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ELECTRONIC MODULE

Abstract

An electronic module includes: an electronic element that has an electrode; an internal connection terminal having conductivity that is electrically connected to the electrode of the electronic element; and a spacer that is disposed between the internal connection terminal and the electronic element, wherein a conductive bonding material is disposed between the internal connection terminal and the spacer, and a protruding portion is formed on a surface of the internal connection terminal on an electronic element side, and a distal end of the protruding portion is brought into contact with an upper surface of the spacer.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese Patent Application No. 2024-20371, filed on Feb. 14, 2024, which is expressly incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to an electronic module.

BACKGROUND ART

[0003] Conventionally, there has been known electronic modules each including an electronic element (for example, a chip), a board on which the electronic element is disposed, and a pin terminal that functions as an internal connection terminal connected to a wiring pattern on the board (see a patent literature 1 described hereinafter). Among the electronic modules of this type, there exists an electronic module of a type where an internal connection terminal is connected to an electrode of an electronic element instead of the wiring pattern. As such an electronic module, there has been known an electronic module where an internal connection terminal is connected to an electrode of an electronic element via a spacer having a flat plate shape (for example, a chip spacer). In this case, the spacer and the electrode of the electronic element are bonded to each other by a solder.

PRIOR ART LITERATURE

Patent Literature

[0004] [Japanese Patent No. 6850938]

SUMMARY OF INVENTION

Technical Problem

[0005] A spacer (for example, a chip spacer) is used for relaxing a thermal stress of a surface of a chip. However, in a case of a structure where an internal connection terminal is connected to the spacer, a thermal stress is generated in a conductive bonding material (solder) between the spacer and the internal connection terminal due to a change in temperature of the outside. Accordingly, a crack is liable to occur in the conductive bonding material (solder) between the spacer and the internal connection terminal thus giving rise to a drawback that there is a possibility of increasing an electric resistance value or deteriorating heat radiation property of the electronic element (for example, a chip). Further, a distal end of the internal connection terminal has a flat shape and hence, there is a possibility that a loose contact occurs between the internal connection terminal and the spacer. The above-mentioned drawbacks are drawbacks that occur in a case where the spacer exists. However, such drawbacks also occur even in a case where a spacer does not exist and, for example, a distal end of an internal connection terminal and an electrode (electricity supply portion) of an electronic element are bonded to each other via a conductive bonding material.

[0006] The present invention has been made in view of the above-mentioned circumstances, and it is an object of the present invention to provide an electronic module that can relax a thermal stress in a conductive bonding material disposed between an internal connection terminal and a spacer (electrode) and, at the same time, can prevent the occurrence of a loose contact between the internal connection terminal and the spacer.

Solution to Problem

[0007] An electronic module according to the present invention is an electronic module that includes: an electronic element that has an electrode; an internal connection terminal having conductivity that is electrically connected to the electrode of the electronic element; and a spacer that is disposed between the internal connection terminal and the electronic element, wherein a conductive bonding material is disposed between the internal connection terminal and the spacer, and a protruding portion is formed on a surface of the internal connection terminal on an electronic

element side, and a distal end of the protruding portion is brought into contact with an upper surface of the spacer.

Advantageous Effects of the Present Invention

[0008] According to the electronic module of the present invention, the electronic module includes: the electronic element that has the electrode; the internal connection terminal having conductivity that is electrically connected to the electrode of the electronic element; and the spacer that is disposed between the internal connection terminal and the electrode of the electronic element, wherein the conductive bonding material is disposed between the internal connection terminal and the spacer, and the protruding portion is formed on a surface of the internal connection terminal on an electronic element side. With such a configuration, it is possible to relax a thermal stress that acts on the conductive bonding material (for example, a solder) between the internal connection terminal on which a thermal stress is concentrated and the spacer.

[0009] Further, the distal end of the protruding portion is brought into contact with the upper surface of the spacer and hence, a contact portion between the distal end of the protruding portion and the upper surface of the spacer becomes a bonding initiation point. Accordingly, the occurrence of a loose contact between the internal connection terminal and the spacer can be suppressed.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. **1** is a perspective view of an external appearance of an electronic module **100** according to an embodiment.

[0011] FIG. **2** is a perspective view illustrating an internal structure of the electronic module **100** according to the embodiment.

[0012] FIG. **3** is a perspective view illustrating a peripheral structure of an internal connection terminal **134** according to the embodiment.

[0013] FIG. **4** is a view illustrating a structure between the internal connection terminal **134** and a spacer **122**.

