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ELECTRONIC MODULE, METHOD OF MANUFACTURING ELECTRONIC MODULE AND ELECTRONIC MODULE MANUFACTURING DEVICE

Abstract

An electronic module includes: a board; electronic elements disposed on the board; and a flat-plate-shaped power terminal being erected upright from the board, wherein the board, the electronic elements and the power terminal are sealed by a sealing member, and the power terminal is configured such that the power terminal is electrically connected with the board, at least a distal end portion of the power terminal protrudes from the sealing member, and a depressed portion that is dented than the other portions is disposed at a position where the power terminal is brought into contact with a surface of the sealing member.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese Patent Application No. 2024-20370, 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, a method of manufacturing an electronic module, and an electronic module manufacturing device.

BACKGROUND ART

[0003] Conventionally, there has been known an electronic module that includes pin terminals that are erected upright from a board, and such a structure is sealed by a sealing member (for example, see patent literature 1).

[0004] In a conventional electronic module **900**, as illustrated in FIG. **11**, pin terminals **972**, **974** protrude from a seal resin **990** and hence, resin sealing is performed using a die that includes a pair of slide portions **922**. To be more specific, in a manufacturing process of the electronic module, the pin terminals **972**, **974** are disposed on a die and, thereafter, the pair of slide portions **922** is made to slide so as to clamp the pin terminals **972**, **974** and hence, it is possible to prevent the seal resin **990** from flowing out from the pair of slide portions **922** thus performing resin sealing. On the pin terminals **972**, **974** of the conventional electronic module **900**, recesses **963** that correspond to distal end portions of the slide portion **922** are formed.

PRIOR ART LITERATURE

Patent Literature

[0005] [Patent Literature 1] WIPO 2020/129195

SUMMARY OF INVENTION

Technical Problem

[0006] Recently, there has been a demand for an electronic module compatible with an electric equipment in which a large current flows. To satisfy such a demand, a case is considered where a plate-shaped power terminal having a current path of a relatively large cross-sectional area is used in place of a pin terminal. However, in the case where the plate-shaped power terminal is used, a contact surface between a slide portion and the power terminal is large and a shear droop surface or a fracture is formed at the time of manufacturing the power terminal due to shearing of a plate member and hence, there is a concern that a gap is formed between a die (slide portion) and the power terminal whereby there exists a drawback that leakage of a resin may occur.

[0007] 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 where leakage of a resin minimally occurs in a sealing step in spite of the use of a plate-shaped power terminal.

Solution to Problem

[0008] An electronic module according to the present invention is an electronic module that includes: a board; an electronic element disposed on the board; and a flat-plate-shaped power terminal being erected upright from the board, wherein the board, the electronic element and the power terminal are sealed by a sealing member, and the power terminal is configured such that at least a distal end portion of the power terminal protrudes from the sealing member, and the power terminal includes a depressed portion that is dented compared to other portions of the power terminal at a position where the power terminal is brought into contact with a surface of the sealing

member.
[0009] A method of manufacturing an electronic module according to the present invention includes: an assembled body forming step of forming an assembled body including a board, an electronic element and a power terminal having a flat plate shape by erecting upright the power terminal on the board on which the electronic element is disposed; an accommodating step of accommodating the board, the electronic element and the first part of the power terminal on a board side in a first cavity of a die, and accommodating a second part of the power terminal on a distal end side into a power terminal accommodating hole that extends from an inner surface of the first cavity; and a sealing step of sealing, after the accommodating step, the board, the electronic element, and the first part of the power terminal by making a sealing material flow into the first cavity, wherein in the accommodating step, the second part of the power terminal is inserted into the power terminal accommodating hole and, thereafter, distal end portions of a pair of slide portions mounted on the die are made to protrude from an inner periphery of the power terminal accommodating hole so as to clamp the power terminal by the pair of slide portions so that the distal end portion of the second part of the power terminal is separated from the first cavity and the distal end portions of the pair of slide portions bite into an outer periphery of the second part of the power terminal whereby a depressed portion is formed on an outer periphery of the second part of the power terminal.
[0010] A manufacturing device of an electronic module according to the present invention is a manufacturing device of an electronic module for carrying out the method of manufacturing an electronic module according to the preset invention. The manufacturing device includes: a first die that has the power terminal insertion hole and includes the pair of slide portions; and a second die that opposedly faces the first die, wherein one side surface of the power terminal is a shear droop surface where a shear droop is formed at an end portion, the other surface of the power terminal is a burr surface that is contiguously formed with a fracture surface of a side surface, and as viewed in a plan view, a recessed portion that corresponds to a cross section of the power terminal is formed on distal end portions of the pair of slide portions respectively, with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the slide portion that is brought into contact with the shear droop surface has a shape that corresponds to the shape of the shear droop surface, and with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the slide portion that is brought into contact with the burr surface is formed such that a protruding portion is formed on both side wall sides of the recessed portion.
Advantageous Effects of the Present Invention
[0011] According to the electronic module of the present invention, the power terminal has the depressed portion that is dented than other portions at the position where the power terminal is brought into contact with the surface of the sealing member. Accordingly, at the time of performing resin sealing using the die, a gap minimally occurs between the die (slide portion) and the power terminal and hence, leakage of a resin can be prevented. As a result, the electronic module according to the present invention, although the electronic module uses the plate-shaped power terminal, becomes an electronic module where leakage of a resin minimally occurs at the time of performing the sealing step.
[0012] According to the method of manufacturing an electronic module and the manufacturing device according to the present invention, by clamping the power terminal by the pair of slide portions, the distal end portion of the power terminal is separated from the first cavity and, at the same time, the distal end portions of the pair of slide portions bite into the outer periphery of the second forming the part of the power terminal thus depressed portion and hence, a gap minimally occurs between the die (slide portion) and the power terminal whereby it is possible to easily prevent the occurrence of leakage of a resin.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. **1**A and FIG. **1**B are perspective views of illustrating an electronic module **100** according to an embodiment. FIG. **1**A is a perspective view of the electronic module **100**, and FIG. **1**B is a front view of the electronic module **100**.

