

DESCRIPTION

Title of Invention

ADHESIVE COMPOSITION, FILM-LIKE ADHESIVE, ADHESIVE
SHEET, AND METHOD FOR PRODUCING SEMICONDUCTOR
5 DEVICE

Technical Field

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

Background Art

10 [0002] Conventionally, silver pastes have been mainly used for joining
a semiconductor element and a support member for semiconductor
element mounting. However, along with the increase in size of
semiconductor elements and the size reduction and performance
15 enhancement of semiconductor packages in recent years, size reduction
and fine miniaturization are also required for the support members for
semiconductor element mounting to be used. Such a requirement
cannot be sufficiently coped with by silver pastes, due to inconvenience
at the time of wire bonding, difficulties in thickness control, void
20 generation, and the like, which occur as a result of wet-spreading
properties, squeeze-out, inclination of semiconductor elements, and the
like. Therefore, in recent years, adhesive sheets including a
film-shaped adhesive have been used instead of silver pastes (see, for
example, Patent Literatures 1 and 2). Such adhesive sheets are used
25 for methods for producing semiconductor devices, such as an individual
piece sticking method and a wafer backside sticking method.

[0003] In a case in which a semiconductor device is produced by an individual piece sticking method, first, an adhesive sheet in a reel form is cut into individual pieces by cutting or punching, and then a film-shaped adhesive and a support member for semiconductor element mounting are stuck together. Subsequently, semiconductor elements that have been divided into individual pieces by a dicing step are joined with the film-shaped adhesive-attached support member for semiconductor element mounting. Subsequently, a semiconductor device is produced through assembling steps such as wire bonding and sealing (see, for example, Patent Literature 3). However, in the case of the individual piece sticking method, there is a problem that a dedicated assembling apparatus for cutting an adhesive sheet and adhering the cut adhesive sheet to a support member for semiconductor element mounting is required, and the production cost is high compared to the method of using a silver paste.

[0004] On the other hand, in a case in which a semiconductor device is produced by the wafer backside sticking method, first, a film-shaped adhesive is stuck to the backside of a semiconductor wafer, and then a dicing sheet is stuck to the other side of the film-shaped adhesive. Subsequently, the semiconductor wafer is divided into individual pieces by dicing, in a state of having the film-shaped adhesive stuck thereto to produce semiconductor elements. Next, the film-shaped adhesive-attached semiconductor elements are picked up and are joined to a support member for semiconductor element mounting. Subsequently, a semiconductor device is produced through assembling steps such as wire bonding and sealing (see, for example, Patent

Literature 4). In this wafer backside sticking method, unlike the individual piece sticking method, a conventional assembling apparatus for silver paste can be used as it is, or can be used after having some parts improved by adding a hot plate or the like, without requiring a dedicated assembling apparatus. Therefore, the wafer backside sticking method tends to be able to relatively suppress the production cost among the methods for producing a semiconductor device using an adhesive sheet.

[0005] In the wafer backside sticking method, from the viewpoint of simplifying the assembling steps, an adhesive sheet obtained by sticking (laminating) a dicing sheet on one surface of a film-shaped adhesive, that is, an adhesive sheet having a function as a dicing sheet and a function as a die bond film in combination (hereinafter, may be referred to as "dicing-die bonding integrated adhesive sheet"), may be used.

When such a dicing-die bonding integrated adhesive sheet is used, sticking the dicing sheet together can be simplified, and a risk of wafer cracking can be reduced. The softening temperature of a dicing sheet is usually 100°C or lower. Therefore, the dicing-die bonding integrated adhesive sheet is required to be stickable to a semiconductor wafer at a temperature lower than 100°C in consideration of the softening temperature of the dicing sheet or the warpage of the semiconductor wafer, and particularly from the viewpoint of suppressing warpage of the semiconductor wafer, the dicing-die bonding integrated adhesive sheet is required to be stickable to a semiconductor wafer at 40°C to 80°C.

[0006] However, when a semiconductor element is connected by wire

bonding, dislocation or detachment may occur between the semiconductor element and a support member for semiconductor element mounting. This is speculated to occur because at a temperature near 175°C, which is a conventional bonding temperature, the film-shaped adhesive adhering the semiconductor element and the support member for semiconductor element mounting becomes soft and is therefore deformed. This phenomenon can become a bigger problem concomitantly as the areas of semiconductor elements become smaller. Therefore, the film-shaped adhesive after curing of the dicing-die bonding integrated adhesive sheet is required to have a sufficiently high-temperature storage modulus (for example, the storage modulus at 175°C is 100 MPa or higher) and a sufficiently high glass transition temperature (for example, the glass transition temperature is 190°C or higher), as wire bonding characteristics.

[0007] Thus far, in order to satisfy the sticking characteristics to semiconductor wafers at low temperatures (low-temperature stickability) and the wire bonding characteristics, an adhesive composition combining a thermoplastic resin having a relatively low glass transition temperature (T_g) and a thermosetting resin has been proposed (see, for example, Patent Literature 5).

Citation List

Patent Literature

[0008] Patent Literature 1: JP No. H3-192178

Patent Literature 2: JP No. H4-234472

Patent Literature 3: JP No. H9-017810

Patent Literature 4: JP No. H4-196246

Summary of Invention

Technical Problem

[0009] However, along with the decrease in area of semiconductor elements, the high-temperature storage modulus of the film-shaped adhesive required at the time of wire bonding is ever increasing, and the film-shaped adhesive is required to have a further improvement of characteristics.

[0010] Thus, it is a main object of the present invention to provide an adhesive composition which has excellent low-temperature stickability when formed into a film-shaped adhesive, and which is capable of forming a cured product having a sufficient high-temperature storage modulus and having a sufficient glass transition temperature.

