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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 July 2002 (25.07.2002)

PCT

(10) International Publication Number
WO 02/058152 A2

(51) International Patent Classification[7]: H01L 25/07, 23/538

(21) International Application Number: PCT/JP02/00167

(22) International Filing Date: 15 January 2002 (15.01.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2001-8823 17 January 2001 (17.01.2001) JP

(71) Applicant (*for all designated States except US*): **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.** [JP/JP]; 1006, Oaza Kadoma, Kadoma-shi, Osaka 571-8501 (JP).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **NOBORI, Kazuhiro** [JP/JP]; 6-6-304, Myokenzaka, Katano-shi, Osaka 576-0021 (JP). **IKEDA, Satoshi** [JP/JP]; 1-24-3-706, Takezono, Senriyama, Suita-shi, Osaka 565-0852 (JP). **KATO, Yasushi** [JP/JP]; 10-8, Hikaridai 6-chome, Seika-cho, Soraku-gun, Kyoto 619-0237 (JP). **NAKAJIMA, Yasufumi** [JP/JP]; 2-5-8, Higashikori, Hirakata-shi, Osaka 573-0075 (JP).

(74) Agents: **AOYAMA, Tamotsu** et al.; AOYAMA & PARTNERS, IMP Building, 3-7, Shiromi 1-chome, Chuo-ku, Osaka-shi, Osaka 540-0001 (JP).

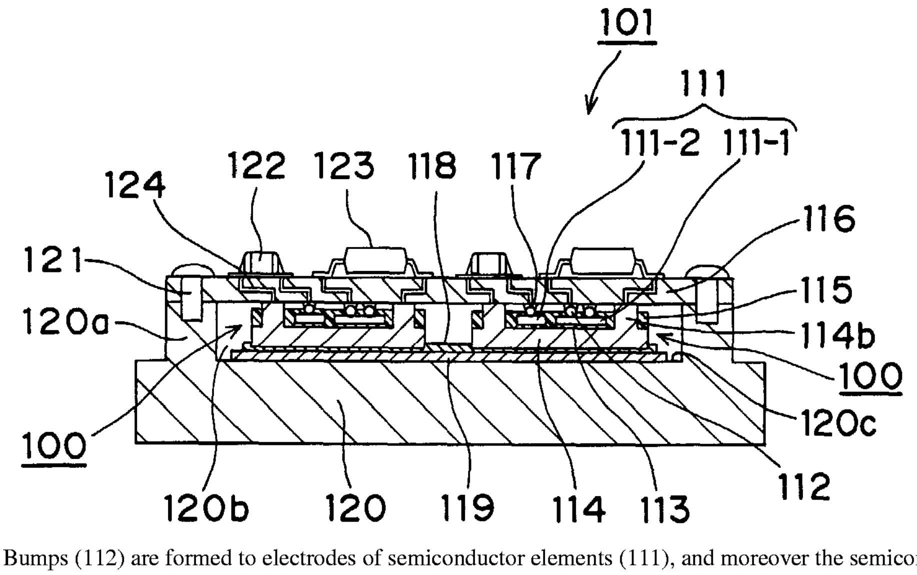
(81) Designated States (*national*): CN, US.

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ELECTRONIC CIRCUIT DEVICE AND METHOD FOR MANUFACTURING THE SAME



(57) Abstract: Bumps (112) are formed to electrodes of semiconductor elements (111), and moreover the semiconductor elements with the bumps are electrically connected to metallic members (114) having installation members (114b), whereby wiring lines are eliminated. A stray inductance and a conduction resistance resulting from the wiring lines can be reduced. A conventional dented connector and a projecting connector are eliminated by connecting the installation members to a second circuit board, enabling the electronic circuit device of the power control system to be made compact.

WO 02/058152 A2

DESCRIPTION

ELECTRONIC CIRCUIT DEVICE AND METHOD FOR MANUFACTURING THE SAME

Technical Field

The present invention relates to an electronic circuit device of a power control system using semiconductor elements such as IGBTs (Insulated Gate Bipolar Transistors), diodes and the like, e.g., for driving motors, and a method for manufacturing the electronic circuit device.

Background Art

Lately a working current in a motor driving device has increased in accordance with an enhancement in performance and function of electronic devices used in the motor driving device, requiring semiconductors to be used to meet a high current. The motor driving device used conventionally is such as shown in Fig. 16. An example of the conventional motor driving device will be described below with reference to the drawing.

In Fig. 16, reference numerals respectively indicate: 1a an IGBT; 1b a diode; 3 a high temperature solder; 4 a metallic element; 5 a sealing resin; 6 a solder; 7 a circuit board; 10 a heat radiation plate; 10a a projecting screw bed; 11 a screw; 12 a surface mounting electronic component (passive element); 13 a surface mounting electronic component (semiconductor element); 14 a metallic base circuit board; 15 a silicone grease; 18 a metallic wire; 19 a metallic lead; 22 a projecting connector; 23 a dented connector; and 24 an insulation resin.

A method for manufacturing the thus-constituted conventional motor driving device will be discussed hereinbelow.

Semiconductor components 1 such as the IGBT 1a, the diode 1b and the like are connected by the high temperature solder 3 to the metallic elements 4. Between the IGBT 1a and the diode 1b and between these semiconductor components 1 and the metallic leads 19 are electrically joined with the use of the metallic wire 18. An aluminum wire or a gold wire is normally used as the metallic wire 18. In using the metallic wire 18 formed of, e.g., aluminum, the metallic wire 18 is connected to a second electrode of the semiconductor component 1 with the use of wedge bonding of the aluminum wire. The second electrode is present oppositely to a first electrode of the semiconductor component 1, which is joined to the metallic element 4. The second electrode of the semiconductor component 1 is formed of aluminum. Oxide films of aluminum surfaces of both the second electrode and the metallic wire 18 are removed when the second electrode and the metallic wire are pressed in contact with each other with an ultrasonic energy being applied thereto in an ordinary temperature state. The second electrode and the metallic wire 18 are thus joined. The metallic wire 18 joined to the second electrode of the semiconductor component 1 is routed to the metallic lead 19 obtained by plating copper with tin and is joined to the metallic lead 19 by the wedge bonding method.

Thereafter, for the purpose of physically protecting the semiconductor component 1 and the metallic wire 18 and improving a reliability, the semiconductor component 1 and the metallic wire 18 are coated and sealed with the sealing resin 5 with the use of the transfer molding technique or injection molding technique. The metallic lead 19 is bent and cut by molds to be even with the metallic element 4. In this sequence of procedures, an electronic component named "TO-220" comprising the semiconductor component 1, the high temperature solder 3, the metallic element 4, the metallic wire 18, the metallic lead 19 and the sealing resin 5 is completed.

After a solder paste is printed onto the metallic base circuit board 14, various components such as the above electronic components "TO-220", the projecting connector 22, etc. are placed on the metallic base circuit board. The whole of the metallic base circuit board 14 is put in a heating furnace, whereby the solder paste is melted. The solder paste is then set by being returned to an ordinary temperature. The set solder 6 electrically and physically joins the metallic base circuit board 14 with the various electronic components such as the electronic components "TO-220", the projecting connector 22, etc.

For providing electric insulation, the sealing resin 24 is applied to the entire metallic base circuit board 14. The metallic base circuit board 14 with the various electronic components is put in a reduced pressure furnace to remove bubbles mixing inside the sealing resin 24 and then put in a heating surface to set the sealing resin 24.

Next, the silicone grease 15 is applied to the heat radiation plate 10. The metallic base circuit board 14 is brought into intimate contact with the heat radiation plate 10 and fixed by screws. Then, by inserting the projecting connector 22 into the dented connector 23 after registering the projecting connector 22 mounted on the metallic base circuit board 14 and the dented connector 23 mounted on the circuit board 7, the circuit board 7 is brought into intimate contact with the projecting screw bed 10a and fixed by the screws 11.

