

# US Patent & Trademark Office

## Patent Public Search | Text View

United States Patent Application Publication

20250259902

Kind Code

A1

Publication Date

August 14, 2025

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### SEMICONDUCTOR PACKAGE, ELECTRONIC DEVICE, AND METHOD FOR MANUFACTURING SEMICONDUCTOR PACKAGE

#### Abstract

A semiconductor package includes a semiconductor chip, a heat radiating member on which the semiconductor chip is mounted, and a sealing member sealing the semiconductor chip. The sealing member is made of a liquid crystal polymer.

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**Family ID:** 1000008563468

**Appl. No.:** 19/193549

**Filed:** April 29, 2025

#### Foreign Application Priority Data

JP	2019-128693	Jul. 10, 2019
JP	2020-113132	Jun. 30, 2020

#### Related U.S. Application Data

parent WO continuation PCT/JP2020/026714 20200708 PENDING child US 17559608  
parent US division 17559608 20211222 PENDING child US 19193549

#### Publication Classification

**Int. Cl.:** **H01L23/29** (20060101); **H01L21/56** (20060101); **H01L23/00** (20060101); **H01L23/373** (20060101); **H01L23/473** (20060101); **H01L25/16** (20230101); **H10D64/23** (20250101); **H10D64/27** (20250101)

**U.S. Cl.:**

**CPC** **H01L23/293** (20130101); **H01L21/561** (20130101); H01L23/3735 (20130101); H01L23/473 (20130101); H01L24/24 (20130101); H01L24/29 (20130101); H01L24/32 (20130101); H01L24/73 (20130101); H01L24/82 (20130101); H01L24/97 (20130101); H01L25/162 (20130101); H01L2224/244 (20130101); H01L2224/245 (20130101); H01L2224/29111 (20130101); H01L2224/29139 (20130101); H01L2224/29147 (20130101); H01L2224/32225 (20130101); H01L2924/1033 (20130101); H01L2924/10344 (20130101); H01L2924/13064 (20130101); H10D64/257 (20250101); H10D64/519 (20250101)

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## **Background/Summary**

CROSS REFERENCE TO RELATED APPLICATIONS [0001] The present application is a divisional application of U.S. Utility patent application Ser. No. 17/559,608 filed on Dec. 22, 2021, which is a continuation application of International Patent Application No. PCT/JP2020/026714 filed on Jul. 8, 2020, which designated the U.S. and claims the benefit of priority from Japanese Patent Application No. 2019-128693 filed on Jul. 10, 2019 and Japanese Patent Application No. 2020-113132 filed on Jun. 30, 2020. The entire disclosures of all of the above applications are incorporated herein by reference.

### **TECHNICAL FIELD**

[0002] The present disclosure relates to a semiconductor package having a semiconductor chip sealed with a sealing member, an electronic device, and a method for manufacturing the semiconductor package.

### **BACKGROUND**

[0003] In a semiconductor package, a semiconductor chip is generally sealed with a sealing member. The sealing member is, for example, made of a glass epoxy resin or the like.

### **SUMMARY**

[0004] The present disclosure described a semiconductor package, an electronic device having the semiconductor package, and a method for manufacturing the semiconductor package. The semiconductor package includes a semiconductor chip, a heat radiating member on which the semiconductor chip is mounted, and a sealing member sealing the semiconductor chip. The sealing member is made of a liquid crystal polymer.

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## **Description**

### **BRIEF DESCRIPTION OF DRAWINGS**

[0005] Features and advantages of the present disclosure will become more apparent from the following detailed description made with reference to the accompanying drawings, in which:

[0006] FIG. 1 is a cross-sectional view of a semiconductor package according to a first embodiment;

[0007] FIG. 2 is a cross-sectional view of a semiconductor chip of the semiconductor package shown in FIG. 1;

[0008] FIG. 3 is a plan view of the semiconductor chip shown in FIG. 1;

[0009] FIG. 4A is a plan view of a heat radiating member of the semiconductor package shown in FIG. 1, when viewed from one side of the heat radiating member;

[0010] FIG. 4B is a plan view of a semiconductor chip and a side sealing part of the semiconductor package shown in FIG. 1, when viewed from one side of the heat radiating member;

[0011] FIG. 4C is a plan view of a first sealing member of the semiconductor package shown in FIG. 1, when viewed from one side of the heat radiating member;

[0012] FIG. 4D is a plan view of the first sealing member and a second sealing member of the semiconductor package shown in FIG. 1, when viewed from one side of the heat radiating member;

[0013] FIG. 5A is a cross-sectional view showing a manufacturing process of the semiconductor package shown in FIG. 1;

[0014] FIG. 5B is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5A;

[0015] FIG. 5C is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5B;

[0016] FIG. 5D is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5C;

[0017] FIG. 5E is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5D;

[0018] FIG. 5F is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5E;

[0019] FIG. 5G is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. 5F;

[0020] FIG. 6 is a plan view of a constituent substrate;

[0021] FIG. 7 is a cross-sectional view of a semiconductor package according to a second embodiment;

[0022] FIG. 8A is a cross-sectional view showing a manufacturing process of the semiconductor package according to the second embodiment;

[0023] FIG. 8B is a cross-sectional view showing a manufacturing process of the semiconductor package according to the second embodiment;

[0024] FIG. 9 is a cross-sectional view of a semiconductor package according to a third embodiment;

[0025] FIG. 10A is a plan view of a heat radiating member of a semiconductor package according to a fourth embodiment, when viewed from one side of the heat radiating member;

[0026] FIG. 10B is a plan view of a semiconductor chip and a side sealing part of the semiconductor package according to the fourth embodiment, when viewed from one side of the heat radiating member;

[0027] FIG. 10C is a plan view of a first sealing member of the semiconductor package according to the fourth embodiment, when viewed from one side of the heat radiating member;

[0028] FIG. 11 is a schematic diagram showing a relationship between connecting vias and the semiconductor chip according to the fourth embodiment;

[0029] FIG. 12A is a plan view of a heat radiating member of a semiconductor package according to a fifth embodiment, when viewed from one side of the heat radiating member;

[0030] FIG. 12B is a plan view of a semiconductor chip and a side sealing part of the semiconductor package according to the fifth embodiment, when viewed from one side of the heat radiating member;

[0031] FIG. 12C is a plan view of a first sealing member according to the fifth embodiment, when viewed from one side of the heat radiating member;

[0032] FIG. 13 is a cross-sectional view of a semiconductor package according to a sixth embodiment;

[0033] FIG. 14 is a cross-sectional view of a semiconductor package according to a seventh

embodiment;

[0034] FIG. **15** is a cross-sectional view showing a state in which the semiconductor package shown in FIG. **14** is mounted on a printed circuit board;

[0035] FIG. **16** is a cross-sectional view of a semiconductor package according to an eighth embodiment;

[0036] FIG. **17** is a cross-sectional view of a semiconductor package according to a ninth embodiment;

[0037] FIG. **18** is a cross-sectional view of a semiconductor package according to a tenth embodiment;

[0038] FIG. **19** is a cross-sectional view of a semiconductor package according to an eleventh embodiment;

[0039] FIG. **20** is a schematic plan view of a portion of a lower layer plate-shaped member shown in FIG. **19**, the portion being located under the semiconductor package;

[0040] FIG. **21** is a cross-sectional view of a semiconductor package according to a twelfth embodiment;

[0041] FIG. **22** is a schematic plan view of a portion of a lower layer plate-shaped member shown in FIG. **21**, the portion being located under the semiconductor package;

[0042] FIG. **23** is a cross-sectional view of a semiconductor package according to a thirteenth embodiment;

[0043] FIG. **24** is a cross-sectional view of a semiconductor package according to a modified example of the thirteenth embodiment;

[0044] FIG. **25** is a cross-sectional view of a semiconductor package according to a fourteenth embodiment;

[0045] FIG. **26** is a cross-sectional view of a semiconductor package according to a fifteenth embodiment;

[0046] FIG. **27** is a cross-sectional view of a semiconductor package according to a sixteenth embodiment;

[0047] FIG. **28** is a cross-sectional view of a semiconductor package according to a seventeenth embodiment;

[0048] FIG. **29** is a cross-sectional view of a semiconductor package according to an eighteenth embodiment;

[0049] FIG. **30** is a cross-sectional view of a semiconductor package according to a nineteenth embodiment;

[0050] FIG. **31** is a cross-sectional view of a semiconductor package according to a twentieth embodiment;

[0051] FIG. **32** is a cross-sectional view of a semiconductor package according to a twenty-first embodiment;

[0052] FIG. **33** is a plan view of a semiconductor package according to a twenty-second embodiment;

[0053] FIG. **34** is a plan view of a semiconductor package according to a twenty-third embodiment;

[0054] FIG. **35** is a plan view of the semiconductor package according to a twenty-fourth embodiment;

[0055] FIG. **36** is a plan view of the semiconductor package according to the twenty-fourth embodiment;

[0056] FIG. **37** is a cross-sectional view of a semiconductor package according to a twenty-fifth embodiment;

[0057] FIG. **38** is a cross-sectional view of a semiconductor package according to a twenty-sixth embodiment;

[0058] FIG. **39** is a cross-sectional view of a semiconductor package according to a twenty-seventh embodiment;

[0059] FIG. **40A** is a cross-sectional view showing a manufacturing process of the semiconductor package according to the twenty-seventh embodiment;  
[0060] FIG. **40B** is a cross-sectional view showing a manufacturing process of the semiconductor package following FIG. **40A**;  
[0061] FIG. **41** is a diagram for explaining a problem in the manufacturing method according to the first embodiment;  
[0062] FIG. **42** is a plan view of a constituent substrate for showing a manufacturing process of a semiconductor package according to a twenty-eighth embodiment;  
[0063] FIG. **43** is a cross-sectional view showing a manufacturing process of a semiconductor package according to a twenty-ninth embodiment;  
[0064] FIG. **44A** is a schematic view showing a manufacturing process of a plate-shaped member constituent component according to a thirtieth embodiment;  
[0065] FIG. **44B** is a schematic view showing a manufacturing process of the plate-shaped member constituent component following FIG. **44A**;  
[0066] FIG. **44C** is a schematic view showing a manufacturing process of the plate-shaped member constituent component following FIG. **44B**;  
[0067] FIG. **45A** is a diagram showing an internal state of an LCP film constituent member before heat treatment;  
[0068] FIG. **45B** is a diagram showing an internal state of the LCP film constituent member before heat treatment;  
[0069] FIG. **46** is a cross-sectional view showing an electronic device according to a thirty-first embodiment;  
[0070] FIG. **47** is a cross-sectional view showing an electronic device according to a thirty-second embodiment;  
[0071] FIG. **48** is a cross-sectional view showing an electronic device according to a thirty-third embodiment;  
[0072] FIG. **49** is a plan view of a first sealing member of a semiconductor package according to another embodiment, when viewed from one side of a heat radiating member;  
[0073] FIG. **50** is a cross-sectional view of a semiconductor package according to another embodiment;  
[0074] FIG. **51** is a cross-sectional view of a semiconductor package according to another embodiment;  
[0075] FIG. **52** is a cross-sectional view of a semiconductor package according to another embodiment; and  
[0076] FIG. **53** is a cross-sectional view of a semiconductor package according to another embodiment.

#### DETAILED DESCRIPTION

[0077] The inventors of the present disclosure have found that, when a semiconductor package in which a semiconductor chip is sealed with a sealing member made of glass epoxy resin is used on a vehicle, cracks are likely to be introduced into the sealing member, resulting in breakage. Namely, a semiconductor package for a vehicle needs to have durability.

[0078] The present disclosure provides a semiconductor package, an electronic device, and a method for manufacturing a semiconductor package, which are capable of suppressing breakage.

[0079] According to an aspect of the present disclosure, a semiconductor package includes a semiconductor chip, a heat radiating member on which the semiconductor chip is mounted, and a sealing member sealing the semiconductor chip, and the sealing member is made of a liquid crystal polymer.

[0080] According to the above aspect, the sealing member is made of a liquid crystal polymer. The liquid crystal polymer is a material having a higher material strength and being softer than a glass epoxy resin. Therefore, it is possible to suppress the introduction of cracks into the sealing member

and restrict the semiconductor package from being broken.

[0081] According to an aspect of the present disclosure, an electronic device includes a semiconductor package, a cooler connected to a heat radiating member of the semiconductor package, and a mounting member electrically connected to a pad of the semiconductor package.

[0082] In this way, the electronic device can be configured using the semiconductor package. Since the electronic device has the cooler connected to the heat radiating member, the heat radiating property can further improve.

[0083] According to an aspect of the present disclosure, a method for manufacturing a semiconductor package includes: preparing a constituent substrate in which regions for constituting a plurality of heat radiating members are sectioned by a dicing line; preparing semiconductor chips having semiconductor elements; placing the semiconductor chips on the regions of the constituent substrate through a bonding member; placing a sealing constituent member accommodating the semiconductor chips; heating the constituent substrate and the semiconductor chips while pressurizing in a stacking direction of the constituent substrate and the semiconductor chips so as to form a sealing member encapsulating the semiconductor chips other than bonded portions of the semiconductor chips bonded with the bonding member and being bonded with the heat radiating members; and dividing the constituent substrate along the dicing line, in which the sealing constituent member is made of a liquid crystal polymer.

[0084] According to the method, a semiconductor package, which is capable of suppressing the introduction of cracks into the sealing member, is manufactured.

[0085] Hereinafter, embodiments of the present disclosure will be described with reference to the drawings. In the embodiments described below, same or equivalent parts are designated with the same reference numerals.

#### First Embodiment

[0086] Configurations of a semiconductor package **10** of a first embodiment will be described with reference to FIGS. **1** to **4D**. The semiconductor package **10** of the present embodiment is preferably mounted on a vehicle and used for the vehicle.

[0087] As shown in FIGS. **1** to **4D**, the semiconductor package **10** includes a heat radiating member **20**, a semiconductor chip **30**, a sealing member **60**, and the like.

[0088] The heat radiating member **20** has an insulating substrate **21** made of silicon nitride (SiN), aluminum nitride (ALN), or the like. The heat radiating member **20** has a first surface metal film **22** formed on a first surface **21a** of the insulating substrate **21**, and a second surface metal film **23** formed on a second surface **21b** of the insulating substrate **21**. In the present embodiment, the first surface metal film **22** and the second surface metal film **23** are made of copper and each have a thickness of about 10 to 100  $\mu\text{m}$ . Further, the first surface metal film **22** and the second surface metal film **23** have the same planar shape and are symmetrically arranged with the insulating substrate **21** interposed therebetween.

[0089] As shown in FIGS. **2** and **3**, the semiconductor chip **30** is formed with a high electron mobility transistor using a two-dimensional electron gas (that is, 2DEG), in the present embodiment. Note that FIG. **2** corresponds to a cross section along the line II-II in FIG. **3**.

[0090] Specifically, the semiconductor chip **30** has a support substrate **31**, a buffer layer **32**, and a semiconductor layer **33** stacked on top of another in the stated order. The semiconductor chip **30** has substantially a rectangular outer shape. The support substrate **31** is made of silicon, silicon carbide (hereinafter, also simply referred to as SiC) or the like. The semiconductor layer **33** is formed by a stack of epitaxial layers such as a gallium nitride (GaN) layer and an aluminum gallium nitride (AlGaN) layer, and a two-dimensional electron gas is generated inside.

[0091] A drain electrode **34** and a source electrode **35** are disposed on the surface of the semiconductor layer **33**, and are separated from each other. In the present embodiment, the drain electrode **34** and the source electrode **35** are each formed in a comb-like shape, and are formed so that the comb teeth mesh with each other. In the present embodiment, the drain electrode **34**

corresponds to a first electrode, and the source electrode **35** corresponds to a second electrode. [0092] Further, on the surface of the semiconductor layer **33**, an insulating film **36** is formed at a portion located between the drain electrode **34** and the source electrode **35**. A gate wiring **37** is formed on the insulating film **36** at a position away from the drain electrode **34** and the source electrode **35**. The gate wiring **37** is appropriately routed along an area located between the source electrode **35** and the drain electrode **34**, and is connected to a gate electrode **38** arranged at the outer edge portion on the surface of the semiconductor layer **33**. Although not particularly limited, the drain electrode **34**, the source electrode **35**, and the gate electrode **38** are made of, for example, copper. The gate wiring **37** is made of, for example, a metal such as aluminum, platinum, or copper, or a poly-semiconductor doped with impurities.

[0093] A protective film **39** is formed on the surface of the semiconductor layer **33** so as to cover the gate wiring **37** while exposing the drain electrode **34**, the source electrode **35**, and the gate electrode **38**.

[0094] A back surface electrode **40** is formed on a surface of the support substrate **31** opposite to the semiconductor layer **33**. The back surface electrode **40** is electrically connected to the source electrode **35**, which will be described in detail later. As a result, the source electrode **35** and the support substrate **31** are electrically connected via the back surface electrode **40**, and a current collapse is suppressed.