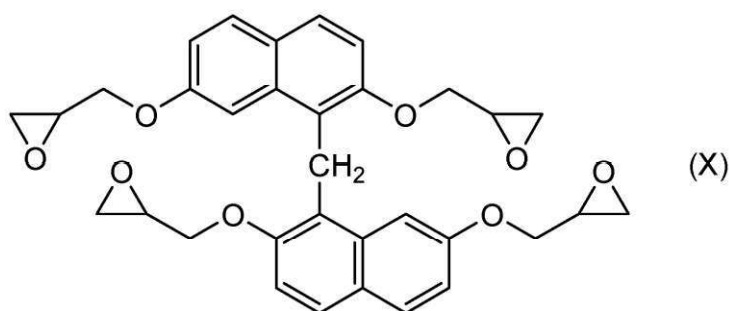
Solution to Problem

[0011] According to an aspect of the present invention, there is provided an adhesive composition containing an epoxy resin, a phenolic resin, an elastomer, and a filler, wherein a content of the filler is 40% to 68% by mass based on the total amount of the epoxy resin, the phenolic resin, the elastomer, and the filler, and the epoxy resin includes an epoxy resin having a naphthalene skeleton. According to such an adhesive composition, the adhesive composition has excellent low-temperature stickability when formed into a film-shaped adhesive and is capable of forming a cured product having a sufficient high-temperature storage modulus and having a sufficient glass transition temperature.

[0012] The epoxy resin having a naphthalene skeleton may be an epoxy

resin having a tetrafunctional or higher-functional epoxy group. The content of the epoxy resin having a naphthalene skeleton may be 14% to 30% by mass based on the total amount of the epoxy resin and the phenolic resin. The epoxy resin having a naphthalene skeleton may include an epoxy resin represented by the following Formula (X):

[0013]



[0014] The adhesive composition according to an aspect of the present invention may be used for a semiconductor device in which a first semiconductor element is connected by wire bonding onto a substrate through a first wire, and a second semiconductor element is pressure-bonded onto the first semiconductor element, in order to pressure-bond the second semiconductor element and to embed at least a portion of the first wire.

[0015] The present invention may also relate to an application (use) as an adhesive or an application (use) for the production of an adhesive, of a composition containing an epoxy resin, a phenolic resin, an elastomer, and a filler, in which a content of the filler is 40% to 68% by mass based on the total amount of the epoxy resin, the phenolic resin, the elastomer, and the filler, and the epoxy resin includes an epoxy resin having a naphthalene skeleton, in a semiconductor device in which a first semiconductor element is connected by wire bonding onto a substrate

through a first wire, and a second semiconductor element is pressure-bonded onto the first semiconductor element, the composition being used in order to pressure-bond the second semiconductor element and to embed at least a portion of the first wire.

5 [0016] According to another aspect of the present invention, there is provided a film-shaped adhesive obtained by forming the above-described adhesive composition into a film shape.

[0017] According to still another aspect of the present invention, there is provided an adhesive sheet comprising a base material and the
10 film-shaped adhesive provided on the base material.

[0018] The base material may be a dicing tape. An adhesive sheet in which the base material is a dicing tape may be referred to as "dicing-die bonding integrated adhesive sheet".

[0019] According to still another aspect of the present invention, there
15 is provided a method for producing a semiconductor device, the method comprising: a wire bonding step of electrically connecting a first semiconductor element onto a substrate through a first wire; a lamination step of sticking the above-described film-shaped adhesive to one surface of a second semiconductor element; and a die bonding step
20 of pressure-bonding the second semiconductor element having the film-shaped adhesive stuck thereto, with the film-shaped adhesive interposed, so as to embed at least a portion of the first wire in the film-shaped adhesive.

[0020] Incidentally, since the semiconductor device is such that a first
25 semiconductor element is connected by wire bonding onto a semiconductor substrate through a first wire, and at the same time, a

second semiconductor element is pressure-bonded onto the first semiconductor element, with a film-shaped adhesive interposed therebetween, the semiconductor device may be a wire-embedded type semiconductor device having at least a portion of the first wire embedded in the film-shaped adhesive, or may be a semiconductor element (semiconductor chip)-embedded type semiconductor device having the first wire and the first semiconductor element embedded in the film-shaped adhesive.

Advantageous Effects of Invention

[0021] According to the present invention, the present invention provides an adhesive composition that exhibits excellent low-temperature stickability when formed into a film-shaped adhesive and is also capable of forming a cured product having a sufficient high-temperature storage modulus and having a sufficient glass transition temperature. A film-shaped adhesive obtained by forming the adhesive composition into a film shape can be useful as an FOD (Film Over Die), which is a semiconductor element (semiconductor chip)-embedded type film-shaped adhesive, or an FOW (Film Over Wire), which is a wire-embedded type film-shaped adhesive. Furthermore, according to the present invention, an adhesive sheet produced using such a film-shaped adhesive, and a method for producing a semiconductor device by using such a film-shaped adhesive are provided.

Brief Description of Drawings

[0022] FIG. 1 is a schematic cross-sectional view illustrating a film-shaped adhesive according to an embodiment.

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

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

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

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.

10 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.

15 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.

20 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

[0023] 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
25 embodiments.

[0024] 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 (meth)acryloyl group.

[0025] [Adhesive composition]

5 The adhesive composition according to an embodiment contains (A) an epoxy resin, (B) a phenolic resin, (C) an elastomer, and (D) a filler. The adhesive composition is thermosetting and can go through a semi-cured (stage B) state and then reach a completely cured product (stage C) state after a curing treatment.

10 [0026] <Component (A): Epoxy resin>

 Component (A) includes (A-1) an epoxy resin having a naphthalene skeleton.

[0027] Regarding the component (A-1), any compound having a naphthalene skeleton can be used without particular limitation.

