(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 February 2016 (11.02.2016)

(10) International Publication Number
WO 2016/021203 A1

(51) **International Patent Classification**:
H01S 5/022 (2006.01) *H01S 5/042* (2006.01)

(21) **International Application Number**:
PCT/JP2015/003966

(22) **International Filing Date**:
6 August 2015 (06.08.2015)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
2014-162643 8 August 2014 (08.08.2014) JP

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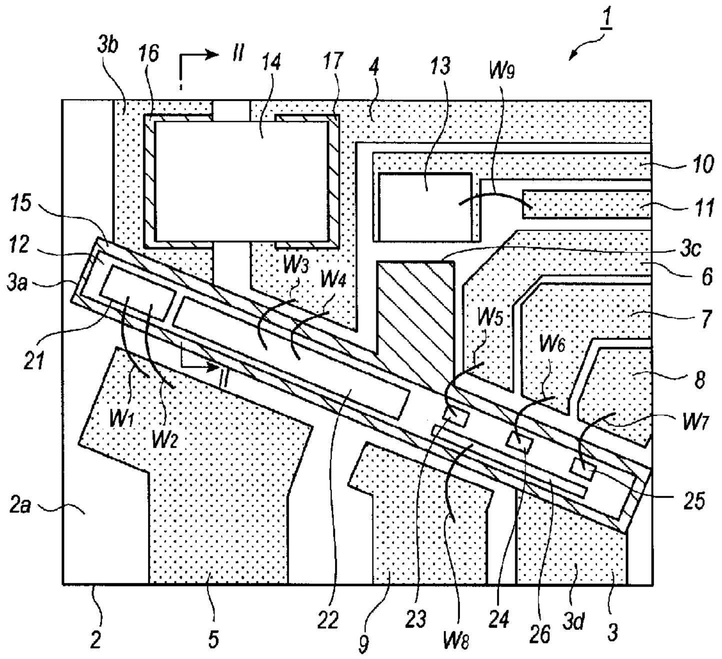
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: LASER ASSEMBLY AND METHOD TO ASSEMBLE LASER ASSEMBLY



(57) **Abstract**: A laser assembly is disclosed. The laser assembly includes a carrier for mounting a semiconductor laser diode (LD) and a capacitor thereon. The carrier provides, in a top surface thereof, a metal pattern having a die area for mounting the LD through a brazing material, a mounting area, and an auxiliary area for absorbing a surplus brazing material. The capacitor is mounted on the mounting area closer to the LD through another brazing material.

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Description

Title of Invention: LASER ASSEMBLY AND METHOD TO ASSEMBLE LASER ASSEMBLY

Technical Field

[0001] The present application relates to a laser apparatus comprising a semiconductor laser diode (LD) and a bypassing capacitor disposed in a vicinity of the LD.

Background Art

[0002] In an optical communication system, an advanced technique to utilize a phase of signal light has become popular to bring further communication capacity. Such an optical communication system is often called as the coherent communication system. Fig. 7 schematically illustrates an arrangement of an optical signal source 100 used in the coherent communication system. The optical signal source 100 shown in Fig. 7 provides an LD 102 biased with a DC power supply 101 and an optical modulator 103. The LD 102 emits continuous-wave (CW) light L11, and the optical modulator 103 modulates the CW light L11 to output a modulated light L12. The optical signal source 100 sometimes installs a wavelength tunable LD as the LD 102 disclosed in, for instance, the United States Patent No. 7,362,782.

Citation List

Patent Literature

[0003] PTL 1: United States Patent No. 7,362,782.

Summary of Invention

Technical Problem

[0004] The LD 102 implemented in the optical signal source 100 is strongly requested to generate the CW light with line width as narrower as possible. Electrical noises superposed on the bias provided to the LD 102 degrade the line width. The DC power supply 101 inherently causes noises, but the bias line 104 sometimes superposes noises by the electro-magnetic interference (EMI), in particular, noises with high frequencies. A bias line for supplying a DC bias usually accompanies with bypassing capacitors against the ground. However, the bypassing capacitor is necessary to be connected to the LD as close as possible because, when a substantial bias line is left between the LD and the bypassing capacitor, the left bias line causes noises. In particular, when the optical modulator 103 modulates the CW light L11 by modulation signals whose frequency reaches and sometimes exceeds 10 GHz, the left bias line between the LD and the bypassing capacitor is further preferable as short as possible.

Solution to Problem

[0005] One aspect of the present application relates to a laser assembly that comprises a carrier, a metal pattern provided on the carrier, an LD, and a capacitor. The metal pattern includes a die area, a mounting area, and an auxiliary area. The die area and the auxiliary area are provided with a brazing material. The LD is mounted on the die area through the brazing material. A feature of the laser assembly of the present application is that the capacitor is mounted on the mounting area through another brazing material that is apart from the brazing material.

