

DESCRIPTION

Title of Invention

ADHESIVE AGENT COMPOSITION, FILM-LIKE ADHESIVE
AGENT, ADHESIVE SHEET, AND SEMICONDUCTOR DEVICE
5 MANUFACTURING METHOD

Technical Field

[0001] The present invention relates to an adhesive composition, a film-form adhesive, an adhesive sheet, and a method for producing a semiconductor device.

10 Background Art

[0002] Conventionally, silver pastes have been mainly used for the joining of semiconductor chips and supporting members for mounting semiconductor chips. However, along with size reduction, integration, and the like of semiconductor chips in recent years, there have been
15 demands for size reduction, integration, and the like also in the supporting members to be used. On the other hand, in the case of using a silver paste, there may be problems such as the occurrence of inconvenience upon wire bonding, which is attributed to protrusion of the paste or tilting of semiconductor chips, difficulties in the control of the film thickness,
20 and void generation.

[0003] Therefore, in recent years, film-form adhesives for joining semiconductor chips and supporting members have been used (see, for example, Patent Literature 1). In a case in which an adhesive sheet including a dicing tape and a film-form adhesive laminated on the dicing
25 tape is used, a film-form adhesive-attached semiconductor chip can be obtained by sticking a film-form adhesive on the rear surface of a

semiconductor wafer and individualizing the semiconductor wafer by dicing. The film-form adhesive-attached semiconductor chip thus obtained can be stuck to a supporting member by means of the film-form adhesive and joined by thermocompression bonding.

5 **Citation List**

Patent Literature

[0004] Patent Literature 1: JP No. 2007-053240

Summary of Invention

Technical Problem

10 [0005] However, as the size of a semiconductor chip decreases, the force exerted per unit area at the time of thermocompression bonding increases, and a phenomenon called bleeding, in which a film-form adhesive protrudes from the semiconductor chip, may occur.

15 [0006] Furthermore, in a case in which a film-form adhesive is used as a film over wire (FOW), which is a wire-embedded type film-form adhesive, or a film over die (FOD), which is a semiconductor chip-embedded type film-form adhesive, high fluidity is required at the time of thermocompression bonding, from the viewpoint of enhancing the embedding properties. Therefore, the frequency of occurrence and the
20 amount of bleeding tend to further increase. Depending on cases, bleeding may occur up to the top face of the semiconductor chip, and as a result, there is a risk that bleeding may lead to electrical defects or wire bonding defects.

25 [0007] The present invention was achieved in view of such circumstances, and it is a main object of the present invention to provide an adhesive composition that has satisfactory embedding properties at the

time of thermocompression bonding and is capable of suppressing bleeding.

Solution to Problem

[0008] An aspect of the present invention provides an adhesive composition. This adhesive composition contains a thermosetting resin, a curing agent, an elastomer, and an inorganic filler. The curing agent includes a phenolic resin having an alicyclic ring. The content of the elastomer is 10 to 80 parts by mass with respect to 100 parts by mass of the thermosetting resin. According to such an adhesive composition, it is possible to suppress bleeding while having satisfactory embedding properties at the time of thermocompression bonding.

[0009] The thermosetting resin may be an epoxy resin. The epoxy resin may include a bisphenol F type epoxy resin.

[0010] The elastomer may be an acrylic resin.

[0011] The inorganic filler may be silica. The content of the inorganic filler may be 25% by mass or more based on the total amount of the adhesive composition.

[0012] The content of the sum of the thermosetting resin, the curing agent, the elastomer, and the inorganic filler may be 95% by mass or more based on the total amount of the adhesive composition.

[0013] The adhesive composition may further contain a curing accelerator.

[0014] The adhesive composition may be a composition that is used in a semiconductor device in which a first semiconductor element is connected by wire bonding onto a substrate by means of a first wire, and a second semiconductor element is also compression-bonded onto the

first semiconductor element, in order to compression-bond the second semiconductor element and also to embed at least a portion of the first wire.

[0015] The present invention may further relate to an application as an adhesive or an application for the production of an adhesive, of a composition containing a thermosetting resin, a curing agent, and an elastomer, with the curing agent including a phenolic resin having an alicyclic ring, in a semiconductor device in which a first semiconductor element is connected by wire bonding onto a substrate by means of a first wire, and a second semiconductor element is also compression-bonded onto the first semiconductor element, in order to compression-bond the second semiconductor element and also to embed at least a portion of the first wire.

[0016] Another aspect of the present invention provides a film-form adhesive obtained by forming the above-mentioned adhesive composition into a film form.

[0017] Still another aspect of the present invention provides an adhesive sheet including a base material and the above-mentioned film-form adhesive provided on the base material.

[0018] The base material may be a dicing tape. Meanwhile, according to the present specification, an adhesive sheet in which the base material is a dicing tape may be referred to as "dicing-die bonding integrated type adhesive sheet".

[0019] The adhesive sheet may further include a protective film laminated on the surface of the film-form adhesive on the opposite side of the base material.

[0020] Still another aspect of the present invention provides a method for producing a semiconductor device, the method including a wire bonding step of electrically connecting a first semiconductor element onto a substrate by means of a first wire, a lamination step of sticking the above-mentioned film-form adhesive on one side of a second semiconductor element, and a die bonding step of subjecting the second semiconductor element having the film-form adhesive stuck thereto, to compression-bonding by means of the film-form adhesive, and thereby embedding at least a portion of the first wire in the film-form adhesive.

[0021] Meanwhile, the semiconductor device may be a wire-embedded type semiconductor device in which a first semiconductor chip is connected by wire bonding onto a semiconductor substrate by means of a first wire, a second semiconductor chip is also compression-bonded onto the first semiconductor chip by means of an adhesive film, and thereby at least a portion of the first wire is embedded in the adhesive film, or may be a chip-embedded type semiconductor device in which a first wire and a first semiconductor chip are embedded in an adhesive film.

Advantageous Effects of Invention

[0022] According to the present invention, there is provided an adhesive composition that has satisfactory embedding properties at the time of thermocompression bonding and is capable of suppressing bleeding. Therefore, a film-form adhesive obtained by forming this adhesive composition into a film form can be useful as a film over die (FOD), which is a semiconductor chip-embedded type film-form adhesive, or a film over wire (FOW), which is a wire-embedded type film-form

adhesive. Furthermore, according to the present invention, there are provided an adhesive sheet obtained using such a film-form adhesive, and a method for producing a semiconductor device.