[0014] FIG. **2**A to FIG. **2**C are views illustrating an internal structure of the electronic module **100** according to the embodiment. FIG. **2**A is a front view where the illustration of a sealing member **190** is omitted from the electronic module **100**, FIG. **2**B is a plan view where the illustration of the sealing member **190** is omitted from the electronic module **100**, and FIG. **2**C is a plan view where the illustration of the sealing member **190**, a first connection frame **132**, a second connection frame **142** and an internal connection frame **152** are omitted.

[0015] FIG. **3**A to FIG. **3**D are views for describing a power terminal **160** according to the embodiment. FIG. **3**A is a front view of the power terminal **160**, FIG. **3**B is a plan view of the power terminal **160**, FIG. **3**C is an enlarged planar cross-sectional view illustrating an A**1**-A**1** cross section in FIG. **3**A, and FIG. **3**D is an enlarged planar cross-sectional view illustrating an A**2**-A**2** cross section in FIG. **3**A.

[0016] FIG. **4**A to FIG. **4**D are views illustrating steps of manufacturing the power terminal **160** according to the embodiment. FIG. **4**A to FIG. **4**D are respective step views.

[0017] FIG. **5** is a flowchart illustrating a method of manufacturing an electronic module according to the embodiment.

[0018] FIG. **6**A and FIG. **6**B are views illustrating a step of accommodating an assembled body in a die **1**. FIG. **6**A is a front cross-sectional view of the step of accommodating the assembled body in the die **1**, FIG. **6**B is a side cross-sectional view at the time of accommodating the assembled body in the die **1**.

[0019] FIG. **7**A and FIG. **7**B are views illustrating a step of clamping the power terminal **160** by a pair of slide portions **24**. FIG. **7**A is a cross-sectional front view of a step of clamping the power terminal **160** by the pair of slide portions **24**, FIG. **7**B is a cross-sectional side view of the step of clamping the power terminal **160** by the pair of slide portions **24**.

[0020] FIG. **8** is a plan view illustrating a mode where the slide portions **24** clamp the power terminal **160** in an accommodating step.

[0021] FIG. **9**A and FIG. **9**B are enlarged plan views of an essential part illustrating the mode where the slide portions **24** clamp the power terminal **160** in the accommodating step.

[0022] FIG. **10**A and FIG. **10**B are views illustrating a mode of a sealing step. FIG. **10**A is a cross-sectional front view illustrating the mode of the sealing step, and FIG. **10**B is a cross-sectional side view of the sealing step.

[0023] FIG. **11** is a cross-sectional view illustrating a resin sealing step in a conventional electronic module. Symbol **910** indicates a board, symbol **920** indicates an electronic element, symbols **932**, **942** indicate connection frames, and symbol **952** indicates an internal connection frame.

DESCRIPTION OF EMBODIMENTS

[0024] Hereinafter, an electronic module, a method of manufacturing an electronic module, and an electronic module manufacturing device are described based on an embodiment illustrated in drawings. The embodiments described hereinafter are 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

1. Electronic Module **100** According to Embodiment.

[0025] First, the electronic module **100** according to the embodiment is described. The electronic

module **100** according to the embodiment includes, as illustrated in FIG. **1**A and FIG. **1**B and FIG. **2**A to FIG. **2**C, a board **110**, electronic elements **120**A, **120**B, a first terminal **130**, a second terminal **140**, a power terminal **160**, a first connection frame **132**, a second connection frame **142**, an internal connection terminal **152** and pin terminals **172**, **174**, **182**, **184**.

[0026] In the description made hereinafter, the description is made by setting a longitudinal direction of the electronic module **100** as a front-and-rear direction, and a lateral direction as a left-and-right direction. Further, the description is made by setting a height direction of the electronic module **100** as an up-and-down direction. In the description made hereinafter, "front", "rear", "left", "right", "up", and "down" are used for the sake of facilitating the description of the present invention, and do not specify the direction that the electronic module **100** is mounted when the electronic module **100** is used.

[0027] As illustrated in FIG. **1**A and FIG. **1**B, resin sealing is applied to the electronic module **100** according to the embodiment using a sealing member **190**. Distal end portions of the first terminal **130**, the second terminal **140**, the power terminal **160**, pin terminals **172**, **174**, **182**, **184**, and the board **110** (a metal plate **113** for heat radiation) are exposed from the sealing member **190**.

[0028] As illustrated in FIG. **1**A and FIG. **1**B and FIG. **2**A to FIG. **2**C, the electronic module **100** according to the embodiment constitutes a half bridge circuit by connecting the electronic elements (semiconductor elements) **120**A, **120**B in series. The second terminal **140** is connected to a high voltage outside the electronic module **100**, and the first terminal **130** is connected to a reference potential. The power terminal **160** is an intermediate point terminal that is connected to an intermediate point between a source electrode of the electronic element **120**A and a drain electrode of the electronic element **120**B. A circuit that constitutes the electronic module **100** may be a full bridge circuit, or other suitable circuits.

[0029] As illustrated in FIG. **2**A, the board **110** is a direct copper bonding board (DCB board) that includes an insulation board (ceramic board) **112**, a circuit wiring **111** formed on an upper surface of the insulation board (ceramic board) **112**, and a metal plate **113** for heat radiation formed on a lower surface (back surface) of the insulation board (ceramic board) **112**. The board **110** may be a suitable board such as a printed circuit board.

[0030] The electronic elements **120**A, **120**B are disposed on a die pad of the circuit wiring **111**. The electronic elements **120**A, **120**B are each formed of a metal-oxide-semiconductor field-effect transistor (MOSFET) where a drain electrode is formed on a board **110** side, and a source electrode and a gate electrode are formed on a side opposite to the board side. The electronic elements **120**A, **120**B may each be a semiconductor element of a different type such as an IGBT, a triac or a diode, or may be an electronic element other than a semiconductor element such as a capacitor or an inductor. Further, the number of electronic elements **120**A, **120**B is not limited to two, and may be one or more.