[0006] Another aspect of the present application relates to a method to assemble a laser assembly. The method includes steps of: (1) forming a metal pattern on a carrier, where the metal pattern includes a die area, a mounting area, and an auxiliary area; (2) depositing a brazing material only on the die area and the auxiliary area of the metal pattern; (3) mounting an LD on the die area as absorbing a surplus brazing material in the auxiliary area; (4) applying another brazing material on the mounting area so as not to be in contact with the brazing material; and (5) mounting a capacitor on the mounting area as interposing the another brazing material between the mounting area and the capacitor.

Advantageous Effects of Invention

[0007] It is possible to reduce noises.

Brief Description of Drawings

[0008] [fig.1]Fig. 1 is a plan view of a laser assembly according to the first embodiment of the present application.

[fig.2]Fig. 2 shows a cross section taken along the ling II-II denoted in Fig. 1.

[fig.3]Fig. 3(A) is a plan view showing a process to assemble the laser assembly according to an embodiment of the present application, and Fig. 3(B) is a plan view showing a process subsequent to the process of Fig. 3(A).

[fig.4]Fig. 4(A) is a plan view showing a process to assembly the laser assembly subsequent to the process shown in Fig. 3(B), and Fig. 4(B) is a plan view of a process subsequent to the process shown in Fig. 4(A).

[fig.5]Fig. 5 shows a cross section of a conventional laser assembly.

[fig.6]Fig. 6 is a plan view of a laser module that implements a laser assembly shown in Fig. 1.

[fig.7]Fig. 7 schematically illustrates a circuit diagram of an optical transmitter for a coherent communication system.

Description of Embodiments

[0009] Next, some embodiments according to the preset application will be described as referring to drawings. In the description of the drawings, numerals or symbols same with or similar to each other will refer to elements same with or similar to each other without duplicating explanations.

[0010] Fig. 1 is a plan view of a laser assembly according to the first embodiment of the present invention, and Fig. 2 shows a cross section of the laser assembly 1 taken along the ling II-II appearing in Fig. 1. The laser assembly 1 of the present embodiment, as shown in Figs. 1 and 2, provides a carrier 2 including a plurality of metal patterns, 3 to 11, on a top surface thereof, a semiconductor laser diode (LD) 12, a thermistor 13, a capacitor 14, and a plurality of bonding wires, W1 to W9.

[0011] The carrier 2, which may be made of inorganic material such as aluminum oxide (AlOx), aluminum nitride (AlN), and so on, provides the metal patterns, 3 to 11, on a top surface 2a thereof. The LD 12, the thermistor 13, and the capacitor 14 are mounted on the metal patterns, and the bonding wires, W1 to W9, connect the metal patterns, 3 to 11, to the LD 12 and the thermistor 13. Although not illustrated in Fig. 2, the carrier 2 may provide a back metal on the back surface 2b opposite to the top surface 2a, where the back metal may be a ground electrode.

[0012] The metal patterns, 3 to 11, may be made of stacked metal coated or plated with gold (Au) and/or platinum (Pt) in the top of the metal stack. The present embodiment provides the metal patterns, 3 to 5, with stacked metals of titanium (Ti), platinum (Pt), and gold (Au). Respective metal patterns, 3 to 11, supply electronic power for heaters, which will be described later, bias voltages, and bias currents to the LD 12. Specifically, the metal pattern 3 provides the ground, while, the metal pattern 4 supplies the bias current. The metal pattern 3, namely the ground pattern, comprises die area 3a, a mounting area 3b, an auxiliary area 3c, and a pad 3d. The die area 3a mounts the LD 12 thereon. The mounting area 3b, which extends from the die area 3a substantially in parallel to the auxiliary area 3c, mounts the capacitor 14. The pad 3d is connected to the outside of the laser assembly to provide the ground potential.

[0013] The LD 12 of the present embodiment has a type of, what is called, a wavelength tunable LD having an optical axis extending in parallel to an optical waveguide implemented within the LD 12. The LD 12 may output light, whose wavelength may be tuned by supplying the bias voltage and/or the bias current through the metal patterns, 3 to 11, from the facet perpendicular to the optical axis. The LD 12 is mounted on the die area 3a through a brazing material 15. Fig. 1 denotes the brazing material 15 by hatched area that covers the whole die area 3a and the auxiliary area 3c. The brazing material 15 may be a solder made of eutectic metal or electrically conductive resin. The LD 12 may provide a back metal to be grounded through the brazing material on the metal pattern 3.

