DESCRIPTION

Title of Invention:

LAMINATE AND METHOD FOR PRODUCING PROCESSED SEMICONDUCTOR SUBSTRATE

Technical Field

[0001]

The present invention relates to a laminate and a method for producing a processed semiconductor substrate.

Background Art

[0002]

There is a demand for semiconductor integration technology in which semiconductor wafers conventionally integrated in a two-dimensional planar direction are further integrated (laminated) also in a three-dimensional direction for the purpose of achieving even higher integration. This three-dimensional lamination is a technology of integrating multiple layers while connecting the layers by a through silicon via (TSV). At the time of multilayer integration, respective wafers to be integrated are thinned by polishing on the side opposite to the formed circuit surface (that is, the back surface), and the thinned semiconductor wafers are laminated.

[0003]

A semiconductor wafer before thinning (also referred

to herein simply as a wafer) is bonded to a support in order to be polished with a polishing apparatus. The adhesion at that time needs to be easily releasable after polishing, and is therefore referred to as temporary adhesion. This temporary adhesion needs to allow easy removal from the support. Otherwise, the thinned semiconductor wafer may be cut or deformed when a large force is applied for the removal. In order to prevent such a situation, the semiconductor wafer is easily removed. On the other hand, it is not also preferable that polishing stress at the time of polishing the back surface of the semiconductor wafer causes the semiconductor wafer to be detached or displaced. Therefore, the performance required for temporary adhesion is to withstand the stress during polishing and to allow for easy removal after polishing.

[0004]

As temporary adhesives used for such temporary adhesion, an adhesive containing polydimethylsiloxane (Patent Literature 1), a temporary adhesive containing an epoxy-modified polysiloxane (Patent Literature 2), and the like have been proposed. In these techniques, the release between the support and the semiconductor wafer is performed by inserting a sharp portion of equipment having a sharp portion, which is called a debonder, into the layer of a temporary adhesive.

[0005]

On the other hand, release between a support and a semiconductor wafer using infrared rays has been proposed.

For example, there has been proposed a releasable adhesive composition for infrared ray release that allows for release by infrared irradiation, the adhesive composition for infrared ray release containing a component (A) cured by a hydrosilylation reaction, and at least one component (B) selected from the group consisting of a component containing an epoxy-modified polyorganosiloxane, a component containing a methyl group-containing polyorganosiloxane, and a component containing a phenyl group-containing polyorganosiloxane (Patent Literature 3).

There has also been proposed a method for releasing a laminate including: a first step of bonding a first body composed of a semiconductor formation substrate and a second body composed of a support substrate that transmits an infrared laser via a first adhesive layer provided on the first body side and a second adhesive layer provided on the second body side to form a laminate, wherein the first adhesive layer is an adhesive layer obtained by curing an adhesive (A) containing a component cured by a hydrosilylation reaction, and the second adhesive layer is an adhesive layer that transmits the infrared laser obtained by using an adhesive (B), which is a polymer

adhesive having an aromatic ring in at least one of a main chain and a side chain; and a second step of performing release between the first adhesive layer and the second adhesive layer by irradiating the laminate with the infrared laser from the second body side (Patent Literature 4).

In the release using infrared rays, the adhesive is deteriorated by irradiation with infrared rays to facilitate release.

Citation List

Patent Literature

[0006]

Patent Literature 1: WO 2017/221772 A

Patent Literature 2: WO 2018/216732 A

Patent Literature 3: WO 2020/100966 A

Patent Literature 4: WO 2020/100965 A

Summary of Invention

Technical Problem

[0007]

Since a certain degree of insertion force is required in the release by the equipment having the sharp portion in the techniques described in Patent Literature 1 and Patent Literature 2, it takes a treatment time and damage to the

semiconductor wafer or the support substrate may be a problem.

In the techniques described in Patent Literature 3 and Patent Literature 4, it is necessary to sufficiently irradiate with an infrared laser in order to facilitate release, but in this case, it takes a long treatment time, and deterioration of cleanability due to deterioration of an adhesive may be a problem.

[0008]

An object of the present invention is to provide a laminate which does not require a treatment time in release using an infrared laser, causes little damage to a body, and has good cleanability, and a method for producing a processed semiconductor substrate or electronic device layer using the laminate.

Solution to Problem

[0009]

As a result of intensive studies to solve the above-mentioned problems, the present inventors have found that the above-mentioned problems can be solved, and completed the present invention having the following gist.

[0010]

That is, the present invention includes the following items.

[1] A laminate including:

a first body that is a semiconductor substrate or an electronic device layer;

a second body that is a support substrate that transmits an infrared laser; and

an infrared-transmitting adhesive layer and an infrared-absorbing layer provided between the first body and the second body.

[2] The laminate according to [1], wherein the infrared-absorbing layer is provided between the first body and the infrared-transmitting adhesive layer.

[3] The laminate according to [1] or [2], wherein the infrared-absorbing layer is formed from an infrared-absorbing composition containing an infrared-absorbing compound.

[4] The laminate according to any one of [1] to [3], wherein a thickness of the infrared-transmitting adhesive layer is thicker than a thickness of the infrared-absorbing layer.

[5] The laminate according to any one of [1] to [4], wherein an insertion force required to separate the first body and the second body by inserting a sharp portion of equipment having a sharp portion between the first body and the second body after irradiating the infrared-absorbing layer with the infrared laser is smaller than an insertion

force required to separate the first body and the second body by inserting the sharp portion between the first body and the second body without irradiating the infrared-absorbing layer with the infrared laser.

[6] A method for producing a processed semiconductor substrate or electronic device layer, the method including:

a processing step of processing the first body of the laminate according to any one of [1] to [5]; and

a separation step of irradiating the infrared-absorbing layer with the infrared laser from the second body side, and then separating the processed first body and the second body.

[7] The method for producing a processed semiconductor substrate or electronic device layer according to [6], wherein by irradiating the infrared-absorbing layer with the infrared laser, an insertion force required to separate the first body and the second body by inserting the sharp portion of equipment having a sharp portion between the first body and the second body is reduced as compared with a case where the infrared-absorbing layer is not irradiated with the infrared laser.

Advantageous Effects of Invention

[0011]

According to the present invention, it is possible to

provide a laminate which does not require a treatment time in release using an infrared laser, causes little damage to a body, and has good cleanability, and a method for producing a processed semiconductor substrate or electronic device layer using the laminate.

Brief Description of Drawings

[0012]

[Fig. 1] Fig. 1 is a schematic cross-sectional view of an example of a laminate according to a first embodiment.

[Fig. 2A] Fig. 2A is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in a first embodiment (part 1).

[Fig. 2B] Fig. 2B is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in a first embodiment (part 2).

[Fig. 2C] Fig. 2C is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in the first embodiment (part 3).

[Fig. 3] Fig. 3 is a schematic cross-sectional view of an example of a laminate according to a second embodiment.

[Fig. 4A] Fig. 4A is a schematic cross-sectional view for illustrating a method for producing a laminate showing

an example in the second embodiment (part 1).

[Fig. 4B] Fig. 4B is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in the second embodiment (part 2).

[Fig. 4C] Fig. 4C is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in the second embodiment (part 3).

[Fig. 4D] Fig. 4D is a schematic cross-sectional view for illustrating a method for producing a laminate showing an example in the second embodiment (part 4).

[Fig. 5A] Fig. 5A is a schematic cross-sectional view for illustrating a processing method of a laminate showing an example in the first embodiment (part 1).

[Fig. 5B] Fig. 5B is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the first embodiment (part 2).

[Fig. 5C] Fig. 5C is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the first embodiment (part 3).

[Fig. 5D] Fig. 5D is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the first embodiment (part 4).

[Fig. 5E] Fig. 5E is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the first embodiment (part 5).

[Fig. 6A] Fig. 6A is a schematic cross-sectional view for illustrating a processing method of a laminate showing an example in a second embodiment (part 1).

[Fig. 6B] Fig. 6B is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the second embodiment (part 2).

[Fig. 6C] Fig. 6C is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the second embodiment (part 3).

[Fig. 6D] Fig. 6D is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the second embodiment (part 4).

[Fig. 6E] Fig. 6E is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the second embodiment (part 5).

[Fig. 6F] Fig. 6F is a schematic cross-sectional view for illustrating a processing method of the laminate showing an example in the second embodiment (part 6).

Description of Embodiments

[0013]

(Laminate)

The laminate according to the present invention includes a first body, a second body, an infrared-transmitting adhesive layer, and an infrared-absorbing

layer.

The first body is a semiconductor substrate or an electronic device layer.

The second body is a support substrate that transmits an infrared laser.

[0014]

The infrared-transmitting adhesive layer and the infrared-absorbing layer are provided between the first body and the second body.

[0015]

In the present invention, an infrared-transmitting adhesive layer and an infrared-absorbing layer are provided between the first body and the second body.

Since the laminate has the infrared-absorbing layer that absorbs the infrared laser, the first body and the second body can be separated with a small irradiation amount of the infrared laser. By doing so, the treatment time is not required. In addition, since it is not necessary to perform release with equipment having a sharp portion, or even when equipment having a sharp portion is used in combination, the insertion force can be reduced, so that damage to the body is low. Since the adhesive layer is infrared-transmitting, excessive deterioration of the adhesive layer by the infrared laser can be avoided. Since the deterioration of the adhesive layer is small, the

cleanability of the adhesive layer is good.

[0016]

Furthermore, in the laminate, the infrared-absorbing layer is preferably provided between the first body and the infrared-transmitting adhesive layer. By doing so, when the first body and the second body are separated, it is possible to perform release without leaving the infrared-transmitting adhesive layer on the semiconductor substrate or the electronic device layer which is the first body. As a result, the burden of cleaning the first body is reduced.

[0017]

The laminate of the present invention is used for temporary adhesion for processing the semiconductor substrate or the electronic device layer, and can be suitably used for processing such as thinning of the semiconductor substrate or the electronic device layer.

While the semiconductor substrate is subjected to processing such as thinning, the semiconductor substrate is supported by the support substrate. On the other hand, after the processing of the semiconductor substrate, the support substrate and the semiconductor substrate are separated.

In addition, while the electronic device layer is subjected to processing such as thinning, the electronic device layer is supported by the support substrate.

Meanwhile, after the processing of the electronic device layer, the support substrate and the electronic device layer are separated.

After the semiconductor substrate or the electronic device layer is separated from the support substrate, the residue of the infrared-absorbing layer and the infrared-transmitting adhesive layer remaining on the semiconductor substrate, the electronic device layer, or the support substrate can be removed by, for example, a cleaning agent composition for cleaning the semiconductor substrate and the like.

[0018]

In the present invention, it is preferable that the insertion force (Fb) required to separate the first body and the second body by inserting a sharp portion of equipment having a sharp portion between the first body and the second body after irradiating the infrared-absorbing layer with the infrared laser is smaller than an insertion force (Fa) required to separate the first body and the second body by inserting the sharp portion between the first body and the second body without irradiating the infrared-absorbing layer with the infrared laser.

The insertion force is indicated as an absolute value.

Examples of the insertion force (Fa) include 0.1 N to

100 N.

[0019]

The ratio (Fb/Fa) of the insertion force (Fb) to the insertion force (Fa) is not particularly limited, but is preferably less than 1.0, more preferably 0.9 or less, and still more preferably 0.6 or less.

The lower limit value of the ratio (Fb/Fa) is not particularly limited, but the ratio (Fb/Fa) may be 0.01 or more, 0.05 or more, or 0.1 or more.

The insertion force is measured, for example, as follows.

After a semiconductor substrate or an electronic device layer and a support substrate are temporarily bonded to each other via an infrared-transmitting adhesive layer and an infrared-absorbing layer to obtain a laminate, and release is performed using a release device. During release, a scraper replacement blade (manufactured by ESCO Company Ltd., blade thickness: 0.2 mm) is mounted on the tip of a force gauge, and the replacement blade is inserted, parallel to the substrate, between the semiconductor substrate or the electronic device layer and the support substrate to form a trigger for release. At this time, the maximum value of the force required to insert the blade is measured with a force gauge and taken as the insertion force.

For example, a force gauge or a texture analyzer can be used to measure the insertion force. An absolute value is used as a value of the force gauge representing the insertion force.

[0020]

Hereinafter, a case where the laminate includes a semiconductor substrate and a case where the laminate includes an electronic device layer will be described in detail separately.

The case where the laminate includes a semiconductor substrate will be described in the following <First embodiment>, and the case where the laminate includes an electronic device layer will be described in the following <Second embodiment>.

[0021]

<First embodiment>

The laminate having a semiconductor substrate is used for processing the semiconductor substrate. While the semiconductor substrate is processed, the semiconductor substrate is bonded to the support substrate. After the processing of the semiconductor substrate, the semiconductor substrate is separated from the support substrate.

[0022]

<<Semiconductor substrate>>

The main material constituting the entire semiconductor substrate is not particularly limited as long as the material is used for this type of application, and examples thereof include silicon, silicon carbide, a compound semiconductor, and an organic resin-attached glass substrate.

The shape of the semiconductor substrate is not particularly limited, and is, for example, a disk shape. The disk-shaped semiconductor substrate does not need to have a completely circular surface, and for example, the outer periphery of the semiconductor substrate may have a linear portion called an orientation flat or may have a cut called a notch.

The thickness of the disk-shaped semiconductor substrate may be appropriately determined depending on the purpose of use of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 500 to 1,000 μm.

The diameter of the disk-shaped semiconductor substrate may be appropriately determined depending on the purpose of use of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 100 to 1,000 mm.

[0023]

The semiconductor substrate may have a bump. The

bump is a protruding terminal. The bump is, for example, an electrode.

In the laminate, when the semiconductor substrate has a bump, the semiconductor substrate has the bump on the support substrate side.

In the semiconductor substrate, the bump is usually formed on a surface on which a circuit is formed. The circuit may be a single layer or a multilayer. The shape of the circuit is not particularly limited.

In the semiconductor substrate, a surface (back surface) opposite to the surface having the bump is a surface to be processed.

The material, size, shape, structure, and density of the bump of the semiconductor substrate are not particularly limited.

Examples of the bump include a ball bump, a print bump, a stud bump, and a plating bump.

Usually, the height, radius, and pitch of the bump are appropriately determined from the conditions of a bump height of approximately 1 to 200 μm, a bump radius of 1 to 200 μm, and a bump pitch of 1 to 500 μm.

Examples of the material of the bump include low melting point solder, high melting point solder, tin, indium, gold, silver, and copper. The bump may contain only a single component or may contain a plurality of

components. More specific examples thereof include alloy plating mainly containing Sn, such as SnAg bumps, SnBi bumps, Sn bumps, and AuSn bumps.

In addition, the bump may have a laminated structure including a metal layer consisting of at least one of these components.

[0024]

An example of the semiconductor substrate is a silicon wafer having a diameter of about 300 mm and a thickness of about 770 μm.

[0025]

<<Support substrate>>

The support substrate is not particularly limited as long as it is a member capable of supporting the semiconductor substrate when the semiconductor substrate is processed and is capable of transmitting an infrared laser, and examples thereof include a silicon support substrate.

