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electrode pad are connected by wire;

wherein the carrier member has a level difference between the light emitting element mounting surface and the electrode pad installation surface, the electrode pad installation surface and circuit board electrode pad surface are coplanar, and the light receiving element is disposed to receive rearward emitted light from the light emitting element.

Claim 2

The optical transmission module of Claim 1, wherein the carrier member level difference is formed by a sloped surface.

Detailed Description of the Invention

[Technical Field]

[0001]

The present invention pertains to an optical transmission module for transmitting optical signals.

[Background Art]

[0002]

For high-speed compact optical transceivers conforming to standards such as XFP (10 Gigabit Form-factor Pluggable) and SFP (Small Form-factor Pluggable), the external dimensions of a package housing the optical module are defined by industry standard specifications. Therefore the size of the optical transmitting module (TOSA: Transmitting Optical Sub-Assembly) housed within the aforementioned package is also constrained.

[0003]

To house an optical transmission module within such a package, the components constituting the optical transmission module, such as an LD (Laser Diode), focusing lens, monitoring PD (Photo Diode) for monitoring the LD optical output, and heat dissipation module, must be efficiently arranged so as to reduce the size of the optical transmission module. An optical transmission module reduced in size in this way is disclosed, for

example, in Patent Document 1.

[0004]

Here, referring to Fig. 6, we explain the outline of a conventional optical transmission module. As shown in Figure 6(A), in optical transmission module 10 a thermoelectric module 12 is disposed within a package 11, and LD 14 is mounted on this thermoelectric module 12 via an LD carrier member 13 with good thermal conductivity ("LD carrier" below).

[0005]

Signal light emitted from LD14 passes through a lens 15 mounted on thermoelectric module 12 and is incident on optical fiber (not shown) at the front of package 11. [In] the thermoelectric module (Thermo-Electric Cooler: TEC) 12, a first flat body 12b is disposed on the heat-absorbing side of thermoelectric conversion element 12a, a second flat body 12c is disposed on the heat-discharging side [thereof], and LD carrier 13 is mounted on the first flat body 12b on the heat-absorbing side. Heat generated by LD14 mounted on LD carrier 13 is dissipated externally via package 11 by thermoelectric module 12.

[0006]

In addition, a multilayer circuit board 17 comprising a lead terminal 16 is mounted on the rear side of package 11 (opposite the side where lens 15 is disposed). A monitor PD 18 is mounted on circuit board 17 via PD carrier 19. As shown in the figure, LD14 and monitor PD18 are positioned in opposition to one another. Note that circuit board 17 comprises a multilayer board such as a first ceramic substrate 17a and second ceramic substrate 17b, and is affixed to package 11 by an insulating block 17c. Interconnect conductors and electrode pads are respectively formed on ceramic substrates 17a and 17b and are utilized to electrically connect thermoelectric module 12, LD 14, and monitor PD18 to external devices.

[0007]

LD14 is electrically connected to an electrode pad formed on interconnect conductors on LD carrier 13; this electrode pad and the electrode pad of circuit board 17 are electrically connected by interconnect wires 20 for driving the LD. Additionally, a

thermistor (not shown) for detecting the temperature of LD14 is also electrically connected via a wire.

[Prior Art Documents]

[Patent Documents]

[0008]

[Patent Document 1] JP Application No. 2008-166730

[Summary of the Invention]

[Problem the Invention Seeks to Solve]

[0009]

From the standpoint of optical coupling efficiency and cost, monitor PD18 should be disposed on the rearward-emitted light optical path so that the LD14 rearward-emitted light P1 can be made directly incident on monitor PD18 without refraction, reflection, or focusing, and also so that this rearward-emitted light can be efficiently received.

[0010]

When driving LD14 at high speed, the length of interconnect wire 20 must be minimized to the maximum extent possible in order to maximally reduce the effect of parasitic inductance in the LD drive interconnect wire 20 on the optical output waveform, and to prevent deterioration of high-frequency characteristics. To shorten the length of interconnect wire 20, the LD carrier electrode pad of LD connected to interconnect wire 20 and the circuit board 17 electrode pad must be disposed on the same plane (same level), and the distance between the two electrode pad portions must be short.

[0011]

As described above, however, when both electrode pads are disposed on the same plane, the LD14 rearward-emitted light P1 cannot be efficiently received on the light-receiving surface of monitor PD18. The amount of incident light on monitor PD18 therefore decreases, causing the current output by monitor PD18 to decrease.