[0014] The LD 12 may include a semiconductor optical amplifier (SOA) region, a gain region, and a tuning region along the optical axis thereof. The SOA, which amplifies light generated by the gain region, includes an electrode 21 to supply a bias current into the SOA. The electrode 21 is connected to the metal pattern 5 by bonding wires, W1 and W2. The gain region, which generates light to be amplified in the SOA, provides an electrode 22 to supply a bias current into the gain region. The electrode 22 is connected to the metal pattern 4 through bonding wires, W3 and W4. The tuning region, which may tune the wavelength of the light generated in the gain region, provides electrodes, 23 to 26, each connected to the metal patterns, 6 to 9, by respective bonding wires, W5 to W8. The electrode 26 extending along the optical axis within the whole tuning region is common to other electrodes, 23 to 25. Although not shown in Fig. 1, several heaters are provided between the electrodes, 23 to 25, and the common electrode 26. The metal patterns, 6 to 8, supply the power to respective heaters to tune the wavelength of the light generated in the gain region. Thus, the wavelength of the light output from the LD 12 through the facet may be tuned.

[0015] The thermistor 13 may sense a temperature of the top surface 2a of the carrier 2. The power supplied to respective heaters in the tuning region may be controlled depending on the temperature of the top surface 2a sensed by the thermistor 13. The thermistor 13 in one electrode thereof faces and comes in contact with the metal pattern 10, and in another electrode thereof is connected to another metal pattern 11 through the bonding wire W9.

[0016] The capacitor 14 is a type of a bypassing capacitor connected in parallel to the LD 12 between the metal patterns, 3 and 4. The capacitor 14 provides two electrodes, one of which is mounted on the mounting area 3b of the metal pattern 3, while, the other is mounted on the metal pattern 4 each through respective brazing materials, 16 and 17. The brazing materials, 16 and 17, for mounting the capacitor 14 preferably has a melting temperature lower than a melting temperature of the other brazing material 15 for mounting the LD 12 onto the die area 3a. In the present embodiment, the former brazing material 16 on the mounting area 3b is apart from the latter brazing material 15 on the die area 3a even after the mount of the capacitor 14, that is, the metal pattern 3 is exposed in the top surface thereof between the brazing materials, 15 and 16.

[0017] Next, a process to assemble the laser assembly 1 will be described as referring to Figs. 3(A) to 4(B) of the plan views of the carrier 2.

[0018] First, the process forms metal patterns, 3 and 4, on the top surface 2a of the carrier 2 as shown in Fig. 3(A) which schematically shows the metal patterns. The process may form the metal patterns, 3 and 4, by patterning a metal or stacked metals deposited on the top surface 2a by, for instance, the metal evaporation, or may form patterned metals, 3 and 4, by the selective deposition of a metal or stacked metals. Next, the process may selectively evaporate tin (Sn) and gold (Au) on the die area 3a and the auxiliary area 3c as the brazing material 15 (Fig. 3B). The AuSn film deposited on the metal pattern may have the composition of gold (Au) to be about 70 % and a thickness thereof around 5 μm, preferably 4 to 6 μm.

[0019] Then, the LD 12 is mounted on the die area 3a (Fig. 4A). Specifically, heating the carrier 2 over 280 °C, preferably up to 280 to 300 °C, the assembling process may place the LD 12 on thus heated brazing material 15. The brazing material 15 may operate not only as an adhesive to fix the LD 12 but to secure an electrically conductive path from the LD 12 to the ground pattern 3. The auxiliary area 3c attributed to the die area 3a may effectively absorb surplus solder 15 oozing out from a gap between the metal pattern 3 and the LD 12 such that oozed brazing material does not invade into the mounting area 3b due to the surface tension of the brazing material. The mounting area 3b shows lesser wettability for the melted brazing material 15 compared with the auxiliary area 3c. Accordingly, the surplus brazing material 15 oozed out from the gap stays within the area where the brazing metal 15 exists.

[0020] Then, the process assembles the capacitor 14 on the metal pattern 3 (Fig. 4B). Specifically, melting and spreading other brazing materials, 16 and 17, on respective metal patterns, 3b and 4; the capacitor 14 is mounted on thus spread brazing materials, 16 and 17. During the melt and the spread of the brazing materials 16, the brazing material 16 is effectively prevented from merging together with the brazing material 15 spread in advance for mounting LD 12. In an example, solder made of tin-antimony (SnSb) is selected and melted at a temperature over 240 °C, preferably 260 °C, on the metal patterns 3b and 4. Because of the lowered temperature for mounting the capacitor 14, the former brazing material 15 for mounting the LD 20 is not melted at all. In the process thus described, two brazing materials, 15 and 16, are spread independently in respective steps, that is, the brazing material 15 is first spread in the die area 3a then the other brazing material 16 is spread in the mounting area. After mounting the capacitor 14, the bonding wire W3 is extended from the LD 12 to the metal pattern 4, which configures a parallel circuit of the LD 12 and the capacitor 14 between the metal patterns, 3 and 4.

