

DESCRIPTION

Title of Invention

RESIN PASTE COMPOSITION FOR BONDING
SEMICONDUCTOR ELEMENT, AND SEMICONDUCTOR
5 DEVICE

Technical Field

[0001] The present invention relates to a resin paste composition for bonding a semiconductor element which is preferable for bonding a semiconductor element, such as IC or LSI, and a support member, such as a lead frame or a glass epoxy wiring board, and a semiconductor device using the same.

Background Art

[0002] In the past, an Au-Si eutectic, solder, a resin paste composition or the like were known as a die bonding material of a semiconductor, and a resin paste composition is widely used in terms of workability and costs.

[0003] Generally, a semiconductor device is manufactured by bonding an element, such as a semiconductor chip, to a lead frame using a die bonding material. Since the mounting on a semiconductor device is a high-density mounting, the mounting method is migrating from a through hole mounting method of the related art to a surface mounting method; however, for the mounting on a substrate, reflow soldering in which the entire substrate is heated using infrared rays or the like is used, and a package is heated to a high temperature of 200°C or higher, and therefore there are cases in which a paste layer is peeled off due to the abrupt expansion of absorbed moisture.

[0004] Therefore, there is a demand for a die bonding paste to have a high bonding strength between a Si chip and a lead frame. In addition, in a resin paste composition used to bond an element, such as a semiconductor chip, to a lead frame, for example, metal powder, such as gold powder, silver powder or copper powder, can be considered to be used as a conductive filler; however, currently, a resin paste composition, in which silver powder is used, is mainly used since silver powder is not as rare as gold powder; compared with copper powder, silver powder is not easily oxidized and has favorable preservation stability, and, furthermore, silver powder is excellent in terms of coating workability, mechanical characteristics and a variety of characteristics that the resin paste composition is asked to have (refer to Patent Literature 1).

Citation List

Patent Literature

[0005] [Patent Literature 1] Japanese Unexamined Patent Application Publication No. 2002-179769

Summary of Invention

Technical Problem

[0006] However, since silver powder is also a noble metal and a highly rare material, there is a desire for the development of a die bonding material in which a more-easily-procurable filler material other than silver powder is used as the die bonding material. Currently, a resin paste composition has not yet obtained in which a material that can replace silver powder is used and the same level of characteristics as in a resin paste composition, in which only silver powder is used, are

exhibited.

[0007] For example, according to the findings by the present inventors, in a case in which some of silver powder in the resin paste composition described in Patent Literature 1 is substituted by aluminum powder, a sufficient die shear strength cannot be obtained.

[0008] An object of the invention is to provide a resin paste composition for bonding a semiconductor element which is excellent in terms of die shear strength and preservation stability even when aluminum powder is used as the conductive filler. In addition, another object of the invention is to provide a semiconductor device manufactured using the resin paste composition for bonding a semiconductor element.

Solution to Problem

[0009] An aspect of the invention relates to a resin paste composition for bonding a semiconductor element containing a compound having a (meth)acryloyloxy group, a polymerization initiator, a flexibility-imparting agent, an amine compound and aluminum powder.

[0010] In the aspect, when the resin paste composition for bonding a semiconductor element has the above specific composition, the resin paste composition for bonding a semiconductor element is excellent in terms of die shear strength and preservation stability even when aluminum powder is used as a conductive filler.

[0011] In the aspect, the resin paste composition for bonding a semiconductor element preferably does not substantially contain an aromatic epoxy resin.

[0012] In a case in which some of silver powder in the resin paste

composition described in Patent Literature 1 is substituted by aluminum powder, a sufficient electric conductivity (sufficiently low volume resistivity) cannot be obtained. However, the resin paste composition for bonding a semiconductor element of the aspect can realize excellent electric conductivity even when aluminum powder is used as the conductive filler if the resin paste composition does not substantially include an aromatic epoxy resin and has the above specific composition.

[0013] In the aspect, the flexibility-imparting agent is preferably a rubber component.

[0014] In addition, in the aspect, the amine compound is preferably dicyandiamide or an imidazole compound.

[0015] In addition, in the aspect, a shape of the aluminum powder is preferably a granular shape, and an average particle diameter of the aluminum powder is preferably in a range of 2 μm to 10 μm .

[0016] In addition, the resin paste composition for bonding a semiconductor element of the aspect may further contain silver powder. Since the resin paste composition for bonding a semiconductor element of the aspect contains aluminum powder as the conductive filler, it is possible to sufficiently obtain a variety of characteristics, such as bonding strength and preservation stability, even when a large amount of highly rare silver powder is not used.

[0017] In addition, in the resin paste composition for bonding a semiconductor element of the aspect, a shape of the silver powder is preferably a flake shape, and an average particle diameter of the silver powder is preferably in a range of 1 μm to 5 μm .

[0018] In addition, in the aspect, a ratio C_1/C_2 of a content C_1 of the

aluminum powder to a content C₂ of the silver powder may be set to 2/8 to 8/2 by mass ratio.

[0019] In addition, in the aspect, the compound having a (meth)acryloyloxy group is preferably a (meth)acrylic acid ester compound.

[0020] Another aspect of the invention relates to a semiconductor device including a support member, a semiconductor element and a bonding layer that is disposed between the support member and the semiconductor element and bonds the support member and the semiconductor element, in which the bonding layer includes a cured product of the resin paste composition for bonding a semiconductor element.

[0021] Since the semiconductor device of the aspect has the support member and the semiconductor element bonded using the resin paste composition for bonding a semiconductor element, the semiconductor element is sufficiently reliable although cheap aluminum powder is used.

Advantageous Effects of Invention

[0022] According to the invention, a resin paste composition for bonding a semiconductor element which is excellent in terms of die shear strength and preservation stability is provided even when aluminum powder is used as a conductive filler. In addition, according to the invention, a semiconductor device manufactured using the resin paste composition for bonding a semiconductor element is provided.

Brief Description of Drawings

[0023] FIG. 1A is a view illustrating an electron micrograph of

VA-2000, FIG. 1B is a view illustrating an electron micrograph of No. 800F, and FIG. 1C is a view illustrating an electron micrograph of No. 500M.

5 FIG. 2A is a view illustrating an electron micrograph of a powder mixture of aluminum powder and silver powder in a resin paste composition obtained in Example 1, and FIG. 2B is a view illustrating an electron micrograph of silver powder in a resin paste composition obtained in Reference Example 1.

10 FIG. 3 is a pattern diagram illustrating a method for producing a test sample used in a measurement of a volume resistivity.

Description of Embodiments

15 [0024] A preferable embodiment of the resin paste composition for bonding a semiconductor element of the invention will be described below. Meanwhile, in the present specification, “(meth)acrylic” refers to acrylic or methacrylic. That is, “having a (meth)acryloyloxy group” means having an acryloyloxy group or a methacryloyloxy group.

20 [0025] The resin paste composition for bonding a semiconductor element according to the present embodiment (hereinafter referred to simply as “resin paste composition”) contains a compound having a (meth)acryloyloxy group (hereinafter sometimes referred to simply as “(A) component”), a polymerization initiator (hereinafter sometimes referred to simply as “(B) component”), a flexibility-imparting agent (hereinafter sometimes referred to simply as “(C) component”), an amine compound (hereinafter sometimes referred to simply as “(D) component”) and aluminum powder (hereinafter sometimes referred to simply as “(E) component”). Since the resin paste composition

25

contains the above specific components, the resin paste composition is excellent in terms of die shear strength and preservation stability.