[0012]

Thus as shown in Figure 6(B), raising the LD mounting surface of LD carrier 13 allows LD 14 rearward-emitted light P1 to be made directly incident on monitor PD 18 so that

monitor PD 18 can efficiently receive the rearward-emitted light. However when the position of the LD carrier 13 mounting surface is thus aligned with the monitor PD 18 light-receiving surface, the position of the electrode pad formed on the same surface as the LD mounting surface is made higher than the circuit board electrode pad surface. This causes a level difference H to form between the two electrode pads, increasing the length of interconnect wire 20 and increasing parasitic inductance, thus degrading high-frequency characteristics.

[0013]

The present invention was developed in light of said circumstances and has the object of providing an optical transmission module in which a monitor PD is disposed to be capable of efficiently receiving rearward-emitted light from an LD, and of shortening the length of wire connecting an LD carrier electrode pad to a circuit board electrode pad.

[Means for Solving the Problem]

[0014]

The optical transmission module of the present invention has: a carrier member on which a light-emitting element is mounted and an light emitting element electrode pad is provided, and a circuit board on which a light-receiving element for monitoring the light output of the light-emitting element is mounted and interconnect conductors and electrode pads are provided; wherein the carrier member electrode pad and the circuit board electrode pad are connected by wire.

The carrier member has a level difference between the light-emitting element mounting surface and the electrode pad installing surface; the electrode pad installing surface and the electrode pad circuit board surface are coplanar, and the light-receiving element is disposed so as to receive rearward-emitted light from the light-emitting element. The carrier member level difference is formed by a sloping surface.

[Effect of the Invention]

[0015]

In present the invention, the monitor PD can be positioned along the optical path of the LD rearward-emitted light, allowing it to receive this light with high efficiency, therefore

the monitor PD can monitor the LD optical output with high precision. Because the length of wire connecting the LD carrier electrode pad to the circuit board electrode path can be shortened, parasitic inductance in the wire can be reduced, preventing the deterioration of high-frequency characteristics.

[Brief Description of Figures]

[0016]

[Figure 1] A front elevation cross-sectional view of an optical transmission module according to the present invention.

[Figure 2] A cross-sectional view of an optical transmission module seen from above.

[Figure 3] A detailed diagram of an LD carrier according to the present invention.

[Figure 4] A detailed diagram of a PD carrier.

[Figure 5] A schematic diagram depicting interconnections between lead terminals.

[Figure 6] A diagram depicting an example of a conventional optical transmission module.

[Description of Embodiments]

[0017]

The present invention is described below with reference to Figures 1 through 5. Figure 1 is a front cross-sectional view of an optical transmission module according to the present invention; Figure 2 is an overhead view of the cross section of an optical transmission module according to the present invention. Figure 3 is a diagram illustrating details of an LD carrier; Figure 4 explains details of the PD carrier. Figure 5 is a schematic diagram explaining interconnects between lead terminals.

[0018]

As shown in Figure 1, the optical transmission module 1 according to the present invention is constituted by installing a thermoelectric module 12 within a package 11, as explained by Figure 6. In thermoelectric module 12, a first flat body 12b is disposed on the heat-absorbing side of thermoelectric conversion element 12a and a second flat body 12c is disposed on the heat-emitting side [thereof]; and an LD carrier 21 is mounted on first flat body 12b on the heat-absorbing side. LD14 is mounted on the LD carrier 21 mounting surface 21a; heat generated by LD14 is exhausted externally by thermoelectric module 12

through package 11.

[0019]

Signal light transmitted from LD14 passes through a lens 15 mounted on thermoelectric module 12 and is incident on optical fiber (not shown) at the front of package 11. In addition, a circuit board 17 comprising lead terminals 16 is mounted at the rear of package 11. A monitor PD 18 is mounted on circuit board 17 via PD carrier 19. As shown in the figure, the light-emitting portion of the LD14 rear-emitting light P1 and the monitor PD18 light-receiving surface are opposed one another. Note that circuit board 17 comprises a multilayer board such as a first ceramic substrate 17a and second ceramic substrate 17b, and is affixed to package 11 by an insulating block 17c. Electrode pads and interconnect conductors (see Figure 2) are formed on each ceramic substrate 17a, 17b, and utilized to electrically connect the thermoelectric module 12, LD 14, monitor PD 18, and external equipment. A via hole 17d is formed in first ceramic substrate 17a.

[0020]

We next explain the structure of an LD carrier 21 according to the present invention. An LD mounting surface 21a for mounting LD 14 and an installation surface 21b for holding LD14 electrode pads 23 are formed on LD carrier 21. LD mounting surface 21a and electrode pad 23 installation surface 21b have a level difference L; this level difference is formed, for example, by a sloped surface 21c. The height position of LD mounting surface 21a is set so that monitor PD 18 can efficiently receive rearward-emitted light P1 from LD 14. Also, the height position of electrode pad 23 mounting surface 21b is set to be coplanar with the electrode pad installation surface 24 on the circuit board 17 second ceramic substrate 17b, as shown by line P3.

