

DESCRIPTION

Title of Invention

FILMY ADHESIVE, ADHESIVE SHEET, SEMICONDUCTOR DEVICE, AND METHOD FOR MANUFACTURING SAME

5 Technical Field

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

Background Art

10 [0002] In recent years, stacked MCPs (Multi Chip Packages) in which semiconductor elements (semiconductor chips) are stacked in multiple stages have been popularly spread, and stacked MCPs are mounted as memory semiconductor packages for mobile telephones and mobile audio devices, and the like. Furthermore, along with multifunctioning
15 of mobile telephones and the like, speed increase, density increase, high integration, and the like of semiconductor packages have also been promoted. Concomitantly with this, attempts have been made to increase the speed by using copper as a wiring material for semiconductor chip circuits. Furthermore, from the viewpoints of enhancing the
20 reliability of connection to complicated mounting boards and promoting heat rejection from semiconductor packages, lead frames and the like that are composed of copper are in use.

[0003] However, since copper has a characteristic of being easily
25 corrodible, and the coating materials for securing insulation properties of circuit surfaces also tend to be simplified from the viewpoint of cost reduction, it tends to become difficult to secure electrical characteristics

of semiconductor packages. Particularly, in semiconductor packages obtained by stacking semiconductor chips in multiple stages, there is a tendency that copper ions generated due to corrosion migrate through the inner part of adhesive, and a loss of electrical signals within a semiconductor chip or between a semiconductor chip and another semiconductor chip easily occurs.

[0004] Furthermore, from the viewpoint of improved functionality, semiconductor elements are connected to complicated mounting boards in many cases, and thus, lead frames composed of copper tend to be preferred in order to enhance the connection reliability. Even in such a case, a loss of electrical signals caused by copper ions generated from a lead frame may bring a problem.

[0005] In addition, with regard to semiconductor packages that use members composed of copper, there is a high possibility that copper ions may be generated from those members and cause electrical failure, and sufficient HAST resistance may not be obtained.

[0006] From the viewpoint of preventing a loss of electrical signals or the like, an investigation has been conducted on adhesives that scavenge copper ions generated inside a semiconductor package. For example, Patent Literature 1 discloses an adhesive sheet for semiconductor device production, the adhesive sheet having a thermoplastic resin that has an epoxy group but does not have a carboxyl group, and an organic complex-forming compound that has a heterocyclic compound containing a tertiary nitrogen atom as a ring atom and forms a complex with a cation.

Citation List

Patent Literature

[0007] Patent Literature 1: JP No. 2013-026566

Summary of Invention

Technical Problem

[0008] However, conventional adhesives are not satisfactory from the viewpoint of suppressing the inconvenience associated with the migration of copper ions within the adhesive, and there is still room for improvement.

[0009] Thus, a main object of the present invention is to provide a film-form adhesive in which the inconvenience associated with the migration of copper ions within the adhesive can be sufficiently suppressed.

Solution to Problem

[0010] The inventors of the present invention conducted a thorough investigation, and they found that the inconvenience associated with migration of copper ions within an adhesive can be sufficiently suppressed by using a leveling agent, thus completing the present invention.

[0011] According to an aspect of the present invention, there is provided a film-form adhesive for adhering a semiconductor element to a support member for mounting the semiconductor element, the film-form adhesive containing a thermosetting resin component and a leveling agent.

[0012] The reason why the migration of copper ions within the adhesive can be sufficiently suppressed by using a leveling agent, is not necessarily clearly known; however, the present inventors speculate that it is because as the leveling agent is intercalated into an adhesive surface layer, the uptake of copper ions itself in the adhesive surface layer is suppressed.

[0013] The leveling agent may be a compound having a siloxane

structure.

[0014] The thermosetting resin component may include a thermosetting resin, a curing agent, and an acrylic rubber.

[0015] A thickness of the film-form adhesive may be 50 μm or less.

5 [0016] According to another aspect of the present invention, there is provided an adhesive sheet comprising a base material and the above-mentioned film-form adhesive provided on one surface of the base material. The base material may be a dicing tape.

10 [0017] According to another aspect of the present invention, there is provided a semiconductor device comprising a semiconductor element; a support member for mounting the semiconductor element; and an adhesive member provided between the semiconductor element and the support member and adhering the semiconductor element to the support member, wherein the adhesive member is a cured product of the above-mentioned film-form adhesive. The support member may include a member composed of copper.

15 [0018] According to another aspect of the present invention, there is provided a method for producing a semiconductor device, the method comprising a step of adhering a semiconductor element to a support member using the above-mentioned film-form adhesive.

20 [0019] According to another aspect of the present invention, there is provided a method for producing a semiconductor device, the method comprising a step of sticking the film-form adhesive of the above-mentioned adhesive sheet to a semiconductor wafer; a step of cutting the semiconductor wafer having the film-form adhesive stuck thereto to produce a plurality of singulated film-form adhesive-attached

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semiconductor elements; and a step of adhering each of the film-form adhesive-attached semiconductor elements to a support member. The method for producing a semiconductor device may further comprise a step of heating the film-form adhesive-attached semiconductor element adhered to the support member, using a reflow furnace.

Advantageous Effects of Invention

[0020] According to the present invention, a film-form adhesive capable of sufficiently suppressing the inconvenience associated with the migration of copper ions within the adhesive is provided. Furthermore, according to the present invention, an adhesive sheet and a semiconductor device, both of which use such a film-form adhesive, are provided. In addition, according to the present invention, a method for producing a semiconductor device using a film-form adhesive or an adhesive sheet is provided.

Brief Description of Drawings

[0021] FIG. 1 is a schematic cross-sectional view illustrating an embodiment of a film-form adhesive.

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

FIG. 3 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet.

FIG. 4 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet.

FIG. 5 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet.

FIG. 6 is a schematic cross-sectional view illustrating an

embodiment of a semiconductor device.

FIG. 7 is a schematic cross-sectional view illustrating another embodiment of the semiconductor device.