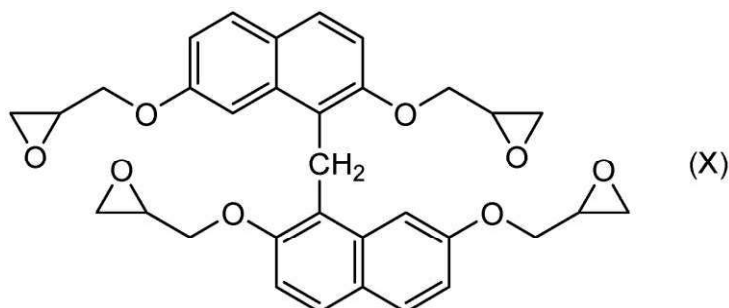
15 Regarding the component (A-1), one kind thereof may be used alone, or two or more kinds thereof may be used in combination. As the component (A) includes the component (A-1), a cured product of the adhesive composition can have a sufficient high-temperature storage modulus and have a sufficient glass transition temperature. The
20 component (A-1) may be an epoxy resin having a tetrafunctional or higher-functional epoxy group.

[0028] Examples of a commercially available product of the component (A-1) include "HP-4700", "HP-4710", "HP-4770" (trade names, all manufactured by DIC Corporation), "NC-7000-L", and "NC-7300-L" (trade names, all manufactured by Nippon Kayaku Co., Ltd.).
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[0029] The component (A-1) may include, for example, an epoxy resin

represented by the following Formula (X).

[0030]



[0031] The softening point of the component (A-1) may be 30°C or higher, from the viewpoint that a cured product of an adhesive composition having a more sufficient high-temperature storage modulus and having a sufficient glass transition temperature tends to be obtained. The softening point of the component (A-1) may be 40°C or higher, 80°C or higher, or 90°C or higher, and may be 120°C or lower, 110°C or lower, or 100°C or lower.

[0032] The epoxy equivalent of the component (A-1) is not particularly limited; however, the epoxy equivalent may be 10 to 600 g/eq, 100 to 500 g/eq, or 120 to 450 g/eq. When the epoxy equivalent of the component (A-1) is in such a range, more satisfactory reactivity and fluidity tend to be obtained.

[0033] The content of the component (A-1) may be 20% to 80% by mass, 30% to 70% by mass, or 30% to 60% by mass based on the total amount of the component (A).

[0034] Regarding the content of the component (A-1), from the viewpoint that superior low-temperature stickability is obtained when the adhesive composition is formed into a film-shaped adhesive, and a more sufficient high-temperature storage modulus tends to be obtained

for a cured product of an adhesive composition, the content may be 14% to 30% by mass based on the total amount of the component (A) and the component (B). The content of the component (A-1) may be 15% by mass or more or 18% by mass or more, and may be 25% by mass or less or 22% by mass or less, all based on the total amount of the component (A) and the component (B).

[0035] The component (A) may include (A-2) an epoxy resin that does not have a naphthalene skeleton, in addition to the component (A-1). Examples of the component (A-2) include diglycidyl ether compounds of polycyclic aromatics such as 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 phenyl aralkyl type epoxy resin, a biphenyl aralkyl type epoxy resin, a polyfunctional phenol, and anthracene (however, naphthalene is excluded). These may be used singly or in combination of two or more kinds thereof. The component (A-2) may be a bisphenol type epoxy resin.

[0036] The epoxy equivalent of the component (A-2) 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-2) is in such a range, more satisfactory reactivity and fluidity tend to be obtained.

[0037] The content of the component (A-2) may be 80% to 20% by mass, 70% to 30% by mass, or 70% to 40% by mass based on the total amount of the component (A).

[0038] The content of the component (A) may be 10% to 50% by mass based on the total amount of the component (A), component (B), component (C), and component (D). The content of the component (A) may be 12% by mass or more, 15% by mass or more, or 18% by mass or more, and may be 40% by mass or less, 30% by mass or less, or 25% by mass or less, all based on the total amount of the component (A), component (B), component (C), and component (D).

[0039] <Component (B): Phenolic resin>

Regarding the component (B), any compound having a phenolic hydroxyl group in the molecule can be used without particular limitation. Examples of the component (B) include 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, and a compound having an aldehyde group, such as formaldehyde, in the presence of an acidic catalyst; a phenol aralkyl resin synthesized from a phenol such as allylated bisphenol A, allylated bisphenol F, allylated naphthalenediol, phenol novolac, or phenol, and/or a naphthol and dimethoxyparaxylene or bis(methoxymethyl)biphenyl; a naphthol aralkyl resin, a biphenyl aralkyl type phenolic resin, and a phenyl aralkyl type phenolic resin. These may be used singly or in combination of two or more kinds thereof. The component (B) may be a novolac type phenolic resin.

[0040] Examples of a commercially available product of the component (B) include RESITOP series (manufactured by Gun Ei Chemical Industry Co., Ltd.), PHENOLITE KA series, TD series (manufactured by DIC Corporation), MILEX XLC series, LX series (manufactured by Mitsui Chemicals, Inc.), and HE series (manufactured by Air Water, Inc.).

[0041] The hydroxyl group equivalent of the component (B) 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) is in such a range, more satisfactory reactivity and fluidity tend to be obtained.

[0042] The ratio of the epoxy equivalent of the component (A) and the hydroxyl group equivalent of the component (B) (epoxy equivalent of component (A)/hydroxyl group equivalent of component (B)) 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, excessive increase of viscosity can be prevented, and more sufficient fluidity can be obtained.

[0043] The content of the component (B) may be 5% to 30% by mass based on the total amount of the component (A), component (B), component (C), and component (D). The content of the component (B) may be 8% by mass or more, 10% by mass or more, or 12% by mass or more, and may be 25% by mass or less, 20% by mass or less, or 18% by mass or less, all based on the total amount of the component

(A), component (B), component (C), and component (D).

[0044] <Component (C): Elastomer>

Examples of the component (C) include a polyimide resin, an acrylic resin, a urethane resin, a polyphenylene ether resin, a polyetherimide resin, a phenoxy resin, and a modified polyphenylene ether resin, and compounds having crosslinkable functional groups may be mentioned. Among these, the component (C) may be an acrylic resin. An acrylic resin means a polymer including a constituent unit derived from a (meth)acrylic acid ester. The acrylic resin may be a polymer including a constituent unit derived from a (meth)acrylic acid ester having a crosslinkable functional group such as an epoxy group, an alcoholic or phenolic hydroxyl group, or a carboxy 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. Regarding the acrylic resin, one kind thereof may be used alone, or two or more kinds thereof may be used in combination.