[0031] In the electronic element **120**A, the source electrode is connected to the first terminal **130** via an internal connection terminal **134** and the first connection frame **132**. Further, the source electrode is connected to the pin terminal **174** that functions as a SENSE terminal via a wire, a circuit wiring or the like not illustrated in the drawing. A gate electrode is connected to the pin terminal **172** via a connection element **176** and a circuit wiring. A drain electrode (not illustrated in the drawing) is connected to the power terminal **160** via the circuit wiring **111**, and the power terminal **160** is electrically connected to an internal connection frame **152**. In the example in FIG. **1**A and FIG. **1**B, the internal connection terminal **134** has a circular shape in cross section.

[0032] In the electronic element **120**B, a source electrode is connected to the internal connection frame **152** via an internal connection terminal **154**, and the internal connection frame **152** is connected to the power terminal **160**. Further, the source electrode is connected to the pin terminal **184** that functions as a SENSE terminal via a wire, a circuit wiring or the like not illustrated in the drawing. A gate electrode is connected to a pin terminal **182** via a connection element **186** and a circuit wiring. A drain electrode (not illustrated in the drawing) is electrically connected to a second

terminal **140** via the circuit wiring **111**, a connection member **178** and the second connection frame **142**. In the example illustrated in FIG. **1**A and FIG. **1**B, the internal connection terminal **154** has a circular shape in cross section, and the connection member **178** has a rectangular shape in cross section.

[0033] As illustrated in FIG. **1**A and FIG. **1**B and FIG. **2**A to FIG. **2**C, the first terminal **130** is disposed on a front side of the electronic module **100** in the front-and-rear direction. The first terminal **130** is formed of a plate-shape member that is made of a flat plate material having conductivity, for example, a copper plate. The first terminal **130** has a through hole **131** that penetrates the first terminal **130** in the up-and-down direction. The through hole **131** has a circular shape, for example, as viewed in the up-and-down direction.

[0034] The first connection frame **132** is electrically connected with the first terminal **130**. The first connection frame **132** is embedded in the sealing member **190**. In the electronic module **100**, the first connection frame **132** is integrally formed with the first terminal **130** using the same plate material.

[0035] The first connection frame **132** includes a through hole (symbol being omitted) that penetrates the first connection frame **132** in the up-and-down direction. The through hole has a circular shape as viewed in the up-and-down direction. An upper end portion of the internal connection terminal **134** engages with the through hole by fitting engagement. The internal connection terminal **134** is fixed to the first connection frame **132** by press-fitting, for example, so as to connect the first connection frame **132** and the source electrode of the electronic element **120**A.

[0036] The second terminal **140** is disposed on a rear side of the electronic module **100** in the front-and-rear direction. The second terminal **140** is formed of a plate-shape member that is made of a flat plate material having conductivity, for example, a copper plate. The second terminal **140** has a through hole **141** that penetrates the second terminal **140** in the up-and-down direction. The through hole **141** has a circular shape, for example, as viewed in the up-and-down direction.

[0037] The second connection frame **142** (internal connection frame) is electrically connected with the second terminal **140**. The second connection frame **142** is embedded in the sealing member **190**. In the electronic module **100**, the second connection frame **142** is integrally formed with the second terminal **140** using the same plate material.

[0038] The internal connection frame **152** is a plate-shaped member that has a through hole (symbol being omitted) and an elongated hole **156** (see FIG. **2**B) that penetrate the internal connection frame **152** in the up-and-down direction. The internal connection frame **152** supports the power terminal **160** and, at the same time, electrically connects the electronic elements **120**A, **120**B and the power terminal **160** to each other. The internal connection frame **152** is disposed on the same plane as the first connection frame **132** and the second connection frame **142**.

[0039] The through hole has a circular shape as viewed in the up-and-down direction, an upper end portion of the internal connection terminal **154** engages with the through hole by fitting engagement. With the use of the internal connection terminal **154**, the internal connection frame **152** and the source electrode of the electronic element **120**A are connected to each other. The elongated hole **156** extends in the front-and-rear direction, and a first part (see symbol **166** in FIG. **3**A to FIG. **3**D described later) is press-fitted into the elongated hole **156** of the power terminal **160**.

[0040] As illustrated in FIG. **1**A to FIG. **3**D, the power terminal **160** is a flat-plate-shaped member that is erected upright from the board **110**. The power terminal **160** is disposed such that the left-and-right direction becomes a plate thickness direction, and is formed in an elongated shape where the up-and-down direction is set as the longitudinal direction. As illustrated in FIG. **3**A to FIG. **3**D, the power terminal **160** is positioned on a more board side than the internal connection frame **152**. The power terminal **160** includes: a first part **166** that is press-fitted into the elongated hole **156**; and a second part **164** that is positioned on a side opposite to a board **110** side of the internal connection frame **152**, and formed with a larger width than the first part **166**.