[0021] Next, advantageous reflecting within the laser assembly 1 will be described as comparing with a conventional arrangement. Fig. 5 shows a cross section of a laser assembly 200 having a conventional arrangement with respect to the LD 12 and the capacitor 14. In the conventional arrangement, although not explicitly illustrated in Fig. 5, the metal pattern 3, especially the die area 3b does not accompany with the auxiliary area 3c, which means that, when the LD 12 is set on the brazing metal 15, surplus portion 15a thereof oozes in all directions as shown in Fig. 5. In particular, the LD 12 of the present embodiment arranges the SOA region, the gain region, and the tuning region along the optical axis thereof, which means that the LD 12 has an enough slender plane shape. When such a slender chip is die bonded on the carrier 2, an enough brazing material 15, namely, eutectic solder, is required for bonding the chip securely. As a result, relatively greater surplus solder oozes out in all directions. In the conventional laser assembly, the metal patterns surrounding the die area 3a are necessary to set a substantial space, sometimes wider than 100 μm, to the die area 3a for preventing the oozed solder from coming in contact to the metal patterns, which inevitably expands the size of the carrier 2. Also, such oozed surplus solder forces a space between the LD 12 and the capacitor 14, which is unfavorable from the viewpoint of the high speed operation of the LD 12.

[0022] On the other hand, the LD assembly 1 of the present embodiment provides the auxiliary area 3c next to the die area 3a in the metal pattern 3. The auxiliary area 3c, where the brazing material 15 is spread in advance to the mount of the LD 12, may effectively absorb the surplus solder, namely, the brazing material 15 oozed out from the gap between the LD 12 and the metal pattern 3 so as to prevent the surplus solder 15 from spreading into the mounting area 3b and coming in contact with the metal patterns surrounding the die area 3a. Accordingly, the metal patterns surrounding the die area 3a may be put closer to the die area 3a.

[0023] Moreover, the assembling process of the LD assembly uses another brazing material, 16 and 17, namely, another eutectic alloy for mounting the capacitor 14 on the mounting area 3b. The other brazing material, 16 and 17, has the melting point lower than the melting point of the former brazing material 15 to mount the LD 12. Thus, the brazing material 16 may be spread close enough to the brazing material 15 spread in advance, and the brazing metal 15, or the mounted LD 12, is not influenced by the process to mount the capacitor 14. Accordingly, the capacitor 14 is able to be mounted close enough to the LD 12, specifically, within 5 to 10 μm from the LD 12, which shows an advantage for the high speed operation of the LD 12.

[0024] Next, some examples using the laser assembly 1, in particular, a laser module installing the laser assembly 1 will be described. Fig. 6 is a plan view magnifying a primary portion of the laser module 50 installing the laser assembly 1. The laser module 50 includes a package 51, the laser assembly 1, a lens 52, a thermo-electric cooler (TEC) 53, and a terminal 54.

[0025] Next, some examples using the laser assembly 1, in particular, a laser module installing the laser assembly 1 will be described. Fig. 6 is a plan view of the laser module 50 installing the laser assembly 1. The laser module 50 includes, in addition to the laser assembly 1, a wavelength locker including first and second beam splitters (BS), 61 and 62, a wavelength filter 64, and first and second photodiodes (PD), 71 and 72.

[0026] The laser assembly 1 is mounted on a thermo-electric cooler (TEC) 53 through the carrier 2 accompanied with a collimating lens 52 and electrically communicate with the outside through a feedthrough 54 that includes a plurality of terminals wire-bonded with the metal patterns, 3 to 10, on the carrier 2. Also, the wavelength locker is mounted on another TEC 63 through a carrier. The laser module 1 with the TEC 53 and the wavelength locker with another TEC are installed within a housing 51.

[0027] The light output from the LD 12 is first collimated by the collimating lens 52, then, enters the first BS 61. The first BS 62 splits the light, one of split light goes to the output port, while, the other of the split light, which is bent by about 90° by the first BS 61 goes to the second BS. The split ratio of the first BS is set to be around 95:5, namely, about 95 % of the collimated light goes to the output port and only 5 % goes ahead to the send BS 62.

[0028] The second BS 62 further splits the light by about 50:50. One of the split light goes to the first PD, while, the rest goes to the wavelength filter 64 which inherently has specific transmittance. The second PD 72 detects the light output from the wavelength filter 64. On the other hand, the first PD 71 may detect raw beam output from the LD 12, which means that the light output from the LD 12 but not affected from any specific optical characteristic. Thus, calculating the ratio of the output from the second PD 72 against the output from the first PD 71, the practical transmittance of the wavelength filter 64 may be determined. Comparing thus obtained transmittance with the practical transmittance of the wavelength filter, the wavelength of the light currently output from the LD 12 may be precisely determined.