[0045] Examples of a commercially available product of the acrylic resin include "SG-70L", "SG-708-6", "WS-023 EK30", "SG-280 EK23", "HTR-860P-3", "HTR-860P-3CSP", and "HTR-860P-3CSP-3DB" (trade names, all manufactured by Nagase ChemteX Corporation).

[0046] The glass transition temperature (T_g) of the component (C) may be -50°C to 50°C or -30°C to 20°C. When the T_g of the component (C) is -50°C or higher, tackiness after forming a film-shaped adhesive is lowered, and handleability tends to be further enhanced. When the T_g of the component (C) is 50°C or lower, fluidity of the adhesive

composition tends to be more sufficiently secured. Here, the glass transition temperature (T_g) of the component (C) means a value measured using DSC (thermal differential scanning calorimeter) (for example, "Thermo Plus 2" manufactured by Rigaku Corporation).

[0047] The weight average molecular weight (M_w) of the component (C) may be 50000 to 1200000, 100000 to 1200000, or 300000 to 900000. When the M_w of the component (C) is 50000 or more, the film-forming properties tend to be superior. When the M_w of the component (C) is 1200000 or less, fluidity tends to be superior. Incidentally, the M_w is a value measured by gel permeation chromatography (GPC) and converted using a calibration curve based on polystyrene standards.

[0048] The measuring apparatus, measurement conditions, and the like of the M_w of the component (C) are as follows.

Pump: L-6000 (manufactured by Hitachi, Ltd.)

Column: Columns having Gelpack GL-R440 (manufactured by Hitachi Chemical Co., Ltd.), Gelpack GL-R450 (manufactured by Hitachi Chemical Co., Ltd.), and Gelpack GL-R400M (manufactured by Hitachi Chemical Co., Ltd.) (each 10.7 mm (diameter) × 300 mm) connected in this order

Eluent: Tetrahydrofuran (THF)

Sample: Solution obtained by dissolving 120 mg of a sample in 5 mL of THF

Flow rate: 1.75 mL/min

[0049] The content of the component (C) may be 5% to 20% by mass based on the total amount of the component (A), component (B),

component (C), and component (D). The content of the component (C) may be 8% by mass or more, 10% by mass or more, or 12% by mass or more, and may be 19% by mass or less, 18% by mass or less, or 17% by mass or less, all based on the total amount of the component (A), component (B), component (C), and component (D). When the content of the component (C) is 5% by mass or more, the low-temperature stickability tends to be superior when the adhesive composition is formed into a film-shaped adhesive. When the content of the component (C) is 20% by mass or less, a more sufficient high-temperature storage modulus tends to be obtained for a cured product of the adhesive composition.

[0050] <Component (D): Filler>

The component (D) may be an inorganic filler. Examples of the component (D) 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, and amorphous silica. These may be used singly or in combination of two or more kinds thereof. Among these, the component (D) may include silica.

[0051] The average particle size of the component (D) may be 0.005 to 2.0 μm , 0.005 to 1.5 μm , or 0.005 to 1.0 μm , from the viewpoint that adhesiveness is further enhanced. Here, the average particle size means a value that can be determined by converting from the BET specific surface area.

[0052] The component (D) may have the surface treated by 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-based coupling agent. Examples of a functional group of the silane-based 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, and an ethoxy group.

[0053] The content of the component (D) is 40% to 68% by mass based on the total amount of the component (A), component (B), component (C), and component (D). The content of the component (D) may be 45% by mass or more, 48% by mass or more, or 50% by mass or more, and may be 65% by mass or less, 60% by mass or less, or 55% by mass or less, all based on the total amount of the component (A), component (B), component (C), and component (D). When the content of the component (D) is 40% by mass or more, a more sufficient high-temperature storage modulus tends to be obtained for a cured product of the adhesive composition. When the content of the component (D) is 68% by mass or less, the low-temperature stickability tends to be excellent when the adhesive composition is formed into a film-shaped adhesive.

[0054] <Component (E): Curing accelerator>

The adhesive composition may further contain component (E). As the adhesive composition contains component (E), adhesiveness and connection reliability tend to be attained in a well-balanced manner. Examples of the component (E) include imidazoles and derivatives thereof, organic phosphorus-based compounds, secondary amines,

tertiary amines, and quaternary ammonium salts. 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 imidazoles and derivatives thereof.

5 [0055] Examples of the imidazoles include 2-methylimidazole, 1-benzyl-2-methylimidazole, 1-cyanoethyl-2-phenylimidazole, and 1-cyanoethyl-2-methylimidazole. These may be used singly or in combination of two or more kinds thereof.

10 [0056] The content of the component (E) may be 0.01% to 0.15% by mass based on the total amount of the component (A), component (B), component (C), and component (D). When the content of the component (E) is in such a range, adhesiveness and connection reliability tend to be attained in a well-balanced manner.

[0057] <Component (F): Coupling agent>

15 The adhesive composition may further contain component (F). As the adhesive composition contains component (F), there is a tendency that the interfacial binding between heterogeneous components can be further increased. Examples of the component (F) include a silane-based coupling agent, a titanate-based coupling agent, and an aluminum-based coupling agent. These may be used singly or in combination of two or more kinds thereof. Among these, the component (F) may be a silane-based coupling agent.