[0041] A distal end of the first part **166** on a board side is electrically connected to the board **110**. The first part **166** constitutes a portion of a circuit wiring that connected between the electronic element **120**A and the electronic element **120**B. The first part **166** is sealed by the sealing member **190**. The power terminal **160** may not be directly electrically bonded to the board **110**.
[0042] The second part **164** is connected to the first part **166**. The second part **164** includes: a connection portion **164***a* where a width (a width in the front-and-rear direction) of the connection portion **164***a* is gradually widened as the connection portion **164***a* becomes away from the first part **166** in the left-and-right direction; and an exposed portion **164***b* (distal end portion) having an approximately rectangular shape that is connected to the connection portion **164***a* and extends toward an upper side.
[0043] The connection portion **164***a* includes: a support portion **167** that supports the power terminal **160** by being brought into contact with the internal connection frame **152**; and protruding portions **162** that protrude from one side surface and the other side surface of the power terminal **160** respectively and has a lower surface that is brought into contact with the internal connection frame **152**. The connection portion **164***a* is sealed by the sealing member **190**.
[0044] The exposed portion **164***b* has an opening **161** formed in a center portion of the exposed portion **164***b*; and a depressed portion **163** that is dented from other portions that are disposed at a position where the exposed portion **164***b* is brought into contact with a surface of the sealing member **190** (a connecting region with the connection portion **164***a*). The exposed portion **164***b* is exposed from the sealing member **190**. The depressed portion **163** is formed in a state where the depressed portion **163** surrounds the entire circumference of the power terminal **160**.
[0045] The power terminal **160** is formed by applying shearing to a flat plate material having conductivity, for example, a metal plate. As illustrated in FIG. **3**C, one side surface **165***a* of the power terminal **160** is a shear droop surface where a shear droop **168***a* is formed at an end portion of the one side surface **165***a*, and the other surface **165***b* of the power terminal **160** is a burred surface that is connected with a fracture surface **168***b* on a side surface. In the depressed portion **163**, an end portion of the other surface **165***b* of the power terminal **160** is dented than other portions of the other surface **165***b* of the power terminal **160** (see FIG. **3**D).
[0046] The sealing member **190** seals the electronic elements **120**A, **120**B, a lower surface of the first terminal **130**, a lower surface of the second terminal **140**, the first connection frame **132**, the second connection frame **142** and the power terminal **160** (the first part **166** and the connection portion **164***a* of the second part). The sealing member **190** is made of a thermosetting molding material formed by adding a silica filler and the like to an epoxy resin that constitutes a main component. The sealing member **190** protects the electronic elements **120** from an environment such as heat, light and moisture.
[0047] The sealing member **190** includes a proximal portion covering portion **192** that covers a proximal portion of the power terminal **160** that protrudes from the sealing member **190** (a proximal portion of a portion of the power terminal **190** that protrudes from a height position of a surface of a region other than the proximal portion covering portion **192** in the sealing member **190**) (see FIG. **1**A and FIG. **1**B). Further, the sealing member **190** also includes the pin terminal proximal portion covering portion **193** that covers the proximal portions of portions of the pin terminals **171**, **174** or the pin terminals **182**, **184** that protrude from the sealing member **190** (the proximal portions of the portions of the pin terminals **172**, **174**, or the pin terminals **182**, **184** that protrude from a height position of a surface of a region other than the pin terminal proximal portion covering portion **193** in the sealing member **190**). The proximal portion covering portion **192** and the pin terminal proximal portion covering portion **193** are formed in shapes such that the proximal portion covering portion **192** and the pin terminal proximal portion covering portion **193** protrude from other portions of the sealing member **190**. The pin terminal base covering portion **193** collectively covers the proximal portions of two pin terminals. However, the pin terminal base covering portion **193** may cover the pin terminals one by one or may collectively cover all four pin

terminals.
[0048] Next, the cross-sectional structure of the power terminal **160** in a horizontal direction and the depressed portion **163** are described with reference to FIG. **3**A to FIG. **4**D.
[0049] The power terminal **160** is manufactured by applying shearing working to a flat plate having conductivity (for example, a metal plate) using a press. To be more specific, as illustrated in FIG. **4**A, a metal flat plate **160**′ is disposed on a die **210** having an opening, and press working is performed by pressing the metal flat plate **160**′ from above using a punch **200**. In such an operation, a tensile stress is generated at a portion of the metal plate **160**′ close to blades of the punch **200** and the die **210**, and a shear droop **168***a* is generated on a surface of the metal flat plate **160**′ (see FIG. **4**C). When a load of the punch **200** is further increased, cracks occur in the metal flat plate **160**′ so that the metal flat plate **160**′ and the power terminal **160** are separated from each other (see FIG. **4**C) whereby the power terminal **160** can be manufactured (see FIG. **4**D). At this point of time, there may be a case where the burrs are formed on a shear surface. However, the burrs can be removed by polishing. The power terminal **160** is formed in this manner.
[0050] As described above, the power terminal **160** is manufactured by applying shearing to the metal flat plate and hence, a burr surface and a shear droop surface are formed. One side surface **165***a* of the power terminal **160** forms the shear droop surface and the other side surface **165***b* of the power terminal **160** forms the burr surface.
[0051] As illustrated in FIG. **3**C, one side surface **165***a* of the power terminal **160** is the shear droop surface where the shear droop **168***a* having a round-shaped surface or an oblique surface is formed at an end portion. The other side surface **165***b* of the power terminal **160** is the burr surface that is contiguously connected with the fracture surface **168***b* of a side surface of the power terminal **160**. An end portion of the other side surface **165***b* is relatively flat. The fracture surface **168***b* is formed on the side portion of the power terminal **160**, and constitutes an oblique surface that is dented toward a burr surface side from the side surface on a shear droop **168***a* side.
[0052] The depressed portion **163** is formed so as to surround the entire circumference of the power terminal **160**. In the depressed portion **163**, one side surface **165***a* of the power terminal **160** is formed in a shape where the shear droop surfaces of other portions are depressed as it is.
[0053] On the other side surface **165***b* of the power terminal **160**, a recessed portion **168***c* that is dented than other portions on the other surface of the power terminal **160** is formed. Further, on the side portion of the power terminal **160**, when the depressed portion **163** of the power terminal **160** is formed (when the power terminal **160** is clamped by a pair of slide portions **24** in a sealing step described later), a depressed material is extruded to the side surface to form an extruded portion **169**.
2. Method of Manufacturing Electronic Module and Manufacturing Device **1** (Die) of Electronic Module According to Embodiment
[0054] Next, the method of manufacturing an electronic module according to the embodiment is described. As illustrated in FIG. **5**, the method of manufacturing an electronic module according to the embodiment includes an assembled body forming step, an accommodating step and a sealing step in this order.
(Assembled Body Forming Step)
[0055] First, the power terminal **160** formed in a flat shape is erected upright on the board **110** on which the electrode elements **120**A, **120**B are disposed thus forming an assembled body that includes the board **110**, the electronic elements **120**A, **120**B, the first terminal **130**, the second terminal **140**, the first connection frame **132**, the second connection frame **142**, the internal connection frame **152**, and the power terminal **160**.
[0056] To be more specific, on the circuit wiring **111** of the board **110**, the electronic elements **120**A, **120**B are disposed via a conductive bonding material (for example, solder). Next, a lead frame where the first terminal **130**, the second terminal **140**, the first connection frame **132**, the second connection frame **142**, and the internal connection frame **152** are surrounded by a frame

body portion (not illustrated in the drawing) is prepared and, then, the lead frame is disposed over the circuit wiring **111**. At this stage of the step, the through hole formed in the first connection frame **132** and the through hole formed in the internal connection frame **152** are arranged to be positioned on electrodes (source electrodes) of the electronic elements **120**A, **120**B respectively.