[0029] When the current wavelength of the LD 12 thus determined is different from a target wavelength of the LD 12, the biases supplied to the LD 12 and the power also supplied to the heaters of the LD 12 may be adjusted such that the current wavelength becomes coincident with, or closer to, the target wavelength.

[0030] The wavelength filter 64 may be, what is called, an etalon filter that inherently shows a periodic transmittance. Setting the target wavelength to be a point at which the periodic transmittance of the etalon filter in a slope thereof becomes large, the current wavelength of the LD 12 may be precisely matched with the target wavelength because of the increased gain of the feedback loop described above.

[0031] Even in the laser module 50, the capacitor 14 may be mounted enough closer to the LD 12 in the mounting area 3b but apart from the die area, which enables the side of the carrier 2 small enough. A smaller carrier 2 results in small heat capacity on the TEC 53. Accordingly, the convergence of the current wavelength on the target wavelength may be accelerated.

[0032] While particular embodiments of the present invention have been described herein for purposes of illustration, many modifications and changes will become apparent to those skilled in the art. For instance, the auxiliary area 3c for absorbing the surplus brazing material 15 is not always to be brought out from the die area 3a along a direction same with that of the mounting area 3b. When the auxiliary area 3c extends perpendicular to the die area 3a toward one direction and the mounting area 3b also extends perpendicular to the die area 3a but toward another direction opposite to the former one, that is, the auxiliary area 3c faces the mounting area 3b as putting the die area 3a therebetween, the capacitor 14 may be mounted further closer to the LD 12.

[0033] The embodiment uses the capacitor 14 having the type of, what is called, a chip capacitor with two electrodes thereof laterally disposed. However, the laser assembly 1 may use a capacitor with the type of a die capacitor with two electrodes thereof vertically disposed. For such an arrangement, the die capacitor 14 is mounted on the mounting area 3b as the bottom electrode thereof faces and comes in contact to the mounting area 3b, while, the top electrode thereof is connected to the metal pattern 4 with a bonding wire. Accordingly, the appended claims are intended to encompass all such modifications and changes as fall within the true spirit and scope of this invention.

Claims

[Claim 1] A laser assembly comprising:
a carrier;
a metal pattern provided on the carrier, the metal pattern including a die area, a mounting area, and an auxiliary area, the die area and the auxiliary area being provided with a brazing material;
a semiconductor laser diode (LD) mounted on the die area through the brazing material; and
a capacitor mounted on the mounting area through another brazing material apart from the brazing material.

[Claim 2] The laser assembly of claim 1,
wherein the auxiliary area extends substantially in parallel to the mounting area.

[Claim 3] The laser assembly of claim 1,
wherein the another brazing material has a melting point lower than a melting point of the brazing material.

[Claim 4] The laser assembly of claim 3,
wherein the brazing material is gold-tin (AuSn), and the another brazing material is tin-antimony (SnSb).

[Claim 5] The laser assembly of claim 1,
wherein the metal pattern stacks titanium (Ti), platinum (Pt), and gold (Au).

[Claim 6] The laser assembly of claim 1,
wherein the carrier is made of aluminum nitride.

[Claim 7] A method to assemble a laser assembly, comprising steps of:
forming a metal pattern on a carrier, the metal pattern including a die area, a mounting area, and an auxiliary area;
depositing a brazing material only on the die area and the auxiliary area of the metal pattern;
mounting a semiconductor laser diode (LD) on the die area as absorbing a surplus brazing material in the auxiliary area;
applying another brazing material on the mounting area so as not to be in contact with the brazing material; and
mounting a capacitor on the mounting area as interposing the another brazing material between the mounting area and the capacitor.

[Claim 8] The method of claim 7,
wherein the process of mounting the capacitor is performed at a tem-

perature lower than a temperature under which the process of mounting the LD is performed.