[0095] In the semiconductor chip **30**, the on and off of the current flowing between the drain electrode **34** and the source electrode **35** via the two-dimensional electron gas is controlled by controlling the gate voltage applied to the gate wiring **37**. That is, the semiconductor chip **30** of the present embodiment is provided with a horizontal semiconductor element that causes a current to flow in a planar direction of the semiconductor chip.

[0096] The semiconductor chip **30** of the present embodiment has the configuration as described above. With the above configuration, the semiconductor chip **30** has substantially the rectangular shape including a first surface side on which the source electrode **35** and the like are disposed, a second surface side on which the back surface electrode **40** is disposed, and a side surface connecting between the first surface side and the second surface side.

[0097] As shown in FIG. **1**, the semiconductor chip **30** is arranged via the bonding member **50** on the first surface metal film **22** formed on the heat radiating member **20** so that the back surface electrode **40** faces the heat radiating member **20**. The bonding member **50** is made of a conductive material. In the present embodiment, the bonding member **50** is provided by a sintered body containing silver tin (AgSn) as a main component. Therefore, the back surface electrode **40** is in a state of being electrically connected to the first surface metal film **22** via the bonding member **50**. In a case where the bonding member **50** is made by mixing copper powder or the like having a higher thermal conductivity than silver tin, the thermal conductivity of the bonding member **50** is further increased.

[0098] In the present embodiment, the bonding member **50** is arranged so as to protrude from the semiconductor chip **30**, when viewed in a stacking direction of the heat radiating member **20** and the semiconductor chip **30** (hereinafter, simply referred to as the stacking direction). In other words, the bonding member **50** is arranged so that the semiconductor chip **30** is located inside the bonding member **50**, when viewed in the stacking direction. Thereby, for example, it is possible to suppress the concentration of stress on the end portion of the bonding surface between the semiconductor chip **30** and the bonding member **50**, as compared with a case where the semiconductor chip **30** protrudes from the bonding member **50** in the stacking direction. As such, it is possible to suppress the occurrence of cracks on the bonding surface between the semiconductor chip **30** and the bonding member **50**.

[0099] The sealing member **60** is arranged on the heat radiating member **20** so as to be bonded to the heat radiating member **20** while sealing portions of the semiconductor chip **30** excluding the portion bonded to the bonding member **50**. That is, the sealing member **60** is arranged on the heat

radiating member **20** so as to seal the first surface side and the side surface of the semiconductor chip **30**. The sealing member **60** includes a side sealing part **70** that seals the side surface of the semiconductor chip **30**, and a surface sealing part **80** that seals the first surface side of the semiconductor chip **30**. The side sealing part **70** and the surface sealing part **80** are each made of a liquid crystal polymer (hereinafter, simply referred to as LCP). Note that the LCP is a material having higher material strength and being softer than glass epoxy resin. That is, the LCP is a material in which cracks are less likely to be introduced than glass epoxy resin.

[0100] In the present embodiment, the side sealing part **70** is an injection-molded product formed by injection molding, and has a substantially rectangular shape. The side sealing part **70** is arranged on the heat radiating member **20** so as to be joined to the heat radiating member **20** while sealing the side surface of the semiconductor chip **30**. Specifically, as shown in FIGS. **1** and **4B**, the side sealing part **70** is formed with a first through hole **71** penetrating in the stacking direction, and the semiconductor chip **30** and the bonding member **50** are disposed in the first through hole **71**. The first through hole **71** is formed so as to expose substantially a central portion of the first surface metal film **22**.

[0101] The side sealing part **70** is further formed with a second through hole **72** so as to expose the outer edge portion of the first surface metal film **22**. A lower connecting via **73** connecting to the first surface metal film **22** is disposed in the second through hole **72**. The lower connecting via **73** is provided by a sintered body containing silver tin as a main component, and is also connected to an upper connecting via **97**, which will be described later. In a case where the lower connecting via **73** is made by mixing copper powder or the like having a higher thermal conductivity than silver tin, the thermal conductivity of the lower connecting via **73** is further increased. In FIG. **4A**, the lower connecting via **73** connecting to the first surface metal film **22** is shown by a dotted line. In the similar figures described later, the lower connecting via **73** connecting to the first surface metal film **22** is also shown by a dotted line. Further, in the present embodiment, the lower connecting via **73** is arranged in a columnar shape.

[0102] As shown in FIGS. **1** and **4C**, the surface sealing part **80** is provided by a stack of film-shaped first sealing member **90** and second sealing member **100**. The first sealing member **90** is made of an LCP film having a first surface **90a** and a second surface **90b**. The first sealing member **90** has a plurality of patterns **91** to **93** formed of copper foil or the like on the first surface **90a** side. The first sealing member **90** is formed with through holes **94** and **96** for exposing the pattern **91** to **93** on the second surface **90b** side. Upper connecting vias **95** and **97** are arranged in the through holes **94** and **96**. The upper connecting vias **95** and **97** are each made of a sintered body containing silver tin as a main component. In a case where the upper connecting via **97** is made by mixing copper powder or the like having a higher thermal conductivity than silver tin, the thermal conductivity of the upper connecting via **97** is further increased.

[0103] Specifically, on the first surface **90a** of the first sealing member **90**, a drain pattern **91** having a shape corresponding to the drain electrode **34** is formed at a position facing the drain electrode **34** of the semiconductor chip **30**. On the first surface **90a** of the first sealing member **90**, a source pattern **92** having a shape corresponding to the source electrode **35** is formed at a position facing the source electrode **35** of the semiconductor chip **30**. On the first surface **90a** of the first sealing member **90**, a gate pattern **93** having a shape corresponding to the gate electrode **38** is formed at a position facing the gate electrode **38** of the semiconductor chip **30**. In the present embodiment, the drain pattern **91** corresponds to a first pattern, and the source pattern **92** corresponds to a second pattern.

[0104] The through holes **94** are formed at a position between the drain pattern **91** and the drain electrode **34**, a position between the source pattern **92** and the source electrode **35**, and a position between the gate pattern **93** and the gate electrode **38**. The upper connecting via **95** is arranged in each of the through holes **94**. As a result, the source pattern **92**, the drain pattern **91**, and the gate pattern **93** are electrically connected to the source electrode, the drain electrode **34**, and the gate



electrode **38** via the upper connecting vias **95**, respectively.

[0105] In the present embodiment, a plurality of the upper connecting vias **95** connecting the drain pattern **91** and the drain electrode **34** and a plurality of the upper connecting vias **95** connecting the source pattern **92** and the source electrode **35** are formed. As a result, the inductance can be reduced and the speed of switching operation can be increased.

[0106] Each of the pattern **91** to **93** is formed of, for example, a copper foil. In this case, each of the pattern **91** to **93** preferably has a thickness of about 18  $\mu\text{m}$  or less so that the thermal expansion of the pattern **93** in the thickness direction does not increase.

[0107] The through hole **96** is formed at a position connecting the source pattern **92** and the second through hole **72** of the side sealing part **70**. The upper connecting via **97** is arranged in the through hole **96**, and is electrically connected to the lower connecting via **73** of the side sealing part **70** and the source pattern **92**. As a result, in the present embodiment, the source electrode **35** of the semiconductor chip **30** is electrically connected to the back surface electrode **40** via the upper connecting vias **95**, the source pattern **92**, the upper connecting via **97**, the lower connecting via **73**, and the first surface metal film **22**.

[0108] In FIGS. **4B** and **4C**, the upper connecting vias **95** and **97** are shown by dotted lines. In the similar figures described later, the upper connecting vias **95** and **97** are shown by the dotted lines. In the present embodiment, the upper connecting via **95** is formed in a columnar shape. Hereinafter, the lower connecting via **73** formed in the side sealing part **70** and the upper connecting via **97** connected to the lower connecting via **73** are collectively referred to as a connecting via **61** formed in the sealing member **60**. That is, in the present embodiment, the connecting via **61** formed in the sealing member **60** is arranged so as to connect the source pattern **92** and the first surface metal film **22**, and has a columnar shape.

[0109] As shown in FIGS. **1** and **4D**, the second sealing member **100** is made of an LCP film and is arranged on the first sealing member **90**. The second sealing member **100** is formed with contact holes **101** that expose the patterns **91** to **93**. As a result, a drain pad **91a** is formed by a portion of the drain pattern **91** exposed from the contact hole **101**. A source pad **92a** is formed by a portion of the source pattern **92** exposed from the contact hole **101**. A gate pad **93a** is formed by a portion of the gate pattern **93** exposed from the contact hole **101**. Although not particularly limited, the thickness of each of the patterns **91** to **93** is, for example, 18  $\mu\text{m}$  or less.

[0110] In the present embodiment, the contact holes **101** are formed at the positions different from the semiconductor chip **30** in the stacking direction. That is, the pads **91a**, **92a**, and **93a** are formed at the positions different from the semiconductor chip **30** in the stacking direction. In other words, the pads **91a**, **92a**, and **93a** are formed so as not to overlap the semiconductor chip **30** in the stacking direction. As a result, when a printed circuit board or the like is mounted on the pads **91a**, **92a**, **93a** via solder or the like, the stress applied to the semiconductor chip **30** can be reduced, and the semiconductor chip **30** can be suppressed from being broken. It should be noted that such a configuration can be appropriately applied in each of embodiments described later.

[0111] The second sealing member **100** is pressurized and integrated with the first sealing member **90** and the like, as will be described later. Therefore, the second sealing member **100** is also in a state of being inserted between the drain pattern **91** and the source pattern **92** formed in the first sealing member **90**. As a result, the second sealing member **100** can exhibit a function as a solder resist and also a function of increasing the insulation creepage distance between the drain pattern **91** and the source pattern **92**.

[0112] The sealing member **60** of the present embodiment has the configuration as described above. The sealing member **60** is arranged so as to be located inside the heat radiating member **20** in the stacking direction, that is, when viewed in the stacking direction. That is, the heat radiating member **20** has a size in which the sealing member **60** is located in the heat radiating member **20** in the stacking direction. Thus, the outer edge portion of the first surface **21a** of the insulating substrate **21** (that is, the heat radiating member **20**) is exposed from the sealing member **60**. As a

result, it is possible to suppress stress from concentrating on the end portion of the bonding surface between the sealing member **60** and the heat radiating member **20**. Therefore, it is possible to suppress the occurrence of cracks on the bonding surface between the sealing member **60** and the heat radiating member **20**, and it is possible to restrict the sealing member **60** from peeling off from the heat radiating member **20**.

[0113] In the present embodiment, respective members are chemically bonded with active groups being bonded to each other, more specifically, covalently bonded (i.e., molecularly bonded) so as to enhance the adhesion. In the present embodiment, the heat radiating member **20** is subjected to ultraviolet treatment or atmospheric pressure plasma treatment after surface cleaning such as ethanol cleaning so as to improve the adhesion between the heat radiating member **20** and the sealing member **60**. Thereafter, an alkaline solution containing a silicate is applied so as to form the active groups in the heat radiating member **20**.

[0114] Further, in order to improve adhesion of the peripheral region of the semiconductor chip **30**, the drain electrode **34**, the source electrode **35**, the gate electrode **38** and the like with the sealing member **60**, the drain electrode **34** and the like are subjected to a surface-cleaning by ethanol cleaning or the like and then an oxide removal by etching with dilute sulfuric acid or the like. Thereafter, by applying an aqueous solution of an organic compound containing a silanol group and an amino group, the active groups are formed on the drain electrode **34** and the like. The peripheral region includes peripheries of the drain electrode **34**, the source electrode **35**, and the gate electrode **38**, and side surfaces of the substrate formed by the stack of the support substrate **31**, the buffer layer **32**, and the semiconductor layer **33**. Since the drain electrode **34**, the source electrode **35**, the gate electrode **38**, and the like are portions connected to the upper connecting vias **95** described later, the active groups may not be formed in these portions. That is, the active groups may be formed only in portions of the semiconductor chip **30** other than the portions where the drain electrode **34**, the source electrode **35**, and the gate electrode **38** are formed.

[0115] Further, the side sealing part **70**, the first sealing member **90** and the second sealing member **100** are subjected to a surface cleaning such as cleaning with ethanol, and then to an ultraviolet treatment or atmospheric plasma treatment, so as to improve adhesion between the side sealing part **70** and the first sealing member **90** and between the first sealing member **90** and the second sealing member **100**. Thereafter, by applying an aqueous solution of an organic compound having a silanol group and an amino group, active groups are formed on the side sealing part **70**, the first sealing member **90** and the second sealing member **100**.

[0116] The semiconductor package **10** of the present embodiment has the configuration as described above. Next, a method for manufacturing the semiconductor package **10** will be described with reference to FIGS. 5A to 5G and FIG. 6. FIGS. 5A to 5G are diagrams showing a process of manufacturing two adjacent semiconductor packages **10**. Actually, a plurality of semiconductor packages **10** more than two are manufactured in the same process, as shown in FIG. 6. Further, when preparing each member in the following steps, a process for forming an active group is appropriately performed.

[0117] First, as shown in FIGS. 5A and 6, a constituent substrate **210**, which is a continuous substrate in which the insulating substrates **21** are integrated through a dicing line DL, is prepared. Then, a first surface metal film **22** and a second surface metal film **23** are formed in the portion of the constituent substrate **210** that becomes the insulating substrate **21**.

[0118] Further, a groove portion **211** is formed on a surface of the constituent substrate **210** on the side on which the second surface metal film **23** is formed. The groove portion **211** is formed at a position corresponding to the dicing line DL and along the dicing line DL. In this case, the groove portion **211** has a depth of about 0.1 t to 0.5 t, where t is the thickness of the constituent substrate **210**. In this case, it is described an example in which the groove portion **211** is formed on the surface of the constituent substrate **210** on the side on which the second surface metal film **23** is formed. However, the groove portion **211** may be formed on a surface of the constituent substrate

**210** on which the first surface metal film **22** is formed. Alternatively, the groove portion **211** may be formed on the surface on which the first surface metal film **22** is formed and on the surface on which the second surface metal film **23** is formed, in the constituent substrate **210**.

[0119] Then, as shown in FIG. 5B, a side constituent member **700** in which side sealing parts **70** are integrated through the dicing line DL is prepared. Next, a first through hole **71** and a second through hole **72** are formed in a portion of the side constituent member **700** that becomes the side sealing part **70**. Thereafter, for example, a sintered body **73a** for constituting a lower connecting via **73** is arranged in the second through hole **72**, such as by press fitting or the like. In this case, a conductive paste for constituting the lower connecting via **73** may be arranged in the second through hole **72** by a printing method or the like. As the sintered body **73a** arranged by press fitting or the like, for example, a sintered body containing silver tin as a main component is used. As the conductive paste arranged by the printing method, a paste provided by mixing a powder containing silver tin as a main component with an organic solvent is used.

[0120] Similarly, as shown in FIG. 5C, a first constituent member **900** in which first sealing members **90** are integrated through the dicing line DL is prepared. Then, a drain pattern **91** and a source pattern **92** are formed on portions of the first constituent member **900** that becomes the first sealing member **90**. Further, in a cross section different from that of FIG. 5C, a gate pattern **93** is formed in a portion of the first constituent member **900** that becomes the first sealing member **90**. Then, through holes **94** and **96** are formed in portions of the first constituent member **900** that become the first sealing member **90** by a laser or the like, and sintered bodies **95a** and **97a** for constituting upper connecting vias **95** and **97** are formed in the through holes **94** and **96** by press fitting or the like. In this case, a conductive paste for constituting the upper connecting vias **95** and **97** may be arranged in the through holes **94** and **96** by a printing method or the like. As the sintered bodies **95a** and **97a** arranged by press fitting or the like, for example, a sintered body containing silver tin as a main component is used. As the conductive paste arranged by the printing method, a paste provided by mixing a powder containing silver tin as a main component with an organic solvent is used.

[0121] Further, as shown in FIG. 5D, a second constituent member **1000** in which second sealing members **100** are integrated through the dicing line DL is prepared. Then, a contact hole **101** is formed in a portion of the second constituent member **1000** that becomes the second sealing member **100**.

[0122] Subsequently, as shown in FIG. 5E, the side constituent member **700** is arranged on the constituent substrate **210**, and the semiconductor chip **30** is arranged in the first through hole **71** via a sintered body **50a** constituting a bonding member **50**. In this case, a conductive paste for constituting the bonding member **50** may be arranged in the first through hole **71** by a printing method or the like. Then, the first constituent member **900** and the second constituent member **1000** are sequentially stacked on the side constituent member **700** and the semiconductor chip **30**. That is, the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000** are arranged on the constituent substrate **210** so as to accommodate the semiconductor chip **30**. In the present embodiment, the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000** correspond to a sealing constituent member. Further, as the sintered body **50a**, for example, a sintered body containing silver tin as a main component is used. As the conductive paste arranged by the printing method, the paste provided by mixing a powder containing silver tin as a main component with an organic solvent is used.