[0026]

The shape of the support substrate is not particularly limited, and examples thereof include a disk shape. The disk-shaped support substrate does not need to have a completely circular surface shape, and for example, the outer periphery of the support substrate may have a straight portion called an orientation flat or may have a cut called a notch.

The thickness of the disk-shaped support substrate may be appropriately determined depending on the size of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 500 to 1,000 μm.

The diameter of the disk-shaped support substrate may be appropriately determined depending on the size of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 100 to 1,000 mm.

[0027]

An example of the support substrate is a silicon wafer having a diameter of about 300 mm and a thickness of about 700 μm.

[0028]

<<Infrared-transmitting adhesive layer>>

The infrared-transmitting adhesive layer is provided between the support substrate and the semiconductor substrate.

The infrared-transmitting adhesive layer is in contact with, for example, the semiconductor substrate. The infrared-transmitting adhesive layer may be in contact with, for example, the support substrate.

The infrared-transmitting adhesive layer is, for example, an adhesive layer formed of an infrared-transmitting adhesive composition.

[0029]

The infrared-transmitting adhesive layer can transmit an infrared laser.

[0030]

<<<Infrared-transmitting adhesive composition>>>

Examples of the infrared-transmitting adhesive composition include a polymer adhesive having an aromatic ring in at least one of a main chain and a side chain.

Specific examples of such a polymer adhesive having an aromatic ring in at least one of the main chain and the side chain include, but are not limited to, a polycarbonate-based adhesive, a polystyrene-based adhesive, a hydrogenated styrene-based thermoplastic elastomer-based adhesive, and the like. That is, the infrared-transmitting adhesive composition contains, for example, a polymer having an aromatic ring in at least one of the main chain and the side chain as an adhesive component. Examples of such a polymer include polycarbonate, polystyrene, and a hydrogenated styrene-based thermoplastic elastomer (for example, styrene-ethylene-butylene-styrene (SEBS) block copolymer).

The polymer adhesive having an aromatic ring in at least one of the main chain and the side chain may be a solvent-free material composed only of a polymer compound (polymer) as an adhesive component or may include a solvent. Examples of such a solvent include aliphatic

hydrocarbons, aromatic hydrocarbons, and ketones, and specific examples thereof include but are not limited to those described above. Such solvents can be used alone or in combination with two or more thereof.

[0031]

The infrared-transmitting adhesive composition may or may not contain a release agent component. Irradiation of the infrared-absorbing layer with the infrared laser is not necessarily performed on the entire region of the infrared-absorbing layer. When the irradiation with the infrared laser is performed on a part of the infrared-absorbing layer, it is preferable that the infrared-transmitting adhesive layer has releasability by itself. In this respect, the infrared-transmitting adhesive composition preferably contains a release agent component.

[0032]

The infrared-transmitting adhesive composition can be produced by mixing a film component and a solvent. However, when a solvent is not contained, the infrared-transmitting adhesive composition can be produced by mixing film components.

The order of mixing is not particularly limited, but examples of a method by which the infrared-transmitting adhesive composition can be easily and reproducibly produced include a method in which all the film components

are dissolved in a solvent, and a method in which a part of the film components is dissolved in a solvent, the rest of the film components are dissolved in a solvent, and the obtained solutions are mixed. In this case, if necessary, a part of the solvent or a film component having excellent solubility can be added at the end.

In preparing the infrared-transmitting adhesive composition, the composition may be appropriately heated as long as the components are not decomposed or deteriorated.

[0033]

The thickness of the infrared-transmitting adhesive layer included in the laminate of the present invention is not particularly limited, but is usually 0.5 to 500 μm, and is preferably 1 μm or more, more preferably 2 μm or more, and still more preferably 3 μm or more from the viewpoint of maintaining the film strength, and is preferably 200 μm or less, more preferably 150 μm or less, still more preferably 100 μm or less, and further preferably 80 μm or less from the viewpoint of avoiding nonuniformity caused by a thick film.

[0034]

The thickness of the infrared-transmitting adhesive layer is usually larger than the thickness of the infrared-absorbing layer.

[0035]

The method for forming the infrared-transmitting adhesive layer from the infrared-transmitting adhesive composition will be described in detail in the description of <<Method for producing one example of laminate in first embodiment>> described below.

[0036]

<Infrared-absorbing layer>

The infrared-absorbing layer is, for example, a layer formed of an infrared-absorbing composition.

The infrared-absorbing layer is provided between the semiconductor substrate and the support substrate.

The infrared-absorbing layer contains, for example, an infrared absorbing compound.

Examples of the infrared absorbing compound include polysiloxane. Polysiloxane has infrared absorptivity because it absorbs infrared rays through siloxane bonds.

The infrared-absorbing composition contains, for example, an infrared-absorbing component.

The infrared-absorbing composition may or may not contain a non-reactive infrared-absorbing component.

[0037]

<<Infrared-absorbing component>>

The infrared-absorbing component is not particularly limited, but is preferably a component that cures, and more preferably a component that cures by a hydrosilylation

reaction.

The component that is cured by a hydrosilylation reaction is not particularly limited, but preferably contains a component containing an alkenyl group having 2 to 40 carbon atoms, the alkenyl group being bonded to a silicon atom (hereinafter, also referred to as “component (A-1)” in some cases), and a component having a Si-H group (hereinafter, also referred to as “component (A-2)” in some cases).

[0038]

<<<Component (A-1) and component (A-2)>>>

The infrared-absorbing composition preferably contains the component (A-1).

The infrared-absorbing composition preferably contains the component (A-2).

Hereinafter, the combination of the component (A-1), the component (A-2), and the platinum group metal-based catalyst (A-3) may be referred to as “curing component (A)” or “component (A)”.

[0039]

From the viewpoint of suitably obtaining the effects of the present invention, the component (A-1) preferably contains a polyorganosiloxane (a1) containing an alkenyl group having 2 to 40 carbon atoms, the alkenyl group being bonded to a silicon atom.

From the viewpoint of suitably obtaining the effects of the present invention, the component (A-2) preferably contains a polyorganosiloxane (a2) having a Si-H group.

Here, the alkenyl group having 2 to 40 carbon atoms may be substituted. Examples of the substituent include a halogen atom, a nitro group, a cyano group, an amino group, a hydroxy group, a carboxyl group, an aryl group, and a heteroaryl group.

[0040]

In another preferred embodiment, the infrared-absorbing composition that is cured by a hydrosilylation reaction contains a polysiloxane (A1) containing one or two or more units selected from the group consisting of a siloxane unit (Q unit) represented by SiO_2, a siloxane unit (M unit) represented by $R^1R^2R^3SiO_{1/2}$, a siloxane unit (D unit) represented by $R^4R^5SiO_{2/2}$, and a siloxane unit (T unit) represented by $R^6SiO_{3/2}$, and a platinum group metal-based catalyst (A-3). The polysiloxane (A1) contains a polyorganosiloxane (a1') containing one or two or more units selected from the group consisting of a siloxane unit (Q' unit) represented by SiO_2, a siloxane unit (M' unit) represented by $R^1'R^2'R^3'SiO_{1/2}$, a siloxane unit (D' unit) represented by $R^4'R^5'SiO_{2/2}$, and a siloxane unit (T' unit) represented by $R^6'SiO_{3/2}$, and also containing at least one selected from the group consisting of M' units, D' units,

and T′ units; and a polyorganosiloxane (a2′) containing one or two or more units selected from the group consisting of a siloxane unit (Q″ unit) represented by SiO_2, a siloxane unit (M″ unit) represented by $R^1″R^2″R^3″SiO_{1/2}$, a siloxane unit (D″ unit) represented by $R^4″R^5″SiO_{2/2}$, and a siloxane unit (T″ unit) represented by $R^6″SiO_{3/2}$, and also containing at least one selected from the group consisting of M″ units, D″ units, and T″ units.

Note that (a1′) is an example of (a1), and (a2′) is an example of (a2).

[0041]

R^1 to R^6 are groups or atoms bonded to a silicon atom, and R^1 to R^6 each independently represent an alkyl group which may be substituted, an alkenyl group which may be substituted, or a hydrogen atom. Examples of the substituent include a halogen atom, a nitro group, a cyano group, an amino group, a hydroxy group, a carboxyl group, an aryl group, and a heteroaryl group.

[0042]

$R^1′$ to $R^6′$ are groups bonded to a silicon atom, and $R^1′$ to $R^6′$ each independently represent an alkyl group which may be substituted or an alkenyl group which may be substituted, provided that at least one of $R^1′$ to $R^6′$ is an alkenyl group which may be substituted. Examples of the substituent include a halogen atom, a nitro group, a cyano

group, an amino group, a hydroxy group, a carboxyl group, an aryl group, and a heteroaryl group.

[0043]

R^1" to R^6" are groups or atoms bonded to a silicon atom, and R^1" to R^6" each independently represent an alkyl group which may be substituted or a hydrogen atom, provided that at least one of R^1" to R^6" is a hydrogen atom. Examples of the substituent include a halogen atom, a nitro group, a cyano group, an amino group, a hydroxy group, a carboxyl group, an aryl group, and a heteroaryl group.

[0044]

The alkyl group may be linear, branched, or cyclic, and is preferably a linear or branched alkyl group. The number of carbon atoms thereof is not particularly limited, and is usually 1 to 40, preferably 30 or less, more preferably 20 or less, and still more preferably 10 or less.

[0045]

Specific examples of the linear or branched alkyl group which may be substituted include, but are not limited to, a methyl group, an ethyl group, an n-propyl group, an i-propyl group, an n-butyl group, an i-butyl group, an s-butyl group, a tertiary butyl group, an n-pentyl group, a 1-methyl-n-butyl group, a 2-methyl-n-butyl group, a 3-methyl-n-butyl group, a 1,1-dimethyl-n-propyl group, a 1,2-

dimethyl-n-propyl group, a 2,2-dimethyl-n-propyl group, a 1-ethyl-n-propyl group, an n-hexyl group, a 1-methyl-n-pentyl group, a 2-methyl-n-pentyl group, a 3-methyl-n-pentyl group, a 4-methyl-n-pentyl group, a 1,1-dimethyl-n-butyl group, a 1,2-dimethyl-n-butyl group, a 1,3-dimethyl-n-butyl group, a 2,2-dimethyl-n-butyl group, a 2,3-dimethyl-n-butyl group, a 3,3-dimethyl-n-butyl group, a 1-ethyl-n-butyl group, a 2-ethyl-n-butyl group, a 1,1,2-trimethyl-n-propyl group, a 1,2,2-trimethyl-n-propyl group, a 1-ethyl-1-methyl-n-propyl group, and a 1-ethyl-2-methyl-n-propyl group, and the number of carbon atoms thereof is usually 1 to 14, preferably 1 to 10, and more preferably 1 to 6. Among them, a methyl group is particularly preferable.

[0046]

Specific examples of the cyclic alkyl group which may be substituted include, but are not limited to, cycloalkyl groups such as a cyclopropyl group, a cyclobutyl group, a 1-methyl-cyclopropyl group, a 2-methyl-cyclopropyl group, a cyclopentyl group, a 1-methyl-cyclobutyl group, a 2-methyl-cyclobutyl group, a 3-methyl-cyclobutyl group, a 1,2-dimethyl-cyclopropyl group, a 2,3-dimethyl-cyclopropyl group, a 1-ethyl-cyclopropyl group, a 2-ethyl-cyclopropyl group, a cyclohexyl group, a 1-methyl-cyclopentyl group, a 2-methyl-cyclopentyl group, a 3-methyl-cyclopentyl group, a

1-ethyl-cyclobutyl group, a 2-ethyl-cyclobutyl group, a 3-ethyl-cyclobutyl group, a 1,2-dimethyl-cyclobutyl group, a 1,3-dimethyl-cyclobutyl group, a 2,2-dimethyl-cyclobutyl group, a 2,3-dimethyl-cyclobutyl group, a 2,4-dimethyl-cyclobutyl group, a 3,3-dimethyl-cyclobutyl group, a 1-n-propyl-cyclopropyl group, a 2-n-propyl-cyclopropyl group, a 1-i-propyl-cyclopropyl group, a 2-i-propyl-cyclopropyl group, a 1,2,2-trimethyl-cyclopropyl group, a 1,2,3-trimethyl-cyclopropyl group, a 2,2,3-trimethyl-cyclopropyl group, a 1-ethyl-2-methyl-cyclopropyl group, a 2-ethyl-1-methyl-cyclopropyl group, a 2-ethyl-2-methyl-cyclopropyl group, and a 2-ethyl-3-methyl-cyclopropyl group; and a bicycloalkyl group such as a bicyclobutyl group, a bicyclopentyl group, a bicyclohexyl group, a bicycloheptyl group, a bicyclooctyl group, a bicyclononyl group, and a bicyclodecyl group, and the number of carbon atoms thereof is usually 3 to 14, preferably 4 to 10, and more preferably 5 to 6.

[0047]

The alkenyl group may be linear or branched, and the number of carbon atoms thereof is not particularly limited, and is usually 2 to 40, preferably 30 or less, more preferably 20 or less, and still more preferably 10 or less.

[0048]

Specific examples of the linear or branched alkenyl group which may be substituted include, but are not limited to, a vinyl group, an allyl group, a butenyl group, and a pentenyl group, and the number of carbon atoms thereof is usually 2 to 14, preferably 2 to 10, and more preferably 1 to 6. Among them, an ethenyl group and a 2-propenyl group are particularly preferable.

Specific examples of the cyclic alkenyl group which may be substituted include, but are not limited to, cyclopentenyl and cyclohexenyl, and the number of carbon atoms thereof is usually 4 to 14, preferably 5 to 10, and more preferably 5 to 6.

[0049]

As described above, the polysiloxane (A1) contains a polyorganosiloxane (a1') and a polyorganosiloxane (a2'), and an alkenyl group contained in the polyorganosiloxane (a1') and a hydrogen atom (Si-H group) contained in the polyorganosiloxane (a2') form a crosslinked structure and cure by a hydrosilylation reaction with the platinum group metal-based catalyst (A-3). As a result, a cured film is formed.

[0050]

The polyorganosiloxane (a1') contains one or two or more units selected from the group consisting of a Q' unit, an M' unit, a D' unit, and a T' unit, and contains at least

one selected from the group consisting of an M′ unit, a D′ unit, and a T′ unit. As the polyorganosiloxane (a1′), two or more polyorganosiloxanes satisfying such conditions may be used in combination.

[0051]

Examples of preferred combinations of two or more types selected from the group consisting of a Q′ unit, an M′ unit, a D′ unit, and a T′ unit include, but are not limited to, (Q′ unit and M′ unit), (D′ unit and M′ unit), (T′ unit and M′ unit), and (Q′ unit, T′ unit, and M′ unit).

[0052]

In addition, when the polyorganosiloxane (a1′) contains two or more polyorganosiloxanes, a combination of (Q′ unit and M′ unit) and (D′ unit and M′ unit), a combination of (T′ unit and M′ unit) and (D′ unit and M′ unit), and a combination of (Q′ unit, T′ unit, and M′ unit) and (T′ unit and M′ unit) are preferable, but are not limited thereto.