In the manner as above, the process of mounting to the metallic base circuit board 14 electronic components which include the electronic components "TO-220" for controlling to switch a motor driving current and require heat radiation, and the process of combining the circuit board 7 including the circuit for controlling the electronic components "TO-220" and requiring no heat radiation are finished.

The above-described arrangement generates a loss caused by a resistance of the metallic wires 18 and the metallic leads 19 and also a stray inductance because of a length of the wires 18 and leads 19. In addition, for example, since the electronic component "TO-220" is equipped with the metallic lead 19, a larger area than an area of the electronic component "TO-220" is required for the metallic base circuit board 14, impeding miniaturization and high-density mounting.

Meanwhile, the motor driving device for electric products alike has been required to be made compact and highly efficient in heat radiation to meet the recent trend towards the lighter, thinner, shorter and smaller construction of the electric products. However, in the event that bubbles are present inside the high temperature solder 3, the bubbles obstruct heat transfer generated by the semiconductor component 1, thereby increasing a resistance from the semiconductor component 1 to the metallic element 4. As a result, only the bubble part becomes high in temperature, which leads to breaking the semiconductor component 1 in the worst case.

As described hereinabove, the metallic wire 18 is joined to the second electrodes of the semiconductor component 1 by the wedge bonding method with the aluminum wire. In the conventional art, the metallic wire 18 is limited in thickness due to the joining method and at the same time, the metallic wire 18 is limited in length due to the arrangement of the substrate electrodes, making it impossible to reduce a wiring resistance. To cope with an on-state resistance decrease in consequence of the recent progress of the semiconductor component 1 is thus hindered, with imposing the problem of a noise increase resulting from electrical signals' being made a high frequency and a large current.

Disclosure of Invention

The present invention is devised to solve the above problems and has for its essential object to provide an electronic circuit device which is compact, has a good heat radiation efficiency and can reduce a resistance and a stray inductance, and a method for manufacturing the electronic circuit device.

In order to accomplish the above objective, an electronic circuit device is provided according to a first aspect of the present invention, which comprises:

a heat radiation required semiconductor element having electrodes formed on both faces opposite to each other;

a first circuit board electrically connected via a metallic plate to a first electrode of the electrodes formed on one face of the two faces of the semiconductor element, on which the metallic plate and the semiconductor element are placed;

a second circuit board arranged to a side of the other face of the two faces of the semiconductor element to be opposite to the first circuit board, with having a control circuit for the semiconductor element; and

a metallic wire for directly electrically connecting a second electrode of the electrodes present at the other face and the second circuit board with each other.

The above metallic wire may be formed including a first bend portion for absorbing expansion and contraction of the first circuit board and the second circuit board resulting from the heat radiation of the semiconductor element.

The metallic wire joined to the second electrode may be extended in a thickness direction of the semiconductor element.

The electronic circuit device may be constituted to further include a heat radiation member with supporting members for placing the first circuit board thereon and supporting the second circuit board, and the metallic wire may be provided with a second bend portion for absorbing, in a state with the second circuit board being supported by the supporting members, expansion and contraction of the first circuit board and the second circuit board resulting from the heat radiation and for pressing the first circuit board against the heat radiation member.

An electronic circuit device of a power control system according to a second aspect of the present invention comprises:

a heat radiation required semiconductor element having first electrodes and second electrodes respectively formed on one face and the other face opposite to each other;

bumps formed on the second electrodes; and

a metallic member having a first face arranged opposite to the first electrodes to be electrically connected to the first electrodes and including installation members formed of a metal erected on the first face along a thickness direction of the semiconductor element in a height to exceed the bumps in the thickness direction when the semiconductor element with the bumps is placed on the first face.

Three or more installation members may be provided to one metallic member in the above electronic circuit device of the second aspect.

The electronic circuit device of the second aspect may further include a second circuit board which is arranged to a side of the other face to be electrically connected to the bumps and leading ends of the installation members and is provided with a control circuit for the semiconductor element.

Also the above electronic circuit device of the second aspect may further include a heat radiation member with supporting members for placing the metallic member thereon via an electric insulating member and dissipating heat conducted from the semiconductor element to the metallic member.

According to a third aspect of the present invention is provided a method for manufacturing an electronic circuit device having:

a heat radiation required semiconductor element having first electrodes and second electrodes respectively formed on one face and the other face opposite to each other;

bumps formed on the second electrodes; and

a metallic member having a first face arranged opposite to the first electrodes to be electrically connected to the first electrodes and including installation members formed of a metal erected on the first face along a thickness direction of the semiconductor element in a height to exceed the bumps in the thickness direction when the semiconductor element with the bumps is placed on the first face,

said method comprising:

bringing the first face of the metallic member and the first electrodes into contact with each other, placing the semiconductor element on the first face, and heating the semiconductor element;

supplying a molten solder to the first face;

relatively pressing the semiconductor element and the metallic member to remove bubbles from inside the molten solder present between the first face and the first electrodes; and

decreasing a temperature of the molten solder while maintaining the pressing state, thereby solidifying the molten solder and joining the semiconductor element and the metallic member.

In the manufacturing method of the third aspect, after the joining the semiconductor element and the metallic member, the method further includes a step of electrically connecting the bumps and leading ends of the installation members to a second circuit board which is arranged to a side of the other face and is provided with a control circuit for the semiconductor element,

wherein, when a plurality of the metallic members are attached to the second circuit board, heights of the installation members of the metallic members may be adjusted to unify all the metallic members in height with respect to the second circuit board.

As described hereinabove, the electronic circuit device according to the first aspect of the present invention is provided with the metallic wire for directly electrically connecting the second electrode formed on the other face of the semiconductor element and the second circuit board arranged to the side of the other face. Since the conventional dented connector and projecting connector can be eliminated, the electronic circuit device can be made compact.

Moreover, when the metallic wire is provided with the bend portion, the bend portion can absorb expansion and contraction between the first circuit board and the second circuit board resulting from the heat of the semiconductor element.

Since the metallic wire is extended in the thickness direction of the semiconductor element, the electronic circuit device can be miniaturized furthermore.

When the metallic wire is extended in the thickness direction of the semiconductor element and is further provided with the second bend portion, not only miniaturizing the electronic circuit device and absorbing the expansion and contraction can be both achieved, but the first circuit board can be pressed against the heat radiation plate, so that the heat can be stably removed.

In the electronic circuit device according to the second aspect of the present invention, the semiconductor element is provided with the bumps to the second electrodes and with the metallic member having installation members, so that wiring lines are eliminated. Consequently, the stray inductance and the conduction resistance resulting from the wiring lines can be reduced.

In the case where a plurality of the metallic members are provided, the height of the metallic members can be uniform by being adjusted by the installation members.

Since the semiconductor element and the second circuit board can be directly electrically connected with each other by providing the metallic member, the conventional dented connector and projecting connector are eliminated, thus making the electronic circuit device small in size. When the heat radiation member is provided to support the second circuit board, the heat from the metallic member can be stably dissipated by the one heat radiation member.

According to the manufacturing method for the electronic circuit device in the third aspect of the present invention, the solder present between the semiconductor element and the metallic member is solidified after the semiconductor element and the metallic member are relatively pressed against each other so as to remove the bubbles from inside the solder. Therefore, the thermal conduction from the semiconductor element to the metallic member will not be obstructed by the bubbles, thus being able to prevent an abnormal temperature rise of the semiconductor element.