Brief Description of Drawings

5 [0023] FIG. 1 is a schematic cross-sectional view illustrating a film-form adhesive according to an embodiment.

FIG. 2 is a schematic cross-sectional view illustrating an adhesive sheet according to an embodiment.

10 FIG. 3 is a schematic cross-sectional view illustrating an adhesive sheet according to another embodiment.

FIG. 4 is a schematic cross-sectional view illustrating a semiconductor device according to an embodiment.

15 FIG. 5 is a schematic cross-sectional view illustrating a series of steps of a method for producing a semiconductor device according to an embodiment.

FIG. 6 is a schematic cross-sectional view illustrating a series of steps of a method for producing a semiconductor device according to an embodiment.

20 FIG. 7 is a schematic cross-sectional view illustrating a series of steps of a method for producing a semiconductor device according to an embodiment.

FIG. 8 is a schematic cross-sectional view illustrating a series of steps of a method for producing a semiconductor device according to an embodiment.

25 FIG. 9 is a schematic cross-sectional view illustrating a series of steps of a method for producing a semiconductor device according to an

embodiment.

Description of Embodiments

[0024] Hereinafter, embodiments of the present invention will be described with appropriate reference to the drawings. However, the present invention is not intended to be limited to the following embodiments.

[0025] According to the present specification, (meth)acrylic acid means acrylic acid or methacrylic acid corresponding thereto. The same also applies to other similar expressions such as a (meth)acryloyl group.

[0026] [Adhesive composition]

The adhesive composition according to the present embodiment contains: (A) a thermosetting resin, (B) a curing agent, (C) an elastomer, and (D) an inorganic filler. The adhesive composition is thermosetting, and the adhesive composition can go through a semi-cured (stage B) state and enter a completely cured product (stage C) state after a curing treatment.

[0027] <Component (A): Thermosetting resin>

Component (A) may be an epoxy resin, from the viewpoint of adhesiveness. Regarding the epoxy resin, any compound having an epoxy group in the molecule can be used without any particular limitation. Examples of the epoxy resin include a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a bisphenol S type epoxy resin, a phenol novolac type epoxy resin, a cresol novolac type epoxy resin, a bisphenol A novolac type epoxy resin, a bisphenol F novolac type epoxy resin, a stilbene type epoxy resin, a triazine skeleton-containing epoxy resin, a fluorene skeleton-containing epoxy resin, a

triphenolmethane type epoxy resin, a biphenyl type epoxy resin, a xylylene type epoxy resin, a biphenyl aralkyl type epoxy resin, a naphthalene type epoxy resin, an epoxy resin having an alicyclic ring, and the like. These may be used singly or in combination of two or more kinds thereof. Among these, the epoxy resin may include a bisphenol F type epoxy resin. As the epoxy resin includes a bisphenol F type epoxy resin, the embedding properties tend to be enhanced. Furthermore, from the viewpoint of fluidity, the epoxy resin may include an epoxy resin having an alicyclic ring, and the epoxy resin having an alicyclic ring may be a dicyclopentadiene type epoxy resin (an epoxy resin having a dicyclopentadiene structure).

[0028] The epoxy equivalent of the component (A) is not particularly limited; however, the epoxy equivalent may be 90 to 600 g/eq, 100 to 500 g/eq, or 120 to 450 g/eq. When the epoxy equivalent of the component (A) is in such a range, satisfactory reactivity and fluidity tend to be obtained. In a case where the component (A) includes a bisphenol F type epoxy resin, the epoxy equivalent of the bisphenol F type epoxy resin may be less than 180 g/eq from the viewpoint of the embedding properties and may be 170 g/eq or 160 g/eq or less. The epoxy equivalent of the bisphenol F type epoxy resin may be 90 g/eq or more, 100 g/eq or more, or 120 g/eq or more.

[0029] <Component (B): Curing agent>

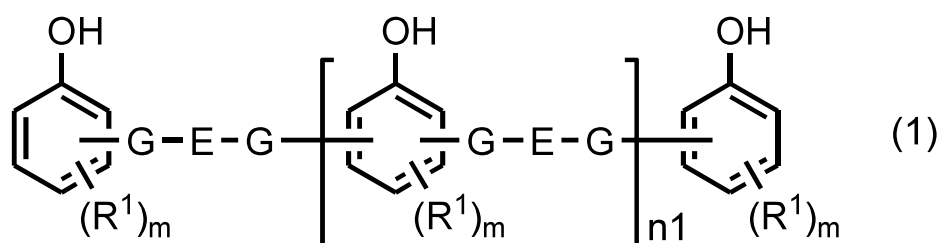
Component (B) includes a phenolic resin having an alicyclic ring (B-1).

[0030] Component (B-1) is a compound having an alicyclic ring and a hydroxyl group in the molecule. The hydroxyl group may be bonded to

the alicyclic ring of the compound or to a site other than the alicyclic ring, through a single bond or a linking group (for example, an alkylene group, an oxyalkylene group, or the like). By including the component (B-1) as the curing agent, it is possible to suppress bleeding while having satisfactory embedding properties at the time of thermocompression bonding.

[0031] The component (B-1) may be, for example, a phenolic resin represented by the following General Formula (1).

[0032]



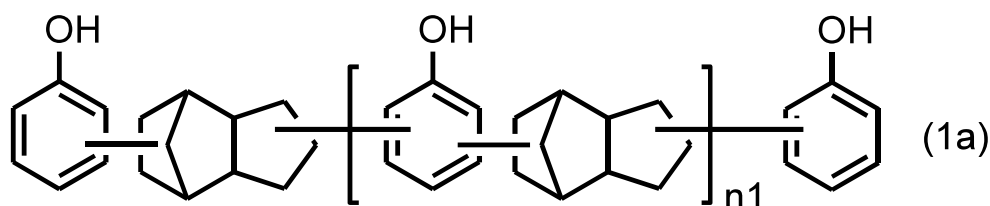
[0033] In Formula (1), E represents an alicyclic ring; G represents a single bond or an alkylene group; R¹'s each independently represent a hydrogen atom or a monovalent hydrocarbon group; n₁ represents an integer from 1 to 10; and m represents an integer from 1 to 3.