[0053]

The polyorganosiloxane (a2′) contains one or two or more units selected from the group consisting of a Q″ unit, an M″ unit, a D″ unit, and a T″ unit, and contains at least one selected from the group consisting of an M″ unit, a D″ unit, and a T″ unit. As the polyorganosiloxane (a2′), two or more polyorganosiloxanes satisfying such conditions may

be used in combination.

[0054]

Examples of preferred combinations of two or more selected from the group consisting of a Q" unit, an M" unit, a D" unit, and a T" unit include, but are not limited to, (M" unit and D" unit), (Q" unit and M" unit), and (Q" unit, T" unit, and M" unit).

[0055]

The polyorganosiloxane (a1') is composed of siloxane units in which alkyl groups and/or alkenyl groups are bonded to silicon atoms of the polyorganosiloxane, and the proportion of alkenyl groups in all substituents represented by R^{1}' to R^{6}' is preferably 0.1 to 50.0 mol%, more preferably 0.5 to 30.0 mol%, and the rest of R^{1}' to R^{6}' can be alkyl groups.

[0056]

The polyorganosiloxane (a2') is composed of siloxane units in which alkyl groups and/or hydrogen atoms are bonded to silicon atoms of the polyorganosiloxane, and the proportion of hydrogen atoms in all substituents and substitutional atoms represented by R^{1}" to R^{6}" is preferably 0.1 to 50.0 mol%, more preferably 10.0 to 40.0 mol%, and the rest of R^{1}" to R^{6}" can be alkyl groups.

[0057]

When the infrared-absorbing composition contains (a1)

and (a2), in a preferred embodiment of the present invention, the molar ratio of the alkenyl group contained in the polyorganosiloxane (a1) and the hydrogen atom constituting the Si-H bond contained in the polyorganosiloxane (a2) is in the range of 1.0:0.5 to 1.0:0.66.

[0058]

The weight-average molecular weight of the polysiloxane such as the polyorganosiloxane (a1) or the polyorganosiloxane (a2) is not particularly limited, and each is typically 500 to 1,000,000, and is preferably 5,000 to 50,000 from the viewpoint of achieving the effects of the present invention with good reproducibility.

In the present invention, the weight-average molecular weight, the number-average molecular weight, and the dispersity of the polyorganosiloxanes can be measured, for example, using a GPC apparatus (EcoSEC, HLC-8320GPC, manufactured by Tosoh Corporation) and a GPC column (TSKgel SuperMultiporeHZ-N and TSKgel SuperMultiporeHZ-H, manufactured by Tosoh Corporation), at a column temperature of 40°C, using tetrahydrofuran as an eluent (elution solvent), at a flow rate of 0.35 mL/min, and using polystyrene (Shodex from Showa Denko K.K.) as a standard sample.

[0059]

The viscosities of the polyorganosiloxane (a1) and the polyorganosiloxane (a2) are not particularly limited, and are each usually 10 to 1,000,000 (mPa·s), and are preferably 50 to 10,000 (mPa·s) from the viewpoint of achieving the effects of the present invention with good reproducibility. The viscosities of the polyorganosiloxane (a1) and the polyorganosiloxane (a2) are values measured with an E-type rotational viscometer at 25°C.

[0060]

The polyorganosiloxane (a1) and the polyorganosiloxane (a2) react with each other by a hydrosilylation reaction. Accordingly, the mechanism of curing is different from, for example, that through silanol groups, and therefore, neither siloxane needs to contain a silanol group or a functional group that forms a silanol group by hydrolysis, such as an alkyloxy group.

[0061]

The content of the infrared-absorbing component in the infrared-absorbing composition is not particularly limited, but is preferably 30 mass% or more, more preferably 50 mass% or more, and particularly preferably 70 mass% or more with respect to the nonvolatile content of the infrared-absorbing composition from the viewpoint of suitably obtaining the effect of the present invention. The upper limit value is not particularly limited, but may

be, for example, 95 mass% or less, 90 mass% or less, or 85 mass% or less.

The nonvolatile content of the infrared-absorbing composition refers to components other than the solvent in the infrared-absorbing composition.

[0062]

<<Platinum group metal-based catalyst (A-3)>>

When the infrared-absorbing component is a component that cures, the infrared-absorbing composition preferably contains a platinum group metal-based catalyst.

The platinum group metal-based catalyst is a platinum-based metal catalyst.

Such a platinum-based metal catalyst is a catalyst for promoting the hydrosilylation reaction between the alkenyl group and the Si-H group.

[0063]

As a specific example of the platinum-based metal catalyst, a catalyst known as a platinum-based compound (platinum or a compound containing platinum) can be used.

Specific examples thereof include platinum fine powder, platinum black, chloroplatinic acid, an alcohol-modified product of chloroplatinic acid, a complex of chloroplatinic acid and diolefin, a platinum-olefin complex, a platinum-carbonyl complex [platinum bis(acetoacetate), platinum bis(acetylacetonate), or the

like], a chloroplatinic acid-alkenylsiloxane complex (chloroplatinic acid-divinyltetramethyldisiloxane complex, chloroplatinic acid-tetravinyltetramethylcyclotetrasiloxane complex, or the like), a platinum-alkenylsiloxane complex (platinum-divinyltetramethyldisiloxane complex, platinum-tetravinyltetramethylcyclotetrasiloxane complex, or the like), and a complex of chloroplatinic acid and an acetylene alcohol. Among them, a platinum-alkenylsiloxane complex is particularly preferable because it has a high effect of promoting the hydrosilylation reaction.

These hydrosilylation reaction catalysts may be used alone, or two or more thereof may be used in combination.

[0064]

The alkenylsiloxane used in the platinum-alkenylsiloxane complex is not particularly limited, and examples thereof include 1,3-divinyl-1,1,3,3-tetramethyldisiloxane; 1,3,5,7-tetramethyl-1,3,5,7-tetravinylcyclotetrasiloxane; alkenylsiloxane oligomers in which some of the methyl groups of the alkenylsiloxane are substituted with ethyl groups, phenyl groups, or the like; and alkenylsiloxane oligomers in which the vinyl groups of these alkenylsiloxanes are substituted with allyl groups, hexenyl groups, or the like. In particular, 1,3-divinyl-1,1,3,3-tetramethyldisiloxane is preferable since the platinum-alkenylsiloxane complex to be produced has good

stability.

[0065]

The content of the platinum group metal-based catalyst (A-3) in the infrared-absorbing composition is not particularly limited, and is, for example, in the range of 0.1 to 50.0 ppm with respect to the total mass of the component (A-1) and the component (A-2).

[0066]

<<Polymerization inhibitor>>

The infrared-absorbing composition may contain a polymerization inhibitor for the purpose of suppressing the progress of the hydrosilylation reaction.

The polymerization inhibitor is not particularly limited as long as it is possible to suppress the progress of the hydrosilylation reaction, and specific examples thereof include alkynyl alcohols such as 1-ethynyl-1-cyclohexanol and 1,1-diphenyl-2-propyn-1-ol.

The amount of the polymerization inhibitor is not particularly limited, but is usually 1,000.0 ppm or more with respect to, for example, the total amount of the polyorganosiloxane (a1) and the polyorganosiloxane (a2) from the viewpoint of obtaining the effect, and is 10,000.0 ppm or less from the viewpoint of preventing excessive suppression of the hydrosilylation reaction.

[0067]

<<Second infrared-absorbing component>>

When the infrared-absorbing component is a component that cures, the infrared-absorbing composition may contain, as the second infrared-absorbing component, a component that does not react with the component that cures (non-reactive infrared-absorbing component).

The second infrared-absorbing component is not particularly limited, but is preferably a polyorganosiloxane from the viewpoint of more suitably obtaining the effects of the present invention.

The polyorganosiloxane usually does not react with an infrared-absorbing component as a curable component.

For example, the polyorganosiloxane as the second infrared-absorbing component is a component that does not cause a hydrosilylation reaction.

[0068]

The polyorganosiloxane usually contains siloxane units (D units), but may contain Q units, M units, and T units. For example, the specific examples include: in the case of only a D unit, in the case of a combination of a D unit and a Q unit, in the case of a combination of a D unit and an M unit, in the case of a combination of a D unit and a T unit, in the case of a combination of a D unit, a Q unit, and an M unit, in the case of a combination of a D unit, an M unit, and a T unit, in the case of a combination

of a D unit, a Q unit, an M unit, and a T unit, and the like.

[0069]

The polyorganosiloxane is not particularly limited, and examples thereof include a polydimethylsiloxane, an epoxy group-containing polyorganosiloxane, a phenyl group-containing polyorganosiloxane, and a carbinol-modified polyorganosiloxane.

[0070]

<<<Polydimethylsiloxane>>>

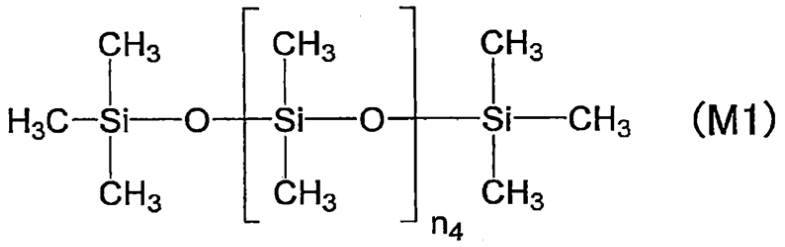
The “polydimethylsiloxane” in the present invention is an unmodified polyorganosiloxane and is a polyorganosiloxane having a methyl group as an organic group bonded to a silicon atom, unlike epoxy group-containing polydimethylsiloxane, phenyl group-containing polydimethylsiloxane, carbinol-modified polyorganosiloxane, and the like.

[0071]

Specific examples of the polydimethylsiloxane include, but are not limited to, those represented by Formula (M1).

[0072]

[Chem. 1]



(M1)

(n_4 represents the number of repeating units, and is a positive integer.)

[0073]

The weight-average molecular weight of the polydimethylsiloxane is not particularly limited, but is usually 100,000 to 2,000,000, and is preferably 200,000 to 1,200,000, and more preferably 300,000 to 900,000 from the viewpoint of achieving the effects of the present invention with good reproducibility. In addition, the dispersity is not particularly limited, and is usually 1.0 to 10.0, and is preferably 1.5 to 5.0 and more preferably 2.0 to 3.0 from the viewpoint of achieving suitable release with good reproducibility. The weight-average molecular weight and the dispersity can be measured by the above-described method related to the polyorganosiloxane.

The viscosity of the polydimethylsiloxane is not particularly limited, but is usually 1,000 to 2,000,000 mm^2/s. Note that the value of the viscosity of the polydimethylsiloxane is expressed as kinematic viscosity, and centistokes (cSt)=mm^2/s. The value can also be

determined by dividing the viscosity (mPa·s) by the density (g/cm^3). That is, the value can be determined from the viscosity measured with an E-type rotational viscometer at 25°C and the density, and can be calculated from the equation: kinematic viscosity (mm^2/s)=viscosity (mPa·s)/density (g/cm^3).

[0074]

<<<Epoxy group-containing polyorganosiloxane>>>

Examples of the epoxy group-containing polyorganosiloxane include those containing a siloxane unit (D^{10} unit) represented by $R^{11}R^{12}SiO_{2/2}$.

[0075]

R^{11} is a group bonded to a silicon atom and represents an alkyl group, and R^{12} is a group bonded to a silicon atom and represents an epoxy group or an organic group containing an epoxy group. Specific examples of the alkyl group include the above-described examples.

The epoxy group in the organic group containing an epoxy group may be an independent epoxy group that is not fused to another ring, or may be an epoxy group forming a fused ring with another ring, such as a 1,2-epoxycyclohexyl group.

Specific examples of the organic group containing an epoxy group include, but are not limited to, 3-glycidoxypropyl and 2-(3,4-epoxycyclohexyl)ethyl.

In the present invention, preferred examples of the epoxy group-containing polyorganosiloxane include, but are not limited to, an epoxy group-containing polydimethylsiloxane.

[0076]

The epoxy group-containing polyorganosiloxane contains the above-described siloxane unit (D^{10} unit), but may contain, in addition to the D^{10} unit, Q units, M units, and/or T units.

In a preferred embodiment of the present invention, specific examples of the epoxy group-containing polyorganosiloxane include a polyorganosiloxane composed only of D^{10} units, a polyorganosiloxane containing D^{10} units and Q units, a polyorganosiloxane containing D^{10} units and M units, a polyorganosiloxane containing D^{10} units and T units, a polyorganosiloxane containing D^{10} units, Q units, and M units, a polyorganosiloxane containing D^{10} units, M units, and T units, or a polyorganosiloxane containing D^{10} units, Q units, M units, and T units.

[0077]

The epoxy group-containing polyorganosiloxane may have an epoxy group in a side chain, may have an epoxy group at one terminal, or may have an epoxy group at both terminals.

[0078]

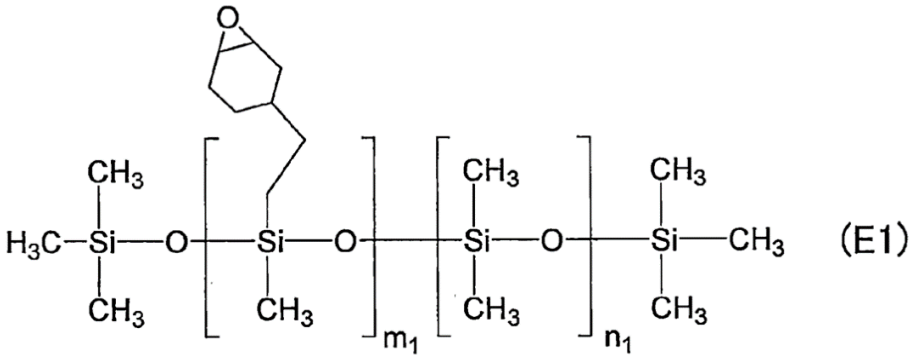
The epoxy group-containing polyorganosiloxane is preferably an epoxy group-containing polydimethylsiloxane having an epoxy value of 0.1 to 5. In addition, the weight-average molecular weight is not particularly limited, and is usually from 1,500 to 500,000, and is preferably 100,000 or less from the viewpoint of suppressing precipitation in the composition.

[0079]

Specific examples of the epoxy group-containing polyorganosiloxane include, but are not limited to, those represented by Formulas (E1) to (E3).

[0080]

[Chem. 2]

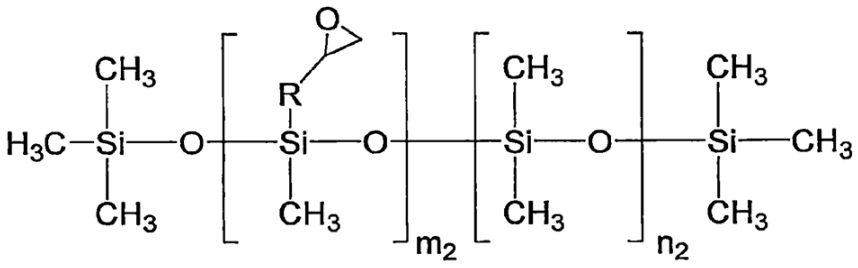


(E1)

(m_1 and n_1 represent the number of respective repeating units, and are positive integers.)