Brief Description of Drawings

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings in which:

Fig. 1 is a sectional view of a second circuit device as an electronic circuit device of a power control system according to a first embodiment of the present invention;

Fig. 2 is a diagram of semiconductor elements constituting a first circuit unit in Fig. 1;

Fig. 3 is a diagram showing a state with bumps formed to the semiconductor elements of Fig. 2;

Fig. 4 is a diagram showing a state in which the semiconductor elements with bumps shown in Fig. 3 are mounted to a metallic member;

Fig. 5 is a diagram of a state having a sealing resin further provided to the state of Fig. 4;

Fig. 6 is a sectional view of a state in which the first circuit unit of Fig. 5 is mounted to a second circuit board;

Fig. 7 is a sectional view of a state in which a plurality of the first circuit units are mounted to the second circuit board;

Fig. 8 is a sectional view of a second circuit device as an electronic circuit device of a power control system according to a second embodiment of the present invention;

Fig. 9 is a sectional view of a modified example of the second circuit device of Fig. 8;

Fig. 10 is a sectional view of a second circuit device as an electronic circuit device of a power control system according to a third embodiment of the present invention;

Fig. 11 is a sectional view of a modified example of the second circuit device of Fig. 10;

Fig. 12 is a sectional view of a second circuit device as an electronic circuit device of a power control system according to a fourth embodiment of the present invention;

Fig. 13 is a sectional view of a modified example of the second circuit device of Fig. 12;

Fig. 14 is a sectional view of a second circuit device as an electronic circuit device of a power control system according to a fifth embodiment of the present invention;

Fig. 15 is a sectional view of a modified example of the second circuit device of Fig. 14; and

Fig. 16 is a sectional view of a conventional electronic circuit device of a power control system.

Best Mode for Carrying Out the Invention

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Electronic circuit devices according to the preferred embodiments of the present invention and a method for manufacturing the electronic circuit devices will be described below with reference to the drawings.

First Embodiment

Fig. 5 shows a first electronic circuit device of a power control system (referred to as "a first circuit unit" hereinbelow) 100 which is one example of the electronic circuit device of the embodiment. Fig. 1 shows a second electronic device of a power control system (referred to as "a second circuit device" below) 101 including the first circuit units 100 which corresponds to another example of the electronic circuit device.

The second circuit device 101 of Fig. 1 is constituted as follows. 111 is a drive semiconductor element which is used in a control system for controlling a driving current to a driving device, e.g., a motor or the like and which requires a heat radiation treatment. The drive semiconductor element includes an IGBT (Insulated Gate Bipolar Transistor) 111-1 and a diode 111-2. As shown in Fig. 3, the drive semiconductor element 111 has first electrodes 111c and second electrodes 111d formed to one face 111a and the other face 111b opposite to each other respectively. 112 are bumps (projecting electrodes) formed on the second electrodes 111d of the drive semiconductor element 111. 114 is a metallic member which radiates and diffuses heat generated from the drive semiconductor element 111 as shown in Fig. 4. A whole of surface of the metallic member 114 is plated with tin after projecting parts corresponding to installation members 114b to be described later are formed to copper as a base material with the use of molds. The metallic member 114 has a first face 114a arranged opposite to the first electrodes 111c to be electrically connected to the first electrodes 111c. 113 is a high temperature solder for joining the first electrodes 111c of the drive semiconductor element 111 and the first face 114a of the metallic member 114 with each other. The aforementioned installation members 114b are projected on the first face 114a in parallel to a thickness direction 111e of the drive semiconductor element 111 and has a height to exceed the bumps 112 in the thickness direction 111e when the drive semiconductor element 111 with the bumps 112 is placed on the first face 114a. Although the installation members 114b of a pair are formed in the embodiment, three or more installation members can be formed for one first circuit unit 100. If three or more installation members are formed, a flatness of the first circuit unit 100 when mounted to a second circuit board 116 can be improved more as will be described later.

As indicated in Fig. 5, 115 is a sealing resin for protecting the drive semiconductor element 111 and the bumps 112, which is applied to the drive semiconductor element 111 mounted together with the bumps 112 to the first face 114a to such a level that nearly half height of the bump 112 is exposed in the thickness direction 111e. The first circuit unit 100 is constituted in the above-described manner.

As is shown in Fig. 6, the first circuit unit 100 is electrically connected with the bumps 112 and leading ends 114c of the installation members 114b through a solder 117 provided thereto to the second circuit board 116 arranged at a side of the other face 111b of the drive semiconductor element 111.

As shown in Fig. 1, the second circuit board 116 includes a control circuit for the drive semiconductor element 111, with electronic components 122 of passive components such as a capacitor, a resistor and the like, and electronic components 123 of active components such as a transistor, a memory, etc. constituting the control circuit mounted to one face or to both faces. Internal wirings 124 are provided in the second circuit board 116 to electrically connect the electronic components 122 and 123 to the drive semiconductor element 111.

A heat radiation member 120 on which the metallic member 114 is placed dissipates heat transferred from the drive semiconductor element 111 to the metallic member 114 into the air. The heat radiation member 120 has also, for instance, a recessed part 120b as shown in Fig. 1 formed by supporting members 120a which support the second circuit board. The first circuit unit 100 is stored in the recessed part 120b and both end parts of the second circuit board 116 are fixed by screws 121 to the pair of the supporting members 120a. An insulating resin 119 of a high heat dissipation efficiency is provided by a heat press method to a bottom face 120c of the recessed part 120b so as to conduct heat from the metallic member 114 to the heat radiation member 120 and at the same time electrically insulate the metallic member 114 and the heat radiation member 120 from each other. Moreover, a silicone grease 118 is filled between the insulating resin 119 and the metallic member 114 to decrease a resistance in heat at a contact portion between the metallic member 114 and the insulating resin 119. Since a height of the metallic member 114 is specified as will be discussed later, the silicone grease 118 works as a buffer to press the metallic member 114 towards the insulating resin 119 thereby bringing the metallic member 114 and the insulating resin 119 into intimate contact with each other at all times. A soft sheet may be used in place of the silicon grease 118.

The second circuit device 101 is constituted as above.

A process of forming the above first circuit unit 100 will be described with reference to Figs. 2-6.

Referring to Fig. 3, gold plating bumps 112 are formed on the second aluminum electrodes 111d of the drive semiconductor element 111 of Fig. 2 with the use of a projecting electrode forming machine which is an improved wire bonding apparatus or with the use of plating. Then as shown in Fig. 4, in a state while the drive semiconductor element 111 is placed to a predetermined position on the first face 114a of the metallic member 114, the drive semiconductor element 111 and the metallic member 114 are put in a high temperature furnace heated to 350°C in which a reducing atmospheric state in a mixed atmosphere of nitrogen and hydrogen is maintained. The molten high temperature solder 113 is supplied, specifically by dropping according to the embodiment, to the first face 114a of the metallic member 114 in the high temperature furnace. In consequence, the first face 114a of the metallic member 114 and the first electrodes 111c of the drive semiconductor element 111 are joined by the high temperature solder 113.

After the high temperature solder 113 is supplied, the drive semiconductor element 111 and the metallic member 114 are relatively pressed against each other to remove bubbles from inside the molten solder present between the first face 114a and the first electrodes 111c. The metallic member 114 is pressed parallel to the drive semiconductor element 111 so as to bring the metallic member 114 into intimate contact with the drive semiconductor element 111. With the absolute contact state maintained, the metallic member 114 and the drive semiconductor element 111 are cooled to solidify the solder 113. The metallic member 114 and the drive semiconductor element 111 are returned to the air after the solidification.

Next in Fig. 5, the sealing resin 115 is formed to mechanically protect the drive semiconductor element 111 itself and joining portions between the drive semiconductor element 111 and the bumps 112. The sealing resin 115 is applied in a liquid state and set by heating, or formed by transfer molding or injection molding technique. The first circuit unit 100 is formed in the process.

Subsequently, for protecting the drive semiconductor element 111 and enabling the drive semiconductor element 111 to be handled as an electronic component, the first circuit unit 100 is joined simultaneously with the electronic components 122 and 123 onto the second circuit board 116 with the use of the solder 117 as shown in Fig. 6. Normally used surface mounting technique (SMT) is employed for the joining.

In the present embodiment as discussed hereinabove, the metallic member 114 is provided with installation members 114b of the metal which project from the first face 114a of the metallic member 114 in the thickness direction 111e of the drive semiconductor element 111. Accordingly, electric connection between the first electrodes 111c of the drive semiconductor element 111 and the second circuit board 116 can be achieved through the installation members 114b, and moreover the metallic member 114 with the drive semiconductor element 111 can be fixed to the second circuit board 116 through the installation members 114b. Since the conventionally required dented connector 23 and projecting connector 22 are hence eliminated, the first circuit unit 100 and the second circuit device 101 can be made compact in size. At the same time, since the second electrodes 111d of the drive semiconductor element 111 are electrically connected to the second circuit board 116 via the bumps 112, a stray capacity can be reduced in comparison with the conventional art which uses the metallic wires 18 and the metallic leads 19 and a resistance can be decreased.