5 [0026] The resin paste composition preferably does not substantially contain an aromatic epoxy resin. In a resin paste of the related art, when aluminum powder is used as a conductive filler, there are cases in which the volume resistivity abruptly increases such that a sufficient electric conductivity cannot be obtained, but a resin paste composition which contains the above specific components and substantially does not contain an aromatic epoxy resin has excellent electric conductivity.

10 [0027] Here, "substantially not containing an aromatic epoxy resin" means that a small amount of an aromatic epoxy resin may be present as long as an abrupt increase in the volume resistivity is not observed. Specifically, the content of the aromatic epoxy resin may be 0.1 mass% or less, and is preferably 0.05 mass% or less in terms of the total amount of the resin paste composition. In addition, the resin paste composition more preferably does not contain the aromatic epoxy resin.

15 [0028] The (A) component is a component that can be also called a matrix that disperses the aluminum powder, the silver powder and the like, and has one or more (meth)acryloyloxy groups in a molecule.

20 The (A) component preferably contains at least one selected from a group consisting of acrylic acid ester compounds and methacrylic acid ester compounds. When a combination of at least one selected from a group consisting of acrylic acid ester compounds and methacrylic acid ester compounds and the aluminum powder is used, the electric

25 conductivity, preservation stability and die shear strength are further improved, and the coating workability and mechanical characteristics

are further improved so that the resin paste composition becomes more preferable for die bonding use.

[0029] Examples of the (A) component include compounds having one (meth)acryloyloxy group in a molecule (hereinafter sometimes referred to as "(A-1) component"), compounds having two (meth)acryloyloxy groups in a molecule (hereinafter sometimes referred to as "(A-2) component") and compounds having three or more (meth)acryloyloxy group in a molecule (hereinafter sometimes referred to as "(A-3) component").

[0030] Examples of the compounds having one acryloyloxy group of the (A-1) component include methyl acrylate, ethyl acrylate, propyl acrylate, isopropyl acrylate, n-butyl acrylate, isobutyl acrylate, t-butyl acrylate, amyl acrylate, isoamyl acrylate, hexyl acrylate, heptyl acrylate, octyl acrylate, 2-ethylhexyl acrylate, nonyl acrylate, decyl acrylate, iso-decyl acrylate, lauryl acrylate, tridecyl acrylate, hexadecyl acrylate, stearyl acrylate, isostearyl acrylate, cyclohexyl acrylate, isobornyl acrylate, tricyclo [5.2.1.0^{2,6}] decyl acrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-8-yloxy ethyl acrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-9-yloxy ethyl acrylate, 2-hydroxyethyl acrylate, 2-hydroxypropyl acrylate, dimer diol mono acrylate, diethylene glycol acrylate, polyethylene glycol acrylate, polypropylene glycol acrylate, 2-methoxyethyl acrylate, 2-ethoxyethyl acrylate, 2-butoxyethyl acrylate, methoxy diethylene glycol acrylate, methoxy polyethylene glycol acrylate, 2-phenoxyethyl acrylate, phenoxy diethylene glycol acrylate, phenoxy polyethylene glycol acrylate, 2-benzoyloxy ethyl acrylate, 2-hydroxy-3-phenoxypropyl acrylate, benzyl acrylate, 2-cyanoethyl

acrylate, γ -acryloxypropyltrimethoxysilane, glycidyl acrylate, tetrahydrofurfuryl acrylate, dicyclopentenylloxyethyl acrylate, dicyclopentanyl acrylate, dicyclopentenyl acrylate, tetrahydropyranyl acrylate, dimethylaminoethyl acrylate, diethylaminoethyl acrylate,

5 1,2,2,6,6-penta methylpiperidiny acrylate, 2,2,6,6-tetramethylpiperidiny acrylate, acryloxyethyl phosphate, acryloxyethyl phenyl acid phosphate, β -acryloyloxyethyl hydrogen phthalate, β -acryloyloxyethyl hydrogen succinate, and the like.

[0031] In addition, examples of the compounds having one

10 methacryloyloxy group of the (A-1) component include methyl methacrylate, ethyl methacrylate, propyl methacrylate, isopropyl methacrylate, n-butyl methacrylate, isobutyl methacrylate, t-butyl methacrylate, amyl methacrylate, iso-amyl methacrylate, hexyl methacrylate, heptyl methacrylate, octyl methacrylate, 2-ethylhexyl

15 methacrylate, nonyl methacrylate, decyl methacrylate, isodecyl methacrylate, lauryl methacrylate, tridecyl methacrylate, hexadecyl methacrylate, stearyl methacrylate, isostearyl methacrylate, cyclohexyl methacrylate, isobornyl methacrylate, tricyclo [5.2.1.0^{2,6}] decyl methacrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-8-yloxy ethyl

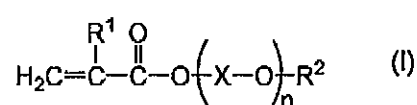
20 methacrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-9-yloxy ethyl methacrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, dimer diol mono-methacrylate, diethylene glycol methacrylate, polyethylene glycol methacrylate, polypropylene glycol methacrylate, 2-methoxyethyl methacrylate, 2-ethoxyethyl

25 methacrylate, 2-butoxyethyl methacrylate, methoxy diethylene glycol methacrylate, methoxy polyethylene glycol methacrylate,

2-phenoxyethyl methacrylate, phenoxydiethylene glycol methacrylate, phenoxy polyethylene glycol methacrylate, 2-benzoyloxyethyl methacrylate, 2-hydroxy-3-phenoxypropyl methacrylate, benzyl methacrylate, 2-cyanoethyl methacrylate, γ -methacryloxypropyl trimethoxysilane, glycidyl methacrylate, tetrahydrofurfuryl methacrylate, dicyclopentenylmethoxyethyl methacrylate, dicyclopentanyl methacrylate, dicyclopentenyl methacrylate, tetrahydropyranyl methacrylate, dimethylaminoethyl methacrylate, diethylaminoethyl methacrylate, 1,2,2,6,6-pentamethyl-piperidinyll methacrylate, 2,2,6,6-tetramethyl piperidinyll methacrylate, methacryloxyethyl phosphate, methacryloxyethyl phenyl acid phosphate, β -methacryloyloxyethyl hydrogen phthalate and β -methacryloyloxyethyl hydrogen succinate.

[0032] The (A-1) component is preferably a compound represented by the following formula (I) from the viewpoint of the die shear strength in a semiconductor device manufactured using the resin paste composition.

[0033] [Chemical Formula 1]



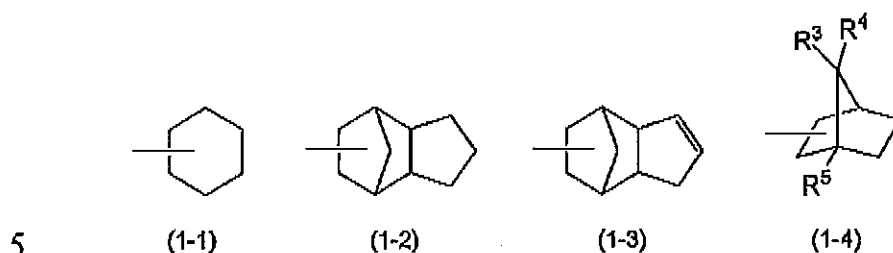
[0034] In the formula, R^1 represents a hydrogen atom or a methyl group, R^2 represents an alicyclic group or a heterocyclic group, X represents an alkylene group having 1 to 5 carbon atoms, and n represents an integer of 0 to 10. When n is an integer of 2 or more, a plurality of Xs may be the same or different. Here, the alicyclic group is a group having a structure in which carbon atoms are bonded in a cyclic shape, and the heterocyclic group is a group having a structure in

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which the carbon atom and a hetero atom are bonded in a cyclic shape.

