d**1** will be unequal to the second length d**2**. Therefore, in this embodiment, two fixtures of different thickness are used, e.g. the first fixture **91** and the second fixture **92**. Furthermore, the length of two bottom structures may be the same, e.g. the bottom structures **92***a* and **92***b* of the second fixture **92**, or different, e.g. the bottom structures **91***a* and **91***b* of the first fixture **91**. For accommodating the longer bottom structure **91***b*, the interposer base **60** in this embodiment has a fixture trench **600***a* with a depth V**1**. Therefore, the first distance T**1**(T**1**=d**1**+h) of the first fixture **91**, the second distance T**2**(T**2**=d**2**+h) of the second fixture **92** and the third distance T**3**(T**3**=d**1**+h+V**1**) of the first fixture **91**, as shown in FIG. **9**, are all different. Nevertheless, as long as the equation h=T**1'1**d**1**=T**2**−d**2**=T**3**−d**1**−V**1** is complied with, wherein T**1**−d**1**, T**2**−d**2**, and T**3**−d**1**−V**1** all define a common height h, the light outlet **6100** and the light inlet **6200** can still be well aligned with the height h (horizontal height). Therefore, the optical signal **680** emitted from or passing through the first optoelectronic element **61** can be coupled to the second optoelectronic element **602** with satisfactory optical wave conducting rate and optical coupling efficiency.

[0034] As described above, the deviation problems encountered in the prior art can be largely ameliorated by the present invention. In practice, the alignment deviation between the height of the light outlet and the height of the light inlet of the optoelectronic module according to the present invention can be controlled to be less than 1.4 micrometers, which is significantly improved compared with the 2.24-5.4 micrometer deviation of the prior art. In addition, the assembling time can be improved from 1-2 minutes to about 10 seconds.

[0035] While the invention has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention needs not to be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

What is claimed is:

1. An optoelectronic module, comprising:

an interposer base having a first recess and a second recess, both formed on a specified surface thereof;

a joint material layer filled in the first recess and the second recess;

a first optoelectronic element placed in the first recess and coupled to the interposer base via the joint material layer, wherein an optical signal is emitted from or passes through a lateral surface of the first optoelectronic element; and

a second optoelectronic element placed in the second recess and coupled to the interposer base via the joint material layer, wherein a lateral surface of the second optoelectronic element faces the lateral surface of the first optoelectronic element for coupling to and receiving the optical signal emitted from or passing through the lateral surface of the first optoelectronic element.

2. The optoelectronic module according to claim **1**, wherein the interposer base is a silicon interposer base.

3. The optoelectronic module according to claim **1**, wherein the interposer base includes:

a pad disposed on a surface of the interposer base, and electrically connected to a pin of the first optoelectronic element or the second optoelectronic element through a metal wire;

a module pin disposed on another surface of the interposer base; and

an interlayer structure electrically connected to the module pin and the pad.

4. The optoelectronic module according to claim **1**, wherein the first optoelectronic element is an optical signal emitting source emitting the optical signal, the second optoelectronic element is a photonics IC receiving the optical signal, the optical signal emitted from the optical signal emitting source is parallel to the specified surface of the interposer base, and a horizontal height of a light outlet of the first optoelectronic element is substantially at the same level as a horizontal height of a light inlet of the second optoelectronic element.

5. The optoelectronic module according to claim **1**, further comprising a third optoelectronic element disposed between the first optoelectronic element and the second optoelectronic element.

6. The optoelectronic module according to claim **1**, wherein the first optoelectronic element and the second optoelectronic element are selected from a group consisting of a laser diode, a light emitting diode, a photodetector, a photonics IC, a condenser lens, an optical splitter, an optical waveguide structure, an optical isolator, an optical collimator, and an optical fiber connector.

7. The optoelectronic module according to claim **1**, wherein the joint material layer in the first recess and the joint material layer in the second recess are different in thickness.

8. The optoelectronic module according to claim **1**, wherein a first thickness of the first optoelectronic element and a second thickness of the second optoelectronic element are different from each other.