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[0058] Examples of the silane-based coupling agent include vinyltrichlorosilane, vinyltriethoxysilane, vinyltris(β -methoxyethoxy)silane, γ -methacryloxypropyltrimethoxysilane,

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β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane,
 γ -glycidoxypropyltrimethoxysilane,
 γ -glycidoxypropylmethyldimethoxysilane, vinyltriacetoxysilane,
 γ -mercaptopropyltrimethoxysilane, γ -aminopropyltrimethoxysilane,
5 γ -aminopropylmethyldimethoxysilane, γ -aminopropyltriethoxysilane,
 γ -aminopropylmethyldiethoxysilane, γ -anilinopropyltrimethoxysilane,
 γ -anilinopropyltriethoxysilane,
 γ -(N,N-dimethyl)aminopropyltrimethoxysilane,
 γ -(N,N-diethyl)aminopropyltrimethoxysilane,
10 γ -(N,N-dibutyl)aminopropyltrimethoxysilane,
 γ -(N-methyl)anilinopropyltrimethoxysilane,
 γ -(N-ethyl)anilinopropyltrimethoxysilane,
 γ -(N,N-dimethyl)aminopropyltriethoxysilane,
 γ -(N,N-diethyl)aminopropyltriethoxysilane,
15 γ -(N,N-dibutyl)aminopropyltriethoxysilane,
 γ -(N-methyl)anilinopropyltriethoxysilane,
 γ -(N-ethyl)anilinopropyltriethoxysilane,
 γ -(N,N-dimethyl)aminopropylmethyldimethoxysilane,
 γ -(N,N-diethyl)aminopropylmethyldimethoxysilane,
20 γ -(N,N-dibutyl)aminopropylmethyldimethoxysilane,
 γ -(N-methyl)anilinopropylmethyldimethoxysilane,
 γ -(N-ethyl)anilinopropylmethyldimethoxysilane,
N-(trimethoxysilylpropyl)ethylenediamine,
N-(dimethoxymethylsilylisopropyl)ethylenediamine,
25 methyltrimethoxysilane, dimethyldimethoxysilane,
methyltriethoxysilane, γ -chloropropyltrimethoxysilane,

hexamethyldisilane, vinyltrimethoxysilane,
γ-mercaptopropylmethyldimethoxysilane, and
γ-ureidopropyltriethoxysilane.

[0059] The content of the component (F) may be 0.1% to 5.0% by mass
5 based on the total amount of the component (A), component (B),
component (C), and component (D). When the content of the
component (F) is in such a range, there is a tendency that the interfacial
binding between heterogeneous components can be increased.

[0060] <Other components>

10 The adhesive composition may further contain an oxidation
inhibitor, a rheology control agent, a leveling agent, and the like as other
components. The content of these components may be 0.01% to 3%
by mass based on the total amount of the component (A), component
(B), component (C), and component (D).

15 [0061] The adhesive composition may be used as a varnish of the
adhesive composition diluted with a solvent. The solvent is not
particularly limited so long as the solvent can dissolve components
other than the component (D). Examples of the solvent include
aromatic hydrocarbons such as toluene, xylene, mesitylene, cumene,
20 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
25 acetate, butyl acetate, methyl lactate, ethyl lactate, and γ-butyrolactone;
carbonic acid esters such as ethylene carbonate and propylene

carbonate; and amides such as N,N-dimethylformamide, N,N-dimethylacetamide, and N-methyl-2-pyrrolidone. These may be used singly or in combination of two or more kinds thereof. Among these, from the viewpoint of solubility and boiling point, the solvent may be toluene, xylene, methyl ethyl ketone, methyl isobutyl ketone, or cyclohexanone.

[0062] The solid component concentration in the varnish of the adhesive composition may be 10% to 80% by mass based on the total amount of the varnish of the adhesive composition.

[0063] The varnish of the adhesive composition can be prepared by mixing and kneading the component (A) to component (F), a solvent, and other components. Incidentally, the order of mixing and kneading of the various components is not particularly limited and can be appropriately set. Mixing and kneading can be carried out by appropriately combining conventional dispersing machines such as a stirrer, a Raikai mixer, a three-roll, a ball mill, and a bead mill.

After the varnish of the adhesive composition is prepared, air bubbles in the varnish may be removed by vacuum defoaming or the like.

[0064] [Film-shaped adhesive]

FIG. 1 is a schematic cross-sectional view illustrating a film-shaped adhesive according to an embodiment. The film-shaped adhesive 10 is obtained by forming the above-described adhesive composition into a film shape. The film-shaped adhesive 10 may be in a semi-cured (stage B) state. Such a film-shaped adhesive 10 can be formed by applying the adhesive composition on a support film. In the

case of using a varnish of the adhesive composition, the film-shaped adhesive 10 can be formed by applying the varnish of the adhesive composition on a support film and removing the solvent by heating and drying.

5 [0065] Examples of the support film include films of polytetrafluoroethylene, polyethylene, polypropylene, polymethylpentene, polyethylene terephthalate, and polyimide. The thickness of the support film may be, for example, 10 to 200 μm or 20 to 170 μm .

10 [0066] Regarding the method of applying a varnish of the adhesive composition on a support 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, and a curtain coating method. The conditions for heating and drying are not
15 particularly limited so long as the conditions are conditions in which the solvent used can be sufficiently volatilized; however, for example, the conditions for heating and drying may be 50°C to 200°C for 0.1 to 90 minutes.

[0067] The thickness of the film-shaped adhesive can be appropriately
20 adjusted according to the use application. The thickness of the film-shaped adhesive may be 5 to 200 μm , 10 to 110 μm , or 15 to 80 μm , from the viewpoint of sufficiently embedding the surface unevenness and the like of a semiconductor element (semiconductor chip), a wire, a wiring circuit of a substrate, and the like.

25 [0068] The storage modulus at 175°C of a cured product of a film-shaped adhesive obtainable by heating the film-shaped adhesive for

one hour at 110°C and then for one hour at 170°C may be 100 MPa or higher, 200 MPa or higher, 500 MPa or higher, or 1000 MPa or higher. When the storage modulus at 175°C of the cured product of the film-shaped adhesive is 100 MPa or higher, dislocation or detachment between a semiconductor element and a support member for semiconductor element mounting can be suppressed. The storage modulus at 175°C of a cured product of the film-shaped adhesive may be, for example, 2000 MPa or lower. The storage modulus at 175°C of a cured product of the film-shaped adhesive means a value measured according to the method described in Examples.