[0035] Examples of the alicyclic group include groups represented by the following formulae (1-1), (1-2), (1-3) or (1-4).

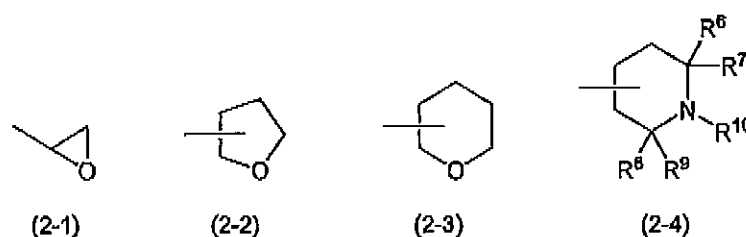
[0036] [Chemical Formula 2]



[0037] In the formula, each of R^3 , R^4 and R^5 independently represents a hydrogen atom or an alkyl group having 1 to 5 carbon atoms.

[0038] Examples of the heterocyclic group include groups represented by the following formulae (2-1), (2-2), (2-3) or (2-4).

10 [0039] [Chemical Formula 3]



[0040] In the formula, each of R^6 , R^7 , R^8 , R^9 and R^{10} independently represents a hydrogen atom or an alkyl group having 1 to 5 carbon atoms.

15 [0041] Examples of the compound represented by the formula (1) include cyclohexyl acrylate, isobornyl acrylate, tricyclo [5.2.1.0^{2,6}] decyl acrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-8-yloxy ethyl acrylate, 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-9-yloxy ethyl acrylate, glycidyl acrylate, tetrahydrofurfuryl acrylate, dicyclopentenyl acrylate, dicyclopentanyloxyethyl acrylate, dicyclopentanyloxyethyl acrylate, dicyclopentanyloxyethyl acrylate,

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tetrahydropyranyl acrylate, dimethylaminoethyl acrylate,
diethylaminoethyl acrylate, 1,2,2,6,6-penta methylpiperidiny acrylate,
2,2,6,6-tetramethyl piperidiny acrylate cyclohexyl methacrylate,
isobornyl methacrylate, tricyclo [5.2.1.0^{2,6}] decyl methacrylate,
5 2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-8-yloxy ethyl methacrylate,
2-(tricyclo) [5.2.1.0^{2,6}] deca-3-ene-9-yloxy ethyl methacrylate, glycidyl
methacrylate, tetrahydrofurfuryl methacrylate, dicyclopentenylloxyethyl
methacrylate, dicyclopentanyl methacrylate, dicyclopentenyl
methacrylate, tetrahydropyranyl methacrylate, dimethylaminoethyl
10 methacrylate, diethylaminoethyl methacrylate, 1,2,2,6,6-pentamethyl
piperidiny methacrylate and 2,2,6,6-tetramethyl piperidiny
methacrylate.

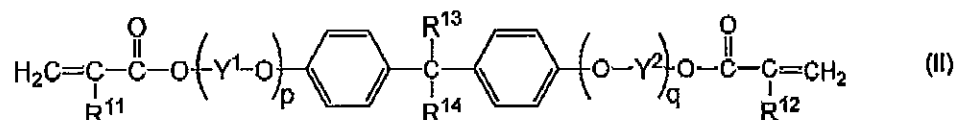
[0042] Examples of the compounds having two acryloyloxy groups in
a molecule of the (A-2) component include ethylene glycol diacrylate,
15 1,4-butanediol diacrylate, 1,6-hexanediol diacrylate, 1,9-nonanediol
diacrylate, 1,3-butanediol diacrylate, neopentyl glycol diacrylate, dimer
diol diacrylate, dimethyloltricyclodecane diacrylate, diethylene glycol
diacrylate, triethylene glycol diacrylate, tetraethylene glycol diacrylate,
polyethylene glycol diacrylate, tripropylene glycol diacrylate,
20 polypropylene glycol diacrylate, bis(acryloxypropyl)
polydimethylsiloxane, bis(acryloxypropyl) methyl siloxane-dimethyl
siloxane copolymers. In addition, examples of the (A-2) component
include reaction products between 1 mole of bisphenol A, bisphenol F
or bisphenol AD and 2 moles of glycidyl acrylate; diacrylates of a
25 polyethylene oxide adduct of bisphenol A, bisphenol F or bisphenol AD;
diacrylates of a polypropylene oxide adduct of bisphenol A, bisphenol F

or bisphenol AD; and the like.

[0043] Examples of the compounds having two methacryloyloxy groups in a molecule of the (A-2) component include ethylene glycol dimethacrylate, 1,4-butanediol dimethacrylate, 1,6-hexanediol dimethacrylate, 1,9-nonanediol dimethacrylate, 1,3-butanediol dimethacrylate, neopentyl glycol dimethacrylate, dimer diol dimethacrylate, dimethylol tricyclodecane dimethacrylate, diethylene glycol dimethacrylate, triethylene glycol dimethacrylate, tetraethylene glycol dimethacrylate, polyethylene glycol dimethacrylate, tripropylene glycol dimethacrylate, polypropylene glycol dimethacrylate, bis(methacryloxypropyl) polydimethylsiloxane, bis(methacryloxypropyl) methylsiloxane-dimethyl siloxane copolymers. In addition, examples of the (A-2) component include reactants between 1 mole of bisphenol A, bisphenol F or bisphenol AD and 2 moles of glycidyl methacrylate; diemethacrylates of a polyethylene oxide adduct of bisphenol A, bisphenol F or bisphenol AD; dimethacrylates of a polypropylene oxide adduct of bisphenol A, bisphenol F or bisphenol AD; and the like.

[0044] The (A-2) component is preferably a compound represented by the following formula (II) from the viewpoint of the die shear strength in a semiconductor device manufactured using the resin paste composition.

[0045] [Chemical Formula 4]



[0046] In the formula, each of R^{11} and R^{12} represents a hydrogen atom or a methyl group respectively, each of R^{13} and R^{14} represents a

hydrogen atom or an alkyl group having 1 to 5 carbon atoms respectively, each of Y^1 and Y^2 represents an alkylene group having 1 to 5 carbon atoms respectively, each of p and q represents an integer of 1 to 20 respectively. When p is an integer of 2 or more, a plurality of Y^1 s may be the same or different. When q is an integer of 2 or more, a plurality of Y^2 s may be the same or different.

[0047] Examples of the compounds having three or more acryloyloxy groups in a molecule of the (A-3) component include trimethylolpropane triacrylate, ethylene oxide-modified trimethylolpropane triacrylate, propylene oxide-modified trimethylolpropane triacrylate, ethylene oxide-propylene oxide-modified trimethylolpropane triacrylate, tetramethylolmethane triacrylate, tetramethylolmethane tetraacrylate, dipentaerythritol pentaacrylate, dipentaerythritol hexaacrylate and pentaerythritol triacrylate.

[0048] Examples of the compounds having three or more methacryloyloxy groups in a molecule of the (A-3) component include trimethylolpropane trimethacrylate, ethylene oxide-modified trimethylolpropane trimethacrylate, propylene oxide-modified trimethylolpropane trimethacrylate, ethylene oxide-propylene oxide-modified trimethylolpropane trimethacrylate, tetramethylolmethane trimethacrylate, tetramethylolmethane tetramethacrylate, dipentaerythritol pentamethacrylate, dipentaerythritol hexamethacrylate and pentaerythritol trimethacrylate.

[0049] As the (A) component, one of the above compounds can be solely used, or a combination of two or more can be used. For example, as the (A) component, a combination of the (A-1) component

and the (A-2) component is preferably used since it is possible to improve die shear strength and workability (viscosity) in a balanced manner.