9. The optoelectronic module according to claim **1**, wherein a first length from a first align point of the first optoelectronic element, where the optical signal passes through the first align point, to a top surface of the first optoelectronic element is substantially equal to a second length from a second align point of the second optoelectronic element, where the optical signal passes through the second align point, to a top surface of the second optoelectronic element.

10. The optoelectronic module according to claim **1**, wherein the joint material layer is formed of a material selected from a group consisting of an alloy soldering material, a silver glue, epoxy, a non-conductive adhesive and a UV-cured adhesive.

11. A method of producing an optoelectronic module, comprising:

providing an interposer base having a first recess and a second recess, both formed on a specified surface thereof;

filling a joint material layer in the first recess and the second recess;

placing a first optoelectronic element in the first recess to be coupled to the interposer base via the joint material layer, wherein an optical signal is emitted from or passes through a first align point at a lateral surface of the first optoelectronic element, and a distance from the first align point to a top surface of the first optoelectronic element is a first length; and

placing a second optoelectronic element in the second recess to be coupled to the interposer base via the joint material layer, wherein a second align point at a lateral surface of the second optoelectronic element faces the lateral surface of the first optoelectronic element, and a distance from the second align point to a top surface of the second optoelectronic element is a second length,

wherein a horizontal height of the first align point of the first optoelectronic element is substantially at the same level as a horizontal height of the second align point of the second optoelectronic element for the second optoelectronic element to couple to and receive the optical signal from the first optoelectronic element.

12. The method according to claim **11**, wherein the first optoelectronic element and the second optoelectronic element are pressed with a fixture to be placed into the first recess and the second recess, respectively, until the fixture urges against the interposer base, wherein the fixture has a first hollow chamber for accommodating the first optoelectronic element, and a second hollow chamber for accommodating the second optoelectronic element.

13. The method according to claim **12**, wherein a first distance between an inner surface of the fixture in contact with the top surface of the first optoelectronic element and the specified surface of the interposer base is equal to a second distance between the inner surface of the fixture in contact with the top surface of the second optoelectronic element and the specified surface of the interposer base.

14. The method according to claim **11**, wherein the first optoelectronic element is pressed with a first fixture to be placed into the first recess until the first fixture urges against the interposer base, and the second optoelectronic element is pressed with a second fixture to be placed into the second recess until the second fixture urges against the interposer base, wherein the first fixture has a first hollow chamber for accommodating the first optoelectronic element, and the second fixture has a second hollow chamber for accommodating the second optoelectronic element.

15. The method according to claim **14**, wherein a difference between a first distance, which is defined from an inner surface of the fixture in contact with the top surface of the first optoelectronic element to the specified surface of the interposer base, and a second distance, which is defined from the inner surface of the fixture in contact with the top surface of the second optoelectronic element to the specified surface of the interposer base, is substantially equal to a difference between the first length and the second length.

16. The method according to claim **14**, wherein a difference between a first distance, which is defined from an inner surface of the fixture in contact with the top surface of the first optoelectronic element to the specified surface of the interposer base, and a second distance, which is defined from the inner surface of the fixture in contact with the top surface of the second optoelectronic element to the specified surface of the interposer base, is substantially equal to a difference between the first length and the second length plus a depth of the fixture trench.

17. The method according to claim **16**, wherein the interposer base includes a fixture trench on the specified surface for optionally receiving a partial structure of at least one of the first fixture and the second fixture.

18. The method according to claim **11**, further comprising a reflow or curing process of the joint material layer after the first optoelectronic element is coupled to the interposer base via the joint material layer in the first recess and the second optoelectronic element is coupled to the interposer base via the joint material layer in the second recess.

19. The method according to claim **11**, wherein the interposer base is a silicon interposer base, and the joint material layer is formed of a material selected from a group consisting of an alloy soldering material, a silver glue, epoxy, a non-conductive adhesive and a UV-cured adhesive.

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