[0057] Next, the first part **166** of the power terminal **160** is inserted into the elongated hole **156** formed in the lead frame (internal connection frame), the internal connection terminals **134**, **154** are inserted into through holes, the pin terminals **172**, **174**, **182**, **184** are inserted into predetermined portions of the lead frame respectively, and the power terminal **160** and the respective pin terminals are brought into contact with the board **110** and, at the same time, the internal connection terminals **134**, **154** are brought into contact with the source electrodes of the electronic elements **120**A, **120**B. In performing such an operation, the power terminal **160**, the internal connection terminals **134**, **154** and the respective pin terminals may be inserted into the lead frame in advance and, the board **110** and the electronic elements **120**A, **120**B may be disposed on the circuit wiring **111** together with the lead frame.

[0058] Next, the board **110**, the electronic elements **120**A, **120**B, the first terminal **120**, the second terminal **140**, the first connection frame **132**, the second connection frame **142**, the internal connection frame **152** and the power terminal **160** are electrically connected with each other by bonding them suitably. As a method of electrically bonding these members, for example, a case is considered where a conductive bonding material (solder) is disposed on connection portions in advance, the respective members are brought into contact with each other, and the respective members are bonded to each other by melting a conductive bonding material by reflowing or the like.

(Configuration of Die **1**)

[0059] Before describing the accommodating step, first, the die **1** that is an electronic module manufacturing device according to the embodiment that accommodates the assembled body is described. As illustrated in FIG. **6**A and FIG. **6**B, the die **1** includes a first die **10**, a second die **20** that opposedly faces the first die **10**, and a drive member **30**. The respective members can be moved in the up-and-down direction.

[0060] The first die **10** has: a first recessed portion **11** that is formed on an opposedly facing surface that opposedly faces the second die **20**; and a mounting portion on which the frame body portion of the lead frame not illustrated in the drawing is mounted.

[0061] The second die **20** has: a second recessed portion **21** formed on an opposedly facing surface that opposedly faces the first die **10**; and a power terminal accommodating hole **22** and a pin terminal accommodating hole **23** that extend upward from the second recessed portion **21**. Slide portions **24** (**24**A to **24**D) are disposed on an inner side portion of the power terminal accommodating hole **22** and the pin terminal accommodating hole **23**. By moving the second die **20** toward the first die **10** thus joining the first die **10** and the second die **20** to each other whereby a first cavity C**1** is formed by the first recessed portion **11** and the second recessed portion **21**.

[0062] A pair of slide portions **24** are disposed on an inner side portion of the power terminal accommodating hole **22** and an inner side portion of the pin terminal accommodating hole **23**. By sliding the pair of slide portions **24** in the horizontal direction thus protruding distal end portions of the slide portions **24** from an inner periphery of the power terminal accommodating hole **22** and hence, the power terminal **160** and respective pin terminals accommodated in the power terminal accommodating hole **22** and the pin terminal accommodating hole **23** can be clamped by the pair of slide portions **24**. With such a configuration, it is possible to separate respective distal end portions **28** of the power terminal accommodating hole **22** and the pin terminal accommodating hole **23** from the first cavity C**1** on a board side. The distal end portion of the pair of slide portions **24** are formed in a tapered shape.

[0063] As illustrated in FIG. **9**A and FIG. **9**B, as viewed in a plan view, the recessed portions **25**A, **25**B that correspond to a cross section of the power terminal **160** are formed on distal end portions

28 of the pair of slide portions **24**A, **24**B respectively. With respect to the pair of slide portions **24**A, **24**B, a shape of a bottom of the recessed portion **25**B in the slide portion **24**B that is brought into contact with the power terminal **165***a* (shear droop surface) has a shape that corresponds to a shape of the shear droop surface. The shape of a bottom of the recessed portion **25**A in the slide portion **24**A that is brought into contact with the power terminal **165***b* (burr surface) has a shape where a protruding portion **26** is formed on both side wall sides of the recessed portion **25**B. Further, a cutaway portion **29** that forms the extruded portion **169** (see FIG. **4**A to FIG. **4**D) is formed on a portion of a shoulder of at least one of the recessed portions **25**A, **25**B.

[0064] The drive member **30** includes a body portion **31** and pressing portions **32**. The body portion **31** is disposed on the second die **20** (a side opposite to a first die **10** side), and is configured to be movable in the up-and-down direction. The pressing portions **32** are brought into contact with oblique surfaces **27** of the slide portions **24** on a proximal end portion side. When the body portion **31** of the drive member **30** approaches the second die **20**, the pressing portions **32** press the oblique surfaces **27** of the slide portions **24** on a proximal end portion side (a side opposite to a distal end side of the power terminal) and hence, the pair of slide portions **24** is made to slide toward the power terminal **160**. Further, by pulling out a separation pin not illustrated in the drawing, the pressing portions **32** (drive member **30**) are moved upward along the oblique surfaces **27** on the proximal end portion side and, at the same time, the pair of slide portions **24** is made to slide in the directions away from each other.

(Accommodating Step)

[0065] Next, the accommodating step is described. As illustrated in FIG. **6**A and FIG. **6**B, in the accommodating step, the board **110**, the electronic elements **120**A, **120**B and a first part **166** of the power terminal **160** on a board side are accommodated in the first cavity C**1** in the die **1**, at the same time, a second part **164** (to be more accurate, the exposed portion **164***b*) of the power terminal **160** on a distal end side is accommodated in the power terminal accommodating hole **22** formed in the die **1** that extends from the inner side of the first cavity C**1**.

[0066] To be more specific, first, the frame body portion (not illustrated in the drawing) of the lead frame not illustrated in the drawing is mounted on the opposedly facing surface of the first die **10**, and the assembled body is disposed in the first recessed portion **11** of the first die **10**. At this stage of the processing, the metal plate **113** for radiating heat of the board **110** is disposed in a state where the metal plate **113** is brought into contact with the first recessed portion **11**. Next, as illustrated in FIG. **6**A and FIG. **6**B, the second die **20** is made to overlap with the first die **10**. In such a state, the first cavity C**1** formed of the first recessed portion **11** of the first die **10** and the second recessed portion **21** of the second die **20** is formed. In the first cavity C**1**, the board **110**, the electronic elements **120**A, **120**B, the first terminal **130**, the second terminal **140**, the first connection frame **132**, the second connection frame **142**, the internal connection **152** and the first part **166** of the power terminal **160** are accommodated. Further, in the power terminal accommodating hole **22** formed in the second die **20** that extends from the inner surface of the first cavity C**1**, an upper portion (exposed portion **164***b*) of the second part **164** of the power terminal **160** is accommodated. In the pin terminal accommodating hole **23** formed in the second die **20** that extends from the inner surface of the first cavity C**1**, upper portions of the pin terminals **172**, **174**, **182**, **184** are accommodated.