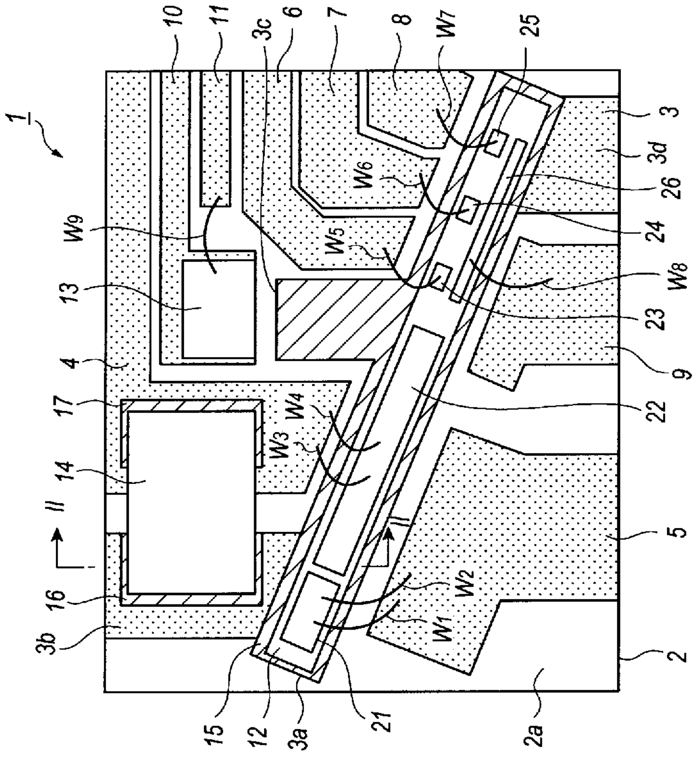
[Claim 9] The method of claim 8,
wherein the brazing material is gold-tin (AuSn), and
wherein the process of mounting the LD includes a process of heating the carrier over 280 °C and placing the LD on the brazing material.

[Claim 10] The method of claim 9,
wherein the another brazing material is tin-antimony (SnSb), and
wherein the process of mounting the capacitor includes a process of heating the carrier over 240 °C but below 280 °C and placing the capacitor on the another brazing material.

[Claim 11] The method of claim 7,
wherein the process of depositing the brazing material includes a process to evaporate the brazing material by a thickness of 4 to 6 μm.

[Claim 12] The method of claim 7,
wherein the process of applying the another brazing material includes processes of:
performing one of processes of heating the carrier up to a temperature lower than a temperature under which the process of mounting the LD on the die area is carried out and placing a grain of the another brazing material on the mounting area, and
spreading the grain within the mounting area not so as to be in contact with the brazing material.

[Fig. 1]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21
3a
12
15
3b
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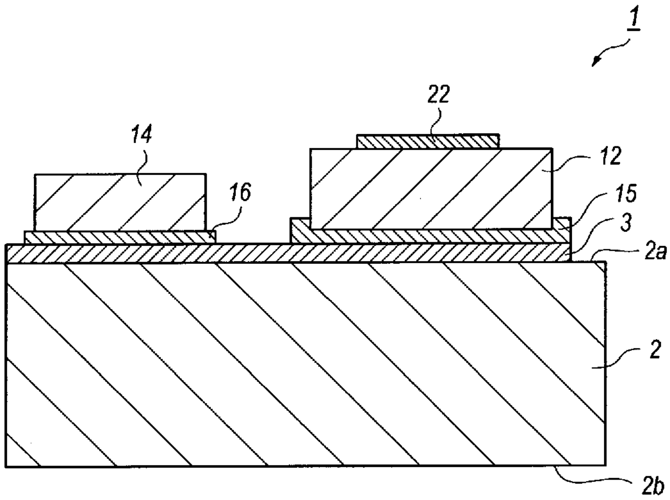
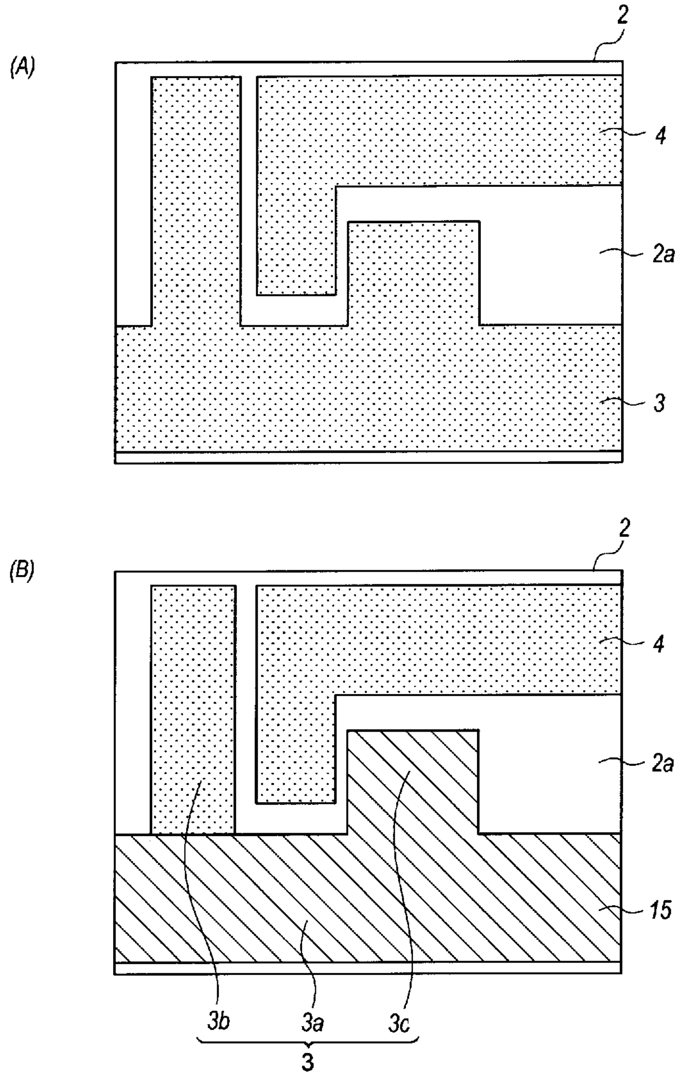
II