5 [0050] The content of the (A) component is preferably 5 mass% to 25 mass%, and more preferably 10 mass% to 20 mass% in terms of the total amount of the resin paste composition. When the content of the (A) component is 5 mass% to 25 mass%, a sufficient die shear strength can be obtained, and air gaps called voids are not easily generated in a cured product of the resin paste composition.

10 [0051] The (B) component is a component for curing the resin paste composition by polymerizing the (A) component, and is preferably a compound that generates radicals through heating and/or light radiation. Examples of the (B) component include a thermal polymerization initiator and a photopolymerization initiator. Meanwhile, one of the
15 (B) components can be solely used, or a combination of two or more can be used.

[0052] Examples of the thermal polymerization initiator include azo-based radical initiators, such as azobisisobutyronitrile and 2,2'-azobis(4-methoxy-2,4-dimethylvaleronitrile); and peroxides, such
20 as 1,1,3,3-tetramethylbutyl peroxy-2-ethylhexanoate, 1,1-bis(t-butylperoxy)cyclohexane, 1,1-bis(t-butylperoxy)cyclododecane, di-t-butylperoxy isophthalate, t-butyl perbenzoate, dicumyl peroxide, t-butyl cumyl peroxide, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane,
25 2,5-dimethyl-2,5-di(t-butylperoxy)hexyne, cumene hydroperoxide, t-butyl peroxy-2-ethylhexanoate, t-hexyl peroxy-2-ethylhexanoate,

2,5-dimethyl-2,5-bis(2-ethylhexanoylperoxy)hexane, and the like.

[0053] Examples of the photopolymerization initiator include acetophenones, such as 1-hydroxy cyclohexyl phenyl ketone and 2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-1-propanone;

5 thioxanthenes, such as 2,4-dimethyl thioxanthone, 2,4-diethylthioxanthone, 2-chlorothioxanthone and 2,4-diisopropyl thioxanthone; ketals, such as acetophenone dimethyl ketal and benzyl dimethyl ketal; and benzophenones, such as benzophenone, 4,4'-bis(diethylamino)benzophenone and 4-benzoyl-4'-methyl diphenyl
10 sulfide; phosphine oxides, such as 2,4,6-trimethyl benzoyl diphenyl phosphine oxide.

[0054] The (B) component is preferably a peroxide since it is possible to reduce the generation of air gaps called voids in a cured product of the resin paste composition. In addition, the 10-hour half-life period
15 temperature of the peroxide is preferably 60°C to 170°C since the curability and viscosity stability of the resin paste composition further improve. Here, the half-life period refers to a period of time necessary for the peroxide to be decomposed at a certain temperature so that the amount of active oxygen becomes half, and the 10-hour half-life period
20 temperature refers to a temperature at which the half-life period becomes 10 hours.

[0055] The half-life period can be measured, for example, in the following manner. First, a peroxide solution having a concentration of 0.1 mol/l is prepared mainly using a relatively inert solution with
25 respect to radicals, for example, benzene, and is sealed in a nitrogen-substituted glass pipe. In addition, the solution is immersed

in a thermostatic bath set to a predetermined temperature, and is thermally decomposed. Generally, the decomposition of a peroxide can be approximately handled as a first-order reaction, and therefore the following formula (i) is obtained wherein x represents the concentration of the peroxide decomposed for t hours, k represents the decomposition rate constant, t represents time, and a represents the initial concentration of the peroxide.

$$dx/dt=k(a-x) \quad (i)$$

In addition, the formula (i) can be transformed into a formula (ii).

$$\ln a/(a-x)=kt \quad (ii)$$

Since the half-life period refers to a time during which the concentration of the peroxide decreases to half of the initial concentration due to decomposition, a formula (iii) is obtained when the half-time period is represented by $t_{1/2}$, and x in the formula (ii) is substituted by $a/2$.

$$kt_{1/2}=\ln 2 \quad (iii)$$

Therefore, it is possible to obtain the decomposition rate constant k from the slope of a straight line obtained through thermal decomposition at a certain temperature and to obtain the half-life period ($t_{1/2}$) at the temperature from the formula (iii).

[0056] The content of the (B) component is preferably 0.1 parts by mass to 10 parts by mass, and more preferably 2 parts by mass to 8 parts by mass with respect to 100 parts by mass of the (A) component in total. When the content of the (B) component is 0.1 parts by mass or more, the curability of the resin paste composition becomes more favorable.

In addition, when the content of the (B) component exceeds 10 parts by mass, a number of volatile components are generated during the curing of the resin paste composition, and there is a tendency that air spaces called voids are easily generated in a cured product of the resin paste composition. One of the (B) component can be solely used, or a combination of two or more can be used.

[0057] The content of the (B) component is preferably 0.1 mass% to 5 mass%, and more preferably 0.6 mass% to 1 mass% in terms of the total amount of the resin paste composition. When the content of the (B) component is 0.1 mass% or more, the curability of the resin paste composition becomes more favorable. In addition, when the content of the (B) component exceeds 5 mass%, a number of volatile components are generated during the curing of the resin paste composition, and there is a tendency that air spaces called voids are easily generated in a cured product of the resin paste composition.

[0058] The (C) component is a component that supplies flexibility to a cured product of the resin paste composition. When the (C) component is blended with the resin paste composition, an effect of mitigating stress with respect to thermal expansion and/or shrinkage can be obtained. The (C) component is not particularly limited, but it is preferable to use at least one selected from a group consisting of liquid rubber and thermoplastic resins.

[0059] Examples of the liquid rubber include liquid rubber having a polybutadiene skeleton, such as polybutadiene, epoxidized polybutadiene, maleic polybutadiene, acrylonitrile-butadiene rubber, acrylonitrile-butadiene rubber having a carboxy group,

amino-terminated acrylonitrile-butadiene rubber, vinyl-terminated acrylonitrile-butadiene rubber and styrene-butadiene rubber.

[0060] The number average molecular weight of the liquid rubber is preferably 500 to 10000, and more preferably 1000 to 5000. When the number average molecular weight is 500 or more, the flexibility-imparting effect becomes superior, and, when the number average molecular weight is 10000 or less, an increase in the viscosity of the resin paste composition by the flexibility-imparting agent is sufficiently suppressed, and workability becomes more favorable. Meanwhile, the number average molecular weight is a value measured using the calibration curve of standard polystyrene through gel permeation chromatography (hereinafter referred to as GPC method).

[0061] Examples of the thermoplastic resin include acrylic resins, such as polyvinyl acetate and polyalkyl acrylate, ϵ -caprolactone-modified polyester, phenoxy resins and polyimide.

[0062] The number average molecular weight of the thermoplastic resin is preferably 10000 to 300000, and more preferably 20000 to 200000. When the number average molecular weight is 10000 or more, the effect of imparting flexibility becomes superior, and, when the number average molecular weight is 300000 or less, an increase in the viscosity of the resin paste composition by the flexibility-imparting agent is sufficiently suppressed, and workability becomes more favorable. Meanwhile, the number average molecular weight is a value measured using the calibration curve of standard polystyrene through the GPC method.

[0063] The resin paste composition preferably contains epoxidized

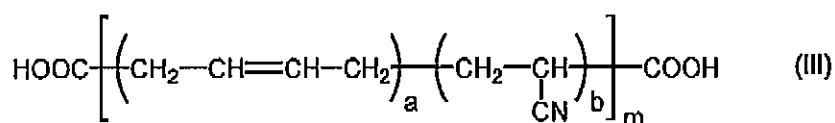
polybutadiene as the (C) component from the viewpoint of the capability of further reducing the elasticity of a cured product.

[0064] The epoxidized polybutadiene can be easily obtained by epoxidizing an ordinary commercially available polybutadiene using a hydrogen peroxide solution, a peracid or the like.