[0034] The number of carbon atoms of E may be 4 to 12, 5 to 11, or 6 to 10. E may be a monocyclic ring or a polycyclic ring; however, E is preferably a polycyclic ring, and more preferably a dicyclopentadiene ring. The alkylene group for G may be an alkylene group having 1 to 5 carbon atoms, such as a methylene group, an ethylene group, a propylene group, a butylene group, or a pentylene group. G is preferably a single bond. The monovalent hydrocarbon group for R¹ may be, for example, an alkylene group such as a methyl group, an ethyl group, a propyl group, a butyl group, or a pentyl group; an aryl group such as a phenyl group or

a naphthyl group; or a heteroaryl group such as a pyridyl group. It is preferable that R¹ is a hydrogen atom.

[0035] The phenolic resin represented by General Formula (1) may be a phenolic resin represented by the following General Formula (1a).

[0036]



[0037] In Formula (1a), n1 has the same meaning as described above.

[0038] Examples of commercially available products of the epoxy resin represented by General Formula (1a) include J-DPP-85, J-DPP-95, J-DPP-115 (all manufactured by JFE Chemical Corporation), and the like.

[0039] The hydroxyl group equivalent of the component (B-1) is not particularly limited; however, the hydroxyl group equivalent may be 80 to 400 g/eq, 90 to 350 g/eq, or 100 to 300 g/eq. When the hydroxyl group equivalent of the component (B-1) is in such a range, satisfactory reactivity and fluidity tend to be obtained.

[0040] The content of the component (B-1) may be 5% by mass or more, 10% by mass or more, or 15% by mass or more, based on the total amount of the adhesive composition. When the content of the component (B-1) is 5% by mass or more based on the total amount of the adhesive composition, there is a tendency that bleeding can be suppressed thoroughly while having more satisfactory embedding properties at the time of thermocompression bonding. The content of the component (B-1) may be 50% by mass or less, 40% by mass or less, or 30% by mass or

less, based on the total amount of the adhesive composition.

[0041] The component (B) may further include a phenolic resin having no alicyclic ring (B-2), in addition to the component (B-1). Examples of the component (B-2) include, for example, a novolac type phenolic resin obtainable by condensing or co-condensing a phenol such as phenol, cresol, resorcin, catechol, bisphenol A, bisphenol F, phenylphenol, or aminophenol, and/or a naphthol such as α -naphthol, β -naphthol, or dihydroxynaphthalene, with a compound having an aldehyde group, such as formaldehyde, in the presence of an acidic catalyst; a phenol aralkyl resin synthesized from a phenol and/or a naphthol, such as allylated bisphenol A, allylated bisphenol F, allylated naphthalenediol, phenol novolac, or phenol, and dimethoxy-para-xylene or bis(methoxymethyl)biphenyl; a naphthol aralkyl resin, a biphenyl aralkyl type phenolic resin, a phenyl aralkyl type phenolic resin, and the like.

These may be used singly or in combination of two or more kinds thereof.

[0042] The hydroxyl group equivalent of the component (B-2) is not particularly limited; however, the hydroxyl group equivalent may be 80 to 400 g/eq, 90 to 350 g/eq, or 100 to 300 g/eq. When the hydroxyl group equivalent of the component (B-1) is in such a range, more satisfactory reactivity and fluidity tend to be obtained.

[0043] The content of the component (B-1) may be 50% to 100% by mass based on the total amount of the component (B). The content of the component (B-1) may be 60% by mass or more or 70% by mass or more based on the total amount of the component (B). The content of the component (B-2) may be 0% to 50% by mass based on the total amount of the component (B). The content of the component (B-2) may

be 40% by mass or less or 30% by mass or less based on the total amount of the component (B).

[0044] In a case in which component (A) is an epoxy resin, the ratio between the epoxy equivalent of the epoxy resin and the hydroxyl group equivalent of the component (B) (epoxy equivalent of epoxy resin/hydroxyl group equivalent of phenolic resin) may be 0.30/0.70 to 0.70/0.30, 0.35/0.65 to 0.65/0.35, 0.40/0.60 to 0.60/0.40, or 0.45/0.55 to 0.55/0.45, from the viewpoint of curability. When this equivalent ratio is 0.30/0.70 or higher, more sufficient curability tends to be obtained.

When this equivalent ratio is 0.70/0.30 or lower, the viscosity can be prevented from becoming excessively high, and more sufficient fluidity can be obtained.

[0045] The content of the sum of the component (A) and the component (B) may be 30% to 70% by mass based on the total amount of the adhesive composition. The content of the sum of the component (A) and the component (B) may be 33% by mass or more, 36% by mass or more, or 40% by mass or more, and may be 65% by mass or less, 60% by mass or less, or 55% by mass or less. When the content of the sum of the component (A) and the component (B) is 30% by mass or more based on the total amount of the adhesive composition, the adhesiveness tends to be enhanced. When the content of the sum of the component (A) and the component (B) is 70% by mass or less based on the total amount of the adhesive composition, there is a tendency that the viscosity can be prevented from becoming excessively low, and bleeding can be further suppressed.

[0046] <Component (C): Elastomer>

The adhesive composition according to the present embodiment contains (C) an elastomer. It is preferable for the component (C) that the glass transition temperature (T_g) of the polymer constituting the elastomer is 50°C or lower.

5 [0047] Examples of the component (C) include an acrylic resin, a polyester resin, a polyamide resin, a polyimide resin, a silicone resin, a butadiene resin, an acrylonitrile resin, modification products of these, and the like.

10 [0048] The component (C) may include an acrylic resin from the viewpoints of solubility in a solvent and fluidity. Here, the acrylic resin means a polymer including a constituent unit derived from a (meth)acrylic acid ester. It is preferable that the acrylic resin is a polymer including a constituent unit derived from a (meth)acrylic acid ester having a crosslinkable functional group such as an epoxy group, an
15 alcoholic or phenolic hydroxyl group, or a carboxyl group, as a constituent unit. Furthermore, the acrylic resin may be an acrylic rubber such as a copolymer of a (meth)acrylic acid ester and acrylonitrile.

[0049] The glass transition temperature (T_g) of the acrylic resin may be -50°C to 50°C or -30°C to 30°C. When the T_g of the acrylic resin is -
20 50°C or higher, there is a tendency that the flexibility of the adhesive composition can be prevented from becoming excessively high. Thereby, it is easier to cut the film-form adhesive at the time of wafer dicing, and it is possible to prevent the occurrence of burrs. When the T_g of the acrylic resin is 50°C or lower, there is a tendency that a decrease
25 in the flexibility of the adhesive composition can be suppressed. Thereby, at the time of sticking the film-form adhesive to a wafer, voids

tend to be easily embedded sufficiently. Furthermore, it is possible to prevent chipping at the time of dicing, which is caused by a decrease in the adhesiveness of the wafer. Here, the glass transition temperature (Tg) means a value measured using a TMA testing apparatus (manufactured by TA Instruments, Inc., TMA400Q).