[0123] Then, as shown in FIG. 5F, the constituent substrate **210**, the side constituent member **700**, the semiconductor chip **30**, the first constituent member **900**, and the second constituent member **1000** are integrated by applying pressure in the stacking direction while heating. At this time, the bonding member **50**, the lower connecting via **73**, and the upper connecting vias **95** and **97** are formed from the sintered bodies **50a**, **73a**, **95a**, and **97a**. Similarly, when the conductive paste is

arranged, the bonding member **50**, the lower connecting via **73**, and the upper connecting vias **95** and **97** are formed from respective conductive pastes.

[0124] Then, as shown in FIG. 5G, the above body is divided into chips along the dicing line DL. In the present embodiment, since the groove portion **211** is formed in the constituent substrate **210**, dicing can be easily performed. Then, the outer edge portion of the sealing member **60** is removed by a laser or the like so that the outer edge portion of the first surface **21a** of the insulating substrate **21** is exposed from the sealing member **60**. In this way, the semiconductor package **10** shown in FIG. 1 is manufactured.

[0125] In the present embodiment, as described above, the sealing member **60** is made of the LCP, and the LCP is a material having higher material strength and being softer than the glass epoxy resin. Therefore, it is possible to suppress the introduction of cracks into the sealing member **60** and the destruction of the semiconductor package **10**.

[0126] The semiconductor package **10** is bonded by chemical bonding in which active groups are bonded to each other at the interface between the heat radiating member **20** and the sealing member **60**. Specifically, the interface between the heat radiating member **20** and the sealing member **60** is covalently bonded. Therefore, it is possible to suppress the occurrence of peeling at the interface between the heat radiating member **20** and the sealing member **60**. Further, the interface between the semiconductor chip **30** and the sealing member **60** is bonded by chemical bonding. Therefore, it is possible to suppress the occurrence of peeling at the interface between the semiconductor chip **30** and the sealing member **60**. Further, since the interface between the semiconductor chip **30** and the sealing member **60** is bonded by chemical bonding, the bondability between the semiconductor chip **30** and the sealing member **60** can be improved. Therefore, it is possible to reduce the area where the semiconductor chip **30** and the sealing member **60** are bonded. In particular, in a case where the support substrate **31** of the semiconductor chip **30** is made of SiC, the cost tends to be higher than that of the case where the support substrate **31** is made of silicon. Therefore, the size of the semiconductor chip **30** can be reduced by reducing the area where the semiconductor chip **30** and the sealing member **60** are bonded to each other, hence the costs can be reduced by reducing the size of the semiconductor chip **30**.

[0127] The bonding member **50** is arranged so that the semiconductor chip **30** is located within the bonding member **50** when viewed in the stacking direction. Therefore, it is possible to suppress the concentration of stress on the end portion of the bonding surface between the semiconductor chip **30** and the bonding member **50**, as compared with the case, for example, where the semiconductor chip **30** protrudes from the bonding member **50** when viewed in the stacking direction. Therefore, it is possible to suppress the occurrence of cracks on the bonding surface between the semiconductor chip **30** and the bonding member **50**.

[0128] Further, the heat radiating member **20** has a size such that the sealing member **60** is located within the heat radiating member **20** when viewed in the stacking direction. Therefore, it is possible to suppress stress from concentrating on the end portion of the bonding surface between the sealing member **60** and the heat radiating member **20**. Therefore, it is possible to suppress the occurrence of cracks on the bonding surface between the sealing member **60** and the heat radiating member **20**, and it is possible to suppress the sealing member **60** from peeling off from the heat radiating member **20**.

[0129] Further, since the side sealing part **70** is provided of an injection molded product, mass production can be easily realized.

[0130] Further, the LCP constituting the second sealing member **100** is arranged between the drain pattern **91** and the source pattern **92**. Therefore, the second sealing member **100** can exhibit a function as a solder resist, and also can exhibit a function of increasing the insulation creepage distance between the drain pattern **91** and the source pattern **92**.

[0131] In the present embodiment, the source electrode **35** of the semiconductor chip **30** is electrically connected to the back surface electrode **40**. Therefore, the current collapse can be

reduced.

[0132] Further, the heat radiating member **20** is configured to have the first surface metal film **22** and the second surface metal film **23** on the insulating substrate **21**. Therefore, it is possible to suppress the heat radiating member **20** from being deformed. In the present embodiment, in this case, the first surface metal film **22** and the second surface metal film **23** have the same shape and are symmetrically formed with respect to the insulating substrate **21** on opposite sides of the insulating substrate **21**. Therefore, it is possible to further suppress the deformation of the heat radiating member **20**.

[0133] When the semiconductor package **10** is manufactured, the groove portion **211** is formed in the constituent substrate **210**. Therefore, dicing can be easily performed. In the present embodiment, then example in which the groove portion **211** is formed before integrating the constituent substrate **210** and the side constituent member **700** or the like is described hereinabove. Alternatively, the groove portion **211** may be formed after the constituent substrate **210** and the side constituent member **700** or the like are integrated. That is, the groove portion **211** may be formed on the constituent substrate **210** before being divided into chips along the dicing line DL.

#### Second Embodiment

[0134] A second embodiment will be described hereinafter. In the present embodiment, the configuration of the side sealing part **70** is modified from that of the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0135] As shown in FIG. 7, in the semiconductor package **10** of the present embodiment, the side sealing part **70** is formed by a stack of plate-shaped members **74** made of LCP films and integrated in layers. The plate-shaped member **74** is configured to have an LCP film **77**, a pattern **75** formed on the LCP film **77**, and a connecting via **76** arranged in a through hole **76a**. That is, in the present embodiment, the plate-shaped members **74** constituting the side sealing part **70** and the first and second sealing members **90** and **100** have similar configurations to each other in which the patterns **75**, **91** to **93** and the vias **73**, **95**, and **97** are appropriately formed in the respective LCP films **77**. The lower connecting via **73** is configured by connecting the patterns **75** and the connecting vias **76** formed in the respective plate-shaped members **74**. That is, the connecting via **61** is made of the upper connecting via **97** and the lower connecting via **73** made of the patterns **75** and the connecting vias **76** formed in the respective plate-shaped members **74**.

[0136] The semiconductor chip **30** of the present embodiment is formed with a horizontal semiconductor element. The pattern **75** formed on each plate-shaped member **74** does not serve as a portion that allows an electric current to flow. Therefore, the pattern **75** formed on each plate-shaped member **74** may be thinner than the patterns **91** to **93** formed in the first sealing member **90**, and is, for example, 12  $\mu\text{m}$  or less. As a result, the quantity of materials constituting the pattern **75** can be reduced.

[0137] In the present embodiment, the connecting vias **76** of the plate-shaped members **74** adjacent to each other in the stacking direction are electrically connected via the pattern **75**. Therefore, the connecting vias **76** of the plate-shaped members **74** may be arranged so as to overlap with each other in the stacking direction, or may be arranged so as not to overlap with each other in the stacking direction.

[0138] Also in the present embodiment, it is preferable that the adjacent plate-shaped members **74** are bonded by chemical bonding in which the active groups are bonded to each other. In this case, for example, the active group may be only formed in the pattern **75** and the via **76**. According to this, it is possible to reduce the cost as compared with the case where the active group is formed on the whole of each plate-shaped member **74**.

[0139] The side sealing part **70** is manufactured by stacking the plate-shaped members **74** and then by applying pressure while heating. That is, in the present embodiment, in the process of FIG. 5B, a plate-shaped member constituent member **770** in which the LCP films **77** are integrated through the

dicing line DL is prepared, as shown in FIG. 8A. The number of plate-shaped member constituent members **770** prepared corresponds to the number of layers for forming the side sealing part **70**. In this case, the number of plate-shaped member constituent members **770** is preferably set such that the total thickness of the plate-shaped member constituent members **770** is larger than the thickness of the semiconductor chip **30**. As a result, it is possible to improve the quality after molding in the step of pressurizing while heating in FIG. 5F and later, which will be described later. Further, the preparing the first constituent member **900** and the second constituent member **1000** in the first embodiment is similar to the preparing the plate-shaped member constituent member **770** on the point that the plate-shaped member **74** in which the LCP films **77** are integrated through the dicing line DL.

[0140] Then, a through hole **71a** corresponding to the first through hole **71** and a through hole **76a** are formed in the plate-shaped member constituent member **770**, and a constituent body **76b** constituting the connecting via **76** is arranged in the through hole **76a**. As the constituent body **76b**, a conductive paste, a sintered body, or the like is used.

[0141] Then, in the process of FIG. 5E, the plate-shaped member constituent members **770** are sequentially stacked on the constituent substrate **210**, and the semiconductor chip **30**, the first constituent member **900**, and the second constituent member **1000** are arranged in order, as shown in FIG. 8B. Although the region constituting one semiconductor package **10** is shown in FIG. 8B, in reality, the portions constituting the plurality of semiconductor packages **10** are continuous to each other through the dicing line DL, as shown in FIG. 5E. Thereafter, the semiconductor package **10** shown in FIG. 7 is manufactured by performing the process shown in FIG. 5F and the processes after FIG. 5F.

[0142] As described above, even if the side sealing part **70** is formed by the stack of plate-shaped members **74** instead of the injection molded product, the same effects as those of the first embodiment can be achieved.

### Third Embodiment

[0143] A third embodiment will be described hereinafter. In the present embodiment, the heat radiating member **20** is not provided with the first surface metal film **22** and the second surface metal film **23**, as compared with the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0144] As shown in FIG. 9, in the semiconductor package **10** of the present embodiment, the heat radiating member **20** is not provided with the first surface metal film **22** and the second surface metal film **23**. The semiconductor chip **30** is arranged on the heat radiating member **20** via the bonding member **50**. The bonding member **50** of the present embodiment is made of a conductive material such as one in which silver particles are mixed with an organic solvent, and has a thickness of about 0.1 nm to 20  $\mu\text{m}$ . That is, the bonding member **50** is sufficiently thinner than the first surface metal film **22** of the first embodiment described above.

[0145] Further, the bonding member **50** is extended along a planar direction of the heat radiating member **20** and is connected to the lower connecting via **73**. That is, the bonding member **50** extends up to a position to be connected to the lower connecting via **73**. The source pattern **92** is connected to the back surface electrode **40** of the semiconductor chip **30** by being connected to the bonding member **50** through the connecting via **61** formed in the sealing member **60**.

[0146] According to this, since the heat radiating member **20** is not provided with the first surface metal film **22** and the second surface metal film **23**, the same effects as those of the first embodiment can be achieved while reducing the number of parts. The bonding member **50** is formed to be sufficiently thinner than the first surface metal film **22**. Therefore, even if the bonding member **50** is not arranged on the second surface **21b** of the insulating substrate **21**, the insulating substrate **21** is less likely to be deformed.

[0147] Further, since the second surface metal film **23** is not arranged on the heat radiating member **20**, the constituent substrate **210** can be easily fixed when the dicing shown in FIG. 5G is

performed in the manufacturing process. Therefore, the dicing can be simplified.

#### Fourth Embodiment

[0148] A fourth embodiment will be described hereinafter. In the present embodiment, the sealing member **60** is formed with a plurality of the connecting vias **61** with respect to the first embodiment described above. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0149] As shown in FIGS. **10A** to **10C**, the semiconductor package **10** of the present embodiment is formed with a plurality of the connecting vias **61**. Specifically, the first surface metal film **22** of the heat radiating member **20** is sectioned into multiple regions including a drain region **22a** connected to the drain pattern **91**, a source region **22b** connected to the source pattern **92**, and a gate region **22c** connected to the gate pattern **93**. The semiconductor chip **30** is arranged on the source region **22b** via the bonding member **50**. In the present embodiment, the drain region **22a** corresponds to a first region, and the source region **22b** corresponds to a second region.

[0150] The side sealing part **70** is formed with a plurality of the lower connecting vias **73** connected to the drain region **22a**. The side sealing part **70** is formed with a plurality of the lower connecting vias **73** connected to the source region **22b**. Further, the side sealing part **70** is formed with a plurality of the lower connecting vias **73** connected to the gate region **22c**.

[0151] The number of the lower connecting vias **73** connected to the source region **22b** is larger than that of the first embodiment. In the present embodiment, the lower connecting vias **73** connected to the drain region **22a** and the lower connecting vias **73** connected to the source region **22b** are located on opposite sides of the semiconductor chip **30**.

[0152] The first sealing member **90** is formed with the upper connecting via **97** so as to be connected to the lower connecting via **73** connected to the drain region **22a**. The first sealing member **90** is formed with the upper connecting via **97** so as to be connected to the lower connecting via **73** connected to the source region **22b**. Further, the first sealing member **90** is formed with the upper connecting via **97** so as to be connected to the lower connecting via **73** connected to the gate region **22c**.

[0153] That is, the sealing member **60** is formed with a connecting via **61** so as to connect the drain pattern **91** and the drain region **22a**. The sealing member **60** is formed with a connecting via **61** so as to connect the source pattern **92** and the source region **22b**. Further, the sealing member **60** is formed with a connecting via **61** so as to connect the gate pattern **93** and the gate region **22c**.

[0154] Further, in the present embodiment, each of the connecting vias **61** has a diameter smaller than that of the upper connecting via **95** connecting the source electrode **35** and the source pattern **92** and the upper connecting via **95** connecting the drain electrode **34** and the drain pattern **91**. In other words, each of the connecting vias **61** has a cross-sectional area smaller than the upper connecting via **95** connecting the source electrode **35** and the source pattern **92** and the upper connecting via **95** connecting the drain electrode **34** and the drain pattern **91**, in a cross section defined orthogonal to the stacking direction.

[0155] As described above, in the present embodiment, the first surface metal film **22** is divided into the plurality of regions. The drain pattern **91** and the gate pattern **93** are connected to the first surface metal film **22** via the connecting vias **61**. Therefore, a large number of connecting vias **61** are formed on the sealing member **60**. Therefore, the connecting vias **61** can suppress the sealing member **60** from expanding in the stacking direction. The present embodiment can achieve the same effects as those of the first embodiment while suppressing the introduction of cracks into the connecting vias **61**.

[0156] In the present embodiment, the connecting via **61** has the smaller diameter than the upper connecting via **95** connecting the drain electrode **34** and the drain pattern **91** and the upper connecting via **95** connecting the source electrode **35** and the source pattern **92**. Therefore, in the manufacturing process, the sintered bodies **73a** and **97a** can be easily arranged in the through holes **72** and **96** by press fitting, as compared with the case where the connecting via **61** has the same

diameter as the upper connecting via **95**. Therefore, the manufacturing process can be simplified. Since the connecting vias **61** are provided for suppressing the thermal expansion of the sealing member **60** and do not allow a current to flow therein, the electrical characteristics of the semiconductor package **10** do not change even if the diameter of the connecting via **61** is reduced. [0157] Although not particularly shown, it is preferable that the number of the connecting vias **61** is larger as the thermal expansion of the sealing member **60** in the stacking direction can be more suppressed. In this case, in order to evenly suppress the thermal expansion of the sealing member **60**, the connecting via **61** may be formed along the outer surface of the sealing member **60**. That is, in the stacking direction, the connecting via **61** may be formed so as to surround the semiconductor chip **30**. In other words, the connecting vias **61** may be formed so as to face the respective side surfaces of the semiconductor chip **30**. For example, in FIGS. **10A** to **10C**, the connecting vias **61** (that is, the lower connecting vias **73** and the upper connecting vias **97**) connecting the drain pattern **91** and the drain region **22a** may be further formed at both ends in the left-right direction of the figure. That is, as shown in FIG. **11**, the connecting vias **61** may be formed so as to surround the semiconductor chip **30**.

#### Fifth Embodiment

[0158] A fifth embodiment will be described hereinafter. In the present embodiment, a test pattern is arranged with respect to the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0159] As shown in FIGS. **12A** to **12C**, in the semiconductor package **10** of the present embodiment, a test pattern **98** is arranged on the first surface **90a** of the first sealing member **90**, and is partitioned from the drain pattern **91**, the source pattern **92**, and the gate pattern **93**. The test pattern **98** is made of copper foil or the like, similarly to the drain pattern **91** or the like.

[0160] Further, the first sealing member **90** is formed with an upper connecting via **97** connected to the test pattern **98**. The side sealing part **70** is formed with a lower connecting via **73** so as to connect the upper connecting via **97** connected to the test pattern **98** and the first surface metal film **22**. That is, the sealing member **60** is formed with a connecting via **61** so as to connect the test pattern **98** and the first surface metal film **22**. The source pattern **92** and the test pattern **98** are both electrically connected to the first surface metal film **22** and have the same potential.

[0161] According to this, by measuring the conduction resistance between the test pattern **98** and the source pattern **92**, the conduction state between the source electrode **35** and the back surface electrode **40** of the semiconductor chip **30** can be inspected, as well as the same effects as those of the first embodiment described above can be achieved.