[0014] FIG. **5** is a perspective view illustrating the structure of an upper surface of the spacer **122** according to the embodiment.

[0015] FIG. **6**A and FIG. **6**B are views illustrating a structure of the internal connection terminal **134** according to the embodiment. FIG. **6**A is a perspective view illustrating a structure of a lower surface of the internal connection terminal **134** in the embodiment. FIG. **6**B is a side view of the internal connection terminal **134** according to the embodiment.

[0016] FIG. **7**A and FIG. **7**B are views illustrating a structure of an internal connection terminal **138** according to a modification. FIG. **7**A is a perspective view illustrating a structure of a lower surface of the internal connection terminal according to the modification. FIG. **7**B is a side view of the internal connection terminal according to the modification.

[0017] FIG. **8** is a view illustrating a modification of an electronic module.

DESCRIPTION OF EMBODIMENTS

[0018] Hereinafter, an electronic module according to an embodiment of the present invention is described with reference to drawings. The embodiment described hereinafter is not intended to limit the invention called for in claims. Further, it is not always the case that all of various constitutional elements and combinations of these constitutional elements described in the embodiment are indispensable as means to solve the problems of the present invention.

Embodiment

[0019] As illustrated in FIG. **1** to FIG. **4**, an electronic module **100** according to the embodiment includes a board (first board) **112**, an electronic element **120** having an electrode (for example, a source electrode described later) **123**, a spacer (chip spacer) **122**, an internal connection terminal

134, a board (second board) **140**, and lead frames (each constituting an external connection terminal, hereinafter referred to as "external connection terminals") **160**, **161**, **162**, **163**, **164**, **165**, **166**, and a mold resin **150**. The external connection terminal **161** is connected to the internal connection terminal **134** at an intermediate position of the internal connection terminal **134**. The electronic element (semiconductor element) **120** is bonded to an upper surface of the board **112** via a solder BM**3**, and an electronic element (semiconductor element: not illustrated in the drawing) is bonded to a lower surface of the board **140**.

[0020] In the embodiment, the electronic module **100** constitutes a half bridge circuit where the electronic element **120** is used at a high side, and the electronic element bonded to the lower surface of the board **140** is used at a low side. There may be also a case where the electronic element **120** is used at the low side, and the electronic element bonded to a lower surface of the board **140** is used at the high side. The electronic module **100** may include constitutional elements other than the members described above. Hereinafter, for the sake of convenience, the description is made with respect to the constitutional elements in the electronic element **120** of the electronic module **100**. The detailed description of the constitutional elements in the electronic element **120** bonded to the lower surface of the board **140** is omitted. In this specification, the expression "electrically connected" may include, besides a case where electricity supply portions of the constitutional elements are directly brought into contact with each other but also a case where the electricity supply portions of the constitutional elements are brought into contact with each other via a different constitutional element having conductivity (for example, a solder or a spacer). The electronic module **100** may have a suitable configuration such as a full bridge circuit other than the half bridge circuit.

[0021] The board **112** has a structure where a copper plate is disposed on both surfaces of a ceramic plate (for example, a DCB board). The board **112** is electrically connected with a drain electrode (not illustrated in the drawing) of the electronic element **120**. The board **112** is not limited to a DCB board, and may be a printed circuit board or the like, for example.

[0022] The electronic element **120** is disposed on the board **112**. The electronic element **120** is a vertical-type MOSFET that includes: a source electrode **123** disposed on a board **112** side; a drain electrode (not illustrated in the drawing) disposed on a board **112** side; and a gate electrode **127** disposed on the same side as the source electrode **123** (see FIG. **3**). The electronic element **120** includes three source electrodes **123** as the source electrodes thereof. The electronic element **120** may be formed of any one of other semiconductor elements such as IGBT, a triac, or a diode. Further, the electronic element **120** may be an electronic element other than the semiconductor element such as a capacitor or an inductor. Further, the number of electronic elements **120** is not limited to two. That is, one electronic element **120** may be used or three or more electronic elements **120** may be used.

[0023] The internal connection terminal **134** is an approximately columnar member having conductivity (see FIG. **4**), and is electrically connected to the electrode (for example, source electrode) **123** of the electronic element **120**. The internal connection terminal **134** is connected to a spacer **122** described later that has a flat plate shape and is made of a conductive material via a conductive boding material (for example, a solder) BM**2**. Further, in the electronic module **100**, three internal connection terminals **134** are provided in conformity with a configuration that the electronic element **120** has three source electrodes **123**. In this embodiment, the description is made by taking the example where the internal connection terminal is made of an approximately columnar member. However, the internal connection terminal **134** may not be limited to an internal connection terminal having an approximately columnar shape, and may be an internal connection terminal having a flat plate shape, for example. Further, in this embodiment, the case is exemplified where a cross-sectional shape of the internal connection terminal is a circular shape. However, the cross-sectional shape of the internal connection terminal is not limited to the circular shape, and the internal connection terminal may have a quadrangular cross-sectional shape or the like.