[0081]

[Chem. 3]

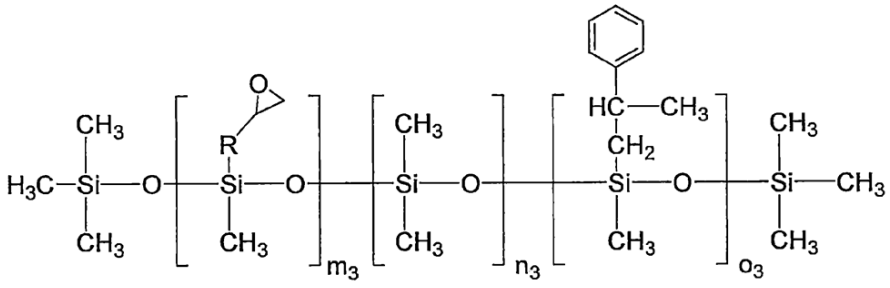


(E2)

(m_2 and n_2 represent the numbers of the respective repeating units and are positive integers, and R is an alkylene group having 1 to 10 carbon atoms which may be interrupted by at least one of an oxygen atom and an unsaturated bond (for example, a carbon-carbon double bond, a carbon-carbon triple bond, or -N=N-).)

[0082]

[Chem. 4]



(E3)

(m_3, n_3, and o_3 represent the numbers of the respective repeating units and are positive integers, and R is an alkylene group having 1 to 10 carbon atoms which may be interrupted by at least one of an oxygen atom and an unsaturated bond (for example, a carbon-carbon double bond, a carbon-carbon triple bond, or -N=N-).)

[0083]

In the general formula, when m_1, m_2, m_3, and O_3 are 2 or more, these repeating units may be arranged adjacent to each other to form a block, or may be randomly arranged.

[0084]

Note that the polyorganosiloxane represented by Formula (E3) has an epoxy group and a phenyl group and is thus an epoxy group-containing polyorganosiloxane and is also a phenyl group-containing polyorganosiloxane. Note that the epoxy group-containing polyorganosiloxane may or may not have a phenyl group.

[0085]

The weight-average molecular weight of the epoxy group-containing polyorganosiloxane is not particularly limited, but is usually 100,000 to 2,000,000, and is preferably 200,000 to 1,200,000, more preferably 300,000 to 900,000 from the viewpoint of achieving the effects of the present invention with good reproducibility. In addition, the dispersity is not particularly limited, and is usually 1.0 to 10.0, and is preferably 1.5 to 5.0 and more preferably 2.0 to 3.0 from the viewpoint of achieving suitable release with good reproducibility. The weight-average molecular weight and the dispersity can be measured by the above-described method related to the polyorganosiloxane.

The viscosity of the epoxy group-containing

polyorganosiloxane is not particularly limited, but is usually 1,000 to 2,000,000 mm^2/s. Note that the value of the viscosity of the epoxy group-containing polyorganosiloxane is expressed as kinematic viscosity, and centistokes (cSt)=mm^2/s. The value can also be determined by dividing the viscosity (mPa·s) by the density (g/cm^3). That is, the value can be determined from the viscosity measured with an E-type rotational viscometer at 25°C and the density, and can be calculated from the equation: kinematic viscosity (mm^2/s)=viscosity (mPa·s)/density (g/cm^3).

[0086]

<<<Phenyl group-containing polyorganosiloxane>>>

Examples of the phenyl group-containing polyorganosiloxane include those containing a siloxane unit (D^{30} unit) represented by $R^{31}R^{32}SiO_{2/2}$.

[0087]

R^{31} is a group bonded to a silicon atom and represents a phenyl group or an alkyl group, and R^{32} is a group bonded to a silicon atom and represents a phenyl group. Specific examples of the alkyl group include the above-described examples, but a methyl group is preferable.

[0088]

The phenyl group-containing polyorganosiloxane contains the above-described siloxane unit (D^{30} unit), but

may contain, in addition to the D^{30} unit, Q units, M units, and/or T units.

[0089]

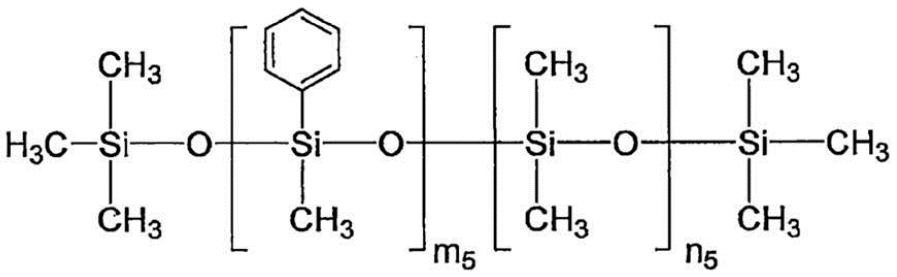
In a preferred embodiment, specific examples of the phenyl group-containing polyorganosiloxane include a polyorganosiloxane composed only of D^{30} units, a polyorganosiloxane containing D^{30} units and Q units, a polyorganosiloxane containing D^{30} units and M units, a polyorganosiloxane containing D^{30} units and T units, a polyorganosiloxane containing D^{30} units, Q units, and M units, a polyorganosiloxane containing D^{30} units, M units, and T units, or a polyorganosiloxane containing D^{30} units, Q units, M units, and T units.

[0090]

Specific examples of the phenyl group-containing polyorganosiloxane include, but are not limited to, those represented by Formula (P1) or (P2).

[0091]

[Chem. 5]



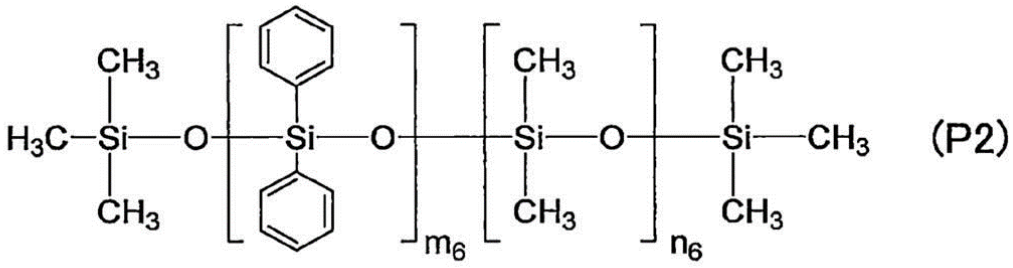
(P1)

(m5 and n5 represent the number of respective

repeating units, and are positive integers.)

[0092]

[Chem. 6]



(m6 and n6 represent the number of respective repeating units, and are positive integers.)

[0093]

In the above general formula, when m_5 and m_6 are 2 or more, these repeating units may be arranged adjacent to each other to form a block, or may be randomly arranged.

[0094]

<<<Carbinol-modified polyorganosiloxane>>>

The carbinol-modified polyorganosiloxane is not particularly limited.

The carbinol-modified polyorganosiloxane is a polyorganosiloxane having a hydroxy group directly bonded to a carbon atom. As described above, the carbinol in the “carbinol-modified polyorganosiloxane” is not limited to methanol in a narrow sense, and includes methanol derivatives.

[0095]

The carbinol-modified polyorganosiloxane is, for example, a carbinol-modified polydimethylsiloxane.

[0096]

The number of hydroxy groups directly bonded to a carbon atom in the carbinol-modified polyorganosiloxane is not particularly limited, and may be one or two or more.

[0097]

The carbinol-modified polyorganosiloxane may have a hydroxy group directly bonded to a carbon atom in a side chain, may have a hydroxy group directly bonded to a carbon atom at one end, or may have hydroxy groups directly bonded to a carbon atom at both terminals.

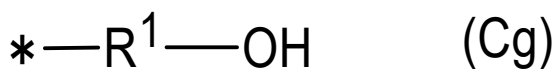
The carbinol-modified polyorganosiloxane preferably has a hydroxy group directly bonded to a carbon atom in a side chain.

[0098]

The carbinol-modified polyorganosiloxane has, for example, a group represented by the following Formula (Cg) as a group directly bonded to a silicon atom.

[0099]

[Chem. 7]



(Cg)

(In Formula (Cg), R^1 represents a group having one or more carbon atoms. * represents a bond bonded to a silicon

atom. However, the hydroxy group in Formula (Cg) is directly bonded to a carbon atom.)

[0100]

The number of hydroxy groups directly bonded to a carbon atom in the group represented by Formula (Cg) may be one or two or more. Examples of the two or more include two, three, four, and the like.

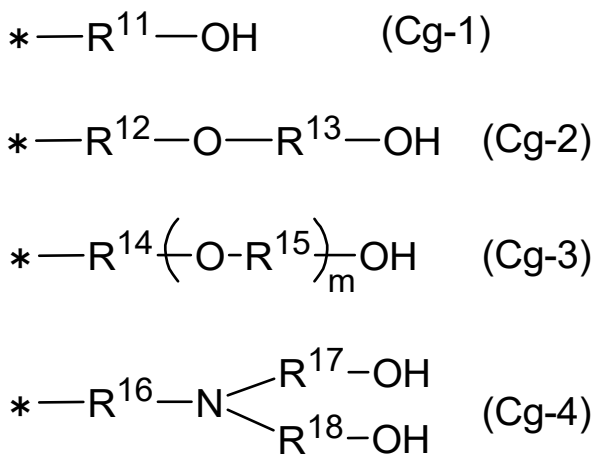
[0101]

The number of carbon atoms in R^1 is not particularly limited, and may be, for example, 1 to 30, 1 to 20, or 1 to 10.

[0102]

Examples of the group represented by Formula (Cg) include groups represented by the following Formulas (Cg-1) to (Cg-4)).

[Chem. 8]



(In Formula (Cg-1), R^{11} represents an alkylene group having 1 to 6 carbon atoms which may be substituted with an

alkoxy group having 1 to 3 carbon atoms.

In Formula (Cg-2), R^{12} represents an alkylene group having 1 to 6 carbon atoms. R^{13} represents an alkylene group having 1 to 6 carbon atoms which may be substituted with an alkoxy group having 1 to 3 carbon atoms or a hydroxy group.

In Formula (Cg-3), R^{14} represents an alkylene group having 1 to 6 carbon atoms. R^{15} represents an alkylene group having 1 to 3 carbon atoms. m represents an integer of 1 to 10.

In Formula (Cg-4), R^{16} to R^{18} each independently represent an alkylene group having 1 to 6 carbon atoms.

In Formula (Cg-1) to Formula (Cg-4), * represents a bond bonded to a silicon atom.)

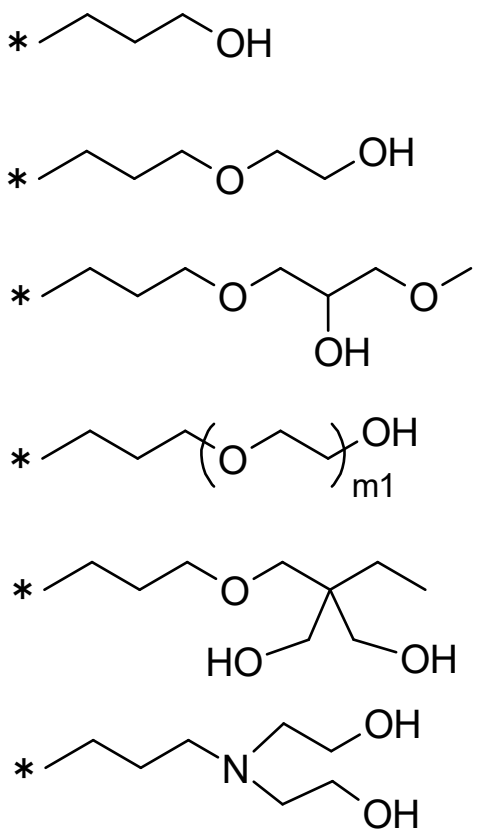
[0103]

The alkylene groups of R^{11} to R^{18} may be linear, branched, or cyclic.

[0104]

Examples of the group represented by Formula (Cg) include the following groups.

[Chem. 9]

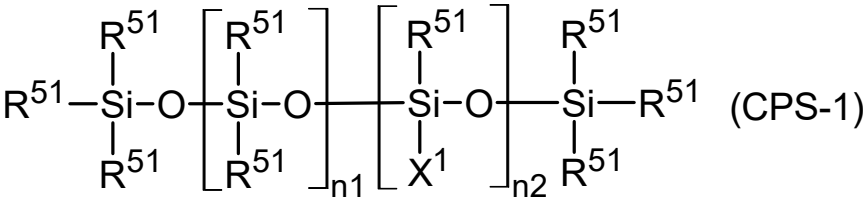


(In the formula, m1 represents an integer of 2 to 10. * represents a bond bonded to a silicon atom.)

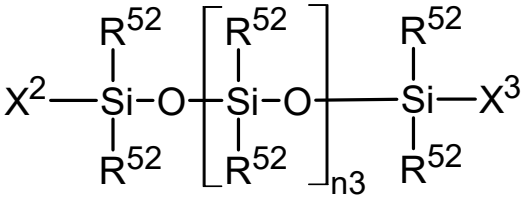
[0105]

The carbinol-modified polyorganosiloxane is represented by, for example, the following Formula (CPS-1) or (CPS-2).

[Chem. 10]



(CPS-1)



(CPS-2)

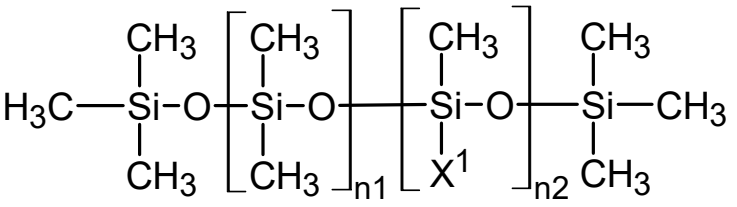
(In Formula (CPS-1), each R^{51} independently represents a hydrocarbon group. X^1 represents the group represented by Formula (Cg). n1 represents an integer of 0 or more. n2 represents an integer of 1 or more.

In Formula (CPS-2), each R^{52} independently represents a hydrocarbon group. X^2 represents the group represented by Formula (Cg). X^3 represents a hydrocarbon group or the group represented by Formula (Cg). n3 represents an integer of 0 or more.)

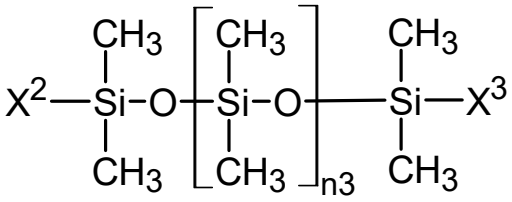
[0106]

Examples of the hydrocarbon groups in R^{51}, R^{52}, and X^3 include alkyl groups having 1 to 8 carbon atoms. As the alkyl group having 1 to 8 carbon atoms, a methyl group is preferable. That is, the carbinol-modified polyorganosiloxane is preferably polydimethylsiloxane represented by the following Formula (CPS-1a) or (CPS-2a).