#### Sixth Embodiment

[0162] A sixth embodiment will be described hereinafter. In the present embodiment, the configurations of the semiconductor chip **30** and the heat radiating member **20** are modified from those of the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0163] As shown in FIG. **13**, in the semiconductor package **10** of the present embodiment, the semiconductor chip **30** is configured to have an insulating substrate **41**, a support substrate **31**, a buffer layer **32**, and a semiconductor layer **33** stacked in order. The insulating substrate **41** is made of silicon nitride, aluminum nitride, or the like. In the present embodiment, the support substrate **31** corresponds to a first substrate, and the semiconductor layer **33** corresponds to a second substrate.

[0164] The planar size of the support substrate **31** and the planar size of the insulating substrate **41** are larger than those of the buffer layer **32** and the semiconductor layer **33**. That is, the support substrate **31** and the insulating substrate **41** each have a shape including a portion protruding from the semiconductor layer **33** and the buffer layer **32**, when viewed in the stacking direction of the insulating substrate **41**, the support substrate **31**, the buffer layer **32**, and the semiconductor layer **33**. Further, an electrode film **42** is formed on the portion of the support substrate **31** that protrudes from the semiconductor layer **33** and the buffer layer **32**. Note that, in the present embodiment, the



semiconductor chip **30** is not provided with the back surface electrode **40**.

[0165] The semiconductor chip **30** is arranged such that the insulating substrate **41** is disposed on the heat radiating member **20** via the bonding member **50**. The bonding member **50** of the present embodiment may be provided by a sintered body made by mixing metal particles, such as silver particles or silver and tin metal particles, in an organic solvent. Alternatively, the bonding member **50** may be provided by a highly heat-dissipating adhesive or the like, as long as the insulating substrate **41** and the semiconductor chip **30** can be mechanically connected to each other.

[0166] The sealing member **60** is formed with the connecting via **61** so as to electrically connect the source pattern **92** and the electrode film **42**. That is, in the present embodiment, the source electrode **35** is electrically connected to the support substrate **31** through the upper connecting via **95**, the source pattern **92**, the connecting via **61**, and the electrode film **42**. Even if the source electrode **35** and the support substrate **31** are electrically connected in this way, the current collapse can be reduced.

[0167] In the present embodiment, since the source electrode **35** and the support substrate **31** are electrically connected as described above, the heat radiating member **20** is provided by a metal plate **24** made of such as copper. Therefore, the heat radiating property of the heat radiating member **20** can be improved, as compared with the case where the heat radiating member **20** is made of silicon nitride, aluminum nitride, or the like.

[0168] As described above, in the present embodiment, since the heat radiating member **20** is provided by the metal plate **24**, the same effects as those of the first embodiment can be obtained while improving the heat radiating property of the heat radiating member **20**.

#### Seventh Embodiment

[0169] A seventh embodiment will be described hereinafter. In the present embodiment, a plurality of semiconductor chips **30** are integrally sealed by a sealing member **60**, with respect to the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0170] The semiconductor package **10** of the present embodiment is a so-called 2-in-1 package in which two semiconductor chips **30** are integrally sealed by the sealing member **60**. The two semiconductor chips **30** have the same configuration. Hereinafter, one semiconductor chip **30** will be referred to as a first semiconductor chip **30a**, and the other semiconductor chip **30** will be referred to as a second semiconductor chip **30b**. In FIG. **14**, the first semiconductor chip **30a** is shown on the right side, and the second semiconductor chip **30b** is shown on the left side.

[0171] Specifically, two first surface metal films **22** are formed on the heat radiating member **20** and are separated from each other. The first semiconductor chip **30a** and the second semiconductor chip **30b** are arranged on the right first surface metal film **22** and the left first surface metal film **22** through the bonding members **50**, respectively.

[0172] The sealing member **60** is arranged so as to integrally seal the first and second semiconductor chips **30a** and **30b**. Specifically, the side sealing part **70** is arranged so as to seal the side surfaces of the first and second semiconductor chips **30a** and **30b**. Further, the surface sealing part **80** is arranged so as to seal the first surfaces of the first and second semiconductor chips **30a** and **30b**.

[0173] The first sealing member **90** is formed with the drain pattern **91** connected to the drain electrode **34** of the first semiconductor chip **30a** and the source pattern **92** connected to the source electrode **35** of the second semiconductor chip **30b**. Further, the first sealing member **90** is formed with a connection pattern **99** that is electrically connected to the source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b**.

Moreover, the first sealing member **90** is formed with the gate pattern **93** connected to the gate electrode **38** of the first semiconductor chip **30a** and the gate pattern **93** connected to the gate electrode **38** of the second semiconductor chip **30b**, in a cross section different from that shown in FIG. **14**.

[0174] The first sealing member **90** is formed with an upper connecting via **95** as to connect the drain electrode **34** of the first semiconductor chip **30a** and the drain pattern **91**. The first sealing member **90** is formed with an upper connecting via **95** so as to connect the source electrode **35** of the second semiconductor chip **30b** and the source pattern **92**. The first sealing member **90** is formed with an upper connecting via **95** so as to connect the source electrode **35** of the first semiconductor chip **30a** and the connection pattern **99**. Also, the first sealing member **30** is formed with an upper connecting via **95** so as to connect the drain electrode **34** of the second semiconductor chip **30b** and the connection pattern **99**. That is, the first semiconductor chip **30a** and the second semiconductor chip **30b** are in a state in which the source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b** are electrically connected to each other.

[0175] Further, the first sealing member **90** is formed with an upper connecting via **95** so as to connect the gate electrode **38** of the first semiconductor chip **30a** and the gate pattern **93** in a cross section different from that shown in FIG. **14**. The first sealing member **90** is formed with an upper connecting via **95** so as to connect the gate electrode **38** of the second semiconductor chip **30b** and the gate pattern **93**.

[0176] The sealing member **60** is formed with a connecting via **61** so as to connect the connection pattern **99** and the first surface metal film **22** on which the first semiconductor chip **30a** is arranged. The sealing member **60** is formed with a connecting via **61** so as to connect the source pattern **92** and the first surface metal film **22** on which the second semiconductor chip **30b** is arranged. As a result, in each of the first and second semiconductor chips **30a** and **30b**, the source electrode **35** and the other surface electrode **40** are electrically connected to each other.

[0177] The second sealing member **100** is formed with contact holes **101** to expose a part of the drain pattern **91**, a part of the source pattern **92**, and a part of the connection pattern **99**. The portions of the drain pattern **91**, the source pattern **92**, and the connection pattern **99** exposed from the contact holes **101** serve as the drain pad **91a**, the source pad **92a**, and the connection pad **99a**.

[0178] Further, the second sealing member **100** has a contact hole **101** formed in a cross section different from that shown in FIG. **14** to expose a part of the gate pattern **93**. Then, as described with reference to FIG. **4D** and the like, the portion of the gate pattern **93** exposed from the contact hole **101** serves as the gate pad **93a**.

[0179] Such a semiconductor package **10** is used, for example, in a DC/DC converter circuit or an inverter circuit so that the first semiconductor chip **30a** constitutes an upper arm and the second semiconductor chip **30b** constitutes a lower arm. In this case, the drain pad **91a** serves as a higher voltage side pad, the source pad **92a** serves as a lower voltage side pad, and the connection pad **99a** serves as an output pad. As shown in FIG. **15**, the semiconductor package **10** is used so as to constitute an electronic device **1** together with a printed circuit board **110** as a mounting member, a cooler **140**, and the like.

[0180] The printed circuit board **110** has a first surface **110a** and a second surface **110b** opposite to the first surface **110a**. The printed circuit board **110** is formed with a first surface wiring pattern **111** on the first surface **110a** and a second surface wiring pattern **112** on the second surface **110b**. The printed circuit board **110** is formed with a through-hole electrode **113** so as to electrically connect the first surface wiring pattern **111** and the second surface wiring pattern **112**. On the printed circuit board **110**, an electronic component **114** such as a ceramic capacitor is arranged on the first surface wiring pattern **111** via solder **115** or the like as a connecting member.

[0181] In the semiconductor package **10**, the drain pad **91a**, the source pad **92a**, and the connection pad **99a** are connected to second surface wiring patterns **112** of the printed circuit board **110** through solder **120** as a connecting member, respectively. Further, in the semiconductor package **10**, the gate pad **93a** is connected to a second surface wiring pattern **112** of the printed circuit board **110** through a solder **120** in a cross section different from that shown in FIG. **15**. The solder **120** is preferably made of solder bumps rather than being arranged in a paste form, so that reliability can

be improved by ensuring the height.

[0182] Further, an underfill material **130** is arranged between the printed board **110** and the semiconductor package **10** in order to ensure the reliability of the solder **120** and the insulation with the drain pad **91a**, the source pad **92a**, the gate pad **93a**, and the connection pad **99a**.

[0183] A cooler **140** is arranged on the second surface metal film **23** of the semiconductor package **10** through a connecting member **141** such as a thermal paste. The cooler **140** is made of metal or the like.

[0184] Also in the semiconductor package **10** in which the plurality of semiconductor chips **30** are integrally sealed by the sealing member **60** as described above, the same effects as those of the first embodiment can be achieved.

#### Modification of Seventh Embodiment

[0185] A modification of the seventh embodiment will be described hereinafter. In the seventh embodiment, the semiconductor package **10** in which the two semiconductor chips **30** are sealed in the sealing member **60** has been described. Alternatively, the semiconductor package **10** may be configured as follows. For example, the semiconductor package **10** may be a so-called 4-in-1 package in which four semiconductor chips **30** are sealed in the sealing member **60**. As another example, the semiconductor package **10** may be a so-called 6-in-1 package in which six semiconductor chips **30** are sealed in the sealing member **60**.

#### Eighth Embodiment

[0186] An eighth embodiment will be described hereinafter. In the embodiment, the semiconductor chip **30** is formed with a vertical semiconductor element, differently from the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0187] As shown in FIG. **16**, in the semiconductor package **10** of the present embodiment, the semiconductor chip **30** is formed with a vertical semiconductor element that causes a current to flow in a thickness direction of the semiconductor chip **30**. For example, the semiconductor chip **30** of the present embodiment has a semiconductor substrate **43** made of silicon, silicon carbide (SiC), or the like. Although the detailed configuration of the semiconductor chip **30** is not shown, the drain electrode **34** is formed on a side adjacent to the heat radiating member **20**, and the source electrode **35** and the like are formed on the side opposite to the heat radiating member **20**. Further, the semiconductor chip **30** is formed with a gate wiring **37**, a gate electrode **38**, and the like on the side opposite to the heat radiating member **20** in a cross section different from that shown in FIG. **16**. In the semiconductor chip **30**, the drain electrode **34** is connected to the first surface metal film **22** through the bonding member **50** having conductivity. In the present embodiment, the drain electrode **34** corresponds to the first electrode and the back surface electrode.

[0188] The source pattern **92** and the drain pattern **91** are formed on the first sealing member **90**. Further, a gate pattern **93** is formed on the first sealing member **90** in a cross section different from that shown in FIG. **16**.

[0189] In the first sealing member **90**, further, a solid pattern **95b** is arranged in the through hole **94** so as to connect the source pattern **92** and the source electrode **35**.

[0190] In the present embodiment, the solid pattern **95b** is arranged so that the resistance can be reduced. Alternatively, the source pattern **92** and the source electrode **35** may be connected by the upper connecting via **95** as in the first embodiment. Further, in a cross section different from that shown in FIG. **16**, the upper connecting via **95** is arranged so as to connect the gate pattern **93** and the gate electrode **38**.

[0191] Further, the sealing member **60** is formed with the connecting via **61** so as to electrically connect the drain pattern **91** and the second surface metal film **22**. As a result, the drain pattern **91** is connected to the drain electrode **34** through the connecting via **61** and the first surface metal film **22**. In order to exert a function of allowing an electric current, it is preferable to form a plurality of the connecting vias **61** so that the inductance can be reduced.

[0192] Also in the configuration in which the semiconductor chip **30** is formed with the vertical semiconductor element, the same effects as those of the first embodiment can be achieved.

#### Ninth Embodiment

[0193] A ninth embodiment will be described hereinafter. In the present embodiment, the plate-shaped member **74** is arranged also between the semiconductor chip **30** and the heat radiating member **20** with respect to the second embodiment. Other configurations are the same as those of the second embodiment, and therefore the descriptions of the same configurations will be omitted.

[0194] In the semiconductor package **10** of the present embodiment, as shown in FIG. **17**, the plate-shaped member **74** is arranged also between the back surface electrode **40** of the semiconductor chip **30** and the heat radiating member **20**. In the present embodiment, the plate-shaped member **74** arranged between the back surface electrode **40** of the semiconductor chip **30** and the heat radiating member **20** is also referred to as a lower layer plate-shaped member **740**, and the plate-shaped member **74** arranged on the lower layer plate-shaped member **740** is also referred to as an intermediate layer plate-shaped member **840**. The lower layer plate-shaped member **740** has a structure in which a lower layer connecting via **760** is appropriately formed in the LCP film **77**. The lower layer plate-shaped member **740** is arranged so as to cover the first surface metal film **22**. The intermediate layer plate-shaped member **840** has a similar configuration in which an intermediate layer pattern **850** and an intermediate layer connecting via **860** are appropriately formed on the LCP film. The intermediate layer plate-shaped member **840** is arranged on the lower layer plate-shaped member **740**.

[0195] The back surface electrode **40** of the semiconductor chip **30** and the first surface metal film **22** are connected to each other through the lower layer connecting via **760** formed in the lower layer plate-shaped member **740**. In the present embodiment, the first surface metal film **22** extends to a position below the intermediate layer connecting via **860** formed in the intermediate layer plate-shaped member **840**. The intermediate layer connecting via **860** is connected to the first surface metal film **22** via the lower layer connecting via **760**. Thereby, in the present embodiment, the back surface electrode **40** of the semiconductor chip **30** is electrically connected to the source electrode **35**. In the present embodiment, the thickness of the first surface metal film **22** is thinner than that of the first surface metal film **22** of the first embodiment so that the lower layer plate-shaped member **740** can cover the first surface metal film **22**. The insulating substrate **21** is not provided with the second surface metal film **23** on the second surface **21b**. However, the insulating substrate **21** may be provided with the second surface metal film **23** on the second surface **21b**.

[0196] In the present embodiment, the outer edge portion of the first surface **21a** of the heat radiating member **20** is also sealed by the sealing member **60**. That is, the sealing member **60** is arranged so that the outer edge end portion coincides with the outer edge portion of the heat radiating member **20** in the stacking direction. This type of semiconductor package **10** can be formed by refraining the removal of the outer edge portion of the sealing member **60** after the dividing along the dicing line DL into the chips in the process shown in FIG. **5G**. Further, in each of the embodiments described above and embodiments described hereinafter, the outer edge portion of the first surface **21a** of the heat radiating member **20** may be sealed by the sealing member **60** or may be exposed from the sealing member **60**, according to the configuration of each embodiment.

[0197] As described above, the lower layer plate-shaped member **740** can be arranged so that the back surface electrode **40** of the semiconductor chip **30** is connected to the source electrode **35** through the lower layer connecting via **760** formed in the lower layer plate-shaped member **740**.

#### Tenth Embodiment

[0198] A tenth embodiment will be described hereinafter. In the present embodiment, the location of the lower layer connecting via **760** is defined with respect to the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0199] As shown in FIG. **18**, the semiconductor package **10** of the present embodiment is arranged

so that a lower layer connecting via **760** is connected to the inner edge portion of the semiconductor chip **30**, and the lower layer connecting via **760** is not connected to the outer edge portion of the semiconductor chip **30**. In the present embodiment, the lower layer connecting via **760** is arranged at a position separated from the outer edge portion of the semiconductor chip **30** by a distance L, which is the thickness of the semiconductor chip **30**.

[0200] In such a semiconductor package **10**, it is possible to suppress the lower layer connecting via **760** from being broken, and it is possible to improve the reliability. That is, the semiconductor chip **30** is more likely to bend as the outer edge portion thereof, and a large stress is likely to be generated. Therefore, by arranging the lower layer connecting via **760** at a position different from the portion where the stress caused in the semiconductor chip **30** is large, it is possible to suppress the lower layer connecting via **760** from being broken.

#### Eleventh Embodiment

[0201] An eleventh embodiment will be described hereinafter. In the present embodiment, the configuration of the lower layer plate-shaped member **740** is modified from that of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0202] As shown in FIGS. **19** and **20**, in the semiconductor package **10** of the present embodiment, the diameter of the lower layer connecting via **760** formed in the lower layer plate-shaped member **740** is different depending on the position where the lower layer connecting via **760** is arranged. Specifically, in the lower layer connecting vias **760**, the diameter of the one connected to the inner edge portion of the semiconductor chip **30** is larger than the diameter of the one connected to the outer edge portion of the semiconductor chip **30**. In other words, in the lower layer connecting vias **760**, the connection area of the portion connected to the inner edge portion of the semiconductor chip **30** is larger than the connection area of the portion connected to the outer edge portion of the semiconductor chip **30**. More specifically, the diameter of the lower layer connecting vias **760** is gradually reduced from the one connected to the inner edge portion of the semiconductor chip **30** toward the one connected to the outer edge portion.