Description of Embodiments

[0022] Hereinafter, embodiments of the present invention will be described with appropriate reference to the drawings. However, the present invention is not limited to the following embodiments. In the following embodiments, constituent elements of the embodiments (also including steps and the like) are not essential unless particularly stated otherwise. The sizes of the constituent elements in each of the drawings are conceptual, and the relative relationship between the sizes of the constituent elements is not limited to the relationship as illustrated in each drawing.

[0023] The same also applies to the numerical values and ranges thereof in the present specification, and the present invention is not intended to be limited. A numerical value range expressed using the term "to" in the present specification represents a range including the numerical values described before and after the term "to" as the minimum value and the maximum value, respectively. With regard to the numerical value range described stepwise in the present specification, the upper limit value or the lower limit value described in one numerical value range may be replaced with the upper limit value or the lower limit value of another stepwise numerical value range described. Furthermore, with regard to a numerical value ranges described in the present specification, the upper limit value or the lower limit value of the numerical value range may be replaced with the values described in Examples.

[0024] According to the present specification, a (meth)acrylate means an acrylate or a methacrylate corresponding thereto. The same also applies to other similar expressions such as a (meth)acryloyl group and a (meth)acrylic copolymer.

5 [0025] The film-form adhesive according to an embodiment is a film-form adhesive for adhering a semiconductor element to a support member for mounting the semiconductor element, and the film-form adhesive contains a thermosetting resin component and a leveling agent.

10 [0026] The film-form adhesive can be obtained by molding an adhesive composition containing: (A) a thermosetting resin component and (B) a leveling agent, into a film shape. The film-form adhesive and the adhesive composition may be an adhesive and a composition, respectively, which can go through a semi-cured (stage B) state and enter a completely cured product (stage C) state after a curing treatment.

15 [0027] According to an embodiment, the (A) thermosetting resin component may include: (A1) a thermosetting resin; (A2) a curing agent; and (A3) an elastomer.

[0028] Component (A1): Thermosetting resin

20 The component (A1) may be an epoxy resin from the viewpoint of adhesiveness. Regarding the epoxy resin, any resin having an epoxy group in the molecule can be used without particular limitations. Examples of the epoxy resin include a bisphenol A type epoxy resin, a bisphenol F type epoxy resin, a bisphenol S type epoxy resin, a phenol novolac type epoxy resin, a cresol novolac type epoxy resin, a bisphenol
25 A novolac type epoxy resin, a bisphenol F novolac type epoxy resin, a stilbene type epoxy resin, a triazine skeleton-containing epoxy resin, a

fluorene skeleton-containing epoxy resin, a triphenolmethane type epoxy resin, a biphenyl type epoxy resin, a xylylene type epoxy resin, a biphenyl aralkyl type epoxy resin, a naphthalene type epoxy resin, a polyfunctional phenol, and a diglycidyl ether compound of a polycyclic aromatic compound such as anthracene. These may be used singly or in combination of two or more kinds thereof. Among these, the component (A1) may be a cresol novolac type epoxy resin, a phenol novolac type epoxy resin, a bisphenol F type epoxy resin, or a bisphenol A type epoxy resin, from the viewpoints of tackiness, pliability, and the like of a film.

[0029] The epoxy equivalent of the epoxy resin is not particularly limited; however, the epoxy equivalent may be 90 to 300 g/eq or 110 to 290 g/eq. When the epoxy equivalent of the epoxy resin is in such a range, there is a tendency that fluidity can be secured while maintaining the bulk strength of the film-form adhesive.

[0030] Component (A2): Curing agent

The component (A2) may be a phenolic resin that can serve as a curing agent for an epoxy resin. Regarding the phenolic resin, any resin having a phenolic hydroxyl group in the molecule can be used without particular limitations. Examples of the phenolic resin include a novolac type phenolic resin obtainable by condensing or co-condensing a phenol such as phenol, cresol, resorcin, catechol, bisphenol A, bisphenol F, phenylphenol, or aminophenol, and/or a naphthol such as α -naphthol, β -naphthol, or dihydroxynaphthalene, with a compound having an aldehyde group, such as formaldehyde, in the presence of an acidic catalyst; a phenol aralkyl resin synthesized from a phenol and/or a naphthol, such as

allylated bisphenol A, allylated bisphenol F, allylated naphthalenediol, phenol novolac, or phenol, and dimethoxy-para-xylene or bis(methoxymethyl)biphenyl; and a naphthol aralkyl resin. These may be used singly or in combination of two or more kinds thereof. Among
5 these, the phenolic resin may be a phenol novolac type phenolic resin or a naphthol aralkyl resin.

[0031] The hydroxyl group equivalent of the phenolic resin may be 70 g/eq or more or 70 to 300 g/eq. When the hydroxyl group equivalent of the phenolic resin is 70 g/eq or more, the storage modulus of the film
10 tends to be further enhanced, and when the hydroxyl group equivalent is 300 g/eq or less, inconvenience caused by the occurrence of foaming, outgassing, and the like can be prevented.

[0032] From the viewpoint of curability, the ratio between the epoxy equivalent of the epoxy resin and the hydroxyl group equivalent of the phenolic resin (epoxy equivalent of epoxy resin/hydroxyl group
15 equivalent of phenolic resin) may be 0.30/0.70 to 0.70/0.30, 0.35/0.65 to 0.65/0.35, 0.40/0.60 to 0.60/0.40, or 0.45/0.55 to 0.55/0.45. When this equivalent ratio is 0.30/0.70 or more, more sufficient curability tends to be obtained. When this equivalent ratio is 0.70/0.30 or less, viscosity
20 can be prevented from excessively increasing, and more sufficient fluidity can be obtained.

[0033] The total content of the component (A1) and the component (A2) may be 5 to 50 parts by mass, 10 to 40 parts by mass, or 15 to 30 parts by mass, with respect to 100 parts by mass of the total mass of the component
25 (A). When the total content of the component (A1) and the component (A2) is 5 parts by mass or more, the elastic modulus tends to be increased

by crosslinking. When the total content of the component (A1) and the component (A2) is 50 parts by mass or less, there is a tendency that film handleability can be retained.