[0024] As illustrated in FIG. **6**A and FIG. **6**B, on a portion of the internal connection terminal **134** on an electronic element **120** side (a portion on a source electrode **123** side), a tapered portion **136** having a frustoconical shape is formed. A protruding portion **137** having a dome shape is formed on a center portion of the tapered portion **136**. A distal end (peak head portion) of the protruding portion **137** and the spacer **122** are brought into contact with each other. A conductive bonding material (for example, a solder) BM**2** is disposed between portions other than a distal end of the protruding portion **137** and the spacer **122** thus bonding the internal connection terminal **134** and the spacer **122** to each other. The distal end of the protruding portion **137** and the spacer **122** may be directly brought into contact with each other, or may be brought into contact with each other with a relatively thin conductive bonding material (for example, a solder) interposed therebetween. The solder BM**2** is applied from the distal end of the protruding portion **137** of the internal connection terminal **134** to an area in the vicinity of an outer peripheral edge via the tapered portion **136**. The expression "an area in the vicinity of an outer peripheral edge" means that the expression also includes a case where the solder BM**2** is applied from the distal end of the protruding portion **137** to a middle portion of the tapered portion **136**.

[0025] The spacer **122** is disposed between the internal connection terminal **134** and the electronic element **120**. As illustrated in FIG. **5**, the spacer **122** is a thin flat-plate member having conductivity (in this embodiment, a copper plate), and is formed in a polygonal shape. Three annular indentations (recessed portions) **128** each having an outer diameter larger than a diameter of the internal connection terminal **134** are formed on an upper surface of the spacer **122**. A distal end (a peak head portion) of the protruding portion **137** of the internal connection terminal **134** is brought into contact with the upper surface of the spacer **122** (specifically, such an upper surface corresponding to a bottom surface of the indentation **128**) via a conductive bonding material (for example, a solder) BM**2** (see FIG. **4**). Alternatively, such a distal end of the protruding portion **137** may be directly brought into contact with the upper surface of the spacer **122**. The number of indentations **128** are not limited to three. It is desired that the number of indentations **128** is not limited to three, and the number of the indentations **128** is the same as the number of internal connection terminals **134**.

[0026] An external appearance shape of the indentation **128** is a shape that corresponds to a cross-sectional shape of the internal connection terminal **134**, and an outer diameter and a depth of the indentation **128** can be changed corresponding to the shape of the internal connection terminal **134**. A lower surface of the spacer **122** is bonded to an upper surface of the electronic element **120** (to be more specific, the source electrode **123**) via a conductive bonding material (for example, a solder BM**1**). In this embodiment, the description has been made by exemplifying a case where the outer shape of the spacer **122** is a polygonal shape. However, the outer shape of the spacer **122** is not limited to a polygonal shape.

[0027] The external connection terminal **161** is a member that is electrically connected with the internal connection terminal **134** between the board **140** and the electronic element **120**. At least one end of the external connection terminal **161** protrudes to the outside of the mold resin **150**. The external connection terminal **161** in the electronic module **100** is a detection terminal with respect to the source electrode **123** of the electronic element **120**.

Advantageous Effects Acquired by Embodiment

[0028] According to the electronic module of the embodiment, the electronic module **100** includes: the electronic element **120** that has the electrode **123**; the internal connection terminal **134** having conductivity that is electrically connected to the electrode **123** of the electronic element **120**; and the spacer **122** that is disposed between the internal connection terminal **134** and the electrode **123** of the electronic element **120**. In the electronic module **100**, the conductive bonding material BM**2** is disposed between the internal connection terminal **134** and the spacer **122**, and the protruding portion **137** is formed on a surface of the internal connection terminal **134** on an electronic element **120** side. With such a configuration, the solder BM**2** has a larger solder thickness at a portion of the

internal connection terminal **134** in the vicinity of an outer peripheral edge than at a distal end of the protruding portion **137** of the internal connection terminal **134** and hence, it is possible to secure a sufficient solder thickness at the portion of the internal connection terminal **134** in the vicinity of the outer peripheral edge of the internal connection terminal **134** on which a thermal stress is concentrated. As a result, a thermal stress that acts on the solder BM**2** that bonds the internal connection terminal **134** and the spacer **122** to each other can be relaxed.