[0065] Examples of commercially available epoxidized polybutadiene include B-1000, B-3000, G-1000, G-3000 (all manufactured by Nippon Soda Co., Ltd.), B-1000, B-2000, B-3000, B-4000 (all manufactured by Nippon Oil Co., Ltd.), R-15HT, R-45HT, R-45M (all manufactured by Idemitsu Kosan Co., Ltd.), EPOLEAD PB-3600 and EPOLEAD PB-4700 (all manufactured by Daicel Chemical Industries, Ltd.). The oxirane oxygen concentration of the epoxidized polybutadiene is preferably 3% to 18%, and more preferably 5% to 15%.

[0066] The resin paste composition preferably contains acrylonitrile-butadiene rubber having a carboxy group as the (C) component since the elasticity of a cured product can be further reduced, and the die shear strength can be further improved. The acrylonitrile-butadiene rubber having a carboxy group is preferably a compound represented by the formula (III).

[0067] [Chemical Formula 5]



[0068] In the formula, m represents an integer of 5 to 50, and each of a and b represents an integer of 1 or more respectively. The ratio of a to b (a/b) is preferably 95/5 to 50/50.

[0069] Examples of commercially available compounds represented

by the formula (III) include Hycar CTBN-2009×162, CTBN-1300×31, CTBN-1300×8, CTBN-1300×13, CTBN-1009SP-S and CTBNX-1300×9 (all manufactured by Ube Industries Ltd.).

5 [0070] The resin paste composition preferably jointly use the epoxidized polybutadiene and the acrylonitrile-butadiene rubber having a carboxyl group as the (C) component from the viewpoint of workability and bonding strength.

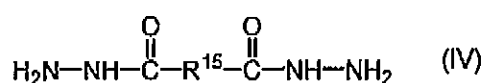
10 [0071] The content of the (C) component is preferably 10 parts by mass to 200 parts by mass, more preferably 20 parts by mass to 100 parts by mass, and still more preferably 40 parts by mass to 80 parts by mass with respect to 100 parts by mass of the (A) component. When the content of the (C) component is 10 parts by mass or more, the effect of imparting flexibility becomes superior, and, when the content of the (C) component is 200 parts by mass or less, an increase in the viscosity of the resin paste composition by the flexibility-imparting agent is sufficiently suppressed, and workability becomes more favorable.

15 [0072] In addition, the content of the (C) component is preferably 3 mass% to 12 mass%, and more preferably 4 mass% to 11 mass% in terms of the total amount of the resin paste composition. When the content of the (C) component is 3 mass% or more, the effect of imparting flexibility becomes superior, and, when the content of the (C) component is 12 mass% or less, an increase in the viscosity of the resin paste composition by the flexibility-imparting agent is sufficiently suppressed, and workability becomes more favorable.

20 [0073] Examples of the (D) component include dicyandiamide, compounds represented by the following formula (IV) (also referred to

as dibasic dihydrazide), microcapsule-type curing agents made up of a reaction product of an epoxy resin and an amine compound, imidazole compounds and the like. One of the (D) component can be solely used, or a combination of two or more can be used.

5 [0074] [Chemical Formula 6]



[0075] In the formula, R^{15} represents an arylene group or an alkylene group having 2 to 12 carbon atoms. The alkylene group may be straight or branched. In addition, examples of the arylene group
10 include p-phenylene group, m-phenylene group and the like.

[0076] Examples of the imidazole compound include 2-methyl imidazole, 2-undecylimidazole, 2-heptadecylimidazole, 1,2-dimethyl imidazole, 2-ethyl-4-methyl imidazole, 2-phenyl imidazole, 2-phenyl-4-methylimidazole, 1-benzyl-2-methylimidazole,
15 1-benzyl-2-phenylimidazole, 2-phenylimidazole isocyanuric acid adduct, and the like.

[0077] AFH, PFH, SFH (all manufactured by Nippon Hydrazine Kogyo Co., Ltd., product names) or the like can be used as the compound represented by formula (IV), NOVACURE (manufactured by
20 Asahi Kasei Corporation, product name) or the like can be used as the microcapsule-type curing agent, and 2P4MHZ, C17Z, 2PZ-OK (all manufactured by Shikoku Chemicals Corporation, product name) or the like can be used as the imidazole compound.

[0078] From the viewpoint of the strength of a cured product, the resin
25 paste composition preferably contains at least one selected from a group

consisting of dicyandiamide and the imidazole compounds, and more preferably contains at least dicyandiamide as the (D) component.

[0079] The content of the (D) component is preferably 0.05 mass% to 1.5 mass%, more preferably 0.1 mass% to 1.0 mass%, and can be set to 0.1 mass% to 0.8 mass% in terms of the total amount of the resin paste composition. When the content of the (D) component is 0.05 mass% or more, curability further improves, and, when the content of the (D) component is 1.5 mass% or less, the stability of the resin paste composition becomes more favorable. In addition, when the content of the (D) is 0.8 mass% or less, there is a tendency that electric conductivity further improves.

[0080] The aluminum powder of the (E) component is a component that replaces some or all of silver powder, which was used as a filler in a resin paste of the related art. In the resin paste composition according to the embodiment, when the above respective components are combined, excellent electric conductivity, preservation stability and die shear strength can be realized even when some or all of silver powder is replaced by the (E) component.

[0081] The average particle diameter of the (E) component is preferably 10 μm or less, more preferably 2 μm to 9 μm , and still more preferably 3 μm to 8 μm . When the average particle diameter is 10 μm or less, the homogeneity and various properties of the resin paste composition become more favorable. Here, the average particle diameter can be obtained as a median size using a particle size distribution measuring apparatus (for example, MICROTRAC X100) in which a laser diffraction method is used. The median size refers to the

value of a particle diameter (D50) at a cumulative rate of 50% in a number-based particle size distribution.

[0082] The apparent density of the (E) component is preferably 0.40 g/cm³ to 1.20 g/cm³, and more preferably 0.55 g/cm³ to 0.95 g/cm³.

5 The shape of the (E) component can be a granular shape, a flake shape, a spherical shape, a needle-like shape, an irregular shape or the like, but is preferably a granular shape.

[0083] The content of the (E) component is preferably 10 mass% to 50 mass%, more preferably 15 mass% to 40 mass%, and particularly
10 preferably 20 mass% to 35 mass% in terms of the total amount of the resin paste composition. When the content of the (E) component is within the above range, the characteristics, such as electric conductivity and viscosity, of the resin paste composition become more preferable as a die bonding material.

15 [0084] The resin paste composition may contain other components, and, for example, the resin paste composition may further contain silver powder. However, since the resin paste composition contains the (E) component which is a component that replaces silver powder, excellent electric conductivity can be obtained even in a case in which the content
20 of silver powder is smaller than that of the resin paste of the related art.

[0085] The average particle diameter of the silver powder is preferably 1 μm to 5 μm. Here, the average particle diameter can be obtained as a median size using a particle size distribution measuring apparatus (for example, MICROTRAC X100) in which a laser diffraction method is
25 used. The median size refers to the value of a particle diameter (D50) at a cumulative rate of 50% in a number-based particle size distribution.