[0034] Component (A3): Elastomer

5 The component (A3) may be an acrylic rubber having a constituent unit derived from a (meth)acrylic acid ester as a main component. The content of the constituent unit derived from a (meth)acrylic acid ester in the component (A3) may be, for example, 70% by mass or more, 80% by mass or more, or 90% by mass or more, based
10 on the total amount of the constituent units. The acrylic rubber may be a component including a constituent unit derived from a (meth)acrylic acid ester having a crosslinkable functional group such as an epoxy group, an alcoholic or phenolic hydroxyl group, or a carboxyl group.

[0035] The glass transition temperature (T_g) of the component (A3) may
15 be -50°C to 50°C or -30°C to 30°C . When the T_g of the component (A3) is -50°C or higher, there is a tendency that the pliability of the adhesive can be prevented from becoming too high. As a result, the film-form adhesive can be easily cut during wafer dicing, and the occurrence of burring can be prevented. When the T_g of the component
20 (A3) is 50°C or lower, there is a tendency that a decrease in pliability of the adhesive can be suppressed. As a result, when the film-form adhesive is stuck to a wafer, voids tend to be easily embedded sufficiently. Furthermore, it is possible to prevent chipping at the time of dicing, which is caused by a decrease in the adhesiveness of the wafer. Here, the glass
25 transition temperature (T_g) means the value measured using a DSC (thermal differential scanning calorimeter) (for example, manufactured

by Rigaku Corporation, Thermo Plus 2).

[0036] The weight average molecular weight (Mw) of the component (A3) may be 100000 to 3000000 or 200000 to 2000000. When the Mw of the component (A3) is in such a range, the film-forming property, and the strength, flexibility, tackiness, and the like in the film shape can be appropriately controlled, and at the same time, excellent reflow characteristics are obtained, while embeddability can be enhanced. Here, the Mw means a value measured by gel permeation chromatography (GPC) and converted using a calibration curve produced with polystyrene standards.

[0037] Examples of a commercially available product of the component (A3) having a constituent unit derived from acrylonitrile include SG-P3, SG-80H, and HTR-860P-3CSP (all manufactured by Nagase ChemteX Corporation).

[0038] The content of the component (A3) may be 50 to 95 parts by mass, 60 to 90 parts by mass, or 70 to 85 parts by mass, with respect to 100 parts by mass of the total mass of the component (A). When the content of the component (A3) is in such a range, there is a tendency that migration (permeation) of copper ions within the adhesive can be more sufficiently suppressed.

[0039] According to another embodiment, the (A) thermosetting resin component may include an elastomer having a crosslinkable functional group such as an epoxy group, an alcoholic or phenolic hydroxyl group, or a carboxyl group, and a curing agent that can react with a crosslinkable functional group. Examples of a combination of an elastomer having a crosslinkable functional group and a curing agent that can react with a

crosslinkable functional group include a combination of an acrylic rubber having an epoxy group and a phenolic resin.

[0040] Component (B): Leveling agent (surface conditioner)

As the film-form adhesive contains the component (B), uptake of copper ions in the adhesive surface layer can be suppressed. The component (B) is not particularly limited as long as it can adjust the surface tension of the film-form adhesive; however, the component (B) may be a compound having a siloxane structure (in other words, a polysiloxane or a silicone). Examples of such a component (B) include polyether-modified, polyester-modified, aralkyl-modified, and phenyl-modified polysiloxanes (silicones). These may be used singly or in combination of two or more kinds thereof.

[0041] Examples of a commercially available product of a compound having a siloxane structure include BYK-307, BYK-310, BYK-333, BYK-377, and BYK-378 (all trade names, manufactured by BYK Japan KK), KF-945 and KF-6204 (all trade names, manufactured by Shin-Etsu Chemical Co., Ltd.).

[0042] The content of the component (B) may be 0.1 to 5.0 parts by mass, 0.15 to 2.0 parts by mass, or 0.2 to 1.5 parts by mass, with respect to 100 parts by mass of the total mass of the component (A). When the content of the component (B) is 0.1 parts by mass or more, there is a tendency that the uptake of copper ions in the adhesive surface layer can be further suppressed.

[0043] The film-form adhesive (adhesive composition) may further contain (C) an inorganic filler, (D) a coupling agent, (E) a curing accelerator, and the like.

[0044] Component (C): Inorganic filler

Examples of the component (C) include aluminum hydroxide, magnesium hydroxide, calcium carbonate, magnesium carbonate, calcium silicate, magnesium silicate, calcium oxide, magnesium oxide, aluminum oxide, aluminum nitride, aluminum borate whiskers, boron nitride, and silica. These may be used singly or in combination of two or more kinds thereof. Among these, the component (C) may be silica from the viewpoint of adjusting the melt viscosity. The shape of the component (C) is not particularly limited; however, the shape may be a spherical shape.

[0045] The average particle size of the component (C) may be 0.01 to 1 μm , 0.01 to 0.8 μm , or 0.03 to 0.5 μm , from the viewpoint of fluidity. Here, the average particle size means a value determined by converting from the BET specific surface area.

[0046] The content of the component (C) may be 0.1 to 50 parts by mass, 0.1 to 30 parts by mass, or 0.1 to 20 parts by mass, with respect to 100 parts by mass of the total mass of the component (A).

[0047] Component (D): Coupling agent

The component (D) may be a silane coupling agent. Examples of the silane coupling agent include γ -ureidopropyltriethoxysilane, γ -mercaptopropyltrimethoxysilane, 3-phenylaminopropyltrimethoxysilane, and 3-(2-aminoethyl)aminopropyltrimethoxysilane. These may be used singly or in combination of two or more kinds thereof.

[0048] Component (E): Curing accelerator

The component (E) is not particularly limited, and any agent that

is generally used can be used. Examples of the component (E) include an imidazole and derivatives thereof, an organic phosphorus-based compound, a secondary amine, a tertiary amine, and a quaternary ammonium salt. These may be used singly or in combination of two or more kinds thereof. Among these, from the viewpoint of reactivity, the component (E) may be an imidazole and derivatives thereof.

[0049] Examples of the imidazole include 2-methylimidazole, 1-benzyl-2-methylimidazole, 1-cyanoethyl-2-phenylimidazole, and 1-cyanoethyl-2-methylimidazole. These may be used singly or in combination of two or more kinds thereof.