[0203] In such a semiconductor package **10**, the temperature of the inner edge portion of the semiconductor chip **30** tends to be higher than that of the outer edge portion. Therefore, heat radiation can be improved by arranging the lower layer connecting via **760** having a larger diameter in the high temperature area of the semiconductor chip **30**. Further, as described in the tenth embodiment, the semiconductor chip **30** is more likely to bend in the outer edge portion than in the inner edge portion, and a large stress is likely to be generated. Therefore, by arranging the lower layer connecting via **760** having a smaller diameter in the portion of the semiconductor chip **30** where the stress tends to increase, it is possible to suppress the lower layer connecting via **760** from being broken. That is, according to the semiconductor package **10** of the present embodiment, it is possible to suppress the destruction of the lower layer connecting via **760** while improving the heat radiation.

#### Twelfth Embodiment

[0204] A twelfth embodiment will be described hereinafter. In the present embodiment, the configuration of the lower layer plate-shaped member **740** is modified from that of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0205] In the present embodiment, as shown in FIG. **21**, the lower layer plate-shaped member **740** is configured by having a first lower layer plate-shaped member **741** and a second lower layer plate-shaped member **742** stacked on the heat radiating member **20**. The first lower layer plate-shaped member **741** is formed with the first lower layer connecting via **761** as the lower layer connecting via **760**. The second lower layer plate-shaped member **742** is formed with a lower layer pattern **752** and a second lower layer connecting via **762** as the lower layer connecting via **760**.

[0206] Specifically, in the second lower layer plate-shaped member **742**, a plurality of second

lower layer connecting vias **762** are formed on the second lower layer plate-shaped member **742** so as to be connected to the back surface electrode **40** of the semiconductor chip **30**, and a second lower layer connecting via **762** is formed so as to be connected to the intermediate layer connecting via **860** formed in the intermediate layer plate-shaped member **840**. A lower layer pattern **752** is formed in the second lower layer plate-shaped member **742** so as to connect the second lower layer connecting vias **762** to each other. That is, the lower layer pattern **752** extends from the position located below the semiconductor chip **30** to the position located below the intermediate layer connecting via **860**.

[0207] In the first lower layer plate-shaped member **741**, a plurality of first lower layer connecting vias **761** are formed so as to connect the lower layer pattern **752** formed in the second lower layer plate-shaped member **742** and the first surface metal film **22**. The first surface metal film **22** of the present embodiment has substantially the same size as the lower layer pattern **752** and is formed so as to face the lower layer pattern **752**. That is, the first surface metal film **22** extends from the position located below the semiconductor chip **30** to the position located below the intermediate layer connecting via **860**, similarly to the lower layer pattern **752**. The first lower layer connecting via **761** is also connected to the lower layer pattern **752** at a position outside the semiconductor chip **30** in the stacking direction.

[0208] In the present embodiment, as shown in FIGS. **21** and **22**, the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** has the diameter larger than that of the second lower layer connecting via **762** formed in the second lower layer plate-shaped member **742**. Further, the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** and the second lower layer connecting via **762** formed in the second lower layer plate-shaped member **742** are arranged at different positions in the stacking direction. In other words, the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** and the second lower layer connecting via **762** formed in the second lower layer plate-shaped member **742** are arranged so as not to overlap in the stacking direction. In the present embodiment, the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** and the second lower layer connecting via **762** formed in the second lower layer plate-shaped member **742** are arranged alternately and in a staggered pattern when viewed in the stacking direction. In FIG. **22**, the first lower layer connecting via **761** is hatched for easy understanding.

[0209] As described above, the lower layer plate-shaped member **740** may be configured by stacking the first lower layer plate-shaped member **741** and the second lower layer plate-shaped member **742**. In such a semiconductor package **10**, the temperature of the second lower layer plate-shaped member **742** tends to be higher than that of the first lower layer plate-shaped member **741**. Therefore, by making the second lower layer connecting via **762** formed in the second lower layer plate-shaped member **742** smaller than the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741**, it is possible to suppress the second lower layer connecting via **762** from being broken and improve the reliability.

[0210] Further, the first surface metal film **22** and the lower layer pattern **752** formed in the second lower layer plate-shaped member **742** extend to the position outside of the semiconductor chip **30** in the stacking direction. The first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** is connected to the lower layer pattern **752** formed in the second lower layer plate-shaped member **742** also at a position outside the semiconductor chip **30** in the stacking direction. Therefore, when the heat generated in the semiconductor chip **30** is propagated from the second lower layer connecting via **762** to the lower layer pattern **752**, the heat diffuses in the lower layer pattern **752** in the planar direction, and is propagated to the insulating substrate **21** through the first lower layer connecting via **761** and the first surface metal film **22**. Therefore, the heat radiation can be improved, as compared with the configuration in which the first lower layer connecting via **761** formed in the first lower layer plate-shaped member **741** is connected to the lower layer pattern **752** formed in the second lower layer plate-shaped member **742** only inside the

semiconductor chip **30** in the stacking direction. In this case, although not particularly shown, by increasing the number of the first lower layer connecting vias **761** to be greater than the number of the second lower layer connecting vias **762**, it is possible to further facilitate heat radiation to the heat radiating member **20**.

[0211] Further, the first lower layer connecting via **761** and the second lower layer connecting via **762** are arranged so as to be at different positions in the stacking direction. Therefore, the stress that can be generated in the first lower layer connecting via **761** and the second lower layer connecting via **762** is reduced, as compared with the case where the first lower layer connecting via **761** and the second lower layer connecting via **762** overlap in the stacking direction. Thus, it is possible to further improve the reliability.

#### Thirteenth Embodiment

[0212] A thirteenth embodiment will be described hereinafter. In the present embodiment, a roughened portion is formed on the insulating substrate **21** as compared with the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0213] In the semiconductor package **10** of the present embodiment, as shown in FIG. **23**, the insulating substrate **21** is formed with a roughened portion **25** in an area bonded to the sealing member **60**. In the present embodiment, the roughened portion **25** is formed in a frame shape surrounding the portion of the insulating substrate **21** on which the first surface metal film **22** is formed. Such a roughened portion **25** is formed, for example, by subjecting the insulating substrate **21** to a laser treatment, a blast treatment, or the like.

[0214] According to this, since the roughened portion **25** is formed on the insulating substrate **21**, the adhesion between the lower layer plate-shaped member **740** and the insulating substrate **21** can be improved in the area where the roughened portion **25** is formed. Therefore, it is possible to suppress the lower layer plate-shaped member **740** and the insulating substrate **21** from peeling off.

#### Modification of Thirteenth Embodiment

[0215] A modification of the thirteenth embodiment will be described hereinafter. In place of the roughened portion **25** formed in the thirteenth embodiment, the insulating substrate **21** may be formed with a groove portion **26**, as shown in FIG. **24**. According to this, in the portion where the groove portion **26** is formed, the adhesion between the LCP film **77** constituting the lower layer plate-shaped member **740** and the insulating substrate **21** can be improved. Thus, the same effects as the twelfth embodiment described above can be achieved. Further, by forming the groove portion **26**, if the peeling progresses from the interface between the lower layer plate-shaped member **740** and the insulating substrate **21**, the groove portion **26** changes the traveling direction of the peeling. Therefore, the progress of peeling can be suppressed.

#### Fourteenth Embodiment

[0216] A fourteenth embodiment will be described hereinafter. In the present embodiment, a recess is formed in the insulating substrate **21** as compared with the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0217] As shown in FIG. **25**, the semiconductor package **10** of the present embodiment has a recessed portion **27** formed on the first surface **21a** side of the insulating substrate **21**. The recessed portion **27** has a bottom surface larger than the size of the flat surface of the semiconductor chip **30**, and a depth shallower than the thickness of the semiconductor chip **30**.

[0218] The first surface metal film **22** extends from the bottom surface of the recessed portion **27** to the periphery of the portion where the recessed portion **27** is formed. The first surface metal film **22** is connected to the lower connecting via **73** at a portion different from the portion where the recessed portion **27** is formed.

[0219] The semiconductor chip **30** is arranged so that the back surface electrode **40** side is received in the recessed portion **27**. However, the semiconductor chip **30** is received in the recessed portion

27 so that the side including the drain electrode 34 and the source electrode 35 protrudes from the recessed portion 27.

[0220] In such a semiconductor package 10, since the semiconductor chip 30 is arranged in the recessed portion 27 formed in the insulating substrate 21, the amount of resin of the sealing member 60 that seals the semiconductor chip 30 can be reduced. Therefore, the amount of LCP used, which tends to be more expensive than the insulating substrate 21, can be reduced, and the cost can be reduced.

#### Fifteenth Embodiment

[0221] A fifteenth embodiment will be described hereinafter. In the present embodiment, the intermediate layer pattern 850 is excluded from the intermediate layer plate-shaped member 840 of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0222] In the semiconductor package 10 of the present embodiment, as shown in FIG. 26, the intermediate layer pattern 850 is not formed in the intermediate layer plate-shaped member 840. The middle layer connecting vias 860 in the intermediate layer plate-shaped member 840 are directly connected to each other.

[0223] Such a semiconductor package 10 is manufactured, for example, as follows. That is, when the plate-shaped member constituent member 770 of FIG. 8A described in the second embodiment is prepared, the through hole 76a is not formed in the plate-shaped member constituent member 770 constituting the intermediate layer plate-shaped member 840, and the constituent body 76b is not arranged. Then, the plate-shaped member constituent member 770 constituting the intermediate layer plate-shaped member 840 and the plate-shaped member constituent member 770 constituting the lower layer plate-shaped member 740 are stacked and preliminarily integrated by temporary pressing or the like. Next, through holes 76a are collectively formed in the plate-shaped member constituent member 770 constituting the intermediate layer plate-shaped member 840 and the plate-shaped member constituent member 770 constituting the lower layer plate-shaped member 740 by using a laser, a drill, a punch, or the like. Subsequently, the constituent body 76b such as the conductive paste is arranged in the through holes 76a. As a result, the intermediate layer connecting via 860 formed in each intermediate layer plate-shaped member 840 is easily connected without forming the intermediate layer pattern 850 in the intermediate layer plate-shaped member 840.

[0224] According to this, since the intermediate layer pattern 850 in the intermediate layer plate-shaped member 840 can be reduced, the number of members can be reduced.

[0225] It should be noted that the configuration of the present embodiment can be applied to each of the embodiments described hereinabove and each of the embodiments described hereinafter. For example, when the present embodiment is applied to the twelfth embodiment, it may be possible to delete the lower layer pattern 752 arranged between the second lower layer connecting via 762 formed in the second lower layer plate-shaped member 742 and the first lower layer connecting via 761 formed in the first lower layer plate-shaped member 741. In this case, the lower layer pattern 752 can be configured to have only a portion located below the semiconductor chip 30. That is, in the semiconductor package 10 of the present embodiment, the pattern 75 may be appropriately removed from the plate-shaped members 74 adjacent to each other in the stacking direction.

#### Sixteenth Embodiment

[0226] A sixteenth embodiment will be described hereinafter. In the present embodiment, the semiconductor chip 30 is formed with the vertical semiconductor element in the configuration of the ninth embodiment. That is, the present embodiment is combination of the ninth embodiment and the eighth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0227] As shown in FIG. 27, in the semiconductor package 10 of the present embodiment, the semiconductor chip 30 is formed with the vertical semiconductor element similar to that of the eighth embodiment. Specifically, the semiconductor chip 30 is formed with the drain electrode 34



on the heat radiating member **20** side and the source electrode **35** on the opposite side to the heat radiating member **20**. Further, the semiconductor chip **30** is formed with a gate wiring **37**, a gate electrode **38**, and the like on the opposite side of the heat radiating member **20** in a cross section different from that of FIG. **27**.

[0228] In the semiconductor chip **30**, the drain electrode **34** is connected to the first surface metal film **22** through the lower layer connecting via **760**. In the present embodiment, the drain electrode **34** corresponds to the first electrode and the back surface electrode.

[0229] In this way, the sealing member **60** may be made of a plurality of plate-shaped members **74**, as well as the semiconductor chip **30** may have the vertical semiconductor element.

#### Seventeenth Embodiment

[0230] A seventh embodiment will be described hereinafter. In the present embodiment, a capacitor is arranged in the sealing member **60** in the configuration of the sixteenth embodiment. Other configurations are the same as those of the sixteenth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0231] In the present embodiment, as shown in FIG. **28**, a capacitor **150** having a pair of electrodes **150a** and **150b** is also arranged in the sealing member **60**. Specifically, the capacitor **150** is located in the vicinity of the semiconductor chip **30** and on the side of the semiconductor chip **30**. Further, the capacitor **150** is arranged so that one electrode **150a** is located on the first sealing member **90** side and the other electrode **150b** is located on the lower layer plate-shaped member **740** side. The capacitor **150** of the present embodiment is made of silicon or the like, and has a thickness substantially equal to the thickness of the semiconductor chip **30**.

[0232] The source pattern **92** formed in the first sealing member **90** extends up to a position facing the capacitor **150**. The first surface metal film **22** formed on the insulating substrate **21** extends up to a position facing the capacitor **150**.

[0233] The one electrode **150a** of the capacitor **150** is connected to the source pattern **92** through the upper connecting via **95**, and is also connected to the first surface metal film **22**, which is connected to the drain electrode **34** of the semiconductor chip **30**, via the lower layer connecting via **760**.

[0234] In the present embodiment, the source pattern **92**, the upper connecting via **95**, the first surface metal film **22**, and the lower layer connecting via **760** correspond to the wiring layer. Such a semiconductor package **10** is manufactured by arranging the capacitor **150** in the plate-shaped member constituent member **770**, similarly to the semiconductor chip **30**.

[0235] In the semiconductor package **10** of the present embodiment, since the capacitor **150** is arranged in the sealing member **60**, the semiconductor chip **30** and the capacitor **150** can be arranged close to each other, and thus the wiring layer connecting the semiconductor chip **30** and the capacitor **150** can be shortened. Therefore, it is possible to reduce the parasitic inductance.

[0236] Further, the semiconductor package **10** of the present embodiment is configured by arranging the capacitor **150** in the sealing member **60** similarly to the semiconductor chip **30**. Therefore, as compared with the case where the capacitor **150** is arranged at another place and connected to the semiconductor chip **30**, the structure can be simplified and the manufacturing process can be simplified.

[0237] Although the example in which the capacitor **150** has the same thickness as the semiconductor chip **30** has been described above, the capacitor **150** may be formed thinner than the semiconductor chip **30** as another example. In this case, for example, the intermediate layer pattern **850** and the intermediate layer connecting via **860** may be appropriately formed in the intermediate layer plate-shaped member **840** arranged between the one electrode **150a** of the capacitor **150** and the source pattern **92**, thereby to connect the one electrode **150a** of the capacitor **150** and the source pattern **92**.

#### Eighteenth Embodiment

[0238] An eighteenth embodiment will be described hereinafter. In the present embodiment, a heat

radiating member is added on the second sealing member **100** of the semiconductor package **10** in the configuration of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0239] In the semiconductor package **10** of the present embodiment, as shown in FIG. **29**, a heat radiating member **160** is also arranged on the second sealing member **100**. In the present embodiment, the heat radiating member **160** is arranged in a portion of the second sealing member **100** different from the portion where the contact hole **101** is formed, while facing the semiconductor chip **30**.

[0240] In the second sealing member **100**, an upper connecting via **103** is formed in a through hole **102** penetrating the second sealing member **100** so as to connect the heat radiating member **160** and the source pattern **92**. As a result, the heat radiating member **160** and the source pattern **92** are thermally connected to each other.

[0241] According to this, the heat generated by the semiconductor chip **30** can be radiated from the heat radiating member **160** as well, so the heat radiating property can be further improved.

#### Nineteenth Embodiment

[0242] A nineteenth embodiment will be described hereinafter. In the present embodiment, a high heat radiating member is added on the heat radiating member **20** side of the semiconductor package **10** in the configuration of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0243] As shown in FIG. **30**, the semiconductor package **10** of the present embodiment has a high heat radiating member **170** on the second surface **21b** of the insulating substrate **21** of the heat radiating member **20**. The high heat radiating member **170** is made of a material having a higher thermal conductivity than that of the insulating substrate **21**. The high heat radiating member **170** of the present embodiment is larger in the size in the planar direction than the heat radiating member **20**. For example, the high heat radiating member **170** is made of a metal material such as copper or aluminum.