Since the wiring resistance is reduced by the joining via the bumps 112 as compared with the conventional art, this enables reduction in on-state resistance and noise.

As above, bubbles are removed from inside the solder 113 by relatively pressing the first electrodes 111c of the drive semiconductor element 111 and the metallic member 114 against each other to join the same. The drive semiconductor element 111 is prevented from abnormally overheating because of voids.

Fig. 7 shows a state in which a plurality of the first circuit units 100 are joined to the second circuit board 116 upon completion of procedures in Figs. 2-5. Although two first circuit units 100 are installed in Fig. 7, needless to say, there may be installed three or more units, or in contrast one unit may be installed. In the case where the plurality of the first circuit units 100 are installed, an error range of heights H1 and H2 of the first circuit units 100 from the second circuit board 116 should be held in a specified value. While the metallic member 114 has the installation members 114b in the embodiment, a height of the installation members 114b of each of the metallic members 114 can be adjusted by, e.g., cutting the installation members 114b, whereby a position accuracy with the error range of within ±50μm can be realized for the heights H1 and H2.

The second circuit device 101 shown in Fig. 1 is a combination of the second circuit board 116 in a state of Fig. 7 with the heat radiation member 120. The second circuit device 101 naturally exerts the same effects as those of the first circuit unit 100.

Second Embodiment

A fourth circuit device 103 as a modified example of the second circuit device 101 will be described with reference to Fig. 8.

The fourth circuit device 103 includes a third circuit unit 102 which is a modified example of the above first circuit unit 100. A reference numeral 133 of Fig. 8 indicates a first circuit board formed of a metal. Single-sided surface mounting is carried out to the second circuit board 116 in Fig. 8.

The third circuit unit 102 has spring wires 136 of a metal and a second metallic member 134 respectively attached in place of the bumps 112 and the metallic member 114 of the first circuit unit 100. The spring wire 136 is a conductor for electrically connecting the drive semiconductor element 111 and the second circuit board 116 with each other, having a second bend portion 136a as indicated in the drawing. In the fourth circuit device 103 of Fig. 8, one end of the spring wire 136 is soldered to the second circuit board 116 penetrating the second circuit board 116. The second metallic member 134 has no installation member 114b. The second bend portion 136a of the spring wire 136 is not resin sealed by the sealing resin 115.

The third circuit unit 102 is constituted the same in other points as the above-described first circuit unit 100.

The third circuit unit 102 of the above constitution has the second metallic member 134 joined to the first circuit board 133 by the solder 117. The first circuit board 133 is placed on the heat radiation member 120 via the silicone grease 118.

In the fourth circuit device 103 constituted as above, the first circuit board 133 can be pressed by the second bend portions 136a of the spring wires 136 to the heat radiation member 120, and moreover a thermal stress can be absorbed by the spring wires 136, so that a high reliability is realized.

Since each of the spring wires 136 is arranged in parallel to the thickness direction 111e and is not directed orthogonally to the thickness direction 111e as illustrated, the fourth circuit device 103 is made compact. Furthermore, since the bubbles present in the solder 113 between the drive semiconductor element 111 and the second metallic member 134 are eliminated, the drive semiconductor element 111 can be prevented from abnormally overheating because of voids.

A fourth circuit device 103-1 shown in Fig. 9 is a modification of the fourth circuit device 103 of Fig. 8, in which spring wires 136-1 are soldered to one face of the second circuit board 116 without penetrating the second circuit board 116 as shown in the drawing. Double-sided mounting is provided to the second circuit board 116. The modified fourth circuit device 103-1 is in the same constitution in other points as the above-described fourth circuit device 103 indicated in Fig. 8.

The same effects as in the fourth circuit device 103 in Fig. 8 can be obtained also in the fourth circuit device 103-1 of Fig. 9.

Third Embodiment

A fifth circuit device 104 as a modified example of the second circuit device 101 will be depicted with reference to Fig. 10.

The fifth circuit device 105 has a constitution that the projecting connector 22 and the dented connector 23 are removed from the driving device described with reference to Fig. 16, and a fresh metallic lead 139 is connected to the metallic wire 18. The operation of removing bubbles described above is carried out in soldering to join the drive semiconductor element 111 and the second metallic member 134. Single-sided surface mounting is provided to the second circuit board 116 in Fig. 8.

The metallic lead 139 is a metal wire with tin plating to copper, which is joined to the aluminum metallic wire 18 subjected to the wedge bonding of aluminum. A first bend portion 139a is formed in the halfway of the metallic lead 139. One end of the metallic lead 139 is soldered through the second circuit board 116. Double-sided mounting is carried out to the second circuit board 116.

Since the projecting connector 22 and the dented connector 23 are eliminated and the metallic lead 139 is directly connected to the second circuit board 116, the fifth circuit device 104 can be made compact. The first bend portion 139a formed to the metallic lead 139 can absorb the thermal stress, thereby realizing a high reliability. Further, since the bubbles are removed from inside the solder 113 present between the drive semiconductor element 111 and the second metallic member 134, the drive semiconductor element 111 can be prevented from abnormally overheating due to voids.

A fifth circuit device 104-1 in Fig. 11 is a modification of the fifth circuit device 104 of Fig. 10. A metallic lead 139-1 is, as shown in the drawing, soldered to one face of the second circuit board 116 without penetrating the second circuit board 116. The constitution of the fifth circuit device 104-1 in other points is the same as that of the above-described fifth circuit device 104 shown in Fig. 10.

The fifth circuit device 104-1 alike can obtain the same effects as in the fifth circuit device 104 in Fig. 10.

Fourth Embodiment

A sixth circuit device 105 as a modified example of the above fourth circuit device 103 will be described below with reference to Fig. 12.

The sixth circuit device 105 is provided with metallic wires 141 in place of the spring wires 136 in the fourth circuit device 103. The metallic wire 141 has a gold ball 140 formed by melting a gold wire by electric spark. The gold ball 140 is joined to the drive semiconductor element 111 or the like. Joining the gold ball 140 is executed by wire bonding technique through heating and ultrasonically vibrating the gold wire. After the joining, the metallic wire 141 is pulled up in the thickness direction 111e, cut to a predetermined length and sealed by the sealing resin 115 to be prevented from deformation. One end of the metallic wire 141 is soldered passing through the second circuit board 116. The constitution in other points of the sixth circuit device is the same as that of the fourth circuit device 103 described earlier and shown in Fig. 8.

According to the sixth circuit device 105, similar to the fourth circuit device 103, since the metallic wires 141 extend in the thickness direction 111e, the sixth circuit device 105 can be made compact. Moreover, since the bubbles are removed from inside the solder 113 present between the drive semiconductor element 111 and the second metallic member 134, the drive semiconductor element 111 can be prevented from abnormal overheating because of voids.

A sixth circuit device 105-1 in Fig. 13 is a modification of the sixth circuit device 105 in Fig. 12, wherein metallic wires 141-1 are soldered to one face of the second circuit board 116 without being passed through the second circuit board 116 as is clear from the drawing. The sixth circuit device 105-1 is constituted the same in other points as the sixth circuit device 105 described above.

The sixth circuit device 105-1 of Fig. 13 can obtain the same effects as the effects of the sixth circuit device of Fig. 12.

Fifth Embodiment

Referring to Fig. 14, a seventh circuit device 106 as a modified example of the fourth circuit device 103 will be depicted herein.

The seventh circuit device 106 uses metallic wires 142 of, e.g., an aluminum wire or a copper wire. The metallic wires 142 are joined to the drive semiconductor element 111 or the like by the wedge bonding technique with ultrasonic vibration applied. The metallic wire 142 after joined is pulled up in the thickness direction 111e, cut to a predetermined length and sealed by the sealing resin 115 to be prevented from deformation. One end of the metallic wire 142 is soldered penetrating the second circuit board 116. The seventh circuit device 106 is constructed the same in other points as the above-described fourth circuit device 103 shown in Fig. 8.