[0050] The film-form adhesive (adhesive composition) may further contain other components. Examples of the other components include a pigment, an ion trapping agent, and an oxidation inhibitor.

[0051] The content of the component (D), component (E), and other components may be 0 to 30 parts by mass with respect to 100 parts by mass of the total mass of the component (A).

[0052] FIG. 1 is a schematic cross-sectional view illustrating an embodiment of the film-form adhesive. A film-form adhesive 1 (adhesive film) illustrated in FIG. 1 is a product obtained by molding the adhesive composition into a film shape. The film-form adhesive 1 may be in a semi-cured (stage B) state. Such a film-form adhesive 1 can be formed by applying the adhesive composition on a support film. In the case of using a varnish of the adhesive composition (adhesive varnish), the component (A) and component (B), as well as other components that are added as necessary are mixed in a solvent, the mixed liquid is mixed or kneaded to prepare an adhesive varnish, the adhesive varnish is applied

on a support film, the solvent is removed by heating and drying the adhesive varnish, and thereby the film-form adhesive 1 can be formed.

[0053] The support film is not particularly limited as long as it can withstand the above-described heating and drying; however, for example, a polyester film, a polypropylene film, a polyethylene terephthalate film, a polyimide film, a polyetherimide film, a polyether naphthalate film, a polymethylpentene film, or the like may be used. The support film may be a multilayer film combining two or more kinds or may be a film having the surface treated with a mold release agent such as a silicone-based agent or a silica-based agent. The thickness of the support film may be, for example, 10 to 200 μm or 20 to 170 μm .

[0054] Mixing or kneading can be carried out using conventional dispersing machines such as a stirrer, a Raikai mixer, a three-roll mill, and a ball mill, by appropriately combining these.

[0055] The solvent to be used for the preparation of the adhesive varnish is not limited so long as the solvent can uniformly dissolve, knead, or disperse various components, and conventionally known solvents can be used. Examples of such a solvent include ketone-based solvents such as acetone, methyl ethyl ketone, methyl isobutyl ketone, and cyclohexanone; dimethylformamide, dimethylacetamide, N-methyl-2-pyrrolidone, toluene, and xylene. The solvent may be methyl ethyl ketone, cyclohexanone, or the like from the viewpoints of having a high drying speed and being inexpensive.

[0056] Regarding the method of applying the adhesive varnish on a support film, any known method can be used, and examples include a knife coating method, a roll coating method, a spray coating method, a

gravure coating method, a bar coating method, and a curtain coating method. The conditions for heating and drying are not particularly limited so long as they are conditions in which the solvent used is sufficiently volatilized; however, heating and drying can be carried out by heating at 50°C to 150°C for 1 to 30 minutes.

[0057] The thickness of the film-form adhesive may be 50 μm or less.

When the thickness of the film-form adhesive is 50 μm or less, since the distance between a semiconductor element and a support member for mounting the semiconductor element is shortened, inconvenience caused

by copper ions tends to occur easily. With regard to the film-form adhesive according to the present embodiment, since it is possible to sufficiently suppress migration (permeation) of copper ions within the adhesive, the thickness of the film-form adhesive can be adjusted to 50 μm or less. The thickness of the film-form adhesive 1 may be 40 μm or

less, 30 μm or less, 20 μm or less, or 15 μm or less. The lower limit of the thickness of the film-form adhesive 1 is not particularly limited; however, the lower limit can be adjusted to, for example, 1 μm or more.

[0058] The time for copper ion permeation of the film-form adhesive 1 in a completely cured (stage C) state (that is, a cured product of the film-form adhesive) may be 200 minutes or longer and may also be 200 minutes or longer, 300 minutes or longer, or 500 minutes or longer.

Inconvenience caused by copper ions tends to easily occur during a high temperature treatment such as a reflow process. Therefore, as the completely cured (stage C) state lasts 200 minutes or longer, it is anticipated that the inconvenience caused by copper ions is less likely to occur.

[0059] FIG. 2 is a schematic cross-sectional view illustrating an embodiment of an adhesive sheet. An adhesive sheet 100 illustrated in FIG. 2 comprises a base material 2 and a film-form adhesive 1 provided on the base material 2. FIG. 3 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet. An adhesive sheet 110 illustrated in FIG. 3 comprises a base material 2; a film-form adhesive 1 provided on the base material 2; and a cover film 3 provided on a surface of the film-form adhesive 1, the surface being on the opposite side of the base material 2.

[0060] The base material 2 is not particularly limited; however, the base material 2 may be a base material film. The base material film may be a film similar to the above-mentioned support film.

[0061] The cover film 3 is used to prevent any damage or contamination of the film-form adhesive and may be, for example, a polyethylene film, a polypropylene film, or a surface peeling agent-treated film. The thickness of the cover film 3 may be, for example, 15 to 200 μm or 70 to 170 μm .

[0062] The adhesive sheets 100 and 110 can be formed by applying an adhesive composition on a base material film, in the same manner as in the above-mentioned method for forming a film-form adhesive. The method of applying an adhesive composition on the base material 2 may be similar to the above-mentioned method of applying an adhesive composition on a support film.

[0063] The adhesive sheet 110 can be obtained by further laminating the cover film 3 on the film-form adhesive 1.

[0064] The adhesive sheets 100 and 110 may also be formed using a film-

form adhesive that has been produced in advance. In this case, the adhesive sheet 100 can be formed by performing lamination under predetermined conditions (for example, room temperature (20°C) or a heated state) using a roll laminator, a vacuum laminator, or the like.

5 From the viewpoint that the adhesive sheet can be continuously produced, and that the efficiency is excellent, the adhesive sheet 100 may also be formed using a roll laminator in a heated state.

[0065] Another embodiment of the adhesive sheet is a dicing-die bonding integrated adhesive sheet, in which the base material 2 is a dicing
10 tape. When a dicing-die bonding integrated adhesive sheet is used, since the process of lamination on a semiconductor wafer is carried out only once, efficient implementation of operation is enabled.