- [0086] The tapped density of the silver powder is preferably 3 g/cm^3 to 6 g/cm^3 . In addition, the specific surface area of the silver powder is preferably $0.5 \text{ m}^2/\text{g}$ to $1 \text{ m}^2/\text{g}$. In addition, the shape of the silver powder can be a granular shape, a flake shape, a spherical shape, a needle-like shape, an irregular shape or the like, but is preferably a granular shape. When a combination of the above silver powder with the aluminum powder is used, a resin paste composition having superior electric conductivity, die shear strength, preservation stability, coating workability and mechanical characteristics can be obtained.
- [0087] The ratio C_1/C_2 (mass ratio) of the content C_1 of the aluminum powder, which is the (E) component, to the content C_2 of the silver powder is preferably $2/8$ to $8/2$, more preferably $3/7$ to $7/3$, and particularly preferably $4/6$ to $6/4$. When the ratio C_1/C_2 is larger than $8/2$, there are cases in which the viscosity of the resin paste increases, and workability degrades.
- [0088] The resin paste composition may further contain conductive fine particles other than the (E) component and the silver powder. The conductive fine particles are preferably conductive fine particles having an average particle size of less than $10 \mu\text{m}$. In addition, examples of the conductive fine particles include conductive fine particles including gold, copper, nickel, iron, stainless or the like.
- [0089] The total content of the (E) component, the silver powder and the conductive fine particles is preferably 60 mass% to 85 mass%, more preferably 65 mass% to 80 mass%, and particularly preferably 70 mass% to 80 mass% in terms of the total amount of the resin paste composition. When total content of the (E) component, the silver

powder and the conductive fine particles are within the above range, the characteristics, such as electric conductivity and viscosity, of the resin paste composition become more preferable as a die bonding material.

[0090] The resin paste composition may further contain a coupling agent. The coupling agent is not particularly limited, and a variety of coupling agents, such as silane coupling agents, titanate-based coupling agents, aluminum-based coupling agents, zirconate-based coupling agent and zircoaluminate-based coupling agents, can be used. One of the coupling agents can be solely used, or a combination of two or more can be used.

[0091] Examples of the silane coupling agent include methyl trimethoxysilane, methyl triethoxysilane, phenyl trimethoxysilane, phenyl triethoxysilane, vinyl trimethoxysilane, vinyl triethoxysilane, vinyltriacetoxysilane, vinyl-tris(2-methoxyethoxy)silane, γ -methacryloxypropyltrimethoxysilane, γ -methacryloxypropyl methyl dimethoxysilane, methyltri(methacryloxyethoxy)silane, γ -acryloxypropyltrimethoxysilane, γ -aminopropyltrimethoxysilane, γ -aminopropyl triethoxysilane, N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane, N- β -(aminoethyl)- γ -aminopropyl methyl dimethoxysilane, N- β -(N-vinyl benzyl aminoethyl)- γ -aminopropyltrimethoxysilane, γ -anilinopropyltrimethoxysilane, γ -ureidopropyltrimethoxysilane, γ -ureidopropyltriethoxysilane, 3-(4,5-dihydro-imidazolyl) propyl triethoxysilane, β -(3,4-epoxy cyclohexyl) ethyl trimethoxysilane, γ -glycidoxypropyltrimethoxysilane, γ -glycidoxypropylmethyldiethoxysilane, γ -glycidoxypropylmethyl

diisoprophenoxy silane, methyltriglycidoxysilane, γ -mercaptopropyl trimethoxysilane, γ -mercaptopropyl triethoxysilane, γ -mercaptopropylmethyldimethoxysilane, trimethylsilyl isocyanate, dimethylsilyl isocyanate, phenylsilyl triisocyanate, tetraisocyanate silane, methyl silyl triisocyanate, vinyl silyl triisocyanate, ethoxysilane triisocyanate and the like.

[0092] Examples of the titanate-based coupling agent include isopropyltriisostearoyl titanate, isopropyl tridodecyl benzenesulfonyl titanate, isopropyl tris(dioctyl pyrophosphate)titanate, tetraisopropyl bis(dioctyl phosphite) titanate, tetraoctyl bis(ditridecylphosphite) titanate, tetra(2,2-diallyl-oxy-methyl-1-butyl) bis(di-tridecyl) phosphite titanate, bis(dioctyl pyrophosphate)oxy acetate titanate, bis(dioctyl pyrophosphate) ethylene titanate, isopropyl trioctanoyl titanate, isopropyl dimethacrylic isostearoyl titanate, isopropyl (dioctyl phosphate) titanate, isopropyl tricumylphenyl titanate, isopropyl tri (N-aminoethyl-aminoethyl) titanate, dicumylphenyl oxyacetate titanate, diisostearoyl ethylene titanate, and the like.

[0093] Examples of the aluminum-based coupling agent include acetoalkoxyaluminum diisopropionate and the like.

[0094] Examples of the zirconate-based coupling agent include tetrapropyl zirconate, tetrabutyl zirconate, tetra(triethanolamine) zirconate, tetraisopropyl zirconate, zirconium acetylacetonate acetylacetone zirconium butyrate, stearic acid zirconium butyrate, and the like.

[0095] In addition, the content of the coupling agent is preferably 0.5 mass% to 6.0 mass%, and more preferably 1.0 mass% to 5.0 mass% in

terms of the total amount of the resin paste composition. When the content of the coupling agent is 0.5 mass% or more, there is a tendency that bonding strength further improves. In addition, when the content of the coupling agent exceeds 6.0 mass%, a number of volatile components are generated during the curing of the resin paste composition, and there is a tendency that air spaces called voids are easily generated in a cured product of the resin paste composition.

[0096] The resin paste composition may further contain an epoxy resin (an epoxy resin other than the aromatic epoxy resin), a silicone resin, an urethane resin, an acrylic resin and the like as the binder resin component.

[0097] It is possible to further add an appropriate combination of a moisture absorbent such as calcium oxide or magnesium oxide; a wetting improver such as a fluorine-based surfactant, a nonionic surfactant or a higher fatty acid; a defoamer such as silicone oil; an ion trapping agent such as an inorganic ion exchanger; and the like to the resin paste composition as necessary.

[0098] The resin paste composition can be obtained by injecting the above respective components collectively or separately into an apparatus obtained by appropriately combining a dispersion apparatus and a dissolution apparatus, such as a stirrer, a hybrid mixer, an automated mortar machine, a three-roll and a planetary mixer, heating the components as necessary, and mixing, dissolving, pulverizing kneading or dispersing the components, thereby forming the components into a paste form.

[0099] The viscosity of the resin paste composition at 25°C is

preferably 30 Pa-s to 200 Pa-s, more preferably 50 Pa-s to 150 Pa-s, and still more preferably 50 Pa-s to 80 Pa-s from the viewpoint of workability.

5 [0100] A semiconductor device according to the embodiment includes a support member, a semiconductor element and a bonding layer that is disposed between the support member and the semiconductor element and bonds the support member and the semiconductor element, and the bonding layer includes a cured product of the resin paste composition. In the semiconductor device, since the support member and the
10 semiconductor element are bonded to each other using a cured product of the resin paste composition, electric conductivity and reliability are excellent.

[0101] Examples of the support member include organic substrates, such as lead frames such as alloy 42 lead frames and copper lead
15 frames, glass epoxy substrates (substrates made of a glass fiber reinforced epoxy resin), and BT substrates (BT resin-used substrates made of cyanate monomer, an oligomer thereof and bismaleimide).

[0102] Examples of a method for bonding the semiconductor element onto the support member using the resin paste composition include the
20 following method.

[0103] First, the resin paste composition is coated on the support member using a method, such as a dispensing method, a screen printing method or a stamping method, so as to form a resin layer. Next, the semiconductor element is pressed from a surface of the resin layer
25 opposite to a support base material, and then the resin layer is heated and cured using a heating apparatus, such as an oven or a heat block.

Thereby, the semiconductor element is bonded onto the support member.

5 [0104] After the semiconductor element is bonded onto the support member, a wire bonding process, a sealing process and the like are carried out as necessary, whereby the semiconductor device according to the embodiment can be obtained. Meanwhile, the wire bonding process and the sealing process can be carried out using a well-known method of the related art.