[0021]

We next explain details of LD carrier 21 using Figures 2 and 3. Figure 2 shows an optical transmission module as seen from above. Figure 3(A) is a view of LD carrier 21 seen from above; Figure 3(B) is a front view of LD carrier 21. Electrode pads 23 provided on the mounting surface 21b of LD carrier 21 comprise an LD cathode electrode pad 23a and an LD anode electrode pad 23b. Both electrode pads (23a, 23b) are formed at the ends (on the

monitor PD18 side) of LD cathode wiring conductor 22a and LD anode wiring conductor 22b, which constitute LD14 interconnect conductors.

[0022]

As shown in Figure 2, LD cathode electrode pad 23a and LD cathode electrode pad 24a on circuit board 17 mounting surface 24 are electrically connected through interconnect wire 25a, and LD anode electrode pad 23b and LD anode electrode pad 24b are electrically connected through interconnect wire 25b. The LD cathode electrode pad 24a and LD anode electrode pad 24b on circuit board 17 installation surface 24 are arranged in parallel to the LD cathode electrode pad 23a and LD anode electrode pad 23b on LD carrier 21 installation surface 21b, and are coplanar (see line P3 in Fig. 1). Note that the interconnect wire 20 shown in Figure 1 is the same as interconnect wires 25a and 25b. LD14 anode terminal 14a is connected to LD anode wiring conductor 22b via interconnect wire 26a.

[0023]

Thus by forming the top surface of LD carrier 21 with an LD mounting surface 21a, which has a level difference, and an electrode pad installation surface 21b, the LD 14 can be disposed so that its rearward-emitted light is efficiently received by monitor PD 18. Forming the level difference with a sloped surface 21c [ensures] that rearward-emitted light from LD14 is not blocked.

Furthermore, since the LD carrier 21 installation surface 21b and the circuit board 17 installation surface 24 are coplanar, the lengths of LD cathode interconnect wire 25a and LD anode interconnect wire 25b can be shortened. As a result, parasitic inductance in the interconnect wires is suppressed, providing a good optical output waveform and enabling higher-speed transmission.

[0024]

In addition, a thermistor 27 for monitoring the temperature of LD 14 is disposed on LD carrier 21. The connection terminals (not shown) on this thermistor 27 are connected to thermistor interconnect conductors 22c, and thermistor electrode pad 23c formed at the ends of thermistor interconnect conductors 22c is electrically connected to circuit board

17 thermistor electrode pad 24c via interconnect wire 25c. Thermistor 27 connection terminal 27a is connected to thermistor interconnect conductor 22c via interconnect wire 26b.

[0025]

A TEC wiring conductor 22d for supplying power to thermoelectric conversion element 12a is provided on first flat body 12b on the heat-absorbing side of thermoelectric module 12 (see Figure 1). The TEC electrode pad 23d for TEC wiring conductor 22d and the TEC electrode pad 24d for circuit board 17 are electrically connected through interconnect wire 25d.

[0026]

Although an example was shown in which the LD carrier 21 level difference was formed by a sloped surface 21c, it may also be step-shaped. In that case, either metallization for wiring is applied to the side surface of the level difference, or the carrier is formed of multiple layers and vias disposed [therein]. In the present embodiment, LD carrier 21 is mounted on first flat body 12b, but if there are no constraints in the mounting surface area, etc., it does not specifically need to be mounted on first flat body 12b. LD carrier 21 may be fabricated from materials with high thermal conductivity, such as aluminum nitride.

[0027]

Next, referring to Fig. 4, we explain details of monitor PD18. Fig. 4(A) is a side elevation of PD carrier 19 seen from the direction of lens 15; Fig. 4(B) is a diagram of PD carrier 19 seen from below. A cathode wiring conductor 22e, electrically connected through interconnect wire 26c to a monitor PD 18 cathode terminal, is disposed on the side and bottom surfaces of PD carrier 19, and a cathode electrode pad 23e is formed on cathode wiring conductor 22e. Cathode electrode pad 23e connects to circuit board 17 wiring conductor 28e through via hole 17e (see Figure 2). An anode electrode pad 23f is formed on monitor PD18 anode wiring conductor 22f, and this anode electrode pad 23f connects to circuit board 17 wiring conductor 28f through via hole 17d (see Figure 2).