[0066] Examples of the dicing tape include plastic films such as a polytetrafluoroethylene film, a polyethylene terephthalate film, a
15 polyethylene film, a polypropylene film, a polymethylpentene film, and a polyimide film. Furthermore, the dicing tape may have been subjected to a surface treatment such as primer coating, a UV treatment, a corona discharge treatment, a polishing treatment, or an etching treatment, as necessary. The dicing tape may have tacky adhesiveness. Such a
20 dicing tape may be a product obtained by imparting tacky adhesiveness to the above-mentioned plastic film and may be a product obtained by providing a tacky adhesive layer on one surface of the above-mentioned plastic film. The tacky adhesive layer may be either a pressure-sensitive type layer or a radiation-curable type layer and is not particularly limited
25 so long as the tacky adhesive layer has sufficient tacky adhesive force that does not allow scattering of semiconductor elements during dicing

and has low tacky adhesive force to the extent that semiconductor elements are not damaged during a subsequent pickup process for semiconductor elements, and any conventionally known tacky adhesive layer can be used.

5 [0067] The thickness of the dicing tape may be 60 to 150 μm or 70 to 130 μm , from the viewpoints of economic efficiency and film handleability.

[0068] Examples of such a dicing-die bonding integrated adhesive sheet include an adhesive sheet having the configuration illustrated in FIG. 4 and an adhesive sheet having the configuration illustrated in FIG. 5. FIG. 4 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet. FIG. 5 is a schematic cross-sectional view illustrating another embodiment of the adhesive sheet. An adhesive sheet 120 illustrated in FIG. 4 comprises a dicing tape 7, a tacky adhesive layer 6, and a film-form adhesive 1 in this order. An adhesive sheet 130 illustrated in FIG. 5 comprises a dicing tape 7 and a film-form adhesive 1 provided on the dicing tape 7.

15 [0069] The adhesive sheet 120 can be obtained by, for example, providing a tacky adhesive layer 6 on a dicing tape 7 and further laminating a film-form adhesive 1 on the tacky adhesive layer 6. The adhesive sheet 130 can be obtained by, for example, sticking a dicing tape 7 and a film-form adhesive 1 together.

20 [0070] The film-form adhesive and the adhesive sheet may be a film-form adhesive and an adhesive sheet that are used for the production of a semiconductor device, and may be the ones that are used for the production of a semiconductor device, the production including a step of

sticking a film-form adhesive and a dicing tape together at 0°C to 90°C to a semiconductor wafer or to semiconductor elements (semiconductor chips) that have been already singulated, subsequently obtaining film-form adhesive-attached semiconductor elements by dividing the assembly with a rotating blade, a laser, or by stretching, and then adhering one of the film-form adhesive-attached semiconductor elements onto an organic substrate, a lead frame, or another semiconductor element.

[0071] Examples of the semiconductor wafer include single crystal silicon, polycrystalline silicon, various ceramics, and compound semiconductors such as gallium arsenide.

[0072] The film-form adhesive and the adhesive sheet can be used as adhesives for die bonding for sticking together a semiconductor element such as IC or LSI with a lead frame such as an alloy 42 lead frame or a copper lead frame; a plastic film of a polyimide resin or an epoxy resin; a product obtained by impregnating a base material such as a nonwoven glass fabric with a plastic such as a polyimide resin or an epoxy resin and curing the resultant; a support member for semiconductor mounting, formed from ceramics and the like such as alumina; or the like.

[0073] The film-form adhesive and the adhesive sheet are suitably used also as adhesives for adhering a semiconductor element to another semiconductor element in a Stacked-PKG having a structure in which a plurality of semiconductor elements are stacked. In this case, one of the semiconductor elements serves as a support member for mounting a semiconductor element.

[0074] The film-form adhesive and the adhesive sheet can also be used as, for example, protective sheets for protecting the back surface of

semiconductor elements in a flip-chip type semiconductor device, sealing sheets for sealing between the surface of semiconductor elements of a flip-chip type semiconductor device and an adherend, or the like.

[0075] A semiconductor device produced using a film-form adhesive will be specifically described using the drawings. In recent years, semiconductor devices having various structures have been proposed, and it should be noted that the use application of the film-form adhesive according to the present embodiment is not limited to the semiconductor device having the structure described below.

[0076] FIG. 6 is a schematic cross-sectional view illustrating an embodiment of a semiconductor device. A semiconductor device 200 illustrated in FIG. 6 comprises a semiconductor element 9; a support member 10 for mounting the semiconductor element 9; and an adhesive member (cured product 1c of a film-form adhesive) provided between the semiconductor element 9 and the support member 10 and adhering the semiconductor element 9 to the support member 10. A connection terminal (not illustrated in the drawing) of the semiconductor element 9 is electrically connected to an external connection terminal (not illustrated in the drawing) through a wire 11 and is sealed by a sealing material 12.

[0077] FIG. 7 is a schematic cross-sectional view illustrating another embodiment of the semiconductor device. In a semiconductor device 210 illustrated in FIG. 7, a semiconductor element 9a of a first stage is adhered, by an adhesive member (cured product 1c of a film-form adhesive), to a support member 10 having a terminal 13 formed thereon, and a semiconductor element 9b of a second stage is further adhered onto

the semiconductor element 9a of the first stage by the adhesive member (cured product 1c of a film-form adhesive). The connection terminals (not illustrated in the drawing) of the semiconductor element 9a of the first stage and the semiconductor element 9b of the second stage are electrically connected to external connection terminals through a wire 11 and are sealed by a sealing material 12. As such, the film-form adhesive according to the present embodiment can also be suitably used in a semiconductor device having a structure in which a plurality of semiconductor elements are stacked.

[0078] The semiconductor devices (semiconductor packages) illustrated in FIG. 6 and FIG. 7 are obtained by, for example, interposing a film-form adhesive between a semiconductor element and a support member or between a semiconductor element and another semiconductor element, adhering the two by subjecting these to heating and pressure-bonding, and subsequently performing a wire bonding step, a sealing step using a sealing material, a heating and melting step including reflow soldering, and the like, as necessary. The heating temperature for the heating and pressure-bonding step is usually 20°C to 250°C, the load is usually 0.1 to 200 N, and the heating time is usually 0.1 to 300 seconds.