[0069] The glass transition temperature (T_g) of a cured product of a film-shaped adhesive obtainable by heating the film-shaped adhesive for one hour at 110°C and then for one hour at 170°C may be 190°C or higher, or may be 195°C or higher, 200°C or higher, or 205°C or higher. When the glass transition temperature (T_g) of the cured product of the film-shaped adhesive is 190°C or higher, dislocation or detachment between a semiconductor element and a support member for semiconductor element mounting can be suppressed. The glass transition temperature (T_g) of a cured product of the film-shaped adhesive may be, for example, 250°C or lower. The glass transition temperature (T_g) of a cured product of the film-shaped adhesive means a value measured according to the method described in Examples.

[0070] [Adhesive sheet]

FIG. 2 is a schematic cross-sectional view illustrating an adhesive sheet according to an embodiment. The adhesive sheet 100 comprises a base material 20 and the above-described film-shaped

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. Examples of the base material film include those listed as examples of the support film as described above.

[0072] The base material 20 may be a dicing tape. Such an adhesive sheet can be used as a dicing-die bonding integrated adhesive sheet. In this case, since the lamination step on a semiconductor wafer needs to be performed 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. Furthermore, the dicing tape may be subjected to a surface treatment such as primer coating, a UV treatment, a corona discharge treatment, a polishing treatment, or an etching treatment, as necessary. The dicing tape may be a tape having tacky adhesiveness. Such a dicing tape may be a product obtained by imparting tacky adhesiveness to the above-described plastic film or may be a product obtained by providing a tacky adhesive layer on one surface of the above-described plastic film.

[0074] The adhesive sheet 100 can be formed by applying the adhesive composition on a base material film, similarly to the above-described method of forming the film-shaped adhesive. The method of applying the adhesive composition on a base material 20 may be similar to the above-described method of applying the adhesive composition on a support film.

[0075] The adhesive sheet 100 may also be formed using a film-shaped adhesive that has been produced in advance. In this case, the adhesive sheet 100 can be formed by performing lamination using a roll laminator, a vacuum laminator, or the like under predetermined conditions (for example, room temperature (20°C) or a heated state). The adhesive sheet 100 can be continuously produced, and in view of being highly efficient, it is preferable that the adhesive sheet is formed using a roll laminator in a heated state.

[0076] FIG. 3 is a schematic cross-sectional view illustrating an adhesive sheet according to another embodiment. The adhesive sheet 110 further comprises a protective film 30 laminated on a surface of the film-shaped adhesive 10, the surface being on the opposite side of the base material 20. Examples of the protective film 30 include those listed as examples of the above-described support film. The thickness of the protective film may be, for example, 10 to 200 μm or 20 to 170 μm.

[0077] [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 to a support member for semiconductor element mounting 14 through a first wire 88, and at the same time, a second semiconductor element Waa is pressure-bonded onto the first semiconductor element Wa, with a film-shaped adhesive 10 interposed therebetween, so that at least a portion of the first wire 88 is embedded in the film-shaped 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 support member for semiconductor element mounting 14 and the second semiconductor element Waa are further electrically connected through a second wire 98, and also, the second semiconductor element Waa is sealed by a sealing material 42.

[0078] 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-shaped adhesive 10 may be a controller chip for driving the semiconductor device 200.

[0079] The support member for semiconductor element mounting 14 comprises an organic substrate 90 having two each of circuit patterns 84 and 94 formed on the surface. The first semiconductor element Wa is pressure-bonded onto the circuit pattern 94, with an adhesive 41 interposed therebetween. The second semiconductor element Waa is pressure-bonded to the support member for semiconductor element mounting 14, with the film-shaped adhesive 10 interposed therebetween, such that the circuit pattern 94 to which the first semiconductor element Wa is not pressure-bonded, the first semiconductor element Wa, and a portion of the circuit patterns 84 are covered. The film-shaped adhesive 10 is embedded in the level difference of the surface unevenness attributed to the circuit patterns 84 and 94 on the support member for semiconductor element mounting 14.

Then, the second semiconductor element Waa, the circuit pattern 84, and the second wire 98 are sealed by a resin sealing material 42.

[0080] [Method for producing semiconductor device]

A method for producing a semiconductor device according to the present embodiment comprises a first wire bonding step of electrically connecting a first semiconductor element onto a substrate through a first wire; a lamination step of sticking the above-described film-shaped adhesive on one surface of a second semiconductor element; and a die bonding step of pressure-bonding the second semiconductor element having the film-shaped adhesive stuck thereto, with the film-shaped adhesive interposed, so as to embed at least a portion of the first wire in the film-shaped adhesive.

[0081] FIG. 5, FIG. 6, FIG. 7, FIG. 8, and FIG. 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 the first wire 88 and the first semiconductor element Wa are embedded, and the semiconductor device 200 is produced by the following order. First, as shown in FIG. 5, a first semiconductor element Wa having an adhesive 41 is pressure-bonded onto a circuit pattern 94 of a support member for semiconductor element mounting 14, and a circuit pattern 84 on the support member for semiconductor element mounting 14 and the first semiconductor element Wa are electrically connected by bonding through a first wire 88 (first wire bonding step).

[0082] Next, an adhesive sheet 100 is laminated on one surface of a

semiconductor wafer (for example, thickness 100 μm , size 8 inches), and the film-shaped adhesive 10 (for example, thickness 110 μm) is stuck to the one surface of the semiconductor wafer by peeling the base material 20. Then, the film-shaped adhesive 10 and a dicing tape are stuck together, and then the assembly is diced into a predetermined size (for example, 7.5 mm on each side) to obtain a second semiconductor element Waa having the film-shaped adhesive 10 stuck thereto, as shown in FIG. 6 (lamination step).