[Fig. 2]

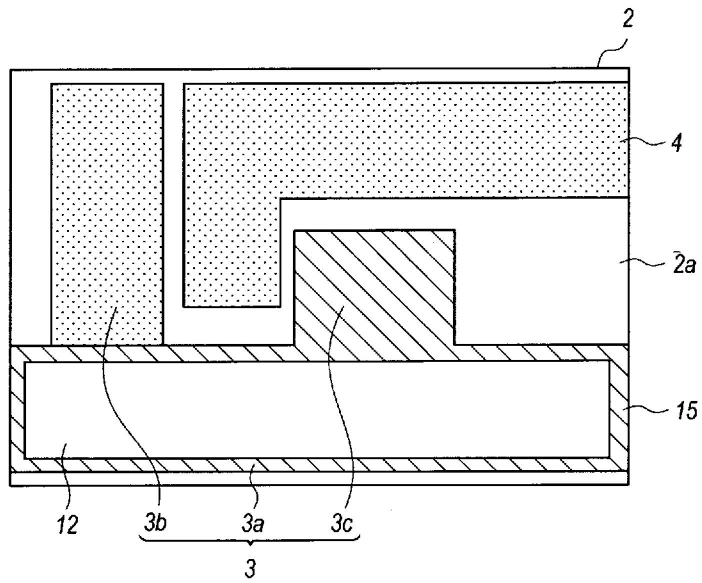


[Fig. 3]



[Fig. 4]

(A)



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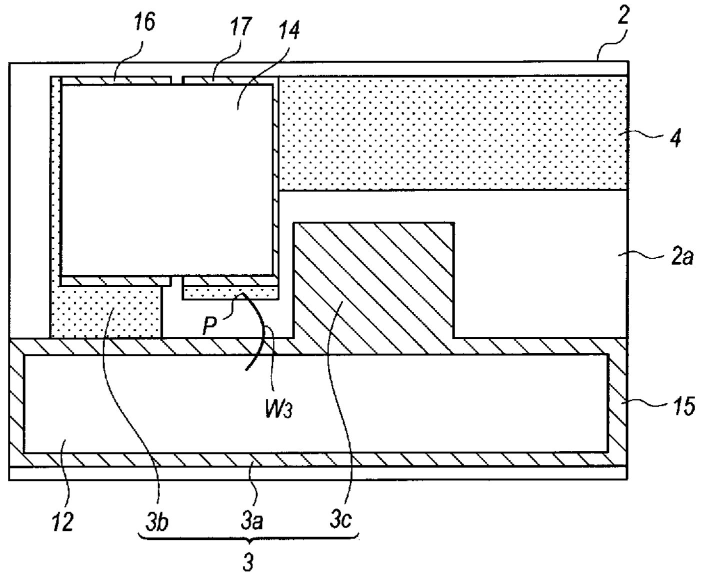
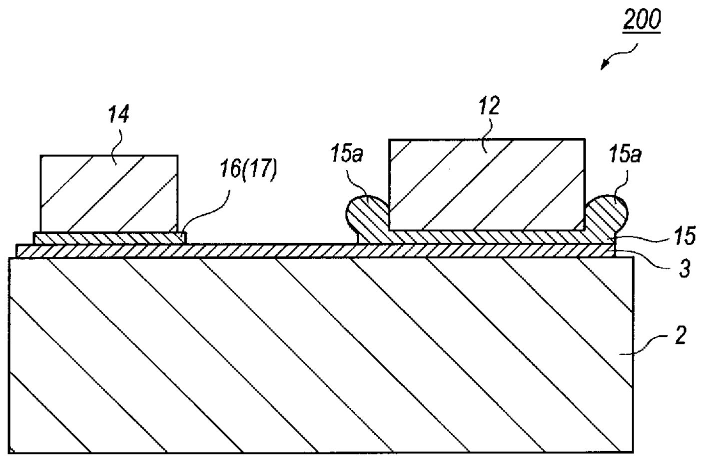
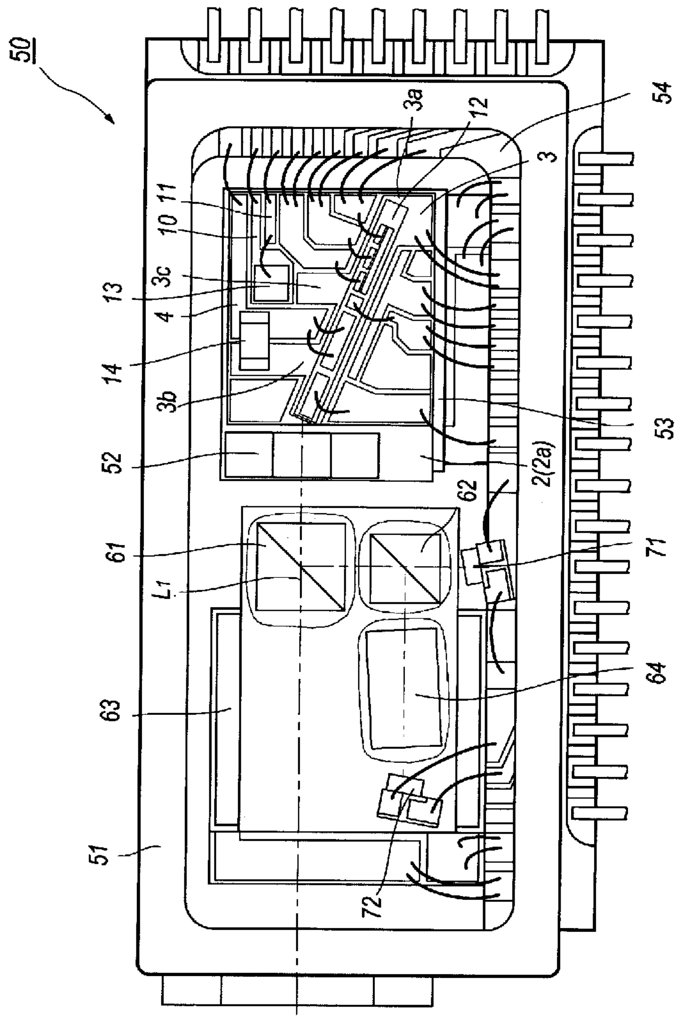