[0050] The weight average molecular weight (Mw) of the acrylic resin may be 100,000 to 3,000,000 or 500,000 to 2,000,000. When the Mw of the acrylic resin is in such a range, the film-forming properties and the strength, flexibility, tackiness, and the like in a film form can be appropriately controlled, the reflow characteristics are also excellent, and the embedding properties can be enhanced. Here, the Mw means a value measured by gel permeation chromatography (GPC) and converted using a calibration curve based on polystyrene standards.

[0051] Examples of commercially available products of the acrylic resin include SG-70L, SG-708-6, WS-023 EK30, SG-280 EK23, and SG-P3 solvent-changed product (all manufactured by Nagase ChemteX Corporation).

[0052] The content of the component (C) is 10 to 80 parts by mass with respect to 100 parts by mass of the component (A). The content of the component (C) may be 20 parts by mass or more, 30 parts by mass or more, 35 parts by mass or more, 40 parts by mass or more, or 42 parts by mass or more, and may be 75 parts by mass or less, 72 parts by mass or less, 70 parts by mass or less, or 68 parts by mass or less, with respect to 100 parts by mass of the component (A). When the content of the component (C) is 10 parts by mass or more with respect to 100 parts by mass of the component (A), handleability (for example, crease

performance and the like) of the film-form adhesive tends to be more satisfactory. When the content of the component (C) is 80 parts by mass or less with respect to 100 parts by mass of the component (A), there is a tendency that the flexibility of the adhesive composition can be prevented from becoming excessively high. Thereby, it is easier to cut the film-form adhesive at the time of wafer dicing, and it is possible to prevent the occurrence of burrs. Furthermore, when the content of the component (C) is 80 parts by mass or less with respect to 100 parts by mass of the component (A), the embedding properties of wires or semiconductor chips tend to be enhanced.

[0053] The content of component (C) may be 10 parts by mass or more, 20 parts by mass or more, or 30 parts by mass or more, and may be 80 parts by mass or less, 75 parts by mass or less, 60 parts by mass or less, or 55 parts by mass or less, with respect to a total amount of 100 parts by mass of the component (A) and the component (B). When the content of the component (C) is 10 parts by mass or more with respect to a total amount of 100 parts by mass of the component (A) and the component (B), handleability (for example, crease performance, and the like) of the film-form adhesive tends to be more satisfactory. When the content of the component (C) is 80 parts by mass or less with respect to a total amount of 100 parts by mass of the component (A) and the component (B), there is a tendency that the flexibility of the adhesive composition can be further prevented from becoming excessively high. Thereby, it is easier to cut the film-form adhesive at the time of wafer dicing, and there is a tendency that it is even further possible to prevent the occurrence of burrs.

[0054] <Component (D): Inorganic filler>

Examples of the inorganic filler include aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, aluminum oxide, aluminum nitride, aluminum borate whiskers, boron nitride, crystalline silica, amorphous silica, and the like. These may be used singly, or two or more kinds thereof may be used in combination. From the viewpoint that the thermal conductivity of the resulting film-form adhesive is further enhanced, the inorganic filler may include aluminum oxide, aluminum nitride, boron nitride, crystalline silica, or amorphous silica. Furthermore, from the viewpoint of adjusting the melt viscosity of the adhesive composition and from the viewpoint of imparting thixotropic properties to the adhesive composition, the inorganic filler may be aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, aluminum oxide, crystalline silica, or amorphous silica, and may be silica (crystalline silica or amorphous silica).

[0055] The average particle size of the component (D) may be 0.005 to 0.5 μm or 0.05 to 0.3 μm , from the viewpoint that adhesiveness is further enhanced. Here, the average particle size means a value that is determined by converting from the BET specific surface area.

[0056] The component (D) may be surface-treated with a surface treatment agent, from the viewpoints of compatibility between the surface of the component (D) and a solvent, other components, and the like, and the adhesive strength. Examples of the surface treatment agent include

a silane coupling agent and the like. Examples of the functional group of the silane coupling agent include a vinyl group, a (meth)acryloyl group, an epoxy group, a mercapto group, an amino group, a diamino group, an alkoxy group, an ethoxy group, and the like.

5 [0057] The content of the component (D) may be 25% by mass or more, 28% by mass or more, or 30% by mass or more, based on the total amount of the adhesive composition. When the content of the component (D) is 25% by mass or more based on the total amount of the adhesive composition, there is a tendency that the dicing characteristics of the
10 adhesive layer before curing are enhanced, and the adhesive force of the adhesive layer after curing is enhanced. As a result, for example, sufficient dicing characteristics are secured even for a film-form adhesive having a relatively large thickness (for example, 20 μm or more, and preferably 30 μm or more) for FOD and FOW applications. The upper
15 limit of the content of the component (D) is not particularly limited; however, the upper limit may be 60% by mass or less, 50% by mass or less, or 40% by mass or less, based on the total amount of the adhesive composition. When the content of the component (D) is 60% by mass or less based on the total amount of the adhesive composition, decrease
20 in fluidity can be suppressed, and it is possible to prevent the elastic modulus of the film-form adhesive after curing from becoming excessively high.

[0058] In the adhesive composition according to the present embodiment, component (A), component (B), component (C), and
25 component (D) are main components, and the content of the sum of the component (A), the component (B), the component (C), and the

component (D) may be 95% by mass or more or 97% by mass or more and may be 100% by mass or less or 99% by mass or less, based on the total amount of the adhesive composition.

[0059] <Component (E): Curing accelerator>

5 The adhesive composition according to the present embodiment may contain (E) a curing accelerator. The curing accelerator is not particularly limited, and agents that are generally used can be used. Examples of the component (E) include an imidazole and derivatives thereof, an organic phosphorus-based compound, a secondary amine, a
10 tertiary amine, a quaternary ammonium salt, and the like. These may be used singly or in combination of two or more kinds thereof. Among these, from the viewpoint of reactivity, the component (E) may be an imidazole or a derivative thereof.

[0060] Examples of the imidazole include 2-methylimidazole, 1-benzyl-
15 2-methylimidazole, 1-cyanoethyl-2-phenylimidazole, 1-cyanoethyl-2-methylimidazole, and the like. These may be used singly or in combination of two or more kinds thereof.