[0079] Regarding the method of interposing the film-form adhesive between a semiconductor element and a support member or between a semiconductor element and another semiconductor element, as described above, the method may be a method for producing a film-form adhesive-attached semiconductor element in advance and then sticking the semiconductor element to a support member or another semiconductor element.

[0080] The support member may include a member composed of copper. In the semiconductor device according to the present embodiment, since a semiconductor element and a support member are adhered by a cured product 1c of a film-form adhesive, even in a case where a member
5 composed of copper is used as a constituent member of the semiconductor device, the influence of the copper ions generated from the member can be reduced, and the occurrence of any electrical inconvenience caused by copper ions can be sufficiently suppressed.

[0081] Here, examples of the member composed of copper include a lead
10 frame, a wiring, a wire, and a heat-dissipating material; however, in all cases where copper is used for any of the members, the influence of copper ions can be reduced.

[0082] Next, an embodiment of the method for producing a semiconductor device in the case of using the dicing-die bonding integrated adhesive sheet illustrated in FIG. 4 will be described. It
15 should be noted that the method for producing a semiconductor device using a dicing-die bonding integrated adhesive sheet is not limited to the method for producing a semiconductor device that will be described below.

[0083] First, a semiconductor wafer is pressure-bonded to a film-form adhesive 1 in an adhesive sheet 120 (dicing-die bonding integrated adhesive sheet), and this is adhered and held to be fixed (mounting step). The present step may also be carried out by pressing the assembly by a pressing member such as a pressure-bonding roll.
20

[0084] Next, dicing of the semiconductor wafer is performed. Thereby,
25 the semiconductor wafer is cut out into a predetermined size to produce

a plurality of singulated film-form adhesive-attached semiconductor elements (semiconductor chips). Dicing can be carried out by, for example, a conventional method from the circuit surface side of the semiconductor wafer. Furthermore, in the present step, for example, a cutting method called full-cut, by which incision up to the dicing tape is performed; a method of dividing the semiconductor wafer by inserting a half-cut incision into the semiconductor wafer and pulling the semiconductor wafer under cooling; a cutting method of using a laser; and the like can be employed. The dicing device used for the present step is not particularly limited, and any conventionally known device can be used.

[0085] In order to detach the semiconductor element adhered and fixed to the dicing-die bonding integrated adhesive sheet, picking up of the semiconductor element is performed. The method for picking up is not particularly limited, and various conventionally known methods can be employed. For example, a method of pushing up individual semiconductor elements using a needle through the dicing-die bonding integrated adhesive sheet side and picking up the pushed semiconductor elements by a pick-up device, and the like may be mentioned.

[0086] Here, picking up is carried out, in a case where the tacky adhesive layer is a radiation (for example, ultraviolet radiation)-curable type, after the tacky adhesive layer is irradiated with radiation. Thereby, the tacky adhesive force of the tacky adhesive layer to the film-form adhesive is decreased, and detachment of the semiconductor element is made easy. As a result, picking up is made possible without damaging the semiconductor element.

[0087] Next, the film-form adhesive-attached semiconductor element formed by dicing is adhered to a support member for mounting a semiconductor element, by means of the film-form adhesive. Adhesion may be carried out by pressure-bonding. The conditions for die bonding are not particularly limited and can be appropriately set according to necessity. Specifically, for example, die bonding can be carried out at a die bonding temperature of 80°C to 160°C, a bonding load of 5 to 15 N, and a bonding time in the range of 1 to 10 seconds.

[0088] If necessary, a step of thermally curing the film-form adhesive may be provided. By thermally curing the film-form adhesive that adheres the support member and the semiconductor element by the above-described adhesion step, adhesive fixing can be achieved more strongly. In the case of performing thermal curing, curing may also be achieved by applying pressure at the same time. The heating temperature for the present step can be appropriately changed depending on the constituent component of the film-form adhesive. The heating temperature may be, for example, 60°C to 200°C. Meanwhile, the step may be carried out while changing the temperature or pressure stepwise.

[0089] Next, a wire bonding step of electrically connecting the tip of a terminal part (inner lead) of the support member with an electrode pad on the semiconductor element using a bonding wire is carried out. As the bonding wire, for example, a gold wire, an aluminum wire, a copper wire, or the like is used. The temperature at the time of performing wire bonding may be in the range of 80°C to 250°C or 80°C to 220°C. The heating time may be several seconds to several minutes. Connecting the wire may also be carried out in a state of being heated in the above-

described temperature range, by using vibration energy induced by ultrasonic waves and pressure-bonding energy induced by applied pressure in combination.

[0090] Next, a sealing step of sealing the semiconductor element using a sealing resin is carried out. The present step is carried out in order to protect the semiconductor element mounted on the support member or the bonding wire. The present step is carried out by molding a resin for sealing in a mold. The sealing resin may be, for example, an epoxy-based resin. The substrate and residue are embedded by heat and pressure at the time of sealing, and detachment at the adhesion interface caused by gas bubbles can be prevented.

[0091] Next, in the post-curing step, the sealing resin that has been insufficiently cured in the sealing step is completely cured. Even in a case where the film-form adhesive is not thermally cured in the sealing step, adhesive fixing is enabled by thermally curing the film-form adhesive together with curing of the sealing resin in the present step. The heating temperature in the present step can be appropriately set according to the type of the sealing resin, and for example, the heating temperature may be in the range of 165°C to 185°C, while the heating time may be about 0.5 to 8 hours.

[0092] Next, the film-form adhesive-attached semiconductor element adhered to the support member is heated using a reflow furnace. In the present step, the resin-sealed semiconductor device may be surface-mounted on the support member. Regarding the method for surface mounting, for example, reflow soldering of supplying solder in advance on a printed wiring board, subsequently heating and melting the solder by

warm air or the like, and performing soldering, and the like may be mentioned. Examples of the heating method include hot air reflow and infrared reflow. Furthermore, the heating method may be heating the entirety or may be heating a local site. The heating temperature may be,
5 for example, in the range of 240°C to 280°C.