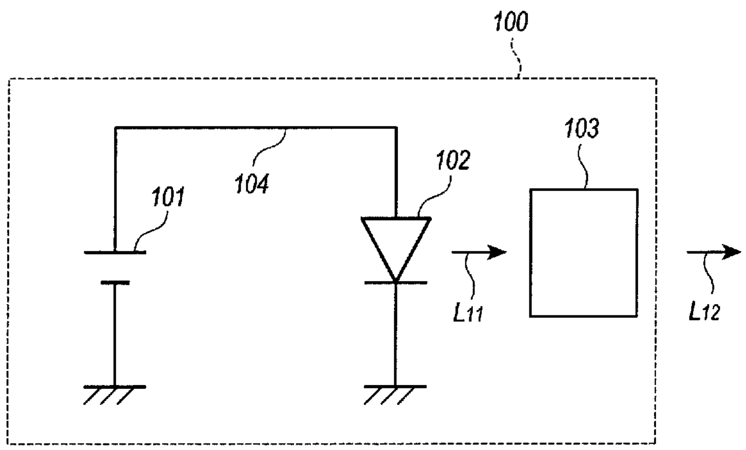
[Fig. 5]



[Fig. 6]



[Fig. 7]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/003966

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01S5/022(2006.01)i, H01S5/042(2006.01)i

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)

Int.Cl. H01S5/00-5/50, H01L21/52, 21/58, 23/12-23/15

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2015
Registered utility model specifications of Japan 1996-2015
Published registered utility model applications of Japan 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0214957 A1 (KIHARA, Toshiaki) 2005.09.29, paragraphs [0057]-[0058], [0083]-[0084], Figs. 8-9, 12 & JP 2005-236297 A	1-12
Y	US 2012/0138665 A1 (OKA, Yoshiki) 2012.06.07, paragraphs [0051]-[0054], Fig. 10 & JP 2012-119637 A	1-12
Y	US 2013/0011104 A1 (SATO, Shunsuke) 2013.01.10, paragraph [0027], Fig. 2 & JP 2013-80900 A	3-4, 8-10, 12

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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14.10.2015	27.10.2015

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-197982 A (KOMATSU ELECTRONICS INC.) 2003.07.11, paragraph [0291] (No Family)	4, 10
Y	US 2002/0121863 A1 (MORISHITA, Yukiko) 2002.09.05, paragraphs [0075]-[0077] & JP 2002-261376 A	5, 11
A	JP 2009-87964 A (KYOCERA CORP.) 2009.04.23, entire text; all drawings (No Family)	1-12
A	JP 2001-237481 A (CITIZEN ELECTRONICS CO., LTD.) 2001.08.31, entire text; all drawings (No Family)	1-12