[0244] The insulating substrate **21** and the high heat radiating member **170** are connected by a bonding member **171** such as a sintered body containing silver tin as a main component. The insulating substrate **21** and the high heat radiating member **170** may be connected through a covalent bond in which active groups are bonded to each other.

[0245] According to this, heat can be radiated from the heat radiating member **20** via the high heat radiating member **170**, so the heat radiating property can be further improved. Further, in the present embodiment, since the size of the high heat radiating member **170** in the planar direction is larger than that of the insulating substrate **21**. Therefore, the heat radiating property can be further improved, as compared with the configuration in which the high heat radiating member **170** is equal to or smaller than the insulating substrate **21** in the planar direction. In a case where the semiconductor package **10** of the present embodiment is mounted on the cooler **140** as in the seventh embodiment, the high heat radiating member **170** is mounted on the cooler **140** via a connecting member **141** such as thermal paste. Therefore, by increasing the size of the high heat radiating member **170** in the planar direction, the contact area between the high heat radiating member **170** and the connecting member **141** can be increased, and thus the heat radiating property can be further improved.

#### Modification of Nineteenth Embodiment

[0246] A modification of the nineteenth embodiment will be described hereinafter. In the nineteenth embodiment described above, the high heat radiating member **170** may be arranged on the back surface electrode **40** side of the semiconductor chip **30**, without using the insulating substrate **21**, as the heat radiating member **20**. In this case, the high heat radiating member **170** has conductivity when it is made of metal. Therefore, when the heat radiating member **20** is provided by the high heat radiating member **170**, the LCP film or the like may be arranged between the high heat radiating member **170** and the first surface metal film **22**.

[0247] In the nineteenth embodiment described above, the second surface metal film **23** may be arranged on the second surface **21b** of the insulating substrate **21** and the thickness of the second surface metal film **23** may be increased as in the first embodiment, so that the second surface metal film **23** functions as the high heat radiating member **170**.

[0248] Further, in the nineteenth embodiment described above, the high heat radiating member **170** may have a smaller size in the planar direction than the insulating substrate **21**.

#### Twentieth Embodiment

[0249] A twentieth embodiment will be described hereinafter. In the present embodiment, the semiconductor package **10** has two semiconductor chips **30** formed with the vertical semiconductor elements in the configuration of the sixteenth embodiment described above. Other configurations are the same as those of the sixteenth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0250] As shown in FIG. **31**, the semiconductor package **10** of the present embodiment is a so-called 2-in-1 package in which two semiconductor chips **30** are integrally sealed by the sealing member **60**, as in the seventh embodiment. The two semiconductor chips **30** each have the same configuration as that of the sixteenth embodiment. That is, each semiconductor chip **30** is formed with the drain electrode **34** on one side and the source electrode **35** and the gate electrode **38** on the other side. Hereinafter, one semiconductor chip **30** will be referred to as a first semiconductor chip **30a**, and the other semiconductor chip **30** will be referred to as a second semiconductor chip **30b**. In FIG. **31**, the first semiconductor chip **30a** is shown on the right side, and the second semiconductor chip **30b** is shown on the left side. The first semiconductor chip **30a** and the second semiconductor chip **30b** are arranged so that the source electrode **35** and the gate electrode **38** are located on the heat radiating member **20** side and the drain electrode **34** is located on the side opposite to the heat radiating member **20**. The gate electrode **38** is located in a cross section different from that shown in FIG. **31**.

[0251] The first sealing member **90** and the second sealing member **100** have the same configurations as those of the seventh embodiment. That is, the first sealing member **90** is formed with the drain pattern **91** connected to the drain electrode **34** of the first semiconductor chip **30a**. The first sealing member **90** is formed with the connection pattern **99** for connecting the source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b**. The first sealing member **90** is formed with the source pattern **92** connected to the source electrode **35** of the second semiconductor chip **30b**.

[0252] Further, the first sealing member **90** is formed with the drain pattern **91**, the source pattern **92**, and the upper connecting via **95** connected to the connection pattern **99**, respectively. The first sealing member **90** is formed with the gate pattern **93** connected to the gate electrode **38** of the first semiconductor chip **30a** and the upper connecting via **95** connected to the gate pattern **93**, in a cross section different from that shown in FIG. **31**. The first sealing member **90** is formed with the gate pattern **93** connected to the gate electrode **38** of the second semiconductor chip **30b** and the upper connecting via **95** connected to the gate pattern **93**, in a cross section different from that shown in FIG. **31**.

[0253] The second sealing member **100** is formed with the contact holes **101** that expose a part of the drain pattern **91**, a part of the source pattern **92**, and a part of the connection pattern **99**. The parts of the drain pattern **91**, the source pattern **92**, and the connection pattern **99** exposed from the contact holes **101** serve as the drain pad **91a**, the source pad **92a**, and the connection pad **99a**. Further, the second sealing member **100** is formed with the contact hole **101** to expose a part of the gate pattern **93**, in a cross section different from that shown in FIG. **31**. The part of the gate pattern **93** exposed from the contact hole **101** serves as the gate pad **93a**.

[0254] The first surface metal film **22** is formed in the area facing the first semiconductor chip **30a** and in the area facing the second semiconductor chip **30b**. The part of the first surface metal film **22** facing the first semiconductor chip **30a** and the part of the first surface metal film **22** facing the

second semiconductor chip **30b** are separated from each other. Further, the part of the first surface metal film **22** facing the first semiconductor chip **30a** has a portion facing the source electrode **35** and a portion facing the gate electrode **38**, and these portions are separated from each other. The part of the first surface metal film **22** facing the second semiconductor chip **30b** has a portion facing the source electrode **35** and a portion facing the gate electrode **38**, and these portions are separated from each other.

[0255] The source electrode **35** of the first semiconductor chip **30a** is connected to the first surface metal film **22** facing the source electrode **35** through the lower layer connecting via **760**. The source electrode **35** of the second semiconductor chip **30b** is connected to the first surface metal film **22** facing the source electrode **35** through the lower layer connecting via **760**. Further, the gate electrode **38** of the first semiconductor chip **30a** is connected to the first surface metal film **22** facing the gate electrode **38** through the lower layer connecting via **760**, in a cross section different from that shown in FIG. **31**. The gate electrode **38** of the second semiconductor chip **30b** is connected to the first surface metal film **22** facing the gate electrode **38** through the lower layer connecting via **760**, in a cross section different from that shown in FIG. **31**.

[0256] The first surface metal film **220** facing the first semiconductor chip **30a** extends up to the position outside of the first semiconductor chip **30a** when viewed in the stacking direction.

Similarly, the first surface metal film **22** facing the second semiconductor chip **30b** extends up to the position outside of the second semiconductor chip **30b** when viewed in the stacking direction.

[0257] The sealing member **60** is formed with a connecting via **61** that connects the connection pattern **99** and the first surface metal film **22** connected to the source electrode **35** of the first semiconductor chip **30a**. The sealing member **60** is formed with a connecting via **61** for connecting the source pattern **92** and the first surface metal film **22** connected to the source electrode **35** of the second semiconductor chip **30b**. Further, the sealing member **60** is formed with a connecting via **61** for connecting the first surface metal film **22** connected to the gate electrode **38** of the first semiconductor chip **30a** and the gate pad **93a**, in a cross section different from that shown in FIG. **31**. The sealing member **60** is formed with a connecting via **61** for connecting the first surface metal film **22** connected to the gate electrode **38** of the second semiconductor chip **30b** and the gate pad **93a**, in a cross section different from that shown in FIG. **31**.

[0258] Such a semiconductor package **10** is used, for example, in a DC/DC converter circuit or an inverter circuit so that the first semiconductor chip **30a** constitutes an upper arm and the second semiconductor chip **30b** constitutes a lower arm. In this case, the drain pad **91a** serves as the higher voltage side pad, the source pad **92a** serves as the lower voltage side pad, and the connection pad **99a** serves as the output pad.

[0259] As described above, the semiconductor package **10** may be configured such that the two semiconductor chips **30** each formed with the vertical semiconductor element are integrally sealed by the sealing member **60**. Further, in the semiconductor package **10**, since the first semiconductor chip **30a** and the second semiconductor chip **30b** can be arranged close to each other, the wiring layer connecting the first semiconductor chip **30a** and the second semiconductor chip **30b** can be shortened. Therefore, it is possible to reduce the parasitic inductance.

[0260] In the present embodiment, as an example, the first semiconductor chip **30a** and the second semiconductor chip **30b** are arranged such that the drain electrode **34** is located on the opposite side of the heat radiating member **20**, and the source electrode **35**, the gate electrode **38**, and the like are located on the heat radiating member **20** side. As another example, the first semiconductor chip **30a** and the second semiconductor chip **30b** may be arranged such that the source electrode **35**, the gate electrode **38**, and the like are located on the opposite side of the heat radiating member **20**, and the drain electrode **34** is located on the heat radiating member **20** side. In such a configuration, the connection relationship between the first surface metal film **22**, the lower layer connecting via **760** and the connecting via **61** formed in the sealing member **60** may be appropriately adjusted so that the connection relationship between the pads **91a**, **92a**, **93a**, **99a** and the first semiconductor chip

**30a** and the second semiconductor chip **30b** has the above-mentioned relationship.

#### Twenty-First Embodiment

[0261] A twenty-first embodiment will be described hereinafter. In the present embodiment, the arrangement of the first semiconductor chip **30a** and the second semiconductor chip **30b** is modified from that of the twentieth embodiment described above. Other configurations are the same as those of the twentieth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0262] In the semiconductor package **10** of the present embodiment, as shown in FIG. **32**, the first semiconductor chip **30a** is arranged such that the drain electrode **34** is located on the side opposite to the heat radiating member **20**, and the source electrode **35** and the gate electrode **38** are located on the heat radiating member **20** side. On the other hand, the second semiconductor chip **30b** is arranged such that the drain electrode **34** is located on the heat radiating member **20** side, and the source electrode **35**, the gate electrode **38**, and the like are located on the opposite side of the heat radiating member **20**. That is, the first semiconductor chip **30a** and the second semiconductor chip **30b** are arranged in opposite directions.

[0263] Further, the first surface metal film **22** formed on the insulating substrate **21** has a part facing the source electrode **35** of the first semiconductor chip **30a** and a part facing the drain electrode **34** of the second semiconductor chip **30b**, and these parts are connected to each other. The source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b** are connected to a common first surface metal film **22** through the lower layer connecting via **760**.

[0264] The drain electrode **34** of the first semiconductor chip **30a** is connected to the drain pattern **91** formed in the first sealing member **90** through the upper connecting via **95**. The source electrode **35** of the second semiconductor chip **30b** is connected to the source pattern **92** formed in the first sealing member **90** through the upper connecting via **95**. The gate electrode **38** of the second semiconductor chip **30b** is connected to the gate pattern **93** formed in the first sealing member **90** through the upper connecting via **95**, in a cross section different from that shown in FIG. **32**.

[0265] The sealing member **60** is formed with a connecting via **61** to connect the connection pattern **99** and the first surface metal film **22** connected to the source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b**.

[0266] As described above, the first semiconductor chip **30a** and the second semiconductor chip **30b** may be arranged in opposite directions. In such a semiconductor package **10**, the source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b** are connected only through the first surface metal film **22** and the lower layer connecting via **760**, so the structure can be simplified.

#### Twenty-Second Embodiment

[0267] A twenty-second embodiment will be described hereinafter. In the present embodiment, the arrangement of the pads **91a**, **92a**, and **93a** of the semiconductor package **10** is modified from that of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0268] The semiconductor package **10** of the present embodiment has a substantially rectangular shape having first to fourth sides **10a** to **10d** when viewed in the stacking direction, as shown in FIG. **33**. The first to fourth sides **10a** to **10d** form two sets of opposed sides. The semiconductor package **10** has a first gate pad **931a** and a second gate pad **932a** as the gate pad **93a**. The first gate pad **931a** and the second gate pad **932a** are located in the outer edge portion of the semiconductor package **10**.

[0269] Specifically, the first gate pad **931a** is arranged near the corner where the second side **10b** and the third side **10c** are connected to each other, and the second gate pad **932a** is arranged near the corner where the third side **10c** and the fourth side **10d** are connected to each other. That is, the first gate pad **931a** and the second gate pad **932a** are arranged at opposite portions in the outer edge

portion, respectively. More specifically, the source pad **92a** is arranged up to the vicinity of the third side **10c**, and the first gate pad **931a** and the second gate pad **932a** are arranged so as to sandwich the source pad **92a**. The gate electrode **38** of the semiconductor chip **30** is connected to the first gate pad **931a** and the second gate pad **932a**.

[0270] In such a semiconductor package **10**, the first gate pad **931a** and the second gate pad **932a** of the semiconductor package **10** are arranged at opposite portions of the outer edge portion, respectively. Therefore, when the semiconductor package **10** is connected to the printed circuit board **110**, one of the gate pads **931a** and **932a** may be connected to the printed circuit board **110**, so that the degree of freedom of wiring on the printed circuit board **110** side can be improved. In this case, for example, when connecting the first gate pad **931a** and the printed circuit board **110**, the length of a wiring layer connecting the first gate pad **931a** and a drive circuit for applying a predetermined voltage to the first gate pad **931a** can be shortened, thereby to suppress the variation in drive voltage. Further, when the semiconductor package **10** is connected to the printed circuit board **110**, one of the gate pads **931a** and **932a** may be connected to the printed circuit board **110**, so that the wiring on the printed circuit board **110** side can be easily routed. For example, it is not necessary to route the wiring of the printed circuit board **110** in multiple layers. As a result, it is possible to suppress the influence of the extra magnetic flux.

#### Twenty-Third Embodiment

[0271] A twenty-third embodiment will be described hereinafter. The present embodiment is configured by combining the twentieth embodiment with the twenty-second embodiment, and the arrangements of the pads **91a**, **92a**, **93a**, and **99a** of the semiconductor package **10** are modified. Other configurations are the same as those of the twenty-second embodiment, and therefore the descriptions of the same configurations will be omitted.

[0272] The semiconductor package **10** of the present embodiment is configured to have the first semiconductor chip **30a** and the second semiconductor chip **30b** as in the twenty-second embodiment. When viewed in the stacking direction, as shown in FIG. **34**, the semiconductor package **10** has pads **911a**, **931a**, **991a**, **932a**, **921a**, **912a**, **933a**, **992a**, **934a**, **922a** arranged along the outer edge.

[0273] Specifically, in the semiconductor package **10**, a first drain pad **911a**, a first gate pad **931a**, a first connection pad **991a**, a second gate pad **932a**, and a first source pad **921a** are arranged side by side in order along the second side **10b**. Further, a second drain pad **912a**, a third gate pad **933a**, a second connection pad **992a**, a fourth gate pad **934a**, and a second source pad **922a** are arranged side by side in order along the fourth side **10d**. That is, the pads **911a**, **931a**, **991a**, **932a**, **921a**, **912a**, **933a**, **992a**, **934a**, and **922a** are arranged at opposite portions of the outer edge portion of the semiconductor package **10**.

[0274] Although not particularly shown, the drain electrode **34** of the first semiconductor chip **30a** is connected to the first drain pad **911a** and the second drain pad **912a**. The source electrode **35** of the second semiconductor chip **30b** is connected to the first source pad **921a** and the second source pad **922a**. The source electrode **35** of the first semiconductor chip **30a** and the drain electrode **34** of the second semiconductor chip **30b** are connected to the first connection pad **991a** and the second connection pad **992a**. The gate electrode **38** of the first semiconductor chip **30a** is connected to the first gate pad **931a** and the third gate pad **933a**. The gate electrode **38** of the second semiconductor chip **30b** is connected to the second gate pad **932a** and the fourth gate pad **934a**.

[0275] According to the present embodiment described above, in the semiconductor package **10**, the pads **911a**, **931a**, **991a**, **932a**, **921a**, **912a**, **933a**, **992a**, **934a**, and **922a** are arranged on the opposite portions of the outer edge portions, respectively. The electrodes **34**, **35**, and **38** of the first semiconductor chip **30a** are electrically connected to the pads **911a**, **931a**, and **991a** arranged side by side along the second side **10b**, and are electrically connected to the pads **912a**, **933a**, and **992a** arranged side by side along the fourth side **10d**. Similarly, the electrodes **34**, **35**, **38** of the second semiconductor chip **30b** are electrically connected to the pads **991a**, **932a**, **921a** arranged side by

side along the second side **10b**, and are electrically connected to the pads **992a**, **934a**, and **922a** arranged side by side along the fourth side **10d**.

[0276] Therefore, the semiconductor package **10** of the present embodiment can form the DC/DC converter circuit or the inverter circuit by connecting the pads **911a**, **931a**, **991a**, **932a** and **921a** arranged along the second side **10b** or the pads **912a**, **933a**, **992a**, **934a** and **922a** arranged along the fourth side **10d** to the printed board **110**. Therefore, the degree of freedom of wiring on the printed circuit board **110** side can be improved, and the same effects as those of the twenty-second embodiment can be achieved.