[0083] 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 tight adhesiveness to a semiconductor wafer can be obtained. When the temperature of the lamination step is 100°C or lower, since excessive flowing of the film-shaped adhesive 10 during the lamination step is suppressed, the lamination step causing a change in thickness or the like can be prevented.

[0084] Examples of the dicing method include blade dicing of using a rotating blade, and a method of cutting the film-shaped adhesive or both the wafer and the film-shaped adhesive by using a laser.

[0085] Then, the second semiconductor element Waa having the film-shaped adhesive 10 stuck thereto is pressure-bonded to the support member for semiconductor element mounting 14, to which the first semiconductor element Wa is connected by bonding through the first wire 88. Specifically, as shown in FIG. 7, the second semiconductor element Waa having the film-shaped adhesive 10 stuck thereto is placed such that the first wire 88 and the first semiconductor element Wa are

covered by the film-shaped adhesive 10, and then the second semiconductor element Waa is fixed to the support member for semiconductor element mounting 14 by pressure-bonding the second semiconductor element Waa to the support member for semiconductor element mounting 14, as shown in FIG. 8 (die bonding step). The die bonding step may be a step of pressure-bonding the film-shaped adhesive 10 under the conditions of 80°C to 180°C and 0.01 to 0.50 MPa for 0.5 to 3.0 seconds. After the die bonding step, the film-shaped adhesive 10 may be pressure-bonded under the conditions of 60°C to 175°C and 0.3 to 0.7 MPa for 5 minutes or longer.

[0086] Next, as shown in FIG. 9, the support member for semiconductor element mounting 14 and the second semiconductor element Waa are electrically connected through 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 by a sealing material 42. By going through such steps, the semiconductor device 200 can be produced.

[0087] As another embodiment, the semiconductor device may be a wire-embedded type semiconductor device in which at least a portion of the first wire 88 is embedded.

Examples

[0088] Hereinafter, the present invention will be described more specifically by way of Examples. However, the present invention is not intended to be limited to these Examples.

[0089] (Examples 1 to 5 and Comparative Examples 1 to 3)

<Production of adhesive sheet>

Varnishes of adhesive compositions were prepared by the following procedure using the various components and contents thereof indicated in Table 1. First, (A) an epoxy resin, (B) a phenolic resin, and (D) a filler were blended, cyclohexanone was added to this, and the mixture was stirred. Subsequently, (C) an elastomer, (E) a curing accelerator, and (F) a coupling agent were added thereto, the mixture was stirred until the various components became uniform, and thereby a varnish of an adhesive composition having a solid content of 40% by mass was obtained.

[0090] Incidentally, the various components in Table 1 are as follows.

[0091] Component (A): Epoxy resin

Component (A-1): Epoxy resin having a naphthalene skeleton

HP-4710 (epoxy resin represented by the above-described Formula (X), manufactured by DIC Corporation, trade name "HP-4710", softening point: 95°C, epoxy equivalent: 170 g/eq)

Component (A-2): Epoxy resin that does not have a naphthalene skeleton

YDF-8170C (bisphenol A type epoxy resin, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., trade name "YDF-8170C", epoxy equivalent: 160 g/eq)

EXA-1514 (bisphenol S type epoxy resin, manufactured by DIC Corporation, trade name "EXA-1514", epoxy equivalent: 300 g/eq)

[0092] Component (B): Phenolic resin

PSM-4326 (phenol novolac type phenolic resin, manufactured by Gun Ei Chemical Industry Co., Ltd., trade name "RESITOP PSM-4326", softening point: 126°C, hydroxyl group equivalent: 105

g/eq)

[0093] Component (C): Elastomer

HTR-860P-3 (acrylic rubber, manufactured by Nagase ChemteX Corporation, trade name "HTR-860P-3", weight average molecular weight 800000, glass transition temperature: -13°C)

[0094] Component (D): Filler

SC2050-HLG (silica filler, manufactured by Admatechs Co., Ltd., trade name "SC2050-HLG", average particle size 0.500 μm)

[0095] Component (E): Curing accelerator

2PZ-CN (1-cyanoethyl-2-phenylimidazole, manufactured by SHIKOKU CHEMICALS CORPORATION, trade name "CUREZOL 2PZ-CN")

[0096] Component (F): Coupling agent

A-189 (γ-mercaptopropyltrimethoxysilane, manufactured by NUC Corporation, trade name "NUC A-189")

A-1160 (γ-ureidopropyltriethoxysilane, manufactured by NUC Corporation, trade name "NUC A-1160")

[0097] Next, the varnish of the adhesive composition thus obtained was applied on a polyethylene terephthalate (PET) film having a thickness of 38 μm, which had been subjected to a mold release treatment, as a base material film, and the varnish was heated and dried for 5 minutes at 140°C. In this manner, the adhesive sheets of Examples 1 to 5 and Comparative Examples 1 to 3, in each of which a film-shaped adhesive having a thickness of 20 μm in a semi-cured (stage B) state was provided on a base material film, were obtained.

[0098] <Evaluation of low-temperature stickability>

Each of the adhesive sheets of Examples 1 to 5 and Comparative Examples 1 to 3 was cut out into a size of 100 mm in length and 50 mm in width, and this was used as a specimen. This specimen was laminated on a surface of a silicon wafer (8 inches in diameter, thickness 400 μm) placed on a support stand, the surface being on the opposite side of the support stand, such that the film-shaped adhesive and the silicon wafer were in contact. Lamination of the film-shaped adhesive was carried out while pressurizing the assembly with a roll (temperature 70°C, linear pressure 39.2 N/cm (4 kgf/cm), feed rate 0.5 m/min). At this time, a case in which the generation of voids between the film-shaped adhesive and the silicon wafer was not observed was rated as "A" for having excellent low-temperature stickability, and a case in which the generation of voids was observed was rated as "B". The results are presented in Table 1.