[0029] Further, the distal end of the protruding portion **137** is brought into contact with the upper surface of the spacer **122** and hence, a contact portion between the distal end of the protruding portion **137** and the upper surface of the spacer **122** becomes a bonding initiation point. Accordingly, the occurrence of a loose contact between the internal connection terminal **134** and the spacer **122** can be suppressed.

[0030] According to the electronic module of the embodiment, the protruding portion **137** is formed at the center portion of the distal end of the internal connection terminal **134** and hence, the protruding portion **137** can be brought into contact with the connection member (the spacer **122** or the electrode **123**) disposed below the protruding portion **137** by a point contact. Accordingly, this contact portion becomes the bonding initiation point and hence, the occurrence of the loose contact between the internal connection terminal **134** and the spacer **122** can be prevented with more certainty.

[0031] Further, according to the electronic module **100** of the embodiment, the portion of the internal connection terminal **134** on the above-mentioned electronic element **120** side is formed in a tapered shape. With such a configuration, with respect to the solder thickness of the solder BM**2** applied from the center of the protruding portion **137** of the internal connection terminal **134** to the outer peripheral edge by way of the tapered portion **136**, such a solder thickness becomes larger at the outer peripheral edge side of the internal connection terminal **134** than at the distal end of the protruding portion **137**. Accordingly, it is possible to ensure a sufficient solder thickness at the portion of the internal connection terminal **134** in the vicinity of the outer peripheral edge of the spacer **122** on which a thermal stress is concentrated. As a result, a thermal stress that acts on the solder BM**2** that bonds the internal connection terminal **134** and the spacer **122** to each other can be relaxed with more certainty.

[0032] The present invention has been described based on the above-mentioned embodiments heretofore. However, the present invention is not limited to the above-mentioned embodiment. The present invention can be carried out in various modes without departing from the gist of the present invention. For example, the following modifications are also conceivable.

Modification of Shape of Distal End of Internal Connection Terminal

[0033] As illustrated in FIG. **7**A and FIG. **7**B, a distal end of the internal connection terminal **138** is formed in a shape where a protruding portion **139** having a circular columnar shape is formed on a center portion of a lower surface of the tapered portion **136** having a frustoconical shape. In other words, the protruding portion **139** is formed on a center portion of a distal end of the internal connection terminal **138**. The distal end of the internal connection terminal **138** is not limited to the above-mentioned distal end shape, and for example, the distal end of the internal connection terminal **138** may have a tapered shape toward the distal end, for example.

Modification of Electronic Module

[0034] In the above-mentioned embodiment, the description has been made with respect to the electronic module where the spacer is disposed between the internal connection terminal and the electronic element.

[0035] On other hand, in the modification, although the shape of the internal connection terminal is equal to the shape of the internal connection terminal in the above-mentioned embodiment, the modification differs from the above-mentioned embodiment with respect to a point that the internal connection terminal is connected to the electrode of the electronic element via the conductive bonding material instead of arranging the spacer between the internal connection terminal and the

electronic element. Hereinafter, the modification is described with reference to FIG. **8**.

[0036] The modification has the same configuration as the embodiment other than the point that the internal connection terminal is connected to the electrode of the electronic element via the conductive bonding material without providing the spacer. Accordingly, only portions that make the modification differ from the embodiment are described and the description of the portions having the substantially same configuration is omitted. Further, with respect to symbols indicating the substantially same portions, in a case where it is unnecessary to differentiate the portions of the modification from the corresponding portions of the embodiment, there may be a case where the same symbols are used. The electronic module according to the modification has substantially the same configuration as the electronic module **100** according to the embodiment 1 with respect to points other than the point that the internal connection terminal is connected to the electrode of the electronic element via the conductive bonding material without providing the spacer and hence, the electronic module according to the modification has the corresponding advantageous effects amongst advantageous effects that the electronic module **100** according to the embodiment 1 has.

[0037] The protruding portion **137** is formed on a portion of the internal connection terminal **134** on an electronic element **120** side (the portion on a source electrode **123** side). The protruding portion **137** having a dome shape is formed at a center portion of the tapered portion **136**. A distal end (peak head portion) of the protruding portion **137** is brought into contact with the source electrode **123** disposed on an upper surface of the electronic element **120** via a conductive bonding material (for example, solder) BM**2**. Alternatively, the distal end of the protruding portion **137** may be directly brought into contact with the source electrode **123**. The electronic module according to the modification has such a configuration and hence, a solder thickness of the solder BM**2** applied from the center of the protruding portion **137** to the outer peripheral edge by way of the tapered portion **136** of the internal connection terminal **134** becomes large on an outer peripheral side of the internal connection terminal **134** (see FIG. **4**).