[0277] It should be noted that such a semiconductor package **10** can also be employed, for example, in a 4-in-1 package or a 6-in-1 package.

#### Twenty-Fourth Embodiment

[0278] A twenty-fourth embodiment will be described hereinafter. In the present embodiment, the arrangement of the gate pad **93a** is modified from that of the twenty-second embodiment. Other configurations are the same as those of the twenty-second embodiment, and therefore the descriptions of the same configurations will be omitted.

[0279] As shown in FIG. **35**, in the semiconductor package **10** of the present embodiment, the semiconductor chip **30** is arranged at a substantially central portion when viewed in the stacking direction. In the semiconductor package **10**, the drain pad **91a** and the source pad **92a** are symmetrically arranged with respect to the virtual line K extending in one direction through the center of the semiconductor chip **30**. In FIG. **35**, the drain pad **91a** is arranged along the fourth side **10d**, and the source pad **92a** is arranged along the second side **10b**. The gate pad **93a** is arranged on the third side **10c** side and is arranged so as to intersect the virtual line K. That is, in the semiconductor package **10** of the present embodiment, there is only one gate pad **93a**.

[0280] According to the present embodiment described above, when the electronic device **1** is configured together with the printed circuit board **110** and the like as in the seventh embodiment, the degree of freedom of wiring on the printed circuit board **110** side can be improved. That is, when the electronic device **1** is configured, the semiconductor package **10** as shown in FIG. **36** is prepared together with the semiconductor package **10** shown in FIG. **35**. The semiconductor package **10** shown in FIG. **36** is obtained by reversing the arrangement of the drain pad **91a** and the source pad **92a** with respect to the semiconductor package **10** shown in FIG. **35**. That is, the drain pad **91a** is arranged along the second side **10b**, and the source pad **92a** is arranged along the fourth side **10d**. Note that, also in the semiconductor package **10** shown in FIG. **36**, there is only one gate pad **93a**.

[0281] When the electronic device **1** is configured, either the semiconductor package **10** shown in FIG. **35** or the semiconductor package **10** shown in FIG. **36** is used according to the restrictions on the printed circuit board **110** side. Therefore, the degree of freedom of wiring on the printed circuit board **110** side can be improved. In other words, the versatility of the semiconductor package **10** can be improved. Further, in the present embodiment, even if the semiconductor package **10** is provided with only one gate pad **93a** as described above, the degree of freedom of wiring on the printed circuit board **110** side can be improved. Therefore, as compared with the case where the two gate pads **93a** are arranged in the semiconductor package **10**, the degree of freedom of wiring on the printed circuit board **110** side can be improved while reducing the size of the semiconductor package **10**.

[0282] Although not particularly shown, even in the semiconductor chip **30** formed with a vertical semiconductor element, the portion where the source electrode **35** can be arranged can be enlarged by using one gate electrode **38**. Therefore, in such a semiconductor chip **30**, it becomes easy to increase the effective region to allow a current to flow, and it is possible to reduce the on-resistance. In other words, when the semiconductor chip **30** having the same on-resistance is configured, the size of the semiconductor chip **30** can be reduced.

#### Twenty-Fifth Embodiment

[0283] A twenty-fifth embodiment will be described hereinafter. In the present embodiment, two capacitors are arranged in the configuration of the twentieth embodiment. Other configurations are the same as those of the twentieth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0284] In the present embodiment, as shown in FIG. 37, a first capacitor **151** having a pair of electrodes **151a** and **151b** and a second capacitor **152** having a pair of electrodes **152a** and **152b** are arranged in the sealing member **60** together with the first semiconductor chip **30a** and the second semiconductor chip **30b**. Note that FIG. 37 shows a cross section at a different position from the cross section shown in FIG. 32 of the twentieth embodiment, and the first semiconductor chip **30a** and the second semiconductor chip **30b** are arranged in a different cross section from FIG. 37. Further, the first capacitor **151** and the second capacitor **152** of the present embodiment are made of silicon or the like, and the thicknesses of the first capacitor **151** and the second capacitor **152** are substantially equal to the thickness of the semiconductor chip **30**.

[0285] The first capacitor **151** and the second capacitor **152** are arranged on the lower layer plate-shaped member **740** in the same manner as the first semiconductor chip **30a** and the second semiconductor chip **30b**. Specifically, each of the first capacitor **151** and the second capacitor **152** is arranged on the lower layer plate-shaped member **740** such that one electrode **151b**, **152b** is located on the lower layer plate-shaped member **740** side, and the other electrode **151a**, **152a** is located on the first sealing member **90** side.

[0286] The electrode **151a** of the first capacitor **151** is connected to the drain pattern **91** formed in the first sealing member **90** through the upper connecting via **95**. The electrode **152a** of the second capacitor **152** is connected to the source pattern **92** formed in the first sealing member **90** through the upper connecting via **95**. Further, the electrode **151b** of the first capacitor **151** and the electrode **152b** of the second capacitor **152** are connected to the first surface metal film **22** through the lower layer connecting via **760**. That is, in the present embodiment, the series structure of the first capacitor **151** and the second capacitor **152** is connected in parallel to the series structure of the first semiconductor chip **30a** and the second semiconductor chip **30b**. In the embodiment, the drain pattern **91**, the source pattern **92**, the upper connecting via **95**, the first surface metal film **22**, and the lower layer connecting via **760** correspond to the wiring layer.

[0287] According to this, the first capacitor **151** and the second capacitor **152** are arranged together with the first semiconductor chip **30a** and the second semiconductor chip **30b**. Therefore, the first semiconductor chip **30a** and the second semiconductor chip **30b** can be arranged in close proximity to the first capacitor **151** and the second capacitor **152**, and the wiring layer connecting these elements can be shortened. Therefore, it is possible to reduce the parasitic inductance. Further, it is possible to restrict the semiconductor package **10** from increasing in size in the thickness direction, as compared with a twenty-fifth embodiment described later.

[0288] In the above, an example of a state in which the series structure of the first capacitor **151** and the second capacitor **152** is connected in parallel to the series structure of the first semiconductor chip **30a** and the second semiconductor chip **30b** has been described. However, the first capacitor **151** and the second capacitor **152** may be connected in parallel with each other with respect to the series structure of the first semiconductor chip **30a** and the second semiconductor chip **30b**.

[0289] Further, the first capacitor **151** and the second capacitor **152** may be formed thinner than the first semiconductor chip **30a** and the second semiconductor chip **30b**, as in the seventeenth embodiment.

#### Twenty-Sixth Embodiment

[0290] A twenty-sixth embodiment will be described hereinafter. In the present embodiment, the arrangement of the first capacitor **151** and the second capacitor **152** is modified from that of the twenty-fifth embodiment. Other configurations are the same as those of the twenty-fifth embodiment, and therefore the descriptions of the same configurations will be omitted.



[0291] In the present embodiment, as shown in FIG. 38, the first capacitor 151 is arranged on the first semiconductor chip 30a, and the second capacitor 152 is arranged on the second semiconductor chip 30b. In the present embodiment, the first capacitor 151 and the second capacitor 152 are arranged so that the pair of electrodes 151a, 151b, 152a, 152b are located on the second sealing member 100 in the planar direction of the semiconductor package 10.

[0292] The sealing member 60 is formed so as to seal the first capacitor 151 and the second capacitor 152 as well. In the present embodiment, the sealing member 60 include an upper layer sealing member 180 arranged on the second sealing member 100. The upper layer sealing member 180 is configured by a stack of upper layer plate-shaped members 940 having the same structure as the intermediate layer plate-shaped member 840, and is appropriately formed with an upper layer pattern 950 and an upper layer connecting via 960.

[0293] In the upper layer sealing member 180, contact holes 181 that expose the upper layer pattern 950 connected to the drain pattern 91, the source pattern 92, and the connection pattern 99 are formed in a layer furthest from the insulating substrate 21 and on the opposite side to the insulating substrate 21. Of the upper layer pattern 950, the portions exposed from the contact hole 181 serves as the drain pad 91a, the source pad 92a, and the connection pad 99a. In a cross section different from that shown in FIG. 38, the gate pad 93a is also provided by the upper layer pattern 950.

[0294] In the first semiconductor chip 30a, the drain electrode 34 is connected to the drain pad 91a through the upper connecting via 97, the drain pattern 91, the upper layer connecting via 960, and the like. In the second semiconductor chip 30b, the source electrode 35 is connected to the source pad 92a through the upper connecting via 97, the source pattern 92, the upper layer connecting via 960, and the like. The connection pattern 99 is connected to the connection pad 99a through the upper connecting via 97, the upper layer connecting via 960, and the like. The gate electrode 38 of the first semiconductor chip 30a and the gate electrode 38 of the second semiconductor chip 30b are connected to the gate pad 93a through the upper connecting via 95, the gate pattern 93, the upper connecting via 960, and the like in the cross-section different from that shown in FIG. 38.

[0295] In the first capacitor 151, the one electrode 151a is connected to the upper layer pattern 950, which serves as the drain pad 91a, through the upper layer connecting via 960 formed in the upper layer sealing member 180. In the second capacitor 152, the other electrode 152b is connected to the upper layer pattern 950, which serves as the source pad 92a, through the upper layer connecting via 960 formed in the upper layer sealing member 180. The other electrode 151b of the first capacitor 151 and the one electrode 152a of the second capacitor 152 are connected through the upper layer pattern 950 formed in the upper layer sealing member 180 and the upper layer connecting via 960 in a cross section different from that shown in FIG. 38.

[0296] As described above, even if the first capacitor 151 and the second capacitor 152 are stacked and arranged on the first semiconductor chip 30a and the second semiconductor chip 30b, the same effects as those of the twenty-fourth embodiment can be achieved. Further, in such a semiconductor package 10, it is possible to suppress an increase in the size in the planar direction, as compared with the configuration of the twenty-fourth embodiment.

#### Twenty-Seventh Embodiment

[0297] A twenty-seventh embodiment will be described hereinafter. In the present embodiment, connection bumps are arranged in the semiconductor package 10 of the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0298] In the semiconductor package 10 of the present embodiment, as shown in FIG. 39, connection bumps 190 are arranged on the drain pad 91a and the source pad 92a. In addition, in a cross section different from that shown in FIG. 39, the connection bump 190 is also arranged on the gate pad 93a. The connection bump 190 is made of, for example, a sintered body containing silver tin as a main component.

[0299] The semiconductor package 10 of the present embodiment has the configuration as

described above. Next, a method for manufacturing the semiconductor package **10** will be described with reference to FIGS. **40A** and **40B**.

[0300] First, as shown in FIG. **40A**, a bump forming body **1900** having a LCP film **191** and a peeling member **192** is prepared. The peeling member **192** is made of a Teflon (registered trademark) film and is provided on the LCP film **191**. Next, through holes **193** are formed in the bump forming body **1900**, and a bump constituent member **190a** for constituting the bump is arranged in the through holes **193**. The through hole **193** is formed at a position and a size corresponding to the contact hole **101**. The bump constituent member **190a** is formed by arranging a conductive paste by a printing method or the like. As the conductive paste, for example, a paste obtained by mixing a powder containing silver tin as a main component with an organic solvent is used. In this case, the organic solvent is evaporated by temporary sintering or the like, if necessary, so that the conductive paste does not come out from the through hole **193**.

[0301] The bump forming body **1900** has the same size in the planar direction as the first constituent member **900** and the like. Although the manufacturing method of one semiconductor package **10** is illustrated in FIGS. **40A** and **40B**, in reality, a plurality of semiconductor packages **10** are collectively manufactured as in the first embodiment.

[0302] Subsequently, as shown in FIG. **40B**, the bump forming body **1900** is arranged so that the bump constituent members **190a** are located on the contact holes **101** of the stacked body subjected up to the process shown in FIG. **5F**. Then, by pressurizing the stacked body in the stacking direction while heating, the connection bumps **190** are produced from the bump forming body **1900** and are connected to the pads **91a**, **92a**, and **99a**. Thereafter, the bump forming body **1900** is removed from the second constituent member **1000** by the peeling member **192** while leaving the connection bumps **190** on the pads **91a**, **92a**, and **99a**. As a result, the connection bumps **190** are arranged on the respective pads **91a**, **92a**, and **99a**.

[0303] Thereafter, although not particularly shown, the stacked body is divided into chips along the dicing line DL, and thus the semiconductor package **10** shown in FIG. **39** is manufactured.

[0304] According to this, when the semiconductor package **10** is mounted on the printed circuit board **110** via the solders **120** as in the seventh embodiment, it becomes easy to secure the space between the semiconductor package **10** and the printed circuit board **110**, and thus easy to secure the thickness of the solders **120**. Therefore, it is possible to reduce the variation in height of the solders **120**. Further, since the distance between the semiconductor package **10** and the printed circuit board **110** can be easily secured, it is possible to improve the injectability of the underfill material **130**.

#### Twenty-Eighth Embodiment

[0305] A twenty-eighth embodiment will be described hereinafter. In the present embodiment, the method for manufacturing the semiconductor package **10** is modified from that of the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0306] First, in the first embodiment, the constituent substrate **210**, which is a multiple continuous substrate, is prepared to manufacture the semiconductor package **10**. In this case, for example, as shown in FIG. **41**, the inner area of the constituent substrate **210** is designated as the constituent region **210a**, the outer edge portion of the constituent substrate **210** is designated as the auxiliary region **210b**. The semiconductor packages **10** are produced from the constituent region **210a** while forming positioning holes and the like in the auxiliary region **210b**.

[0307] In FIG. **41**, the region where the first surface metal films **22** are arranged is the constituent region **210a**. The auxiliary region **210b** is arranged so as to surround the constituent region **210a**. In such a constituent substrate **210**, the auxiliary region **210b** tends to be a wasteful region.

[0308] Therefore, in the present embodiment, as shown in FIG. **42**, the outer edge portion of the constituent substrate **210** is also used the constituent region **210a** for constituting the semiconductor packages **10**. Further, a part of the outer edge portion of the constituent substrate

**210** is used as the auxiliary region **210b**. That is, in the outer edge portion of the constituent substrate **210**, the constituent region **210a** and the auxiliary region **210b** both exist.

[0309] In the present embodiment, when the constituent substrate **210** has a rectangular shape as a planar shape, the corner portions are used as the auxiliary region **210b**. In FIG. **42**, the region where the first surface metal film **22** is not formed is the auxiliary region **210b**. In this case, the auxiliary regions **210b** are preferably arranged so as to be asymmetric with respect to the center of the constituent substrate **210**, as shown in FIG. **42**. As a result, the position of the constituent substrate **210** can be easily recognized, and the positioning can be enhanced.

[0310] According to this, since it is not necessary to arrange the auxiliary region **210b** over the entire outer edge portion of the constituent substrate **210**, the constituent substrate **210** can be effectively used. Although the manufacturing method has been described in association with the first embodiment as an example, the same applies to the case of manufacturing the semiconductor package **10** of the second embodiment and the ninth embodiment.

#### Twenty-Ninth Embodiment

[0311] A twenty-ninth embodiment will be described hereinafter. In the present embodiment, grooves are formed in the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000** of the first embodiment. Other configurations are the same as those of the first embodiment, and therefore the descriptions of the same configurations will be omitted.

[0312] In the present embodiment, as shown in FIG. **43**, in the process of FIG. **5E**, the side constituent member **700** formed with a groove **701**, the first constituent member **900** formed with a groove **901**, and the second constituent member **1000** formed with a groove **1001** are stacked. The grooves **701**, **901**, and **1001** are formed at positions corresponding to the dicing line DL.

[0313] The groove **701**, **901**, and **1001** are formed when the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000** are prepared in the processes of FIGS. **5B** to **5D**, respectively. Further, the groove **701**, **901** and **1001** are formed by, for example, a laser or the like. In the present embodiment, the groove portion **211** is not formed on the constituent substrate **210**. However, the groove portion **211** may be formed in the constituent substrate **210**.

Thereafter, the stacked members are integrated by pressurizing while heating as shown in FIG. **5F**.

[0314] As described above, even if the grooves **701**, **901**, and **1001** are formed on the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000**, the dicing can be facilitated. Further, since the grooves **701**, **901**, and **1001** are formed in the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000**, the influence of the heat shrinkage of the LCP films of the members **700**, **900**, and **1000** can be suppressed by the grooves **701**, **901**, and **1001** after the integrating in the process shown in FIG. **5F**.

[0315] In the present embodiment, the grooves **701**, **901**, **1001** are formed before integrating the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000**, as an example. As another example, the groove **1001** may be formed in the second constituent member **1000** after integrating the side constituent member **700**, the first constituent member **900**, and the second constituent member **1000**.