[0067] In the accommodating step, the power terminal **160** and the respective pin terminals are accommodated in the power terminal accommodating hole **22** and the pin terminal accommodating holes **23** and, thereafter, the pair of slide portions **24** is made to slide (protrude) from the inner peripheries of the power terminal accommodating hole **22** and the respective pin terminal accommodating holes **23** thus allowing the pair of slide portions **24** to clamp the second part **164** of the power terminal **160** and the respective pin terminals (see FIG. **7**A and FIG. **7**B). The position at which the slide portions **24** clamp the power terminal **160** is the position spaced apart from the internal connection frame **152** of the second part **164** by a predetermined length.

[0068] In allowing the slide portions **24** to clamp the power terminal **160**, the body portion **31** of the drive member **31** is moved toward the second die **20** (see FIG. **7**A, FIG. **7**B and FIG. **8**). With such an operation, the pressing portions **32** press the oblique surfaces **27** of the pair of slide portions **24** on a proximal end portion side and hence, the slide portions **24** simultaneously slide, can simultaneously clamp the power terminal **160**. In the same manner, the respective pin terminals can be simultaneously clamped by the pair of slide portions **24**.

[0069] At this stage of the processing, distal end portions of the pair of slide portions **24** (slide portions **24**A, **24**B) bite into an outer periphery of the power terminal **160** so that the depressed portion **163** is formed. Further, in a state where the pair of slide portions **24** clamp the power terminal **160** therebetween, the power terminal **160** is surrounded by the inner periphery of the power terminal accommodating hole **22** and the slide portions **24** and hence, a second cavity C**2** is formed in a space associated with the first cavity C**1** (see FIG. **7**A and FIG. **7**B). Further, a space that covers the exposed portion **166***a* of the power terminal **160** is spaced apart from the second cavity C**2** by the slide portions **24**.

[0070] In the same manner, also with respect to the pin terminals, distal end portions of the pair of slide portions **24** (slide portions **24**C, **24**D) bite into an outer periphery of each pin terminal so that a dented portion is formed on the pin terminal (see symbol **963** in FIG. **11** with respect to the configuration of the recessed portion). In a state where the pair of slide portions (slide portions **24**C, **24**D) clamp the pin terminal, the pin terminal is surrounded by an inner periphery of the pin terminal accommodating hole **23** and the slide portions **24** so that a third cavity C**3** is formed in a space associated with the first cavity C**1**. Further, a space that covers the distal end portion of each pin terminal by the slide portions **24** is spaced apart from the third cavity C**3**.

(Sealing Step)

[0071] Next, the sealing member **190** (resin) is made to flow into the first cavity C**1** thus sealing the board **110**, the electronic elements **120** and the first part **166** of the power terminal **160** by the sealing member **190** (see FIG. **10**A and FIG. **10**B). Further, the sealing member **190** (resin) flows into the second cavity C**2** from the first cavity C**1** thus forming the proximal portion covering portion **192** and, at the same time, the sealing member **190** (resin) flows into also the third cavity C**3** thus forming the pin terminal proximal portion covering portion **193**.

[0072] After curing the resin that forms the sealing members **190** (including the proximal portion covering portion **192** and the pin terminal proximal portion covering portion **193**), the electronic module **100** is taken out from the die **1**. Then, the frame body portion of the lead frame (not illustrated in the drawings) is separated from the electronic module **100** by cutting. In this manner, the electronic module **100** can be manufactured.

3. Advantageous Effects Acquired by Electronic Module **100**, the Method of Manufacturing Electronic Module and the Electronic Module Manufacturing Device **1** According to the Embodiment

[0073] According to the electronic module **100** of the embodiment, the power terminal **160** has the depressed portion **163** that is dented than other portions at the position where the power terminal **160** is brought into contact with the surface of the sealing member **190**. Accordingly, at the time of performing sealing using the die **1**, a gap is minimally formed between the die **1** (slide portions **24**) and the power terminal **160** and hence, the occurrence of leakage of a resin can be prevented. As a result, the electronic module **100** according to the embodiment becomes an electronic module where leakage of a resin minimally occurs in the sealing step in spite of the use of the plate-shaped power terminal **160**.

[0074] Further, according to the electronic module **100**, and the method of manufacturing the electronic module of the embodiment, the electronic module **100** includes the internal connection frame **152** that is a flat-plate-shaped member having the elongated hole **156** (see FIG. **2**B), supports the power terminal, and electrically connects the electronic elements **120**A, **120**B and the power terminal **160** with each other. Accordingly, the plate-shaped power terminal can be supported in a

stable manner. Further, the circuit wiring can be constituted of the internal connection frame **152** and the power terminal **160** and hence, a mounting area for mounting the wiring on the board can be made small thus enabling downsizing of the electronic module. Further, the circuit wiring can be constituted in a stereoscopic space and hence, it is possible to provide the electronic module having high degree of freedom in designing.

[0075] Further, according to the electronic module **100** of the embodiment, in the power terminal **160**, the first part **166** that is positioned on a board side of the inner connection frame **152** is press-fitted into the elongated hole **156** and hence, the power terminal **160** can be supported in a stable manner. Further, the close contact property between the internal connection frame **152** and the power terminal **160** can be increased. Still further, the second part **164** that is positioned on a side opposite to the board side of the internal connection frame **152** is formed with a width greater than a width of the first part **166** and hence, a cross-sectional area of a current path is increased thus facilitating the flow of a large current.