[0061] The content of the component (E) may be 0.01 to 3 parts by mass or 0.03 to 1 part by mass with respect to a total amount of 100 parts by
20 mass of the component (A), component (B), and component (C). When the content of the component (E) is in such a range, there is a tendency that curability and reliability can be achieved in a well-balanced manner.

[0062] <Other components>

25 The adhesive composition according to the present embodiment may further contain an oxidation inhibitor, a silane coupling agent, a rheology control agent, and the like as other components. The content

of these components may be 0.01 to 3 parts by mass with respect to a total amount of 100 parts by mass of the component (A), component (B), and component (C).

[0063] The adhesive composition according to the present embodiment may be used as an adhesive varnish diluted with a solvent. The solvent is not particularly limited as long as it can dissolve components other than the component (D). Examples of the solvent include aromatic hydrocarbons such as toluene, xylene, mesitylene, cumene, and p-cymene; aliphatic hydrocarbons such as hexane and heptane; cyclic alkanes such as methylcyclohexane; cyclic ethers such as tetrahydrofuran and 1,4-dioxane; ketones such as acetone, methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone, and 4-hydroxy-4-methyl-2-pentanone; esters such as methyl acetate, ethyl acetate, butyl acetate, methyl lactate, ethyl lactate, and γ -butyrolactone; carbonic acid esters such as ethylene carbonate and propylene carbonate; amides such as N,N-dimethylformamide, N,N-dimethylacetamide, and N-methyl-2-pyrrolidone; and the like. These may be used singly or in combination of two or more kinds thereof. Among these, the solvent may be toluene, xylene, methyl ethyl ketone, methyl isobutyl ketone, or cyclohexanone, from the viewpoints of solubility and the boiling point.

[0064] The solid component concentration in the adhesive varnish may be 10% to 80% by mass based on the total mass of the adhesive varnish.

[0065] The adhesive varnish can be prepared by mixing and kneading the component (A), component (B), component (C), component (D), a solvent, and if necessary, component (E), as well as other components. Mixing and kneading can be carried out by appropriately combining

conventional dispersing machines such as a stirrer, a grinding machine, a three-roll mill, a ball mill, and a bead mill. In a case in which the component (D) is mixed into the adhesive varnish, the time for mixing can be shortened by mixing in advance the component (D) and low molecular weight components and then incorporating high molecular weight components thereto. Furthermore, after the adhesive varnish is prepared, gas bubbles in the varnish may be removed by vacuum degassing or the like.

[0066] [Film-form adhesive]

FIG. 1 is a schematic cross-sectional view illustrating a film-form adhesive according to an embodiment. The film-form adhesive 10 is obtained by forming the above-mentioned adhesive composition into a film form. The film-form adhesive 10 may be in a semi-cured (stage B) state. Such a film-form adhesive 10 can be formed by applying the adhesive composition on a supporting film. In the case of using an adhesive varnish, the film-form adhesive 10 can be formed by applying the adhesive varnish on a supporting film and removing the solvent by heating and drying the solvent.

[0067] The supporting film is not particularly limited, and examples include films of polytetrafluoroethylene, polyethylene, polypropylene, polymethylpentene, polyethylene terephthalate, polyimide, and the like. The thickness of the supporting film may be, for example, 10 to 200 μm or 20 to 170 μm .

[0068] Regarding the method of applying an adhesive varnish on a supporting film, any known method can be used, and examples include a knife coating method, a roll coating method, a spray coating method, a

gravure coating method, a bar coating method, a curtain coating method, and the like. The conditions for heating and drying are not particularly limited as long as the conditions are conditions in which the solvent used is sufficiently volatilized; however, for example, the conditions may be 50°C to 200°C for 0.1 to 90 minutes.

[0069] The thickness of the film-form adhesive can be appropriately adjusted according to the use application. The thickness of the film-form adhesive may be 20 to 200 μm , 30 to 200 μm , or 40 to 150 μm , from the viewpoint of sufficiently embedding the surface unevenness of a semiconductor chip, a wire, a wiring circuit of a substrate, and the like.

[0070] [Adhesive sheet]

FIG. 2 is a schematic cross-sectional view illustrating an adhesive sheet according to an embodiment. The adhesive sheet 100 includes a base material 20 and the above-mentioned film-form adhesive 10 provided on the base material.

[0071] The base material 20 is not particularly limited; however, the base material may be a base material film. The base material film may be a film similar to the above-mentioned supporting film.

[0072] The base material 20 may be a dicing tape. Such an adhesive sheet can be used as a dicing-die bonding integrated type adhesive sheet. In this case, since the lamination step on a semiconductor wafer is carried out once, the operation can be made more efficient.

[0073] Examples of the dicing tape include plastic films such as a polytetrafluoroethylene film, a polyethylene terephthalate film, a polyethylene film, a polypropylene film, a polymethylpentene film, and a polyimide film, and the like. Furthermore, if necessary, the dicing tape

may be subjected to a surface treatment such as primer application, a UV treatment, a corona discharge treatment, a polishing treatment, or an etching treatment. It is preferable that the dicing tape has tacky adhesiveness. Such a dicing tape may be a product obtained by imparting tacky adhesiveness to the above-mentioned plastic film or may be a product in which a tacky adhesive layer is provided on one surface of the above-mentioned plastic film.

[0074] The adhesive sheet 100 can be formed by applying an adhesive composition on a base material film, similarly to the above-mentioned method for forming a film-form adhesive. The method of applying the adhesive composition on a base material 20 may be similar to the above-mentioned method of applying the adhesive composition on a supporting film.

[0075] The adhesive sheet 100 may be formed using a film-form adhesive that has been produced in advance. In this case, the adhesive sheet 100 can be formed by performing lamination under predetermined conditions (for example, room temperature (20°C) or a heated state) using a roll laminator, a vacuum laminator, or the like. It is preferable that the adhesive sheet 100 is formed using a roll laminator in a heated state, from the viewpoint that production can be carried out continuously, and the efficiency is good.

[0076] The thickness of the film-form adhesive 10 may be 20 to 200 μm , 30 to 200 μm , or 40 to 150 μm , from the viewpoint of the embedding properties for the surface unevenness of a semiconductor chip, a wire, a wiring circuit of a substrate, and the like. When the thickness of the film-form adhesive 10 is 20 μm or more, more sufficient adhesive force

tends to be obtained, and when the thickness of the film-form adhesive 10 is 200 μm or less, it is economically efficient, and it is possible to meet the requirement for the size reduction of semiconductor devices.