According to the seventh circuit device 106 similar to the fourth circuit device 103, since the metallic wires 142 extend in the thickness direction 111e, the seventh circuit device 106 can be formed compact in size. Also since the aluminum or copper is used for the metallic wire, the seventh circuit device 106 can be constructed inexpensively as compared with the case of using the gold wire. Besides, the process of removing bubbles prevents the drive semiconductor element 111 from being abnormally overheated.

The seventh circuit device 106 in Fig. 13 is modified by way of example to a seventh circuit device 106-1 shown in Fig. 14. As indicated in the drawing, metallic wires 142-1 are soldered to one face of the second circuit board 116 without penetrating the second circuit board. The modified seventh circuit device 106-1 is in the same constitution in other points as the aforementioned seventh circuit device 106.

The seventh circuit device 106-1 of Fig. 14 can obtain the same effects as the seventh circuit device 106 in Fig. 13.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

CLAIMS

1. An electronic circuit device which comprises:

a heat radiation required semiconductor element (111) having electrodes (111c, 111d) formed on both faces (111a, 111b) opposite to each other;

a first circuit board (133) electrically connected via a metallic plate (134) to a first electrode (111c) of the electrodes formed on one face (111a) of the two faces of the semiconductor element, on which the metallic plate and the semiconductor element are placed;

a second circuit board (116) arranged to a side of the other face (111b) of the two faces of the semiconductor element to be opposite to the first circuit board, with having a control circuit for the semiconductor element; and

a metallic wire (136, 136-1, 139, 139-1, 141, 141-1, 142, 142-1) for directly electrically connecting a second electrode (111d) of the electrodes present at the other face and the second circuit board with each other.

2. The electronic circuit device according to claim 1, wherein the metallic wire has a first bend portion (139a) for absorbing expansion and contraction of the first circuit board and the second circuit board resulting from

the heat radiation of the semiconductor element.

3. The electronic circuit device according to claim 1, wherein the metallic wire joined to the second electrode extends in a thickness direction (111e) of the semiconductor element.

4. The electronic circuit device according to claim 3, which further includes a heat radiation member (120) with supporting members (120a) for placing the first circuit board thereon and supporting the second circuit board, wherein the metallic wire has a second bend portion (136a) for absorbing, in a state with the second circuit board being supported by the supporting members, expansion and contraction of the first circuit board and the second circuit board resulting from the heat radiation and for pressing the first circuit board against the heat radiation member.

5. An electronic circuit device which comprises:

a heat radiation required semiconductor element (111) having first electrodes (111c) and second electrodes (111d) respectively formed on one face (111a) and the other face (111b) opposite to each other;

bumps (112) formed on the second electrodes; and

a metallic member (114) having a first face (114a) arranged opposite to the first electrodes to be electrically connected to the first electrodes and including installation members (114b) formed of a metal erected on the first face along a thickness direction (111e) of the semiconductor element in a height to exceed the bumps in the thickness direction when the semiconductor element with the bumps is placed on the first face.

6. The electronic circuit device according to claim 5, wherein three or more installation members are provided to one metallic member.

7. The electronic circuit device according to claim 5, further including a second circuit board (116) which is arranged to a side of the other face to be electrically connected to the bumps and leading ends (114c) of the installation members and is provided with a control circuit for the semiconductor element.

8. The electronic circuit device according to claim 6, further including a second circuit board (116) which is arranged to a side of the other face to be electrically connected to the bumps and leading ends (114c) of the installation members and is provided with a control circuit for the semiconductor element.

9. The electronic circuit device according to claim 7, which further includes a heat radiation member (120) with supporting members (120a) for placing the metallic member thereon via an electric insulating member

(119) and dissipating heat conducted from the semiconductor element to the metallic member.

10. The electronic circuit device according to claim 8, which further includes a heat radiation member (120) with supporting members (120a) for placing the metallic member thereon via an electric insulating member (119) and dissipating heat conducted from the semiconductor element to the metallic member.

11. A method for manufacturing an electronic circuit device having:

a heat radiation required semiconductor element (111) having first electrodes (111c) and second electrodes (111d) respectively formed on one face (111a) and the other face (111b) opposite to each other;

bumps (112) formed on the second electrodes; and

a metallic member (114) having a first face (114a) arranged opposite to the first electrodes to be electrically connected to the first electrodes and including installation members (114b) formed of a metal erected on the first face along a thickness direction (111e) of the semiconductor element in a height to exceed the bumps in the thickness direction when the semiconductor element with the bumps is placed on the first face,

said method comprising:

bringing the first face of the metallic member and the first electrodes into contact with each other, placing the semiconductor element on the first face, and heating the semiconductor element;

supplying a molten solder to the first face;

relatively pressing the semiconductor element and the metallic member to remove bubbles from inside the molten solder present between the first face and the first electrodes; and

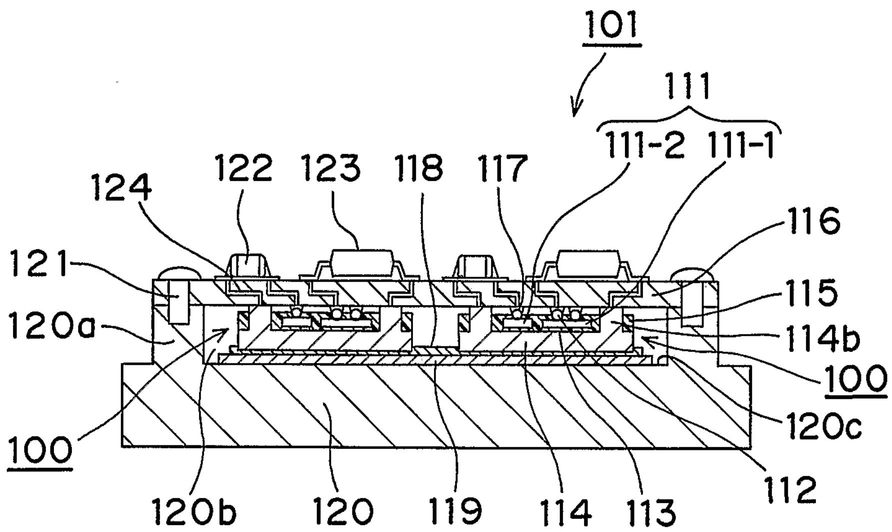
decreasing a temperature of the molten solder while maintaining the pressing state, thereby solidifying the molten solder and joining the semiconductor element and the metallic member.

12. The method for manufacturing the electronic circuit device according to claim 11, which further comprises:

after the joining the semiconductor element and the metallic member, electrically connecting the bumps and leading ends (114c) of the installation members to a second circuit board (116) which is arranged to a side of the other face and is provided with a control circuit for the semiconductor element,

wherein, when a plurality of the metallic members are attached to the second circuit board, heights of the installation members of the metallic members are adjusted to unify all the metallic members in height with respect to the second circuit board.