[0076] Further, according to the electronic module **100** of the embodiment, at the depressed portion **163**, the end portion of the other surface **165***b* (burr surface) of the power terminal **160** is dented than the other portions of the other surface **165***b* of the power terminal **160**. Accordingly, in the sealing step, it is possible to make the slide portions **24** bite into the other surface **165***b* of the power terminal **160** and hence, it is possible to prevent leakage of a resin from a fracture surface with certainty. Even when it is intended to remove a gouge (a portion of an end portion on a burr surface side retracted toward an inside) in the vicinity of a fracture surface, a depressed wall portion does not move toward the gouge. However, an end portion of the other surface **165***b* (burr surface) of the power terminal **160** is dented than other portions of the other surface **165***b* of the power terminal **160** and hence, such a gouge can be filled up.

[0077] According to the electronic module **100** of the embodiment, the depressed portion **163** is formed so as to surround the entire circumference of the power terminal **160** and hence, in the sealing step, it is possible to make the slide portions **24** bite into the entire plate-shaped power terminal **160** and hence, leakage of a resin can be prevented with more certainty.

[0078] Further, according to the electronic module **100** of the embodiment, at the depressed portion **163**, on a side surface of the power terminal **160**, the release portion **169** that protrudes toward the outside is formed and hence, in the accommodating step, a material of the plate member depressed by the slide portions **24** is extruded to the release portion **169**. Accordingly, it is possible to prevent a phenomenon that the material is extruded to an unexpected portion so that the power terminal **160** is deformed, and a phenomenon that a gap is formed between the slide portions **24** and the power terminal **160** so that leakage of a resin occurs.

[0079] According to the electronic module **100** of the embodiment, the sealing member **190** has the proximal portion covering portion **192** that covers the proximal portion of the power terminal **160** that protrudes from the sealing member **190**. Accordingly, a creepage distance from a portion that is exposed from the sealing member **190** such as the pin terminal **172** disposed adjacently to the power terminal **160** can be increased and hence, it is possible to provide an electronic module with minimum erroneous operations. Further, it is possible to protect the portion that is exposed from the sealing member **190** in the power terminal **160** that is weak against an impact and hence, it is possible to provide an electronic module having high impact resistance.

[0080] Further, the electronic module **100** according to the embodiment includes the pin terminals **172** or the like having a pin shape that are erected upright from the board **110**, and the sealing member **190** has the pin terminal proximal portion covering portion **193** that covers the proximal portions of the pin terminals **172** that protrude from the sealing member **190**. Accordingly, it is possible to increase a creepage distance from the portion that is exposed from the sealing member **190** at the power terminal **160** disposed adjacently to the pin terminals **172** and the like or other pin terminals and the like. Accordingly, it is possible to provide the electronic module with minimum erroneous operations. Further, it is possible to protect the portions of the power terminal **172** and

the like that are exposed from the sealing member **190** and are weak against an impact and hence, also from this point of view, it is possible to provide an electronic module having high impact resistance.

[0081] According to the method of manufacturing the electronic module of the embodiment, by clamping the power terminal **160** by the pair of slide portions **24**, the distal end portion of the power terminal **160** is separated from the first cavity C**1**, and at the time of clamping the power terminal **160** by the pair of slide portions **24**, the distal end portions of the pair of slide portions **24**A, **24**B that protrude from the inner periphery of the power terminal accommodating holes **22** bite into the outer periphery of the second part **164** of the power terminal **160** thus forming the depressed portions **163**. Accordingly, a gap is minimally formed between the die **1** (slide portions **24**) and the power terminal **160** and hence, it is possible to prevent the occurrence of leakage of a resin.

[0082] According to the method of manufacturing the electronic module of the embodiment, both distal end portions of the pair of slide portions **24** are formed in a tapered shape. Accordingly, in the sealing step, at the time of clamping the power terminal **160**, the depressed portion **163** can be easily formed on the power terminal **160** thus making the slide portions **24** bite into the power terminal **160**. As a result, a gap minimally occurs between the power terminal **160** and the slide portions **24**.

[0083] According to the method of manufacturing the electronic module and the electronic module manufacturing device of the embodiment, in the accommodating step, on the distal end portions of the pair of slide portions **24** of the die **1**, the recessed portions **25**A, **25**B that correspond to the cross section of the power terminal **160** as viewed in a plan view are formed respectively. With respect to the pair of slide portions **24**, the shape of the bottom of the recessed portion **25**A of the slide portion **24**A that is brought into contact with one side surface (shear droop surface) **165***a* has the shape that corresponds to the shape of the one side surface (shear droop surface) **165***a*. On the other hand, with respect to the pair of slide portions **24**, the shape of the bottom of the recessed portion **25**B of the slide portion **24**B that is brought into contact with the burr surface has the shape where the protruding portion **26** is formed on both side wall sides of the recessed portion **25**B. Accordingly, the depressed portion **163** that correspond to the difference between the shear droop surface and the burr surface can be formed and hence, it is possible to prevent leakage of a resin with more certainty.

[0084] According to the method of manufacturing the electronic module of the embodiment, the cutaway portion **29** is formed on shoulder portions of the recessed portions **25**A, **25**B of at least one (slide portion **24**B) of the pair of slide portions **24**.

[0085] Accordingly, in the accommodating step, at the time of forming the depressed portion by clamping the power terminal **160** with the slide portions **24**, a material of the power terminal **160** moves to portions of the cutaway portion **29** and forms the release portion **169**.

[0086] Although the present invention has been described based on the above-mentioned embodiment heretofore, 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. [0087] (1) The positions, the connections, the numbers and the like of the constitutional elements described in the above-mentioned respective (including the respective embodiments modifications) are provided for an exemplifying purpose, and these values can be suitably changed so long as the advantageous effects of the present invention are not impaired. [0088] (2) In the above-mentioned embodiment, the present invention is applied to the electronic module that includes the pin terminals. However, the present invention is not limited to such a configuration. The present invention may be applied to an electronic module that does not use pin terminals. [0089] (3) In the above-mentioned embodiment, the present invention is applied to the terminal that is used at the middle point terminal as the power terminal. However, the present invention is not limited to such a

configuration. The present invention may be applied to the terminal other than the middle point terminal (for example, the first terminal, the second terminal). [0090] (4) In the above-mentioned embodiment, the present invention is applied to the electronic module that includes the internal connection frame. However, the present invention is not limited to such a configuration. The present invention may be applied to the electronic module that does not include the internal connection frame. [0091] (5) In the above-mentioned embodiment, the first die is used as an upper die, and the second die is used as a lower die. However, the present invention is not limited to such a configuration. The first die may be used as the lower die and the second die may be used as the upper die. In this case, the lead frame is disposed on the opposedly facing surface of the second die in a state where the power terminal and the pin terminal of the assembled body are inserted into the power terminal accommodating hole **22** and the pin terminal accommodating hole **23** formed in the second die. Then, a drive member is also disposed below the second die, and the pressing portion is moved upward so as to move the pair of slide portions in the horizontal direction.