[0077] FIG. 3 is a schematic cross-sectional view illustrating an adhesive sheet according to another embodiment. An adhesive sheet 110 further includes a protective film 30 laminated on the surface of the film-form adhesive 10 on the opposite side of the base material 20. The protective film 30 may be a film similar to the above-mentioned supporting film. The thickness of the protective film may be, for example, 15 to 200 μm or 70 to 170 μm .

[0078] [Semiconductor device]

FIG. 4 is a schematic cross-sectional view illustrating a semiconductor device according to an embodiment. The semiconductor device 200 is a semiconductor device in which a first semiconductor element Wa of a first stage is connected by wire bonding onto a substrate 14 by means of a first wire 88, a second semiconductor element Waa is also compression-bonded onto the first semiconductor element Wa by means of a film-form adhesive 10, and thereby at least a portion of the first wire 88 is embedded in the film-form adhesive 10. The semiconductor device may be a wire-embedded type semiconductor device in which at least a portion of the first wire 88 is embedded, or may be a semiconductor device in which the first wire 88 and the first semiconductor element Wa are embedded. Furthermore, in the semiconductor device 200, the substrate 14 and the second semiconductor element Waa are further electrically connected by means of a second wire 98, and also, the second semiconductor element Waa is sealed by a sealing

material 42.

[0079] The thickness of the first semiconductor element Wa may be 10 to 170 μm , and the thickness of the second semiconductor element Waa may be 20 to 400 μm . The first semiconductor element Wa embedded inside the film-form adhesive 10 is a controller chip for driving the semiconductor device 200.

[0080] The substrate 14 is formed from an organic substrate 90 having circuit patterns 84 and 94 respectively formed at two sites each on the surface. The first semiconductor element Wa is compression-bonded onto a circuit pattern 94 by means of an adhesive 41. The second semiconductor element Waa is compression-bonded onto the substrate 14 by means of the film-form adhesive 10 such that a circuit pattern 94 onto which the first semiconductor element Wa is not compression-bonded, the first semiconductor element Wa, and a portion of the circuit pattern 84 are covered. At the level difference of the surface unevenness attributed to the circuit patterns 84 and 94 on the substrate 14, the film-form adhesive 10 is embedded. Further, the second semiconductor element Waa, the circuit pattern 84, and the second wire 98 are sealed by a sealing material 42 made of a resin.

[0081] [Method for producing semiconductor device]

The method for producing a semiconductor device according to the present embodiment includes a first wire bonding step of electrically connecting a first semiconductor element onto a substrate by means of a first wire, a lamination step of sticking the above-mentioned film-form adhesive on one side of a second semiconductor element, and a die bonding step of subjecting the second semiconductor element to which

the film-form adhesive is stuck, to compression-bonding by means of a film-form adhesive, and thereby embedding at least a portion of the first wire in the film-form adhesive.

[0082] FIGS. 5 to 9 are schematic cross-sectional views illustrating a series of steps of the method for producing a semiconductor device according to an embodiment. The semiconductor device 200 according to the present embodiment is a semiconductor device in which a first wire 88 and a first semiconductor element Wa are embedded, and the semiconductor device 200 is produced by the following procedure.

First, as shown in FIG. 5, the first semiconductor element Wa having an adhesive 41 is compression-bonded onto a circuit pattern 94 on a substrate 14, and the circuit pattern 84 on the substrate 14 and the first semiconductor element Wa are electrically connected by bonding by means of the first wire 88 (first wire bonding step).

[0083] Next, the adhesive sheet 100 is laminated on one side of a semiconductor wafer (for example, thickness 100 μm , size: 8 inches), the base material 20 is peeled off, and thereby the film-form adhesive 10 (for example, thickness 110 μm) is stuck on one side of the semiconductor wafer. Then, a dicing tape is pasted together with the film-form adhesive 10, subsequently the assembly is diced into a predetermined size (for example, 7.5 mm on each side), and thereby, as shown in FIG. 6, a second semiconductor element Waa having the film-form adhesive 10 stuck thereto is obtained (lamination step).

[0084] The temperature conditions for the lamination step may be 50°C to 100°C or 60°C to 80°C. When the temperature of the lamination step is 50°C or higher, satisfactory adhesiveness to the semiconductor wafer

can be obtained. When the temperature of the lamination step is 100°C or lower, since the film-form adhesive 10 excessively flowing during the lamination step is suppressed, the occurrence of a change in the thickness and the like can be prevented.

5 [0085] Regarding the dicing method, for example, blade dicing of using a rotating blade, a method of cutting the film-form adhesive or both the wafer and the film-form adhesive using a laser, and the like may be mentioned.

10 [0086] Then, the second semiconductor element Waa having the film-form adhesive 10 stuck thereto is compression-bonded onto the substrate 14, onto which the first semiconductor element Wa is connected by bonding by means of the first wire 88. Specifically, as shown in FIG. 7, the second semiconductor element Waa having the film-form adhesive 10 stuck thereto is placed such that the first wire 88 and the first
15 semiconductor element Wa are covered by the film-form adhesive 10, and subsequently, as shown in FIG. 8, the second semiconductor element Waa is compression-bonded onto the substrate 14. Thereby, the second semiconductor element Waa is fixed to the substrate 14 (die bonding step). In the die bonding step, it is preferable that the film-form
20 adhesive 10 is compression-bonded for 0.5 to 3.0 seconds under the conditions of 80°C to 180°C and 0.01 to 0.50 MPa. After the die bonding step, the film-form adhesive 10 is pressed and heated for 5 minutes or longer under the conditions of 60°C to 175°C and 0.3 to 0.7 MPa.

25 [0087] Next, as shown in FIG. 9, the substrate 14 and the second semiconductor element Waa are electrically connected by means of a

second wire 98 (second wire bonding step), and then the circuit pattern 84, the second wire 98, and the second semiconductor element Waa are sealed with a sealing material 42. By going through such steps, the semiconductor device 200 can be produced.

5 [0088] A semiconductor device as another embodiment may also be a wire-embedded type semiconductor device in which at least a portion of the first wire 88 is embedded.

Examples

10 [0089] Hereinafter, the present invention will be more specifically described by way of Examples. However, the present invention is not intended to be limited to these Examples.