[0028]

As shown in Fig. 2, multiple lead terminals (16a-16f) are electrically connected to the ends of interconnect conductors (28a-28f) formed on circuit board 17. Note that the interconnect conductors are formed on second ceramic substrate 17b, shown in Figure 1.

[0029]

As shown in Figures 2 and 5, thermistor lead terminals 16c₁ and 16c₂ are connected to thermistor 27 through interconnect conductors 28c₁, 28c₂, and 28c₃. PD terminals 16e and 16f are connected to monitor PD 18 through interconnect conductors 28e and 28f or the like. LD lead terminals 16a and 16b are connected to LD 14 through interconnect conductors 28a, 28b or the like. TEC terminals 16d₁ and 16d₂ are connected to thermoelectric conversion element 12a through interconnect conductors 28d₁ and 28d₂ or the like.

[Explanation of Reference Numerals]

[0030]

1, 10, 10'...optical transmission module; 11...package; 12...thermoelectric module (TEC); 12a...thermoelectric conversion element; 12b...first flat body; 12c...second flat body; 13, 21...LD carrier; 21a...LD mounting surface; 21b, 24...electrode pad installation surface; 13c...level difference; 14...LD; 14a...anode terminal; 15...lens; 16, 16a-16f...lead terminals; 17...circuit board; 17a, 17b...ceramic substrate; 17c...insulating block; 17d, 17e...via holes; 18...monitor PD; 18a...cathode terminal; 19...PD carrier; 20...interconnect wire; 22a to 22f...interconnect conductors; 23, 23a to 23f, 24a to 24d...electrode pads; 25a to 25d, 26a to 26c...interconnect wires; 27...thermistor; 27a...connection terminal; 28a to 28f...interconnect conductors.