Claims

1. An electronic module comprising: a board; an electronic element disposed on the board; and a flat-plate-shaped power terminal being erected upright from the board, wherein the board, the electronic element and the power terminal are sealed by a sealing member, and the power terminal is configured such that at least a distal end portion of the power terminal protrudes from the sealing member, and the power terminal includes a depressed portion that is dented than the other portions of the power terminal at a position where the power terminal is brought into contact with a surface of the sealing member.
2. The electronic module according to claim 1 further comprising: an internal connection frame that is a flat-plate-shaped member having an elongated hole, the internal connection frame configured to support the power terminal and also configured to electrically connect the electronic element and the power terminal, the sealing member is configured to seal the board, the electronic element, the internal connection frame, and the power terminal, and in the power terminal, a first part of the internal connection frame that is positioned on a board side is press-fitted in the elongated hole, and a second part of the internal connection frame that is positioned on a side opposite to the board side is formed with a width greater than a width of the first part.
3. The electronic module according to claim 1, wherein one side surface of the power terminal is a shear droop surface where a shear portion is formed at an end portion, an other surface of the power terminal is a burr surface that is contiguously formed with a fracture surface of a side surface, and at the depressed portion, an end portion of an other surface of the power terminal is dented than the other portions on the other surface of the power terminal.
4. The electronic module according to claim 1, wherein the depressed portion is formed in a state where the depressed portion surrounds an entire circumference of the power terminal.
5. The electronic module according to claim 1, wherein in the depressed portion, a release portion that protrudes toward an outside is formed on a side surface of the power terminal.
6. The electronic module according to claim 1, wherein the sealing member has a proximal portion covering portion that covers a proximal portion of a portion of the power terminal that protrudes from the sealing member.
7. The electronic module according to claim 1, further comprising a pin-shaped pin terminal that is erected upright from the board, at least a distal end portion of the pin terminal being protruding from the sealing member, wherein the sealing member includes a pin terminal proximal portion covering portion that is configured to cover a proximal portion of a portion of the pin terminal that protrudes from the sealing member.
8. A method of manufacturing an electronic module comprising: an assembled body forming step of forming an assembled body including a board, an electronic element and a power terminal

having a flat-plate-shape by erecting upright the power terminal on the board on which the electronic element is disposed; an accommodating step of accommodating the board, the electronic element and a first part of the power terminal on a board side in a first cavity of a die, and accommodating a second part of the power terminal on a distal end side into a power terminal accommodating hole that extends from an inner surface of the first cavity; and a sealing step of sealing the board, the electronic element, and the first part of the power terminal by making a sealing material flow into the first cavity, wherein in the accommodating step, the second part of the power terminal is inserted into the power terminal accommodating hole and, thereafter, distal end portions of a pair of slide portions mounted on the die are made to protrude from an inner periphery of the power terminal accommodating hole so as to clamp the power terminal by the pair of slide portions so that the distal end portion of the second part of the power terminal is separated from the first cavity and the distal end portions of the pair of slide portions bite into an outer periphery of the second part of the power terminal whereby a depressed portion is formed.

9. The method of manufacturing an electronic module according to claim 8, wherein distal end portions of both of the pair of slide portions are formed in a tapered shape.

10. The method of manufacturing an electronic module according to claim 8, wherein one side surface of the power terminal is a shear droop surface where a shear droop is formed on an end portion of the one side surface, an other side surface of the power terminal is a burr surface that is contiguously formed with a fracture surface of a side surface of the power terminal, in the accommodating step, as viewed in a plan view, on distal end portions of the pair of slide portions of the die, a recessed portion that corresponds to a cross section of the power terminal is formed respectively, with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the slide portion that is brought into contact with the shear droop surface has a shape that corresponds to the shape of the shear droop surface, and with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the slide portion that is brought into contact with the burr surface is formed such that a protruding portion is formed on both side wall sides of the recessed portion.

11. The method of manufacturing an electronic module according to claim 8, wherein a cutaway portion is formed on a portion of a shoulder of a recessed portion in at least one of the pair of slide portions.

12. The method of manufacturing an electronic module according to claim 8, wherein in the assembled body forming step, the assembled body is assembled including an internal connection frame that is a flat-plate-shaped member having an elongated hole, supports the power terminal, and electrically connects the electronic element and the power terminal to each other, the power terminal is supported by press-fitting the first part of the power terminal into the elongated hole, and the electronic element and the power terminal are electrically connected to each other, and in the sealing step, the board, the electronic element, the internal connection frame and the power terminal are sealed by a sealing member, and a second part of the power terminal is formed with a width greater than a width of the first part.

13. A manufacturing device of an electronic module for carrying out the method of manufacturing an electronic module according to claim 8, the manufacturing device comprising: a first die that has the power terminal insertion hole and includes the pair of slide portions; and a second die that opposedly faces the first die, wherein one side surface of the power terminal is a shear droop surface where a shear droop is formed at an end portion, an other surface of the power terminal is a burr surface that is contiguously formed with a fracture surface of a side surface, and as viewed in a plan view, a recessed portion that corresponds to a cross section of the power terminal is formed on distal end portions of the pair of slide portions respectively, with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the slide portion that is brought into contact with the shear droop surface has a shape that corresponds to the shape of the shear droop surface, and with respect to the pair of slide portions, a shape of a bottom of the recessed portion of the

slide portion that is brought into contact with the burr surface is formed such that a protruding portion is formed on both side wall sides of the recessed portion.