[Chem. 11]



(CPS-1a)



(CPS-2a)

(In Formula (CPS-1a), X^1 represents the group represented by Formula (Cg). n1 represents an integer of 0 or more. n2 represents an integer of 1 or more.

In Formula (CPS-2a), X^2 represents the group represented by Formula (Cg). X^3 represents a methyl group or the group represented by Formula (Cg). n3 represents an integer of 0 or more.)

[0107]

Note that the carbinol-modified polyorganosiloxane represented by Formula (CPS-1) and the carbinol-modified polydimethylsiloxane represented by Formula (CPS-1a) have a hydroxy group directly bonded to a carbon atom in a side chain.

The carbinol-modified polyorganosiloxane represented by Formula (CPS-2) and the carbinol-modified polydimethylsiloxane represented by Formula (CPS-2a) have a hydroxy group(s) directly bonded to a carbon atom at one terminal or both terminals.

[0108]

Note that when n2 is 2 or more in the carbinol-modified polyorganosiloxane represented by Formula (CPS-1), siloxane units represented by $-Si(R^{51})(X^{1})-O-$ may be arranged adjacent to each other to form a block, or may be randomly arranged.

In addition, when n2 is 2 or more in the carbinol-modified polydimethylsiloxane represented by Formula (CPS-1a), siloxane units represented by $-Si(CH_3)(X^{1})-O-$ may be arranged adjacent to each other to form a block, or may be randomly arranged.

[0109]

The weight-average molecular weight of the carbinol-modified polyorganosiloxane is not particularly limited, but is usually 500 to 1,000,000, and is preferably 5,000 to 50,000 from the viewpoint of achieving the effects of the present invention with good reproducibility. In addition, the dispersity is not particularly limited, and is usually 1.0 to 10.0, and is preferably 1.5 to 5.0 and more preferably 2.0 to 3.0 from the viewpoint of achieving suitable release with good reproducibility.

The viscosity of the carbinol-modified polyorganosiloxane is not particularly limited, but is usually 100 to 200,000 mm^2/s. Note that the value of the viscosity of the polydimethylsiloxane is expressed as

kinematic viscosity, and centistokes (cSt)=mm^2/s. The value can also be determined by dividing the viscosity (mPa·s) by the density (g/cm^3). That is, the value can be determined from the viscosity measured with an E-type rotational viscometer at 25°C and the density, and can be calculated from the equation: kinematic viscosity (mm^2/s)=viscosity (mPa·s)/density (g/cm^3).

[0110]

The polyorganosiloxanes as the second infrared-absorbing component can be used singly or in combination of two or more kinds thereof. Here, the two polyorganosiloxanes in the two or more polyorganosiloxanes mean, for example, a combination of polydimethylsiloxane and an epoxy group-containing polyorganosiloxane, a combination of polydimethylsiloxane and a phenyl group-containing polyorganosiloxane, and the like, and do not mean, for example, a combination of two epoxy group-containing polyorganosiloxanes having different molecular weights, viscosities, types of epoxy groups, and the like.

[0111]

The polyorganosiloxane as the infrared-absorbing component (B) may be a commercially available product or a synthesized product.

Examples of commercially available polyorganosiloxanes include, but are not limited to,

WACKERSILICONE FLUID AK series (AK50, AK 350, AK 1000, AK 10000, AK 1000000) and GENIOPLAST GUM, which are products manufactured by Wacker Chemie AG, dimethyl silicone oil (KF-96L, KF-96A, KF-96, KF-96H, KF-69, KF-965, KF-968) and cyclic dimethyl silicone oil (KF-995), manufactured by Shin-Etsu Chemical Co., Ltd.; epoxy group-containing polyorganosiloxane manufactured by Gelest, Inc. (trade names: CMS-227, ECMS-327, EMS-622), epoxy group-containing polyorganosiloxane manufactured by Shin-Etsu Chemical Co., Ltd. (KF-101, KF-1001, KF-1005, X-22-343), epoxy group-containing polyorganosiloxane (DOWSIL BY16-839, DOWSIL8413, DOWSIL8411) manufactured by Dow Toray Co., Ltd.; and phenyl group-containing polyorganosiloxane (PMM-1043, PMM-1025, PDM-0421, PDM-0821) manufactured by Gelest, Inc., phenyl group-containing polyorganosiloxane (KF50-3000CS) manufactured by Shin-Etsu Chemical Co., Ltd., and phenyl group-containing polyorganosiloxane (TSF431, TSF433) manufactured by Momentive Performance Materials, Inc.

[0112]

In addition, examples of commercially available carbinol-modified polyorganosiloxanes include KF6000, KF6001, KF6002, KF6003, X-22-4039, and X-22-4015 manufactured by Shin-Etsu Chemical Co., Ltd.; DMS-C15, DMS-C16, DMS-C21, DMS-C23, DBE-C25, DBE-C22, DMS-CA21, DMS-CS26, CMS-221, CMS-222, CMS-832, CMS-626, MCR-C12, MCR-C18,

MCR-C22, MCS-C11, MCS-C13, MCR-C61, MCR-C62, and MCR-C63 manufactured by Gelest, Inc.; and DOWSIL BY 16-201, DOWSIL SF 8427 Fluid, and DOWSIL SF 8428 Fluid manufactured by Dow Toray Co., Ltd.

[0113]

The content of the second infrared-absorbing component in the infrared-absorbing composition is not particularly limited, but is preferably 0.01 mass% or more, more preferably 0.05 mass% or more, and particularly preferably 0.10 mass% or more with respect to the nonvolatile content of the infrared-absorbing composition. The upper limit is not particularly limited, but is, for example, preferably 30 mass% or less, more preferably 25 mass% or less, and particularly preferably 20 mass% or less.

[0114]

<<Solvent>>

The infrared-absorbing composition may contain a solvent for the purpose of adjusting the viscosity. Specific examples thereof include aliphatic hydrocarbons, aromatic hydrocarbons, and ketones, but are not limited thereto.

More specific examples of the solvent include, but are not limited to, hexane, heptane, octane, nonane, isononane, decane, undecane, dodecane, isododecane,

menthane, limonene, toluene, xylene, mesitylene, cumene, MIBK (methyl isobutyl ketone), butyl acetate, diisobutyl ketone, 2-octanone, 2-nonanone, 5-nonanone, cyclohexanone, propylene glycol monomethyl ether acetate, and propylene glycol monomethyl ether. Such solvents can be used alone or in combination with two or more thereof.

[0115]

When the infrared-absorbing composition contains a solvent, the content thereof is appropriately determined in consideration of the desired viscosity of the composition, the coating method to be employed, the thickness of the film to be prepared, and the like, and is, for example, in a range of about 10 to 90 mass% with respect to the entire composition.

[0116]

The viscosity of the infrared-absorbing composition used in the present invention is not particularly limited, and is usually 500 to 20,000 mPa·s, and preferably 1,000 to 10,000 mPa·s at 25°C.

[0117]

An example of the infrared-absorbing composition used in the present invention can be produced by mixing the infrared-absorbing component (A), the second infrared-absorbing component (B) and a solvent.

The mixing order is not particularly limited, but

examples of the method by which the infrared-absorbing composition can be easily and reproducibly produced include, but are not limited to, a method in which the infrared-absorbing component (A) and the second infrared-absorbing component (B) are dissolved in a solvent, and a method in which the infrared-absorbing component (A) and a part of the second infrared-absorbing component (B) are dissolved in a solvent, the rest of the second infrared-absorbing component (B) is dissolved in a solvent, and the obtained solutions are mixed. When the infrared-absorbing composition is prepared, the components may be heated as appropriate, as long as the components are not decomposed or deteriorated.

In the present invention, for the purpose of removing foreign matter, a solvent, a solution, or the like to be used may be filtered using a filter or the like during the production of the infrared-absorbing composition or after mixing all the components.

[0118]

As the infrared-absorbing composition, for example, an adhesive described in WO2017/221772, a temporary adhesive described in WO2018/216732, a temporary adhesive described in WO2019/009365, an infrared-absorbing composition described in WO2020/111069, and an infrared-absorbing composition described in WO2021/131925 can be

used. The contents of these publications are incorporated herein by reference to the same extent as if fully set forth.

[0119]

The thickness of the infrared-absorbing layer is not particularly limited, but is usually 0.01 to 20 μm, and is preferably 0.03 μm or more, more preferably 0.05 μm or more, and still more preferably 0.1 μm or more from the viewpoint of maintaining the film strength, and is preferably 10 μm or less, more preferably 8 μm or less, more preferably 5 μm or less, and still more preferably 2 μm or less from the viewpoint of avoiding nonuniformity caused by a thick film.

[0120]

The method for forming the infrared-absorbing layer from the infrared-absorbing composition will be described in detail in the description of <<Method for producing one example of laminate in first embodiment>> described below.

[0121]

Hereinafter, an example of the configuration of the laminate of the first embodiment will be described with reference to the drawings.

Fig. 1 illustrates a schematic cross-sectional view of an example of a laminate of the first embodiment.

The laminate of Fig. 1 includes a semiconductor

substrate 1, an infrared-absorbing layer 2, an infrared-transmitting adhesive layer 3, and a support substrate 4 in this order.

The infrared-absorbing layer 2 and the infrared-transmitting adhesive layer 3 are provided between the semiconductor substrate 1 and the support substrate 4. The infrared-absorbing layer 2 is in contact with the semiconductor substrate 1. The infrared-transmitting adhesive layer 3 is in contact with the infrared-absorbing layer 2 and the support substrate 4.

[0122]

<<Method for producing one example of laminate in first embodiment>>

A method for producing a laminate will be described below with the laminate illustrated in Fig. 1 as an example of the laminate in the first embodiment.

An example of the laminate of the present invention can be produced, for example, by a method including the following steps 1 to 3.

First step: a step of coating an infrared-absorbing composition onto a semiconductor substrate to form an infrared-absorbing layer

Second step: a step of coating an infrared-transmitting adhesive composition onto a support substrate to form an infrared-transmitting adhesive coating layer

Third step: a step of heating the infrared-transmitting adhesive coating layer in a state where the infrared-transmitting adhesive coating layer and the infrared-absorbing layer are in contact with each other to form the infrared-transmitting adhesive layer.

[0123]

The method for coating the infrared-transmitting adhesive composition is not particularly limited, but is usually a spin coating method. Incidentally, a method of separately forming a coating film by a spin coating method or the like, forming a sheet-like coating film, and sticking the sheet-like coating film as an infrared-transmitting adhesive coating layer can be adopted.

The heating temperature of the applied infrared-transmitting adhesive composition varies depending on the type and amount of the adhesive component contained in the infrared-transmitting adhesive composition, whether or not a solvent is contained, the boiling point of the solvent to be used, the desired thickness of the infrared-transmitting adhesive layer, and the like, and thus cannot be generally determined, but the heating temperature is usually 80 to 150°C, and the heating time is usually 30 seconds to 5 minutes.

When the infrared-transmitting adhesive composition contains a solvent, the applied infrared-transmitting

adhesive composition is usually heated.

The film thickness of the infrared-transmitting adhesive coating layer obtained by coating the infrared-transmitting adhesive composition and heating the composition as necessary is usually about 5 to 500 μm, and finally is appropriately determined so as to fall within the range of the thickness of the infrared-transmitting adhesive layer described above.

[0124]

The method for coating the infrared-absorbing composition is not particularly limited, but is usually a spin coating method.

The heating temperature of the applied infrared-absorbing composition varies depending on the type and amount of the infrared-absorbing compound contained in the infrared-absorbing composition, the desired thickness of the infrared-absorbing layer, and the like, and thus cannot be generally defined, but from the viewpoint of achieving a suitable infrared-absorbing layer with good reproducibility, the heating temperature is 80°C or more and 300°C or less, and the heating time is appropriately determined usually in the range of 10 seconds to 10 minutes depending on the heating temperature. The heating temperature is preferably 100°C or higher and 280°C or lower, and more preferably 150°C or higher and 250°C or

lower. The heating time is preferably 30 seconds or more and 8 minutes or less, and more preferably 1 minute or more and 5 minutes or less.

The heating can be performed using a hot plate, an oven, or the like.

The film thickness of the infrared-absorbing layer obtained by coating the infrared-absorbing composition and heating the composition as necessary is usually about 5 nm to 100 μm.

[0125]

In an example of the present invention, the laminate of the present invention can be obtained by combining such coating layers to be in contact with each other, bringing the two layers into close contact with each other by applying a load in the thickness direction of the semiconductor substrate and the support substrate while performing heat treatment or decompression treatment or both thereof, and then performing post-heat treatment. Note that which treatment condition of heat treatment, decompression treatment, and combination use of both is adopted is appropriately determined in consideration of various circumstances such as the type of the infrared-transmitting adhesive composition, the specific composition of the infrared-absorbing composition, the compatibility of films obtained from both compositions, the film thickness,

and the required adhesive strength.

[0126]

The heat treatment is appropriately determined from the range of usually 20 to 150°C from the viewpoint of removing the solvent from the composition, the viewpoint of softening the infrared-transmitting adhesive coating layer to achieve suitable bonding with the infrared-absorbing layer, and the like. In particular, from the viewpoint of suppressing or avoiding excessive curing and unnecessary deterioration of the adhesive component, the heating temperature is preferably 130°C or lower, and more preferably 90°C or lower, and the heating time is appropriately determined depending on the heating temperature and the type of the adhesive. However, from the viewpoint of reliably exhibiting suitable adhesion, the heating time is usually 30 seconds or longer, preferably 1 minute or longer. From the viewpoint of suppressing deterioration of the infrared-transmitting adhesive layer and other members, the heating time is usually 10 minutes or shorter, preferably 5 minutes or shorter.

[0127]

In the decompression treatment, the infrared-transmitting adhesive coating layer and the infrared-absorbing layer that are in contact with each other may be exposed to an atmospheric pressure of 10 to 10,000 Pa. The

time for the decompression treatment is usually 1 to 30 minutes.

[0128]

From the viewpoint of obtaining a laminate in which the substrate can be satisfactorily separated with good reproducibility, the two layers in contact with each other are bonded to each other preferably by decompression treatment, and more preferably by combined use of heat treatment and decompression treatment.

[0129]

The load in the thickness direction of the semiconductor substrate and the support substrate is not particularly limited as long as the load does not adversely affect the semiconductor substrate, the support substrate, and the two layers therebetween, and can bring them into close contact with each other, but is usually within the range of 10 to 1,000 N.

[0130]

The temperature of the post-heating is preferably 120°C or higher from the viewpoint of achieving a sufficient curing rate and the like, and is preferably 260°C or lower from the viewpoint of preventing deterioration of the substrate and each layer, and the like.

The post-heating time is usually 1 minute or more,

and preferably 5 minutes or more from the viewpoint of achieving suitable bonding of the substrate and the layer constituting the laminate, and is usually 180 minutes or less, and preferably 120 minutes or less from the viewpoint of suppressing or avoiding an adverse effect on each layer due to excessive heating, and the like.

The heating can be performed using a hot plate, an oven, or the like. When post-heating is performed using a hot plate, heating may be performed with either the semiconductor substrate or the support substrate of the laminate facing downward. Preferably, the post-heating is performed with the semiconductor substrate facing downward from the viewpoint of achieving suitable release with excellent reproducibility.