Fig. 1



101
111
111-2 111-1
122 123 118 117
124
116
121
115
120a
114b
100
120c
100
112
120b 120 119 114 113

Fig. 2

Fig. 3

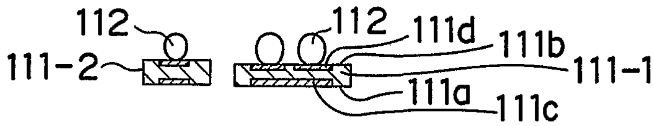


Fig. 4

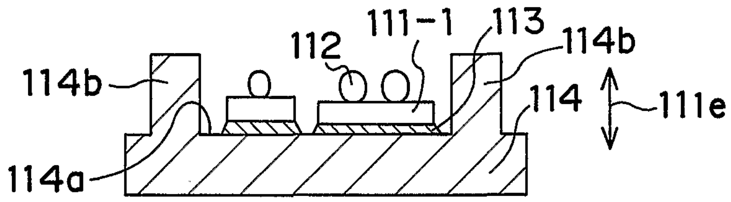


Fig. 5

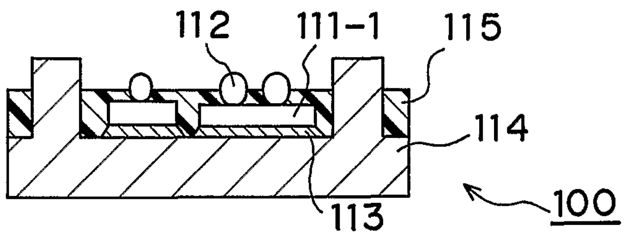


Fig. 6

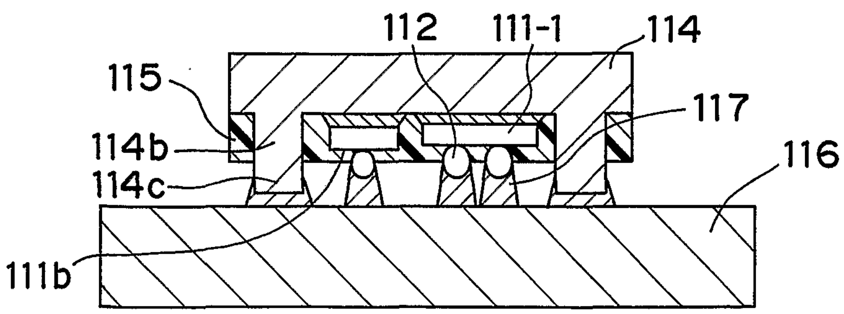


Fig. 7

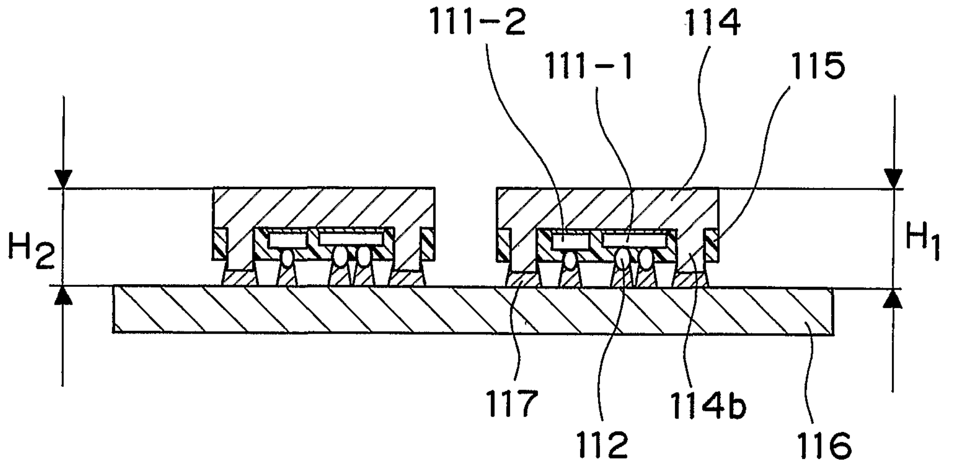


Fig.8

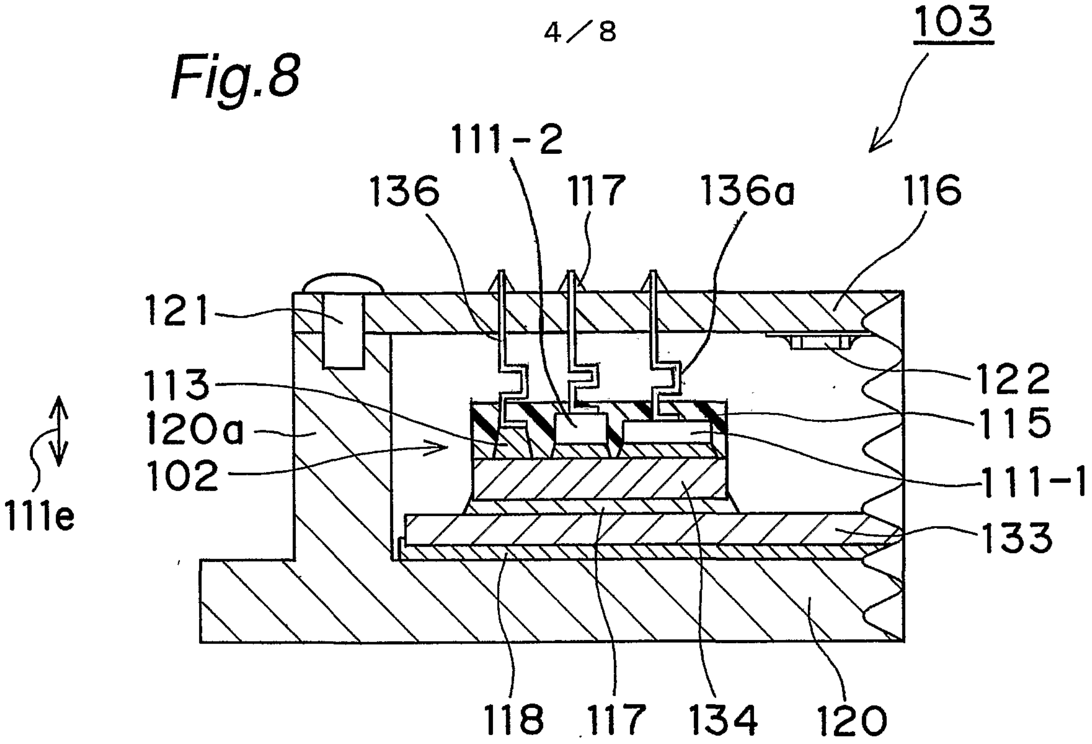

103
111-2
136
117
136a
116
121
122
113
115
120a
102
111-1
111e
133
118
117
134
120

Fig.9

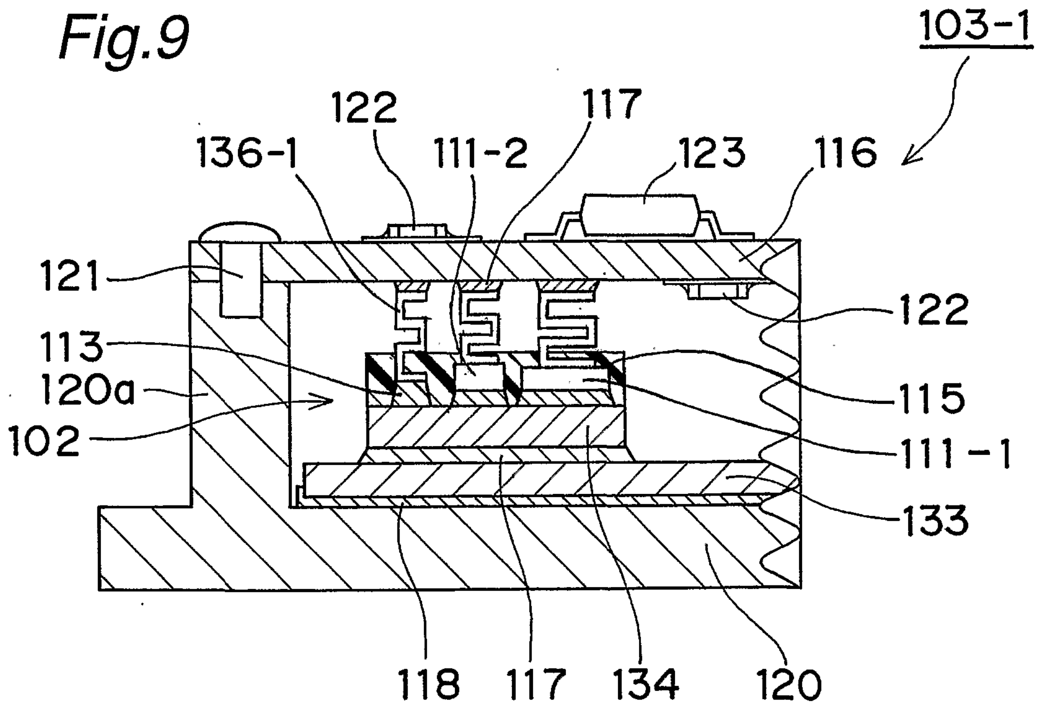

103-1
122
117
136-1
111-2
123
116
121
122
113
120a
115
102
111-1
133
118
117
134
120