10 [0105] The heating and curing can be carried out under conditions of, for example, a heating temperature of 150°C to 220°C (preferably 180°C to 200°C) and a heating time of 30 seconds to 2 hours (preferably 1 hour to 1.5 hours).

15 [0106] Generally, in a case in which an organic substrate is used as the support member, since there is a concern that moisture absorbed by the organic substrate may evaporate due to the heating during bonding so as to cause voids, the organic substrate is preferably dried before being assembled.

[0107] Thus far, the preferable embodiment of the invention has been described, but the invention is not limited to the embodiment.

20 [0108] For example, the invention enables an application of a composition containing a compound having a (meth)acryloyloxy group, a polymerization initiator, a flexibility-imparting agent, an amine compound and aluminum powder to an adhesive for bonding a semiconductor element.

25 [0109] In addition, the invention may be an application of a composition containing a compound having a (meth)acryloyloxy group,

a polymerization initiator, a flexibility-imparting agent, an amine compound and aluminum powder to manufacturing of an adhesive for bonding a semiconductor element.

[Examples]

5 [0110] Hereinafter, the invention will be described specifically using examples, but the invention is not limited to the examples.

[0111] Components used in the examples and comparative examples will be exemplified below.

10 (1) A compound having a (meth)acryloyloxy group ((A) component)

· FA-512M (manufactured by Hitachi Chemical Co., Ltd., the product name of dicyclopentenylloxyethyl methacrylate) ((A-1) component)

15 · R-712 (manufactured by Nippon Kayaku Co., Ltd., the product name of 4 mole ethylene oxide adduct diacrylate of bisphenol F) ((A-2) component)

(2) A polymerization initiator ((B) component)

· PERHEXA 25B (manufactured by NOF Co., Ltd., the product name of 2,5-dimethyl-2,5-bis(t-butylperoxy)hexane)

20 (3) A flexibility-imparting agent ((C) component)

· CTBN1300×31 (manufactured by Ube Industries, Ltd., the product name of a carboxyl group-containing acrylonitrile butadiene copolymer)

25 · EPOLEAD PB4700 (manufactured by Daicel Chemical Industries Co., Ltd., the product name of epoxidized polybutadiene, number average molecular weight: 3500)

(4) An amine compound ((D) component)

· JER CURE DICY7 (manufactured by Mitsubishi Chemical Co., Ltd., the product name of dicyandiamide)

5 · 2P4MHZ-PW (manufactured by Shikoku Chemicals Co., Ltd., the product name of 2-phenyl-4-methyl-5-hydroxymethyl imidazole)

(5) Aluminum powder ((E) component)

10 · VA-2000 (manufactured by Yamaishi Metal Co., Ltd., the product name of aluminum powder, shape: granular, average particle diameter=6.7 μm)

· No. 800F (manufactured by Minaruko Co., Ltd., the product name of aluminum powder, shape: granular, average particle diameter=3.1 μm)

15 · No. 500M (manufactured by Minaruko Co., Ltd., the product name of aluminum powder, shape: granular, average particle diameter=10.4 μm)

[0112] Meanwhile, FIG. 1A is a view illustrating an electron micrograph of VA-2000, FIG. 1B is a view illustrating an electron micrograph of No. 800F, and FIG. 1C is a view illustrating an electron micrograph of No. 500M. In addition, regarding the average particle diameter of each aluminum powder, the particle size distribution was measured using a particle size distribution measuring apparatus (for example, MICROTRAC X100) in which a laser diffraction method was used, and the value at 50% accumulation (number-based) was used as the average particle diameter. The results are described in Table 1.

20

25

[0113] [Table 1]

	Shape	Average particle diameter (μm)	Maximum particle diameter (μm)	Particle size distribution (μm ; volume-based)		
				10%	50%	100%
VA-2000	Granular	6.7	37.00	3.02	6.74	15.58
No. 800F	Granular	3.1	18.50	1.57	3.13	6.15
No. 500M	Granular	10.4	52.33	5.50	10.40	20.14

[0114] (6) Silver powder

· AgC-212DH (the product name of silver powder manufactured by Fukuda Metal Foil Powder Industry Co., Ltd., shape: flake, average particle size=2.9 μm)

5

· SF-65LV (the product name of silver powder manufactured by Ferro Japan KK, shape: flake, the average particle diameter=3.5 μm)

(7) A coupling agent

· KBM-403 (the product name of organosilane manufactured by Shin-Etsu Chemical Co., Ltd.)

10

(8) An aromatic epoxy resin

· N-665-EXP (the product name of cresol novolac-type epoxy resin manufactured by DIC Co., Ltd., epoxy equivalent=198 to 208)

[0115] (Examples 1 to 8, Comparative Example 1, Reference Example 1)

15

The respective components were mixed at the blend proportions (mass ratios) shown in Table 2 or 3 using a planetary mixer, and then defoaming treatments were carried out at 666.61Pa (5 Torr) or less for 10 minutes, thereby obtaining resin paste compositions.

20

[0116] The characteristics (viscosity, viscosity stability, die shear bonding strength and volume resistivity) of the obtained resin paste compositions were measured using the following methods. The results

were as described in Table 2 or 3. Meanwhile, FIG. 2A is a view illustrating an electron micrograph of a powder mixture of aluminum powder and silver powder in a resin paste composition obtained in Example 1, and FIG. 2B is a view illustrating an electron micrograph of silver powder in a resin paste composition obtained in Reference Example 1.

[0117] (Measurement of viscosity and viscosity stability)

(a) Viscosity

The viscosity (Pa·s) at 25°C was measured using an EDH-type rotary viscometer (manufactured by Tokyo Keiki Co., Ltd.).

(b) Viscosity stability

The viscosities measured in (a) were used as initial values, sampling times were set to 1 day, 3 days and 7 days, and the viscosity (Pa·s) at 25°C was measured using an EDH-type rotary viscometer (manufactured by Tokyo Keiki Co., Ltd.).

[0118] (Measurement of die shear strength)

The resin paste composition (approximately 0.5 mg) was coated on each of substrates of a Ni/Au-plated copper frame (abbreviated to "Ni/Au-plated" in Table 2), an Ag-plated lead frame (abbreviated to "Ag-spot-plated" in Table 2) and an Ag-ring-plated copper frame (abbreviated to "Ag-ring-plated" in Table 2), a 3 mm×3 mm Si chip (thickness: approximately 0.4 mm) was pressed on the substrate, furthermore, the resin paste composition was heated up to 180°C for 30 minutes in an oven, and cured at 180°C for 1 hour, thereby obtaining a test sample.

[0119] For each of the obtained test samples, the shear bonding

strength (MPa) when the sample was held at 260°C for 20 seconds was measured using an automated bond tester (BT4000, manufactured by Dage Japan Co., Ltd.). Meanwhile, in the measurement of the die shear strength, 10 test samples were used for each substrate, and the average value was evaluated.

[0120] (Measurement of coating workability)

The resin paste composition was filled into a syringe, ejected 20 times on a glass substrate from a 21G (inner diameter: 570 μm) nozzle using a dispenser (SHOTminiSL, manufactured by Musashi Engineering, Inc.), and coated. The shapes of the resin paste composition coated on the glass substrate were observed using a microscope (KH-3000, manufactured by Hirox-Japan, Co., Ltd.). The coated shape at this time became a horn-like protrusion shape, the number of protrusion portions that collapsed outside the coated portion were counted, and the coating workability was evaluated according to the following evaluation criteria.

<Evaluation criteria>

A: the number of collapsed protrusion portions is zero.

B: the number of collapsed protrusion portions is one to three.