[0093] In a case where semiconductor elements are stacked in multiple layers, the thermal history of the wire bonding step and the like increases, and the influence of gas bubbles present at the interface between the film-form adhesive and the semiconductor elements on detachment may
10 become serious. However, since the film-form adhesive according to the present embodiment uses a specific acrylic rubber, the cohesive force is decreased, and embeddability tends to be enhanced. Therefore, gas bubbles are not easily entrained into the semiconductor device, gas bubbles can be easily diffused in the sealing step, and detachment caused
15 by gas bubbles at the adhesion interface can be prevented.

Examples

[0094] Hereinafter, the present invention will be specifically described based on Examples; however, the present invention is not intended to be limited to these.

20 [0095] [Production of film-form adhesive]

(Examples 1 to 3 and Comparative Example 1)

<Preparation of adhesive varnish>

To compositions composed of an epoxy resin as (A1) a thermosetting resin, a phenolic resin as (A2) a curing agent, and (C) an
25 inorganic filler with the product names and composition ratios (unit: parts by mass) shown in Table 1, cyclohexanone was added, and the mixtures

were stirred and mixed. To these mixtures, acrylic rubbers as (A3) an elastomer as shown in Table 1 were added and stirred, (D) a coupling agent, (E) a curing accelerator, and (B) a leveling agent as shown in Table 1 were further added to the mixtures, and the mixtures were stirred until the various components became uniform to prepare adhesive varnishes. Incidentally, the numerical values for the component (A3) and the component (C) shown in Table 1 mean parts by mass of the solid content.

[0096] (A) Thermosetting resin component

(A1) Thermosetting resin

(A1-1) YDCN-700-10 (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd., o-cresol novolac type epoxy resin, epoxy equivalent: 209 g/eq)

(A2) Curing agent

(A2-1) PSM4326 (trade name, manufactured by Gun-Ei Chemical Industry Co., Ltd., phenol novolac resin, hydroxyl group equivalent: 105 g/eq)

(A3) Elastomer

(A3-1) SG-P3 (trade name, manufactured by Nagase ChemteX Corporation, a methyl ethyl ketone solution of an acrylic rubber having an epoxy group, weight average molecular weight of the acrylic rubber: 850000)

[0097] (B) Leveling agent

(B1) BYK-333 (trade name, manufactured by BYK Japan KK, polyether-modified polydimethylsiloxane)

[0098] (C) Inorganic filler

(C1) SC2050-HLG (trade name, manufactured by Admatechs

Company Limited, silica filler dispersion liquid, average particle size 0.50 μm)

[0099] (D) Coupling agent

(D1) A-189 (trade name, manufactured by Nippon Unicar Company Limited, γ-mercaptopropyltrimethoxysilane)

(D2) A-1160 (trade name, manufactured by Nippon Unicar Company Limited, γ-ureidopropyltriethoxysilane)

[0100] (E) Curing accelerator

(E1) 2PZ-CN (trade name, manufactured by SHIKOKU CHEMICALS CORPORATION, 1-cyanoethyl-2-phenylimidazole)

[0101] <Production of film-form adhesive>

Each of the adhesive varnishes thus produced was filtered through a 100-mesh filter and was subjected to vacuum defoaming. As a base material film, a polyethylene terephthalate (PET) film having a thickness of 38 μm that had been subjected to a mold release treatment was prepared, and the adhesive varnish after vacuum defoaming was applied on the PET film. The applied adhesive varnish was heated and dried in two stages for 5 minutes at 90°C and subsequently for 5 minutes at 130°C, and film-form adhesives of Examples 1 to 3 and Comparative Example 1 in the stage B state were obtained. With regard to the film-form adhesive, the thickness was adjusted to 10 μm by adjusting the coating amount of the adhesive varnish.

[0102] [Measurement of copper ion permeation time]

<Preparation of liquid A>

2.0 g of anhydrous copper(II) sulfate was dissolved in 1020 g of distilled water, the solution was stirred until copper sulfate completely

dissolved, and an aqueous solution of copper sulfate in which the copper ion concentration was a concentration of 500 mg/kg in terms of Cu element was prepared. The aqueous solution of copper sulfate thus obtained was designated as liquid A.

5 [0103] <Preparation of liquid B>

1.0 g of anhydrous sodium sulfate was dissolved in 1000 g of distilled water, and the solution was stirred until sodium sulfate completely dissolved. To this, 1000 g of N-methyl-2-pyrrolidone (NMP) was further added, and the mixture was stirred. Subsequently,
10 the mixture was air-cooled to room temperature, and an aqueous solution of sodium sulfate was obtained. The solution thus obtained was designated as liquid B.

[0104] <Measurement of copper ion permeation time>

The film-form adhesives of Examples 1 to 3 and Comparative
15 Example 1, all of which were in the stage B state, were further heated and dried at 170°C for one hour, and the film-form adhesives of Examples 1 to 3 and Comparative Example 1, which were in the stage C state, were produced. Each of the film-form adhesives (thickness: 10 μm) of Examples 1 to 3 and Comparative Example 1 in the stage C state was cut
20 out into a circular shape having a diameter of about 3 cm. Next, two sheets of silicon packing sheets having a thickness of 1.5 mm, an outer diameter of about 3 cm, and an inner diameter of 1.8 cm were prepared. The film-form adhesive cut out into a circular shape was interposed between two sheets of silicon packing sheets, and this was interposed
25 between the flange parts of two glass cells having a volume of 50 mL and fixed with a rubber band.

[0105] Next, 50 g of liquid A was poured into one of the glass cells, and 50 g of liquid B was poured into the other glass cell. Mars Carbon (manufactured by STAEDTLER Mars GmbH & Co. KG, ϕ 2 mm/130 mm) as a carbon electrode was inserted into each of the cells. The liquid A side was designated as an anode, the liquid B side was designated as a cathode, and the anode was connected to a direct current power supply (manufactured by A&D Company, Limited, direct current power supply device AD-9723D). Furthermore, the cathode and the direct current power supply were connected in series through an ammeter (manufactured by Sanwa Electric Instrument Co., Ltd., Digital multimeter PC-720M). At room temperature, voltage was applied at an applied voltage of 24.0 V, and measurement of the current value was initiated after the application. Measurement was performed until the current value exceeded 5 μ A, and the time point at which the current value reached 1 μ A was designated as the copper ion permeation time. The results are presented in Table 1. In the present evaluation, it can be said that as the permeation time is longer, migration (permeation) of copper ions is suppressed.