[0090] (Example 1 to 8 and Comparative Examples 1 to 4)

<Production of adhesive sheet>

15 The various components described below were mixed at the mixing ratios (parts by mass) shown in Table 1 and Table 2, and a varnish of an adhesive composition having a solid content of 40% by mass was prepared using cyclohexanone as a solvent. Next, the varnish thus obtained was filtered through a 100-mesh filter and was subjected to vacuum degassing. The varnish after vacuum degassing was applied on
20 a polyethylene terephthalate (PET) film having a thickness of 38 μm that had been subjected to a mold release treatment as a base material film. The varnish thus applied was dried by heating in two stages for 5 minutes at 90°C and subsequently for 5 minutes at 140°C. In this way, an adhesive sheet including a film-form adhesive having a thickness of 110
25 μm in a semi-cured (stage B) state on a base material film was obtained.

[0091] Meanwhile, the various components in Table 1 and Table 2 are as

follows.

[0092] (A) Thermosetting resin

A-1: Epoxy resin having a dicyclopentadiene structure,
manufactured by DIC Corporation, trade name: HP-7200L, epoxy
5 equivalent: 250 to 280 g/eq

A-2: Epoxy resin having a dicyclopentadiene structure,
manufactured by Nippon Kayaku Co., Ltd., trade name: XD-1000, epoxy
equivalent: 254 g/eq

A-3: Alicyclic epoxy resin, manufactured by Daicel Corporation,
10 trade name: EHPE3150, epoxy equivalent: 170 to 190 g/eq

A-4: Polyfunctional aromatic epoxy resin, manufactured by
Printec Corporation, trade name: VG3101L, epoxy equivalent: 210 g/eq

A-5: Cresol novolac type epoxy resin, manufactured by Nippon
Steel & Sumikin Chemical Co., Ltd., trade name: YDCN-700-10, epoxy
15 equivalent: 209 g/eq

A-6: Bisphenol F type epoxy resin (liquid at 25°C), manufactured
by DIC Corporation, trade name: EXA-830CRP, epoxy equivalent: 159
g/eq

(B) Curing agent

20 (B-1) Phenolic resin having alicyclic ring

B-1-1: Phenolic resin having a dicyclopentadiene structure
represented by General Formula (1a), manufactured by JFE Chemical
Corporation, trade name: J-DPP-85, hydroxyl group equivalent: 164 to
167 g/eq, softening point 85°C to 89°C

25 B-1-2: Phenolic resin having a dicyclopentadiene structure
represented by General Formula (1a), manufactured by JFE Chemical

Corporation, trade name: J-DPP-115, hydroxyl group equivalent: 177 to 181 g/eq, softening point 107°C to 116°C

(B-2) Phenolic resin having no alicyclic ring

B-2-1: Bisphenol A novolac type phenolic resin, manufactured by DIC Corporation, trade name: LF-4871, hydroxyl group equivalent: 118 g/eq

B-2-2: Phenyl aralkyl type phenolic resin, manufactured by Mitsui Chemicals, Inc., trade name: XLC-LL, hydroxyl group equivalent: 175 g/eq

B-2-3: Phenyl aralkyl type phenolic resin, manufactured by AIR WATER INC., trade name: HE100C-30, hydroxyl group equivalent: 170 g/eq

(C) Elastomer

C-1: Epoxy group-containing acrylic resin (acrylic rubber), manufactured by Nagase ChemteX Corporation, trade name: SG-P3 solvent-changed product, weight average molecular weight: 800000, glycidyl functional group monomer ratio: 3%, Tg: -7°C

C-2: Acrylic resin (acrylic rubber), manufactured by Nagase ChemteX Corporation, trade name: SG-70L, weight average molecular weight: 900000, acid value: 5 mg KOH/g, Tg: -13°C

C-3: Carboxyl group-containing acrylic resin (acrylic rubber), manufactured by Nagase ChemteX Corporation, trade name: SG-708-6, weight average molecular weight: 700000, acid value: 9 mg KOH/g, Tg: 4°C

(D) Inorganic filler

D-1: Silica filler dispersion liquid, molten silica, manufactured by

Admatechs Company Limited, trade name: SC2050-HLG, average particle size: 0.50 μm

(E) Curing accelerator

E-1: 1-Cyanoethyl-2-phenylimidazole, manufactured by SHIKOKU CHEMICALS CORPORATION, trade name: CUREZOL 2PZ-CN

[0093] <Evaluation of various physical properties>

For the adhesive sheets thus obtained, evaluation of embedding properties and the amount of bleeding was carried out.

[0094] [Evaluation of embedding properties]

The embedding properties of an adhesive sheet were evaluated by producing the following evaluation sample. A base material film of the film-form adhesive (thickness 110 μm) obtained as described above was peeled off, the film-form adhesive was stuck to a dicing tape, and thus a dicing-die bonding integrated type adhesive sheet was produced. Next, a semiconductor wafer (8 inches) having a thickness of 100 μm was prepared, and this was stuck to the adhesive side of the dicing-die bonding integrated type adhesive sheet by heating to 70°C. Subsequently, this semiconductor wafer was diced into a size of 7.5 mm on each side, and thereby a semiconductor chip A was obtained. Next, a semiconductor wafer (8 inches) having a thickness of 50 μm and a dicing-die bonding integrated type adhesive sheet different from the above-described one (manufactured by Hitachi Chemical Co., Ltd., trade name: HR9004-10) (thickness 10 μm) were prepared, and the semiconductor wafer was stuck to the adhesive side of the dicing-die bonding integrated type adhesive sheet by heating to 70°C. Subsequently, this semiconductor wafer was

diced into a size of 4.5 mm on each side, and thereby a die bonding film-attached semiconductor chip B was obtained. Next, a substrate for evaluation having a total thickness of 260 μm and having a solder resist (manufactured by TAIYO NIPPON SANSO CORPORATION, trade name: AUS308) applied thereon was prepared, and the semiconductor chip B and the substrate for evaluation were compression-bonded under the conditions of 120°C, 0.20 MPa, and 2 seconds such that the die bonding film of the semiconductor chip B and the solder resist of the substrate for evaluation were in contact. Subsequently, the semiconductor chip A and the semiconductor chip B were compression-bonded under the conditions of 120°C, 0.20 MPa, and 1.5 seconds such that the film-form adhesive of the semiconductor chip A and the semiconductor wafer of the semiconductor chip B were in contact, and thus an evaluation sample was obtained. At this time, alignment was implemented such that the semiconductor chip B that had been first compression-bonded would come at the center of the semiconductor chip A. The evaluation sample obtained as such was observed to see the presence or absence of voids with an ultrasonic digital image diagnostic apparatus (manufactured by Insight k.k., probe: 75 MHz). In a case in which voids were observed, the proportion of the area of voids per unit area was calculated, and these analysis results were evaluated as the embedding properties. The evaluation criteria are as follows. The results are presented in Table 1 and Table 2.