#### Thirtieth Embodiment

[0316] A thirtieth embodiment will be described hereinafter. In the present embodiment, the method for manufacturing the plate-shaped member **74** is modified from that of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0317] In the present embodiment, the plate-shaped member **74** constituting the sealing member **60** is manufactured as follows. First, as shown in FIG. **44A**, a LCP film constituent member **7400** is prepared. In this case, the internal state of the LCP film constituent member **7400** is in an amorphous state, as shown in FIG. **45A**.

[0318] Next, the LCP film constituent member **7400** is heat-treated and crystallized as shown in FIG. **45B**. The heat treatment is performed at about 300° C., which is a temperature lower than the melting point temperature of the LCP film constituent member **7400**, for several tens of minutes to several hours. In this case, it is preferable to raise the temperature stepwise from about 270° C. to about 300° C. As a result, it is possible to prevent the LCP film constituent member **7400** from melting.

[0319] Further, in a process different from that shown in FIG. **44A**, a metal sheet constituent member **7500** made of copper or the like is prepared, as shown in FIG. **44B**. Thereafter, as shown in FIG. **44C**, the LCP film constituent member **7400** and the metal sheet constituent member **7500** are laminated and integrated, thereby to form the plate-shaped member constituent member **770**. The laminating process is performed by pressurizing while heating. However, the heating time in the laminating process of the LCP film constituent member **7400** and the metal sheet constituent member **7500** is extremely short, as compared to the heating time in the process of the heat-treatment of the LCP film constituent member **7400** for crystallizing. Therefore, the LCP film constituent member **7400** is not crystallized only by heating in this laminating process.

[0320] Thereafter, although not shown in particular, the cutting or the like is performed as necessary, and then etching or the like is performed to form into a pattern **75** having a desired shape. Further, the sintered body or the conductive paste for constituting the connecting via **76** is arranged. In this way, the plate-shaped member **74** is produced.

[0321] Although the plate-shaped member constituent member **770** has been described above as an example, the first constituent member **900** and the second constituent member **1000** are also formed in the same manner.

[0322] According to this, since the LCP film constituent member **7400** is crystallized, when the plate-shaped member constituent member **770** (that is, the plate-shaped member **74**) and the semiconductor chip **30** or the like are integrated by pressurizing while heating, the deviation of the pattern **75** and the connecting via **76** can be suppressed. Therefore, it is possible to prevent the adjacent plate-shaped members **74** from not being electrically connected in the stacking direction.

#### Thirty-First Embodiment

[0323] A thirty-first embodiment will be described hereinafter. In the present embodiment, the electronic device **1** is configured by mounting the semiconductor package **10** on the printed circuit board **110** with respect to the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0324] In the present embodiment, as shown in FIG. **46**, an electronic device **1** has a semiconductor package **10**, a printed circuit board **110**, a cooler **140**, and a pressing member **300**.

[0325] The printed circuit board **110** is formed with a hole **116** penetrating in the thickness direction. Further, the printed circuit board **110** is formed with a plurality of terminals **117** exposed into the holes **116**. Although the configuration of the printed circuit board **110** is simplified in FIG. **46**, the printed circuit board **110** is appropriately formed with the first surface wiring pattern **111**, the through-hole electrode **113**, and the like, similarly to the printed circuit board **110** shown in FIG. **15**.

[0326] The semiconductor package **10** is connected to the printed circuit board **110** by connecting the drain pad **91a** and the source pad **92a** to the terminals **117** via the solder **120**. The semiconductor package **10** is connected to the printed circuit board **110** by connecting the gate pad **93a** to the terminals **117** via the solder **120** in a cross section different from that shown in FIG. **46**.

[0327] Further, in the semiconductor package **10**, the heat radiating member **20** is connected to the cooler **140** through a connecting member **141** such as grease.

[0328] The pressing member **300** is provided by a housing or the like, and has a pressing portion **301** protruding in one direction. The pressing portion **301** is made of an elastic body such as rubber, and is provided with the same number as the number of terminals **117** connected to the semiconductor package **10**. In the present embodiment, since the terminals **117** are connected to the

drain pad **91a**, the source pad **92a**, and the gate pad **93a**, three pressing portions **301** are provided. [0329] The pressing member **300** is arranged so that the portions of the terminals **117** of the printed circuit board **110** connected to the pads **91a**, **92a**, and **93a** are pressed toward the semiconductor package **10** by the pressing portions **301**.

[0330] In this way, the electronic device **1** may be configured by using the semiconductor package **10**. In the electronic device **1** of the present embodiment, since the portions of the terminals **117** connected to the pads **91a**, **92a**, and **93a** are pressed, it is possible to suppress the variation in distance between the semiconductor package **10** and the cooler **140**. In addition, since the distance between the semiconductor package **10** and the cooler **140** can be easily reduced, the heat radiation property can be improved.

#### Thirty-Second Embodiment

[0331] A thirty-second embodiment will be described hereinafter. The present embodiment is a modification of the thirtieth embodiment in which the configuration of the electronic device **1** is modified. Other configurations are the same as those of the thirtieth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0332] As shown in FIG. **47**, the printed circuit board **110** in the electronic device **1** of the present embodiment does not have the holes **116** in the printed circuit board **110**, and has the same configuration as that of the seventh embodiment. The printed circuit board **110** is fixed to the cooler **140** by a fastening member **118** such as a screw. Although the configuration of the printed circuit board **110** is simplified in FIG. **47**, the printed circuit board **110** is formed with the first surface wiring pattern **111**, the through-hole electrode **113**, and the like, similarly to the printed circuit board **110** shown in FIG. **15**.

[0333] In the semiconductor package **10**, the drain pad **91a** and the source pad **92a** are connected to the second surface wiring pattern **112** of the printed circuit board **110** through the solder **120**, respectively. Further, the gate pad **93a** is connected to the other surface wiring pattern **112** of the printed circuit board **110** through the solder **120** in a cross section different from that shown FIG. **13**. The underfill material **130** is arranged between the printed circuit board **110** and the semiconductor package **10**.

[0334] The pressing member **300** has a configuration in which the pressing portion **301** can press the printed circuit board **110** toward the cooler **140** as a whole. Further, the pressing member **300** presses the printed circuit board **110** toward the cooler **140**, thereby pressing the semiconductor package **10** toward the cooler **140**.

[0335] Even in the configuration in which the semiconductor package **10** is pressed via the printed circuit board **110** in this way, the same effects as those of the thirtieth embodiment can be achieved. Further, by directly pressing the printed circuit board **110**, the pressing portion **301** can easily restrict deformation of the printed circuit board **110** away from the semiconductor package **10** and can easily absorb the thickness variation in the printed circuit board **110**.

#### Thirty-Third Embodiment

[0336] A thirty-third embodiment will be described hereinafter. In the present embodiment, the electronic device **1** is configured using the semiconductor package **10** of the ninth embodiment. Other configurations are the same as those of the ninth embodiment, and therefore the descriptions of the same configurations will be omitted.

[0337] In the electronic device **1** of the present embodiment, as shown in FIG. **48**, the cooler **140** is formed with a recess **142**. The semiconductor package **10** is arranged so as to cover the open end of the recess **142** via a seal member **143** such as an O-ring. The recess **142** is connected to a cooling pipe or the like (not shown), and is configured to allow a cooling medium to flow through the cooling pipe. That is, the recess **142** is formed so as to form a cooling passage **142a** through which the cooling medium flows. As the cooling medium, for example, water, a general antifreeze solution, or the like is used.

[0338] In the present embodiment, the projection and recess structure **21c** is formed on the second

surface **21b** of the insulating substrate **21**. Although not shown in FIG. **48**, the pads **91a**, **92a**, and **93a** of the semiconductor package **10** are electrically connected to the printed circuit board **110** in the same manner as in the thirty-first embodiment and the like.

[0339] In such an electronic device **1**, the cooling medium flows through the recess **142**, so that the heat radiation can be further improved. Further, in the electronic device of the present embodiment, the projection and recess structure **21c** is formed on the second surface **21b** side of the insulating substrate **21**, and thus the contact area between the heat radiating member **20** and the cooling medium can be increased. Therefore, the heat radiation performance can be further improved.

#### Other Embodiments

[0340] Although the present disclosure has been described in accordance with the embodiments, it is understood that the present disclosure is not limited to such embodiments or structures. The present disclosure encompasses various modifications and variations within the scope of equivalents. In addition, various combinations and forms, and further, other combinations and forms including only one element, or more or less than these elements are also within the scope and the scope of the present disclosure.

[0341] In each of the embodiments described above, the bonding of the members may be mechanical bonding, instead of chemical bonding, to improve the adhesion. For example, in the first embodiment, the heat radiating member **20** and the sealing member **60** may be subjected to a roughening treatment by irradiating the heat radiating member **20** with plasma or the like so that the adhesion is improved by the anchor effect.

[0342] In the first embodiment or the like, the second surface metal film **23** may not be formed symmetrically with the first surface metal film **22**. Alternatively, the second surface metal film **23** may not be arranged. The bonding member **50** may be arranged within the semiconductor chip **30**, when viewed in the stacking direction. The heat radiating member **20** may be arranged within the sealing member **60**, when viewed in the stacking direction. Even in such a configuration, by providing the sealing member **60** by the LCP, the same effects as those of the first embodiment can be achieved. Also in the other embodiments having the first surface metal film **22** and the second surface metal film **23**, the configuration thereof may be appropriately modified in these ways.

[0343] In the first embodiment described above, for example, in place of arranging the sintered body **73a** in the second through hole **72** of the side constituent member **700**, a metal film (that is, lower connecting via **73**) may be formed in the second through hole **72** by a CVD method or the like. Such a configuration is the same for the first constituent member **900**. Further, these configurations can be appropriately applied to other embodiments.

[0344] In each of the embodiments described above, the semiconductor chip **30** may be formed with a super junction MOSFET or an IGBT. Further, the semiconductor chip **30** may be configured by using a support substrate **31** made of gallium oxide, gallium nitride or the like, in place of the support substrate **31** made of silicon or SiC.

[0345] In the first embodiment described above, when the semiconductor package **10** is manufactured, the processes of FIGS. **5E** and **5F** may be performed as follows. That is, in the process of FIG. **5E**, the side constituent member **700** may be arranged on the constituent substrate **210**, and the semiconductor chip **30** may be arranged in the first through hole **71** via the sintered body **50a**, and then these components may be temporarily joined to each other at a low temperature. Thereafter, the first constituent member **900** and the second constituent member **1000** may be stacked in order on the side constituent member **700** and the semiconductor chip **30**, and then these components may be integrated by performing the process of FIG. **5F**. Similarly, in the second embodiment described above, after the plate-shaped member constituent member **770** constituting the side sealing part **70** and the semiconductor chip **30** or the like are temporarily joined, the first constituent member **900** and the second constituent member **1000** may be stacked and integrated. Further, these manufacturing methods can be appropriately applied in each of the embodiments described above.

[0346] Further, in each of the embodiments described above, as shown in FIG. 49, slits **91b** to **93b** may be formed in the patterns **91** to **93** formed on the first sealing member **90**, respectively. Specifically, in the respective patterns **91** to **93**, slits **91b** to **93b** are formed by removing portions different from the portions connected to the upper connecting vias **95** and **97**. According to this, since the stress can be released by the slits **91b** to **93b**, the stress applied to the upper connecting vias **95** and **97** from the patterns **91** to **93** can be relaxed. In this case, the stress applied to the upper connecting via **97** can be further reduced by forming the slits **92b** so as to substantially surround the upper connecting via **97** in the stacking direction, for example, as in the upper connecting via **97** connected to the source pattern **92**. It is not always necessary that all the patterns **91** to **93** have the slits **91b** to **93b**. The slits **91b** to **93b** may be formed in any one or two patterns.

[0347] Further, in the ninth embodiment, the lower layer connecting via **760** may have a cylindrical shape, as shown in FIG. 50. It should be noted that such a lower layer connecting via **760** is applicable to each embodiment having the lower layer connecting via **760**.

[0348] Further, in the ninth embodiment described above, the pads **91a**, **92a**, **93a** may be formed at different positions from the connecting via **61** in the stacking direction, as shown in FIG. 51. In other words, the pads **91a**, **92a**, **93a** may be formed at positions that do not overlap with the connecting via **61** in the stacking direction. According to this, when the printed circuit board **110** is mounted on the pads **91a**, **92a**, **93a** via the solder **120** or the like, the stress applied to the connecting via **61** can be reduced and the connecting via **61** can be suppressed from being broken. In this case, the source pad **92a** may be arranged between the connecting via **61** and the semiconductor chip **30** in the stacking direction, as shown in FIG. 51. Alternatively, the source pad **92** may be arranged on the side opposite to the semiconductor chip **30** with respect to the connecting via **61**, as shown in FIG. 52.

[0349] Further, as shown in FIG. 53, a plurality of connecting vias **61** may be arranged in the circumferential direction around the pads **91a**, **92a**, and **93a** at positions different from the pads **91a**, **92a**, and **93a** in the stacking direction. In this case, it is preferable that the plurality of connecting vias **61** are arranged at equal intervals in the circumferential direction. According to this, when the printed circuit board **110** is mounted on the pads **91a**, **92a**, and **93a** via the solder **120** or the like, the stress is easily applied to the connecting vias **61** in a dispersed manner, and thus the semiconductor chip **30** will not receive a large stress. The configurations shown in FIGS. 51 to 53 can also be appropriately applied to the embodiments described above.

[0350] In addition, each of the embodiments described above can be combined as appropriate. For example, the second embodiment may be appropriately combined with another embodiment so that the side sealing part **70** is composed of a plurality of plate-shaped members **74**. For example, the third embodiment may be appropriately combined with another embodiment so that the bonding member **50** and the connecting via **61** are joined to each other, and the first surface metal film **22** and the second surface metal film **23** may not be provided. For example, the fourth embodiment may be appropriately combined with another embodiment so as to have a plurality of the connecting vias **61**, such as the connecting via **61** connecting the drain pattern **91** and the drain region **22a**. For example, the fifth embodiment may be appropriately combined with another embodiment so as to have the test pattern **98**. For example, the sixth embodiment may be appropriately combined with another embodiment so that the semiconductor chip **30** has the insulating substrate **41** and the heat radiating member **20** is made of the metal plate **24**. For example, the seventh embodiment may be appropriately combined with another embodiment so that the plurality of semiconductor chips **30** are integrally sealed by the sealing member **60**. Further, the same described above may be appropriately applied to the eighth to the thirty-second embodiments. Moreover, the combinations of the embodiments described above may be further combined with another embodiment described above.

## Claims

1. A method for manufacturing a semiconductor package in which a semiconductor chip is sealed by a sealing member, the method comprising: preparing a constituent substrate including a plurality of heat radiating regions for a plurality of heat radiating members, the plurality of regions being sectioned by a dicing line; preparing the semiconductor chip having a semiconductor element; placing the semiconductor chip on at least one of the heat radiating regions through a bonding member; placing a sealing constituent member on the constituent substrate for accommodating the semiconductor chip; forming the sealing member from the sealing constituent member by heating the sealing constituent member while pressuring in a stacking direction of the constituent substrate and the semiconductor chip, the sealing member sealing the semiconductor chip excluding a part bonded with the bonding member and is bonded with the constituent substrate; and cutting along the dicing line, wherein the sealing constituent member is made of a liquid crystal polymer, and in the forming of the sealing member, at least one of interfaces of different members including an interface between the heat radiating member and the sealing member is bonded by covalent bonding as chemical bonding.
  2. The method according to claim 1, further comprising: forming an active group on the heat radiating member by applying an alkaline solution containing a silicate, before the forming of the sealing member; and forming an active group on the sealing constituent member by applying an aqueous solution of an organic compound containing a silanol group and an amino group, before the forming of the sealing member.
  3. The method according to claim 1, wherein in the preparing the constituent substrate, the constituent substrate having a groove portion is prepared, wherein the groove portion is formed at a position corresponding to the dicing line on a surface of the constituent substrate opposite to a surface on which the semiconductor chip is placed.
  4. The method according to claim 3, wherein in the preparing of the constituent substrate, the groove portion has a depth being 0.1 t or more and 0.5 t or less, in which t is a thickness of the constituent substrate.
  5. The method according to claim 1, wherein the preparing of the constituent substrate having the groove portion includes forming the groove portion after the forming of the sealing member.
  6. The method according to claim 1, wherein in the placing of the sealing constituent member, the sealing constituent member including a side sealing part that is made by injection molding and is to be bonded with the heat radiating member while sealing a side surface of the semiconductor chip is placed, the placing of the sealing constituent member includes forming a thorough hole in the side sealing part and arranging a conductive material in the through hole, before the side sealing part is placed, and in the forming of the sealing member, the conductive material is connected to a predetermined part.
  7. The method according to claim 1, wherein the placing of the sealing constituent member includes preparing a plate-shaped member constituent member, and stacking the plate-shaped member constituent member, and the preparing the plate-shaped member constituent member includes preparing a film constituent member made of a liquid crystal polymer and in an amorphous state, and crystalizing the film constituent member by heat treatment.
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