[0106] [Measurement of die shear strength after curing]

<Production of semiconductor device>

A dicing tape (manufactured by Hitachi Chemical Co., Ltd., thickness 110 μ m) was prepared, each of the film-form adhesives (thickness 10 μ m) of Examples 1 to 3 and Comparative Example 1 in the stage B state was stuck thereto to produce a dicing-die bonding integrated adhesive sheet comprising a dicing tape and a film-form adhesive. A semiconductor wafer having a thickness of 400 μ m was laminated on the

film-form adhesive side of the dicing-die bonding integrated adhesive sheet at a stage temperature of 70°C, and dicing samples were produced.

[0107] Each of the dicing samples thus obtained was cut using a fully automatic dicer DFD-6361 (manufactured by DISCO Corporation).

5 Cutting was performed by a step-cut method of using two sheets of blades, and dicing blades ZH05-SD3500-N1-xx-DD and ZH05-SD4000-N1-xx-BB (all manufactured by DISCO Corporation) were used. The cutting conditions were set to a speed of blade rotation of 4000 rpm, a cutting speed of 50 mm/sec, and a chip size of 5 mm × 5 mm. Regarding
10 the cutting, first stage cutting was performed such that about 200 μm of the semiconductor wafer would remain, and subsequently, second stage cutting was performed such that an incision of about 20 μm would be inserted into the dicing tape.

[0108] Subsequently, semiconductor chips obtained by cutting were
15 thermally pressure-bonded onto a solder resist (TAIYO HOLDINGS CO., LTD., trade name: AUS-308). The pressure-bonding conditions were set to a temperature of 120°C, a duration of 1 second, and a pressure of 0.1 MPa. Subsequently, the samples obtained by pressure-bonding were introduced into a dryer and were cured for one hour at 170°C. The

20 semiconductor chips pressure-bonded to the solder resist were cured, and the die shear strength after curing between the semiconductor chip and the solder resist was measured by suspending and pulling the semiconductor chip using a universal bond tester (manufactured by Nordson Advanced Technology (Japan) K.K., trade name: Series 4000).

25 The measurement conditions were set to a stage temperature of 250°C. The results are presented in Table 1.

[0109] Table 1

			Comp. Exam. 1	Exam. 1	Exam. 2	Exam. 3
Component (A)	(A1)	(A1-1)	11	11	11	11
	(A2)	(A2-1)	6	6	6	6
	(A3)	(A3-1)	73	73	73	73
Component (B)	(B1)		-	0.25	0.5	1.0
Component (C)	(C1)		8	8	8	8
Component (D)	(D1)		0.4	0.4	0.4	0.4
	(D2)		1.2	1.2	1.2	1.2
Component (E)	(E1)		0.02	0.02	0.02	0.02
Copper ion permeation time (minutes)	Stage C @1 μ A		180	321	923	878
Die shear strength after curing (MPa)	250°C		2.0	2.0	2.0	2.0

[0110] As shown in Table 1, in the film-form adhesives of Examples 1 to 3, permeation of copper ions became difficult as compared to the film-form adhesive of Comparative Example 1. In this regard, it is speculated that the surface tension of the adhesive was decreased by the leveling agent, and uptake of copper ions in the adhesive surface layer was suppressed.

[0111] As described above, it was verified that the film-form adhesive of the present invention is capable of sufficiently suppressing the inconvenience associated with the migration of copper ions within the adhesive.

Reference Signs List

[0112] 1: film-form adhesive, 2: base material, 3: cover film, 6: tacky adhesive layer, 7: dicing tape, 9, 9a, 9b: semiconductor element, 10: support member, 11: wire, 12: sealing material, 13: terminal, 100, 110, 120, 130: adhesive sheet, 200, 210: semiconductor device.

CLAIMS

[Claim 1] A film-form adhesive for adhering a semiconductor element to a support member for mounting the semiconductor element, the film-form adhesive comprising a thermosetting resin component, a leveling agent, and inorganic filler, wherein the thermosetting resin component comprises a thermosetting resin, a curing agent, and an elastomer, and with respect to 100 parts by mass of the total mass of the thermosetting resin, the curing agent, and the elastomer, the total content of the thermosetting resin and the curing agent is 15 to 30 parts by mass, the content of the elastomer is 70 to 85 parts by mass, the content of the leveling agent is 0.2 to 1.5 parts by mass, and the content of inorganic filler is 0.1 to 20 parts by mass with respect to 100 parts by mass.

[Claim 2] The film-form adhesive according to claim 1, wherein the leveling agent is a compound having a siloxane structure.

[Claim 3] The film-form adhesive according to claim 1 or 2, wherein a thickness of the film-form adhesive is 50 μm or less.

[Claim 4] An adhesive sheet comprising:
a base material; and
the film-form adhesive according to any one of claims 1 to 3 provided on one surface of the base material.

[Claim 5] The adhesive sheet according to claim 4, wherein the base material is a dicing tape.

[Claim 6] A semiconductor device comprising:

5 a semiconductor element;
 a support member for mounting the semiconductor element; and
 an adhesive member provided between the semiconductor element and the support member, and adhering the semiconductor element to the support member,

10 wherein the adhesive member is a cured product of the film-form adhesive according to any one of claims 1 to 3.

[Claim 7] The semiconductor device according to claim 6, wherein the support member includes a member composed of copper.

15

[Claim 8] A method for producing a semiconductor device, the method comprising adhering a semiconductor element to a support member using the film-form adhesive according to any one of claims 1 to 3.

20

[Claim 9] A method for producing a semiconductor device, the method comprising:

 sticking the film-form adhesive of the adhesive sheet according to claim 4 or 5 to a semiconductor wafer;

25 cutting the semiconductor wafer having the film-form adhesive stuck thereto to produce a plurality of singulated film-form adhesive-

attached semiconductor elements; and

adhering each of the film-form adhesive-attached semiconductor elements to a support member.

- 5 [Claim 10] The method for producing a semiconductor device according to claim 9, further comprising heating the film-form adhesive-attached semiconductor element adhered to the support member, using a reflow furnace.