FIG. 1

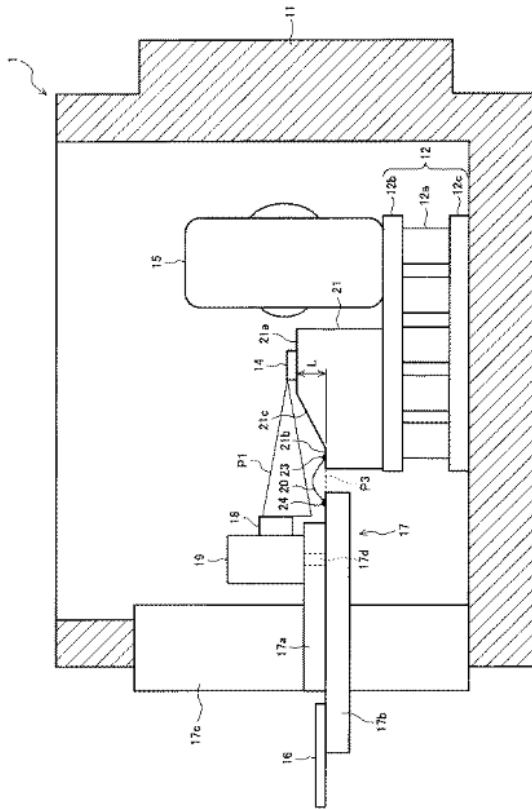


FIG. 2

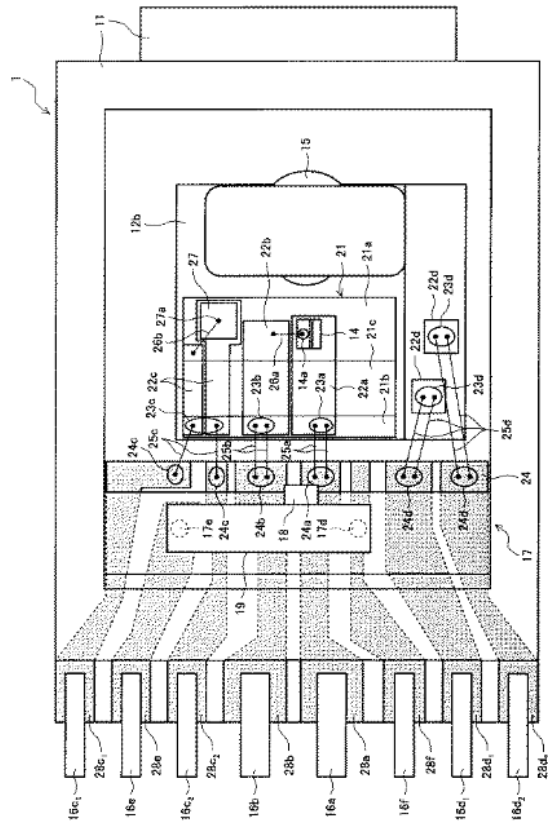


FIG. 3

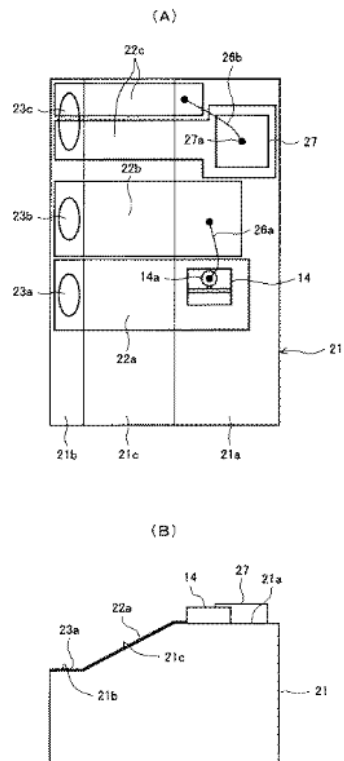


FIG. 4

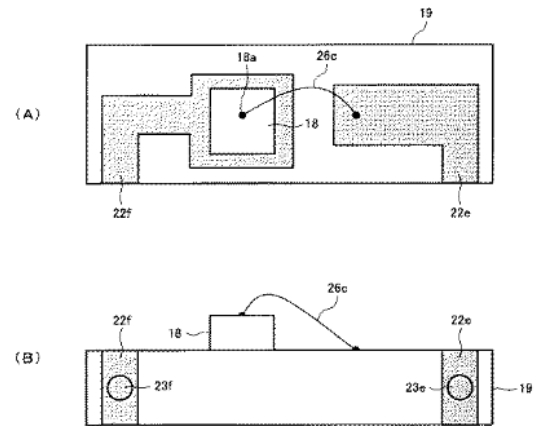


FIG. 5

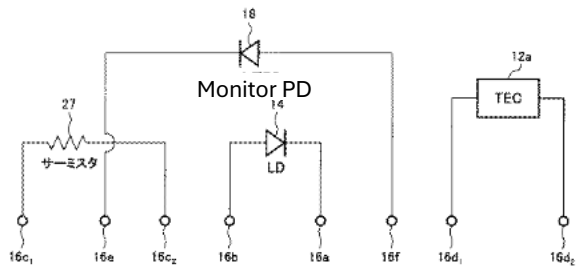
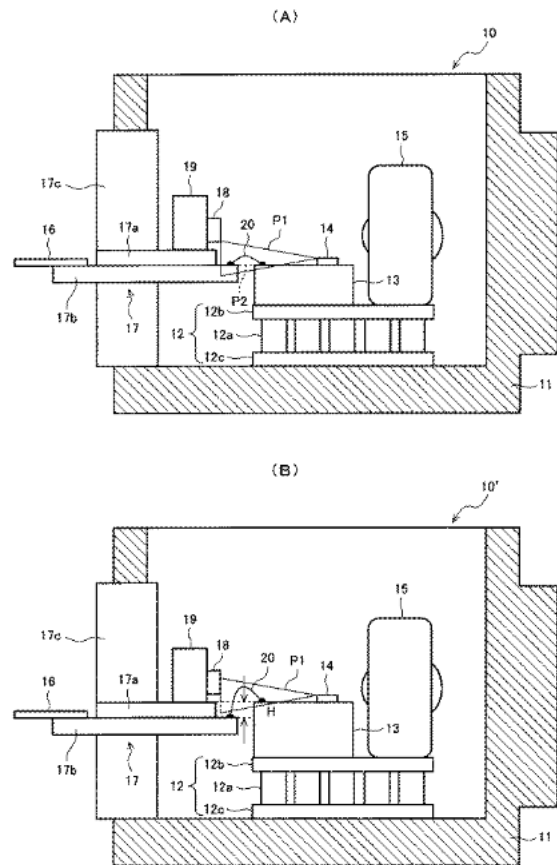


FIG. 6



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CERTIFICATION OF TRANSLATION

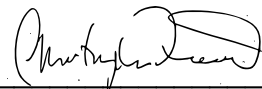
I, Christopher L. Field, residing at 52 Sherman Bridge Rd., Wayland MA, 01778, United States of America, declare and state as follows:

I am well acquainted with the English and Japanese languages. I have professionally translated numerous Japanese documents of legal and/or technical content into English. I am fully accredited by the American Translators Association (ATA) for Japanese to English translation, and my ATA certification number is 423514.

I have personally translated the attached document, entitled "**Japanese Patent 2010-161146**." I hereby certify that the English translation of the attached documents is an accurate translation to the best of my knowledge and ability.

I further declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed at Wayland, Massachusetts, 10 November 2025.

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Christopher Field

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