A: Voids were not observed.

B: Voids were observed; however, the proportion thereof was less than 5% by area.

C: Voids were observed, and the proportion thereof was 5% by area or more.

[0095] [Evaluation of amount of bleeding]

For the samples rated as "A" or "B" in the above-described evaluation for embedding properties, an evaluation of the amount of bleeding was carried out. Evaluation samples for the evaluation of the amount of bleeding were produced similarly to the evaluation samples produced for the above-described evaluation of embedding properties. The amounts of protrusion of the film-form adhesive were measured at the center of the four edges of each evaluation sample using a microscope, and the maximum value was designated as the amount of bleeding. The results are presented in Table 1 and Table 2.

[0096] Table 1

Item		Exam. 1	Comp. Exam. 1	Exam. 2	Comp. Exam. 2	Exam. 3	Comp. Exam. 3
Component (A)	A-1	-	-	-	-	-	-
	A-2	-	-	-	-	-	-
	A-3	-	-	-	-	-	-
	A-4	-	-	20	20	-	-
	A-5	35	35	-	-	20	20
	A-6	-	-	15	15	10	10
Component (B)	B-1-1	15	-	-	-	20	-
	B-1-2	-	-	15	-	-	-
	B-2-1	-	-	-	15	-	-
	B-2-2	-	15	-	-	-	-
	B-2-3	-	-	-	-	-	20
Component (C)	C-1	20	20	20	20	20	20
	C-2	-	-	-	-	-	-
	C-3	-	-	-	-	-	-
Component (D)	D-1	30	30	30	30	30	30
Component (E)	E-1	0.05	0.05	0.05	0.05	0.05	0.05
Embedding properties		B	C	A	B	B	C
Amount of bleeding (µm)		56.3	-	62.7	100.4	52.9	-

[0097] Table 2

Item	Exam. 4	Exam. 5	Exam. 6	Comp. Exam. 4
Component (A)	A-1	-	10	-
	A-2	35	-	-
	A-3	25	-	-
	A-4	-	10	30
	A-5	-	-	-
	A-6	5	10	-
Component (B)	B-1-1	20	20	-
	B-1-2	-	20	-
	B-2-1	-	-	-
	B-2-2	-	-	-
	B-2-3	-	-	25
Component (C)	C-1	15	15	-
	C-2	-	15	15
	C-3	-	5	-
Component (D)	D-1	30	30	30
Component (E)	E-1	0.05	0.05	0.05
Embedding properties	A	B	A	C
Amount of bleeding (µm)	59.5	58.6	63.7	-

[0098] As shown in Table 1 and Table 2, in Examples 1 to 6 including a phenolic resin having an alicyclic ring, bleeding could be suppressed while satisfactory embedding properties were maintained, compared to Comparative Examples 1 to 4 that did not include the epoxy resin. From these results, it was verified that the adhesive compositions according to the present invention are capable of suppressing bleeding while having satisfactory embedding properties at the time of thermocompression bonding.

Industrial Applicability

[0099] As shown from the results given above, since the adhesive composition according to the present invention is excellent from the viewpoint of having satisfactory embedding properties at the time of thermocompression bonding and being capable of suppressing bleeding, a film-form adhesive obtained by forming the adhesive composition into a film form can be useful as a film over die (FOD), which is a chip-embedded type film-form adhesive, or a film over wire (FOW), which is a wire-embedded type film-form adhesive.

Reference Signs List

[0100] 10: film-form adhesive, 14: substrate, 20: base material, 30: protective film, 41: adhesive, 42: sealing material, 84, 94: circuit pattern, 88: first wire, 90: organic substrate, 98: second wire, 100, 110: adhesive sheet, 200: semiconductor device, Wa: first semiconductor element, Waa: second semiconductor element.

CLAIMS

1. A semiconductor device comprising a cured product of an adhesive composition comprising a thermosetting resin, a curing agent, an elastomer, and an inorganic filler,
 - 5 wherein the curing agent comprises a phenolic resin having an alicyclic ring,
the content of the elastomer is 10 to 80 parts by mass with respect to 100 parts by mass of the thermosetting resin, and
wherein the semiconductor device comprises a first semiconductor element connected by wire bonding onto a substrate by means of a first
10 wire, and a second semiconductor element compression-bonded onto the first semiconductor element using the adhesive composition in order to compression-bond the second semiconductor element and also to embed at least a portion of the first wire.
- 15 2. The semiconductor device according to claim 1, wherein the thermosetting resin is an epoxy resin.
3. The semiconductor device according to claim 2, wherein the epoxy resin comprises a bisphenol F type epoxy resin.
4. The semiconductor device according to any one of claims 1 to 3,
20 wherein the elastomer is an acrylic resin.
5. The semiconductor device according to any one of claims 1 to 4, wherein the inorganic filler is silica.
6. The semiconductor device according to any one of claims 1 to 5, wherein the content of the inorganic filler is 25% by mass or more based
25 on the total amount of the adhesive composition.
7. The semiconductor device according to any one of claims 1 to 6,

wherein the content of the sum of the thermosetting resin, the curing agent, the elastomer, and the inorganic filler is 95% by mass or more based on the total amount of the adhesive composition.

5 8. The semiconductor device according to any one of claims 1 to 7, further comprising a curing accelerator.

9. The semiconductor device according to any one of claims 1 to 8, wherein the adhesive composition is formed into a film form.

10 10. A semiconductor device according to claim 9, wherein
the film-form adhesive is provided on a base material, and
wherein the base material is a dicing tape.

11. The semiconductor device according to claim 10, further comprising a protective film laminated on the surface of the film-form adhesive on the opposite side of the base material.

15 12. A method for producing the semiconductor device according to claim 9, the method comprising:

connecting the first semiconductor element onto the substrate by means of the first wire electrically;

sticking the film-form adhesive on one side of the second semiconductor element; and

20 20 subjecting the second semiconductor element having the film-form adhesive stuck thereto, to compression-bonding by means of the film-form adhesive, and thereby embedding at least a portion of the first wire in the film-form adhesive.

25