Fig.10

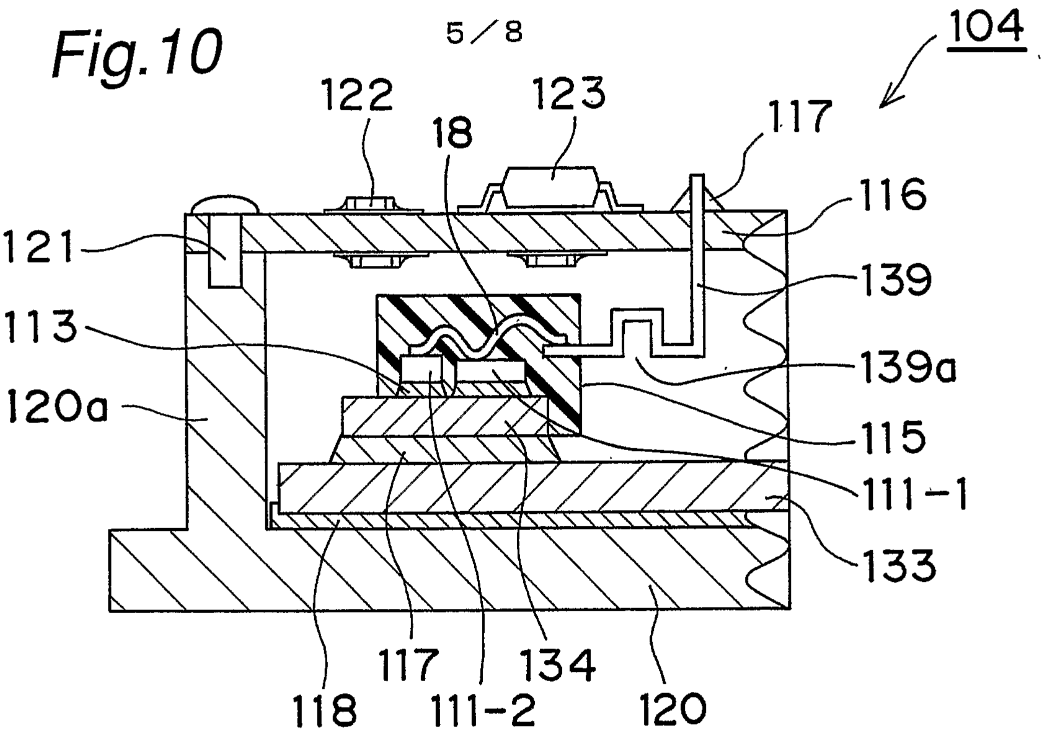

104
122
123
18
117
116
121
139
113
139a
120a
115
111-1
133
117
134
118
111-2
120

Fig.11

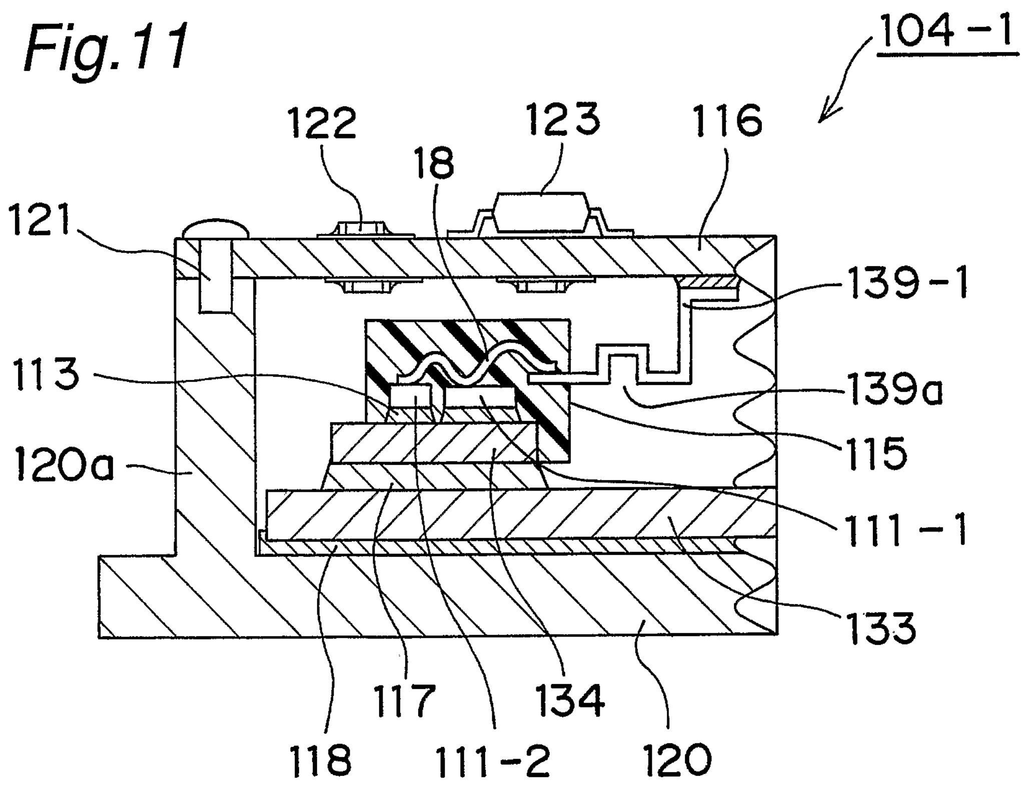

104-1
122
123
116
18
121
139-1
113
139a
115
120a
111-1
133
117
134
118
111-2
120

Fig.12

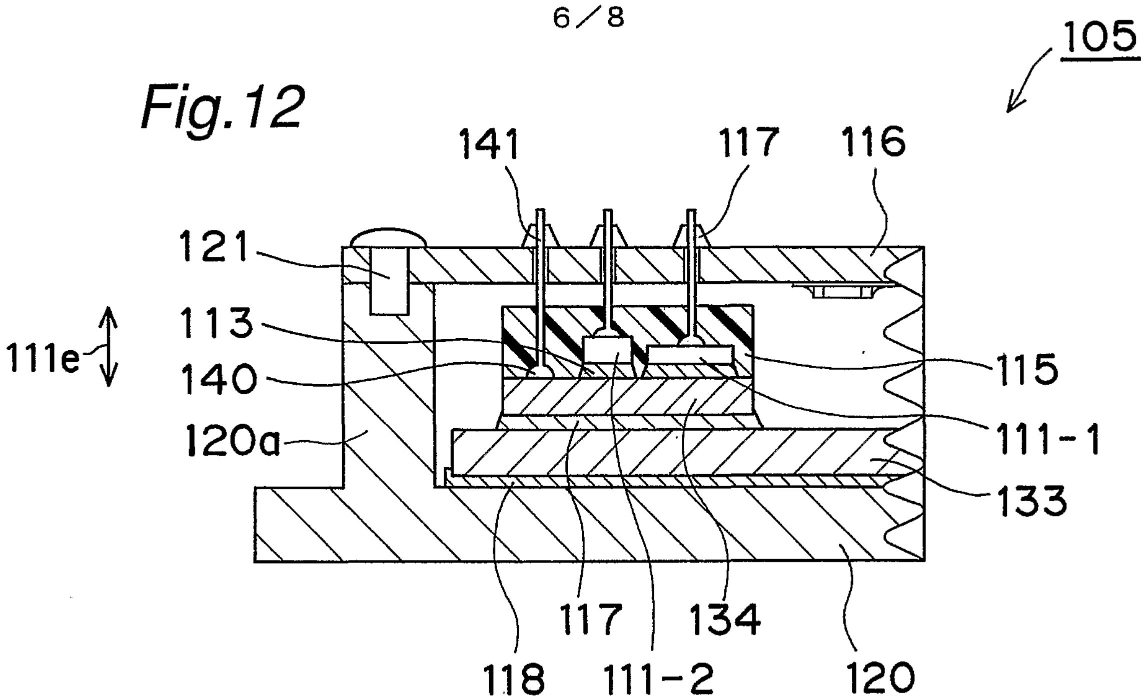

105
141
117
116
121
113
111e
140
120a
115
111-1
133
117
134
118
111-2
120