One object of the post-heat treatment is to achieve an infrared-transmitting adhesive layer and an infrared-absorbing layer which are more suitable self-standing films.

[0131]

Hereinafter, an example of a method for producing the laminate of Fig. 1 will be described with reference to Figs. 2A to 2C.

Figs. 2A to 2C are views for describing one aspect of producing the laminate.

First, a laminate in which the infrared-absorbing

layer 2 is formed on the semiconductor substrate 1 is prepared (Fig. 2A). This laminate can be obtained, for example, by coating an infrared-absorbing composition onto the semiconductor substrate 1 and heating the composition.

Separately, a laminate in which the infrared-transmitting adhesive coating layer 3a is formed on the support substrate 4 is prepared (Fig. 2B). This laminate can be obtained, for example, by coating an infrared-transmitting adhesive composition onto the support substrate 4 and heating the composition.

Next, the laminate illustrated in Fig. 2A and the laminate illustrated in Fig. 2B are bonded so that the infrared-absorbing layer 2 and the infrared-transmitting adhesive coating layer 3a are in contact with each other. Then, after a load is applied in the thickness direction between the semiconductor substrate 1 and the support substrate 4 under reduced pressure, a heating device (not illustrated; a hot plate) is disposed on the surface opposite to a surface of the semiconductor substrate 1 with which the infrared-absorbing layer 2 is in contact, and the infrared-transmitting adhesive coating layer 3a is heated and cured by the heating device to be converted into the infrared-transmitting adhesive layer 3 (Fig. 2C).

The laminate is obtained by the steps illustrated in Figs. 2A to 2C.

[0132]

Note that, in Fig. 1, in the laminate, the semiconductor substrate 1, the infrared-absorbing layer 2, the infrared-transmitting adhesive layer 3, and the support substrate 4 are stacked in this order, and thus the above-described production method has been exemplified. However, for example, when producing the laminate in which the semiconductor substrate 1, the infrared-transmitting adhesive layer 3, the infrared-absorbing layer 2, and the support substrate 4 are stacked in this order, the laminate can be produced by a method including a first step of coating a surface of a semiconductor substrate with an infrared-transmitting adhesive composition and, if necessary, heating the composition to form an infrared-transmitting adhesive coating layer, a second step of coating a surface of a support substrate with an infrared-absorbing composition and, if necessary, heating the composition to form an infrared-absorbing layer, and a third step of bringing the infrared-transmitting adhesive coating layer of the semiconductor substrate and the infrared-absorbing layer of the support substrate into close contact with each other by applying a load in the thickness direction of the semiconductor substrate and the support substrate while performing at least one of heat treatment and decompression treatment, and then performing

post-heat treatment to form a laminate.

Note that as long as the effect of the present invention is not impaired, coating and heating of each composition may be sequentially performed on any one of the substrates.

[0133]

<Second embodiment>

The laminate including an electronic device layer is used for processing of the electronic device layer. While the electronic device layer is being processed, the electronic device layer is bonded to the support substrate. After processing the electronic device layer, the infrared-absorbing layer is irradiated with, for example, an infrared laser, and then the electronic device layer is separated from the support substrate.

[0134]

<<Electronic Device Layer>>

The electronic device layer refers to a layer having an electronic device, and in the present invention, the electronic device layer refers to a layer in which a plurality of semiconductor chip substrates are embedded in a sealing resin, that is, a layer including a plurality of semiconductor chip substrates and a sealing resin disposed between the semiconductor chip substrates.

Here, the “electronic device” means a member

constituting at least a part of an electronic component. The electronic device is not particularly limited, and can be one in which various mechanical structures and circuits are formed on the surface of a semiconductor substrate. The electronic device is preferably a composite of a member made of metal or a semiconductor and a resin that seals or insulates the member. The electronic device may be one in which a rewiring layer, which will be described below, and/or a semiconductor element or other elements are sealed or insulated with a sealing material or an insulating material, and has a single-layer or multi-layer structure.

[0135]

<<Support substrate>>

As the support substrate, those similar to those described in the section of <<Support Substrate>> above of <First embodiment> above are exemplified.

[0136]

<<Infrared-absorbing layer>>

The infrared-absorbing layer is formed using, for example, an infrared-absorbing composition.

The infrared-absorbing layer is described in detail in the section of <<Infrared-absorbing layer>> in <First embodiment> above.

[0137]

<<Infrared-transmitting adhesive layer>>

The infrared-transmitting adhesive layer is formed using the above-described infrared-transmitting adhesive composition.

The infrared-transmitting adhesive layer is described in detail in the section of <<Infrared-transmitting adhesive layer>> in <First embodiment>.

[0138]

Hereinafter, an example of the configuration of the laminate of the second embodiment will be described with reference to the drawings.

Fig. 3 shows a schematic cross-sectional view of an example of the laminate of the second embodiment.

The laminate of Fig. 3 includes a support substrate 24, an infrared-transmitting adhesive layer 23, an infrared-absorbing layer 22, and an electronic device layer 26 in this order.

The electronic device layer 26 includes a plurality of semiconductor chip substrates 21 and a sealing resin 25 which is a sealing material disposed between the semiconductor chip substrates 21.

The infrared-absorbing layer 22 and the infrared-transmitting adhesive layer 23 are provided between the electronic device layer 26 and the support substrate 24. The infrared-absorbing layer 22 is in contact with the electronic device layer 26. The infrared-transmitting

adhesive layer 23 is in contact with the infrared-absorbing layer 22 and the support substrate 24.

[0139]

<<Method for Producing One Example of Laminate in Second Embodiment>>

A method for producing a laminate will be described below with the laminate illustrated in Fig. 3 as an example of the laminate in the second embodiment.

The laminate of the present invention can be produced, for example, by a method including the following steps 1 to 5.

Step 1: a step of coating an infrared-transmitting adhesive composition to the surface of the support substrate to form an infrared-transmitting adhesive coating layer (as necessary, further heating is performed to form an infrared-transmitting adhesive layer)

Step 2: a step of coating an infrared-absorbing composition to a surface of the infrared-transmitting adhesive coating layer or the infrared-transmitting adhesive layer to form an infrared-absorbing composition coating layer (as necessary, further heating is performed to form the infrared-absorbing layer).

Step 3: a step of placing the semiconductor chip substrate on the infrared-absorbing composition coating layer or the infrared-absorbing layer, and bonding the

semiconductor chip substrate to the infrared-absorbing composition coating layer or the infrared-absorbing layer while performing at least one of a heating treatment and a decompression treatment.

Step 4: a step of curing the infrared-absorbing composition coating layer by post-heat treatment to form an infrared-absorbing layer

Step 5: step of sealing the semiconductor chip substrate fixed on the infrared-absorbing layer using a sealing resin

To describe step 3 in more detail, for example, there is the following step (i) of the embodiment.

(i) A semiconductor chip substrate is placed on the infrared-absorbing composition coating layer or the infrared-absorbing layer and brought into close contact with the infrared-absorbing composition coating layer or the infrared-absorbing layer by applying a load in a thickness direction of the semiconductor chip substrate and the support substrate while performing at least one of a heating treatment and a decompression treatment, and the semiconductor chip substrate is bonded to the infrared-absorbing composition coating layer or the infrared-absorbing layer.

[0140]

Step 4 may be performed after the semiconductor chip

substrate in step 3 is bonded to the infrared-absorbing composition coating layer, or may be performed in combination with step 3. For example, by placing a semiconductor chip substrate on the infrared-absorbing composition coating layer, and heating and curing the infrared-absorbing composition coating layer while applying a load in the thickness direction of the semiconductor chip substrate and the support substrate, adhesion between the semiconductor chip substrate and the infrared-absorbing composition coating layer and curing from the infrared-absorbing composition coating layer to the infrared-absorbing layer may be performed together, and the infrared-absorbing layer and the semiconductor chip substrate may be bonded together.

In addition, step 4 may be performed before step 3, and the infrared-absorbing layer and the semiconductor chip substrate may be bonded to each other while the semiconductor chip substrate is placed on the infrared-absorbing layer and a load in the thickness direction of the semiconductor chip substrate and the support substrate is applied.

[0141]

The coating method, the heating temperature, the heating means, and the like of the applied infrared-absorbing composition and infrared-transmitting adhesive

composition are as described in <<Method for producing one example of laminate in first embodiment>> of <First embodiment>.

[0142]

Hereinafter, the procedure of the method for producing a laminate of the second embodiment will be described in more detail with reference to the drawings. In this producing method, the laminate illustrated in Fig. 3 is manufactured.

As illustrated in Fig. 4A, an infrared-transmitting adhesive coating layer 23′ consisting of an infrared-transmitting adhesive composition is formed on the support substrate 24. At that time, the infrared-transmitting adhesive coating layer 23′ may be heated to form the infrared-transmitting adhesive layer 23.

Next, as illustrated in Fig. 4B, an infrared-absorbing composition coating layer 22′ consisting of an infrared-absorbing composition is formed on the infrared-transmitting adhesive coating layer 23′ or the infrared-transmitting adhesive layer 23. At that time, the infrared-absorbing composition coating layer 22′ may be heated to form the infrared-absorbing layer 22.

Next, as illustrated in Fig. 4C, the semiconductor chip substrate 21 is placed on the infrared-absorbing layer 22 or the infrared-absorbing composition coating layer 22′,

and while performing at least one of the heat treatment and the pressure reduction treatment, a load is applied in the thickness direction of the semiconductor chip substrate 21 and the support substrate 24 to bring them into close contact, and the semiconductor chip substrate 21 is bonded to the infrared-absorbing layer 22 or the infrared-absorbing composition coating layer 22′. When the semiconductor chip substrate 21 is bonded to the infrared-absorbing composition coating layer 22′, the infrared-absorbing composition coating layer 22′ is cured by post-heat treatment to form the infrared-absorbing layer 22, and the semiconductor chip substrate 21 is fixed to the infrared-absorbing layer 22.

When the infrared-absorbing composition coating layer 22′ is subjected to post-heat treatment, the infrared-transmitting adhesive coating layer 23′ may also be subjected to post-heat treatment to form the infrared-transmitting adhesive layer 23.

Next, as illustrated in Fig. 4D, the semiconductor chip substrate 21 fixed on the infrared-absorbing layer 22 is sealed using a sealing resin 25. In Fig. 4D, the plurality of semiconductor chip substrates 21 temporarily adhered onto the support substrate 24 via the infrared-absorbing layer 22 is sealed with the sealing resin 25. The electronic device layer 26, which includes the

semiconductor chip substrate 21 and the sealing resin 25 between the semiconductor chip substrates 21, is formed on the infrared-absorbing layer 22, and as described above, the electronic device layer 26 is a base material layer in which the plurality of semiconductor chip substrates are embedded in the sealing resin.

[0143]

<<<Sealing Step>>>

The semiconductor chip substrate 21 is sealed using a sealing material.

As the sealing material for sealing the semiconductor chip substrate 21, a member capable of insulating or sealing a member made of metal or a semiconductor is used.

In the present invention, for example, a resin composition (sealing resin) is used as the sealing material. The type of the sealing resin is not particularly limited as long as the sealing resin can seal and/or insulate metal or a semiconductor, and for example, an epoxy-based resin or a silicone-based resin is preferably used.

The sealing material may contain, in addition to the resin component, other components such as a filler. Examples of the filler include spherical silica particles.

In the sealing step, for example, a sealing resin heated to 130 to 170°C is supplied onto the infrared-

absorbing layer 22 so as to cover the semiconductor chip substrate 21 while maintaining a high viscosity state, and is compression molded to form a layer consisting of the sealing resin 25 on the infrared-absorbing layer 22. At this time, the temperature condition is, for example, 130 to 170°C. In addition, the pressure applied to the semiconductor chip substrate 21 is, for example, 50 to 500 N/cm^2.

[0144]

(Method for Producing Processed Semiconductor Substrate or Processed Electronic Device Layer)

When the laminate according to the present invention is used, a method for producing a processed semiconductor substrate or a method for producing a processed electronic device layer can be provided.

In the "method for producing a processed semiconductor substrate", the laminate described in the section of <First embodiment> above of the (Laminate) above is used. In addition, in the "method for producing a processed electronic device layer", the laminate described in the section of <Second embodiment> above of the (Laminate) above is used.

The "method for producing a processed semiconductor substrate" will be described in <Third embodiment> below, and the "method for producing a processed electronic device

layer” will be described in <Fourth embodiment> below.

[0145]

A method for producing a processed semiconductor substrate or electronic device layer includes the following steps.

·Processing step of processing first body of laminate of present invention

·Separation step of irradiating the infrared-absorbing layer with an infrared laser from the second body side, and then separating the processed first body and second body

[0146]

Examples of the infrared laser include a laser having a wavelength of 1 μm to 20 μm. The wavelength of the infrared laser is preferably 9.2 to 10.8 μm.

Examples of the light source of the infrared laser include a semiconductor laser, a He-Ne laser, an Ar laser, a carbon dioxide laser, a YAG laser, and a fiber laser.

The output of the infrared ray by the infrared laser is, for example, preferably 10 W to 100 W, and more preferably 30 W to 90 W.

[0147]

Irradiation of the infrared-absorbing layer with the infrared laser is not necessarily performed on the entire region of the infrared-absorbing layer. Even if the region

irradiated with the infrared laser and the region not irradiated with the infrared laser are mixed, the second body can be released from the laminate by applying a slight external force and pulling up the second body as long as the adhesive strength of a part of the infrared-absorbing layer is sufficiently reduced. The ratio and positional relationship between the region irradiated with the infrared laser and the region not irradiated with the infrared laser vary depending on the infrared-absorbing composition forming the infrared-absorbing layer, the thickness of the infrared-absorbing layer, the intensity of the infrared laser to be irradiated, and the like, but those skilled in the art can appropriately set the conditions without requiring an excessive test. For example, a region not irradiated with the infrared laser may be provided next to a region irradiated with the infrared laser, with the same width as the drawing line width of the infrared ray.

Irradiation of the infrared-absorbing layer with the infrared laser may be performed only at an end portion of the infrared-absorbing layer sandwiched between the first body and the second body.

[0148]

After the infrared-absorbing layer is irradiated with the infrared laser, in order to more easily separate the

first body and the second body, equipment having a sharp portion may be inserted between the first body and the second body.

[0149]

Examples of the method for separating the first body and the second body include a method in which the first body and the second body are each held by a holder after the adhesive force of the infrared-absorbing layer is reduced by irradiation of the infrared laser to the infrared-absorbing layer, and one or both of the holders are moved in a direction in which the first body and the second body are separated.

Examples of the holder include a suction plate.

[0150]

In the separation step, preferably, by irradiating the infrared-absorbing layer with an infrared laser, compared to a case where the infrared-absorbing layer is not irradiated with an infrared laser, the insertion force required when the sharp portion of the equipment having the sharp portion is inserted between the first body and the second body to separate the first body and the second body is reduced. In other words, it is preferable that the insertion force (Fb) required to separate the first body and the second body by inserting a sharp portion of equipment having a sharp portion between the first body and

the second body after irradiating the infrared-absorbing layer with the infrared laser is smaller than an insertion force (Fa) required to separate the first body and the second body by inserting the sharp portion between the first body and the second body without irradiating the infrared-absorbing layer with the infrared laser.