[0038] Accordingly, a sufficient solder thickness can be secured between the area in the vicinity of an outer peripheral edge of the internal connection terminal **134** and the electrode **123** where a thermal stress is concentrated. As a result, a thermal stress that acts on the solder BM**2** that bonds the internal connection terminal **134** and the electrode **123** to each other can be relaxed.

[0039] The protruding portion **137** is formed on a distal end side of the internal connection terminal **134** and hence, it is possible to bring the protruding portion **137** into a point contact with the electrode **123 4** the electronic element **120**. Accordingly, this contact portion becomes a bonding initiation point and hence, the occurrence of a loose contact between the internal connection terminal **134** and the electrode **123** can be prevented.

[0040] According to the electronic module of the modification, the electronic module includes: the electronic element **120** that has the electrode **123** and; the internal connection terminal **134** having conductivity that is electrically connected to the electrode **123** of the electronic element **120**, and the conductive bonding material BM**2** is disposed between the internal connection terminal **134** and the electrode **123** of the electronic element **120**. The protruding portion **137** is formed on the surface of the internal connection terminal **134** on an electronic element **120** side, and the distal end of the protruding portion **137** is brought into contact with the electrode **123** of the electronic element **120**. With such a configuration, a solder thickness of the solder BM**2** becomes large in the area in the vicinity of the outer peripheral edge of the internal connection terminal **134** compared to the distal end of the protruding portion **137** of the internal connection terminal **134**. Accordingly, it is possible to ensure a sufficient solder thickness in the area in the vicinity of the outer peripheral edge of the internal connection terminal **134** to which a thermal stress is concentrated. As a result, a thermal stress that acts on the solder BM**2** that bonds the internal connection terminal **134** and the electrode **123** to each other can be relaxed.

[0041] Further, the distal end of the protruding portion **137** is brought into contact with the upper surface of the electrode **123** of the electronic element **120** and hence, the contact portion between

the distal end of the protruding portion **137** and the upper surface of the electrode **123** becomes a bonding initiation point. Accordingly, the occurrence of a loose contact between the internal connection terminal **134** and the electrode **123** can be suppressed.
[0042] Further, according to the electronic module **100** of the embodiment, on the upper surface of the spacer **122**, indentation portions **128** each has a shape corresponding to a cross-sectional shape of the internal connection terminal **134** are formed, and the positions where the indentations **128** are formed are disposed at positions corresponding to the positions of the internal connection terminals **134**. Accordingly, the indentation portions **128** impart a self-alignment effect to the internal connection terminals **134** that are inserted into the lead frame **161** and hence, the positional displacement of the spacer **122** can be prevented.

Claims

1. An electronic module comprising: an electronic element that has an electrode; an internal connection terminal having conductivity that is electrically connected to the electrode of the electronic element; and a spacer that is disposed between the internal connection terminal and the electrode of the electronic element, wherein a conductive bonding material is disposed between the internal connection terminal and the spacer, and a protruding portion is formed on a surface of the internal connection terminal on an electronic element side, and a distal end of the protruding portion is brought into contact with an upper surface of the spacer.
2. An electronic module comprising: an electronic element that has an electrode; and an internal connection terminal having conductivity that is electrically connected to the electrode of the electronic element, wherein a conductive bonding material is disposed between the internal connection terminal and the electrode of the electronic element, and a protruding portion is formed on a surface of the internal connection terminal on an electronic element side, and a distal end of the protruding portion is brought into contact with an electrode of the electronic element.
3. The electronic module according to claim 1, wherein a protruding portion is formed on a center portion of a distal end of the internal connection terminal.
4. The electronic module according to claim 2, wherein a protruding portion is formed on a center portion of a distal end of the internal connection terminal.
5. The electronic module according to claim 1, wherein a portion of the internal connection terminal on an electronic element side has a tapered shape.
6. The electronic module according to claim 2, wherein a portion of the internal connection terminal on an electronic element side has a tapered shape.
7. The electronic module according to claim 1, wherein an indentation having a shape that corresponds to a cross-sectional shape of the internal connection terminal is formed on an upper surface of the spacer, and the indentation is formed at a position that corresponds to a position of the internal connection terminal.