C: the number of collapsed protrusion portions is four to nine.

D: the number of collapsed protrusion portions is ten or more.

[0121] (Measurement of volume resistivity)

FIG. 3 is a pattern diagram illustrating a method for producing a test sample used in the measurement of the volume resistivity. A test sample was produced as illustrated in FIG. 3 using the resin paste composition, a glass slide (manufactured by TGK, dimensions=76

mm×26 mm, thickness=0.9 mm to 1.2 mm) and a paper tape (manufactured by Nitto Denko CS System Corporation, No. 7210F, width dimension=18 mm, thickness=0.10 mm). For the produced test sample, the volume resistivity ($\Omega\text{-cm}$) was measured using a digital
5 multimeter (TR6846, manufactured by Advantest Co., Ltd.).

[0122] Meanwhile, the test sample was produced using the following method. First, as illustrated in FIG. 3A, three pieces of paper tape 2 were attached onto a main surface of a glass slide 1 so that intervals between the paper tape 2 became approximately 2 mm. Next, as
10 illustrated in FIG. 3B, a resin paste composition 3 was placed on the glass slide 1 exposed between the paper tape 2, extended using a squeegee, and coated so that the thickness of the resin paste composition became the same thickness of the paper tape. In addition, the paper tape 2 was removed, and the resin paste composition 3 was heated at
15 180°C for 1 hour in an oven so as to be cured, thereby producing a test sample 10 illustrated in FIG. 3C. The produced test sample 10 has a structure in which a 2 mm-wide resin layer 4 made of a cured product of the resin paste composition was provided on the main surface of the glass slide 1. The volume resistivity of the resin layer 4 was measured
20 using the above method.

[0123] [Table 2]

	Example 1	Example 2	Example 3	Example 4	Example 5
(A) component	FA-512M	8.0	8.0	8.0	8.0
	R-712	6.0	6.0	6.0	6.0
(B) component	PERHEXA25B	1.0	1.0	1.0	1.0
(C) component	CTBN1300x31	1.0	1.0	1.0	1.0
	EPOLEAD PB4700	5.0	5.0	10.0	5.0
(D) component	jER CURE DICY7	0.3	0.5	1.0	-
	2P4MHZ-PW	-	-	-	0.3
(E) component	VA-2000	31.0	31.0	31.0	31.0
	No. 800F	-	-	-	-
	No. 500M	-	-	-	-
Silver powder	AgC-212DH	47.5	47.5	47.5	47.5
	SF-65LV	-	-	-	-
Coupling agent	KBM-403	2.5	2.5	2.5	2.5
Aromatic epoxy resin	N-665-EXP	-	-	-	-
	Initial	67	99	103	65
	After one day	66	96	102	65
	After two days	61	94	100	63
Viscosity	After seven days	62	91	95	58
	Ni/Au-plated	5.2	4.7	4.3	4.5
	Ag-spot-plated	3.8	4.2	4.0	3.0
	Ag-ring-plated	4.0	3.8	3.8	4.0

Coating workability	A	B	B	B	A
Volume resistivity ($\times 10^{-2} \Omega \cdot \text{cm}$)	1.24	26.4	286	1.34	3.80

[0124] [Table 3]

		Example 6	Example 7	Example 8	Comparative Example 1	Reference Example 1
(A) component	FA-512M	8.0	8.0	8.0	8.0	6.0
	R-712	6.0	6.0	6.0	6.0	8.4
(B) component	PERHEXA25B	1.0	1.0	1.0	1.0	0.7
(C) component	CTBN1300x31	1.0	1.0	1.0	1.0	0.7
	EPOLEAD PB4700	5.0	5.0	4.0	5.0	4.8
(D) component	JER CURE DICY7	0.3	0.3	0.3	-	0.3
	2P4MHZ-PW	-	-	-	-	-
(E) component	VA-2000	-	-	31.0	31.0	-
	No. 800F	31.0	-	-	-	-
	No. 500M	-	31.0	-	-	-
Silver powder	AgC-212DH	47.5	47.5	47.5	47.5	59.7
	SF-65LV	-	-	-	-	16.6
Coupling agent	KBM-403	2.5	2.5	2.5	2.5	0.7
Aromatic epoxy resin	N-665-EXP	-	-	1.0	-	1.3
	Initial	185	109	125	62	57
Viscosity	After one day	154	103	122	61	56
	After two days	139	85	121	58	56
	After seven days	121	79	115	56	55
Die shear strength (MPa)	Ni/Au-plated	4.0	4.0	5.5	2.2	5.2
	Ag-spot-plated	3.3	3.3	4.0	1.2	3.1

	Ag-ring-plated	5.7	5.7	4.7	3.8	6.0
Coating workability		D	A	C	A	A
Volume resistivity ($\times 10^{-2} \Omega\text{-cm}$)		5.72	8.30	1490	2.90	1.19

5 [0125] As described in Tables 2 and 3, the resin paste compositions of Examples all exhibited a high die shear strength with respect to the substrates, and had excellent bonding properties. In addition, the resin paste compositions of Examples also had favorable preservation stability. In addition, in the resin paste of Examples 1 to 7, excellent electric conductivities could be obtained even without using a large amount of highly rare silver.

Industrial Applicability

10 [0126] The resin paste composition for a semiconductor element of the invention is excellent in terms of die shear strength and preservation strength even when aluminum powder is used as a conductive filler, and can be preferably used for bonding between a semiconductor element and a support member.

Reference Signs List

15 [0127] 1 ... GLASS SLIDE, 2 ... PAPER TAPE, 3 ... RESIN PASTE COMPOSITION, 4 ... RESIN LAYER, 10 ... TEST SAMPLE

CLAIMS

1. A resin paste composition for bonding a semiconductor element comprising:
 - a compound having a (meth)acryloyloxy group;
 - 5 a polymerization initiator;
 - a flexibility-imparting agent;
 - an amine compound; and
 - aluminum powder.
2. The resin paste composition for bonding a semiconductor element according to Claim 1, substantially not comprising an aromatic epoxy resin.
- 10 3. The resin paste composition for bonding a semiconductor element according to Claim 1 or 2,
 - wherein the flexibility-imparting agent includes a rubber
 - 15 component.
4. The resin paste composition for bonding a semiconductor element according to any one of Claims 1 to 3,
 - wherein the amine compound is dicyandiamide and/or an imidazole compound.
- 20 5. The resin paste composition for bonding a semiconductor element according to any one of Claims 1 to 4,
 - wherein a shape of the aluminum powder is a granular shape,
 - and
 - an average particle diameter of the aluminum powder is in a
 - 25 range of 2 μm to 10 μm .
6. The resin paste composition for bonding a semiconductor element

according to any one of Claims 1 to 5, further comprising:

silver powder.

7. The resin paste composition for bonding a semiconductor element according to Claim 6,

5 wherein a shape of the silver powder is a flake shape, and
 an average particle diameter of the silver powder is 1 μm to 5 μm .

8. The resin paste composition for bonding a semiconductor element according to Claim 6 or 7,

10 wherein a ratio C_1/C_2 of a content C_1 of the aluminum powder to a content C_2 of the silver powder is 2/8 to 8/2 by mass ratio.

9. The resin paste composition for bonding a semiconductor element according to any one of Claims 1 to 8,

15 wherein the compound having a (meth)acryloyloxy group is a (meth)acrylic acid ester compound.

10. A semiconductor device comprising:

a support member;

a semiconductor element; and

20 a bonding layer that is disposed between the support member and the semiconductor element and bonds the support member and the semiconductor element,

 wherein the bonding layer includes a cured product of the resin paste composition for bonding a semiconductor element according to any one of Claims 1 to 9.

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