The insertion force is indicated as an absolute value.

Examples of the insertion force (Fa) include 0.1 N to 100 N.

[0151]

The ratio (Fb/Fa) of the insertion force (Fb) to the insertion force (Fa) is not particularly limited, but is preferably less than 1.0, more preferably 0.9 or less, and still more preferably 0.6 or less.

The lower limit value of the ratio (Fb/Fa) is not particularly limited, but the ratio (Fb/Fa) may be 0.01 or more, 0.05 or more, or 0.1 or more.

The insertion force is measured, for example, as described above.

[0152]

<Third embodiment>

The method for producing a processed semiconductor substrate of the present invention includes the following step 5A and the following step 6A. The method for

producing a processed semiconductor substrate may further include the following step 7A.

Here, step 5A is a step of processing the semiconductor substrate in the laminate described in the section of <First embodiment> above.

In addition, step 6A is a step of separating the processed semiconductor substrate in step 5A and the support substrate.

In addition, step 7A is a step of cleaning the processed semiconductor substrate after step 6A.

[0153]

The processing performed on the semiconductor substrate in step 5A is, for example, processing on the side opposite to the circuit surface of the wafer, and includes thinning of the wafer by polishing the back surface of the wafer. Thereafter, for example, a through-silicon via (TSV) or the like is formed, and the thinned wafer is then released from the support substrate to form a laminate of wafers which are three-dimensionally mounted. In addition, for example, before or after that, a wafer back surface electrode and the like are also formed. Heat of approximately 250 to 350°C is applied to thinning of a wafer and a TSV process in a state of being bonded to the support substrate. The laminate of the present invention, which usually includes the infrared-transmitting adhesive

layer and the infrared-absorbing layer, has heat resistance to the load.

The processing performed on the semiconductor substrate in step 5A may be a step of dicing the semiconductor substrate.

The processing is not limited to the above-described processing, and includes, for example, implementation of a process of mounting a semiconductor component in a case where a substrate for mounting the semiconductor component is temporarily adhered to the support substrate to support the substrate.

[0154]

In 6A step, the method of separating (releasing) the semiconductor substrate and the support substrate is the separation step described above.

[0155]

The substrate can be cleaned by spraying a cleaning agent composition onto the surface of at least one of the separated semiconductor substrate and the support substrate, or immersing the separated semiconductor substrate or the support substrate in a cleaning agent composition.

In addition, the surface of the processed semiconductor substrate or the like may be cleaned using a removal tape or the like.

As an example of cleaning the substrate, step 7A of cleaning the processed semiconductor substrate may be performed after step 6A.

Examples of the cleaning agent composition to be used for cleaning include the following.

[0156]

The cleaning agent composition usually contains a solvent.

Examples of the solvent include lactones, ketones, polyhydric alcohols, compounds having an ester bond, derivatives of polyhydric alcohols, cyclic ethers, esters, and aromatic organic solvents.

Examples of the lactones include γ-butyrolactone.

Examples of the ketones include acetone, methyl ethyl ketone, cyclohexanone, methyl-n-pentyl ketone, methyl isopentyl ketone, and 2-heptanone.

Examples of the polyhydric alcohols include ethylene glycol, diethylene glycol, propylene glycol, and dipropylene glycol.

Examples of the compound having an ester bond include ethylene glycol monoacetate, diethylene glycol monoacetate, propylene glycol monoacetate, and dipropylene glycol monoacetate.

Examples of the derivatives of polyhydric alcohols include monoalkyl ethers such as monomethyl ether,

monoethyl ether, monopropyl ether, and monobutyl ether of the polyhydric alcohols or the compounds having an ester bond, or compounds having an ether bond such as monophenyl ether. Among them, propylene glycol monomethyl ether acetate (PGMEA) and propylene glycol monomethyl ether (PGME) are preferable.

Examples of the cyclic ethers include dioxane.

Examples of the esters include methyl lactate, ethyl lactate (EL), methyl acetate, ethyl acetate, butyl acetate, methyl pyruvate, ethyl pyruvate, methyl methoxypropionate, and ethyl ethoxypropionate.

Examples of the aromatic organic solvents include anisole, ethyl benzyl ether, cresyl methyl ether, diphenyl ether, dibenzyl ether, phenetole, butyl phenyl ether, ethylbenzene, diethylbenzene, pentylbenzene, isopropylbenzene, toluene, xylene, cymene, and mesitylene.

These can be used alone or in combination with two or more thereof.

Among them, propylene glycol monomethyl ether acetate (PGMEA), propylene glycol monomethyl ether (PGME), cyclohexanone, and ethyl lactate (EL) are preferable.

[0157]

In addition, a mixed solvent obtained by mixing PGMEA and a polar solvent is also preferable. The blending ratio (mass ratio) may be appropriately determined in

consideration of compatibility between PGMEA and the polar solvent or the like, and is preferably in the range of 1:9 to 9:1, more preferably 2:8 to 8:2.

For example, when EL is blended as the polar solvent, the mass ratio of PGMEA:EL is preferably 1:9 to 9:1, more preferably 2:8 to 8:2. In addition, when PGME is blended as the polar solvent, the mass ratio of PGMEA:PGME is preferably 1:9 to 9:1, more preferably 2:8 to 8:2, still more preferably 3:7 to 7:3. In addition, when PGME and cyclohexanone are blended as the polar solvent, the mass ratio of PGMEA:(PGME + cyclohexanone) is preferably 1:9 to 9:1, more preferably 2:8 to 8:2, still more preferably 3:7 to 7:3.

[0158]

The cleaning agent composition may contain or may not contain a salt, but it is preferable that the cleaning agent composition does not contain a salt from the viewpoint of enhancing versatility in processing a semiconductor substrate using a laminate, and suppressing cost.

[0159]

An example of the case where the cleaning agent composition contains a salt includes a cleaning agent composition containing a quaternary ammonium salt and a solvent.

The quaternary ammonium salt is composed of a quaternary ammonium cation and an anion, and is not particularly limited as long as the quaternary ammonium salt is used for this type of application.

Such quaternary ammonium cations typically include tetra(hydrocarbon)ammonium cations. On the other hand, examples of an anion paired therewith include, but are not limited to, a hydroxide ion (OH^-); a halogen ion such as a fluorine ion (F^-), a chlorine ion (Cl^-), a bromine ion (Br^-), and an iodine ion (I^-); a tetrafluoroborate ion (BF_4^-); or a hexafluorophosphate ion (PF_6^-).

[0160]

The quaternary ammonium salt is preferably a halogen-containing quaternary ammonium salt, and more preferably a fluorine-containing quaternary ammonium salt.

In the quaternary ammonium salt, the halogen atom may be contained in the cation or the anion, and is preferably contained in the anion.

[0161]

In a preferred embodiment, the fluorine-containing quaternary ammonium salt is tetra(hydrocarbon)ammonium fluoride.

Specific examples of the hydrocarbon group in tetra(hydrocarbon)ammonium fluoride include an alkyl group having 1 to 20 carbon atoms, an alkenyl group having 2 to

20 carbon atoms, an alkynyl group having 2 to 20 carbon atoms, and an aryl group having 6 to 20 carbon atoms.

In a more preferred embodiment, the tetra(hydrocarbon)ammonium fluoride includes tetraalkylammonium fluoride.

Specific examples of tetraalkylammonium fluoride include, but are not limited to, tetramethylammonium fluoride, tetraethylammonium fluoride, tetrapropylammonium fluoride, and tetrabutylammonium fluoride. Among them, tetrabutylammonium fluoride is preferable.

[0162]

As the quaternary ammonium salt such as tetra(hydrocarbon)ammonium fluoride, a hydrate may be used. In addition, the quaternary ammonium salts such as tetra(hydrocarbon)ammonium fluoride may be used alone or in combination of two or more thereof.

The amount of the quaternary ammonium salt is not particularly limited as long as the quaternary ammonium salt dissolves in the solvent contained in the cleaning agent composition, but is usually 0.1 to 30 mass% with respect to the cleaning agent composition.

[0163]

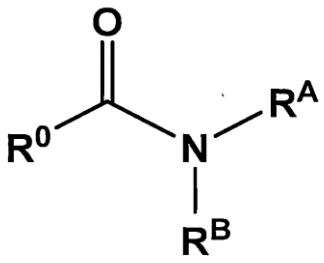
When the cleaning agent composition contains a salt, the solvent to be used in combination is not particularly limited as long as the solvent is used for this type of

application and dissolves a salt such as a quaternary ammonium salt, but from the viewpoint of obtaining a cleaning agent composition having excellent cleanability with good reproducibility, the viewpoint of obtaining a cleaning agent composition having excellent uniformity by dissolving a salt such as a quaternary ammonium salt well, and the like, the cleaning agent composition preferably contains one or two or more amide-based solvents.

[0164]

Suitable examples of the amide-based solvents include an acid amide derivative represented by Formula (Z).

[Chem. 12]



(Z)

[0165]

In the formula, R^0 represents an ethyl group, a propyl group or an isopropyl group, and is preferably an ethyl group or an isopropyl group, and more preferably an ethyl group. R^A and R^B each independently represent an alkyl group having 1 to 4 carbon atoms. The alkyl group having 1 to 4 carbon atoms may be linear, branched, or cyclic, and specific examples thereof include a methyl

group, an ethyl group, a propyl group, an isopropyl group, a cyclopropyl group, a n-butyl group, an isobutyl group, a s-butyl group, a t-butyl group, and a cyclobutyl group. Among them, R^A and R^B are preferably a methyl group or an ethyl group, more preferably both are a methyl group or an ethyl group, and still more preferably both are a methyl group.

[0166]

Examples of the acid amide derivative represented by Formula (Z) include N,N-dimethylpropionamide, N,N-diethylpropionamide, N-ethyl-N-methylpropionamide, N,N-dimethylbutyramide, N,N-diethylbutyramide, N-ethyl-N-methylbutyramide, N,N-dimethylisobutyramide, N,N-diethylisobutyramide, or N-ethyl-N-methylisobutyramide. Among them, N,N-dimethylpropionamide and N,N-dimethylisobutyramide are particularly preferable, and N,N-dimethylpropionamide is more preferable.

[0167]

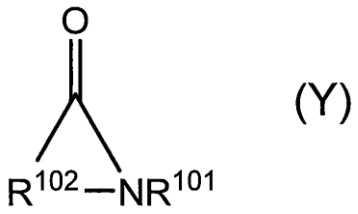
The acid amide derivative represented by Formula (Z) may be synthesized by a substitution reaction between a corresponding carboxylic acid ester and an amine, or a commercially available product may be used.

[0168]

Another example of the preferable amide-based solvents includes a lactam compound represented by Formula

(Y).

[Chem. 13]



(Y)

[0169]

In Formula (Y), R^{101} represents a hydrogen atom or an alkyl group having 1 to 6 carbon atoms, and R^{102} represents an alkylene group having 1 to 6 carbon atoms. Specific examples of the alkyl group having 1 to 6 carbon atoms include a methyl group, an ethyl group, an n-propyl group, and an n-butyl group, and specific examples of the alkylene group having 1 to 6 carbon atoms include, but are not limited to, a methylene group, an ethylene group, a trimethylene group, a tetramethylene group, a pentamethylene group, and a hexamethylene group.

[0170]

Specific examples of the lactam compound represented by Formula (Y) include an α-lactam compound, a β-lactam compound, a γ-lactam compound, and a δ-lactam compound, and these compounds can be used alone or in combination of two or more thereof.

[0171]

In a preferred embodiment, the lactam compound

represented by Formula (Y) contains 1-alkyl-2-pyrrolidone (N-alkyl-γ-butyrolactam), in a more preferred embodiment, contains N-methylpyrrolidone (NMP) or N-ethylpyrrolidone (NEP), and in a still more preferred embodiment, contains N-methylpyrrolidone (NMP).

[0172]

The cleaning agent composition used in the present invention may contain water as the solvent, but usually, only an organic solvent is intended to be used as the solvent, for example, from the viewpoint of avoiding corrosion of the substrates and the like. In this case, it is not denied that hydrated water of the salt or trace amounts of water contained in the organic solvent are contained in the cleaning agent composition. The water content of the cleaning agent composition used in the present invention is usually 5 mass% or less.

[0173]

The constituent elements and method elements related to the above-described steps of the method for producing a processed semiconductor substrate of the present invention may be variously changed without departing from the gist of the present invention.

The method for producing a processed semiconductor substrate of the present invention may include steps other than the above-described steps.

[0174]

In the releasing method of the present invention, when the semiconductor substrate or the support substrate of the laminate of the present invention is light-transmissive, the semiconductor substrate and the support substrate of the laminate are separated by irradiating the infrared-absorbing layer with an infrared laser from the semiconductor substrate side or the support substrate side.

In an example of the laminate of the present invention, the semiconductor substrate and the support substrate are temporarily adhered so as to be suitably releasable by the infrared-transmitting adhesive layer and the infrared-absorbing layer. Therefore, for example, when the support substrate has optical transparency, the semiconductor substrate and the support substrate can be easily separated by irradiating the infrared-absorbing layer with an infrared laser from the support substrate side of the laminate. Usually, release is performed after the semiconductor substrate of the laminate is processed.

[0175]

An example of the third embodiment will be described with reference to Figs. 5A to 5E. This example is an example of production of a thinned semiconductor substrate.

First, a laminate is prepared (Fig. 5A). This laminate is the same laminate as the laminate illustrated

in Figs. 1 and 2C.

Next, the surface of the semiconductor substrate 1 opposite to the surface in contact with the infrared-absorbing layer 2 is polished using a polishing apparatus (not illustrated) to thin the semiconductor substrate 1 (Fig. 5B). A through electrode or the like may be formed on the thinned semiconductor substrate 1.

Next, the infrared-absorbing layer 2 is irradiated with the infrared laser L from the support substrate 4 side (Fig. 5C). The irradiation of the infrared laser may be performed on the entire surface or a part of the infrared-absorbing layer 2.

Next, the thinned semiconductor substrate 1 and the support substrate 4 are separated using a release device (not illustrated) (Fig. 5D).

Then, the thinned semiconductor substrate 1 is obtained (Fig. 5E).

In this embodiment, since the infrared-absorbing layer 2 is provided between the semiconductor substrate 1 and the infrared-transmitting adhesive layer 3, it is possible to perform release without leaving the infrared-transmitting adhesive layer 3 on the semiconductor substrate 1.

However, residues of the infrared-absorbing layer 2 and the infrared-transmitting adhesive layer 3 may slightly

remain on the thinned semiconductor substrate 1. Therefore, it is preferable to clean the thinned semiconductor substrate 1 using the cleaning agent composition to remove the residues of the infrared-absorbing layer 2 and the infrared-transmitting adhesive layer 3 from the semiconductor substrate 1.

[0176]

<Fourth embodiment>

The method for producing a processed electronic device layer of the present invention includes the following step 5B and the following step 6B. The method for producing a processed electronic device layer may further include the following step 7B.