Fig.13

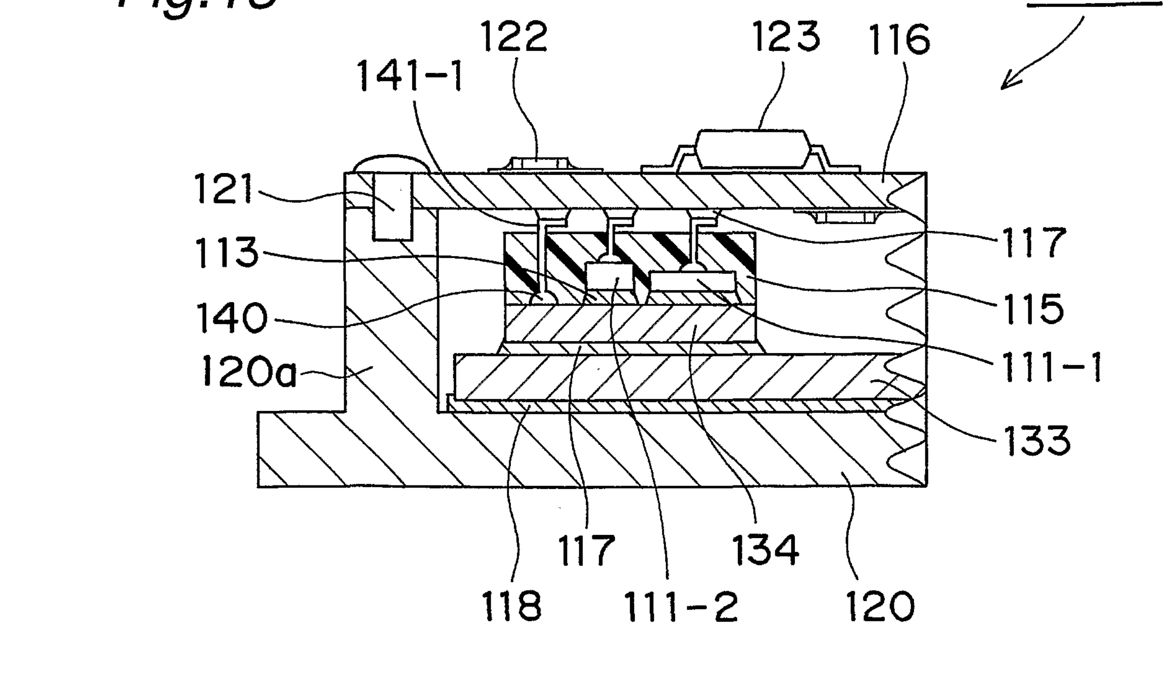

105-1
122
123
116
141-1
121
117
113
115
140
111-1
120a
133
117
134
118
111-2
120

Fig.14

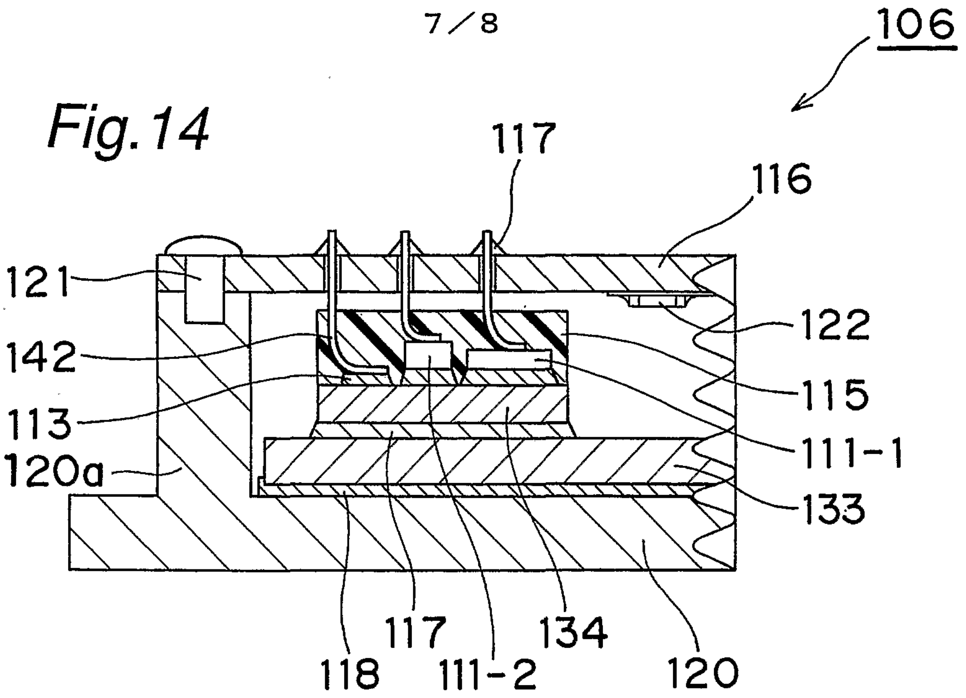

106
117
116
121
122
142
115
113
111-1
120a
133
118
117
111-2
134
120

Fig.15

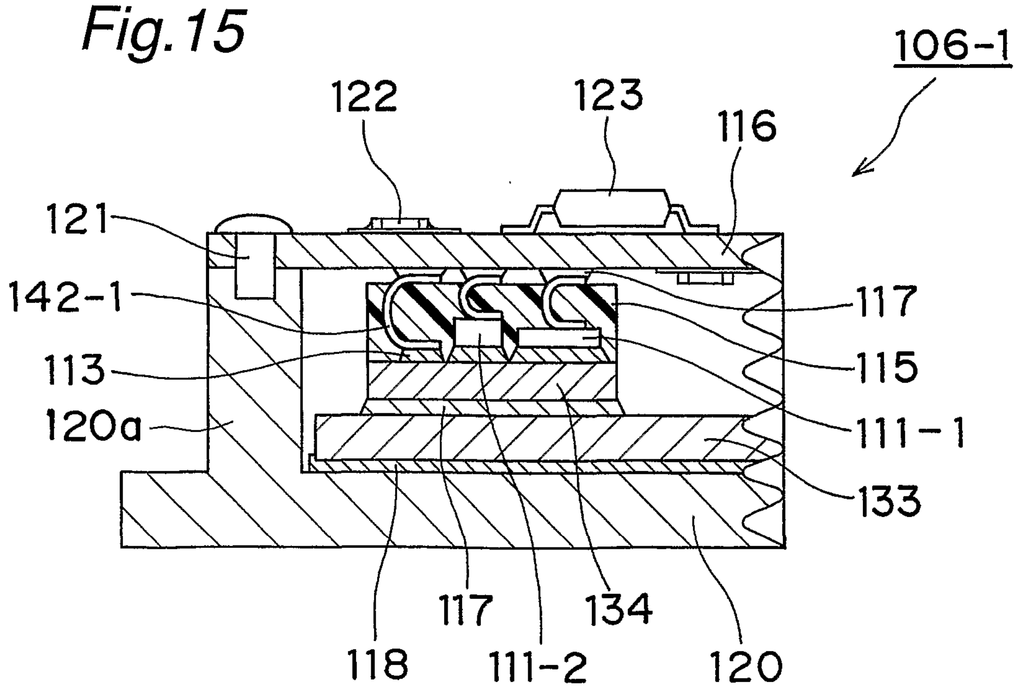

106-1
122
123
116
121
117
142-1
115
113
111-1
120a
133
118
117
111-2
134
120

Fig. 16