[0099] <Measurement of high-temperature storage modulus and glass transition temperature of film-shaped adhesive after curing>

A cured product of a film-shaped adhesive was obtained by heating each of the adhesive sheets of Examples 1 to 5 and Comparative Examples 1 to 3 for one hour at 110°C and then heating for one hour at 170°C. For the cured product of the film-shaped adhesive, the storage modulus at 175°C (high-temperature storage modulus) was determined by applying a tensile load to the cured product of the film-shaped adhesive using a dynamic viscoelasticity analyzer (manufactured by Rheology Co., Ltd., trade name DVE-V4), and measuring the viscoelasticity of the cured product of the film-shaped adhesive in a temperature-dependent measurement mode of making measurement

from 25°C to 300°C under the conditions of a frequency of 10 Hz and a rate of temperature increase of 3°C/min. Regarding the high-temperature storage modulus, a larger value (for example, 100 MPa or higher) means superior wire bonding characteristics. The peak top temperature of the loss tangent ($\tan \delta$), which is represented by the proportion of the loss modulus with respect to the high-temperature storage modulus, was determined as the glass transition temperature. Regarding the glass transition temperature, a larger value (for example, 190°C or higher) means superior wire bonding characteristics. The results are presented in Table 1.

[0100] Table 1

Item			Exam. 1	Exam. 2	Exam. 3	Exam. 4	Exam. 5	Comp. Exam. 1	Comp. Exam. 2	Comp. Exam. 3
Component (A)	Component (A-1)	HP-4710	7	5	10	5	8	10	4	-
		YDF-8170C	14	10	10	16	17	20	9	14
	Component (A-2)		-	-	-	-	-	-	-	7
Component (B)	PSM-4326		14	10	15	14	17	19	8	14
(A-1)/[(A) + (B)]*100 (%)			20.0%	20.0%	28.6%	14.3%	19.0%	20.4%	19.0%	0%
Component (C)	HTR-860P-3		15	10	15	15	18	21	9	15
Component (D)	SC2050-HLG		50	65	50	50	40	30	70	50
(D)/[(A) + (B) + (C) + (D)]*100 (%)			50%	65%	50%	50%	40%	30%	70%	50%
Component (E)	2PZ-CN		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Component (F)	A-189		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	A-1160		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Low-temperature stickability			A	A	A	A	A	A	B	A
High-temperature storage modulus (175°C) (MPa)			600	1200	770	450	120	50	2600	90
Glass transition temperature (°C)			205	200	220	191	190	190	200	165

[0101] As shown in Table 1, Examples 1 to 5 in which the content of a filler in the adhesive composition was 40% to 68% by mass based on the total amount of an epoxy resin, a phenolic resin, an elastomer, and a filler, and the epoxy resin included an epoxy resin having a naphthalene skeleton, were all superior in terms of the low-temperature stickability, high-temperature storage modulus, and glass transition temperature. On the other hand, Comparative Example 1 in which the content of the filler was less than 40% by mass was not sufficient in terms of the high-temperature storage modulus. Furthermore, Comparative Example 2 in which the content of the filler was more than 68% by mass was not sufficient in terms of the low-temperature stickability. Furthermore, Comparative Example 3 in which the epoxy resin did not include an epoxy resin having a naphthalene skeleton was not sufficient in terms of the high-temperature storage modulus and the glass transition temperature. From these results, it was verified that the adhesive composition according to the present invention exhibits excellent low-temperature stickability when formed into a film-shaped adhesive and can form a cured product having a sufficient high-temperature storage modulus and having a sufficient glass transition temperature.

Reference Signs List

[0102] 10...film-shaped adhesive, 14...support member for semiconductor element mounting, 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. An adhesive composition comprising:

an epoxy resin;

a phenolic resin;

an elastomer; and

a filler,

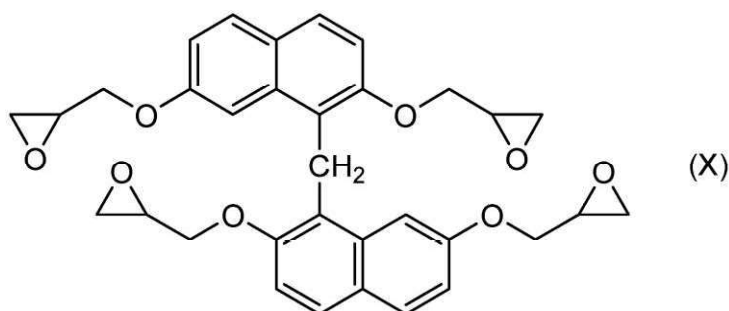
wherein a content of the filler is 40% to 68% by mass based on the total amount of the epoxy resin, the phenolic resin, the elastomer, and the filler, and

the epoxy resin comprises an epoxy resin having a naphthalene skeleton.

2. The adhesive composition according to claim 1, wherein the epoxy resin having a naphthalene skeleton is an epoxy resin having a tetrafunctional or higher-functional epoxy group.

3. The adhesive composition according to claim 1 or 2, wherein a content of the epoxy resin having a naphthalene skeleton is 14% to 30% by mass based on the total amount of the epoxy resin and the phenolic resin.

4. The adhesive composition according to any one of claims 1 to 3, wherein the epoxy resin having a naphthalene skeleton comprises an epoxy resin represented by the following Formula (X):



5. A film-shaped adhesive obtained by forming the adhesive composition according to any one of claims 1 to 4 into a film shape.

6. An adhesive sheet comprising:

a base material; and

5 the film-shaped adhesive according to claim 5 provided on the base material.

7. The adhesive sheet according to claim 6, wherein the base material is a dicing tape.

8. A method for producing a semiconductor device, the method comprising:

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electrically connecting a first semiconductor element onto a substrate through a first wire;

sticking the film-shaped adhesive according to claim 5 on one surface of a second semiconductor element; and

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pressure-bonding the second semiconductor element having the film-shaped adhesive stuck thereto, with the film-shaped adhesive interposed, so as to embed at least a portion of the first wire in the film-shaped adhesive.