Here, step 5B is a step of processing the electronic device layer in the laminate described in the section of <Second embodiment> above.

In addition, step 6B is a step of separating the electronic device layer processed in step 5B from the support substrate.

In addition, step 7B is a step of cleaning the processed electronic device layer after step 6B.

Hereinafter, a specific example of the fourth embodiment will be described with reference to Figs. 6A to 6F.

[0177]

Examples of the processing performed on the electronic device layer in step 5B include a grinding step and a wiring layer formation step.

[0178]

<<Grinding Step>>

The grinding step is a step of grinding the resin part of the layer of the sealing resin 25 in the electronic device layer 26 such that a part of the semiconductor chip substrate 21 is exposed.

For example, as illustrated in Fig. 6B, the sealing resin portion is ground by grinding the layer of the sealing resin 25 of the laminate illustrated in Fig. 6A until the layer has a thickness substantially equal to that of the semiconductor chip substrate 21. Note that the laminate illustrated in Fig. 6A is the same laminate as the laminate illustrated in Figs. 3 and 4D.

[0179]

<<Wiring layer formation step>>

The wiring layer formation step is a step of forming a wiring layer on the exposed semiconductor chip substrate 21 after the grinding step.

In Fig. 6C, a wiring layer 28 is formed on an electronic device layer 26 including a semiconductor chip substrate 21 and a layer of a sealing resin 25.

The wiring layer 28 is also called a redistribution

layer (RDL), and is a thin-film wiring body constituting wiring connected to a substrate, and may have a single-layer or multi-layer structure. The wiring layer may be, but is not limited to, one in which wiring is formed of a conductor (for example, metals such as aluminum, copper, titanium, nickel, gold, and silver, and alloys such as a silver-tin alloy) between dielectrics (for example, silicon oxide (SiO_x) or a photosensitive resin such as photosensitive epoxy).

Examples of the method for forming the wiring layer 28 include the following methods.

First, a dielectric layer of silicon oxide (SiO_x), a photosensitive resin, or the like is formed on the layer of the sealing resin 25. The dielectric layer consisting of silicon oxide can be formed by, for example, a sputtering method, a vacuum vapor deposition method, or the like. The dielectric layer consisting of a photosensitive resin can be formed by coating the layer of the sealing resin 25 with a photosensitive resin by a method such as spin coating, dipping, roller blade, spray coating, or slit coating.

Subsequently, wiring is formed on the dielectric layer with a conductor such as metal. As a method for forming the wiring, for example, known semiconductor process techniques such as lithography processing such as photolithography (resist lithography) or etching processing

can be used. Examples of such lithography processing include lithography processing using a positive resist material and lithography processing using a negative resist material.

In the method for producing a laminate according to a fourth embodiment, a bump can be further formed or an element can be mounted on the wiring layer 28. The element can be mounted on the wiring layer 28 using, for example, a chip mounter or the like.

The laminate according to the fourth embodiment may be a laminate prepared in a process based on a fan-out-type technology in which a terminal provided on a semiconductor chip substrate is mounted on a wiring layer extending outside a chip area.

[0180]

In 6B step, the method for separating (releasing) the electronic device layer and the support substrate is the separation step described above.

[0181]

Figs. 6D to 6F are schematic cross-sectional views for illustrating a separation method of the laminate. One embodiment of the method for producing the semiconductor package (electronic component) can be described with reference to Figs. 6D to 6F.

As illustrated in Fig. 6D, the step of separating the

laminate is a step of separating the electronic device layer 26 and the support substrate 24 by irradiating the infrared-absorbing layer 22 with the infrared laser L through the support substrate 24 to deteriorate the infrared-absorbing layer 22.

After the infrared-absorbing layer 22 is irradiated with the infrared laser L to deteriorate the infrared-absorbing layer 22, the support substrate 24 is separated from the electronic device layer 26 as illustrated in Fig. 6E.

In this embodiment, since the infrared-absorbing layer 22 is provided between the electronic device layer 26 and the infrared-transmitting adhesive layer 23, release can be performed so that the infrared-transmitting adhesive layer 23 does not remain on the electronic device layer 26.

The irradiation conditions, irradiation methods, and the like of the infrared laser with respect to the infrared-absorbing layer are as described in the section of <Third embodiment> above.

[0182]

The substrate can be cleaned by spraying the cleaning agent composition onto the surface of at least one of the separated electronic device layer and the support substrate, or immersing the separated electronic device layer or the support substrate in the cleaning agent

composition.

In addition, the surface of the processed electronic device layer or the like may be cleaned using a removal tape or the like.

As described above, a processed electronic device layer (electronic component) as illustrated in Fig. 6F can be suitably obtained.

[0183]

The constituent elements and method elements related to the above-described steps of the method for producing a processed electronic device layer of the present invention may be variously changed without departing from the gist of the present invention.

The method for producing a processed electronic device layer of the present invention may include steps other than the above-described steps.

Examples

[0184]

Hereinafter, the present invention will be more specifically described with reference to Examples, but the present invention is not limited to the following Examples. The apparatus used is as follows.

[0185]

[Apparatus]

(1) Stirrer A: Rotation and revolution mixer ARE-500, manufactured by THINKY CORPORATION

(2) Stirrer B: Mixing rotor VMR-5R, manufactured by AS ONE Corporation

(3) Measurement of viscosity: TVE-22H, rotational viscometer manufactured by Toki Sangyo Co., Ltd.

(4) Spin coating device: coater manufactured by APOGEE Co., Ltd.

(5) Vacuum heating bonding apparatus: VE09-07, manufactured by Ayumi Industry Co., Ltd.

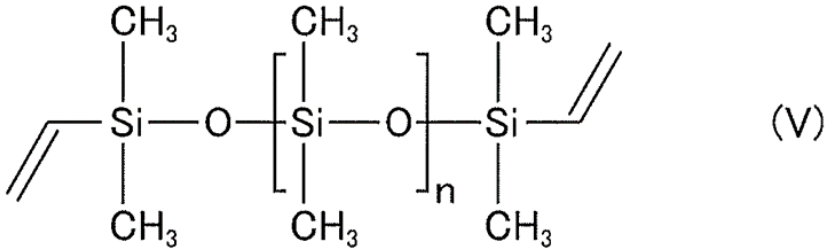
(6) Force gauge: RZE-10 manufactured by Aikoh Engineering Co., Ltd.

(7) Infrared laser release device: AFS-MCTII-FX manufactured by Aflair

[0186]

The structures and properties of the polysiloxanes used (formula (V) and formula (W)) are shown below.

[Chem. 14]



(V)

[0187]

(In formula (V), n represents the number of repeating

units and is a positive integer.) Polysiloxanes having a structure represented by formula (V) and exhibiting the characteristics in Table 1 below were used.

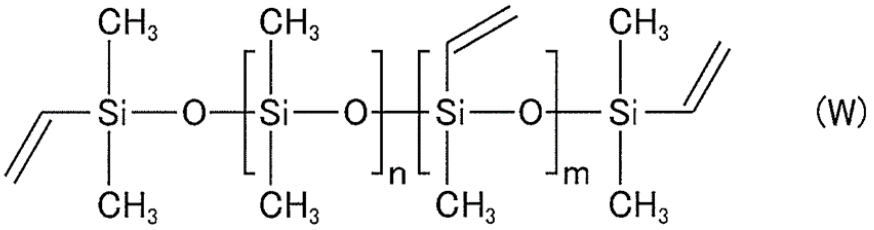
[0188]

[Table 1]

Vinyl group-containing linear polydimethylsiloxane	Number average molecular weight Mn	Vinyl group content (mol/kg)
V1	6000	0.24

[0189]

[Chem. 15]



(W)

(In formula (W), n and m represent the number of repeating units, and each independently represent a positive integer.) It also has 2.7 mol/kg of vinyl groups and the number average molecular weight (Mn) as determined by GPC is 9000.

[0190]

[1] Preparation of infrared-absorbing composition and infrared-transmitting adhesive composition

[Preparation Example 1]

To a 100 mL lidded glass container, 0.06 g of 1,1-diphenyl-2-propyn-1-ol (manufactured by Tokyo Chemical Industry Co., Ltd.) and 0.12 g of 1-ethynyl-1-cyclohexanol (manufactured by Wacker Chemie AG) were added, and the mixture was stirred with a stirrer A for 5 minutes to obtain a mixture (I).

To a 50-mL screw tube, 1.0 g of the polysiloxane of formula (W) and 0.13 g of a platinum catalyst (valence 0, platinum content 1wt%) diluted with the polysiloxane of formula (W) were added, and the mixture was stirred with a stirrer A for 5 minutes to obtain a mixture (II).

To the obtained mixture (I), 5.7 g of a p-menthane solution (concentration: 81.7 mass%) of a vinyl group-containing MQ resin (manufactured by Wacker Chemie AG) and 18.1 g of the following mixture A were added, and the mixture was stirred with a stirrer A for 5 minutes to obtain a mixture (III).

Mixture A: a mixture obtained by mixing a vinyl group-containing MQ resin (manufactured by Wacker Chemie AG), a vinyl group-containing linear polydimethylsiloxane represented by formula (V) and having a viscosity of 200 mPa · s (V1 in Table 1), and a SiH group-containing linear polydimethylsiloxane having a viscosity of 100 mPa · s (manufactured by Wacker Chemie AG) at a mass ratio of 54.5:36.0:9.5

To the obtained mixture (III), 0.5 g of the mixture (II) was added, and the mixture was stirred with a stirrer A for 5 minutes to obtain a mixture (IV).

Finally, the obtained mixture (IV) was filtered through a nylon filter 300 mesh to obtain an infrared-absorbing composition.

[0191]

[Preparation Example 2]

To a 50-mL screw tube were added 6.0 g of a hydrogenated styrene-based block copolymer (SEPTON 4033, manufactured by KURARAY CO., LTD.) and 44.0 g of cyclopentanone, and the mixture was stirred with a stirrer A for 5 minutes to obtain an infrared-transmitting adhesive composition.

[0192]

[2] Production of substrate with infrared-absorbing layer

[Production Example 1]

The infrared-absorbing composition obtained in Preparation Example 1 was applied to a 4 cm square silicon substrate by spin coating at 2000rpm for 30 seconds, and then heated at 90°C for 1.5 minutes, at 130°C for 5 minutes, and at 200°C for 5 minutes to form an infrared-absorbing layer.

[0193]

[3] Preparation of laminate

[Example 1]

The infrared-transmitting adhesive composition obtained in Preparation Example 2 was applied to a 4 cm square silicon substrate by spin coating at 950rpm for 30 seconds, and then heated at 200°C for 1 minute to form an infrared-transmitting adhesive coating layer. Thereafter, in a vacuum heating laminating apparatus, the silicon substrate having the infrared-transmitting adhesive coating layer and the silicon substrate on which the infrared-absorbing layer produced in Production Example 1 was formed were laminated so that the infrared-transmitting adhesive coating layer and the infrared-absorbing layer were in contact with each other, thereby preparing a laminate. Bonding was performed using a vacuum heating bonding apparatus at a temperature of 200°C and a degree of vacuum of 1000 Pa under a load of 150 kg for 3 minutes.

The thickness of the infrared-absorbing layer in the laminate was 1 μm. The thickness of the infrared-transmitting adhesive layer in the laminate was 4.5 μm.

[0194]

[4] Laser irradiation

[Example 2]

The laminate produced in Example 1 was placed such that the substrate on which the infrared-absorbing layer

was formed was on the device (lower) side, and the entire surface of a 4 cm square substrate was irradiated with a laser having a wavelength of 9.3 μm from a direction perpendicular to the silicon wafer on the carrier (upper) side using an infrared laser release device. The laser irradiation conditions were as follows.

·Scan speed: 1000 nm/sec

·Laser power: 60 W

·Frequency: 20 Hz

[0195]

[5] Evaluation of insertion force

[Example 3]

The device side of the laser-irradiated laminate in Example 2 was fixed on a workbench with a double-sided tape. Next, a force gauge blade having a razor blade attached to the tip thereof was inserted into the infrared-transmitting adhesive layer of the fixed laminate, and the maximum value of the absolute value of the force gauge at that time was taken as the insertion force.

[0196]

[Comparative Example 1]

The insertion force was evaluated by the same test method as in Example 3 except that the laminate prepared in Example 1 was used.

In Comparative Example 1, infrared laser irradiation

was not performed.

[0197]

The evaluation results of Example 3 and Comparative Example 1 are shown in Table 2.

[0198]

[Table 2]

	Insertion force (N)
Example 3	13.7 N
Comparative Example 1	Not insertable

[0199]

From the results of Example 3 and Comparative Example 1, it became clear that in a case where the infrared laser irradiation is performed, in the laminate on which the infrared-absorbing layer is formed, equipment having a sharp portion can be inserted between the substrates with a low insertion force. From this, it was confirmed that when the composition and process according to the present invention were used, the substrate was less damaged when the laminate was separated, and release was possible.

Reference Signs List

[0200]

1 Semiconductor substrate

2 Infrared-absorbing layer

3	Infrared-transmitting adhesive layer
3a	Infrared-transmitting adhesive coating layer
4	Support substrate
21	Semiconductor chip substrate
22	Infrared-absorbing layer
22′	Infrared-absorbing composition coating layer
23	Infrared-transmitting adhesive layer
23′	Infrared-transmitting adhesive coating layer
24	Support substrate
25	Sealing resin
26	Electronic device layer
28	Wiring layer
L	Infrared laser

CLAIMS

[claim 1] A laminate comprising:

a first body that is a semiconductor substrate or an electronic device layer;

a second body that is a support substrate that transmits an infrared laser; and

an infrared-transmitting adhesive layer and an infrared-absorbing layer provided between the first body and the second body.

[claim 2] The laminate according to claim 1, wherein the infrared-absorbing layer is provided between the first body and the infrared-transmitting adhesive layer.

[claim 3] The laminate according to claim 1, wherein the infrared-absorbing layer is formed from an infrared-absorbing composition containing an infrared-absorbing compound.

[claim 4] The laminate according to claim 1, wherein a thickness of the infrared-transmitting adhesive layer is thicker than a thickness of the infrared-absorbing layer.

[claim 5] The laminate according to claim 1, wherein an insertion force required to separate the first body and the second body by inserting a sharp portion of equipment having a sharp portion between the first body and the second body after irradiating the infrared-absorbing layer with the infrared laser is smaller than an insertion force

required to separate the first body and the second body by inserting the sharp portion between the first body and the second body without irradiating the infrared-absorbing layer with the infrared laser.

[claim 6] A method for producing a processed semiconductor substrate or electronic device layer, the method comprising:

a processing step of processing the first body of the laminate according to any one of claims 1 to 5; and

a separation step of irradiating the infrared-absorbing layer with the infrared laser from the second body side, and then separating the processed first body and the second body.

[claim 7] The method for producing a processed semiconductor substrate or electronic device layer according to claim 6, wherein by irradiating the infrared-absorbing layer with the infrared laser, an insertion force required to separate the first body and the second body by inserting the sharp portion of equipment having a sharp portion between the first body and the second body is reduced as compared with a case where the infrared-absorbing layer is not irradiated with the infrared laser.